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Driving Innovation to Curb Climate Change

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Recommendations for COP 27

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2022 has been dramatic for the global climate crisis.[1] Record-breaking heat, droughts and flooding in Europe, China, Pakistan, India, the Middle East, Africa and the United States among others show that the climate crisis is already having catastrophic impacts with only a 1.2°C rise in global temperatures experienced so far. Other signs are worrying, too. Carbon emissions in 2021 reached a new peak after a slowdown in 2020. Rapid melting of ice in Greenland and the Antarctic is now expected to lead to larger than projected increases in sea levels by the end of the century, whereas rapid thawing of permafrost in the Arctic is increasing methane emissions. As the world gets closer to a 1.5°C rise, the risk of passing irreversible tipping points – such as the collapse of the Greenland or West Antarctic ice fields – increases.[2]

Policy action is being taken across the world with 137 countries and many global firms now publicly committed to achieving net zero.[3] Progress in reducing emissions is being made in many countries, especially through greater use of renewable energy and improvements in energy efficiency, but the big questions are whether the world is moving fast enough and how the transition to net zero can be accelerated. The turmoil in energy markets due to Russia's invasion of Ukraine has further increased pressure to reduce dependence on fossil fuels and increase resilience. Renewable energy – often domestically produced – is increasingly seen as a more reliable and cheaper source of energy than fossil fuels. These developments help accelerate the transition.

1 The author would like to thank Chiara Criscuolo, Antoine Dechezleprêtre, Paul Hofheinz, Alice Iordache, Grace Milne, David Osimo and Andrew W. Wyckoff for comments and useful discussions. Any errors of fact or judgment are the author's sole responsibility.

2 David I. Armstrong McKay, Arie Staal, Jesse F. Abrams, Ricarda Winkelmann, Boris Sakschewski, Sina Loriani, Ingo Fetzer, Sarah E. Cornell, Johan Rockström and Timothy M. Lenton, "Exceeding 1.5°C Global Warming Could Trigger Multiple Climate Tipping Points," *Science*, 09 September 2022.

3 Visit https://zerotracker.net.

‘The big questions are whether the world is moving fast enough and how the transition to net zero can be accelerated.’

The policy tools for climate action are well understood and there is much experience across the world in implementing climate policies and strategies. Among the key elements are policies to level the playing field for low-carbon technologies relative to incumbent, fossil-fuel based ones, by “getting prices right” and eliminating the green premium that low-carbon technologies currently need to pay. Such policies seek to adjust for the negative impacts of carbon emissions on the economy and society by adjusting prices, for example, through the implementation of carbon taxes, tradeable permits such as Europe’s Emissions Trading System and the removal of fossil fuel subsidies.[4] Also among the key elements of climate policy are actions to strengthen markets for low-carbon technologies through supportive regulation, technological standards or innovative public procurement. And a third key element are policies that directly mobilise investment and encourage innovation in low-carbon activities and technologies.[5]

The role of innovation – which involves the creation and diffusion of new products, processes and methods – is recognised in these policies and strategies but does not yet receive as much attention as needed. This may be because it is not always clear how policy can drive innovation and how quickly policies for innovation can deliver. Low-carbon innovation policies therefore remain underutilised compared to the important contribution they can make and are not sufficiently integrated in governments’ overall thinking and strategies for climate change, including the global debate about to unfold at the 27th Conference of the Parties of the United Nations Framework on Combatting Climate Change (UNFCCC), also known as COP 27. Considering the importance of innovation, this is a critical policy gap. Some progress is being made; in 2022, the sixth Intergovernmental Panel on Climate Change (IPCC) assessment report – a science-based report which informs the United Nations conference – included a separate chapter on innovation for the first time.[6] There are several reasons why innovation is so important:[7]

- **Innovation can accelerate the transition to net zero.** It is among the most important policy tools that can help accelerate the transition by developing new options and alternatives and driving down costs. This reduces the green premium and makes it easier for firms and households to invest in these technologies, helping to accelerate change. The COVID-19 crisis has shown that innovation can deliver solutions that make a genuine difference in a global crisis. Given the growing cost of climate-related damages and growing risk of climate tipping points, it is crucial to accelerate the transition and to reach net-zero objectives as soon as possible. Innovation provides this opportunity.

- **Innovation provides both global and local benefits.** Progress in low-carbon innovation in one country has global benefits. Rapid, ongoing progress in solar, wind and battery technologies driven by a small number of lead innovators has benefitted all, as it has led to dramatically lower prices for these clean technologies. The average price of solar photovoltaic fell to 0.057 $/KWh (0.050 €/Kwh) in 2020, down from 0.381 (0.287 €/Kwh)in 2010, and for onshore wind to 0.039 $/Kwh (0.034 €/Kwh) in 2020 from 0.089 (0.067 €/Kwh) in 2010, both below the costs of fossil-fuel based alternatives.[8] Given the global nature of climate change, this

4 This policy brief will use the term low-carbon technologies for all technologies that address climate change, even if some technologies may be aimed at mitigating other greenhouse gases, such as methane.

5 For more, see Filippo Maria D’Arcangelo, Ilai Levin, Alessia Pagani, Mauro Pisu and Åsa Johansson, *A Framework to Decarbonise the Economy* (Paris: OECD, 2022).

6 Intergovernmental Panel on Climate Change, Working Group III, *Contribution to the Sixth Assessment Report* (Geneva: United Nations, 2022). See especially Chapter 16: “Innovation, Technology Development and Transfer.”

7 For more, see Nicholas Stern and Anna Valero, “Innovation, Growth and the Transition to Net-Zero Emissions,” *Research Policy*, November 2021, and OECD, *Driving Low-Carbon Innovations for Carbon Neutrality* (Paris: OECD, 2022, forthcoming). See, also, the fascinating discussion on Driving Innovation for Net-Zero: Evidence, Tools and Policies, an OECD conference.

8 Visit International Renewable Energy Agency, *Global Trends: Costs* at www.irena.org. Data accessed September 2022. Data in dollars will be converted to euros using annual average exchange rates for the year throughout this policy brief.

‘The COVID-19 crisis has shown that innovation can deliver solutions that make a genuine difference in a global crisis.’

decline in costs is crucial as it enables clean technologies like these to be adopted across the globe, even in low-income economies, instead of fossil-fuel based alternatives. Innovation policies can therefore have global benefits for the fight against climate change. At the same time, they provide benefits to the domestic economy and society, for example by reducing pollution and making cities more liveable, and because they allow countries to benefit from trade in low-carbon products, services and technologies, thus supporting local jobs and incomes.

- **Innovation allows sustainable economic growth and climate action to go hand in hand.** It is key to a future that combines rapid progress to a net-zero world and sustainable economic growth. Innovation drives productivity growth, including in the use of energy, materials and resources, and can thus enable a much more rapid decoupling of resource use from economic growth.[9] Although some have argued for “degrowth” strategies characterised by negative economic and income growth for many countries and income groups, moving towards a net-zero world will require a massive expansion of sustainable activities, such as clean energy, infrastructure, buildings, environmental services, food and transport systems. In addition, as many low-income economies and some advanced economies are still faced with high levels of poverty, income growth remains urgently needed for many in the world. However, any future growth should be sustainable and circular, including in using far fewer natural resources, and be fully aligned with net-zero goals.

- **Innovation is well accepted and complementary to other climate actions.** It holds a special place in overall climate strategies. It is among the least controversial elements of climate policies, as seen in a recent cross-country survey, implying there is widespread political support for such policies, as illustrated also by the passing of the Inflation Reduction Act in the U.S., where several previous efforts to introduce climate legislation had failed.[10] Moreover, innovation can strengthen the effectiveness and reduce the costs of implementation of other policy instruments, such as carbon taxes, thus lowering the overall costs of policy action.[11]

Given these and other benefits, innovation urgently needs to become a more central policy tool in the global strategy to address climate change. Thus far, global efforts are insufficient. Recent OECD work shows that investment in clean energy and low-carbon research and development has remained flat for many decades, while the share of clean patenting has declined since 2015 despite the growing urgency of climate action.[12] In recent years, progress has been made that may turn these trends around, with more attention for climate-related innovation policies in the EU recovery packages and initiatives such as the European Green Deal, Korea’s green deal, clean energy policies in China and the recent climate-related policies in the U.S. Inflation Reduction Act.

However, given the urgent need to accelerate progress to net zero, more is needed. The International Energy Agency’s 2021 roadmap to net zero shows that half of the required technologies for net zero by 2050 are still in a prototype phase and not ready for widespread deployment.[13] And while most of the technologies required

9 Kornelis Blok, Paul Hofheinz and John Kerkhoven, *The 2015 Energy Productivity and Economic Prosperity Index: How Efficiency Will Drive Growth, Create Jobs and Spread Wellbeing throughout Society* (Brussels: The Lisbon Council, 2015).

10 Antoine Dechezleprêtre, Adrien Fabre, Tobias Kruse, Bluebery Planterose, Ana Sanchez Chico and Stefanie Stantcheva, “Fighting Climate Change: International Attitudes Toward Climate Policies,” *OECD Economics Department Working Paper*, No. 1714 (Paris: OECD, July 2022).

11 OECD (2022, forthcoming), op. cit.

12 Ibid.

13 International Energy Agency, Net Zero by 2050: *A Roadmap for the Global Energy Sector (Paris: IEA, 2021).*

'Investment in clean energy and low-carbon research and development has remained flat for many decades.'

for net zero exist at some level of development, they are often – with notable exceptions such as solar and wind energy – too expensive, not yet available at scale, and therefore not yet operational and competitive with existing technologies, slowing their uptake across the economy.[14]

More investment and progress in research and innovation are therefore needed. Moreover, given the global nature of climate change, global take-up of these innovations is essential. Even if all advanced economies would become carbon neutral by 2050, climate change will not be halted unless carbon neutrality is achieved at the global level. International cooperation in innovation and international technology diffusion are therefore key elements of global strategies for low-carbon innovation.

14 See also, Intergovernmental Panel on Climate Change (2022), op. cit.

15 International Energy Agency, op cit., Stern and Valero, op. cit., OECD (2022, forthcoming), op. cit.

Four Recommendations for Governments and COP 27

So what should be done to accelerate low-carbon innovation and speed up the global transition to net zero? And how can COP 27 contribute to these actions? There are many elements to a comprehensive and systemic approach to low-carbon innovation. Several recent studies have pointed to a range of policies that can contribute.[15] We have four recommendations:

1. **Deploy** available low-carbon innovation across the economy and society
2. **Drive** further low-carbon innovation to address technological gaps and reduce costs
3. **Develop Demand** and strengthen markets for low-carbon innovation
4. **Double Down** on international cooperation

Recommendation 1: Deploy available low-carbon innovation across the economy and society

The first imperative for low-carbon innovation policies is to ensure that innovation and technologies already available at scale are adopted as widely and rapidly as possible across the economy and society, including in developing and low-income economies. This is no small task, as history shows that technologies are often adopted only slowly over time, by both businesses and households. Digital technologies, such as the mobile phone and the Internet, have been the exception with rapid global take-up achieved in less than 20 years. The uptake of low-carbon innovations will need to move just as quickly. Two actions are particularly important here.

- **Support the diffusion of low-carbon innovation in the business sector.** Business accounts for the bulk of carbon emissions and therefore plays a critical role in mitigating emissions. Moreover, business is the main source of investment in innovation and will need to provide the bulk of investment in low-carbon activities. Supporting low-carbon innovation from business by de-risking private investment in new technologies and facilitating the uptake of available technologies is therefore important and included in many of the national policies that are currently being implemented, including the European Green Deal and the U.S.

‘The share of clean patenting has declined since 2015 despite the growing urgency of climate action.’

Inflation Reduction Act. Governments gathered at COP 27 have a wide range of tools at their disposal to stimulate the diffusion of low-carbon innovation in the business sector, including tax credits, loans, grants and subsidies.[16] As new technologies reach sufficient scale and costs go down, less support may be needed for technologies that are fully competitive with existing alternatives. Moreover, demand-side policies, aimed at strengthening markets for low-carbon innovation, will be crucial for the diffusion of technologies.

- **Support the diffusion of low-carbon technologies to households.** Helping firms adopt low-carbon technologies is not enough. Households are key too. Enabling households to embrace clean technologies, such as heat pumps, building insulation, solar photovoltaic and low-carbon transport, is therefore an important element of any policy agenda for low-carbon innovation. Many countries are already implementing supportive policies in this area and some lessons have been learned. With prices of many low-carbon technologies declining rapidly, governments don’t always need to give much support anymore, e.g., for solar photovoltaic installations that may pay themselves back in a short period. However, many households don’t have the financial means to make the initial investment and need to be assisted through some financial or tax support. The REPowerEU initiative, national policies in many EU countries and the U.S. Inflation Reduction Act all include incentives to help households purchase clean technologies, such as electric vehicles and heat pumps. Tax incentives can work in some of these areas, if buyers receive the benefit at the time of purchase. Subsidies and rebates can also work. Strengthening such support is important, in particular at the current time of high energy prices, as it can help bring down energy bills and ensure future sustainability.

Recommendation 2: Drive further low-carbon innovation

The second task for low-carbon innovation policies is to further drive innovation, address gaps and develop break-through technologies where needed; improve the performance of existing technologies, including in enabling them to operate at scale; and bring down their costs. Three actions are particularly important in this context.

- **Boost mission-oriented policies and moon shots to address innovation gaps and deliver breakthrough innovations.** Among the most urgent needs for innovation is progress in breakthrough technologies, notably in areas beyond energy, for example in certain industrial sectors as well as in aviation, agriculture and shipping. As noted by the IEA in their net-zero roadmap and catalogued in the IEA’s *ETP Clean Energy Technology Guide*, a database of clean energy data and information, about half of the technologies needed to meet net-zero goals are not yet ready for the market, which implies they are still too expensive or not yet able to operate at scale.[17] Only two – electric vehicles and lighting – are considered fully on track to reach 2030 and 2050 goals. Progress is being made in several important sectors, e.g., steel, cement, hydrogen, shipping, aviation and others, but more is needed. Focused mission-oriented policies, involving business,

16
See e.g., OECD (2022, forthcoming), op. cit.; and Nicholas Bloom, John Van Reenen and Heidi Williams, “A Toolkit of Policies to Promote Innovation,” *Journal of Economic Perspectives*, Summer 2019.

17
International Energy Agency (2021), op. cit. See also https://www.iea.org/articles/etp-clean-energy-technology-guide.

‘Innovation urgently needs to become a more central policy tool in the global strategy to address climate change.’

academia and other stakeholders, can help drive innovation in important areas. Mission-oriented policies – or moon shots – are inspired by high-profile technical missions like the U.S. Apollo programme are rapidly becoming a more important focus of policy, as also shown during the COVID-19 pandemic (e.g., operation warp speed in the U.S.), with climate-related missions growing in importance.[18]

Mission Innovation is a global cooperative effort of 20 major economies that was launched in 2015 in the side-lines of the COP 21 meeting to strengthen clean energy innovation. Its second phase, launched in 2021 during COP 26, is focused on a set of specific clean-energy solutions to enhance technology deployment through improvements in costs, performance and scale.[19] Also important is the Breakthrough Agenda which was launched by 45 world leaders at COP 26 to accelerate innovation and deployment of clean technologies, notably for the power sector, hydrogen, road transport, steel and agriculture.[20] COP 27 will be a key opportunity to strengthen and deepen such collaborations on mission innovation and moon shots among governments, business, academia and other stakeholders. However, mission innovation at the national and regional level is important too. In Europe, one of the five missions under the EU’s Horizon programme is adaptation to climate change for the European Union’s regions and communities. A more specific mission-oriented innovation policy is Norway’s Pilot-E which supports climate emission free and energy saving solutions from idea to market.

Business innovation will play a key role in missions and moon shots and governments need to support them, including by de-risking investment in breakthrough technologies. Recent research has shown that direct support for business research and development, for example through grants and public procurement, is better suited to steering innovation towards a specific mission than indirect support such as research and development tax credits.[21] At the same time, governments will need to balance support for breakthrough innovation with their support for short- and medium-term innovation, aiming at the diffusion of existing technologies. Both will be needed. Recent analysis of innovation policies in the Netherlands, for example, showed that the bulk of government support was focused on the diffusion of market-ready technologies, and very little on emerging technologies, such as green hydrogen.[22] Support for large demonstration projects for new technologies will be particularly important. Recent initiatives are promising, such as the announcement by 16 countries at the September 2022 Clean Energy Forum to commit $94 billion [€91 billion] for clean energy demonstration.[23]

Another particularly important issue for mission-oriented innovation is how to foster collaboration between businesses and with academic institutions, for example through public-private partnerships and industry consortia, notably for the pre-competitive stages of research. While competition between firms will be an important driver of innovation, such competition should balance the need for cooperation and sharing of knowledge on potential key technologies and breakthroughs, including across countries.[24] An interesting example is the World

18 The EC-OECD STIP Compass provides an interesting toolkit on mission innovation policies. Visit https://stip.oecd.org/moip/.

19 See the 2021 joint launch statement at http://mission-innovation.net/about-mi/overview/2021-joint-launch-statement/.

20 See the announcement at COP26 launching the agenda: https://ukcop26.org/breakthrough-agenda-launching-an-annual-global-checkpoint-process-in-2022/

21 OECD (2022, forthcoming), op. cit.

22 OECD, *Policies for a Carbon-Neutral Industry: Lessons from the Netherlands* (Paris: OECD, 2021).

23 See https://www.energy.gov/articles/united-states-announces-94-billion-global-public-funding-accelerate-clean-energy-worldwide. The exchange rate is the average 2022 euro-dollar exchange rate; data up to 01 October 2022.

24 See David M. Hart and Hoyu Chong, “Climate Innovation Policy from Glasgow to Pittsburgh,” *Nature Energy*, September 2022.

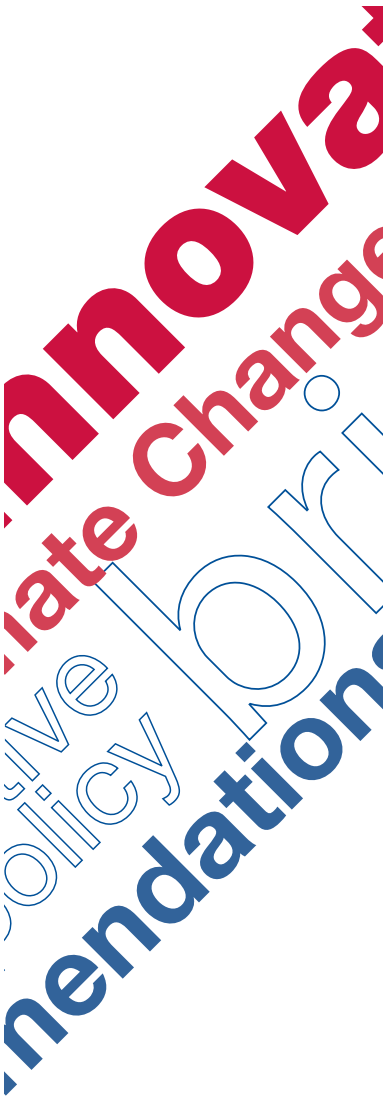
‘Given the urgent need to accelerate progress to net zero, more is needed.’

Economic Forum’s First Movers Coalition, a collaboration of 55 global firms that emerged at COP 25. These firms are making advance purchase commitments for low-carbon products, thus strengthening market development, and are also working together to address roadblocks in the development of low-carbon technologies.[25] Collaborations like this are not only important to drive a common agenda, e.g., for a specific industry or breakthrough technology, but also to share knowledge and experience and galvanise political support for further action. In bringing global actors together, COP 27 can help in strengthening and broadening such collaborations.

25 Visit https://www.weforum.org/first-movers-coalition.

- **Mobilise public research and development systems in support of climate-related innovation.** As climate change is an existential threat for humanity, addressing climate change must be the top priority for public investment in research and development of all countries involved in COP 27. While climate change has become a high priority in many countries’ public research and development efforts, most research and development systems haven’t been fully mobilised yet or put on a “war” footing commensurate with the existential threat humanity is facing. The experience with COVID-19 has demonstrated that greater public investment in research and development and higher prioritisation do accelerate innovation. Given the scale and nature of the climate challenge, there is every reason for such investment to involve a substantial increase in public research and development, but it can also involve the reprioritisation of existing public research and development, for example if a country is faced with important supply-side gaps, e.g., in researchers and equipment. Public research and development should not only focus on speeding up the development of technologies for climate-change mitigation, but also explore technologies that can help the world adapt to climate change. New materials will be important, for example, to help address supply gaps in several scarce resources that are key to clean energy and battery technologies. Finland’s Polar Night Energy, for example, uses sand heated to high temperatures to store energy for district heating. Public research and development should explore all possible options and technologies that could contribute to addressing climate change. Knowing more about all available options reduces uncertainty and increases the range of technologies that can be applied, if needed. Mobilising public research and development is the responsibility of individual countries, but COP 27 can help in encouraging such action.

- **Support the scaling of low-carbon innovation startups.** Entrepreneurs and startups are important drivers of innovation and are key to challenging incumbents and developing new technologies. During the COVID crisis, young and sometimes relatively small firms like Moderna, Inc and BioNTech SE were key to developing the mRNA vaccines that became core to the pandemic response. Many promising examples are now also emerging in low-carbon innovation, for example in the steel industry where H2 Green Steel AB in Sweden is among the first firms to produce low-carbon steel based on hydrogen. Enabling young firms to start, experiment, scale and – where necessary – fail, is therefore essential for low-carbon innovation. But recent analysis shows that despite the growing need



‘Demand-side policies, aimed at strengthening markets for low-carbon innovation, will be crucial for the diffusion of technologies.’

and demand for such startups, growth has been slow in recent years with a stagnation in venture capital (VC) funding in low-carbon innovation.[26] Some countries are therefore taking action to stimulate startups and help them reach scale. For example, Germany’s cabinet recently approved the establishment of a €30 billion fund to promote technology startups and enable them to scale in Europe. Support for scaling startups will mainly have to come from national governments. However, COP 27 can help in providing firms with the long-term perspective that they will need to succeed. The main challenge for low-carbon innovation is often not a lack of funding or promising ideas, but a lack of sufficiently strong policy signals that ensure a strong and growing market for these innovations. Policies to foster demand for low-carbon innovation, as will be discussed in the next recommendation, are therefore important and need to be a core part of strategies to drive innovation.

Recommendation 3: Develop demand for low-carbon innovation

The third key area for policy action on low-carbon innovation is to strengthen demand and improve the market for low-carbon innovation technologies and products. New technologies and products will not succeed unless there is a strong and growing market. Demand-side policies are therefore key in complementing supply-side policies that seek to accelerate innovation. Four important policy actions can be considered here.

- **Commit and stick to long-term net-zero goals.** Politically, perhaps the most important action that policymakers can take to support low-carbon innovation is to commit to a net-zero future – at COP 27, at the national level and across the broadest possible political spectrum. Innovation is risky and typically bears its greatest results in the medium to long term. The evidence from decades of research is clear: setting long-term targets and sticking to them generates confidence in government policy, reduces uncertainty and allows businesses, households and other actors to make the long-term commitments and investments that are required to make the transition to net zero.[27] Reaffirming, implementing and strengthening the commitments made at previous COP meetings will be key.

- **Tilt the playing field in favour of low-carbon innovation.** Today, the global economy is still heavily tilted in favour of fossil fuels. Explicit fossil fuel subsidies alone amounted to almost $700 billion [€592 billion] across 51 economies in 2021, double the levels in 2020.[28] Moreover, the negative economic and social impacts of fossil fuels in terms of pollution and their impact on people’s health, nature and society are not reflected in prices, distorting markets and decision making. Estimates of such implicit subsidies for fossil fuels, that account for environmental costs and other costs related to fossil suggest these were over $5 trillion [€4.4 trillion] in 2020.[29] Due to the war in Ukraine, concerns about energy security and high energy prices, many governments are currently giving large fossil fuel subsidies. It will be important to unwind these subsidies as soon as possible. Adjusting for these distortions and tilting the playing field in favour of low-carbon activities is thus crucial in unleashing low-carbon innovation.

26 OECD (2022, forthcoming), op. cit.

27 See Clara Berestycki, Stefano Carattini, Antoine Dechezleprêtre and Tobias Kruse (2022), “Measuring and Assessing the Effects of Climate Policy Uncertainty,” *OECD Economics Department Working Papers*, No. 1724 (Paris: OECD, 2022)

28 OECD/IEA, *OECD Inventory of Support Measures for Fossil Fuels* (Paris: OECD/IEA, 2022).

29 See the very interesting fossil fuel subsidies discussion from the International Monetary Fund at https://www.imf.org/en/Topics/climate-change/energy-subsidies.

‘Helping firms adopt low-carbon technologies is not enough. Households are key too.’

This can be done by the introduction and expansion of carbon taxes or equivalent economic instruments such as tradeable permits, e.g., Europe’s Emissions Trading System (ETS), and by the removal of explicit fossil fuel subsidies. OECD data for over 40 economies show that in 2021 more than 60% of economic activity was still not subject at all to carbon taxation and only 10% was taxed by carbon taxes of over $60.00 [€50.70] per ton of carbon.[30] Governments all need to take action to broaden the use of carbon taxes, although this will be difficult at the current time of high energy prices. At the global level, it will be important to develop more coherent and coordinated approaches on how to best use carbon taxes within global climate change strategies. This is being explored in several fora, for example the OECD’s Inclusive Forum on Carbon Mitigation Approaches currently being developed.[31]

Improving the playing field goes beyond taxes and subsidies. Fossil fuels have underpinned the global economy for a very long time and the industry is deeply rooted in institutions and power structures, which is helping to shelter firms from policy changes that may affect their business model. Overcoming this incumbency will be critical but will be a difficult political challenge in many countries, notably those that have drawn large financial benefits from the fossil fuel industry or that rely on the industry for their public finances. History suggests that supporting the industries of the past over the industries of the future slows down the inevitable change and reduces the benefits that countries can draw from the new industries. For example, a recent IEA report shows that the renewable-energy sector already accounts for more jobs than the fossil-fuel industry.[32]

- **Implement climate-friendly regulation and accelerate the setting of supportive technical standards.** Implementing new technologies can run afoul of existing rules and regulations and lack of supportive technical standards. For example, inefficient planning and permitting procedures are slowing down investments in wind and solar energy in many countries. In most EU countries, planning procedures for onshore wind energy take more than five years, considerably above the two years recommended by the EU.[33] Implementing climate-friendly regulations and accelerating planning and permitting procedures will be crucial in speeding up the transition to a net-zero future.

  Technological standards that support low-carbon innovation, for example building codes, standards for heating systems and the like, are also key. Given the growing availability of cost-effective solutions for net zero, it is crucial that all new buildings and heating meet high energy standards and – to the extent possible – are equipped with their own supportive low-carbon energy systems, such as heat pumps or solar panels. Standards can also help with the existing building stock, to encourage building retrofitting and improve efficiency. The technical possibilities for neutral or even CO_2-absorbing houses continue to expand. For example, a recent prize-winning design in the Netherlands is a house that is for 95% made from biobased products (notably straw) enabling it to store 90 tonnes of CO_2.[34] The house is also energy positive and produces more energy than it uses. Delivering newbuilds with poor energy ratings in 2022,

30 OECD, *Effective Carbon Rates 2021: Pricing Carbon Emissions through Taxes and Emissions Trading* (Paris: OECD, 2021).

31 See the OECD ministerial statement of June 2022 announcing the launch of the Forum: https://www.oecd.org/newsroom/oecd-2022-ministerial-statement-and-outcomes.htm

32 International Energy Agency, *World Energy Employment*, September 2022.

33 Harriet Fox, “Ready, Set, Go: Europe’s Race for Wind and Solar,” *Ember*, 27 July 2022.

34 See Ballast Nedam Development Lanceert Klimaatpositief Natuurhuis van Stro, (in Dutch) at https://www.ballast-nedam.nl/nieuwsoverzicht/2022/ballast-nedam-development-lanceert-klimaatpositief-natuurhuis-van-stro.

'Progress is being made in several important sectors, e.g., steel, cement, hydrogen, shipping, aviation and others, but more is needed.'

as is still the case in several EU countries, is therefore very far out of line with good practice and risks locking in poor energy performance for many generations. A recent IEA report urges the global introduction of mandatory zero-carbon-ready building energy codes by 2030, but notes that many countries have long lead times to develop and implement new codes.[35] Accelerating the process to set such standards is key. Coordination in international standard-setting will also be important for many technologies to help level the playing field and increase market size and scale.

- **Invest in supportive infrastructure and skills.** The transition to a low-carbon economy, based on clean technologies, will be far-reaching and require changes and investment in many areas. Two key elements that are complementary to low-carbon innovation are investment in infrastructure and skills. Investments in infrastructure include the large investments required – $820 billion [€693 billion] annually by 2030 according to the IEA – to connect new renewable energy, notably solar and wind, to power grids, and create cross-border supergrids that increase trade in low-carbon energy and enhance resilience and security.[36] Other infrastructure includes new transport infrastructure or infrastructure for green hydrogen, that will be required as a renewable energy source in certain areas where electricity or sustainable bioenergy are not better, more efficient alternatives. Efficient planning and permitting rules, as discussed above, will be important in enabling the rapid roll-out of this infrastructure.

  Together with the investments in capital go investments in people and new "green" skills, including advanced technical skills to help develop new technologies, but also skills to use and service new technologies, and use them across society. Investing in such skills will not only support innovation but will also help people make the transition in the labour market, helping them move from declining industries – such as fossil fuel-based – to emerging and growing industries such as renewable energy, recycling and environmental services.

  The need for complementary policies and investments in these two areas is an important reminder that innovation is never just about technology, but about a range of technological, process and system changes that need to be implemented together to make new technologies work in the real world.

Recommendation 4: Double down on international cooperation

The climate crisis is a global crisis as emissions from any one country have global impact. It can only be addressed if all countries in the world move to net-zero emissions, although with differences in the speed with which this can be achieved given vastly different starting points. International cooperation in achieving net zero, including through cooperation in science, technology and innovation, therefore needs to be an important element of the global strategy for low-carbon innovation. This is also because a global strategy for innovation helps foster global markets, which allows for scale and more rapid declines in costs and prices, making low-carbon innovations more affordable for all.[37] Moreover, international

35 International Energy Agency, *"Technology and Innovation Pathways for Zero-Carbon-Ready Buildings by 2030,"* September 2022.

36 International Energy Agency (2021), op. cit.

37 See Laura Diaz Anadon, Aled Jones and Cristina Peñasco, *Ten Principles for Policymaking in the Energy Transition: Lessons from Experience* (London: EEIST, 2022).

‘Focused mission-oriented policies, involving business, academia and other stakeholders, can help drive innovation in important areas.’

collaboration allows for the sharing of good policy practices and helps level the playing field. The IEA has noted that without international collaboration, the transition to net zero could be delayed by decades.[38] By achieving an international agreement in 2015, previous COP meetings have already contributed greatly to this global goal.

Financing is an important element in enabling low-income economies to achieve their net-zero goals and can facilitate the adoption of low-carbon technologies. Many sources of financing will be required, such as blended finance that strategically uses development financing to mobilise private capital.[39] Developed countries also made a commitment in 2009 to provide financial support to developing economies of $100 billion [€103 billion] a year to help them make the transition and take climate action. Financial commitments thus far remain short of this original goal and will not be enough given the scale of the challenge.[40]

However, financial support is not and should not be the only tool that is used to accelerate the diffusion of low-carbon technologies across the globe. Other instruments and mechanisms exist that can and should be used more to support international technology diffusion and international innovation cooperation.[41] This includes stronger international cooperation in science, technology and innovation between governments and with stakeholders, either bilaterally or through multilateral channels and international organisations such as the IEA and the International Renewable Energy Agency (IRENA). Initiatives such as Mission Innovation and the Breakthrough Agenda are showing the way forward.

Implementing supportive trade and intellectual property rights policies that balance incentives for innovation and its diffusion across the world are also important and can help facilitate technology transfer. It will be particularly important to reduce existing trade barriers that may affect the diffusion of low-carbon innovations and avoid new ones.

More generally, it is critical to reframe international cooperation away from a focus on a unidirectional transfer of technology from advanced to developing economies towards a more cooperative and equal relationship that allows for the building of international partnerships and local capacity for innovation.[42] COP 27 can make an important contribution to this reframing by strengthening and broadening existing partnerships and by developing new ones, for example between developing economies, where there is much scope for partnering and learning.

Making policy work

Implementing these four recommendations – as part of an overall climate strategy – will not be without costs and challenges, but these will be small relative to the benefits and damages avoided. With rapidly declining costs of renewables and high costs of fossil fuels, some recent studies now suggest many trillion euros of financial savings associated with climate policy action and a massive shift to renewables.[43]

38
International Energy Agency (2021), op. cit.

39
See OECD, “Blended Finance Guidance for Clean Energy,” *OECD Environment Policy Papers*, No. 31, August 2022.

40
In 2020, $83.3 billion [€73.0 billion] was mobilised and provided. See OECD, *Aggregate Trends of Climate Finance Provided and Mobilised by Developed Countries in 2013-2020*, July 2022.

41
See e.g., Ambuj D. Sagar, “Broadening the Mission of Mission Innovation,” *Nature Energy*, September 2022, and Nimisha Pandey, Heleen de Coninck and Ambuj D. Sagar, “Beyond Technology Transfer: Innovation Cooperation to Advance Sustainable Development in Developing Countries,” *WIREs Energy Environment*, 18 November 2021.

42
Ibid.

43
Robert Way, Matthew C. Ives, Penny Mealy and J. Doyne Farmer, “Empirically Grounded Technology Forecasts and the Energy Transition,” Joule, 21 September 2022.

‘Adjusting distortions and tilting the playing field in favour of low-carbon activities is crucial in unleashing low-carbon innovation.’

The war in Ukraine is contributing to an alignment of the three key objectives of energy policy – security, affordability and sustainability – with renewable energy at its core.[44] Accelerating low-carbon innovation will also speed up the transition to net zero, which will help reduce the growing economic, environmental and social costs of the climate crisis.

Moreover, using innovation as a core policy tool will help the world get to net zero while enabling sustainable economic growth and protecting jobs, incomes and livelihoods in developed and developing countries alike. Politically, no government will be able to make the difficult transition to net zero if citizens are expected to absorb large reductions in income, as is suggested by “degrowth” scenarios. Indeed, making the transition to net zero in a fair and equitable way is among the greatest challenges for climate policy.[45]

Innovation and technology are not miracle cures or a silver bullet to address climate change. They can only work if they are part of – and fully integrated in – a broader strategy. Moreover, technological fixes can have their drawbacks that need to be considered when implementing policy. For example, cleaner technologies might increase efficiency and lower costs that could then increase demand – the so-called rebound effect. Moreover, the growing use of digital technologies such as cloud services, bitcoin mining and artificial intelligence is rapidly increasing demand for electricity. In addition, the growth of digital technologies is leading to growing electronic waste. These challenges – and others – must be addressed as part of an overall agenda focused on low-carbon innovation.

Building political support for such an agenda will be key and will benefit from actions that quickly show results for citizens, for example financial assistance for building insulation, heat pumps, solar photovoltaic and other actions that help citizens make the transition and reduce their energy bills.[46] Helping make cities more liveable, reducing air pollution and creating new jobs in low-carbon industries will help too. Making the transition fair and equitable will be key, as there is a risk that the poorest households and communities will be hit hardest without supporting policy action. Integrating these concerns in key policies, such as the design of carbon taxes, the removal of fossil-fuel subsidies, support programmes, or education and training, will be key to ensuring a transition that is perceived as fair and just.

The experience with COVID-19 shows that science and innovation systems across the globe can be mobilised quickly and effectively to address a deadly global crisis. While the mobilisation for COVID-19 was not perfect and lessons can be learned for innovation systems and policies more generally, academia, research institutions, small and large businesses managed to develop a very wide range of new technologies in a short time in response to a global crisis.[47]

Actions to mobilise low-carbon innovation can and should be taken by many actors and at many different levels. Cities and municipalities can develop shared (such as district) heating systems or low-carbon transport systems. Academic

44 See: https://about.bnef.com/blog/after-ukraine-the-great-clean-energy-acceleration/

45 See OECD (2021), op. cit. for further discussion on the role of redistributive policies in the climate policy agenda.

46 See Nicholas Stern and Anna Valero, op. cit.

47 See, e.g., OECD, *Science, Technology and Innovation Outlook 2021: Times of Crisis and Opportunity* (Paris: OECD, 2021).

‘A global strategy for innovation helps foster global markets, which allows for scale and more rapid declines in costs and prices.’

institutions and research funding institutions can mobilise the research community and orient it towards key challenges, both in fundamental and applied research. Business can drive innovation, strengthen collaboration and galvanise support for further action. Citizens can take their own actions to adopt low-carbon innovations or reduce demand. Foundations can drive innovation and collaboration too. But governments are crucial to establishing the frameworks and policies that give direction, reduce uncertainty and provide society with the common goal of a sustainable future. This is where COP 27 can make a difference.

As the world is now facing its largest, and most existential global crisis ever, it is time to mobilise science and innovation systems to the maximum extent. We must use their great potential to address the climate crisis. Researchers, innovators, entrepreneurs and others will step up to the plate, as they have done before, but urgently need to be further mobilised by policymakers and given every opportunity to make a difference.

There is no time to waste.

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