OECD Regional Outlook 2021

ADDRESSING COVID-19 AND MOVING TO NET ZERO GREENHOUSE GAS EMISSIONS

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Foreword

The fifth edition of the OECD Regional Outlook: Addressing COVID-19 and moving to net zero greenhouse gas emissions comes at a critical juncture. The COVID 19 crisis has laid bare a number of weaknesses in our economic and social systems and, in doing so, starkly revealed the interconnectivity between the environment, economies and people. Many of these weaknesses were apparent before COVID-19 but less so the costs of inaction to address them and, in turn, their unprecedented consequences.

We have learnt how quickly a crisis in one domain can spread to another: what started as and remains a health crisis very quickly became an unmatched economic crisis. We have learnt of the paramount importance of early, decisive action to tackle risks and build resilience. We have learnt that environmental degradation is an important enabler of zoonotic risks and, as such, a threat to resilience. We have a much better understanding, today, of the importance of resilience in efforts to build back better and, as this edition of the OECD Regional Outlook shows, of how important it is to take into account the spatial dimension in the recovery process.

The health and economic crisis triggered by COVID-19 stands out not only as the most significant in a century but for the territorial diversity of its impacts and responses. The climate challenge is just as global and territorially diverse. Greenhouse gas emissions and their sources vary enormously across regions and the impacts of tackling climate change will also be vastly different across territories. Specific place-based policies will be vital in mitigating the effects of those impacts on the most vulnerable regions.

However, while most OECD countries have set net-zero greenhouse gas emission targets for 2050, the regional dimension is too often ignored. As this edition of the OECD Regional Outlook shows, this is a mistake. Recognising the place-based dimension from the outset of the design and implementation of mitigation policies will allow those targets to be reached more effectively. Indeed, well-chosen policies to adapt to inevitable climate change can have important well-being benefits, which are often local. Integrating subnational and regional government action into a multilevel governance framework is therefore a key part of building back better.

Since its creation in 1999, the OECD Regional Development Policy Committee has consistently argued for place-based policies, which can effectively address the diversity of economic, social, demographic, institutional and geographic conditions across regions. They also ensure that a wide range of sectoral policies, from transport and education to innovation and health, are co-ordinated with each other. This OECD Regional Outlook aims to serve as a guide to help policymakers at all levels of government build back better.

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Executive summary

Place-based policies are essential to building an inclusive, resilient and sustainable recovery from the COVID-19 crisis

The COVID-19 pandemic has had a profound impact on the health of our societies and economies. It has highlighted that risks to human health can trigger a systemic crisis. Economic and social systems may only be as resilient as their weakest link. The interdependencies between resilience and inclusiveness have thus been laid bare. Anticipation has proven critical to mitigating systemic crises. However, while the crisis is global, there are significant differences across countries and the impacts also differ strongly within countries. Understanding the causes of these spatial differences and, in particular, dealing with their outcomes, especially for the most vulnerable and worst-hit communities, is critical for improving resilience and "building back better". Resilience also requires that we address the global environmental challenges – including climate change – that make pandemics more likely. All of this reinforces the importance of multi-level governance and local actors in implementing and designing mitigation measures and in supporting an inclusive and resilient recovery.

The COVID-19 crisis is unrivalled in scale and regional differences in a century

COVID-19 has reinforced existing territorial inequalities. Whilst density was initially expected to be an important determinant in infection rates, containment strategies, including the ability to work from home, have lessened its impact. People living in poorer areas, in crowded living conditions and working in jobs less amenable to remote working, were harder hit than their more affluent neighbours. Rural areas were generally exposed later. Their disproportionate shares of older and less healthy populations, more limited health capacities and lower shares of jobs amenable to remote working were readily exploited by the virus.

Employment at risk from lockdowns varied from less than 15% to more than 35% across 314 regions in 2020, with those dependent on heavily affected sectors, such as tourism, particularly exposed. The potential for remote working across regions is also uneven. Equally, differences exist in the relative importance of non-standard employment, which includes undeclared, temporary or self-employed workers, who often benefit less from social protection. These differences contribute to regional employment and poverty impacts.

The substantial costs of the COVID-19 pandemic to human life and economies, with its territorially different impacts, reinforce the importance of place-based, co-ordinated policy responses. While effective central governments need to set the national strategy, these need to go hand in hand with bottom-up local approaches.

Climate change is a global challenge requiring local, inclusive and early action

Climate challenge also threatens the foundations of well-being. It is also global and territorially different, albeit on a larger scale and longer time horizon than the COVID-19 crisis. Responses also need to include regional and local actors. Key risks from global warming above 2 degrees Celsius include worldwide food shortages as well as high risks of water scarcity in dryland regions. To prevent these risks, most OECD countries are aiming for net-zero domestic greenhouse gas (GHG) emissions by 2050. Costs vary and can be modest in fossil fuel-importing high-income regions. Well-being benefits beyond the protection of the climate, for example from lower air pollution, as well as growth in new green technologies, could more than offset the costs in many places. However, in some places, the transition costs may be higher and policies and support will be needed to address the needs of vulnerable communities in particular, to avoid new geographies of discontent emerging.

Subnational governments have a strong stake in this transformation because:

- Variation in emissions per capita is larger within than between countries.
- Well-being benefits largely arise locally.
- Regional governments are better placed to understand local vulnerabilities.
- Subnational governments have key competencies in energy use, land use and urban policy.
- Governments at all levels need to assess investment decisions against the net-zero-emission target.

Delaying action raises costs substantially. It also raises risks of dangerous, irreversible climate “tipping points”. Many regions are far off near-term benchmarks, for example in phasing out coal, expanding renewables or refurbishing buildings. Similarly, regions are not preparing road-freight hubs for zero-emission technologies and logistics. Many city dwellers are able to reach destinations more quickly in their own car than in shared transport, especially in poorer cities. Marginalised poor people bear the highest risks from climate change.

Multi-level governance and finance need to mainstream the climate challenge

Subnational governments are responsible for most public spending and investment with impacts on the climate and environment.

- Transfers between subnational governments need to be linked to climate policy goals so that subnational governments have the incentives and resources to act consistently with net-zero emissions.
- Subnational revenue and spending should integrate green budgeting and public procurement while eliminating environmentally harmful subsidies.
- Borrowing frameworks should make room for investments that serve the net-zero-emission transition.
- Governance structures and policy evaluation that integrate the scientific community in collective decisions help ensure early cost-saving actions.

Cities require major rapid transformations

Metropolitan regions contribute more than 60% of production-based GHG emissions. Moreover, in high-income cities, emissions inherent in the consumption of goods and services, which are largely produced elsewhere, are often much higher than production-based emissions.

- National urban policies should co-ordinate sectoral policies, such as transport and housing, across metropolitan areas and their hinterlands, to reach net-zero emissions.
- Cities can adopt policies to reach net-zero emissions in conjunction with better urban living. For example, digital-based, on-demand ride-sharing not only lowers emissions and energy consumption but also reduces congestion and pollution while saving costs, boosting innovation and freeing urban space, provided it replaces individual car use. Mobility in the Greater Dublin Area, for example, could be delivered with only 2% of the current number of vehicles and 37% less congestion while improving connectivity and equitable access to the population.
- Cities hold large potential for modular technologies to integrate renewables, heat pumps and other green infrastructure.
- High-income cities can take the lead on circular economy initiatives to make consumption more consistent with net-zero emissions, by eliminating food waste and encouraging sharing and reuse of goods for example.

Rural regions are pivotal for their natural endowments

Ecosystem services and the potential from the use of renewables in rural regions are key to well-being and reducing emissions. But ageing, lower education levels and less diversified economic activity put rural regions with carbon-intensive industries at bigger risk and per capita emissions are often higher in rural than metropolitan regions.

- Rewarding ecosystem benefits boosts GHG emission reduction and rural development.
- Participation in profit and decision-making makes renewables projects more attractive in rural regions, where they are often needed the most.
- Innovation in agriculture, urban-rural connections and renewable energies can help diversify economic activity.
- Low operating costs of electric vehicles carry significant potential for rural regions, where car use is particularly intensive. Laying out charging infrastructure seamlessly requires particular attention in thinly populated areas.

Smart specialisation and well-designed support help leave no region behind

On average across regions, only 2.3% of employment is in sectors broadly defined as being at potential risk of some employment loss from climate policies consistent with the Paris Agreement. But in some large subnational regions, this may exceed 6%, such as Gyeongnam Region in Korea and Silesia in Poland, and some of these risks may even be concentrated within these regions. Some of them already have higher poverty and long-term unemployment, reinforcing the importance of supporting the transition in strongly affected places early on, whilst also helping to keep political support for the transition. In this context, smart specialisation can connect new, net-zero-emission activities to established local businesses, skills and assets, avoiding regional economic decline.

- Building consensus around future specialisations among early local stakeholders from higher education institutions, innovative businesses, regional and local governments, is key.
- Skills mapping can identify future occupations and skill needs. Engaging local employers can help align skills with needs for reaching net-zero emissions.

Part I The resilience of rural and urban regions in the COVID-19 crisis

1 The COVID-19 crisis in urban and rural areas

The COVID-19 pandemic has brought much human suffering. It has underlined that risks to the foundations of human well-being are real global threats with multiple knock-on effects on economy and society. While the crisis is global, the impacts are territorially different. Well-connected urban areas were among the first exposed to the pandemic. In rural areas, older and less healthy populations often faced limited healthcare capacity. In urban and rural regions alike, poor areas with crowded living and working conditions have suffered worse health outcomes.

The economic crisis COVID-19 has triggered exceeds the global financial and economic crisis from 2008 in scale and regional differentiation. Employment at risk varied from less than 15% to more than 35% across 314 regions in 2020, often reflecting sectoral specialisation, such as in tourism. Potentials for remote working are also uneven. Differences in non-standard employment contribute to regionally different employment and poverty impacts across regions. This includes undeclared, temporary or self-employed workers, who often benefit less from social protection.

COVID-19 has hit regions across the world but timing and impacts have differed

Since the World Health Organization (WHO) declared COVID-19 a "public health emergency of international concern" on 30 January 2020, the pandemic has triggered a global crisis, characterised by multiple knock-on effects on economies and societies, making this a systemic crisis. The impacts differ strongly across territories, including within countries. This applies to the spread of the virus and its health consequences as well as to the impacts of the ensuing economic crisis and its effects on employment and poverty. The COVID-19 pandemic, therefore, offers lessons in preventing and coping with systemic crises in the future.

COVID-19 has hit urban regions early

At the beginning of the pandemic, some of the largest global cities (e.g. London, Madrid, Milan, New York City) had the highest incidence of COVID-19 cases per capita. Epidemiological models predicted that without mitigation strategies, the disease would spread faster in urban metropolitan areas than rural areas (Stier, Berman and Bettencourt, 2020[1]). However, many areas that were initially hard hit by COVID-19 enacted containment measures such as widespread closures of commerce and strict limits on travel. These rules, combined with voluntary social distancing, led to large declines in mobility by foot, car and public transit, particularly in the largest cities (Ramuni, 2020[2]).

Indeed, some of the densest cities in the world managed to bring initial outbreaks of COVID-19 under control with a very low incidence of infections and deaths. For example, Australia, Japan and South Korea brought prevalence down dramatically – including in cities like Seoul, Sydney and Tokyo – emphasising anticipation, early preparation and a proactive approach when caseloads were still low and using mitigation measures such as mask-wearing (Chapter 2).

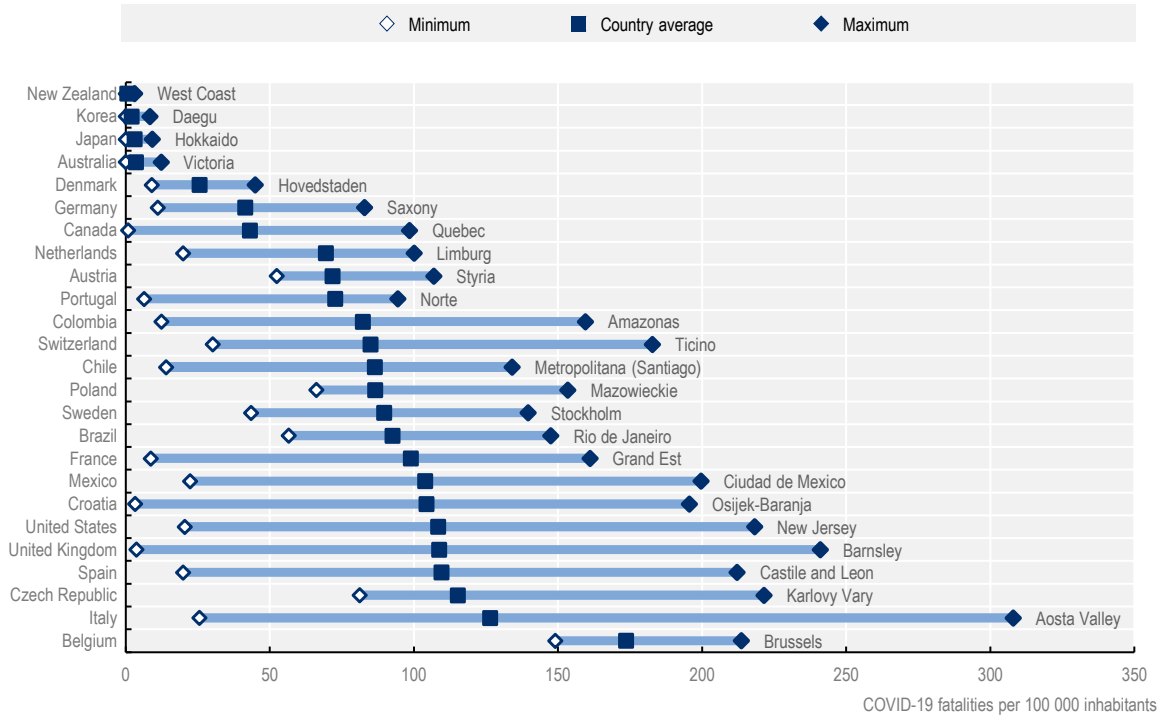
Whilst density itself does not appear to be a determining factor, in part reflecting the strong policy responses (Hamidi, Sabouri and Ewing, 2020[3]), many large cities such as Brussels, Mexico City, Paris, Santiago de Chile and Stockholm have fared worse than other regions (Figure 1.1). Places marked with inequalities and a high concentration of urban poor living in crowded housing do appear to be more vulnerable than those that are better resourced, less crowded and more equal (Iacobucci, 2020[4]).

Most cities rely on public transit networks but these do not appear to have been a significant vector of transmission (Florida, Rodriguez-Pose and Storper, 2020[5]). For instance, contract-tracing efforts in France and Japan have not identified any coronavirus clusters from transit use. There are a number of factors that may help to explain this. Coronavirus transmission may be lower in trains and subways (especially given the fact that many had advanced ventilation systems before COVID-19) than other enclosed spaces because commuters usually stay for brief periods of time and refrain from talking. In most OECD cities, widespread avoidance of public transit has continued since the onset of COVID-19, resulting in less crowded travel conditions coupled with mitigation measures such as mask-wearing rules to limit the virus' spread. Equally, it is possible that contact tracing has not identified significant numbers of virus transmission on transit systems because of the dispersed nature of transit compared to other settings (O'Sullivan, 2020[6]). Certainly, the high incidence rates among public transit drivers and operators suggests some caution in interpretation, at least with respect to long travel times. Nevertheless, the evidence points strongly to household contacts as being the main source of contagion, followed by workplaces (Brandily et al., 2020[7]).

Large, global cities experienced earlier cases of COVID-19, due to their strong connectedness to other places. For example, South German and Northern Italian regions and their cities may well have been hit early within their countries because of their stronger connections to China via global value chains.

Figure 1.1. Within-country differences in COVID-19 mortality

COVID-19 fatalities per 100 000 inhabitants, TL2 regions, as of January 2021



Note: COVID-19 mortality definitions and their attribution to location differ across countries. For example the location may be where death occurred or where the deceased lived. The 24 countries are OECD countries plus Brazil and Croatia. In some countries, including Belgium and France, the location of death is recorded rather than the location in which the deceased lived. As of the end of 2020, there were no subnational data for Estonia, Finland, Greece, Hungary, Iceland, Ireland, Israel, Latvia, Lithuania, Luxembourg, Norway, the Slovak Republic and Slovenia. For New Zealand, data is available by District Health Boards. For Canada and Japan, one province (Prince Edward Island) and one prefecture (Iwate) respectively are missing. For the United States, only the 50 states are considered. In the United Kingdom, data is available for upper-tier local authorities. Data were retrieved on 7 January 2021.
Source: OECD (2020[8]), "The territorial impact of COVID-19: Managing the crisis across levels of government", https://www.oecd.org/coronavirus/policy-responses/the-territorial-impact-of-covid-19-managing-the-crisis-across-levels-of-government-d3e314e1/.

StatLink https://doi.org/10.1787/888934236513

To slow the spread of COVID-19, many workplaces shifted in-person jobs to telework when the pandemic began in March and have continued to encourage remote work since. However, a large share of lower-wage workers in urban areas hold service jobs in hospitality, childcare, retail and personal services that depend on face-to-face interactions (OECD, 2020[9]). They reside in less affluent, more crowded, peripheral areas and have been more vulnerable to infection. Many of these service jobs were declared essential and continued to take place in person, while others were curtailed by social distancing.

Better high-speed Internet coverage in urban areas means that their residents are more able to use the Internet to replace in-person interactions with virtual ones (OECD, 2019[10]). Shifts to virtual interactions have happened for educational and social purposes (e.g. school, video chats with friends and family). Higher rates of digitisation have helped some cities compensate for physical space constraints, with large shifts from in-person to online shopping especially for grocery stores and pharmacies (Farrell et al., 2020[11]). Cities with weaker digital infrastructure may have been less able to substitute virtual for physical contacts, contributing to more infections.

Whilst there remains considerable uncertainty about the longer-term economic and social consequences of COVID-19, it is clear that the pandemic has, at least in the short term, dampened the vibrant activities of cities. Many trends that started before the crisis, such as digitalisation – including greater potential for remote working – have accelerated. The pandemic has also raised awareness among policy makers and the public at large about the importance of protecting sustainable ecosystems. As a result, city planners are already beginning to place higher emphasis on open spaces, mixed-use architecture and contactless digital commerce.

Rural areas have not been spared

In theory, lower population density should make the risk of COVID-19 transmission lower in rural areas. However, since the virus arrived in rural areas later, residents may have developed a false sense of security and taken fewer precautions (Peters, 2020[12]). Super-spreader events including wedding parties and religious services fuelled the spread of COVID-19 in rural parts of many countries. Meatpacking plants emerged as virus hot spots in rural areas of Germany, Ireland and the US. In the US, rural area COVID-19 case rates outpaced urban area rates from August 2020 onward (Leatherby, 2020[13]). College towns in the US were also disproportionately affected by outbreaks and there was more resistance to mask-wearing in rural areas than urban ones (Haischer et al., 2020[14]).

Within countries, densely populated urban areas were the hardest hit in the first half of 2020. In rural areas, COVID-19 mortality rates increased particularly from August 2020 onwards. Socio-economic indicators, (such as teleworking and income per capita) may explain why, in the second half of 2020, the outbreak was more deadly in rural areas in France, Italy and the US and, to a lesser extent, the UK (Figure 1.2). Once the pandemic reached rural areas, their larger shares of the elderly population were more vulnerable to it.

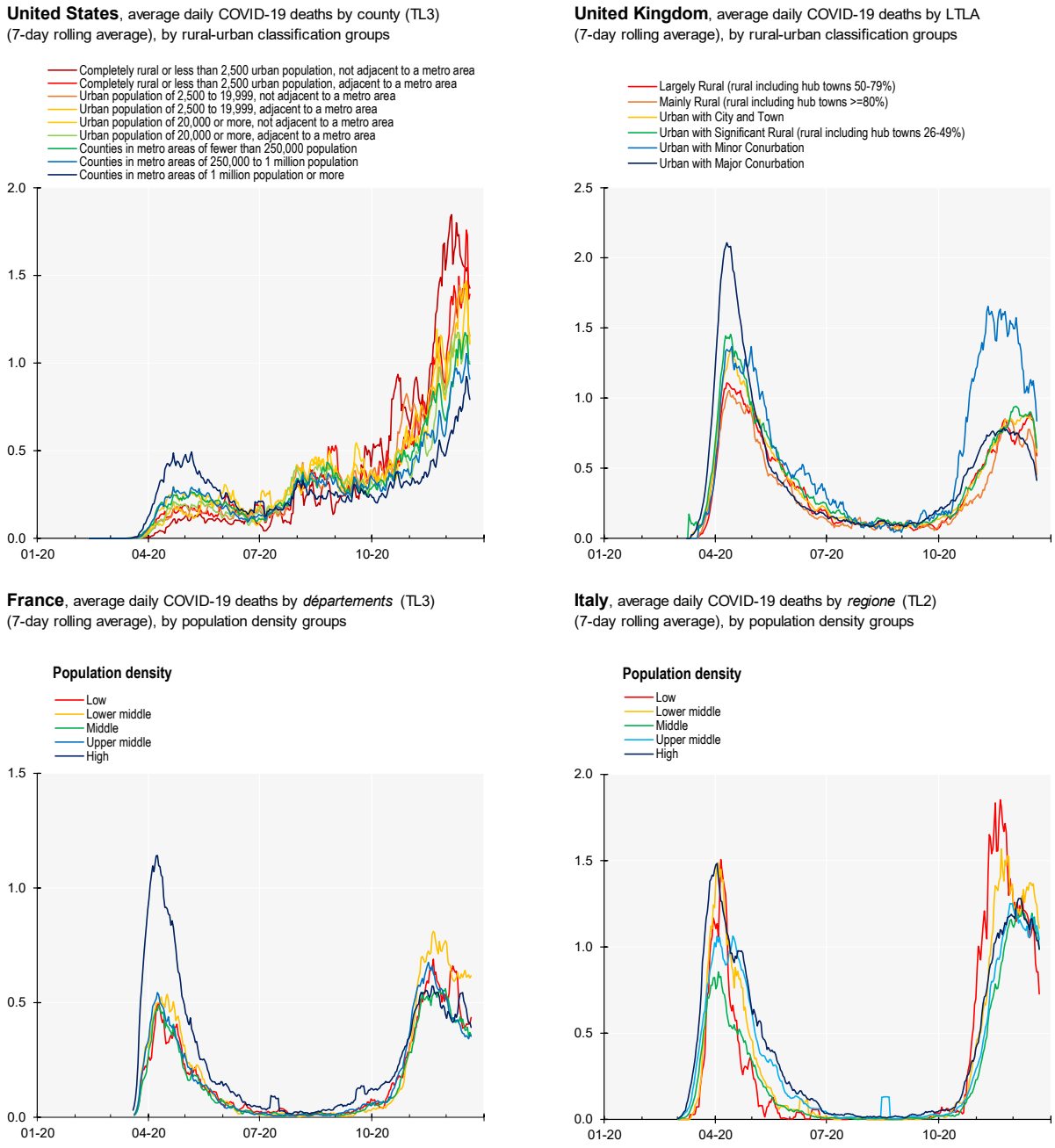
The populations of rural areas are at greater risk of COVID-19 complications and mortality. The virus is particularly dangerous for older individuals and rural areas generally have higher proportions of older residents. Rural residents also have a higher prevalence of pre-existing conditions and comorbidities (e.g. diabetes, heart disease, obesity and smoking) that put them at greater risk of COVID-19 complications (Peters, 2020[12]). Some remote, Indigenous communities face additional barriers such as limited access to public health information (including community-based data collection), healthcare and sanitation (UN, 2020[15]).

Rural hospitals are less able to handle an influx of COVID-19 patients because they tend to have fewer specialists and less technology and capacity (e.g. intensive care unit [ICU] beds per capita) (OECD, 2020[16]). In the US, for example, mortality from cancer, diabetes and influenza is generally higher in rural areas in normal times. Furthermore, across different countries, a number of urban dwellers have moved away from cities to spend the lockdown in secondary houses or with their families in rural regions. This movement of people increased the risk of spreading the virus to lower density areas. With low rural hospital density, virus outbreaks can easily overwhelm a single hospital. Urban hospital systems have a greater ability to handle idiosyncratic surges. For example, if an outbreak happens in one part of a large city, doctors and emergency services can direct patients to a nearby hospital with spare capacity. Instead, in rural areas, the next-closest hospital may be prohibitively far.

Indigenous communities residing in rural areas face particular challenges. There are approximately 39 million Indigenous peoples across 13 OECD countries. Countries that work closely with the OECD also have significant Indigenous populations (e.g. Argentina, Brazil, Costa Rica, Indonesia and Peru). Indigenous peoples are nearly three times as likely to be living in extreme poverty, making it more difficult to sustain themselves when unable to work. Indigenous peoples are also more concentrated in rural areas than non-Indigenous populations. Many Indigenous communities experience overcrowded and multi-generational housing, poorer health outcomes, with limited access to health services and infrastructure. All these factors exacerbate the risk of contracting COVID-19, especially in remote communities. Research

from the US suggests that the rate of new COVID-19 cases per 1 000 people is four times higher in Indian reservations than in other parts of the US.

Figure 1.2. COVID-19 mortality per 100 000 inhabitants, daily average



Note: COVID-19 mortality definitions and their attribution to location differ across countries. For example the location may be where death occurred or where the deceased lived. In France, population density is low where population per square kilometre ranges from 0 and 45 inhabitants, lower-middle from 46 to 67, middle from 68 to 110, upper-middle from 110 to 215 and high if greater than 215. In Italy, population density is low where population per square kilometre ranges from 0 to 72 inhabitants, lower-middle from 73 to 126, middle from 127 to 171, upper-middle from 171 to 268 and high if greater than 268.

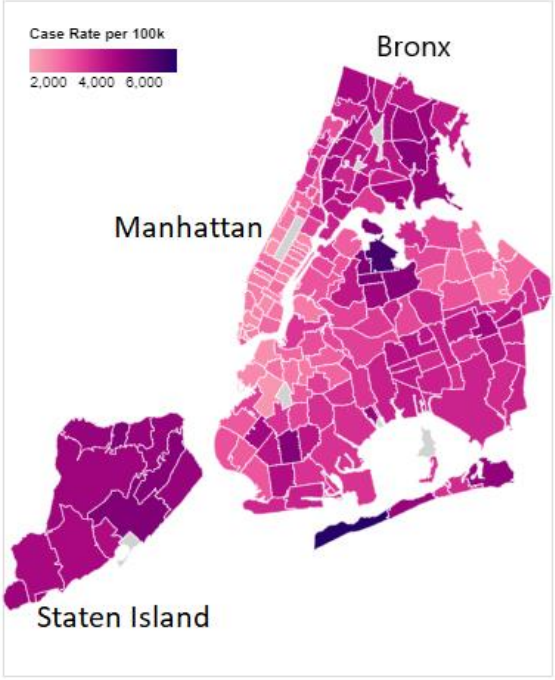
Source: OECD (2020[8]), "The territorial impact of COVID-19: Managing the crisis across levels of government", https://www.oecd.org/coronavirus/policy-responses/the-territorial-impact-of-covid-19-managing-the-crisis-across-levels-of-government-d3e314e1/.

Poorer populations are more affected

In most OECD countries, the number of residents living in crowded and deprived conditions is larger in urban than rural areas but, wherever they live, vulnerable populations experienced elevated rates of COVID-19 contagion and adverse health outcomes. Poorer, working-class boroughs of New York City such as the Bronx and Staten Island had up-to-three-times the incidence of COVID-19 compared to the richer borough of Manhattan (Figure 1.3). Regions in the south of England (UK) had lower virus prevalence whereas poorer regions in the north – especially those around Hull, Liverpool, Newcastle and Sheffield – had a higher prevalence (Figure 1.4).

Figure 1.3. New York City COVID-19 cases by zip code

Cumulative cases per 100 000 inhabitants as of 10 December 2020



Source: New York City (n.d.[17]), *Total Data*, https://www1.nyc.gov/site/doh/covid/covid-19-data-totals.page (accessed on 10 December 2020).

In rural areas in some countries, crowded living quarters for many migrant workers, refugees and Indigenous peoples resemble the overcrowding of households in deprived areas of large cities. In urban areas, deprived residents face crowded living conditions along with other problems faced by rural residents: namely, less Internet connectivity, more COVID-19 comorbidities and, in some countries, substantially less access to healthcare (Brandily et al., 2020[7]).

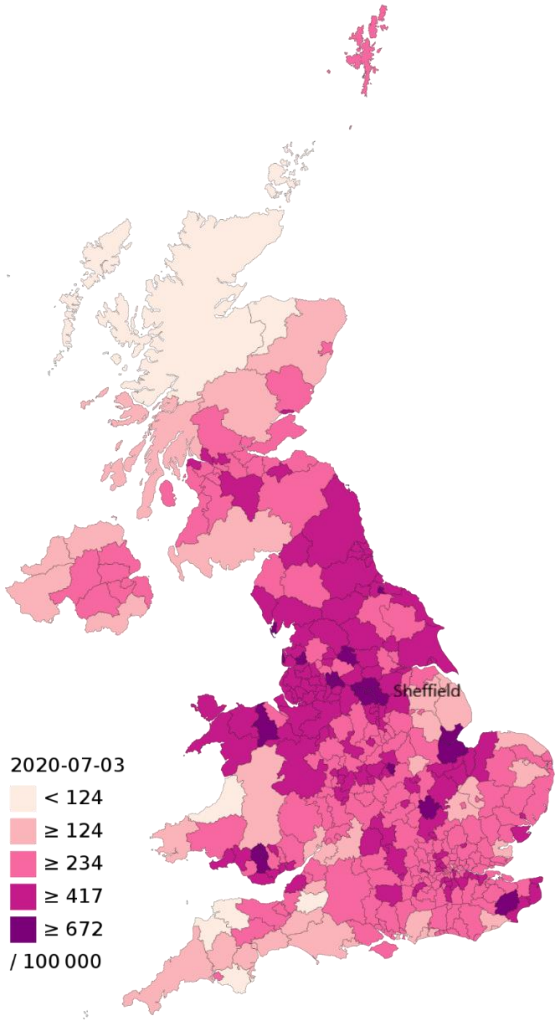
Residents of crowded housing are also more likely to be essential workers in the provision of essential services. Whilst the scope of essential jobs is broad (including medical professions), jobs designated as essential in food retailing, passenger and freight transport, for example – often on modest wages – require in-person interactions that increase virus exposure (Brandily et al., 2020[7]). In fact, essential workers have an estimated 55% higher likelihood of being positive for COVID-19 than those classified non-essential. The effect is not only driven by the healthcare and social assistance workers. Dependents cohabiting with an essential worker have a 17% higher likelihood of being COVID-19 positive compared to those cohabiting with a non-essential worker and 38% for roommates cohabiting with an essential worker. Intrahousehold transmission appears to be an important transmission mechanism (Song et al., 2021[18]).

Workers in informal employment, of which there are 2 billion (sixty-one percent of the world's employed population), are particularly vulnerable. In addition to having higher exposure to health and safety risks, informal workers are often obliged to work without appropriate physical protection such as masks or hand disinfectants. Moreover, informal workers have limited (often negligible) social protection and less recourse to benefit from health and safety standards, including hygiene and social distancing protocols introduced by most governments around the world. Nor can they access paid sick leave, which, when sufficiently generous, can reduce workplace transmission by convincing workers who might have contracted the virus to stay home.

The impact of COVID has compounded existing socio-economic vulnerabilities and disproportionately affected vulnerable populations and minorities, in terms of infection and health risks (OECD, 2020[19]). In addition, while a disproportionate share of essential workers are low-paid workers, low-paid workers in non-essential jobs have also been the most vulnerable to job and income loss in many regions, in part reflecting the lower possibilities to telework.

Figure 1.4. United Kingdom COVID-19 cases by lower-tier local authority area

Cumulative cases per 100 000 inhabitants as of 4 June 2020



Source: Ythlev (2020[20]), *COVID-19 Outbreak UK Per Capita Cases Map*, https://commons.wikimedia.org/wiki/File:COVID-19_outbreak_UK_per_capita_cases_map.svg.

Worldwide environmental challenges contribute to sparking and diffusing pandemics

Human interference with biodiversity helps create the conditions for pathogens to leap from animals to humans, creating zoonotic diseases, such as COVID-19 (OECD, 2020[21]). According to the 2020 Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) Workshop Report on Biodiversity and Pandemics "the underlying causes of pandemics are the same global environmental changes that drive biodiversity loss and climate change (IPBES, 2020[22])." Land-use change, in particular deforestation, degradation and fragmentation of animals' habitat, agriculture intensification, as well as wildlife trade and climate change have all played a role. Another important driver of infectious diseases is agriculture expansion and intensification, and particularly mass animal farming (Rohr et al., 2019[23]). High-density industrialised livestock operations are already more vulnerable to losses of animals to diseases. Both increased host density and increased contact rates between people and animals facilitate the transmission of diseases and can cause increases in infectious diseases. In addition, increased poaching of wildlife and illegal resource extraction in some countries contributes to the loss of rural livelihoods and reduced capacity for monitoring and enforcement (OECD, 2020[21]). It is therefore paramount to understand and integrate into policymaking the connection between the environmental and public health agendas (O'Callaghan-Gordo and Antó, 2020[24]). Along with COVID-19, many deadly pathogens in recent memory – such as dengue and more recently HIV, Ebola, SARS – have taken this interspecies leap: 70% of emerging diseases and almost all known pandemics are zoonotic. Effective biodiversity conservation and sustainable land use, including halting deforestation, will limit the risk of zoonotic transfer while also helping to maintain the existing ecosystem services (OECD, 2020[21]).

Land use change is a particularly large driver of pandemics, responsible for more than 30% of emerging disease events (IPBES, 2020[22]). Regional governments can contribute towards more sustainable land use governance and reduce the role of land use change in pandemic emergence since they are often in charge of local spatial planning and land use policies. Biodiversity benefits, including lower risks to human health from zoonotic diseases, should be assessed and incorporated in major developments and land use projects. Additionally, policies targeting the reduced role of land use change to pandemics through ecological restoration and biodiversity conservation have synergies with combating climate change and its effects, and can promote jobs (OECD, 2020[25]). The conservation and restoration of ecosystems can reduce the risk of zoonotic diseases. Limiting climate change will therefore also contribute to avoiding rising zoonotic disease risk.

The pandemic also highlighted the link between air pollution and mortality from COVID-19. Indoor and outdoor air pollution exacerbate the airborne transmission of SARS-CoV-2 as well as the health impacts once infected (OECD, 2020[21]). A number of studies have demonstrated that a small increase in particulate matter (PM2.5) is associated with an increase in the COVID-19 death rate of 8%-16%, depending on the region. Socially disadvantaged groups are more exposed and vulnerable to air pollution, which makes them potentially more vulnerable to adverse health impacts, including from COVID-19.

Policies to reach net-zero greenhouse gas (GHG) emissions as targeted by many OECD countries for 2050 and policies to adapt to now inevitable climate change offer important synergies with this agenda, as argued in Part II of this *Regional Outlook*, although also a few trade-offs, which need to be minimised. Better air quality, improved water quality, effective waste management and enhanced biodiversity protection will go hand in hand with emission reduction if well-designed and reduce the vulnerability of communities to pandemics. It will also improve overall societal well-being and resilience.

As argued in Part II, integrating environmental health in policies to improve resilience offers many benefits beyond limiting risks related to pandemics. Good air quality generates wide benefits for public health and well-being along with economic benefits as a result of fewer air pollution-related illnesses, positive impacts on cognition and learning, and higher productivity. Similarly, improving access to safely managed drinking water and sanitation will bring important benefits to the most disadvantaged in both OECD and non-OECD countries. In OECD countries, improved access can significantly enhance inclusiveness for under-

privileged groups such as people with health conditions, groups in substandard housing, migrants and homeless people. In many developing countries, women and girls, in particular, are often responsible for collecting water and suffer most from inadequate access to sanitation. Biodiversity conservation and sustainable use are also key as biodiversity and ecosystem services provide benefits of USD 125-140 trillion per year (i.e. more than one and a half times the size of global gross domestic product [GDP]).

The economic crisis is profound and geographically diverse

The economic crisis triggered by COVID-19 may be the most serious economic crisis in a century. The social and economic impacts of the lockdowns and other restrictions to slow the pandemic are diverse and more geographically differentiated than in the 2008 global financial crisis. Whilst a number of factors, as shown above, help to explain differences in rates of infections or death across regions, differences in economic impacts are largely driven by industrial structures, degree of integration into global value chains, and, of course, the stringency and length of containment measures. Indeed, although most policy responses were initially implemented at the national level, in many countries, as the crisis unfolded, these became more localised. (OECD, 2020[8]).

Wholesale and retail trade, accommodation and food service sectors were heavily affected by closures, physical distancing and travel disruption, hitting metropolitan regions and tourist regions first. Lower local consumption reinforced the impact of lost tourism – affecting large retailers, general-purpose stores and businesses in the hospitality industry. Box 1.1 shows impacts on a selection of cities. Manufacturing is also a high-risk sector, as it is particularly affected by disruptions of value chains, especially by lockdowns and mobility restrictions.

Box 1.1. Estimates of economic impacts in cities

Many cities across the OECD reported major impacts:

- COVID-19 caused a marked contraction in the economy of Greater Montreal in the second quarter of 2020. The social distancing required to avoid infection and reduce mortality slowed economic activity in retail businesses, personal services and passenger transport (especially air and public transport). Supply chain disruptions and recessions among major trading partners weaken exports, investment and tourism in the medium term.
- An impact study of confinement on the job market in Madrid, Spain, estimated that 2 months of confinement would result in the loss of 60 500 jobs and even 108 000 if counting indirect employment. This represents 5.4% of total employment. The breakdown by sector of the data places hospitality as the most affected sector (31.8%, with 19 227 fewer jobs) followed by retail trade (11.3%, with 6 850 fewer jobs), personal services (5.6%, which means 3 425 fewer jobs) and culture (2.5%, with 1 497 fewer jobs).
- After 2 months of confinement, Bogotá's (Colombia) GDP was estimated to fall around 4% and unemployment reached 18%. With 3 months of confinement, the drop would be -8%, never seen in the history of the city.

Source: OECD (2020[19]), "Cities policy responses", https://www.oecd.org/coronavirus/policy-responses/cities-policy-responses-fd1053ff/.

In the US, the initially hardest-hit counties and metropolitan areas constitute the core of its productive capacity. The 50 hardest-hit US counties "support more than 60 million jobs and 36% of its GDP" (Muro, Whiton and Maxim, 2020[42]). Economically vulnerable regions may often have been at bigger risk, for example, because of less sectoral diversification and less digital infrastructure. Indeed, in the European Union (EU), regions that received significant cohesion funds from the EU before the crisis have experienced larger relative declines in GDP (European Committee of Regions, 2020[26]), suggesting the crisis may widen geographic disparities in economic performance. Rural areas may have benefitted from temporarily higher demand but their structural characteristics have also made them more vulnerable (Box 1.2).

Box 1.2. Economic impacts in rural regions

The temporary relocation of urban dwellers to rural areas may have produced positive consumption effects in some rural areas, despite the overall decline in demand with confinement. Researchers in the US observed a temporary increase in consumption of primary consumption goods, though the demand for luxury goods declined in urban and rural areas. Rural areas specialised in agriculture and food processing may have been able to boost production and sales.

Nonetheless, rural regions have been particularly vulnerable because they have:

- A much less diversified economy.
- A large share of workers in essential jobs (agriculture, food processing, etc.), coupled with a limited capability to undertake these jobs from home, and poorer high-speed Internet infrastructure. This has made telework and social distancing much harder to implement.
- Lower incomes and lower savings may have forced rural people to continue to work and/or not visit the hospital when needed.

Shortages of seasonal and temporary workers have been a significant challenge, with some jurisdictions at risk of losing a planting season as a result of border closures. Disruptions of perishable cargo trade that affect food markets created an additional burden for rural food businesses.

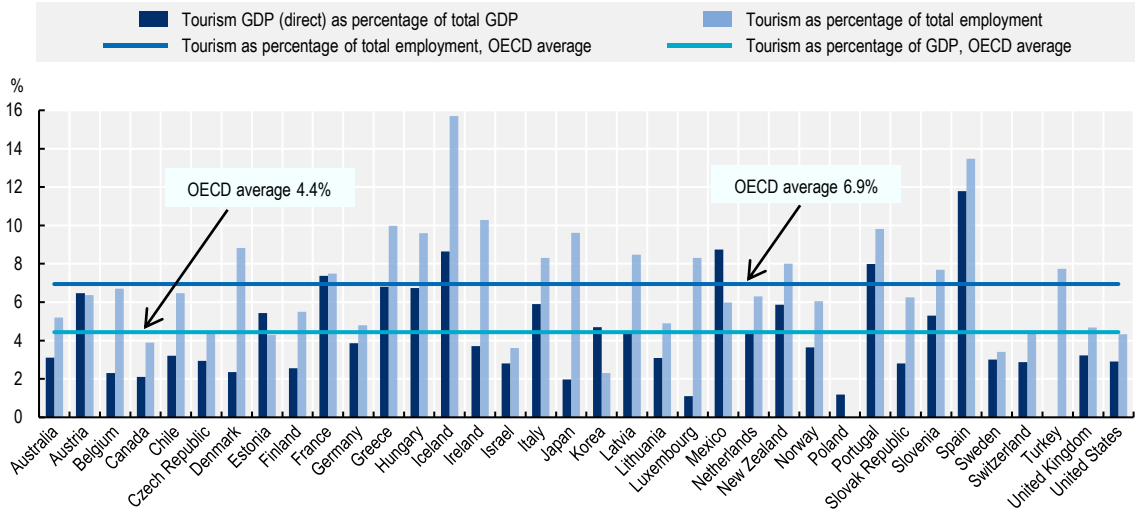
Source: OECD (2020[16]), "Policy implications of coronavirus crisis for rural development", https://read.oecd-ilibrary.org/view/?ref=134_134479-8kq0i6epcq&title=Policy-Implications-of-Coronavirus-Crisis-for-Rural-Development.

The fall in travel hurts regions that depend heavily on tourism

The emergence of COVID-19 around the globe led to concerns over travellers contracting and transmitting the virus. Before the pandemic, the tourism sector directly accounted for nearly 5% of GDP and 7% of employment worldwide (Figure 1.5) but it collapsed as many countries instituted testing and quarantine restrictions for international travellers and even outright bans. The OECD estimates that international tourism fell by 80% in 2020.

Business travel was hard hit and many cultural activities, festivals, cruises and large events were cancelled or rescheduled for post-COVID times (OECD, 2020[27]). Even after some bans were lifted, tourism – especially involving international travel – remained very depressed. The fall in domestic tourism was smaller but still enormous. For example, both Spain and the UK expect declines of around 50% in their domestic tourism in 2020 (OECD, 2020[28]).

Figure 1.5. Direct contribution of tourism in OECD economies



Note: GDP refers to gross value added [GVA] for Canada, Chile, Colombia, Denmark, Finland, Germany, Greece, Hungary, Israel, Italy, Latvia, Lithuania, Mexico, the Netherlands, New Zealand, Portugal, Sweden, Switzerland, the United Kingdom and the United States. GDP data for France refer to internal tourism consumption. GDP data for Korea and Spain includes indirect effects.
Source: OECD Tourism Statistics (Database).

Affected places include coastal areas, mountainous regions, small cities and other places with natural and social attractions. In these places, tourist spending supports local restaurants, shops and cultural activities and many businesses in related industries (e.g. food production, agriculture, transport, business services). Small places that depend on tourism have less diversified economies and are thus less resilient to shocks. When tourism workers' income falls, the entire local economy is affected through demand effects.

Islands, such as Crete, Greece's South Aegean and Ionian islands and Spain's Balearic and Canary Islands, are among the most tourist-centric economies (OECD, 2020[9]). Islands also have minimal surface transport links and are thus more dependent on mass transit air and ship arrivals. In addition to islands, some mainland port cities suffered disproportionately because of the halt in cruise ship travel.

Ski resorts, especially those with a high share of international travellers, have been severely impacted by COVID-19 and related containment measures. While many European countries had lulls in the prevalence of the virus over the summer, the peak winter season for ski resorts coincided with a virus resurgence. As a result, most countries decided to prohibit ski activity during their regions' peak 2020-21 tourist season.

Cities experienced large drops in tourism while some mountain and lake regions within driving distance of large cities received more visitors than usual in their off-seasons. Some places even instituted temporary tourism bans (e.g. Norway) and ran public campaigns (e.g. Canada) to protect rural populations and their health systems.

Urban destinations usually rely on a mix of international and domestic tourists that visit for business and leisure purposes. Business travel plunged with the advent of COVID-19 and since then, most meetings and conferences have been called off or replaced with virtual events. Leisure travel dropped due to cancelled events, restrictions on commerce and movement, and real and perceived COVID-19 risks. Although larger cities are not wholly reliant on tourism, the decline in travel had a negative impact on many low-skilled, vulnerable workers. In the US, employment in the leisure and hospitality sector was halved from February to April; despite a partial recovery, the sector shed more than 3 million employees (20% of its workforce) from November 2019 to November 2020 (U.S. Bureau of Labor Statistics, 2020[29]).

The drop in economic activity resulted in significant but temporary environmental improvements

CO_2 emissions declined by 8% worldwide in 2020, to levels of 10 years ago (OECD, 2020[21]). However, this temporary reduction is not expected to have any long-term impact. Moreover, unless energy use, land use and urban policies are profoundly transformed, the annual flow of emissions will continue to rise. As highlighted in Part II of this *Regional Outlook* report, it is the stock of cumulated CO_2 emissions that counts for the climate. Only moving to net-zero CO_2 emissions can halt global warming.

Air pollution also declined temporarily as industrial activity, ground transport and air travel dropped for several months. Reduced transport in particular has had a positive impact on air quality during confinement in many cities (OECD, 2020[19]). In regions with lockdowns, there was a decrease of 50%-75% in road transport and up to 95% in rush-hour traffic congestion in major cities. Compared with 2019, levels of pollution in New York, US, have decreased by nearly 50%. Cities in China and India also recorded major reductions in sulphur oxide concentrations as industrial activities were curtailed (OECD, 2020[19]) but countries have since reported a rapid return to rising levels (OECD, 2020[21]).

The drop-in economic activity has also led to an improvement in water quality in waterways and coastal zones. However, this will also be a temporary phenomenon as water pollution is expected to increase once economic activity resumes. By contrast, waste management challenges have increased as governments deal with major increases in protective equipment and demand for single-use plastics while recycling diminished (OECD, 2020[21]). The impacts on the most vulnerable segments of society need to be taken into account, especially from contaminated sites and in areas that lack access to adequate housing and clean water.

The temporary nature of the environmental improvements illustrates how closely environmental impacts still relate to economic activity. To address the risks to the foundations of human well-being from climate change while improving inclusive economic prosperity, it is necessary to decouple economic activity from GHG emissions not only in relative but in absolute terms, requiring broad and profound transformation of regional economies, the theme of Part II of this *Regional Outlook* report.

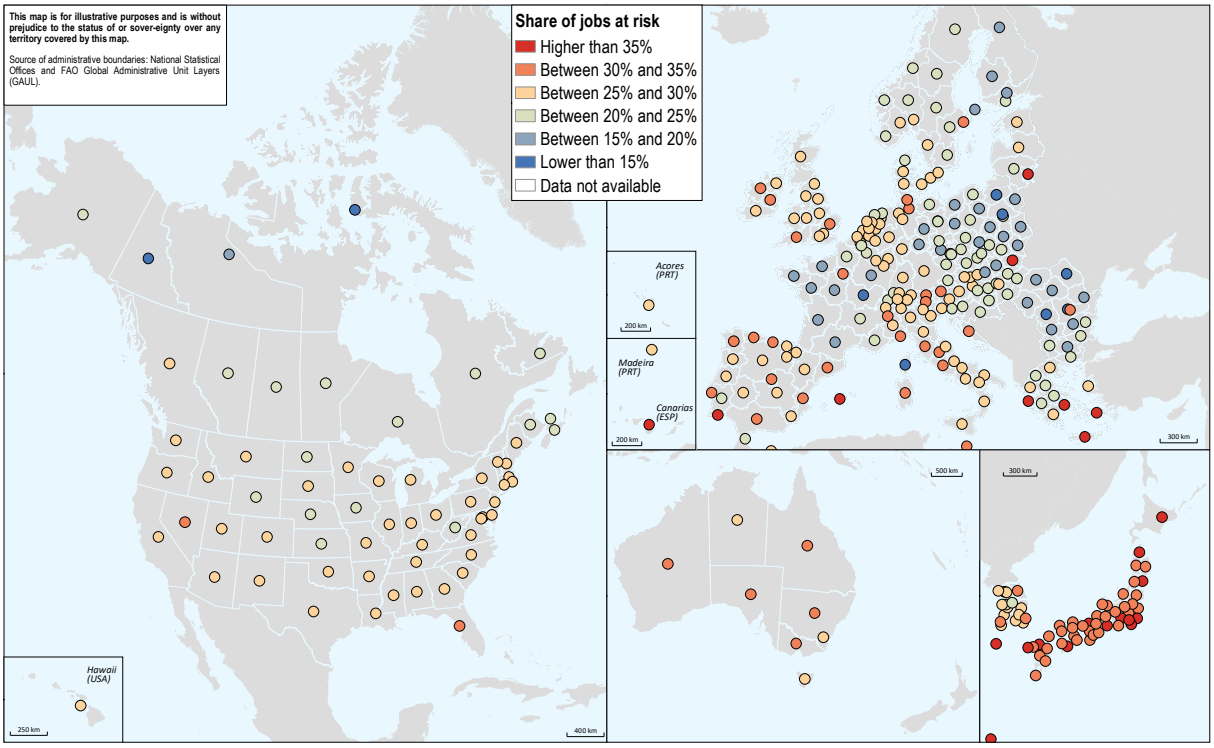
Employment at risk varies strongly with the sectoral specialisation of regions

Evaluating regional employment at risk from a lockdown in a region can be estimated based on the specific sectors of activity. On this basis, employment at risk may vary from less than 15% to more than 35% across 314 regions in 30 OECD and 4 non-OECD European countries in May 2020 (Figure 1.6). In 1 of 5 OECD/EU regions, more than 30% of jobs are potentially at risk during a lockdown.

In Europe, several major tourist regions have over 40% of jobs at risk. In Korea, the largest share of jobs at risk is in Jeju-do, a region where tourism is important too. Similarly, in North America, Nevada stands out as having the highest share of jobs at risk, followed by Hawaii. In most regions, accommodation and food, wholesale and retail as well as art and entertainment account for most jobs at risk (Figure 1.7).

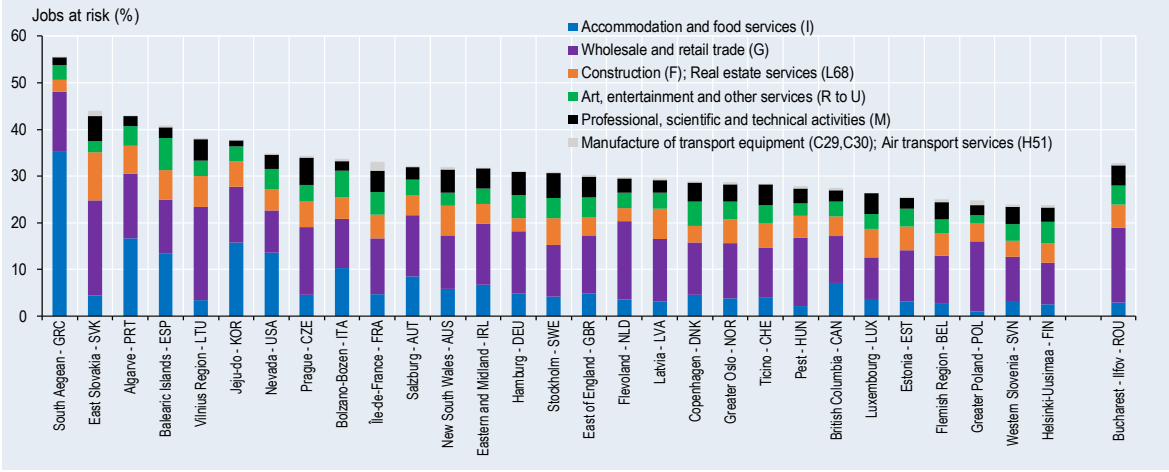
In roughly one-quarter of countries, the capital region has the highest share of jobs at risk. This includes the Czech Republic, Denmark, Finland, France, Lithuania, Norway, Sweden, as well as Romania. Greece and Spain follow the same pattern if their island regions, which are highly exposed to the decline in tourism, are excluded. On the other hand, large cities tend to have other protective factors – a more diverse economy, a more skilled labour force, a larger share of jobs compatible with teleworking – which can help them adapt and facilitate economic recovery (OECD, 2020[30]).

Figure 1.6. Share of jobs potentially at risk from COVID-19 containment measures



Source: OECD (2020[8]), "The territorial impact of COVID-19: Managing the crisis across levels of government", https://www.oecd.org/coronavirus/policy-responses/the-territorial-impact-of-covid-19-managing-the-crisis-across-levels-of-government-d3e314e1/.

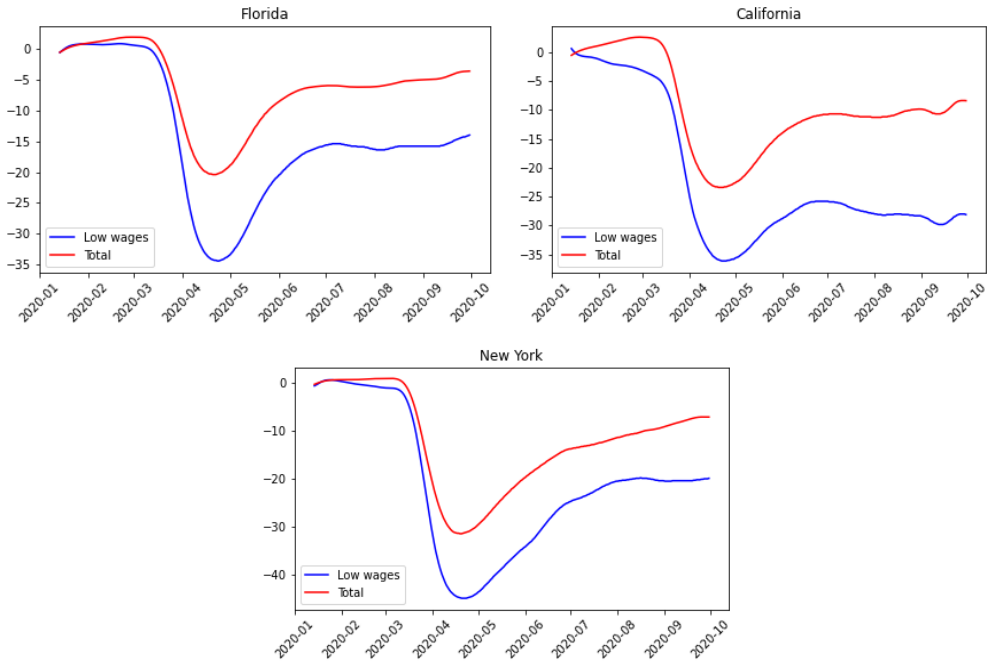
Figure 1.7. Regions with the highest share of jobs at risk by country, TL2 regions



Source: OECD (2020[30]), *Job Creation and Local Economic Development 2020: Rebuilding Better*, https://dx.doi.org/10.1787/b02b2f39-en.

The pace of employment recovery has been uneven. In the US, some states such as Florida have seen employment levels rebound considerably from the crisis lows, although remaining below pre-crisis levels, while in others, such as California, employment levels have only seen a marginal improvement from the crisis lows. (Figure 1.8).

Figure 1.8. Employment changes relative to January 2020



Note: Low wages are annual wages below USD 27 000 per year.
Source: Opportunity Insights (n.d.[31]), *Economic Tracker*, https://www.tracktherecovery.org/.

Unemployment is spiking unevenly across local labour markets. Countries that relied on expanded unemployment benefits or stimulus payments to support workers through job losses or reductions in working hours saw unemployment significantly increase in the first half of 2020. In contrast, countries that made widespread use of job retention schemes, such as short-time work programmes, which cover the wages of furloughed workers, staved off initial increases in unemployment. However, when these schemes are rolled back and businesses manage prolonged drops in demand, unemployment will pick up in many places. In countries where unemployment increased significantly and with available data, regional divides are apparent. For example, in the US, the August 2020 unemployment rate ranged from 4.0% in Nebraska to 13.2% in Nevada. Across the US, unemployment rose more in urban areas than rural ones (USDA ERS, 2020[32]). Some of this rise reflects cancellations of large in-person events such as conferences and music performances in urban areas. Urban areas with many knowledge workers also have many low-pay service jobs that depend on in-person interactions and demand for such services fell sharply. Cities in which many high-pay workers can telework saw disproportionate declines in job postings in services like retail and food preparation (Kolko, 2020[33]).

Regions with high shares of precarious workers are particularly hit

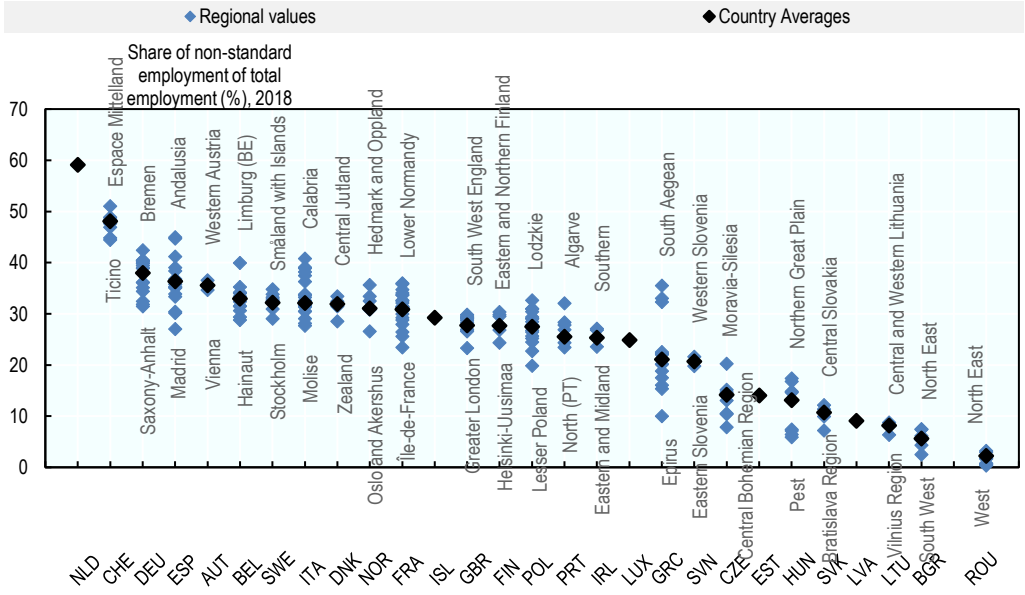
Regional differences in non-standard employment can also explain within-country differences in job losses. Workers in non-standard employment, including informal, undeclared, part-time employment, are often low-pay workers, who generally experience lower levels of job security (if any). Employers may choose not to renew temporary contracts even when dismissal protection regulations prevent them from laying off permanent workers. Workers in non-standard employment are amongst the hardest hit by the crisis. They are highly represented in some of the most impacted sectors, such as the arts, entertainment and tourism. They are often less well covered by social protection, notably unemployment insurance, may not benefit from paid sick leave nor possibly from health insurance, in countries where there is no universal health

insurance scheme. Evidence from Canada, France and Italy suggest workers on temporary contracts were among the first to lose their jobs. Part-time workers may also be subject to less protection.

Temporary work is not evenly spread across territories and is more common in regions with a lower-educated workforce, higher unemployment and a smaller share of gross value-added in tradeable sectors. In over half of European countries with more than 1 region, the share of temporary employment varies over 5 percentage points across regions and, in several, over 10 percentage points. Overall, low-skilled workers are at higher risk of being in temporary work than the higher-skilled, and that likelihood is even higher in rural areas than in cities (OECD, 2020[30]).

Figure 1.9. Temporary employment patterns are not uniform within countries

Temporary employment as a share of dependent employment across selected European countries, large TL2 regions, 2018



Note: Non-standard employment includes individuals in temporary contracts (both full- and part-time) as well as workers in a permanent part-time employment.
Source: OECD (2020[30]), *Job Creation and Local Economic Development 2020: Rebuilding Better*, https://dx.doi.org/10.1787/b02b2f39-en.

Small- and medium-sized enterprises (SMEs) are overrepresented in sectors that have been highly impacted

On average across OECD countries, SMEs are estimated to account for 75% of employment in the most affected sectors. In Ireland, for example, SMEs accounted for 79% of annual turnover in 2017 in highly affected sectors while the share of SMEs in total business sector value-added was 44% in 2016 (OECD, 2020[30]). SMEs are less equipped to manage major shocks since they have much lower equity and financial reserves and less scope to access external debt or equity.

On average across OECD countries, about 15% of working people are self-employed and about one-third of them are employers, with marked differences across regions. They do not always benefit from unemployment insurance and sick leave. The way in which many of the self-employed engage with their customers, suppliers, staff and collaborators are being uprooted by the COVID-19 crisis. Many are losing clients, particularly where their businesses involve consumer or business services that are delivered face-to-face, fields in which the self-employed often dominate. While some of the self-employed are able to

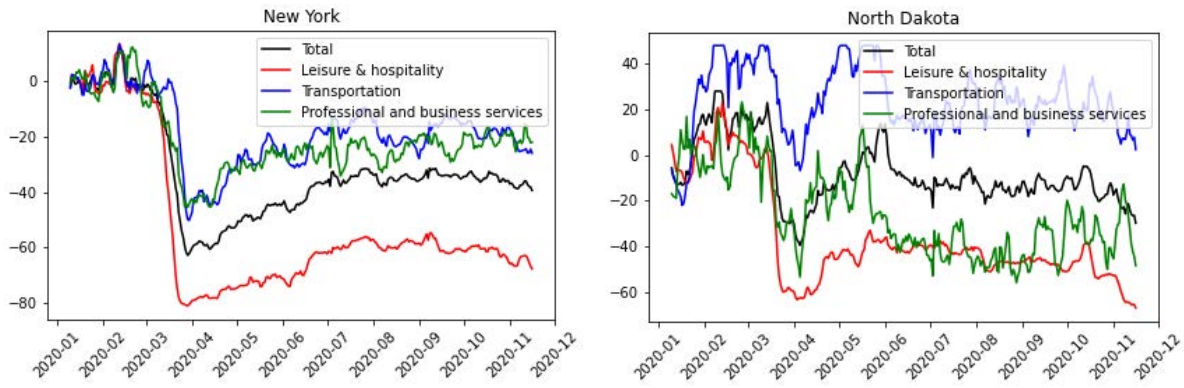
mitigate the adverse impacts by going online for customer and staff interactions, low digital capacities often holds them back and there is a risk that this could lead to new digital gaps emerging with early adopters. In addition, emergency support measures do not reach all SMEs (especially informal SMEs). (OECD, 2021[34]).

SMEs and the self-employed are particularly dependent on their local economies for demand and access to business support but local economies and communities also depend on healthy SMEs. Beyond the jobs they provide, they are often active corporate citizens and are an important component of dynamic and vital local communities. Thus, the impact of potential SME closures goes beyond just the economic activity and jobs they are directly responsible for (OECD, 2020[30]).

The impact on small business may be long-lasting, as customers may be permanently lost to larger (especially digital) competitors, consumer confidence in the ability of smaller firms to provide products safely is dented, business networks are damaged, skilled employees that were furloughed find new jobs elsewhere, and deferred investment decisions impact on output. In the United States, small businesses' income remained around 40% below the pre-crisis level in the state of New York end-2020 (Figure 1.10) with similar patterns in other north-eastern states, despite the reductions in COVID-19 case load and death rates. More generally, sunk-cost characteristics of business investment may imply that a loss of capital stock following a large shock is not recovered, especially if uncertainty remains large and even if demand returns. This is likely to impact employment too. This may be especially true for small businesses, which cannot borrow easily.

Figure 1.10. Business income has remained low in New York and fell more recently in North Dakota

Small business income relative to January 2020



Source: Opportunity Insights (n.d.[31]), *Economic Tracker*, https://www.tracktherecovery.org/.

Cultural activities and their locations have been badly hit

Social distancing brings ongoing challenges to venue-based cultural activities such as theatres and museums (see Box 1.3). Cultural and creative activities account for about 1% to somewhat above 5% of employment across OECD regions. The high share of self-employed, freelancers and SMEs in the cultural sector creates unique challenges that general public support schemes are not always well-tailored to address.

Box 1.3. Cultural and creative sectors risk long-lasting decline, impacting creativity and well-being

Venue-based sectors (such as museums, the performing arts, live music, festivals, cinema, etc.) are the hardest hit by social distancing measures. The abrupt drop in revenues puts their financial sustainability at risk and has resulted in reduced earnings and layoffs. It also has repercussions throughout their supplier networks, hitting suppliers in both creative and non-creative sectors. Some cultural and creative sectors, such as online content platforms, have seen an increase in demand for cultural content streaming during lockdowns but the benefits from this extra demand have largely accrued to the largest firms in the industry.

The effects will be long lasting due to a combination of several factors. The impacts on distribution channels and the drop in investment will affect the production of cultural goods and services and their diversity in the months, if not years, to come. Over the medium term, the anticipated lower levels of international and domestic tourism, drop in general demand and reductions of public and private funding for arts and culture, especially at the local level, could amplify this negative trend even further.

In the absence of responsive public support and recovery strategies, the downsizing of cultural and creative sectors will have a negative impact on cities and regions in terms of jobs and revenues, creation, innovation, citizen well-being and overall vibrancy and diversity. Much of the broad support to workers and firms rolled out in response to COVID-19 was not well suited to the peculiarities of the sector. Cultural and creative sectors largely consist of micro firms, non-profit organisations and creative professionals, often operating on the margins of financial sustainability. Large public and private cultural institutions and businesses depend on this dynamic ecosystem for the provision of creative goods and services. Employment and income support measures are not always accessible or adapted to the new and non-standard forms of employment (freelance, intermittent, hybrid – e.g. combining salaried part-time work with freelance work) that tend to be more precarious and are more common in this sector. SME finance measures could also be better adapted to businesses with significant intangible assets.

Source: OECD (2020[30]), *Job Creation and Local Economic Development 2020: Rebuilding Better*, https://dx.doi.org/10.1787/b02b2f39-en.

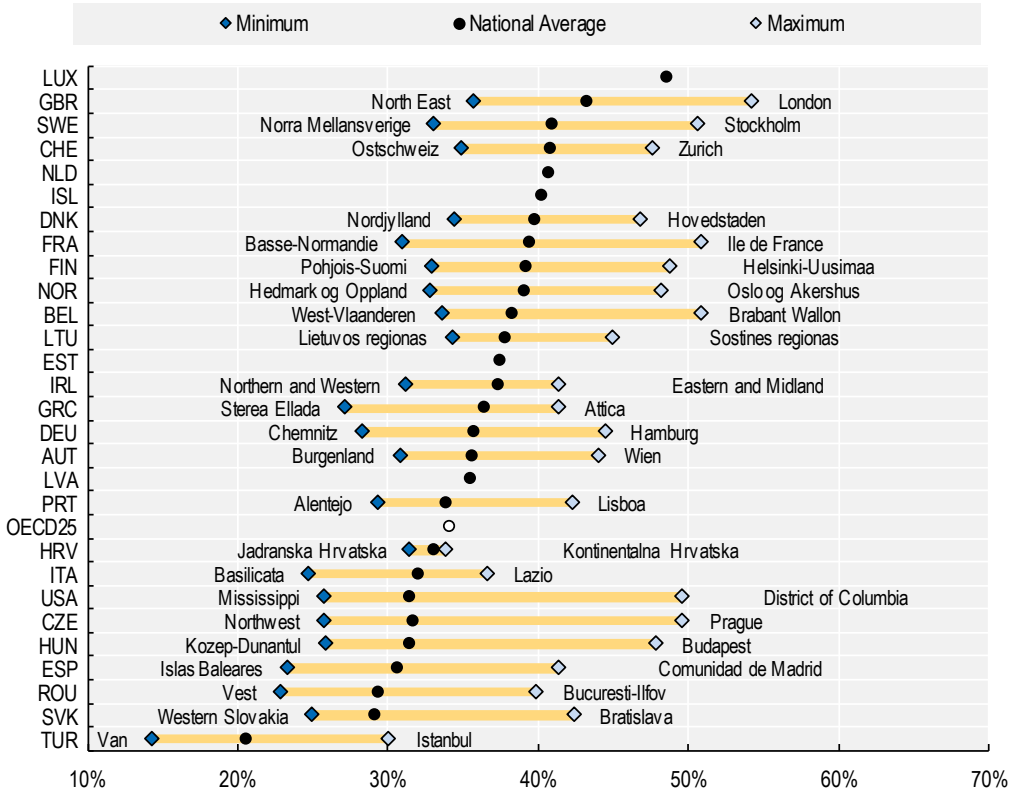
Telework mitigates the impact of confinement on jobs in some regions

The extent to which occupations can be performed remotely is an important mitigating factor with respect to the economic impact and cost of COVID-19 containment and contributes to territorial differences in resilience. This strongly depends on the nature of the tasks. The OECD recently estimated the share of occupations amenable to remote working in OECD regions based on the tasks performed by workers. The potential for remote working is unevenly distributed within countries (Figure 1.11). Urban areas display a 9 percentage point higher share of occupations that can be performed remotely than rural areas.

In most countries, large cities and capital regions offer the largest potential for remote working. On average, there is a 15-percentage point difference between the region with the highest and lowest potential for remote working in a given country. These findings hold under the assumption that all workers – regardless of location – have access to an efficient Internet connection and the necessary equipment. As a consequence, differences arising from connectivity and available equipment might also determine the potential for actual telework opportunities, most likely reinforcing urban-rural divides.

Figure 1.11. The possibility to work remotely differs among and within countries

Share of jobs that can potentially be performed remotely (%), 2018, NUTS-1 or NUTS-2 (TL2) regions



Note: The number of jobs in each country or region that can be carried out remotely as the percentage of total jobs. Countries are ranked in descending order by the share of jobs in total employment that can be done remotely at the national level. Regions correspond to NUTS-1 or NUTS-2 regions depending on data availability. Outside European countries, regions correspond to Territorial Level 2 (TL2) regions, according to the OECD Territorial Grid.

Source: OECD (2020[8]), "The territorial impact of COVID-19: Managing the crisis across levels of government", *OECD Policy Responses to Coronavirus (COVID-19)*, https://www.oecd.org/coronavirus/policy-responses/the-territorial-impact-of-covid-19-managing-the-crisis-across-levels-of-government-d3e314e1/.

Going forward, it is likely that there will be a "new normal" whereby many employees and companies will leverage the potential of teleworking. More recently, a poll in Belgium indicated that up to 90% of employees would like to continue teleworking when restrictions are lifted. Digitalisation, a major game-changer during the crisis, will remain a key component of a "new normal", although teleworking ability varies both across and within countries. House price movements also suggest people relocating to less densely areas but still connected to urban areas. Such relocation appears to be more marked among individuals who can telework (Ramani and Bloom, 2021[35]).

Recovery may be marked by structural change and increased poverty risk

If past patterns hold true, the hardest-hit places could struggle for years to come (OECD, 2020[30]). Stop-and-go measures may continue until vaccination is widely available. Some of the sectors that have been particularly hard hit by containment measures are unlikely to recover quickly. For example, culture and creative industries take a deep and prolonged hit.

Many job losses during recessions are not cyclical but rather reflect an acceleration of structural changes. Accordingly, these jobs are unlikely to recover even when the economic situation improves. This can be especially problematic for local economies where concentrated job losses in specific sectors can have large negative spill-overs in the local economy more generally. Poor labour market outcomes, such as unemployment and low wages, can be associated with a broader range of quality-of-life challenges at the individual and community level, including poor mental and physicalhealth . Likewise, local downturns can put significant pressure on local public budgets, impacting local quality of life and public services such as education and infrastructure (OECD, 2020[30]).

Some labour market transitions initiated before the COVID-19 pandemic could gather momentum and become abrupt changes. Technological change, globalisation, the green transition and demographic change were already reshaping the geography of jobs and labour forces prior to the COVID-19 crisis. These transitions will both create and destroy jobs, but not necessarily in the same places or requiring the same skills. The green transition could also receive new momentum as part of stimulus packages (OECD, 2020[30]).

. The share of jobs at risk from automation ranges from around 4% to almost 40% across regions. While places facing higher risks tend to have a lower-educated workforce and are less urbanised, the rapid uptake of teleworking could expand job creation outside of traditional high-growth centres.

There is some discussion around whether increased possibilities for teleworking will lead many people to leave cities and establish their residencies in remote areas, yet there are reasons that make this unlikely. People are attracted to dense places for their employment opportunities but also for the access to services and amenities they offer. At the same time, people could access these benefits and additional ones such as lower housing prices and less congestion in intermediate cities and/or well-connected rural areas. The long-term impact on the urban/rural spatial equilibrium may be difficult to predict, though telework at least in a hybrid form is likely to remain a permanent feature of work to some degree (OECD, 2020[8]).

Tourism should rebound with a highly effective vaccine but risks remain

As a labour-intensive sector, the impacts on local employment in tourism destinations will be profound. Even after COVID-19 risks fade, travel faces considerable headwinds to a full rebound. Some of the telework that necessitated online meetings enabled technology and habits that may prove to be permanent, leading to lower demand for in-person business meetings and conferences. Even with a highly effective vaccine, some travellers – particularly older ones – may be reluctant to board cruise ships, travel in trains and airplanes, and interact with groups in tours and hotels. Finally, the COVID-19-induced global economic crisis will almost certainly dampen consumer confidence and spending. On the other hand, since domestic and international travel has been risky and restricted for a year or more, there is pent-up demand for travel. For example, some countries that eased their containment measures (e.g. Denmark, Iceland, New Zealand) have already seen rebounds in domestic tourism (OECD, 2020[28]).

The supply-side of tourism may also be restricted in the future. The tourism sector is dominated by SMEs such as hotels, restaurants and shops that are less resilient to downturns compared to larger businesses (OECD, 2020[36]). Some of the hardest-hit small businesses have closed, especially in areas with incomplete government aid. They may not reopen if their owners' skills and business fixed assets can be transferred to other uses. In Mexico, which relies heavily on tourism, more than 1 million SMEs have closed permanently (Téllez, 2020[37]). Some large tourist-dependent businesses (e.g. hotels) also shut because they could not withstand the loss in revenue from extended COVID-related closures. In addition to business closures, staggering declines in cultural and recreational activities combined with an uncertain future could imply less investment in such infrastructure (e.g. museums, theatres, ski lifts, casinos, amusement parks) going forward. Some organisers and performers may have already changed their livelihoods to depend less on in-person group events.

Poverty and adverse well-being impact on vulnerable groups is set to increase sharply

In large cities with often expensive housing in urban centres, polarised labour markets often mean strong divides between high-skilled workers with relatively secure jobs and low-skilled workers in face-to-face service and retail jobs at risk and subject to higher infection risk and higher risk of heavy symptoms (OECD, 2020[30]). For Manchester, UK, for example, socio-economic inequalities are considered the priority emergency to recover from the crisis (OECD, 2020[19]). In Bristol, UK, findings from a survey showed that black, Asian-origin workers and other ethnic minorities were overrepresented in sectors that have been hit the hardest, including taxi drivers and low-income jobs among the self-employed. This was compounded by unequal access in terms of health, housing and information and communication technology (ICT) access (OECD, 2020[19]). Homeless people, estimated to be 1.9 million across OECD countries, have no or limited means of isolating and protecting themselves from infection.

For the elderly, COVID-19 places a severe restriction on their autonomous daily life, in addition to the higher risk of complication in case of infection. Many of whom live alone may not have a family member or friend to rely on and those who live in care homes are most affected by physical distancing. Non-elderly persons with a high risk of COVID-19 complications and their households are also more affected than the rest of the population. Among the elderly, COVID-19-related lockdowns has generated particularly marked loneliness and other psychological impacts. Low-income households may not have access to local professional help, especially if local and regional governments lack resources to provide them where demand may be particularly high (see below).

Women, who are overrepresented in service sectors that rely on contact with customers (e.g. tourism, hotels, restaurants) are more likely to be negatively affected by the economic downturn from the COVID-19 pandemic and women face additional risks of infection (including for hospital and long-term care staff) and domestic violence. In some countries, including Canada and Japan, additional childcare burdens at home led to large declines in women's labour force participation, which could have longer-run impacts on gender employment gaps (Djankov and Zhang, 2020[38]).

School closures also risk exacerbating inequities in education outcomes as parents play a larger role in their children's learning when schools are closed or virtual. The pandemic and its economic crisis have also brought a higher incidence of mental illnesses, notably depression, to which vulnerable groups including youth are more sensitive. For example, in France, the incidence of depression among young people has increased and this incidence is also likely to be geographically uneven. In terms of economic impacts, many young entrants to the labour market are unable to find work yet are ineligible for furlough and unemployment insurance schemes (Cajner et al., 2020[39]). Recent graduates may be disproportionately disadvantaged in their later careers (Altonji, Kahn and Speer, 2016[40]) and the effects may be stronger in countries with dual labour markets.

Workers in informal undeclared jobs are typically not covered by social safety nets, such as unemployment or housing benefit. In the Global South, up to 80% of urban employment is in the informal sector. Some of the biggest challenges from the crisis are likely to be a significant rise in income inequality and poverty. Estimates suggest that up to 400 million people worldwide could be pushed into extreme poverty, adding to the roughly 700 million in poverty prior to the pandemic. A large share of the new extremely poor is projected to be in South and Southeast Asia and Sub-Saharan Africa. These are also countries where large numbers of urban citizens live in precarious, densely packed and underserved slums, characterised by high levels of informal employment and often an inability to adhere to social distancing measures, even more so if its inhabitants want to avoid starvation (Gulati et al., 2020[41]). Young people entering the labour market are at particularly stark risk of being durably affected in their earnings prospects. Labour market entrants with relatively weak labour market prospects are particularly likely to suffer for many years from the impact of a local recession on their career entry.

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2 Policy responses to the COVID-19 crisis

Governments at all levels have taken unprecedented actions to contain the spread of COVID-19 and mitigate the large economic impacts. Local and regional actors play an increasingly important role. The substantial costs of the COVID-19 pandemic to human life and economies and their territorially different impacts highlight that a place-based, co-ordinated policy response is central. While central governments need to set the strategy, bottom-up approaches produce inclusive, local responses. Preventive, anticipative action minimises major adverse impacts on health, well-being and the economy.

In view of the bigger health and economic impacts on vulnerable groups, efforts to halt the pandemic need to be combined with support to disadvantaged areas. Hardest-hit regions and cities may face the biggest loss in revenues and the biggest increase in spending. Without concerted action, this could derail rebuilding efforts in the regions hit the most. Multi-level public finance arrangements need to respond to asymmetric increases in healthcare needs, unemployment and poverty.

Societies have shown they are willing to act to overcome the crisis. This can inspire lasting transformations, notably to address the climate challenge. National, regional and local governments need to deploy economic stimulus in a way that is consistent with these transformations.

Policy responses need to include cities and rural regions

Governments at all levels have taken unprecedented actions to contain the spread of COVID-19 and mitigate the large economic impacts on people and firms described in Chapter 1. Local and regional actors play an increasingly important role. They often implement emergency support policies on behalf of national governments, complement them with local actions to fill gaps for specific sectors or populations and help local workers and firms navigate the sometimes-complex patchwork of schemes (OECD, 2020[1]).

As shown in Chapter 1, the economic, fiscal and social impact of the COVID-19 crisis on territories is differentiated, and its diverse risks vary greatly depending on the location (OECD, 2020[2]). This regionally differentiated impact calls for a territorial approach to policy responses on the health, economic, social and fiscal fronts and strong inter-governmental co-ordination. Recovery strategies also need to have an explicit territorial dimension and therefore need to involve subnational governments at all levels in their implementation.

Cities are on the frontline of responses to the COVID-19 crisis

Often hit first by the initial waves of the pandemic, cities play a key role to implement measures to contain infections and cope with economic impacts but also provide laboratories for bottom-up and innovative recovery strategies. COVID-19 has accelerated transformations towards inclusive, green and smart cities, although these continue to fall short of what is needed to reach net-zero greenhouse gas (GHG) emissions in 2050, a target set by most OECD countries to align with the Paris Climate Agreement (Part II of this *Regional Outlook* report).

Cities crisis management responses have first related to social distancing, workplaces and commuting, protection of vulnerable groups, ensuring local service delivery, support to businesses and citizen engagement. Many cities are also planning for life beyond COVID-19 with a range of investments to pair recovery with environmental sustainability including clean forms of urban mobility and energy efficiency.

The following are some steps taken by city governments (OECD, 2020[2]).

Prevention and effective early action

In some Asian countries, early action, particularly in early testing and extensive tracing of COVID-19 cases, teleworking and lockdown orders, have succeeded in avoiding large outbreaks in several hyper-dense cities such as Hong Kong (China), Seoul and Tokyo.

Several mayors and local administrations have developed innovative ways to inform, reassure and communicate. They have developed a wide range of digital tools to cope with daily needs and health issues, including public information programmes, websites, posters, advertisements and social media.

The crisis has prompted some cities to expand facilities and services to prevent and reduce health crisis impacts. Seoul, Korea, has made a large investment in public healthcare, establishing a monitoring system of the pandemic and new municipal facilities that include a public medical school and research centres on infectious diseases. To help reduce virus transmission within households, especially mixed-generation ones, governments in some countries (e.g. Finland, Italy, Lithuania) arranged special isolation accommodation for people who contracted the virus (Haroon et al., 2020[3]). These may in particular serve to alleviate low-income households who often live in crowded housing and who are more exposed to both infections and socio-economic effects of the crisis, as argued above.

Supporting inclusiveness

Support measures to vulnerable groups are diverse and include food programmes for children and the elderly, meal and pharmaceuticals delivery, special care for elderly and disabled people, emergency

shelter and housing, distribution of masks, vouchers for essential goods, installation of sanitary facilities, exemptions or deferrals from rental payments for residents of social housing, mortgage payment assistance, waiver or relief of utility payments and emergency phone lines. Some have engaged unemployed people in paid work to improve public services needed in the crisisand provided more subsidised social services (e.g. early childhood services for children).

Bristol in the United Kingdom (UK), for example, is supporting and taking into consideration studies and recommendations by civil society organisations addressing social disparities. One example is the work conducted by the Bristol-based Black South West Network (BSWN), which has provided support to Black, Asian and Minority Ethnic businesses, communities and organisations, through advice and monitoring of the impact of the crisis on these communities (OECD, 2020[4]).

The use of digital tools

Digitalisation has been a crucial lever in cities' response to the pandemic, with tools monitoring contagion risk and, in some cases, ensuring the respect of confinement and social distancing, while also enabling the continuity of services and economic activity. These tools and the changes in habits they have entailed will remain a permanent component of cities' recovery phase and increased preparedness for potential new waves. This prompted reflections on issues of privacy rights and the universality of Internet access.

In terms of contact tracing and ensuring social distancing in Daegu, Korea, the epidemiological investigation during the outbreak was able to use the smart city data hub to trace patient routes. Seoul, Korea, used geo-localisation data, bank card usage and video surveillance. Other cities opted for less individualised monitoring options, such as using urban data to observe collective density and mobility patterns. For instance, Mexico City, Mexico, used a partnership with Google Maps and Waze to monitor mobility trends and Budapest, Hungary, is using smart city tools to identify high concentrations of people.

The digital divide is one of the many inequalities exposed by COVID-19. Cities initially provided rapid or temporary measures to try to bridge that gap. Boston in the United States (US) is working to address the digital divide by providing high school students with a free "cell phone hotspot". Boston and New York schools have also provided tablets to students, though meeting demand has been a challenge and there might be students who cannot access the Internet. In Yokohama, Japan, some school lessons were made available on a local TV station. Milan, Italy, has launched a call for donations of devices or Internet connections to schools. The city of Toronto, Canada, has partnered with information and communication technology (ICT) companies to provide free temporary Internet access for low-income neighbourhoods, long-term care homes and shelters.

Urban mobility

Mobility has been strongly impacted by the COVID-19 pandemic and has provided cities with the momentum to rethink urban space and propose alternatives. For example, cities have been promoting cycling. Moving into more long-term and permanent strategies, cities are now investing in active mobility infrastructure, improved public transport safety and accessibility, and zero-emission transport options, such as electric vehicles and scooters. Part II of this *Regional Outlook* report shows how important it is to take these measures on a large scale across all cities to reach net-zero GHG emissions but also avoid unnecessary costs, strengthen well-being, move towards a fairer allocation of urban space and thereby strengthen cities' international attractiveness and competitiveness.

While the impact of COVID-19 on public transport has been significant in most OECD countries, transport systems have shown a remarkable capacity to enforce hygiene measures during lockdowns, thus contributing to avoiding transport-related clusters. Many urban public transport systems ensured a minimum level of service to facilitate distancing. Urban transport around the world has also faced unprecedented low levels of ridership and corresponding losses in fare revenue.

Going forward, and as described in Part II, a diversification of public transport offers, including digital-platform-based ride-sharing can help avoid congested public transport while reducing individual car use and make it more responsive to demand in real time.

Urban planning and design

Cities are adapting urban design, reclaiming public space for citizens and rethinking the location of essential urban functions to ensure easier access to services and amenities while securing safety and health. Concepts such as the "15-minute city" have gained traction as a means to increase the quality and sustainability of life in cities, by ensuring access to 6 essential functions in a short perimeter: to live, work, supply, care, lean and enjoy. This can be well aligned with net-zero-emission strategies and boost well-being beyond the pandemic, as accessibility is improved with less energy use in transport. This would need to be built into a comprehensive urban net-zero transport concept, including transport pricing (Part II of this Regional Outlook).

Montreal, Canada, is one of the many cities enabling social distancing through the extension of terraces on sidewalks and pedestrianisation of streets. This further confirms the benefits of Montreal's "human scale" as the city is already a juxtaposition of neighbourhoods, each with easily accessible public services and amenities.

Rural regions face specific vulnerabilities. Short-term responses during the COVID-19 crisis have focused on emergency measures to improve health and access to medical services and other basic services in rural areas. Improving digital infrastructure was another focal point. These have shed light on the high vulnerability of rural regions, calling for specific measures for them. Bottom-up initiatives involving civil society and voluntary support groups have emerged to support rural communities.

Health responses and improving access to the medical and other basic services

Several countries have mobilised health workers in different ways to ensure services in remote territories. Initiatives range from making health services more accessible and delivering medical equipment, to information and self-assessment tools for citizens, or bringing rural citizens closer to health services.

The European Union (EU) developed a platform containing a growing list of open-source software and hardware solutions to assist medical staff, public administrations, businesses and citizens in their daily activities.

In Mexico, a platform of about 300 professionals from different fields joined efforts to create and donate 3D-printed medical devices to rural hospitals. The platform has facilitated the donation of medical equipment, such as masks and respirators, as well as monetary donations to supply the needs of local hospitals.

Korea has provided on-demand services in locations where physical facilities are unavailable, as well as improved medical services to all people regardless of location. The Korean government plans to transform medium-sized regional hospitals into first-class medical institutions that can treat all kinds of diseases.

In Spain, in the Basque Country region, a programme relying on volunteers and the network of pharmacies provides a service to the elderly population with chronic diseases and living alone, ensuring they will not have to go to the pharmacy and thus avoid coronavirus exposure.

Other measures have ranged from securing food availability in rural areas, for example with networks of local citizens/producers to deliver food and other basic products, assisting the elderly and solidarity initiatives, providing emergency aid and maintaining essential services.

Improving digital infrastructure and accessibility

While 85% of urban households had access to 30 Mbps of broadband before the crisis, only 56% of rural households had access.

- The US has provided funding to entities seeking to deploy broadband in rural areas. The CARES Act also allocated USD 25 million to the United States Department of Agriculture's Distance Learning and Telemedicine programme, helping rural communities by funding connectivity to combat the effects of remoteness and low population density.
- Poland has introduced an investment plan of EUR 6.6 billion to reinforce public investment expenditure including a specific fund for the deployment of broadband networks.
- The government of Austria created Digital Team Austria, a group of companies that will offer services including online meetings, digital collaboration, cyber security and/or Internet access free of charge for at least three months.
- Korea has allocated funds for wider 5G wireless network coverage, development of next-generation smartphone models and easing regulations to speed up innovation to foster the transition to new telecommunication systems. This programme is part of a package of measures that will generate an economic stimulus in a post-COVID-19 phase by relying heavily on artificial intelligence (AI) and wireless telecommunication technology.

Managing the crisis across levels of government

"Strong co-ordination between all actors in charge of the response at central and regional levels is the basis of an effective response" (WHO, 2020[5]). It has increasingly emerged that this requires leadership and co-ordination by the national government and effective co-ordination mechanisms among levels of government. On the health front, many countries have increasingly adopted territorial approaches to response measures. On the economic front, governments have provided massive fiscal support to protect businesses, households and vulnerable populations. Since March 2020, they have pledged to spend more than USD 12 trillion globally. More than two-thirds of OECD countries have introduced measures to support subnational finance on the spending and revenue sides and have relaxed fiscal rules.

The territorial approach to the health crisis and the role of subnational governments

Many countries have adopted local lockdowns to limit the large costs of national confinements. Effective co-ordination among subnational authorities, health agencies and the central government are essential to managing local outbreaks. Effective testing strategies with the tracing of contacts, combined with social distancing can limit containment measures and reduce their economic impacts. They are best put in place when caseloads are low, as part of a preventive approach to avoid rising caseloads which may then require lockdowns. They require accurate data and information about infections and contacts at the local level, to quickly deploy test results and trace contacts, as in Korea (Box 2.1).

European countries increased their capacities and generalised testing for suspicious cases when caseloads had already reached high levels between May and November 2020 (Figure 2.1). In the EU27, more than 6 million reverse transcription polymerase chain reaction (RT-PCR) tests were taken every week in October compared to 1.5 million in April (OECD, 2020[2]). Subnational governments play a leading role in implementing the "track, isolate, test and treat" strategy. To reduce the risk of new waves of COVID-19 outbreaks, 70%-90% of all people who have been in contact with an infected person need to be traced, tested and isolated if infected. This is most effective when caseloads are still small, so requires a preventive, anticipatory approach (OECD, 2020[6]).

In decentralised contexts, while central governments should provide financial resources and co-ordination, policy delivery is the responsibility of regional and local governments. In countries with more centralised health service delivery, local and regional governments contribute to the organisation of testing and isolation measures. In either case, it is important to leave room for local initiatives and experimentation. To make the most of local initiatives and experimentation and learn from the rich experience they generate, it is important to produce data and use them to evaluate impacts.

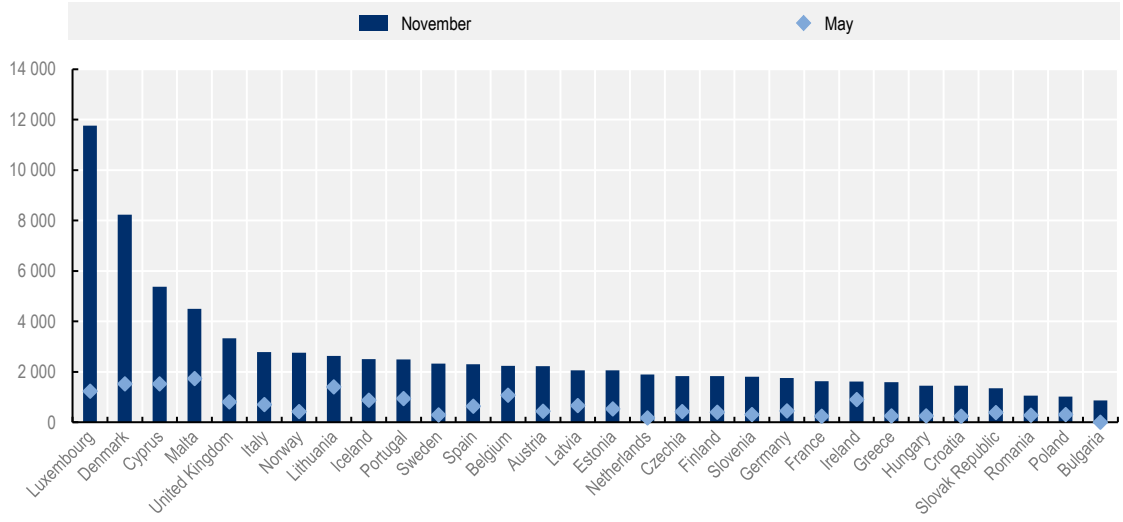
Box 2.1. Local action contributes to successful early testing and tracing strategies

Testing and contact tracing were at the core of Korea's successful strategy. Local governments are responsible for COVID-19 screening stations and treatment centres. Korean local experiments in drive-thru screening have become national and international models.

After the SARS outbreak in 2003, Korea's governance reform has scaled up medical capacity and prepared the health administration. An effective infection disease risk alert system and strong co-ordination mechanisms with clear assignment of responsibilities among central and subnational governments, medical institutes and the private sector, have contributed to the success of its co-operative governance model in 2020, which is characterised by the centralised guidance from the Central Disease Control Headquarters and the decentralised implementation by subnational governments. Elsewhere, poorly co-ordinated actions have instead resulted in a disjoined crisis response and generated collective risk.

Figure 2.1. European countries increased testing in the course of the crisis

Average weekly number of tests per 100 000 inhabitants



Source: OECD (2020[2]), "The territorial impact of COVID-19: Managing the crisis across levels of government", https://www.oecd.org/coronavirus/policy-responses/the-territorial-impact-of-covid-19-managing-the-crisis-across-levels-of-government-d3e314e1/; European Centre for Disease Prevention and Control.

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Nearly all surveyed EU subnational governments consider co-ordination among all levels of government in the design and implementation of measures very important for a successful crisis exit (Figure 2.2). Other key factors they highlighted also relate to co-ordination, such as the possibility of adapting measures to the local situation and the relationship between subnational governments, the private sector and the public. Seventy-one percent of surveyed subnational governments highlighted that the lack of vertical and horizontal co-ordination is among the biggest challenge in managing the health crisis (OECD-CoR, 2020[7]).

Vertical co-ordination among the national and subnational governments is the "first step of an effective response", as stated by the World Health Organization (WHO) at the pandemic's outset. In places where subnational governments operate with high degrees of autonomy, policy responses are more likely to be fragmented (OECD, 2020[2]). There is a greater risk of operating with one-size-fits-all measures that may not address local needs in more centralised countries. Crisis management tools in a broad range of policy areas, including healthcare, social services, economic development and public investment, are shared across levels of government and therefore require effective vertical co-ordination**.** Unilateral decisions without prior consultation with all stakeholders spurred non-compliant behaviours and even large-scale demonstrations in France, Italy, Spain, the UK and the US.

Horizontal co-ordination is as important as vertical co-ordination, particularly in decentralised and federal countries where crisis responses are differentiated across territories (OECD, 2020[2]). Horizontal co-ordination across jurisdictions allows addressing cross-jurisdictional issues and achieve economies of scope. Some jurisdictions may face an immediate trade-off between adequately responding to the crisis locally and supporting neighbouring jurisdictions with information (on infections and local measures) and resources (equipment, personnel and funds). Going forward, cross-jurisdiction co-operation will be essential to support the recovery process and avoid a fragmented approach to public investment.

New co-ordination platforms and associations of regional and local governments support crisis management

Federal and unitary countries have introduced and mobilised vertical co-ordination mechanisms during the pandemic. Newly created institutions have supported inter-governmental co-ordination in 8 out of 17 surveyed OECD countries (OECD, 2020[8]). The Risk Assessment Group and the Group of Experts in charge of the Exit Strategy in Belgium and the New Emergency Management Office in Colombia for example are providing such platforms. National associations of subnational governments are important to foster vertical co-ordination efforts by disseminating information, identifying and sharing solutions and supporting the implementation of emergency measures by their members (Box 2.2). The more decentralised the country, the greater the need to mobilise co-ordination platforms to minimise the risk of a fragmented policy response. Such platforms allow enhancing the evaluation of policy measures and promoting feedback on what works and what issues emerge across different levels of government.

Box 2.2. Examples of vertical and horizontal co-ordination for crisis management

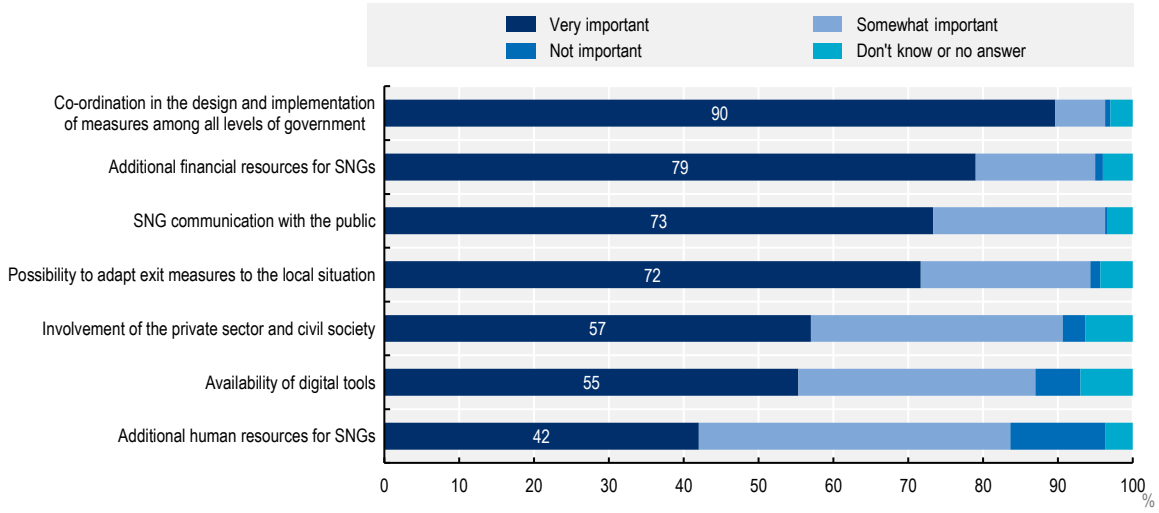
Associations of regional and local governments act as interlocutors between national and subnational governments. They also co-ordinate efforts among their members, identify solutions and help implement emergency measures. Regular dialogue between the national government and these associations can be particularly valuable to address crisis-generated social and economic damage. In Australia, the government introduced the National Cabinet to bring together the prime minister and first ministers of Australian states and territories. In Chile, the Social Committee for COVID-19, formed by representatives of municipal associations, government authorities, academics and professional from the health sector, helped to strengthen the action plan. In Spain, the Conference of Presidents, a multi-lateral co-operation body between the central government and the governments of the

autonomous communities, became the operative instrument for multi-level dialogue to co-ordinate resources based on the territorial situations. Canada and Korea developed "whole-of-government" approaches to call on all levels of governments to work in co-operation (OECD, 2020[2]).

In Denmark, municipalities purchase protective equipment through joint procurement (Aarhus Kommune, 2020[9]). In France, inter-municipal co-operation bodies have multiplied initiatives to support their member municipalities by acting as a platform and an operational actor (ADCF, 2020[10]). In Switzerland, the Conference of Cantonal Governments co-ordinated regular meetings between all 26 cantons (KDK, 2020[11]). In the US, governors of New York, New Jersey, Pennsylvania and Connecticut adopted a common set of guidelines on social distancing (New York State, 2020[12]).

Figure 2.2. Policy tools at the core of a successful exit strategy

Answers from subnational government officials to the question: How important do you consider the following factors to be for a successful exit strategy from the crisis?

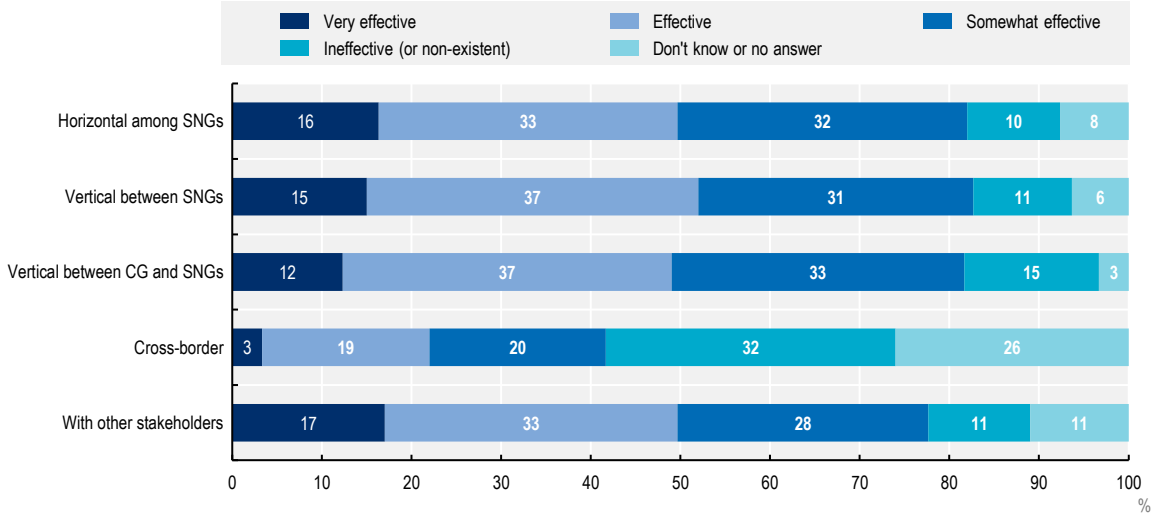


Note: Subnational governments (SNGs) submitted their answer to the survey in June-July 2020.
Source: OECD-CoR (2020[7]), "The impact of the COVID-19 crisis on regional and local governments: Main findings from the joint CoR-OECD survey", http://www.oecd.org/regional/multi-level-governance.htm.

Many countries have experienced co-ordination challenges between national and subnational governments. Only around half of the respondents representing subnational governments in the EU believe that co-ordination mechanisms have been effective (Figure 2.3). A critical issue emerged in international cross-border regions where co-operation has been more difficult because of borders closure and the lack of effective co-ordination arrangements (OECD, 2020[2]). In many cases, EU member states have implemented uncoordinated border closures and unilateral measures. Around one-third of respondents to the OECD-CoR survey reported that cross-border co-operation between subnational governments was broadly ineffective or non-existent, while only 22% found such co-operation effective (OECD-CoR, 2020[7]). However, several cross-border co-operation mechanisms worked well and, arguably, allowed for increased resilience and paving the ground for reinforced co-operation (EU Committee of the Regions, 2020[13]). Cross-border transfers of COVID-19 patients have been made possible in the context of pre-existing co-operation agreements among France (Grand-Est), Germany (Baden-Württemberg and Rhineland-Palatinate), Luxembourg and Switzerland (OECD, 2020[2]). The regions of South Tyrol, Trentino and Tyrol at the Italian-Austrian border set up a co-ordination unit (OECD, 2020[2]).

Figure 2.3. Co-ordination mechanisms effectiveness during the first phase of the crisis

Answers from subnational government officials to the question: How effective have the following co-ordination mechanisms been in managing the COVID-19 crisis in your country?



Note: CG: central government. SNGs submitted their answer to the survey in June-July 2020.
Source: OECD-CoR (2020[7]), "The impact of the COVID-19 crisis on regional and local governments: Main findings from the joint CoR-OECD survey", http://www.oecd.org/regional/multi-level-governance.htm.

Fiscal policy needs to respond to territorial impacts of the crisis

The COVID-19 crisis and the associated policy responses have had a strong negative effect on subnational government finances (Figure 2.4), which has differed across regions (Box 2.3). The crisis is reported to have a somewhat larger impact on revenue than on expenditure. Large municipalities tend to expect bigger impacts than smaller ones: About two-thirds of surveyed municipalities with populations above 250 000 inhabitants expect the impact to be highly negative, against 41% where the population is below 10 000 inhabitants (OECD-CoR, 2020[7]). The US National League also reported a severe and long-lasting impact on US cities with a loss of own-source revenue reaching 21.6% in 2020 (US National League of Cities, 2020[14]). Already in June 2020, most subnational governments noted a dangerous "scissors effect" of rising expenditure and falling revenues (CoR-OECD, 2020[15]).

Box 2.3. The impact on subnational finance is asymmetric

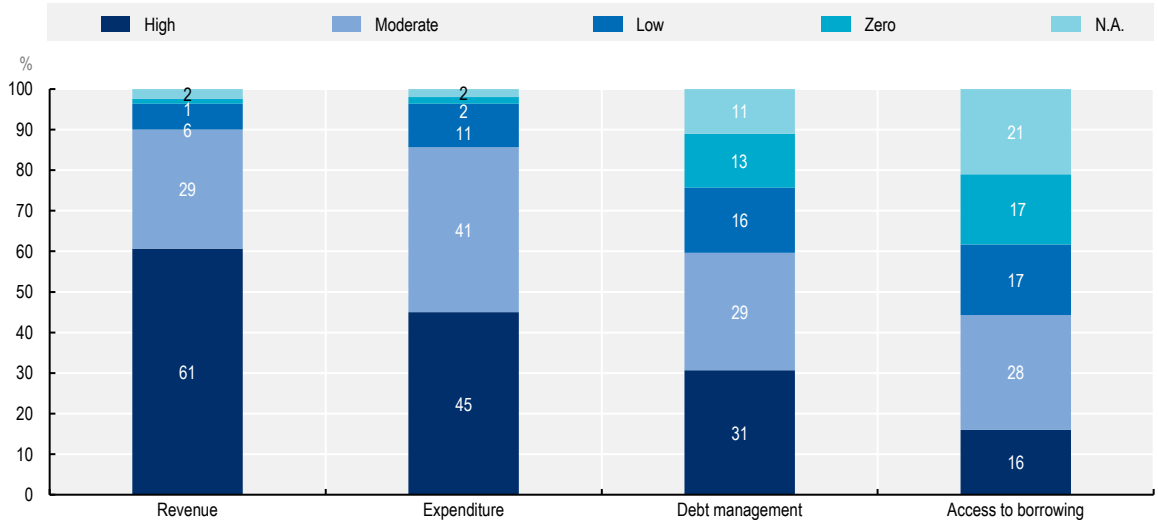
The impact on subnational finance is asymmetric due to different exposure and vulnerability to the health and economic crisis across countries, regions, municipalities and levels of government. The impact at the subnational level depends on several financial and budgetary factors:

- The degree of decentralisation and the assignment of spending responsibilities.
- The characteristics of subnational government revenues, in particular the elasticity of fiscal revenue with respect to the business cycle.
- The ability of subnational governments to absorb exceptional stress, determined by their capacity to adjust their expenditure and revenues to urgent needs.

- The fiscal health and financial conditions of subnational governments, determined by the *ex ante* budget balance and debt ratios, the level of cash treasury and set-aside reserves.
- The scope and efficiency of support policies from higher levels of government.

Figure 2.4. Impact of the COVID-19 crisis on subnational finances in the European Union

Answers from subnational government officials to the question: How negative do you expect the impact of COVID-19 to be on your revenue, expenditure, debt management and access to borrowing?



Note: N.A.: Not applicable. Subnational governments submitted their answer to the survey in June-July 2020.
Source: OECD-CoR (2020[7]), "The impact of the COVID-19 crisis on regional and local governments: Main findings from the joint CoR-OECD survey", http://www.oecd.org/regional/multi-level-governance.htm.

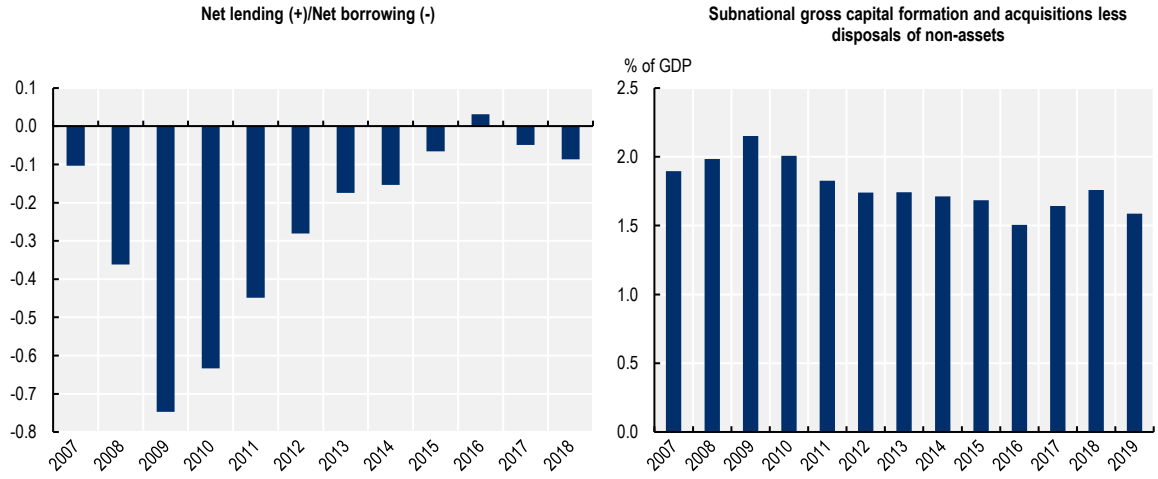
Subnational budget consolidation measures after 2010 led to drops in subnational public investment (Figure 2.5), with a likely negative effect on private investment, and hampered growth in many OECD countries (OECD, 2020[2]). With a substantial share of subnational governments reporting budgetary impacts, including on debt management and access to borrowing, risks of premature consolidation may also exist in the current crisis, if subnational government finances do not receive sufficient support. In some regions and cities, public investment projects have already been cancelled or postponed. Reducing public investment would also be inconsistent with the net-zero GHG emission transition, which requires both different and more investment, as shown in Part II of this *Regional Outlook* report.

The impact on subnational government expenditure varies with spending responsibilities

In 2017, subnational health expenditure accounted for 24.5% of public health expenditure and 11.5% of total subnational expenditure (Figure 2.**6**).[1] In many countries, subnational governments are responsible for critical aspects of healthcare systems, including emergency services and hospitals. Subnational governments also have expenditure responsibilities in social protection including social assistance and social benefits (14% of subnational expenditure). Beyond health and social responsibilities, education (24%), public administration (15%), economic development and transport (13%) have all been disrupted at the subnational level and subnational governments are facing a number of complex and costly tasks. Subnational governments have also been involved in delivering support policies for small- and medium-sized enterprises (SMEs) and the self-employed, as well as infrastructure investment.

Figure 2.5. Subnational governments' budget and investment, 2007-19

Fiscal consolidation measures in the decade to the COVID-19 crisis have been associated with a lower share of subnational public investment in gross domestic product (GDP) in OECD countries



Note: Unweighted average net lending/net borrowing as a percentage of GDP for subnational governments (state and local governments) in 36 OECD countries between 2007 and 2018. In Turkey, data are available over 2009-19. Colombia is not included. Unweighted average subnational gross capital formation and acquisitions less disposals of non-assets as a percentage of GDP (state and local governments) in 34 OECD countries between 2007 and 2019. In Turkey, data are available over 2009-19. Chile, Colombia and Lithuania are not included.
Source: OECD Fiscal Decentralisation Database, OECD National Accounts database.

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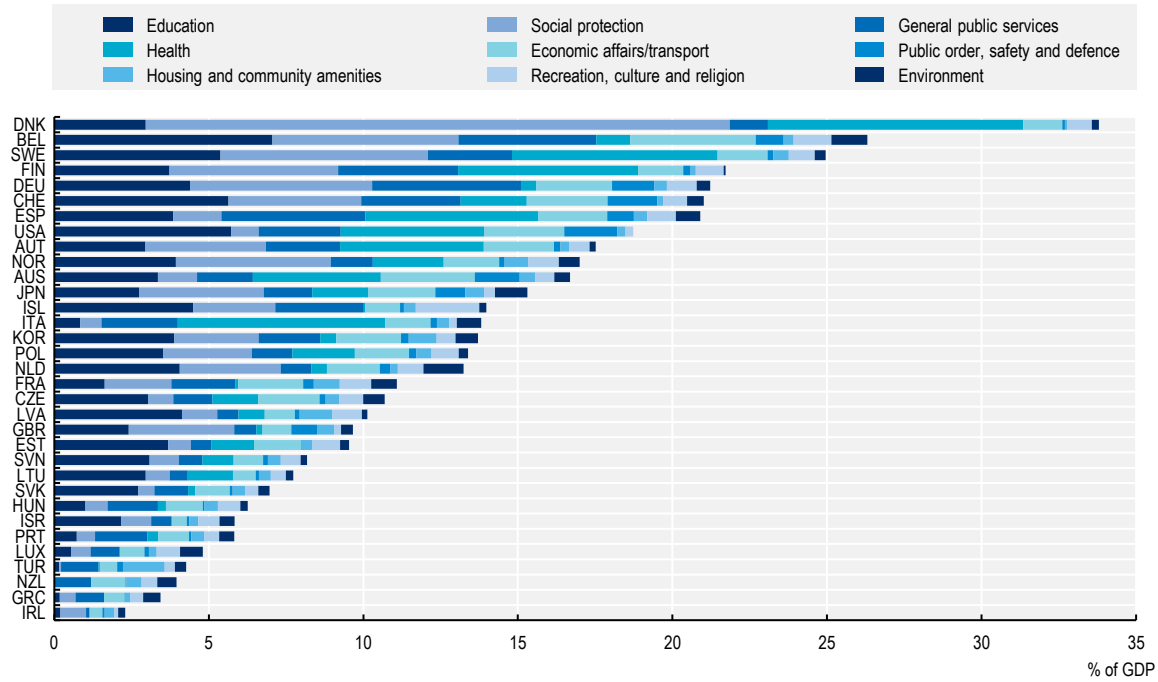
Figure 2.6. Breakdown of subnational government expenditure by function (COFOG), 2017



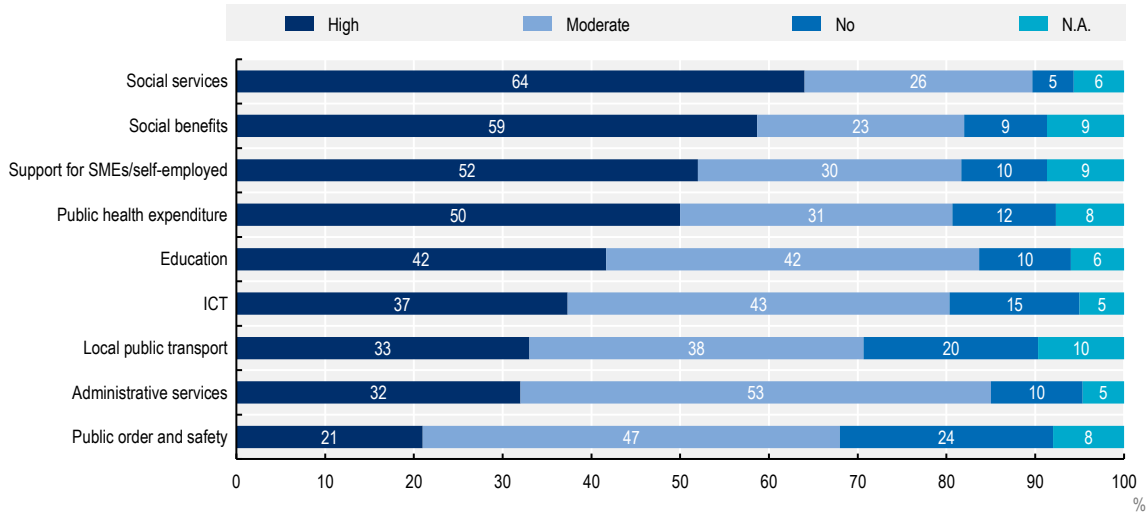
Note: COFOG: Classification of the Functions of Government.
Source: OECD (2020[16]), *Subnational Governments in OECD Countries: Key Data - 2020 Edition*, OECD, Paris.

StatLink https://doi.org/10.1787/888934236570

Health and social protection are putting pressure on subnational government finances (Box 2.4) and is expected to grow in the medium term. Some spending items could decrease temporarily amid the closure of some public services as well as lower energy and commodity prices. According to the OECD-CoR survey, subnational governments in the EU anticipate significant expenditure increases in social services and benefits, support to SMEs and the self-employed, and public health (Figure 2.7). Some expenditure increases should also arise from the digitalisation of services in education, local public transport, administrative services and public order and safety. Regions are more likely to experience increased spending on health, support to SMEs and the self-employed as well as adaptation of public transport than municipalities, reflecting the broader responsibilities of regions in these service areas (OECD-CoR, 2020[7]).

Figure 2.7. COVID-19 pressure on subnational expenditures, by service area

Answers from subnational government officials to the question: In the following service areas, how much pressure do you expect the COVID-19 crisis to put on your subnational entity's expenditure?



Note: N.A.: Not applicable. Subnational governments submitted their answer to the survey in June-July 2020.
Source: OECD-CoR (2020[7]), "The impact of the COVID-19 crisis on regional and local governments: Main findings from the joint CoR-OECD survey", http://www.oecd.org/regional/multi-level-governance.htm.

Box 2.4. Pressure on subnational government spending is strong, especially for social services

The COVID-19 crisis is placing strong pressure on subnational social protection spending given its impact on elderly and dependant people, those with chronic or long-term illnesses, the poor and low-income families. Among OECD countries, social protection represents 14% of total subnational public expenditure, though this is much higher in countries where subnational governments have significant social protection responsibilities (e.g. Austria, Belgium, Germany, Japan, Nordic countries and the UK). There are large disparities in social protection spending among OECD countries but when social protection is not a subnational government's responsibility, it nevertheless often has to respond to social emergencies. During the pandemic, subnational governments have undertaken initiatives to provide social and community support to vulnerable populations (OECD, 2020[4]). In the longer term, social expenditure will certainly continue to increase as more welfare benefits need to offset the impact of higher unemployment and the number of aid seekers.

Regional and local governments have differentiated responsibilities in health services. Therefore, the crisis will have a differentiated impact within the subnational government sector. In most federal countries, healthcare is a major responsibility of state governments, which are responsible for secondary care, hospitals and specialised medical services. The role of municipalities in healthcare generally concentrates on primary care centres and prevention. However, in some countries, municipalities or inter-municipal co-operation bodies may have wide responsibilities in healthcare services and infrastructure. In the EU, 69% of responding regional governments reported facing high pressure on their health expenditure, compared to 44% of municipalities, likely reflecting their broader responsibilities in this area in many EU countries (OECD-CoR, 2020[7]). In unitary countries, the role of regional governments may be also significant (e.g. Denmark, Italy and Sweden).

Economic affairs[2] represent 13.6% of subnational spending in the OECD on average. Subnational governments in the OECD account for approximately 34% of total public spending in this area, although in some countries, more than 50%, e.g. in Australia, Belgium, Japan and Spain, and even 69% in the US. Some subnational governments are supporting their local economies, notably SMEs, the self-employed, informal workers and highly affected sectors. In the longer term, subnational governments may be further mobilised to participate in stimulus packages targeting public investment.

The impact on subnational government revenue depends on the structure of subnational government revenue

In countries where subnational governments are largely funded by central government transfers (e.g. Estonia, Lithuania, Mexico, the Slovak Republic), the negative impact may be smaller than in federal countries where most transfers to local governments come from state governments that may not be able to sustain their transfers (Chernick, Copeland and Reschovsky, 2020[17]). Impacts will vary with revenue structure (Box 2.5). Historical elasticities of subnational government revenue to the business cycle do not allow to accurately forecast future revenue even if projected GDP growth and output gaps were accurate (OECD, 2020[8]). Country-level elasticities of subnational government revenue with respect to the business cycle have been estimated in previous cycles. The current crisis is different because economic sectors are asymmetrically affected by government response measures, particularly restrictions on mobility and gatherings, in a way that has never been observed (OECD, 2020[18]). Therefore, within countries, changes in individual subnational government revenue will depend on the regional economy and tax base exposure to affected industries, stimulus plans, as well as backward and forward participation in global value chains.

The COVID-19 pandemic is expected to result in a strong drop in shared and own-source tax revenue. Declining economic activity, employment and consumption arising from COVID-19, and particularly containment measures, will automatically reduce receipts from personal income tax (PIT), corporate income tax (CIT) and value added tax (VAT). CIT and VAT may be more affected than PIT as national governments have supported personal income and saving has risen in some countries. Measures such as tax breaks, exemptions, deferrals and tax rate cuts decided in stimulus packages will lower tax receipts, as will increasing non-payment, for example because of bankruptcy. As subnational government revenues are often based on the previous year (e.g. income taxes), most will see the situation worsen in 2021 and even 2022. Other subnational taxes may be affected by the recession and fiscal policy decisions: taxes on businesses (Austria, France, Germany and Luxembourg), economic activities (Italy, Japan, Korea), real estate activities, consumption and commodities. Recurrent property taxes on buildings and businesses are less volatile but were sometimes waved to support businesses. Nevertheless, any correction on land and real estate prices or higher bankruptcies rates would inevitably lead to decreasing revenues in 2021 and 2022.

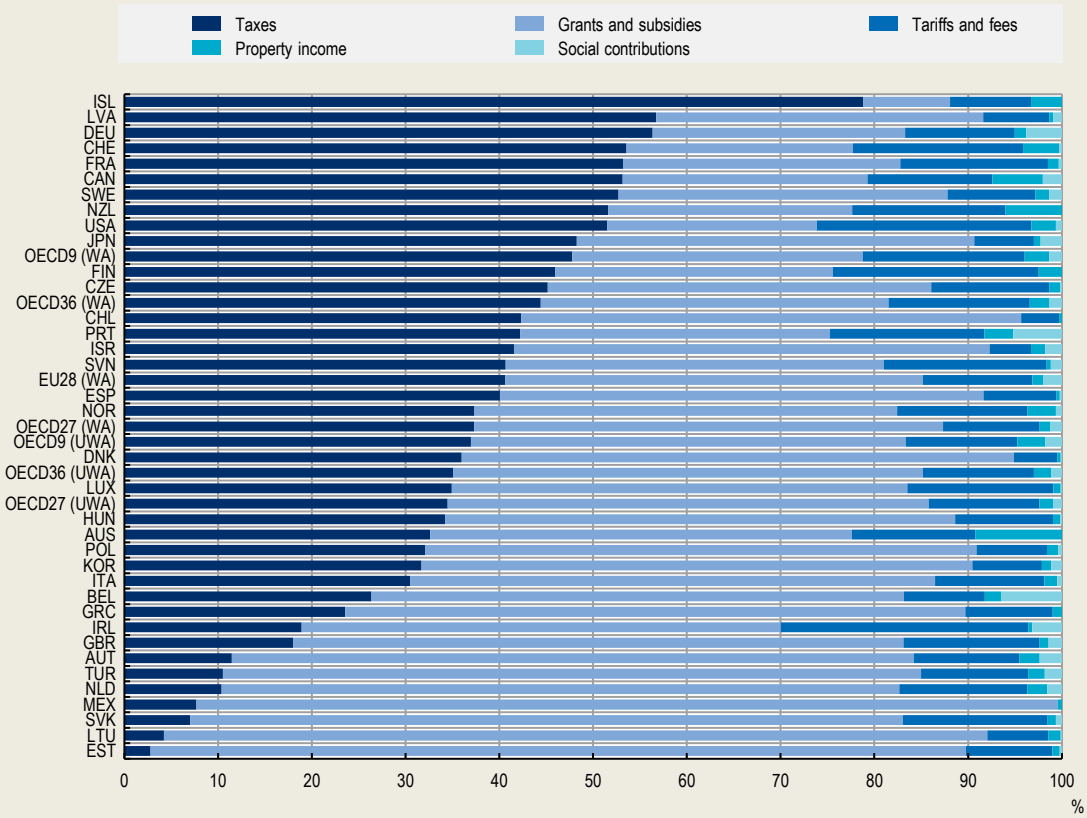
The closure of public facilities and less public transport use have reduced revenues from user charges and fees. Drops in such revenue could be compounded by a rise in unpaid fees. Income from physical and financial assets, such as rental revenues, dividends from local public companies, sales of land and royalty revenues have dipped when economies went into lockdowns. The global negative demand shock for raw materials has pushed down prices and output but a strong recovery could be supportive in 2021. Subnational governments dependent on revenue from oil production may also experience a substantial revenue decline in 2020, e.g. in Australia, Canada, Mexico and Norway (S&P Global Ratings, 2020[19]). About two-thirds of subnational governments are anticipating a decline in property income.

Box 2.5. Revenue impacts will vary with revenue structure

In countries where subnational government revenue comes mainly from taxes, user charges, fees and income from assets, the impact may be even larger (Figure 2.8), although this depends on the sensitivity of tax bases to the economic activity and policy decisions. In the EU, subnational tax revenue is anticipated to be the most affected revenue source, followed by tariffs and fees (OECD-CoR, 2020[7]). Grants and subsidies, as well as property income, are expected to decrease to a lesser extent (Figure 2.9) (OECD-CoR, 2020[7]).

Figure 2.8. Sources of subnational government revenues vary across countries

Breakdown of subnational government revenues by category, percentage of total revenue, 2018

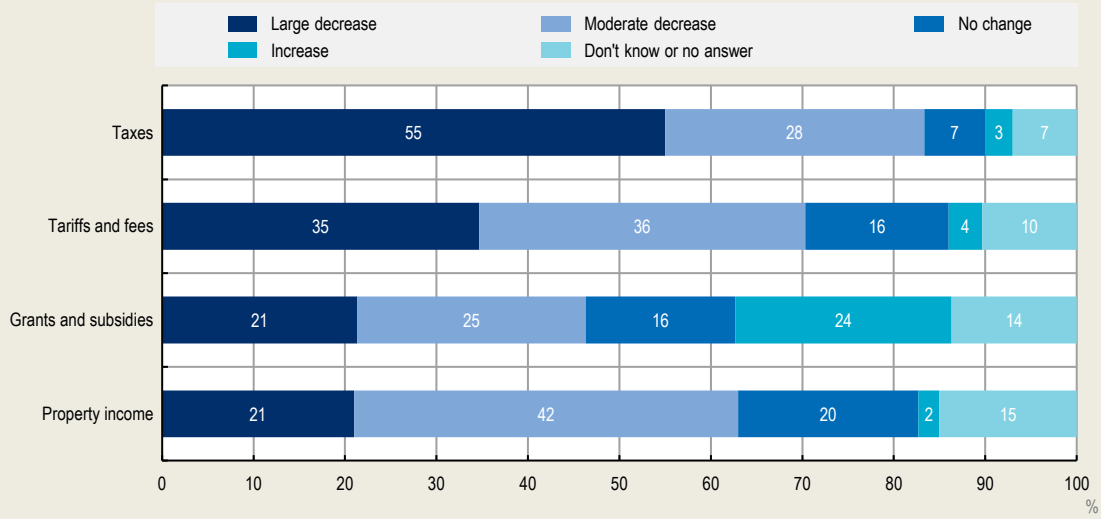


Note: Australia and Chile: estimates from IMF Government Finance Statistics. 2017 data.
Source: OECD (2020[16]), *Subnational Governments in OECD Countries: Key Data - 2020 Edition*, OECD, Paris.

StatLink https://doi.org/10.1787888934236589

Figure 2.9. Impact on subnational revenue, by revenue source

Answers from subnational government officials to the question: Relative to pre-crisis projections, what impact do you expect on the revenues of your subnational entity?



Note: Subnational governments submitted their answer to the survey in June-July 2020.
Source: OECD-CoR (2020[7]), "The impact of the COVID-19 crisis on regional and local governments: Main findings from the joint CoR-OECD survey", http://www.oecd.org/regional/multi-level-governance.htm.

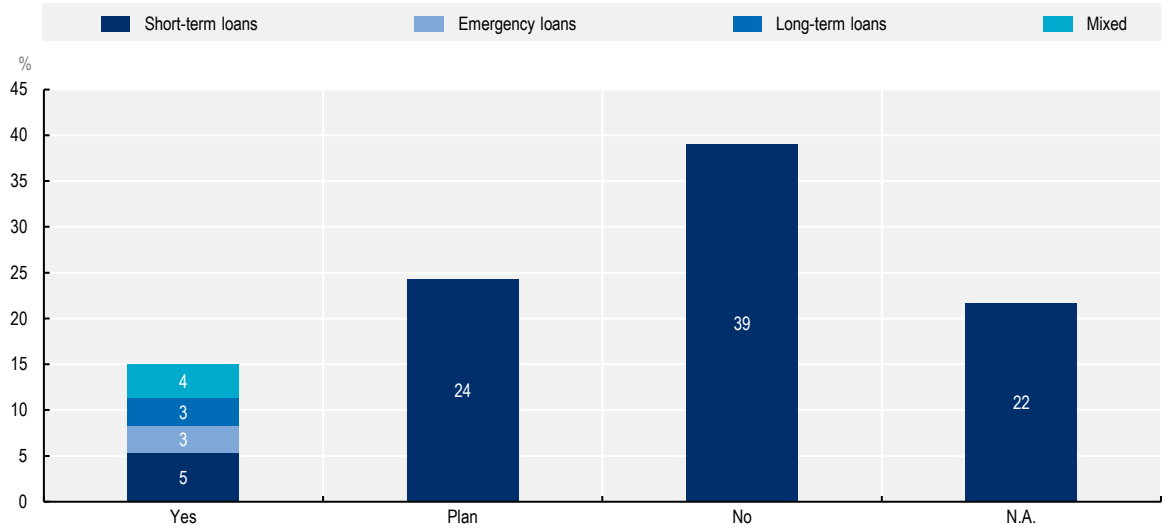
Subnational government debt is rising substantially

The strong decrease in revenues, combined with a marked increase in expenditure is leading to higher subnational government deficits and debt, as in the wake of the 2008 crisis (OECD, 2020[20]; 2013[21]) albeit with likely more asymmetric and generally bigger effects than back then. Short-term borrowing to bridge delays in revenue and cover a lack of liquidity has already significantly increased in some countries. Many national governments have facilitated subnational government access to short-term borrowing and credit lines, including specific COVID-19 credit lines. By June 2020, 15% of surveyed subnational governments in the EU had increased borrowing to cope with the crisis and 24% were planning to increase borrowing (Figure 2.10). Short-term and emergency loans represented more than half of new subnational government borrowing in the EU in June 2020.

Long-term borrowing is also expected to increase, including finance recovery programmes. Several governments have relaxed regulatory constraints on long-term borrowing, notably on capital markets. Stimulus measures and automatic stabilisers have increased deficits while GDP decreased in most economies in 2020. As a result, general government debt-to-GDP ratios will rise by an average of 15.7 percentage points in 2020 according to the IMF October 2020 Fiscal Monitor. Global subnational annual gross borrowing grew in 2020 by about 29% to USD 2.2 trillion, mostly because of the crisis (S&P Global Ratings, 2020[22]). Australia, Canada, China, Germany and Japan would make up about two-thirds of gross subnational borrowing in 2020 because subnational governments, particularly regions and large cities, have applied countercyclical fiscal policies (S&P Global Ratings, 2020[22]). Subnational governments' debt-to-GDP ratios of these countries were already above the OECD average before the pandemic. Poor fiscal performance and creditworthiness may hinder access to new borrowing, although central banks have pledged to ease monetary conditions and ensure low interest rates (OECD, 2020[18]).

Figure 2.10. New borrowing to cope with the COVID-19 crisis

Answers from subnational government officials to the question: Has your subnational entity increased its borrowing to cope with the COVID-19 crisis?



Note: N.A.: Not applicable. Subnational governments submitted their answer to the survey in June-July 2020.
Source: OECD-CoR (2020[7]), "The impact of the COVID-19 crisis on regional and local governments: Main findings from the joint CoR-OECD survey", http://www.oecd.org/regional/multi-level-governance.htm.

Effects on subnational government finances are asymmetric and some will be delayed

Subnational governments in more decentralised countries are more likely to experience large losses in revenue (OECD-CoR, 2020[7]). The immediate impact may be stronger for municipalities but in the medium term may be greater for regions. While municipalities' revenues are directly impacted by the crisis, the fiscal shock on many regional governments could be delayed to 2021 and 2022 because a large share of their revenues depends on taxes sensitive to previous years' economic activity. Subnational government exposure depends on the resilience of local economies and their tax bases as well as fiscal equalisation. Regions where hospitality, retail and transportation represent a large share of value-added are more exposed.

Equalisation systems may not absorb asymmetric effects in full. Many equalisation systems themselves may be susceptible to the contraction in economic activity. According to a survey by the OECD Network on Fiscal Relations, 8 out of 17 country respondents anticipate a fall in total equalising transfers, whereas only Canada anticipates an increase to 1 of its 2 equalising transfers (the Territorial Financing Formula). This suggests that equalisation systems may have a pro-cyclical impact (OECD, 2020[23]). Equalisation formulae may also not be able to fully offset the asymmetric impact of the crisis on revenues and spending across regions, aggravating socio-economic discrepancies, as the crisis has hit locations with much precarious and low-pay employment the most. Some equalisation systems may offset differences in revenues but not in spending. For example, in Germany, public investment was relatively low in municipalities with high spending on federally mandated social transfers following the global financial crisis (Fuentes Hutfilter et al., 2016[24]). Negative impacts on inclusiveness may result especially in countries where subnational governments have responsibilities for social protection and health.

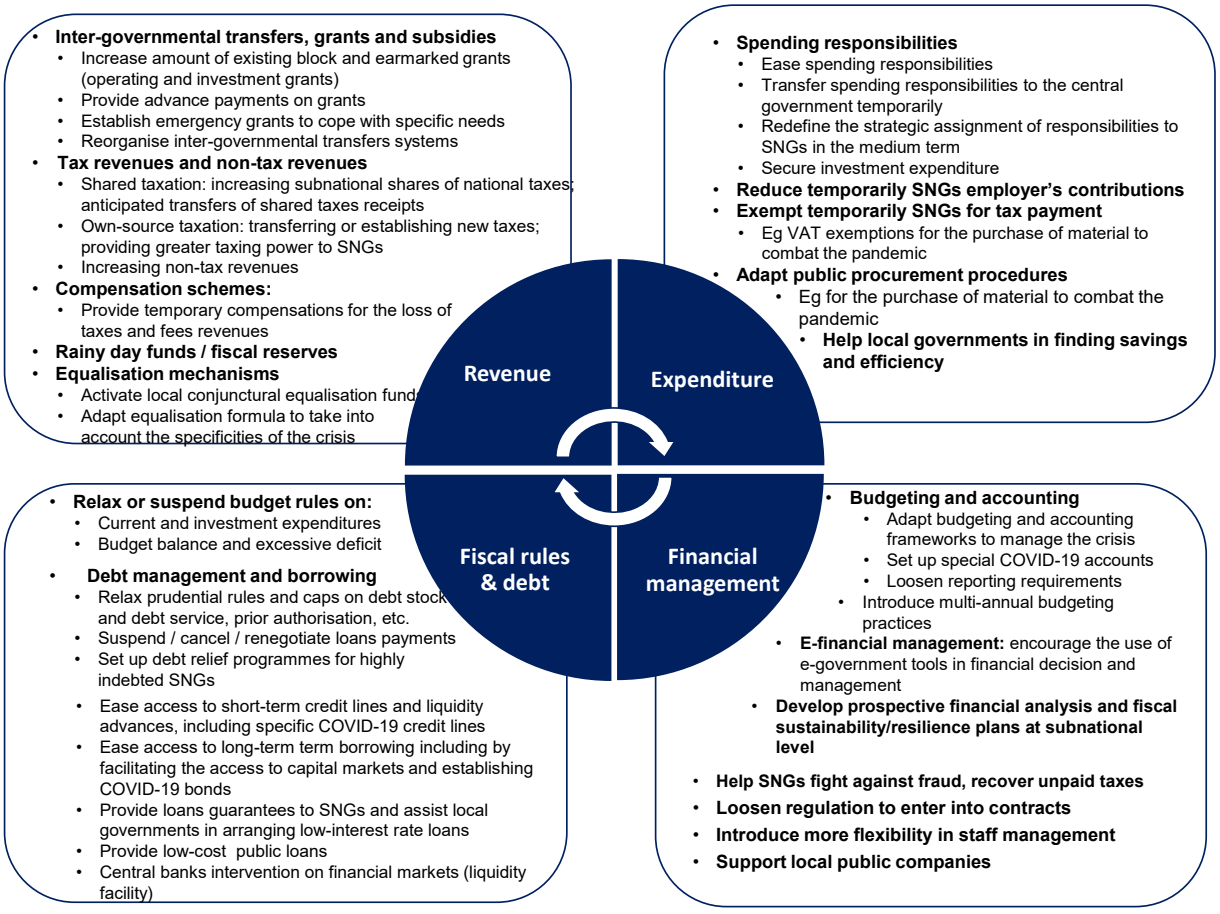
Pre-crisis levels of indebtedness and cash reserves also matter. Interest rates close to zero limit the impact on long-term debt sustainability, especially if subnational governments can secure longer-term borrowing. However, some subnational governments and sovereigns may be subject to high or rising risk premia,

which could aggravate asymmetric territorial impacts by limiting fiscal support available in some of the most vulnerable regions. For example, in March 2020, US municipal bond yields soared by 150 basis points amid concerns over delayed revenues and liquidity shortages. The Municipal Liquidity Facility announced by the Federal Reserve in April 2020 to conduct municipal bonds purchases allowed yields to decrease to 30 basis points above their pre-crisis level (OECD, 2017[25]), with higher yields in states where COVID-19 incidence was greater.

Central and subnational governments are taking steps to counter the "scissors effect"

Without sufficient compensation for the extra spending and revenue losses caused by COVID-19, many subnational governments could be forced to implement sharp cuts on spending. This would endanger the efforts for a co-ordinated recovery response and weaken the equity and quality of service availability among subnational governments. Many central governments have therefore announced considerable fiscal support measures. State governments in federal countries have also announced measures to support local governments. All in all, two-thirds of OECD countries have adopted measures in support of subnational government finance. Fiscal measures can be classified into four categories (Figure 2.11): revenue and expenditure measures, financial management measures as well as measures related to fiscal rules (Box 2.6).

Figure 2.11. Emergency fiscal measures to support subnational governments



Source: OECD (2020[2]), "The territorial impact of COVID19: Managing the crisis across levels of government", https://www.oecd.org/coronavirus/policy-responses/the-territorial-impact-of-covid-19-managing-the-crisis-across-levels-of-government-d3e314e1/.

Box 2.6. Providing fiscal relief to subnational governments

Fiscal rules are generally pro-cyclical when they are rigid. Such rules may be relaxed during a crisis, along two lines: i) formal escape clauses can be triggered by prescribed circumstances; ii) effective suspension can be announced when it is unreasonable to expect subnational governments to comply (OECD, 2020[23]). During the pandemic, revenue measures have been applied and fiscal rules have been suspended frequently; in the EU, 46% of responding subnational governments reported that some fiscal rules have been relaxed and 18% that they will be in the near term (OECD-CoR, 2020[7]).

Extraordinary grants to subnational governments can compensate for tax revenue losses and increased expenditure. They are more appropriate than temporary recentralisation of public services or local tax rates hikes because they allow for a place-based approach and foster local aggregate demand. As an immediate response, support from higher levels of government in the form of grants is the most common measure taken across OECD countries (OECD, 2020[23]). However, future consolidation plans loom. Reforms that ensure the stability, operational capacity and resilience of subnational finance are important and should be carefully planned and implemented, especially where subnational regions have an important role to play in providing social protection.

In countries where fiscal co-ordination is already well developed and effective, support measures have been developed and discussed between responsible national ministries and representatives of subnational governments. Formal or informal agreements in several countries with the national associations of subnational governments provide urgent support, compensation schemes and other financial measures. Support can also be indirect, such as to public transport, energy and other subnational-government-owned utility companies.

Public investment can contribute to recovery and reduce upcoming risks

Immediate fiscal responses to COVID-19 granted financial and liquidity support to firms, their workers and households. Since June, many national governments have announced large economic recovery packages, much larger than in 2008, focusing on public investment. These investment recovery packages are prioritising: i) the strengthening of healthcare systems; ii) digitalisation diffusion; iii) the transition to a carbon-neutral economy (OECD, 2020[2]). The OECD and the International Monetary Fund (IMF) have made a strong call to scale up public investment to address the challenges to the COVID-19 recovery. Subnational governments play a key role, as they are responsible for 57% of public investment in OECD countries. It is crucial that recovery packages are consistent with the transition to net-zero GHG emissions, targeted by most OECD countries by 2050, to avoid a global climate crisis and make sure investment remains productive over the next ten years and beyond. As argued below, this consistency is not yet achieved.

In June 2020, 31% of surveyed EU subnational governments were actively providing public investment stimulus measures and 30% direct support to the local economy. Only 9% were doing both, suggesting that in the early phase of the recovery, there was a trade-off between short-term direct support and longer-term public investment stimulus (OECD-CoR, 2020[7]). In the EU, 40% of responding regions were providing public investment stimulus and 26% of responding municipalities. While near-zero interest rates make a strong case for resorting to deficit spending to provide both direct support and public investment, these trade-offs and the large amounts of public funds disbursed reinforce the case for improving data, so support is provided to households and firms most in need and spending is effective in achieving near-term and long-term targets.

The OECD estimates that a 1% GDP increase in public investment in advanced economies and emerging markets could spur GDP by 0.8% in normal times but more likely by 1% in crisis times across G7 countries,

though impacts vary depending on openness, monetary stance and capacity to borrow without rising risk premia (OECD, 2018[26]). It could create between 20 and 33 million jobs, directly and indirectly (IMF, 2020[27]). Local, regional and national governments should invest in post-crisis priorities in health, digitalisation and environment infrastructure (OECD, forthcoming[28]). The EU Recovery plan is providing funds to this end (Box 2.7).

As highlighted by the OECD Recommendation on Effective Public Investment Across Levels of Government (2014[29]), the impact of public investment depends on how governments manage this shared competency across levels of government. Several tools can strengthen the coherence of infrastructure investment among levels of government, such as co-financing arrangements, contracts between levels of government, formal consultation processes, national agencies or representatives working with subnational areas, or other forms of regular inter-governmental dialogue. Seeking complementarities across sectors into integrated strategies allows more efficient use of public resources and mutually reinforcing investments, for example in housing and transport networks (OECD, forthcoming[28]).

The demand for infrastructure was already high before the COVID-19 crisis. The OECD has estimated that globally USD 95 trillion in public and private investment will be needed in energy, transport, water and telecommunications infrastructure between 2016 and 2030 (OECD, 2017[25]). In view of the long-lived nature of infrastructure, it is critical that infrastructure investment is undertaken in a way that is consistent with the net-zero GHG emission objectives adopted by most OECD countries for 2050, otherwise budgetary and environmental sustainability are compromised. Cities and regions have important needs for maintenance and new investment in renewable energy, low-carbon buildings, energy efficiency, waste and pollution management systems and clean public transport. As argued in Part II of this *Regional Outlook* report, government spending plans need to be aligned with climate policy scenario analysis, backcasting infrastructure requirements using the 2050 net-zero GHG emissions objective as a starting point. Investment stimulus projects need to be well thought through and appraised to be consistent with long-term targets. This may be a challenge after many years of budgetary consolidation and may require investing in the capacity of local and regional governments to define and implement such investment projects.

Employment gains from redirecting and boosting investment so economic activity becomes consistent with the net-zero transition can relieve the economic impacts of the COVID-19 crisis (Unsworth et al., 2020[30]). Short-term employment opportunities include accelerated wind turbine installation and operation, construction and operation of electric vehicle charging infrastructure, active mobility infrastructure and pilot projects to scale up hydrogen production as well as research and development (R&D) in industrial zero-emission consistent production. COVID-19 fiscal recovery packages could accelerate progress on the net-zero transition also with energy-efficient retrofits in buildings (Hepburn et al., 2020[31]). When investing in low-carbon and climate-resilient infrastructure that supports a regionally balanced economic recovery, national governments need to recognise the crucial role that local authorities play, including though setting priorities for the first retrofitting of buildings and in local transport (ADEPT, 2020[32]). Expanding skills needed to address these challenges is another place-based priority to accelerate the transition.

Box 2.7. The European Union Recovery Plan

The EU is providing significant funds to help member states tackle the COVID-19 crisis, for example:

- EUR 37 billion from the EU budget is available to support healthcare systems, SMEs and labour markets through the Coronavirus Response Investment Initiative.
- EUR 28 billion in structural funds from 2014-20 national envelopes not yet allocated to projects are eligible for crisis response.

- EUR 800 million from the EU Solidarity Fund are directed at the hardest-hit countries by extending the scope of the fund to public health crises.

Unlike in 2008, the EU mobilised the cohesion policy to address the COVID-19 crisis, lifting or modifying the rules that apply to European Structural and Investment Funds. As of October 2020, more than 100 programmes have changed to respond to the COVID-19 crisis. Through the Coronavirus Response Investment Initiative Plus, member states can transfer money between different funds. Money can be redirected to the most affected regions. Finally, member states can request up to 100% financing from the EU budget between 1 July 2020 and 30 June 2021 for programmes dealing with the pandemic's impact.

The EU has enabled maximum flexibility in the application of EU rules on the use of national funds:

- State aid measures to support businesses and workers.
- Public finances and fiscal policies to accommodate exceptional spending.

On 21 July, the EU announced that EUR 390 billion would be distributed as grants and EUR 360 billion would be available in loans to member states. The EU proposes borrowing up to EUR 750 billion.

Source: European Council (2020[33]), *COVID-19 Coronavirus Outbreak and the EU's Response*, https://www.consilium.europa.eu/en/policies/coronavirus/.

The public investment strategies are not yet consistent with a climate-neutral economy

A sustainable fiscal response requires it to be climate-consistent. Whether protracted financial, economic and environmental risks result from higher debt will depend on the consistency of government stimulus spending with needed future economic transformations, notably the transition to net-zero GHG emissions by 2050. As shown in Part II of this *Regional Outlook* report, the consistency of activity, investment and infrastructure financing needs to be assessed in a place-based manner to ensure sustainable regional development.

Employing economic stimulus to invest in infrastructure and encourage private investment in a way that is consistent with the transition to a climate-neutral economy, while discouraging investment that is inconsistent with this transition, starting this year, could turn the COVID-19 crisis into an opportunity to prevent a major climate crisis. As discussed in Part II of this *Regional Outlook* report, doing so early reduces the cost of the transition and would also reduce financial risks from failed investment. Such investment requires a place-based approach and could also reduce air, water and land pollution and thereby reduce health risks and generate human well-being benefits.

Current assessments suggest that consistency of stimulus programmes is not achieved. Only 42% of respondents in an EU survey of subnational governments stated that they are considering promoting a green or sustainable agenda as part of their COVID-19 exit strategy and recovery plans (OECD-CoR, 2020[7]). According to the Energy Policy Tracker, national and subnational governments in a range of OECD countries have committed 40% more funding to support fossil fuel energy than to support clean energy production and consumption between the start of the COVID-19 pandemic and the end of 2020. Additionally, at least up until August 2020, the recovery packages of 5 major emitters (China, EU27, India, South Korea and the US), which committed 8% to 14% of GDP, mostly did not make climate change mitigation at the core of the planned spending (Climate Action Tracker, 2020[34]). The EU and South Korea have a focus on green recovery for part of their stimulus packages, while other governments are set to spend more on sustaining the fossil fuel industry and airlines. The economic stimulus packages, announced by October 2020 in 16 of the G20 countries, may have a net negative effect on the environment (Vivid Economics, 2020[35]). Countries that have committed to green recoveries are still allocating more towards activities that are harmful to the environment and maintain or increase GHG emissions than

towards activities that are beneficial to the environment and reduce emissions. Moreover, biodiversity aspects have largely been neglected in green recovery plans. However, the share of green spending in recovery packages announced by the second lockdown has increased compared to those announced during the first lockdown.

Regional and local governments play a leading role in delivering employment and skills

In almost half of OECD countries with available data, local and regional governments are wholly or partially responsible for implementing active labour market policies and can therefore contribute to a policy response that takes territorial differences in crisis impacts into account. For example, based on their understanding of local labour market dynamics, they can co-ordinate with employers to identify and deliver "top up" training to help displaced workers transition quickly to new opportunities or co-ordinate local services for the most disadvantaged job seekers. Personal connections between service providers at the local level often reinforce this co-ordination.

Recommendations for local employment action, mostly laid out in the report *Job Creation and Local Economic Development 2020: Rebuilding Better* (OECD, 2020[1]), include:

- Strengthen local employment and training systems to manage the additional pressures.
- Consider complementary measures for the hardest-hit places as national schemes are rolled back. Support firms in implementing social distancing, including through adaptations to the built environment.
- Upgrade frontline public employment service capacities and virtual services, to help places hardest hit in the short term and support broader economic transitions in places facing longer-term challenges. Intervene early to prevent longer-term labour market disengagement.
- Target active labour market policies to both individual and community characteristics and ensure accountability mechanisms take local conditions into account. Address other barriers to employment (e.g. childcare, mental health challenges).
- Adapt local training provision in light of increased demands, system constraints and local needs.
- Prevent disadvantage from becoming entrenched for young people, the low-skilled and women. Expand outreach to hard-to-reach populations, including through partnerships with local community organisations. Particular concern should be to support the career start of young people, especially among those who do not have the best job prospects, to avoid difficulties at the beginning of the career having long-lasting adverse impacts.
- Integrate the use of teleworking by firms into local development strategies and upgrade digital infrastructure, particularly in rural areas.
- Investing in biodiversity protects ecosystem services essential to human well-being and reduces risks of zoonotic epidemics. It can also support rural development by creating jobs in activities, such as ecosystem restoration, reforestation, invasive alien species management and environmental monitoring and enforcement, which tend to be labour intensive and quick to implement.

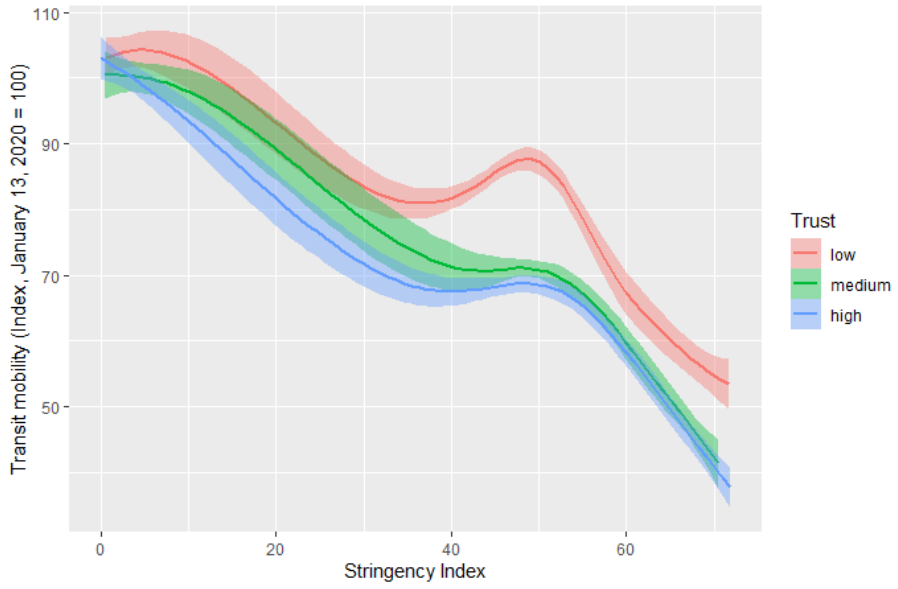
Already following the global financial crisis, lagging places performed better in terms of employment if they had an industrial composition that facilitated greater inter-sectoral worker flows (e.g. workers from one sector were able to move into another) and if they enjoyed larger changes in occupational structure. These findings suggest that growth of local economies increasingly depends on their ability to "rewire" and adjust to changing labour market realities. This will also be important for regions that need to wind down industrial activities which are inconsistent with a net-zero-emission transition or which face major challenges, as discussed in more detail in Part II (OECD, 2020[1]).

Citizen trust facilitates effective policy response

In some countries, surveys suggest that trust in the national government has increased during the crisis. Where it has not, the gap is often filled by increased trust in local government (Edelman, 2020[36]). Europeans tend to trust regional and local authorities more than they trust their national government. About 48% believe they respond appropriately to overcome the crisis (EU Committee of the Regions, 2020[13]). Citizen trust in government results in greater compliance with government response measures. Stringent response measures are more effective where trust is high. This relationship holds between countries and within countries. In the US, for example, a given increase in stringency is associated with a bigger decline in mobility where trust is relatively strong and therefore, most likely, in a bigger decline in the spread of the pandemic (Figure 2.12). In Europe, compliance with public health policies is also higher where trust is high (Bargain and Aminjonov, 2020[37]).

Figure 2.12. Transit mobility decreases more with COVID-19 containment measures where citizen trust is high

Stringency of measures and transit mobility in US states, grouped by citizen trust



Note: Data for the Stringency Index and transit mobility are retrieved daily at the state level in the US and span from 13 January 2020 to 15 December 2020. The Oxford COVID-19 Government Response Tracker systematically collects information on several different common policy responses that governments have taken to respond to the pandemic on 19 indicators such as school closures and travel restrictions. The Stringency Index records the strictness of "lockdown style" policies that primarily restrict people's behaviour. The transit mobility index is generated by counting the number of requests made to Apple Maps for directions in select countries/regions, sub-regions and cities versus their level on 13 January 2020. States are classified in three-tier trust groups according to state-level measures of voter turnout. The correlation of transit mobility with the stringency of measures is shown with the "Loess method", a non-parametric regression approach.
Source: OECD (2020[2]), "The territorial impact of COVID-19: Managing the crisis across levels of government", https://www.oecd.org/coronavirus/policy-responses/the-territorial-impact-of-covid-19-managing-the-crisis-across-levels-of-government-d3e314e1/.

Trust in government may play a positive role in COVID-19 health outcomes. Mortality rates tend to be higher in countries with less trust in the government. They are above 50 per 100 000 inhabitants in 86% of countries where trust in government is low, 71% where trust is medium and 46% where trust is high. Many factors may be at play, including health and social system capacity or deprivation levels. Governments facing lower degrees of trust may have difficulty enforcing containment measures and ensuring their population's compliance with public health measures (OECD, 2020[2]). Less success in curbing mortality may also have diminished citizen trust. While this crisis may be generating rising levels of trust in government, the challenge for public officials will be to continue building it up and maintain it. All levels of

government may want to take stock and evaluate the trust-building actions. While it can take many years to build trust, it can be rapidly lost (Edelman, 2020[36]).

Lessons learned from the COVID crisis for regional, urban and rural policies

The substantial costs of the COVID-19 pandemic to human life and economies and their territorially differentiated distribution highlights that a place-based and co-ordinated emergency response strategy is central. A place-based approach allows local actors to act swiftly and specifically to vulnerabilities. Partnerships across government levels allow generating agreed-upon objectives, priorities and plans. Effective central-government-level leadership needs to set the strategy and guidelines. Bottom-up approaches have produced innovative ways to deal with the emergency of the crisis and have built up trust among citizens and policymakers across government levels. A clear, commonly understood and agreed delineation of roles and responsibilities and well-capacitated, financially endowed subnational governments facilitate such partnerships. Clear, rapid, regular and accurate communication across levels and government and citizens helps government respond in a timely and targeted manner and promotes knowledge sharing. All of this needs to be supported by good data – to spot emerging risks, better target policy responses and evaluate policy measures for their effectiveness and their costs. By improving trust in institutions and people such an approach can further improve effectiveness.

Anticipatory action minimises major adverse impacts on health, well-being and the economy. To reinforce a place-based preventive approach to any potential future pandemic outbreaks, it would be useful to identify which regions are vulnerable to early transmission of shocks, along global value chains and transport links for example, as well as those regions which may play key roles to play in preventing the development of zoonotic pandemics. Ultimately there may not be a trade-off between dealing with the health crisis and the economic crisis, as postponing interventions may require longer or heavier restrictions, with a higher cost in terms of health impacts, economic impacts and particularly adverse impacts on vulnerable people. Countries and regions which have incorporated previous experience in health crisis management have been better prepared to co-ordinate actions, anticipate and thereby limit adverse impacts. This can also be a source of learning for others. This reinforces the need for evaluation too – it should be important to evaluate the impacts of containment and support measures to learn and share best practice between tiers of government. Promoting the use of digital tools, transferable skills and active labour market policies also help. Subnational governments have an important role to play.

Urban and rural vulnerabilities need to be addressed in their specificity. In rural regions, this requires improving access to digital infrastructure, better access to healthcare and other key services. This illustrates that the quest of cost reduction and efficiency risks being counterproductive if it hurts resilience. Cities' resilience would improve with less inequality in housing and access to jobs and key facilities. Better connections of cities with the rural environments can provide relief for urban and rural dwellers alike, fostering potentials for local markets.

The crisis has shown that we have not yet adequately addressed inequality – the vulnerable are the most exposed to risk, lacking the means and buffers to protect themselves. In the COVID-19 crisis, inequality fuelled the pandemic as the virus raced through overcrowded accommodation and meant the poor often had to continue working in risky face-to-face jobs to sustain themselves. Workers on non-standard employment, often on low pay, also face the biggest economic impacts. Without concerted action, this could derail rebuilding efforts in the regions hit the most, contributing to a downward spiral for affected regions that may be hard to escape once set in motion, as experience with regional development shows. Therefore, as national emergency support such as short-time work schemes is phased out, place-based support for poor and worst-affected households, firms and workers to adapt to the "new normal", will become more important (OECD, 2020[1]). Subnational governments are often well placed to help workers into new jobs, provide needed training and social services. In view of the narrow relationship between

poverty on the one hand and the incidence of infection on the other, combining preventive efforts with generous support when isolating infected people in disadvantaged areas may be particularly promising. It may also help maintain a voluntary approach to prevention and crisis management, reinforcing trust.

Multi-level public finance arrangements may have too narrowly focused on debt and deficits for sustainability. They also need to integrate environmental and social aspects of sustainability. This requires adequate and prompt fiscal equalisation across regions with compensation to adapt to asymmetric spending increases and revenue shortfalls. A comprehensive subnational government finance review would help countries improve fiscal resilience and flexibility, in particular the capacity of subnational governments to respond to asymmetric increases in poverty and healthcare needs. It will be important to ensure a good balance in revenue and spending assignments, sufficient autonomy and flexible recourse to debt. As argued in Part II of this *Regional Outlook* report, funding arrangements for subnational governments need to integrate GHG emission reduction objectives. After the financial crisis, investment recovery funds were often fragmented in small projects at the municipal level, rather than at the regional level. Intermediary levels of government – regions, states, provinces – should be actively involved in implementing national investment recovery strategies with long-term and cross-cutting priorities, including the climate challenge.

More resilient regions: A regional development policy priority post-COVID-19

More resilient regions mean ensuring they are able to absorb, recover from or adapt to the impact of economic, financial, environmental, political and social shocks or chronic pressure. This is particularly important when a crisis is systemic, as in the case of COVID-19. It started as an infectious disease but has ended up affecting most aspects of economic and social life with multiple knock-on effects. The nature of the knock-on effects may not be known in advance. COVID-19 also reveals that risks to the foundations of human well-being, notably public health, can be the source of a systemic crisis. The COVID-19 crisis has demonstrated that anticipation and early action, integrating scientific advice in governance, are key to addressing such systemic crises. This requires better planning to anticipate needs and prepare for risks and pre-emptive action to head off emerging risks. Similarly, longer-term risks around climate change and the transition to climate-neutral models have been postponed too long.

Resilience is about preventing, limiting and reversing damaging knock-on effects while meeting the needs of citizens and businesses as well as possible. This will only be possible if known upcoming challenges for protecting and further improving well-being are anticipated and addressed. Therefore, resilience cannot mean returning to previous modes of regional development. Instead, it requires their transformation. The close relationship of COVID-19 with global environmental challenges illustrates that regional development must in particular integrate these challenges to be resilient.

The COVID-19 crisis recovery, therefore, needs to be an opportunity to accelerate the transformation of economies to address these challenges. Civic duty and community involvement are prevailing over individual interest to protect vulnerable groups. Local governance and networks are important for regional recovery and resilience. This can inspire lasting behavioural shifts to make cities and regions more resilient to address the climate challenge, where effective early action is crucial to minimise costs. To ensure reconstruction provides lasting benefits and avoids financial risks from failed investment, economic activity needs to be redeveloped in a way that is consistent with net-zero GHG emissions. Recovery packages do not yet achieve that. Part II of this *OECD Regional Outlook* report discusses ways for regional development to assess benefits and vulnerabilities and make progress to incorporate the climate challenge.

The COVID-19 crisis has also revealed how intricately resilience relates to inclusiveness. Efforts to prevent or limit the crisis early on protect vulnerable individuals the most. At the same time, alleviating economic impacts to worst-hit regions and communities and providing the resources to them to respond, is particularly effective in strengthening resilience, as the system may only be as strong as the most vulnerable communities in it. It can also garner support for a preventive approach and build up trust.

Since the climate challenge is also systemic, on a larger scale and longer time horizons, the experience with the COVID-19 crisis has rich lessons for climate policy. This includes the need for a place-based, inclusive approach. These are explored in Part II of this report.

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Notes

[1] 24.5% and 11.5% refers to unweighted average for OECD countries. When taking weighted averages (by population), subnational governments represent 31.8% of total non-consolidated public health expenditure, 38% of consolidated public health expenditure and 18% of subnational government expenditure.

[2] Economic affairs are mainly composed of transport but also include commercial and labour affairs, economic interventions, agriculture, energy, mining, manufacturing, construction, etc.

Part II The resilience of rural and urban regions in the transition to net-zero greenhouse gas emissions

3 Reaching net-zero greenhouse gas emissions: The role for regions and cities

Climate change is a global challenge threatening the foundations of human wellbeing. To limit negative impacts, most OECD countries aim for net-zero domestic greenhouse gas emissions by 2050. Deep and broad transformations of economies will be needed. Impacts, local conditions and vulnerabilities vary across territories and by degree of rurality. For example, within-country variation in emissions is larger than between countries. Most OECD countries still have regions with coal-fired electricity generation far removed from short-term net-zero-consistent benchmarks. Poorer cities and rural regions are more car-dependent, making them more sensitive to the costs of decarbonising transport. Further, employment at risk is modest but regionally concentrated. Therefore, there is a need for place-based and regionally-balanced policies aligned with national and global objectives, to address climate change, mitigation and adaptation. Moreover, climate change mitigation brings well-being benefits, beyond the protection of the climate, that arise locally and in the near term. These can be major motivators for local action as they can more than offset mitigation costs. Delaying action raises costs. Vulnerable communities require support.

The case for regional action

Addressing climate change is a global challenge requiring local action

OECD countries are increasingly recognising the urgent need to act on climate change, both to mitigate global warming and adapt to climate change which is already unavoidable. While these challenges are global, requiring multilateral and national action, they also require strong local actions and place-based policies that align with national and global objectives. As argued below, addressing challenges through a well-being perspective makes it easier and more rewarding for citizens and policymakers in regions and cities to integrate climate action in all decisions concerning place-based development. Doing so harnesses the multiple non-climate benefits and helps minimise trade-offs and vulnerabilities. These benefits can offset the net cost of climate action, often in full. Unlike the climate benefits themselves, many of these well-being gains arise locally and immediately and, therefore, decisively reinforce the case for integrating climate policy in regional development.

This Chapter sets out why climate policy and resulting wellbeing impacts are central to regional development policies, which is also developed in *Accelerating Climate Action: Refocusing Policies through a Well-being Lens* (2019[1]). The Chapter also includes a discussion of indicators to support evidence-based policies, building on existing OECD data that regions can already use to monitor progress as well as upcoming climate hazards. The following section in this chapter will discuss policies to move regional policymaking closer to achieving regional development in a way that is consistent with climate objectives.

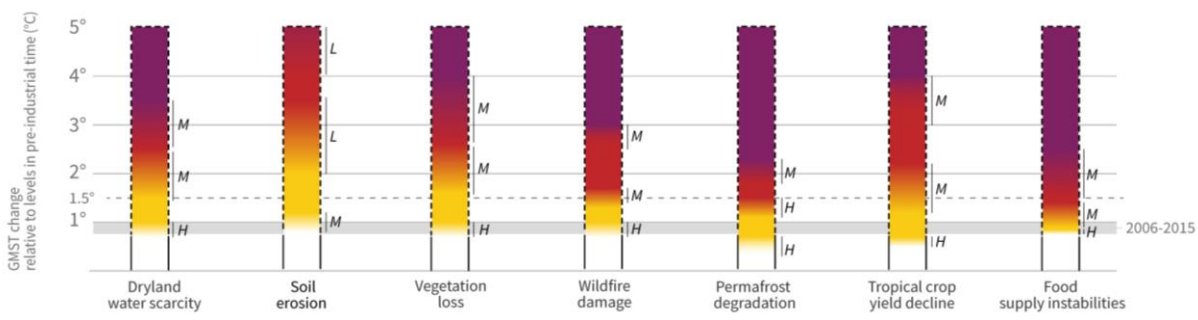
Many OECD countries have set net-zero targets for their domestic greenhouse gas (GHG) emissions by 2050 or earlier. These include European Nordic countries, Canada, Korea, New Zealand (albeit excluding agricultural emissions and including international offsets), Switzerland, the United Kingdom (UK) and the European Union (albeit excluding aviation and shipping). They have done so recognising that high-income countries have a particular role to play in meeting the objective of the Paris agreement to limit global warming to well below 2 degrees and make efforts to limit it to 1.5°C (Climate Change Committee, 2019[2]). In addition, they will need to contribute to support emission reductions in poorer countries. Some emerging economies, including Chile and Costa Rica, have also set similar targets for their domestic emissions. Bhutan has already reached net-zero GHG emissions and its target is to keep it that way. Most recently, China has announced its aim to reach carbon neutrality by 2060. Overall, 126 countries have committed to climate or carbon neutrality by mid-century (Climate Analytics/New Climate Institute, n.d.[3]). Taken together, and assuming they are implemented, they may limit global warming to around 2.5°C by the end of the century. However, if human-made net CO_2 emissions remain positive, they will continue to raise global average temperatures.

Reaching the objectives of the Paris Agreement will prevent major threats to the foundations of human well-being. These threats are substantially worse under 2°C than under 1.5°C. For example, key risks from 2°C and above for the use of land include worldwide food shortages, high impacts and risks of dryland water scarcity and large-scale wildfires in many regions (Figure 3.1). The very high risk and impact of permafrost degradation include the release of GHG (methane and CO_2), in turn possibly further accelerating climate change (IPCC, 2018[4]). The Arctic ice sheet's temperature sensitivity alone implies 1.3 metres of sea level rise per degree of warming up to 2°C above pre-industrial levels, almost doubling to 2.4 metres per degree of warming between 2°C and 6°C and increasing to approximately 10 metres per degree of warming between 6°C and 9°C. This implies very large sea level increases even within the Paris Agreement temperature limits and catastrophic increases beyond, though they would occur after the end of the 21st century (Garbe et al., 2020[5]). The experience of the COVID-19 crisis shows that risks to the foundations of human well-being, notably human health, can create systemic effects throughout the economy (Box 3.1). The emergence of new human diseases is also closely linked to the loss and degradation of ecosystems and habitats, which in turn is driven by climate change, resource extraction, urban and agricultural expansion and pollution (Rohr et al., 2019[6]). With a global temperature rise of

1.5°C, risks and impacts still include, for example, regional food insecurity. Limiting global warming to 1.5°C is likely unavoidable but feasible if rapid action is taken.

The later the peak of emissions is reached, the faster and bigger emission reductions will be necessary worldwide since it is the stock of cumulated CO_2 that counts. This risk is aggravated as incremental global warming can trigger an increasing number of "tipping points". These are climate-change-induced events that irreversibly feed back to global warming, such as the melting of the West Antarctic or Greenland Ice Sheets or permafrost melting. They may reduce or undo remaining margins to reach set targets. Most would add to global warming. Delays would also increase the need to rely on CO_2 removal (carbon dioxide removal, CDR). There is uncertainty about the scalability of removal technologies needed to reach net-negative emissions. For example, a major avenue of CDR is the sustainable use of bioenergy (which may be CO_2 neutral) combined with carbon capture and storage (BECCS). It is not fully understood how land use and land management choices for large-scale BECCS will affect ecosystem services and sustainable development (IPCC, 2018[4]). Extreme climate events, such as large-scale wildfires, can also put afforestation as well as bioenergy use combined with carbon capture and storage – key CO_2 removal options – at risk. Tipping points can accelerate climate change to the point that it may irreversibly pose severe risks for health, economies, political stability (especially for the most climate-vulnerable) and, ultimately, the habitability of the planet for humans. Social and technological trends and decisions occurring over the next decade or two could significantly influence the trajectory of the Earth System for tens to hundreds of thousands of years and potentially lead to conditions that would be inhospitable to current human societies and many other contemporary species (Steffen et al., 2018[7]). Solar radiation modification could reduce some of the risks related to rising temperature but faces large uncertainties and knowledge gaps as well as substantial risks and institutional and social constraints to deployment related to governance, ethical concerns and impacts on sustainable development (IPCC, 2018[4]).

Figure 3.1. Climate change is a threat to the foundations of human well-being



Note: This chart illustrates some of the impacts of climate change that relate to land use. For example, on the food supply instabilities, the chart shows that the level of impact and risk of food supply instabilities goes up from high (red area) to very high (purple area) at global warming of around 2°C with medium confidence. Very high impact and risk means, more concretely, sustained food supply disruptions globally. For wildfire damage, the red colour means, for example, a 50% increase in area burnt in the Mediterranean region and purple, 100 million people or more affected.

Source: IPCC (2019[8]), *Climate Change and Land - Summary for Policy Makers*, https://www.ipcc.ch/site/assets/uploads/2019/08/4.-SPM_Approved_Microsite_FINAL.pdf.

To limit the global temperature rise to 1.5°C by 2100 with a probability of at least 50%, CO_2 emissions would need to be brought to net-zero worldwide around 2050, while other sources of human-made global warming, including from other GHG emissions, would need to be at least stabilised (IPCC, 2018[4]). This is equivalent to reducing emissions by almost 9% per year. Unlike CO_2, methane is short-lived so positive emissions can be consistent with constant global temperature. Objectives to reach net-zero domestic GHG emissions by 2050 hence go somewhat further than net-zero CO_2 emissions targets. Countries should take into account common but differentiated responsibilities and respective capabilities as set out in the

Paris Agreement. This may justify more ambitious targets for high-income countries. A target of net-zero GHG emissions in 2050 will imply net-negative CO_2 emissions by 2050. Regions that mostly emit CO_2, including cities, will need to reach net-zero emissions before 2050 and likely before 2045. In any case, to halt global warming on longer time scales, CO_2 emissions need to become net-negative worldwide.

Box 3.1. Lessons from the COVID-19 crisis in a regional, urban and rural context

The COVID-19 crisis has revealed the close relationship between risks to the foundations of human well-being, environmental impacts and cascading systemic impacts on the economy and society. Human health risks are key. Climate change also poses risks to the foundations of human well-being, including health, with potential systemic knock-on effects. These are even bigger and on a longer time scale. They also vary across regions and cities and, as in the COVID-19 crisis, participation of local and regional decision-makers and multi-level governance has proven essential.

- The COVID-19 crisis shows the importance of anticipation, preparedness and early action to mitigate human well-being and systemic risks and take cost-minimising action. They are also key to prevent and limit the well-being risks from climate change and drive down emissions while extending economic prosperity. They require integrating scientific advice in the decision-making progress among citizens, parliaments and governments at all levels.
- Moving from an economic growth paradigm to well-being and sustainable development paradigm can help identify systemic risks by putting human health impacts first and thereby reinforce resilience.
- The COVID-19 crisis shows that inclusiveness is key to resilience. Access of all households to adequate housing, social safety nets, including health services, water and sanitation, energy supply, adequate income, communication and education improve the resilience of societies. They will also be key in the transition to net-zero GHG emission economies and to adapt to climate change. The cost of the crisis response and the zero-emission transition will also need to be shared fairly across households and firms.
- The COVID-19 crisis has shown that societies can embrace strong action to mitigate risks to the foundations of well-being but also that they are sensitive to economic risks to their livelihoods. This further reinforces the case for anticipatory, preventive action.
- The COVID-19-related lockdowns have had near-term benefits for the environment, including on CO_2 emissions, but at the expense of a major decline in economic activity. This illustrates how closely intertwined fossil fuels remain with economic activity. So far, GHG emissions and other environmental impacts have risen with economic activity. This link must be broken.
- Small- and medium-sized enterprises (SMEs) have been vulnerable to the COVID-19 related impacts and their vulnerability has increased risks of precariousness and poverty. But they have also contributed to resilience with innovation and flexibility. Looking ahead, they may be particularly vulnerable in the zero-emission transition, as they may be more emission-intensive and find integrating new technologies more difficult. They may also have less scope to diversify activity (including geographically) as well as more limited access to financial markets and the scale economies of new technologies. Framework conditions need to put them in a position to develop business models consistent with net-zero emission economies.
- It is key to identify factors that create resistance to early action. The COVID-19 crisis illustrates the governance needs to integrate governments and parliaments at all levels, the public, employers, workers and scientific advice. Vested economic interests around fossil fuels have been a major source of resistance against climate policy. Clear, democratic, participative governance structures help to identify risks and actions to mitigate them.

- Globalisation has an ambivalent relationship with resilience in the COVID-19 crisis and the climate challenge. The flow of goods, services, workers and capital can alleviate asymmetric impacts across regions to the epidemic or climate change, for example, to ensure regional food supply. However, it can put local resilience at risk when global supply chains are disrupted and make local initiatives to internalise environmental costs of production more difficult.

Policies to overcome the economic impact of COVID-19 must therefore be chosen so they help advance with the just transition to net-zero GHG economies. This includes public investment and requires a place-based approach. There is a risk that stimulus packages are employed to expand well-established economic activities, especially in regions highly invested in fossil fuels and hit by the COVID-19 crisis.

Recent emission trends and emissions projected on the back of current policies are a long way off meeting these objectives. There is no sign of GHG emissions peaking in the next few years. The COVID-19 crisis has temporarily reduced emissions but with little long-term effect as emissions have fallen little with economic activity and bounce back unless energy use, land use and urban development are transformed (UNEP, 2020[9]). Policies laid out in countries' nationally determined contributions (NDCs) to the Paris Agreement imply emissions will continue to rise (UNEP, 2019[10]). By 2030, emissions may be 27% and 38% higher than is needed to limit warming to 2°C and 1.5°C respectively. NDC commitments and current policies may be consistent with 3-degree warming by 2100 and rising beyond. Moreover, some countries are not on track to meet their own NDC commitments (Climate Analytics/New Climate Institute, n.d.[3]).

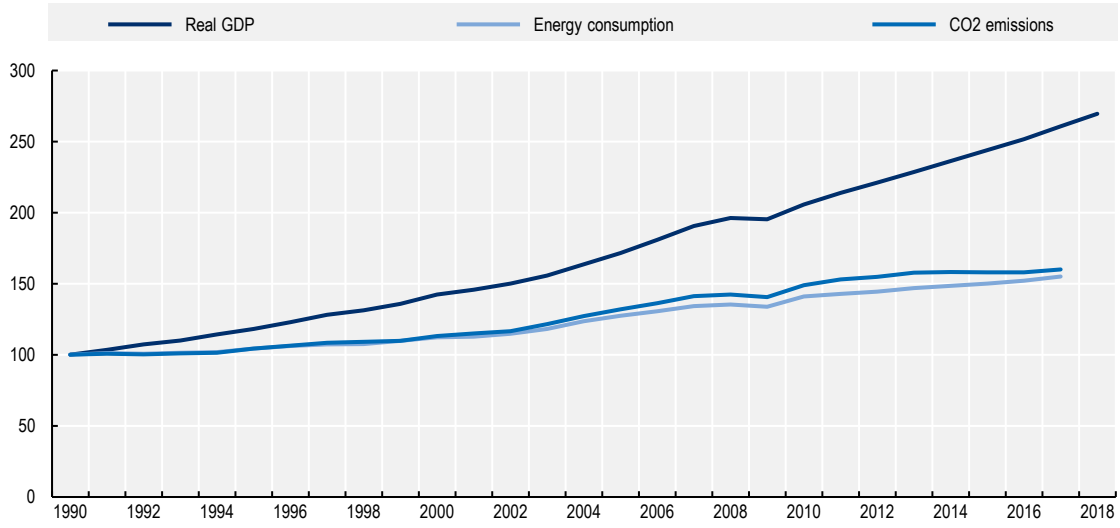
Transformations unprecedented in scale and scope are needed

To achieve these objectives, deep transformations of economic systems of unprecedented breadth over a short period of time are needed (IPCC, 2018[4]). To achieve net-zero emissions by 2050, immediate, unprecedented and ambitious actions are required (IPCC, 2018[11]; Fragkos, 2020[12]). Policy efforts often tend to focus on single and often technological solutions, without taking into account the broader infrastructural and societal implications (Chapman, 2019[13]). The close historic relationship of GHG emissions, energy use and gross domestic product (GDP) illustrates the scale of needed transformations (Figures 3.2 and 3.3).

For GHG emissions to reach net-zero, they must be decoupled from GDP in absolute terms. As the recent OECD report *Managing Environmental and Energy Transitions for Regions and Cities* (OECD, 2020[14]), has highlighted, relative decoupling (GHG emissions rising less than GDP) is frequent. However, examples of absolute long-term decoupling of environmental pressures are rare but absolute decoupling is needed for environmental sustainability with respect to key environmental challenges such as biodiversity loss and GHG emissions. Recently, some high-income countries have decoupled GDP from production and, to a lesser extent, consumption-based CO_2 emissions (Haberl et al., 2020[15]). CO_2 emissions have slightly decoupled from energy use and GDP in absolute terms since 2000 (Figure 3.3) but energy-related emissions still contribute to around 80% of GHG emissions in OECD countries, with widespread sectoral contributions to emissions across regions (Chapter 2). Some key well-being gains, such as better air quality, are negatively related to emissions.

Figure 3.2. World CO_2 emissions have decoupled from GDP only in relative terms, and not from energy consumption

World GDP, final energy consumption and CO_2 emissions

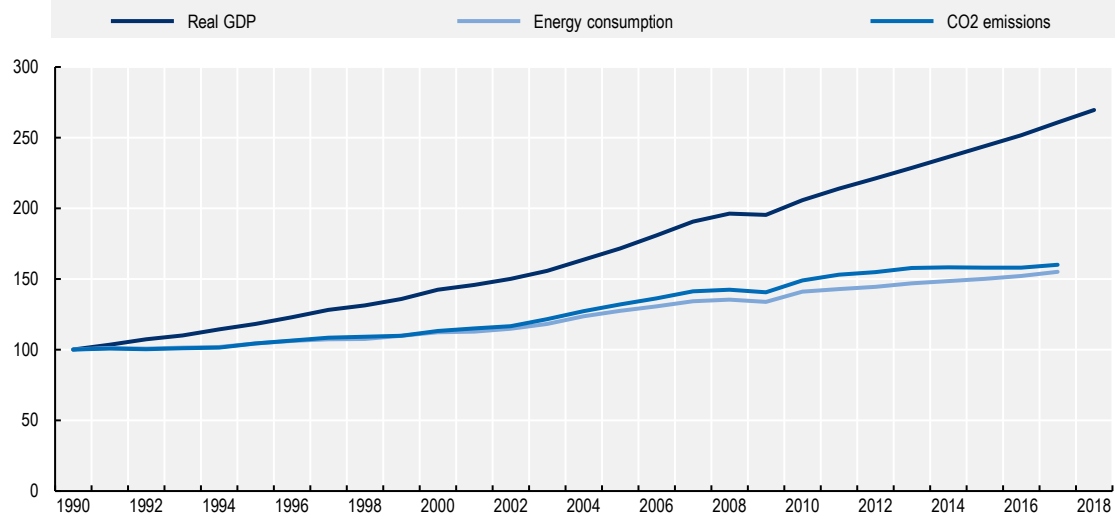


Note: Indices 100 in 1990.
Source: OECD (n.d.[16]), Green Growth (database), OECD, Paris; IEA (n.d.[17]), *World Energy Balances*, International Energy Agency.

StatLink https://doi.org/10.1787/888934236608

Figure 3.3. OECD CO_2 emissions may have decoupled from GDP and energy consumption in absolute terms

OECD GDP, final energy consumption and CO_2 emissions



Note: Indices, 100 in 1990.
Source: OECD (n.d.[16]), Green Growth (database), OECD, Paris; IEA (n.d.[17]), *World Energy Balances*, International Energy Agency.

StatLink https://doi.org/10.1787/888934236627

The three pillars of climate mitigation action – energy, land use and urban policy (New Climate Economy, 2019[18]) -- are at the heart of regional development.

- Moving to net-zero emissions requires most final energy demand to be electrified and most electricity generation moved to zero-carbon sources, mostly renewable. To limit the costs and environmental impacts, energy efficiency is key. As pointed out in by the OECD and the European Union (EU) (2020[14]), the share of renewables needs to rise from 15% of the primary energy supply in 2015 to two-thirds by 2050 (IEA, 2019[19]). The energy intensity of GDP may need to fall by about two-thirds by 2050 (IRENA, 2020[20]). Technologies not yet deployed to scale, including hydrogen and carbon capture and storage, will also play an important role (IEA, 2020[21]). Urban, regional and rural policymakers will need to integrate transformations in the energy system, including shifting spatial distribution of electricity supply and energy transformation as well as stronger differentiation of pricing of electricity across time and space. They will also need to manage the activities that may be inconsistent with zero emission goals, while protecting vulnerable groups from employment loss.
- Around 23% of global GHG emissions are related to land use (IPCC, 2019[22]). Food systems are responsible for one-third of global GHG emissions (OECD, 2019[1]). These include agricultural emissions as well as emissions from land use change, such as deforestation or loss of peatland. Land use is also central to net-negative CO_2 emissions.
- Cities account for about 70% of demand-based energy-related CO_2 emissions, as the recent OECD report *Managing Environmental and Energy Transitions for Regions and Cities* (OECD, 2020[14]) has highlighted, following International Energy Agency (IEA) estimates based on United Nations (UN) urban population statistics. Urbanisation is expected to continue increasing, especially in middle-income countries, and is strongly associated with increases in energy demand. New buildings already need to be constructed consistent with net-zero emissions in high-income countries and all existing buildings refurbished. The complex socio-economic and geographic systems of cities and regions within which they are integrated, requires a specific approach to urban planning and energy-using activities, including transport. How related long-lived infrastructure is laid out is key. In regions where urbanisation is advancing, incorporating zero-emission development provides opportunities to provide services of cities at lower cost, while providing the mitigation, adaptation and associated co-benefits.

Subnational governments play a key role in climate change mitigation

Energy and land use relate closely to local endowments in natural resources and infrastructure which contribute to define the spatial distribution of economic activity. Local conditions are critical for defining net-zero emission strategies, for example for connecting people to jobs, for the specific industrial mix and enterprise fabric of cities and regions. Fifty percent to 80% of adaptation and mitigation actions require regional and local implementation. They have been undervalued, though in federal countries they tend to be better acknowledged (OECD, 2020[14]). Yet subnational governments have key relevant competencies for climate policy (Box 3.2).

Effective place-based action requires co-ordinating national and international policies, to meet national and international commitments and policy frameworks. Local governments may have direct power over less than a third of urban GHG emissions reduction potential, with over two-thirds depending on either national and state governments or co-ordination across levels of government. For example, pricing of GHG emissions is cost-minimising if broad and even. Therefore, prices are ideally set at the supranational or, failing that, national level. However, CO_2 emissions are priced well below international climate cost benchmarks and prices are uneven across sectors and fuels (OECD, 2018[23]). Pricing of non-CO_2 emissions, such as methane emissions in agriculture, is rare. The difficulties in achieving broad pricing often reflect distributional issues. Using place-based criteria for the distribution of carbon tax revenues, as

has been done in Canada, may help achieve progress. In any case, pricing is not enough. Excessively short time horizons in investment decisions and knowledge externalities call for policy instruments to guide investment, often at the regional level. There is a need to make substitutes available for high-emission activity, requiring place-based collective decisions about networks such as energy or transport.

Box 3.2. The key competencies of subnational governments in climate policy

The recent OECD report *An integrated approach to the Paris Climate Agreement* (Matsumoto et al., 2019[24]) has highlighted that local and regional governments have jurisdiction over crucial sectors for climate action, including buildings and parts of transportation, other local infrastructure and waste management. Many decisions taken by local authorities, such as local regulation on transport, building construction mandates, spatial planning and economic policies, determine GHG emissions directly or indirectly.

Cities and regions can also set examples of progressive emission reduction. They can develop, diffuse and implement technological and social innovations, from e-scooters to zero-carbon local housing strategies. They may be able to take action more rapidly as they have close contact with citizens and businesses, as well as strong knowledge of local conditions and capabilities.

Local authorities are well-positioned to implement national emission reduction policies and are instrumental in embedding climate action into spatial planning, infrastructure, local policies and budget through locally-tailored climate strategies in line with national objectives. Local governments play an essential role in supporting the most vulnerable as they understand the local issues faced by their citizens.

Regions, facilitate co-ordination between the national and local levels, as well as co-operation among local authorities. Regions have a role in climate mitigation and adaptation, given their responsibilities in several areas having an impact on economic development (Matsumoto et al., 2019[24]).

Local well-being gains can offset the cost of a net-zero-emission transition

The sharp drop in the cost of renewable electricity has lowered the cost of net-zero-emission transitions. The performance and cost of batteries, which help to integrate electricity from intermittent renewables in energy use, has also improved sharply. They are often already cheaper than fossil fuel-incumbent technologies, even without carbon pricing. Recent estimates for the UK suggest the resource cost of the zero-emission transition may amount up to 1%-2% of GDP until 2050 (Climate Change Committee, 2019[2]). Costs are concentrated on the last 10%-20% of emissions abatement. The resource cost refers to the net resources that need to be devoted to the transition, include higher investment. Negative GDP impacts of the transition are more likely and more marked in fossil fuel-exporting regions (EC, 2018[25]; OECD, 2017[26]). Negative impacts are also more likely in regions with emission-intensive activities which are difficult to decarbonise. The impact on the competitiveness of sectors subject to international competition may depend on who bears resource costs in these sectors, especially if climate policies proceed at unequal speed across countries. For example, if taxpayers assume resource costs in such sectors, competitiveness in these sectors may be preserved, and resources would not need to be reallocated to other sectors. Such reallocation may or may not affect national GDP (OECD, 2017[26]) but would further impact the distribution of economic activity across regions.

Investment in research and development (R&D) and deployment of zero-emission technologies can lead to more rapid cost reductions than projected and such cost reductions could also boost economic activity (New Climate Economy, 2019[18]). Regions that attract such investment may benefit the most. For example, the cost of producing and using hydrogen – which can be produced with zero emissions and allows long-

term storage of energy – has fallen substantially since 2019. Such cost declines may be the most likely in replicable, modular technologies, such as in renewables and batteries. They have not occurred in nuclear energy nor, so far, in carbon capture and storage (Climate Change Committee, 2019[2]). Policies to boost zero-emission-consistent investment and innovation bring about such cost reductions. The GDP impact of decisive climate action may also turn positive if accompanied by GDP-boosting structural reforms and zero-carbon consistent investment, while carbon tax revenues could deliver substantial public debt reductions (OECD, 2017[26]).

Achieving net-zero GHG emissions can result in substantial well-being gains, which can offset these costs including human health. These benefits range from health and productivity to reducing energy poverty. Overall, the societal well-being gains of climate neutrality remain largely unaccounted for (IPCC, 2018[4]). A recent quantified assessment for the UK includes time gains from less traffic congestion as well as health improvements from a shift to active mobility (walking, cycling), from less meat-intensive diets, improved air quality and reduced traffic noise (Climate Change Committee, 2019[2]). These estimates suggest that welfare impacts could reach a similar magnitude as the costs in high-income, fossil-fuel importing countries and regions. The estimates are a broad approximation and do not include well-being benefits which are difficult to quantify in monetary equivalents, including: health benefits from improved housing quality; lower water and air pollution; improved biodiversity; climate resilience and recreational benefits from transformations in land use and agriculture. The benefits of reduced air pollution may also be underestimated given the increased evidence of the damaging impact of air pollution on a broad range of human well-being and health outcomes in recent years. Economic outcomes may also improve with health. Lower air pollution (Dechezleprêtre, 2019[27]) also boosts productivity. Several studies find that air quality co-benefits offset a large proportion of climate policy costs (Karlsson, Alfredsson and Westling, 2020[28]). For the East Asia region, the co-benefits of climate change mitigation in terms of human health may reach 6% of GDP, when also including the impact on adaptation costs. This exceeds the estimated cost of mitigation of 2% of GDP (Xie et al., 2018[29]). Focusing on urban contexts, expenditures may be mostly offset by the local co-benefits. Welfare effects may be strongly positive yet with slightly negative GDP and employment effects. Economic co-benefits of climate change mitigation policies in urban mobility, for example, can be put forward as a forceful argument for policymakers to take action (Wolkinger et al., 2018[30]).

Well-being gains associated with emission reductions need to be included in project appraisal. To scale up and deploy finance for environmental and energy transitions, well-being gains should be integrated in cost-benefit analysis. Environmental and social criteria can be included in cost-benefit analysis to make environmental costs and benefits part of a broad economic analysis (OECD, 2020[14]). For example, the valuation of biodiversity and ecosystem services helps monetise environmental impacts of policies and investment projects (OECD, 2018[31]). Appraisal guidance may need to be updated to reflect these benefits.

Despite potentially low overall costs overall, within countries, mitigation measures may have more profound impacts on some regions than others, and households and businesses in these regions will need to be actively supported through the transition to avoid creating new geographies of discontent and societal pressures that may, in turn, slow progress towards the zero-carbon goals. Central and supranational regional policy to address differences in regional impacts on well-being, employment and GDP and identify vulnerable regions and individuals and compensate them. Policymakers will also need to pay attention not to reward investment that has been inconsistent with the zero-emission transition, as this would harm incentives for appropriate investment going forward.

Early action is key to avoid high costs

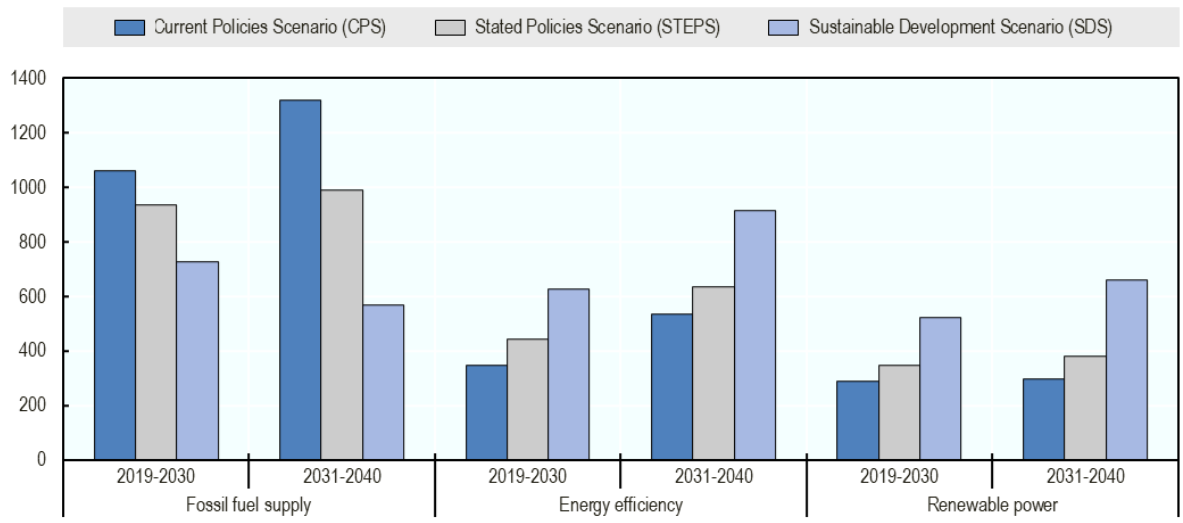
Good policy design is vital to keeping costs low and maximising benefits including a stable long-term direction with clear governance, regular reviews for flexibility, use of markets to find the best solutions, support for large-scale deployment and R&D of new technologies (Climate Change Committee, 2019[2]). Integrating climate policy into development plans promotes synergies to reduces climate change risk and

enhance resilience, while also helping to minimise costs. Regional, urban and rural policies will be discussed in more detail in the following chapter.

Delayed action raises costs globally but also locally, in cities and regions where the delays occur. The costs of delaying action to stabilise GHG for a 1.5℃ may be USD 5 trillion per year (7% of annual world GDP) (Sanderson and O'Neill, 2020[32]). Higher local costs result because later reductions will require faster expansion of new technologies, raising susceptibility to errors (Chapman, 2019[13]). Moreover, if investment in long-lived capital goods and infrastructure is not consistent with the zero-carbon transition, it would need to be written off before its economically useful life, resulting in wasted investment spending. Stopping investment in infrastructure that is inconsistent with the net-zero-emission transition is key to avoiding unnecessary costs. Current and stated policies imply investment paths that are inconsistent with reaching the Paris objectives, resulting in increasing stranded asset risks over time. Stranded asset risks are particularly large in fossil fuel supply (Figure 3.4).

Figure 3.4. Energy investment with current or stated policies differs sharply from investment needed to meet the Paris Climate Agreement

USD billion



Note: The Current Policies Scenario shows what happens if the world continues along its present path, without any additional changes in policy. The Stated Policies Scenario incorporates today's policy intentions and targets. The Sustainable Development Scenario maps out a way to meet sustainable energy goals, including limiting global warming to well below 2°C and lowering air pollution while providing universal access to energy.
Source: OECD-EU (2020); IEA (2019[33]), *World Energy Outlook 2019*, https://www.iea.org/reports/world-energy-outlook-2019 (accessed on 3 April 2020).

Regions heavily invested in fossil fuel extraction and transformation are therefore particularly at risk from stranded assets. This applies in particular to those regions where extraction and processing costs are particularly high. Production in these regions is priced out of the market first when fuel prices fall. Stranded asset risks are also higher if a large share of this cost is undertaken upfront when extraction projects are undertaken. For example, a decisive transition to net-zero emissions in major oil-importing economies would result in substantial GDP losses in oil-producing regions in Canada and the United States (US), where oil is extracted at higher costs than by other supplying regions (Mercure et al., 2018[34]).

Stranded assets concern all regions and cities. For example, new buildings need to be zero-emission-consistent today to avoid needing to be refurbished at a higher cost later. Since cars are used for about 15 years in high-income countries, purchases of new cars with internal combustions engines in countries

and after 2035 would be sub-optimal in countries and regions with net-zero CO_2 emission targets for 2050. The projected availability of low-cost electric cars suggests that the sale of new cars with internal combustion engines should be phased out even by 2030 (Climate Change Committee, 2019[2]) as announced in a few countries, such as the UK. Delayed action also means forgoing the local well-being and environmental benefits of emission reduction.

Transitions need to be inclusive within and across regions

Only a just transition can garner broad engagement and support. Climate change threatens the livelihoods of poor and vulnerable households, firms and regions the most. As the COVID-19 crisis has illustrated, broad support among citizens and the business community for policies to mitigate makes it easier to respond to systemic challenges. The well-being benefits of the zero-carbon transition can benefit vulnerable households that, within metropolitan areas, often live in areas most exposed to air and noise pollution. At the same time, job loss and adapting to zero-carbon modes of moving or housing and related costs are particularly difficult for low-income households that have fewer opportunities and resources to adapt.

A just transition approach involves an explicit focus on how a policy could be used to benefit disadvantaged groups and to take active measures to address economic inequalities and mitigate regressive outcomes as argued in *Managing Environmental and Energy Transitions for Regions and Cities* (OECD, 2020[14]). The pathway to positive equality outcomes involves carefully considering who might be impacted by a given policy and involving these groups or communities in the decision-making process (Chapman, 2019[13]). Policy measures with potentially negative impacts on household income or livelihoods must be accompanied by corresponding mitigating measures, such as exemptions, subsidies, compensation for losses and concrete support to help affected individuals and communities. In policy implementation, utilising the local workforce where possible can help achieve an equitable distribution of benefits at the local level, or by training local unemployed people to fill new jobs, and by ensuring that new employment opportunities do not exacerbate existing inequalities (Ürge-Vorsatz, Boza-Kiss and Chatterjee, 2019[35]). A wider public needs to be aware of the required transition and needs to be involved in future benefits (Chapman, 2019[13]).

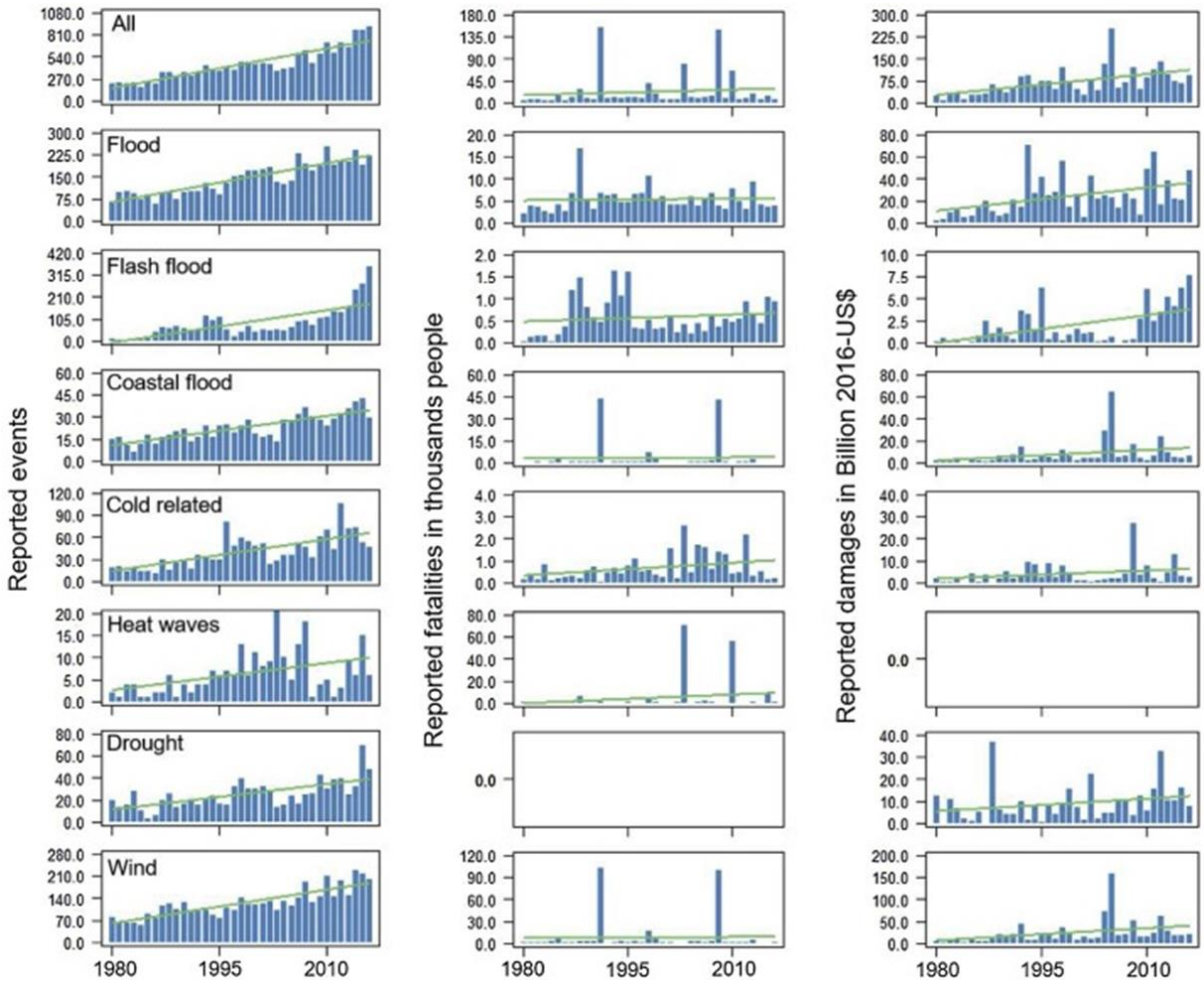
Adaptation will have to complement mitigation but it cannot be a substitute. Global warming of 2°C and higher poses risks for human well-being which adaptation may not be able to counter. For example, cities can cope with a 20-30 cm rise in sea level by building dams and other forms of protection. However, if the sea level rises by several metres, such a dam no longer helps.

Place-based adaptation is needed as a complement of decisive mitigation

Warming of up to 1.5℃ is inevitable and humanity must adapt to it. Article 7 of the Paris Agreement recognises adaptation as a global goal and key to protect human livelihoods and ecosystems. Humans have always adapted to changing environmental conditions but anthropogenic climate change from GHG emissions poses a particular challenge as the speed of change is unprecedented. Moreover, today's larger population implies an increasing number of people at climate risk, especially vulnerable low-income households in highly exposed regions with weak physical social and knowledge infrastructure. The current interconnected globalised economy makes it more vulnerable through supply chain disruption, resulting in differentiated place-based impacts (Okazumi and Nakasu, 2015[36]).

Extreme weather events are increasingly related to climate change. Climate-related hazardous events show an increasing trend during the period 1980 to 2016 for economic loss and human lives (Formetta and Feyen, 2019[37]). Flood- and wind-related events dominate reported events and wind caused 40% of fatalities from extreme weather events. However, economic losses may be underestimated as they are usually estimated using disaster databases that report only insured losses and do not cover indirect and intangible damages (Forzieri et al., 2018[38]).

Figure 3.5. Hazards and their impacts from 1980 to 2016



Source: Formetta, G. and L. Feyen (2019[37]), "Empirical evidence of declining global vulnerability to climate-related hazards", https://doi.org/10.1016/j.gloenvcha.2019.05.004; with data from Munich Re (n.d.[39]), *NatCatServices (database)*, which reports insured and direct losses only.

Without adaptation, consequences are substantial. For instance, with current climatic conditions, 1 in 5 people in cities are exposed to flood and 6% of cities risk being entirely flooded, as a recent OECD CFE report, *Cities in the World: A New Perspective on Urbanisation*, has shown (2020[40]). Worldwide flood loss from sea level rise of 40 cm in 2050 in 136 coastal cities is projected to reach USD 1 trillion per year compared to USD 6 billion in 2005 (Hallegatte et al., 2013[41]). Around 63 million people per year would be at risk of flooding even under a 1.5℃ warming (IPCC, 2018[11]). Exposure to a higher temperature and heatwaves raises mortality substantially, even under 1.5°C (Zhang et al., 2018[42]). Without adaptation, damage from multiple climate hazards to the present stock of infrastructure, for example in Europe, is projected to increase more than tenfold, from EUR 3.4 billion/year in 2010 to EUR 37 billion/year by 2100 (Forzieri et al., 2018[38]). The estimated damage could be much larger if interdependent and cascading damages are included. The additional impact of a one decimal increase in temperature is higher, the higher the temperature.

Adaptation can reduce climate risk substantially and more effectively under 1.5℃ warming than under 2℃ warming (IPCC, 2018[11]) (Box 3.3). Adaptation can also generate additional benefits, including leisure benefits of nature and environmental awareness (Kim and Song, 2019[43]). It can also stimulate innovation,

which in turn can boost economic activity (Global Commission on Adaptation, 2019[44]). Green Infrastructure (GI) is especially notable for multiple benefits alongside adaptation (Box 3.4).

Box 3.3. Examples of quantified adaptation benefits

Taking decisive adaptation action such as reducing coastal flood risks in 136 cities in the face of socio-economic vulnerability can reduce flood loss from USD 1 trillion to USD 52 billion by 2050 (Hallegatte et al., 2013[41]). Decisive adaptation action in Alaska was found to reduce expenditure on infrastructure by USD 2.3 billion this century (Melvin et al., 2017[45]). Climate-proofing existing infrastructures generate a benefit-cost ratio of four, only counting avoided losses from future climate hazards. Better drainage and flood barriers can generate positive returns for 60% of the roads that are exposed to at least a single flood event by investing just 2% of road value (Koks et al., 2019[46]). Investing USD 1.8 trillion could generate a net benefit of USD 7.1 trillion by 2030 (Global Commission on Adaptation, 2019[44]).

Climate change can exacerbate pre-existing social inequalities and social conflict (Hsiang et al., 2017[47]; Hsiang and Burke, 2014[48]). The marginalised and the poor bear the highest costs of damage relative to their income and are disproportionately at higher risk to hazards (Winsemius et al., 2018[49]). Elderly people, women and those with lower education level are more vulnerable to increased temperature variation for example (Marí-Dell'Olmo et al., 2019[50]). Part of the poverty-increasing impact of climate change comes from the adaptation of markets. For example, climate change will induce changes in land prices which will make poor people live and work where they are more exposed. Food-importing regions will be more affected by rising food prices and poor populations will be the most affected. Indigenous peoples too are especially vulnerable to the impacts of climate change since they usually live in vulnerable environments, including small islands, high-altitude zones, desert margins and the circumpolar Arctic (Nakashima et al., 2012[51]). For instance, in Canada's Northern regions, this is having increasingly widespread repercussions on the life of Northern Peoples, such as with respect to food, their environment and ecology (OECD, 2020[52]). Regional governments will need to counter these trends, bearing in mind that rising poverty may further reduce the poor's representation in adaptation decisions. They will also need to emphasise preventive action to avoid moral hazard.

Hence, inclusive regional development not only reduces poverty and improves resilience to a broad range of socio-economic shocks but also resilience to climate change. Improving inclusive outcomes in terms of regional convergence of productivity, access to basic infrastructure services, notably health, water and sanitation and modern energy by 2030, as in the UN Sustainable Development Goal (SDG) objectives, as well as good social income protection systems diminish the impact of climate change on poverty substantially. Strong mitigation action will prevent the poverty-increasing effects of climate change.

Box 3.4. Benefits of Green Infrastructure (GI)

Flood mitigation works that include GI components can provide multiple benefits, including energy saving due to the thermal insulation provided by green roofs as well as carbon sequestration, surface temperature reduction provided by pervious pavement and emissions reduction from energy saving (Alves et al., 2019[53]). The benefits net of cost were valued at EUR 2.91/m^2/year for the Sint Maarten Island in the Netherlands (Alves et al., 2019[53]).

The multifunctionality of GI was demonstrated in a case study of 447 projects reporting 964 benefits (Kim and Song, 2019[43]), which in broader terms were socio-cultural benefits, potential reduction in grey

infrastructure needs, flood protection and ecosystem protection among others. For example, a 20% increase in green space can provide heat island reduction benefits even in cities with cool temperate climates, reducing local surface temperature peaks by 2℃ (Emmanuel and Loconsole, 2015[54]). This can reduce energy demand for cooling and thereby also contribute to mitigation. Urban green space also enhances residents' well-being in its own right (Hiscock et al., 2017[55]).

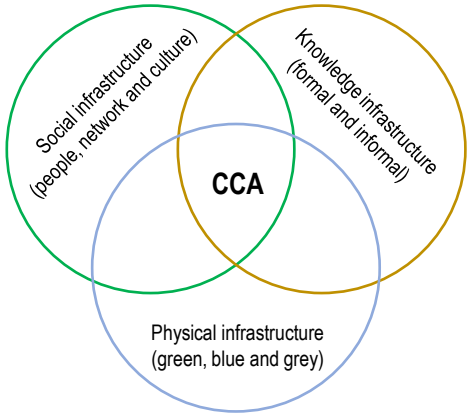
Limitations of GI mostly arises from under-researched and therefore unclear outcomes (Sussams, Sheate and Eales, 2015[56]). For example, there are few studies to determine the full range of health and other well-being outcomes (Venkataramanan et al., 2019[57]). Incorporating these well-being outcomes can significantly increase perceived co-benefits, boosting adaptation (EC, 2019[58]).

Regional governments need to embrace adaptation beyond built infrastructure and disaster management

Adaptation costs and benefits arise mostly locally (Greenhill, Dolšak and Prakash, 2018[59]) but benefits also cross boundaries. For example, in 2011, floods in Thailand affected the global information technology (IT) and automobile industries through ruptures in supply chains in Japan in particular (Okazumi and Nakasu, 2015[36]). Multi-level governance is key, including partnership among civil societies, businesses and communities (IPCC, 2012[60]; 2018[11]). The need to strengthen resilience through greater co-ordinated effort was also demonstrated during the COVID-19 health pandemic (OECD, 2020[61]).

The simplest description of adaptation is building resilience to climate risk with disaster management (Dolšak and Prakash, 2018[62]; IPCC, 2018[11]) and preparedness of physical infrastructures. Physical infrastructure includes nature-based "green" and aquatic-based "blue" infrastructures, in addition to the traditional grey structures (Alves et al., 2019[53]). But adaptation is also underpinned by socio-cultural and political systems (Grecksch and Klöck, 2020[63]; Pelling, 2010[64]) leading to different levels of exposure and vulnerability (IPCC, 2014[65]; 2012[60]). Focusing only on physical infrastructure and tangible assets loses track of impacts on social well-being especially among on marginalised and poor people who bear the highest costs of damage relative to their income and are disproportionately at higher risk to hazards (Winsemius et al., 2018[49]). These different dimensions can be integrated into a broader definition of infrastructure, to encompass physical, social and knowledge infrastructures (Figure 3.6).

Figure 3.6. The three integrated infrastructures of climate change adaptation (CCA)



An explicit focus on social infrastructure facilitates an inclusive approach. Social infrastructure includes people, their networks and culture. Social networks at the local level can identify vulnerable people and exposed physical infrastructure. They also create sources of resilience through mutual support, such as

through business organisations or neighbourhood associations. Subnational governments are well-placed to draw on the resources of local networks. In rural regions in particular, regional governments are needed to co-ordinate local government action, as rural municipalities are often very small. Community views on climate impacts on their livelihoods can help uncover and overcome exposure and vulnerability and increase communities' willingness to participate in adaptation (Krauß and Bremer, 2020[66]).

Knowledge infrastructure (Taylor et al., 2020[67]) includes both formal and informal knowledge and its integration in decision-making (Box 3.5). For example, experiential local knowledge and context-based rich narratives can be added to existing geographical information tools (Taylor et al., 2020[67]). They can drive policy discussion towards alternative perspectives on building urban resilience. Integrating these features in adaptation requires transforming the governance system. (Flores et al., 2019[68]). For example, the European Climate Adaptation Platform (Climate-ADAPT), a partnership between the European Commission (EC) and the European Environment Agency, was created to learn and share adaptation experiences. Drawing on formal and informal knowledge may help improve the range of costs and benefits taken into account in project appraisal, especially in the context of unknown climate events and systemic risks.

Box 3.5. Knowledge infrastructure

Formal knowledge is scientific or technical. It includes any technology used for data and information flow such as early warning and observatory systems, which are primarily used for preventive adaptation. Informal knowledge consists of local practices and Indigenous experience (Krauß and Bremer, 2020[66]), which can identify local context-specific vulnerabilities and impacts. It requires stakeholder engagement and a participatory approach. Integrating local knowledge alongside formal scientific knowledge enriches the knowledge base (Ainsworth et al., 2020[69]) in the sense of filling the gaps that may exist within each of these knowledge domains. While policy decisions need to be based on scientific knowledge, decisions to make the most of synergies and trade-offs require local and informal knowledge, as the COVID-19 crisis has illustrated. This also improves the chances of collective support.

Climate change will pose challenges to both urban and rural areas (OECD, 2020[14]). Local urban heat islands, for instance, can increase local temperatures and modify meteorology in cities. These effects can damage physical and social infrastructure, and increase energy demand for space cooling, further driving up energy demand during higher peak loads. Tree cover has major impacts on land surface temperature in heatwaves. Much urban population lives in low-lying coastal areas.

Rural areas may face future increased food market volatility, shifts and losses in plant and animal species and, depending on the region, increased water scarcity, coastal erosion or wildfires. Changes in the timing of seasons, temperatures and precipitation will also shift the locations where rural land-based economic activities, like agriculture, forestry and tourism can thrive. More workers in rural areas may work outdoors, exposing them more strongly to weather-related risks, such as excessive heat. Both urban and rural areas are expected to experience major impacts on water quality and quantity, resulting in fierce competition between water uses. Consequently, water policies need to be adjusted to changing local conditions and water governance frameworks to manage trade-offs across water users, rural and urban areas, as well as generations will need to be implemented (OECD, 2021[70]).

City and regional government agencies and organisations have developed adaptation plans and policies. Examples include disaster risk management, infrastructure systems, agricultural adaptation and public health. Adaptation requires co-operative private sector and governmental activities and integration with a broad range of policies, for instance on land use planning, resource management and health. Current efforts are insufficient. Most businesses do not get involved in adaptation for example. In the UK, only 20% take preventive action, by following up on risk assessments periodically and by identifying and implementing solutions (GRI, 2019[71]). This is unlikely to be cost-effective. In high-income OECD countries, much progress has been made in identifying local hazards and making this information available. However, this is less true for regions in low-income countries. As a result, adaptation spending is skewed and does not correspond to vulnerabilities.

Higher resolution climate modelling is needed to identify regional climate change hazards and appropriate adaptation action. More precise regional attribution of drought and flood risks for example will allow better-targeted adaptation action. This may require centralising climate modelling research at the continental level to bundle the resources needed for high-resolution modelling of climate impacts. Close co-ordination of climate modelling with regional and local policymakers, who understand local vulnerabilities, will also enable climate modelling to respond to local development needs. Integrating climate modelling and regional development is therefore important (Shepherd and Sobel, 2020[72]).

Systemic risks from a simultaneous breakdown

Regions are increasingly physically interconnected through trade and digital information flows. This makes them more vulnerable to system failures and breakdown where a single climate hazard can lead to cascading extreme events (Pescaroli et al., 2018[73]) also referred to as systemic risks (OECD, 2003[74]). It can occur with “unusual combinations of processes” (Zscheischler et al., 2018[75]). Climate change may well add to such systemic risks as they are without historical precedence. It can complicate understanding, preparation and prediction of future hazards, which interact with socio-economic transformations, such as automation (Colvin et al., 2020[76]). Cascading risks are growing with climate risk for systems such as critical infrastructures (Suo, Zhang and Sun, 2019[77]). They may be non-linear, stochastic and interconnected (Renn, 2016[78]). Box 3.6 provides examples.

Box 3.6. Examples of cascading events

- The 2011 Chao Phraya floods in Thailand, where 744 people lost lives and economic growth decreased by 3.7% alongside chain-reaction damage across the globe through supply chain disruptions for the automotive and IT industries.
- The 2011 tsunami in Japan destabilised the Fukushima nuclear plant with a loss of 15 891 human lives and a damage cost of USD 140 billion (Okazumi and Nakasu, 2015[36]) with supply chain disruptions in electronics components.
- The 2017 flooding in Houston, US, caused by Hurricane Harvey, resulting in the explosion and fire of a chemicals plant. The US is inflicted with such disaster on a yearly basis, costing between USD 6 billion to 16 billion (Cutter, 2018[79]).

The cost of such cascading risks when accounting for their interactions is more than the sum of individual events (Zscheischler et al., 2018[75]). This reinforces the need for coherence between disaster risk reduction (DRR) and climate change adaptation (CCA) (OECD, 2020[80]).

The ongoing COVID19 health pandemic reminds us that regions need to be resilient to socio-economic risks, which are the consequence of uncertain cascading events. It further shows that cascading events can undermine socio-economic development more generally. For example, the cascading impacts of

COVID 19 caused supply chain disruption and lowered investment confidence across the globe, as well as the human development index to turn negative (UNDP, 2020[81]; OECD, 2020[61]).

To tackle systemic risks (Dodman et al., 2019[82]), top-down impact modelling should be complemented with science-based storytelling, to allow societies to understand the implications, and bottom-up approaches, allowing local and regional key stakeholders to engage collaboratively (Zscheischler et al., 2018[75]). This requires the need for integration of different knowledge paradigms and multi-level governance. To test the readiness and adaptive capacity of critical infrastructures, low probability events with high potential impact need to be considered, including weather events (Pescaroli et al., 2018[73]).

Strengthening resilience to systemic crisis events with unknown knock-on effects requires a holistic and participatory approach (Edwards, 2009[83]; OECD, 2003[74]). An example is the "4 Es" framework: Engagement, Education, Empowerment and Encouragement (Edwards, 2009[83]). Individual citizens and communities need to engage with the climate policy agenda to gain trusted information. Critical reflection on this information empowers them to participate in decision-making and encourages them to respond quickly to problems before they fully materialise. This is vital to reduce disaster risks. Bounded rationality may however limit these responses when humans are faced with something they have never experienced. Governments, therefore, need to elaborate choice options to build resilience (Edwards, 2009[83]). This can be facilitated by local and regional councils providing dedicated government staff and going beyond communicating towards engaging with individuals and communities for better collective and individual decisions. Educating the communities on risk management should connect to their ways of living, which can empower them to act. This shows the need for place-based resilience programmes within the purview of local and regional governments.

Where do regions stand: Indicators of progress, well-being impacts and vulnerabilities

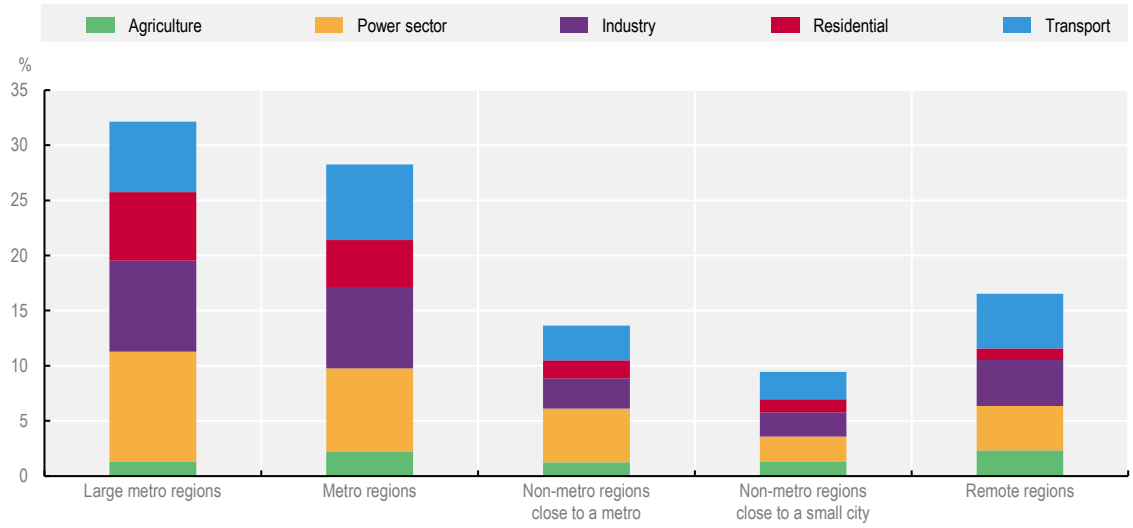
GHG emissions across OECD regions: Many variations across territories but not over time

Metropolitan regions contribute about 60% of production-based GHG emissions (excluding emissions from land use and land use change) across OECD countries (Box 3.7, Figure 3.7). However, metropolitan emissions are the lowest per capita (Figure 3.8). Remote rural regions may emit three times more per capita than large metropolitan regions, illustrating the extent of transformations of economic activities required in remote regions. The remote rural regions' contribution to total emissions is the largest in transport and industry. They also make the largest contribution to agricultural emissions. In metropolitan regions, emissions from electricity generation as well as the residential sector also make large contributions. Regional production-based emissions are particularly useful to understand where production will require the most transformation and related policy action.

Across all region types, per capita emissions have fallen little since 2010. Emissions and GDP per capita are positively correlated and more clearly so if the highest-emitting regions are not considered (Annex Figure 3.A.1). This relationship would be clearer if emissions were measured on a demand basis rather than on a production basis, as high-income regions consume more goods and services, including emission-intensive ones. Yet some high-emitting activities, such as heavy industry are located in low-income countries with low consumption of goods and services. Indeed, among regions with high GDP, the spread in emissions per capita is particularly wide. In those high GDP regions with low per capita production-based emissions, demand-based emissions are still likely to be high.

Figure 3.7. Metropolitan regions emit the most greenhouse gas emissions

Contribution to GHG emissions by type of region, 2018

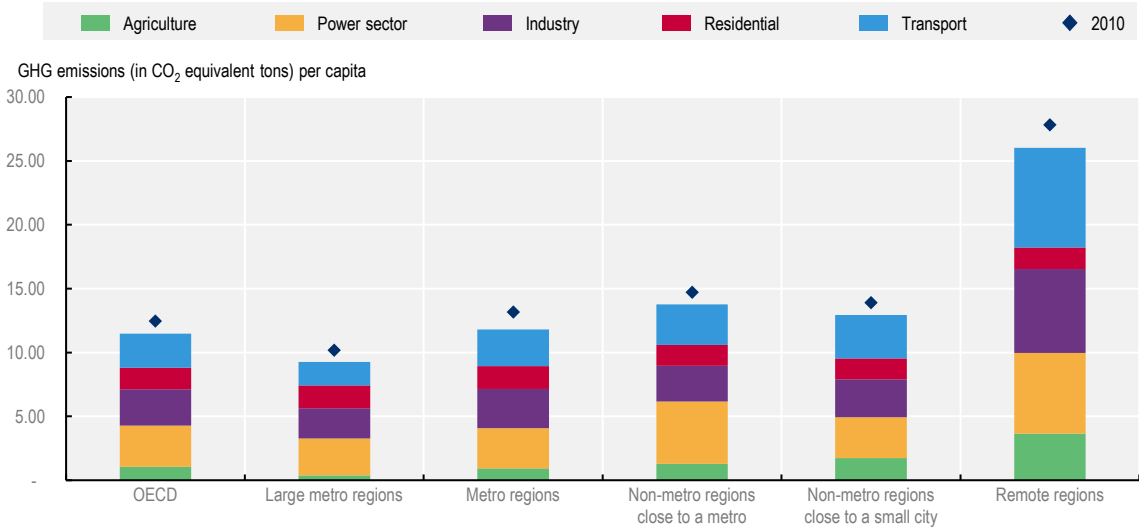


Note: OECD countries, Bulgaria and Romania. GHG emissions excluding emissions from land use and land use change.
Source: OECD calculations based on EC (2020[84]), *EDGAR - Emissions Database for Global Atmospheric Research*, Joint Research Centre, European Commission.

StatLink https://doi.org/10.1787/888934236646

Figure 3.8. Greenhouse gas emissions per capita are highest in remote regions

GHG emissions per capita by type of region, 2018



Note: OECD countries, Bulgaria and Romania. GHG emissions excluding emissions from land use and land use change.
Source: OECD calculations based on EC (2020[84]), *EDGAR - Emissions Database for Global Atmospheric Research*, Joint Research Centre, European Commission.

StatLink https://doi.org/10.1787/888934236665

Box 3.7. Regional greenhouse gas emission data

GHG emission data are mostly collected nationally and internationally. Regional data are collected using local emission inventories only in a few countries. Where available, they are typically not comparable across countries. Sectors may be defined differently and regionally collected data do not always cover all emissions. In this *OECD Regional Outlook* report, regional emissions are estimated on the basis of the Emissions Database for Global Atmospheric Research of the EC's Joint Research Centre (EDGAR, JRC 2020). It attributes national GHG emissions to locations according to about 300 proxies for 26 main sectors and subsectors, depending on the type of technology and International Energy Agency (IEA) fuel types, following Intergovernmental Panel on Climate Change (IPCC) reporting formats and guidelines. Locations of emissions are identified with various sources of spatial research (Janssens-Maenhout et al., 2019[85]). The emissions data used in this study are from Crippa et al. (2020[86]) for CO_2, while non-CO_2 GHG emissions data are from EDGAR.[1] Total GHG emissions are expressed as CO_2 equivalents calculated using the 100-year global warming potential in the IPCC 5th Assessment report (AR5). The proxies capture a substantial part but not all of the local emission determinants. For example, residential emission estimates capture buildings and population but not the degree of building insulation. Location estimates of agricultural emissions capture the number and species of ruminant animals but not how they are fed.

The emissions are attributed to five sectors:

1. The power supply sector contains all combustion of fuels for electricity and heat generation.
2. The industry covers the whole value chain from mining primary materials to manufacturing and recycling products. They include energy use process emissions and fugitive emissions.
3. Agriculture includes agricultural soils, agricultural waste burning, enteric fermentation and manure management.
4. The residential sector includes buildings and waste.
5. Transport encompasses freight and passenger ground, sea and air transport.

Residential emissions are attributed spatially using high-resolution criteria on population and built-up density. The dataset classifies six categories of human settlements (mostly uninhabited rural and dispersed rural areas, villages, towns, suburbs and urban centres) using satellite imagery. These data are combined with population density from the latest population censuses. Emissions from combustion in the household and commercial sectors are attributed to total population density maps for all fossil fuels.

Agricultural emission sources are attributed spatially according to agricultural land use, soil type, local livestock density and crop type datasets and maps from the UN Food and Agricultural Organization (FAO). Fuel combustion emissions in the agricultural sector are distributed over "rural" areas (mostly uninhabited rural and dispersed rural areas) for all fuels with the exception of natural gas which is assumed to be used mainly in cities, towns, villages and to a lesser extent in rural areas. A fishing map is also used.

Industrial and power sector emissions are mainly located at the plant location co-ordinates on point source grid maps. Power plant emissions have been distributed according to the point source distribution data sets, including intensity parameters and differentiating the fuel types coal, gas and oil. However, data on the location of power plants date back to 2012. A specific proxy captures emissions in the non-metallic minerals production (mainly cement and lime) for the world-leading producers of cement based on the plant locations and annual throughput. The difference between the total of the facility emissions and the country total of the given sector is distributed using urban population data. Gas flaring activities are distributed on night-time light data for areas with strong gas flaring activities

such as the North Sea Region. The co-ordinates of coal mines help locate related emissions, distinguishing between hard and brown coal mines.

Transport route information is used for the spatial attribution of transport emissions. Different proxy data layers for three road types worldwide (highways, primary and secondary, residential and commercial roads) are obtained from OpenStreetMap and combined with different weighting factors for the emission distribution for each road type, depending on the type of vehicles circulating on the type of roads. While the intensity of road use is not directly taken into account, the proximity of secondary roads may capture some road intensity use. Similar data are used for railways and inland waterways. For maritime traffic, identification and tracking data are used and for air, data from International Civil Aviation Organisation as well as flight information, taking into account flight patterns and their role in emissions (landing/take-off cycle).

For residual emissions which cannot be located, especially in the industrial and power sector, population-based gap-filling techniques are used.

To get a sense of the accuracy of the regional emissions estimates based on the EDGAR model from the EC JRC, the values can be compared to the regional emissions data published by the national statistical offices (NSOs) for those countries for which they are available. These include Australia, Belgium, Canada, the Netherlands, New Zealand, Sweden, the UK and the US. It is not a perfect comparison because the scope of emissions in both sources rarely match exactly (e.g. not all sectors or not all types of GHGs may be covered by the NSOs). Still, there is a high correlation between both sources in the emissions values for the same region (both for small [TL3] and large [TL2] regions). Since the emissions data published by the NSOs cover on average only 88% of emissions covered by the EC JRC, the EC JRC estimate is usually higher than the NSO value for the same region. However, in a few regions, EC JRC estimates and NSO values differ significantly. The two most extreme examples are Alberta and the Australian Capital Territory. The EC JRC estimated emissions for Alberta are only half those measured by the Canadian NSO, while the EC JRC estimate for the Australian Capital Territory is ten times those measured by the Australian NSO.

In the US, the North American Carbon Program (NACP) has followed a similar approach as the EC JRC. Their Vulcan database estimates CO_2 emissions using emissions factors and spatial information on industrial and electricity generation facilities and roads among other things. For 48 US cities, the estimated CO_2 emissions were compared to self-reported emission inventories of those cities (Gurney et al., 2021[87]). On average, the self-reported emissions are smaller than the estimated emissions.

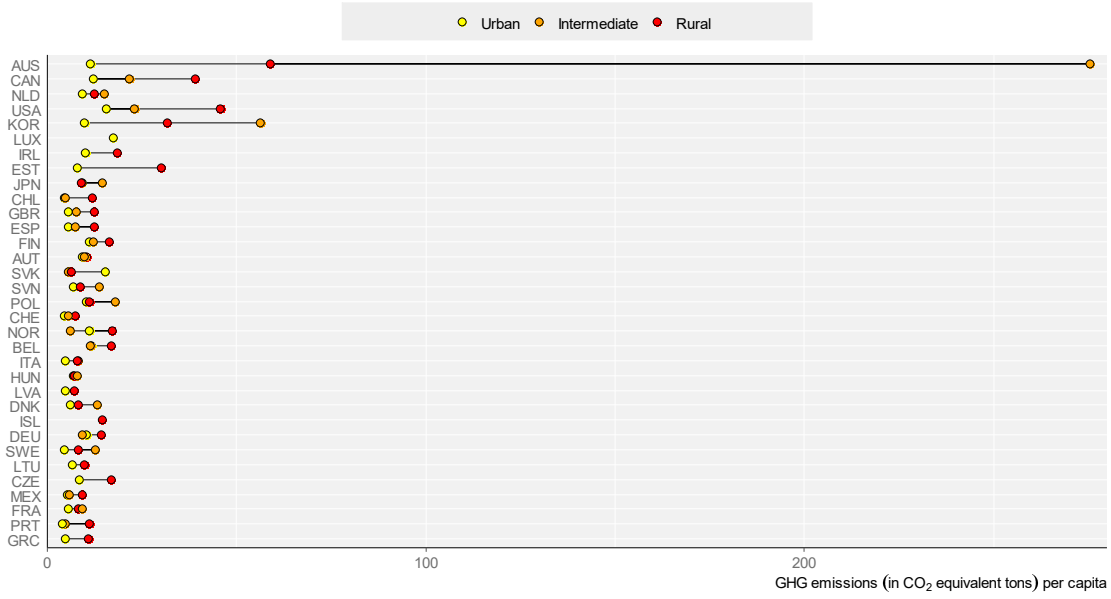
Rural regions emit the most GHGs in per capita terms in most countries (Figure 3.9). Within-country regional variation in emissions is larger than between countries (Figure 3.10) and there is much variation in agriculture, power generation and industry-related emissions (Figures 3.11 and 3.12). The highest-emitting regions are in Australia, Canada, New Zealand and the US. In these regions, emissions related to power generation and industrial emissions dominate. High power and industry emissions often entail higher transport emissions, likely reflecting freight in getting fossil fuels or industrial production to final demand. Energy-supply-related activity and energy-intensive industry are capital-intensive and capital goods are often long-lived. These regions may therefore be subject to substantial stranded assets risks. Regions with the highest agricultural emissions are in Australia, Chile, New Zealand and the US. Since 2010, emissions per capita have not fallen substantially in most of them.

In some top-emitting regions, GDP per capita is particularly high, especially in North America, highlighting the entailing economic and financial risks which need to concern policymakers, especially in high-emission regions, beyond those shown here. This may also concern intensive agricultural regions, where agricultural production is capitalised in land values. These regions do not, however, stand out in terms of life

satisfaction, for which differences are much smaller, perhaps because much of the GDP accrues to capital owners who do not reside in the region (Annex Figure 3.A.2).

Figure 3.9. In most countries, rural regions have the highest emissions per capita

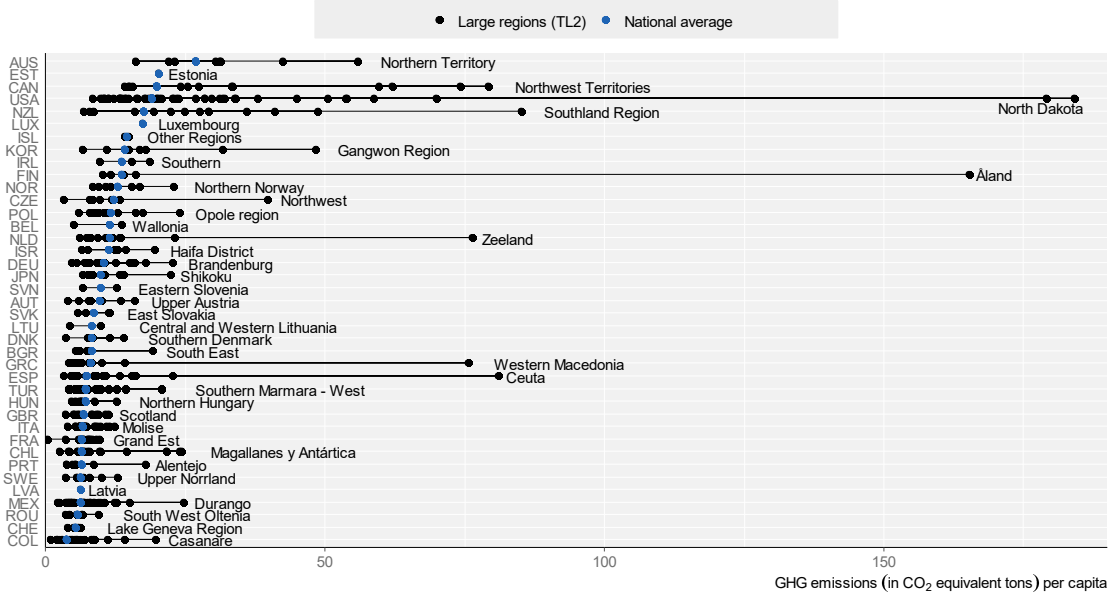
GHG emissions per capita by type of region in each country, weighted averages of small regions (TL3), 2018



Source: OECD calculations based on EC (2020[84]), *EDGAR - Emissions Database for Global Atmospheric Research*, Joint Research Centre, European Commission.

Figure 3.10. Within-country variation is larger than between countries

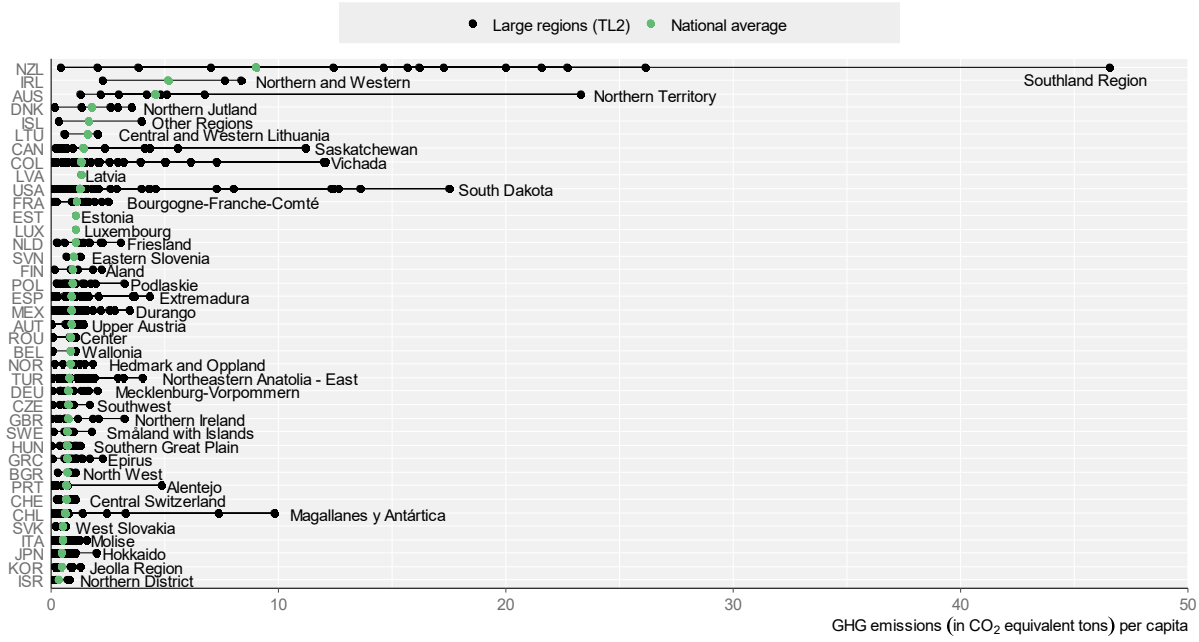
GHG emissions per capita from all sectors, large regions (TL2), 2018



Source: OECD calculations based on EC (2020[84]), *EDGAR - Emissions Database for Global Atmospheric Research*, Joint Research Centre, European Commission.

Figure 3.11. Agricultural emissions per capita are particularly high in New Zealand

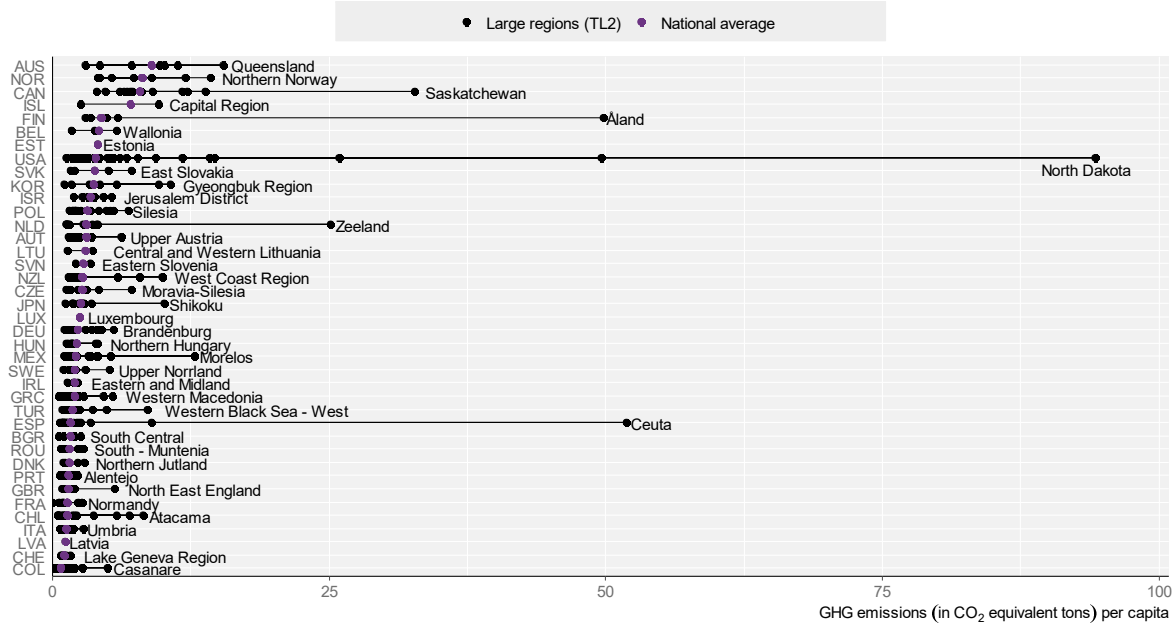
GHG emissions per capita from agriculture, large regions (TL2), 2018



Source: OECD calculations based on EC (2020[84]), *EDGAR - Emissions Database for Global Atmospheric Research*, Joint Research Centre, European Commission.

Figure 3.12. Industrial emissions per capita are high in Australia, Norway and North America

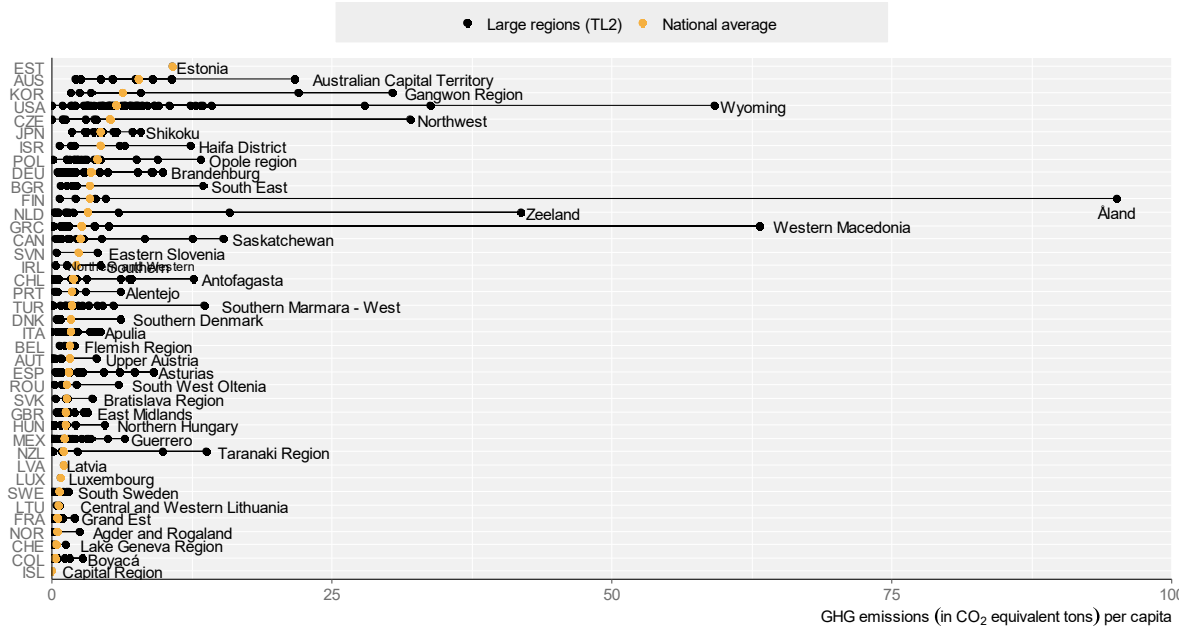
GHG emissions per capita from industry, large regions (TL2), 2018



Source: OECD calculations based on EC (2020[84]), *EDGAR - Emissions Database for Global Atmospheric Research*, Joint Research Centre, European Commission.

Figure 3.13. Energy emissions per capita are high in some Dutch, Finnish, Greek and US regions

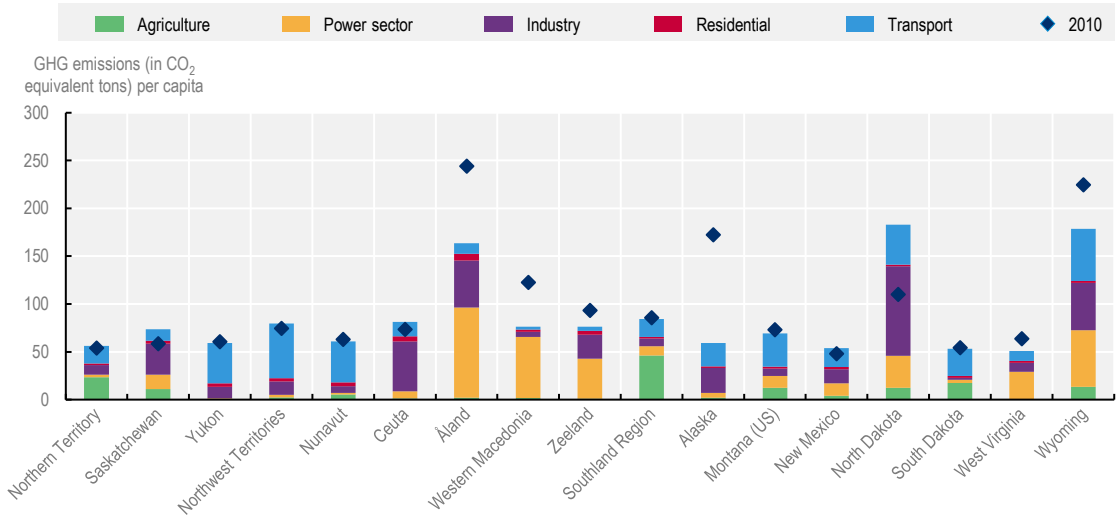
GHG emissions per capita from the power sector, large regions (TL2), 2018



Source: OECD calculations based on EC (2020[84]), *EDGAR - Emissions Database for Global Atmospheric Research*, Joint Research Centre, European Commission.

Figure 3.14. In most of the highest-emitting regions, energy supply, transport and industry-related emissions dominate

GHG emissions per capita in the highest-emitting large regions (TL2), 2018

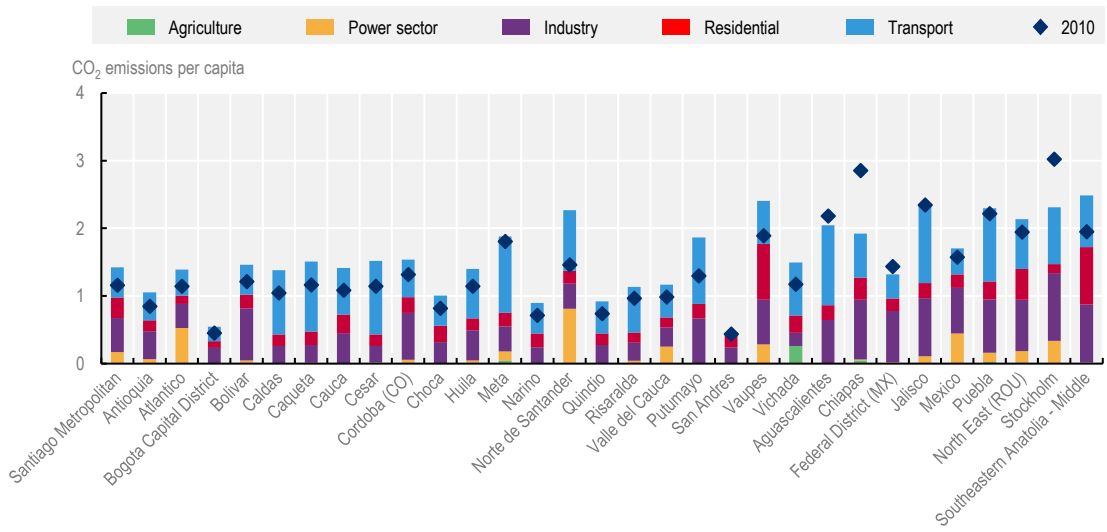


Source: OECD calculations based on EC (2020[84]), *EDGAR - Emissions Database for Global Atmospheric Research*, Joint Research Centre, European Commission.

Few regions have yet reached CO_2 emissions which are close to zero. Many OECD regions have set a net-zero GHG emission target, which will in practice mean reaching net-negative CO_2 emissions to offset positive non-CO_2 emissions, notably methane. The emissions data shown here do not capture carbon sinks, as they exclude emissions from land use and land use change, which can be negative. However, afforestation and reforestation, a major potential carbon sink, can in any case only absorb a flow of CO_2 emissions in the growth phase. All large regions (TL2) with estimated production-based emissions below 2.5 tons of CO_2 are located in middle-income South and Central American regions (Figure 3.15) except the Swedish capital Stockholm and Romania's North East region. These regions typically do not host CO_2 intensive power supply but also have much lower transport emissions per capita.

Figure 3.15. Some OECD regions emit little CO_2, mostly in middle-income regions of South America

CO_2 emissions per capita across OECD, large regions (TL2), 2019



Source: OECD calculations based on EC (2020[84]), *EDGAR - Emissions Database for Global Atmospheric Research*, Joint Research Centre, European Commission.

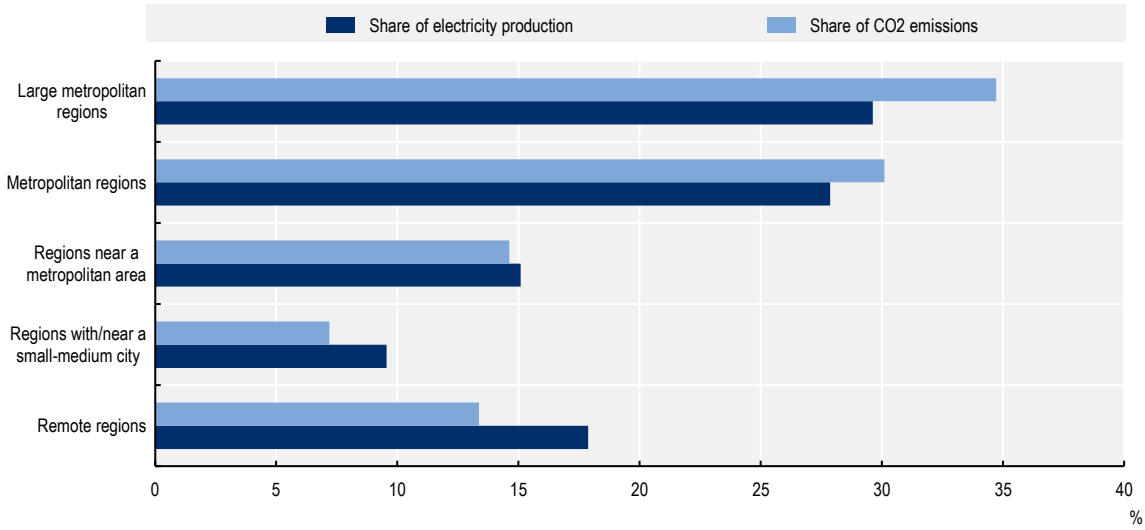
Most regions need to move more decisively to renewables in electricity generation

Moving towards a low-carbon economy is central to halting global warming. Since much energy use, for example in transport, needs to be electrified in the transition to net-zero emissions by 2050, progress in moving to zero-carbon electricity generation needs to be particularly rapid, so energy supply can move to decarbonised electricity. Electrification of end-use sectors can then contribute to decarbonisation in a cost-effective and timely way. Yet, the transition to zero-carbon electricity production remains unequal across OECD regions.

As highlighted in *Regions and Cities at a Glance 2020* (OECD, 2020[88]), for the same amount of electricity production, high-carbon-intensive regions release, on average, 23 times more tons of CO_2 than low-carbon-intensive regions within each country. Behind such stark inequalities in carbon efficiency is the shift towards renewable sources for electricity production (see next section). Rural regions are less carbon-intensive in electricity production than metropolitan regions, generating 27% of the electricity but only 20% of the CO_2 (Figures 3.16 and 3.17). These differences also have implications for regional development. As the following sections show, many regions are far off near-term benchmarks for meeting the Paris Agreement.

Figure 3.16. Rural regions are less carbon-intensive in electricity production

Contribution to electricity production and related emissions by type of region, averages of small regions (TL3), 2017

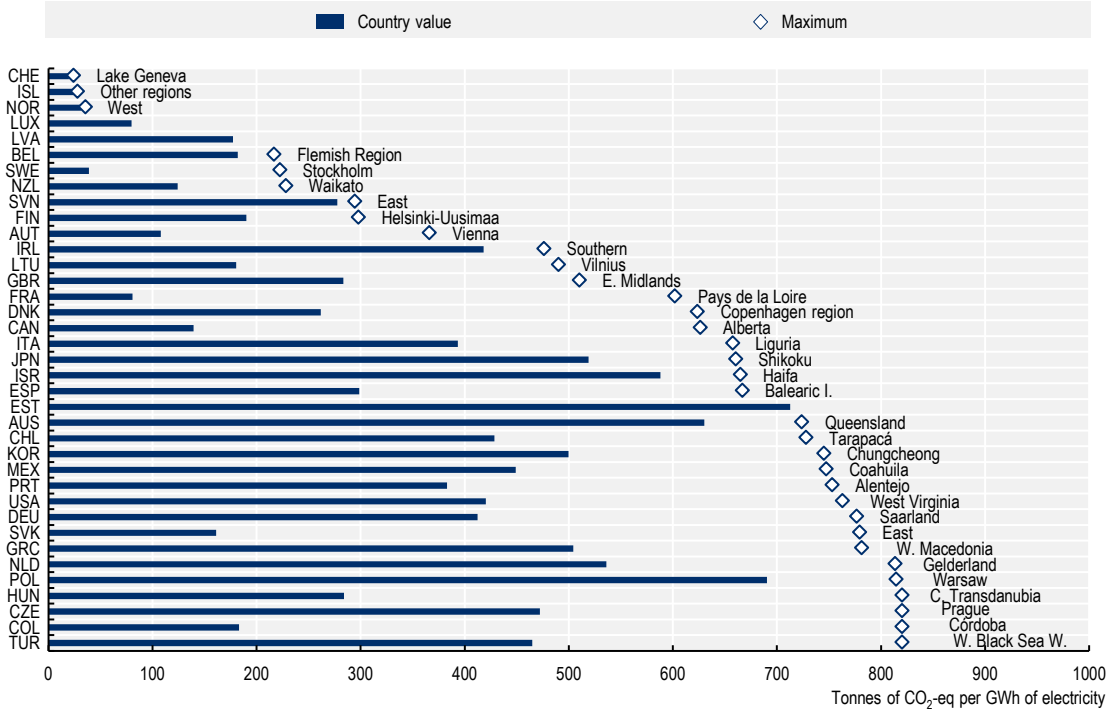


Source: OECD (2020[88]), *OECD Regions and Cities at a Glance 2020*, https://doi.org/10.1787/959d5ba0-en.

StatLink https://doi.org/10.1787/888934236684

Figure 3.17. Regional disparities in CO_2 emissions of electricity generation can be large

Tons of CO_2 emissions per gigawatt-hour of electricity generated, large regions (TL2), 2017



Source: OECD (2020[88]), *OECD Regions and Cities at a Glance 2020*, https://doi.org/10.1787/959d5ba0-en.

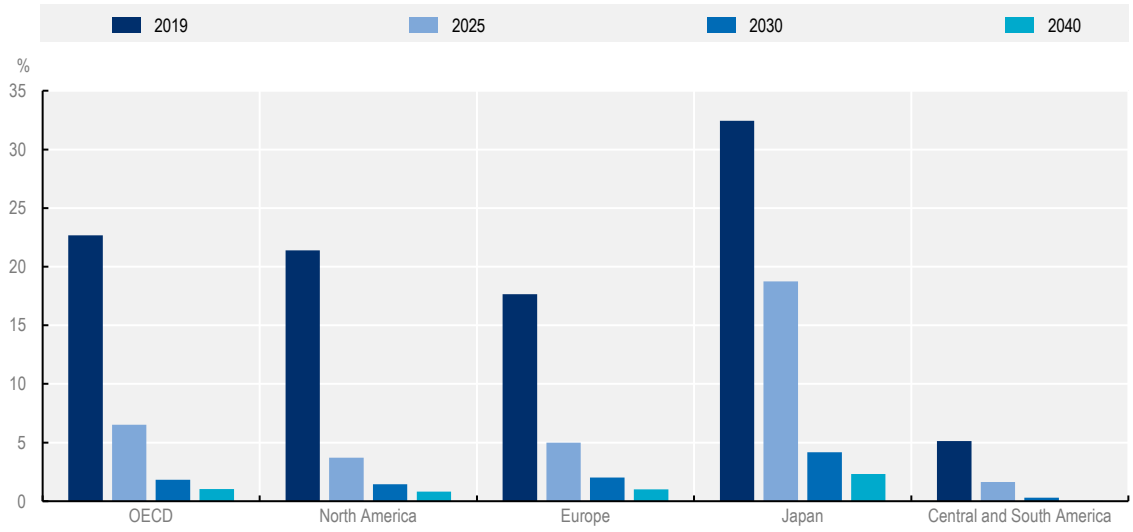
StatLink https://doi.org/10.1787/888934236703

Most OECD countries still have regions that rely on coal-fired electricity generation

As the most carbon-intensive energy source, coal will be the first fossil fuel that will have to be phased out in electricity generation. Indeed the IEA Sustainable Development Scenario (IEA SDS), which is consistent with the Paris Agreement, indicates that the average share of coal-fired electricity generation across OECD countries should be no more than 6.5% by 2025 and fall close to zero by 2040 (Figure 3.18). Coal use for electricity generation should be nearly extinguished by 2050, also in developing economies. Countries, regions and cities with net-zero-emission objectives by 2050 may need to exceed IEA SDS benchmarks. The Powering Past Coal Alliance, in which many OECD countries are members, has set a more stringent benchmark. It argues that the share of coal-fired electricity generation across the OECD should be phased out completely by 2031 for cost-effective climate mitigation consistent with the Paris Agreement (Climate Analytics, 2019[89]).

Figure 3.18. To be aligned with the goals of the Paris Agreement, coal-fired electricity should be largely eliminated by 2030

Maximum share of coal-fired electricity generation, according to the IEA SDS



Source: IEA (2020[90]), *World Energy Outlook 2020*, https://dx.doi.org/10.1787/557a761b-en.

StatLink https://doi.org/10.1787/888934236722

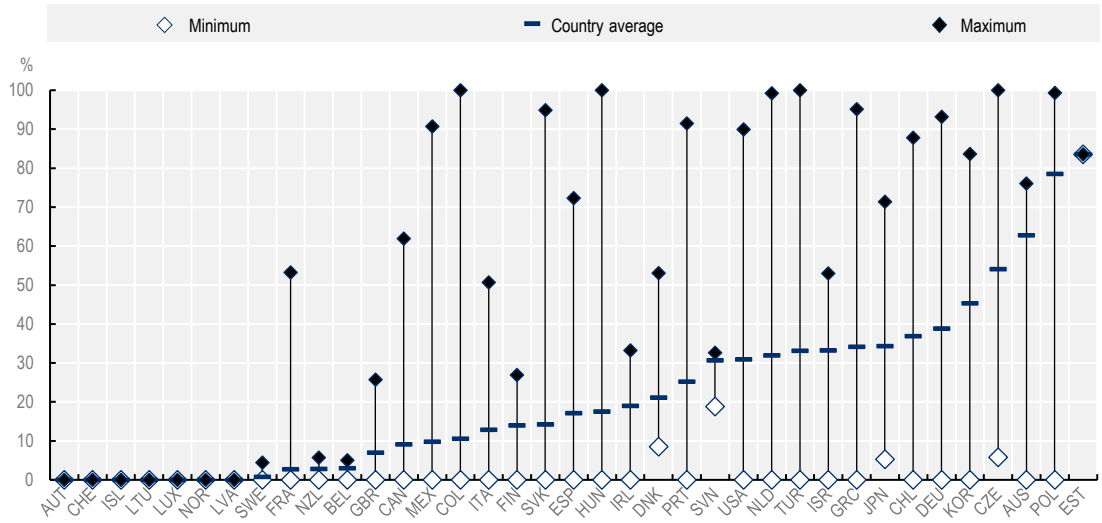
Currently, 167 out of 425 (39%) large OECD regions (TL2) are above the 2025 IEA benchmark for OECD countries. Among 37 OECD and partner countries for which data are available, only 7 countries are coal-free in all regions (Figure 3.19). Twenty-three countries still have at least 1 region where coal accounts for over 50% of electricity generation. Within countries with regions that still use some coal, it is usually concentrated in some (Figure 3.20). Countries where all regions hosted coal-fired electricity generation in 2017 include the Czech Republic, Denmark and Japan.

The top 10 regions by coal-fired electricity generation combined produce 27.7% of coal-fired electricity generation across the 37 OECD and partner countries. In these regions, owners of related capital and workers may jointly oppose a rapid coal exit and convince the regional government to do the same. Such resistance is likely to be stronger where coal use is based on local mining. Electricity generation is capital-intensive and not job-intensive. Many more jobs are at stake when electricity generation is based on local

coal mines (see employment section below). Since these regions are large, they may also risk holding back zero-emission transition at higher government levels (Figure 3.21).

Figure 3.19. Most OECD countries still have at least one region with over 50% coal-fired electricity

Share of coal-fired electricity generation, large regions (TL2), 2017

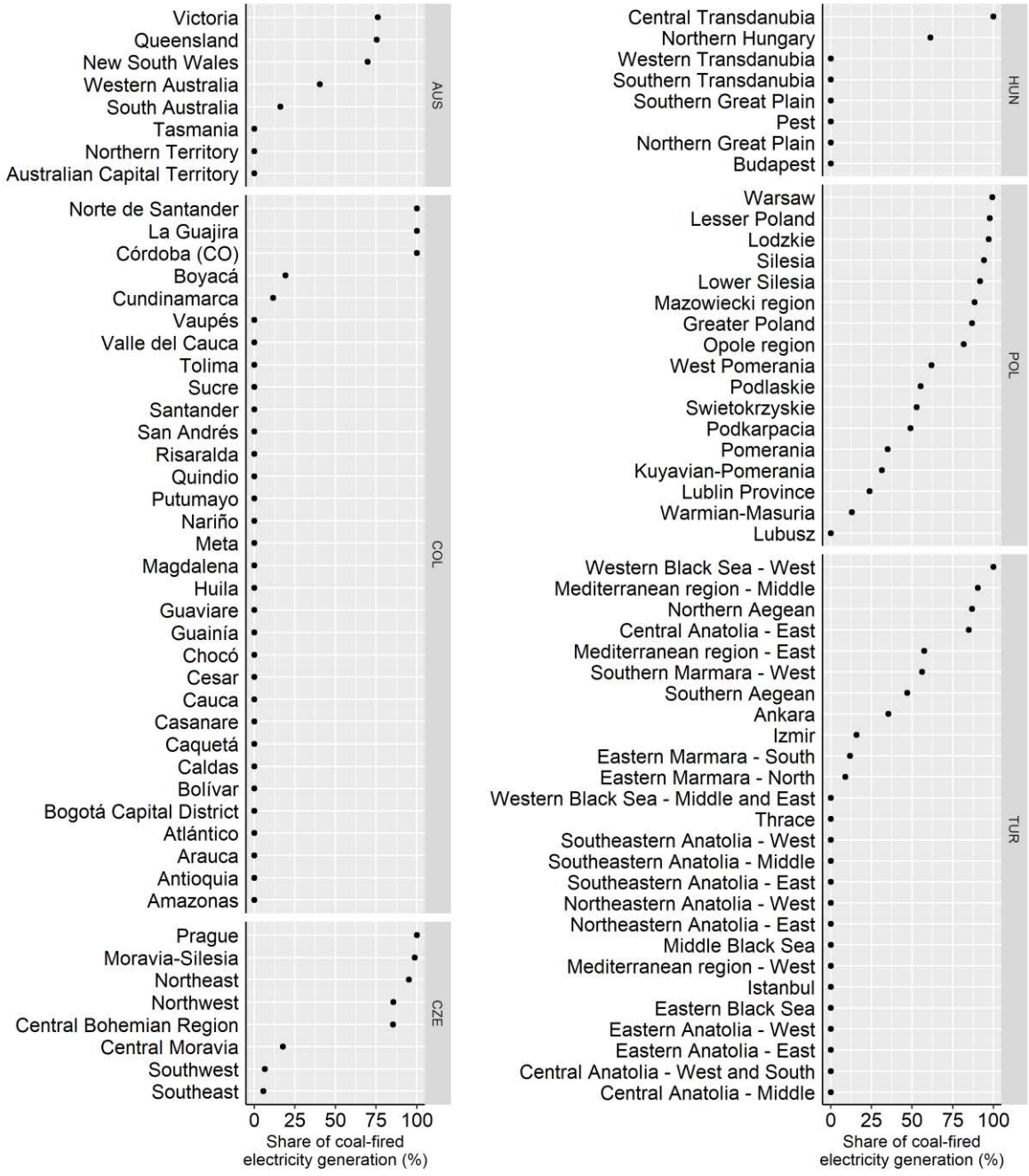


Source: OECD calculations based on WRI (n.d.[91]), *Global Power Plant Database*, https://datasets.wri.org/dataset/globalpowerplantdatabase.

StatLink https://doi.org/10.1787/888934236741

Figure 3.20. Coal usage for electricity generation tends to be regionally concentrated

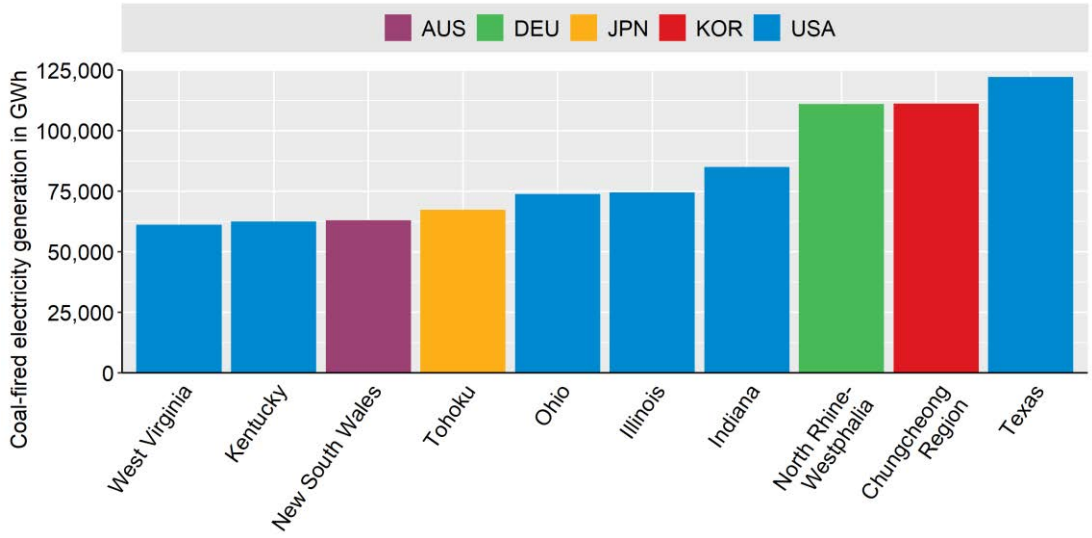
Share of electricity generation from coal, large regions (TL2) of countries with large regional variation, 2017



Source: OECD calculations based on WRI (n.d.[91]), *Global Power Plant Database*, https://datasets.wri.org/dataset/globalpowerplantdatabase.

Figure 3.21. The 10 largest regional users of coal for electricity generation, generate over a fourth of coal-fired electricity in OECD countries

Coal-fired electricity generation in gigawatt-hours, top 10 large regions (TL2) with the highest coal-fired electricity production, 2017



Source: OECD calculations based on WRI (n.d.[91]), *Global Power Plant Database*, https://datasets.wri.org/dataset/globalpowerplantdatabase.

StatLink https://doi.org/10.1787/888934236760

Continued coal use can have negative impacts on coal-using and other regions. For example, air and land pollution from coal-fired power plants can be substantial and can travel far. Thermal power plants in regions subject to drought risk, which will rise with climate change in many regions, pose risks for reliable operation and aggravate risks for biodiversity and competing water use. Further risks of holding on to coal include forgoing renewable electricity production, which is sometimes already cheaper to coal, even in power plants and in the absence of adequate carbon pricing. A successful example of a coal exit in all its regions is the UK, which still produced 40% of electricity from coal in 2012. The coal exit did not generate any significant impact on the economy or electricity supply after 2012. The UK abandoned coal mining much earlier. Impacts on coal mining employment is investigated below.

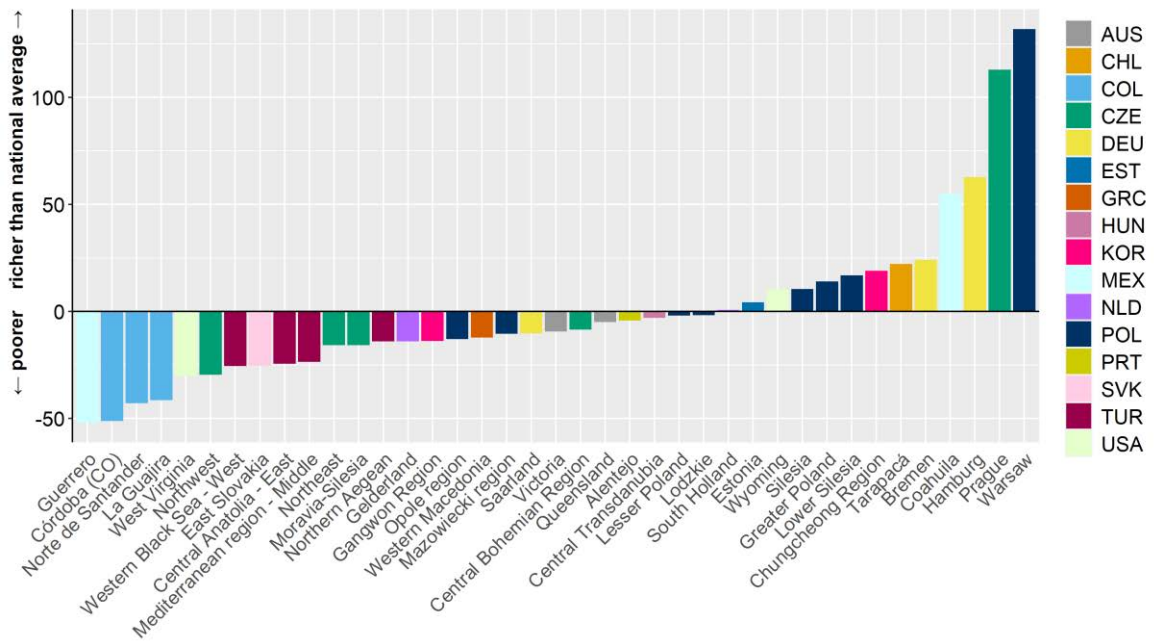
Within each country, regions with more coal-fired electricity do not generally differ from regions with less coal-fired electricity in terms of GDP per capita, life satisfaction or poverty risk. Poverty risk is assessed from individuals' survey respondents indicating there have been times in the past 12 months when they did not have enough money to buy food that they or their family needed (data on not having enough money to provide adequate shelter or housing provides similar results). Still, some regions with intensive coal use do much more poorly than their national averages, especially with respect to GDP per capita, sharply so in Colombia and Mexico (Figure 3.22). The biggest coal-using regions, particularly in Japan and the US, and regions producing all electricity with coal have mostly lower GDP per capita than their country averages.

Most regions are no longer adding or planning to add new capacity (Figures 3.23 and 3.24). Indeed, adding such capacity would expose regions to stranded asset risks, resulting in financial market risks and economic costs. Seeing that OECD regions should be phasing out coal by 2030 and the average lifespan of a coal power plant is 40 years, these planned additional generating capacities are unlikely to be aligned with the Paris Agreement. However, Australia, Colombia, Czech Republic, Greece, Japan, Korea, Mexico,

Poland and Turkey still have regions where additional capacity is planned (Global Energy Monitor, 2020[92]). Carbon capture use and storage (CCUS) could mitigate related emissions, but is not being deployed at scale and would raise generation costs substantially.

Figure 3.22. GDP per capita is much lower than the national average in some regions with intensive coal use

Relative difference regional GDP per capita to country means (in %), large regions (TL2) with more than 75% coal-fired electricity generation, 2017

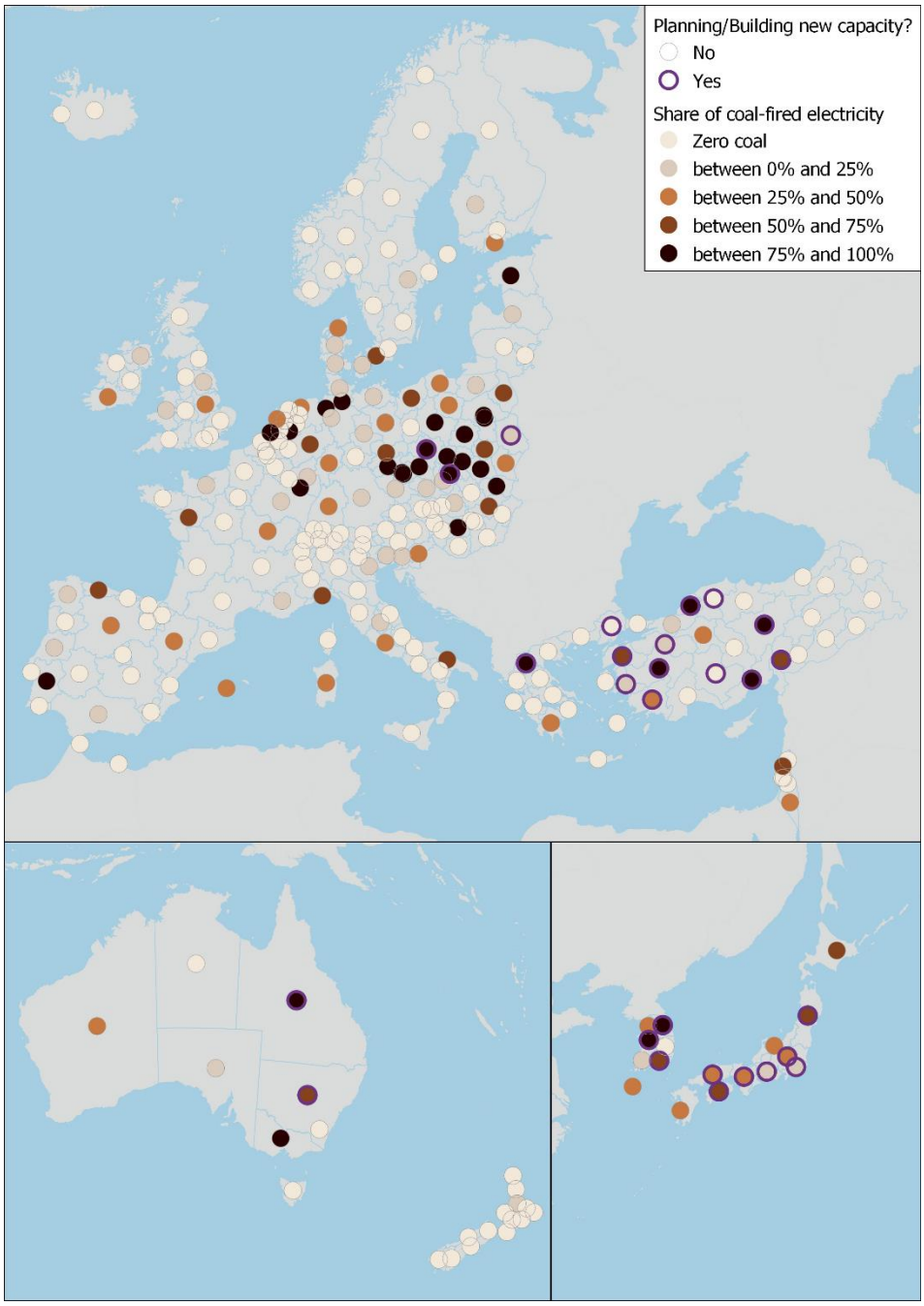


Note: Data for 2018 or most recent year available, GDP per capita is USD per capita, PPP, prices from 2015.
Source. OECD Statistics.

StatLink https://doi.org/10.1787/888934236779

Figure 3.23. Fewer OECD regions are adding new coal-fired electricity capacity

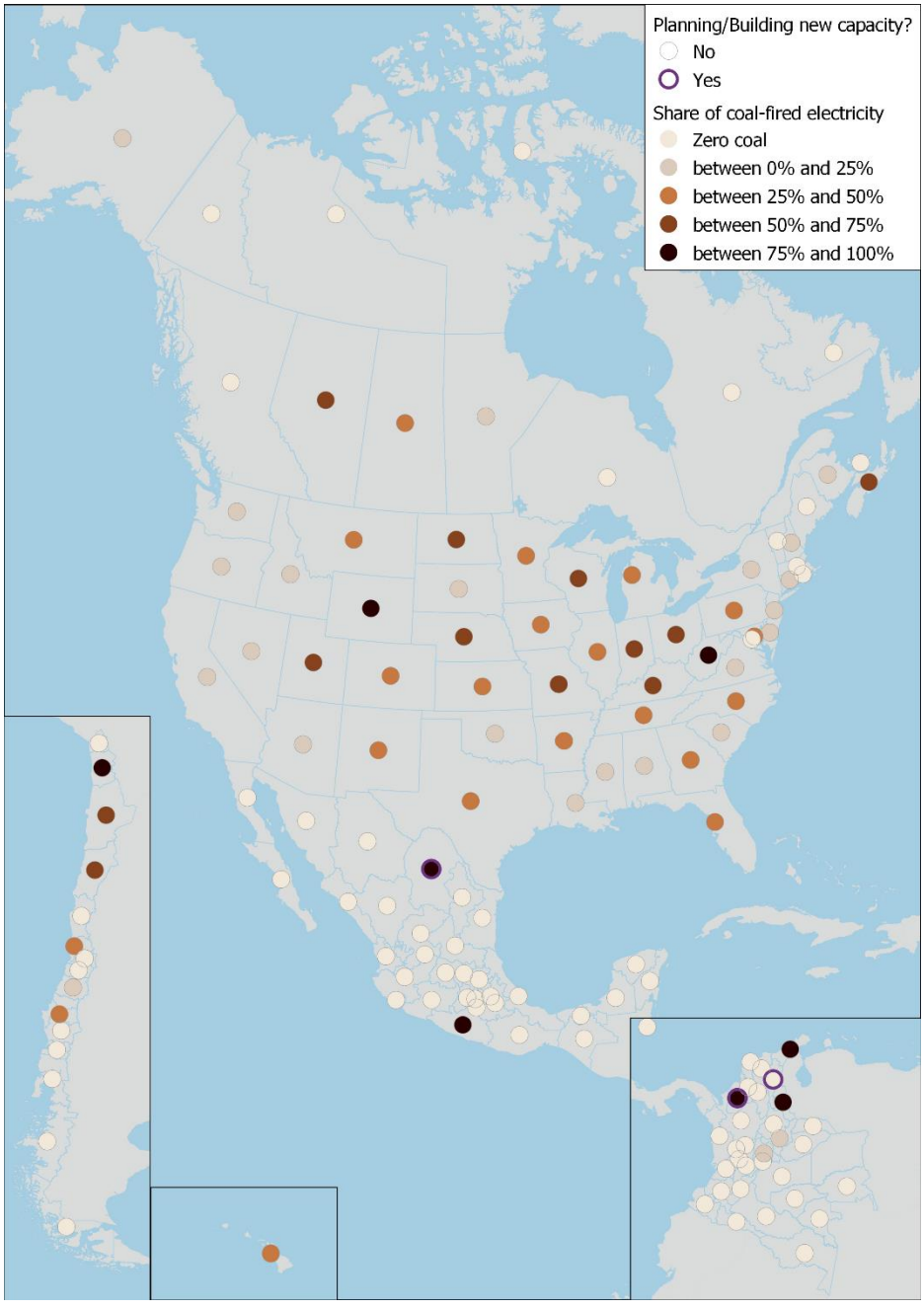
Shares of coal-fired electricity generation in large regions (TL2), 2017, and whether that region still has new coal-fired electricity capacity planned* (last updated in April 2021)



Note: This map is for illustrative purposes and is without prejudice to the status of or sovereignty over any territory covered by this map.
* New planned capacity is defined as new capacity announced, pre-permit, permit or in construction.
Source: OECD calculations based on WRI (n.d.[91]), *Global Power Plant Database*, https://datasets.wri.org/dataset/globalpowerplantdatabase; Global Energy Monitor (2020[92]), *Global Coal Plant Tracker*, https://endcoal.org/tracker/ (accessed on 16 April 2021); Source of administrative boundaries: National statistical offices, Eurostat (European Commission) © EuroGeographics and FAO Global Administrative.

Figure 3.24. Most OECD regions, especially in the Americas, are no longer adding new coal-fired electricity capacity

Shares of coal-fired electricity generation in large regions (TL2), 2017, and whether that region still has new coal-fired electricity capacity planned* (last updated in April 2021)



Note: This map is for illustrative purposes and is without prejudice to the status of or sovereignty over any territory covered by this map.
* New planned capacity is defined as new capacity announced, pre-permit, permit or in construction.
Source: OECD calculations based on WRI (n.d.[91]), *Global Power Plant Database*, https://datasets.wri.org/dataset/globalpowerplantdatabase; Global Energy Monitor (2020[92]), *Global Coal Plant Tracker*, https://endcoal.org/tracker/ (accessed on 16 April 2021); Source of administrative boundaries: National statistical offices, Eurostat (European Commission) © EuroGeographics and FAO Global Administrative.

Remote regions produce the most electricity, per capita, using renewables

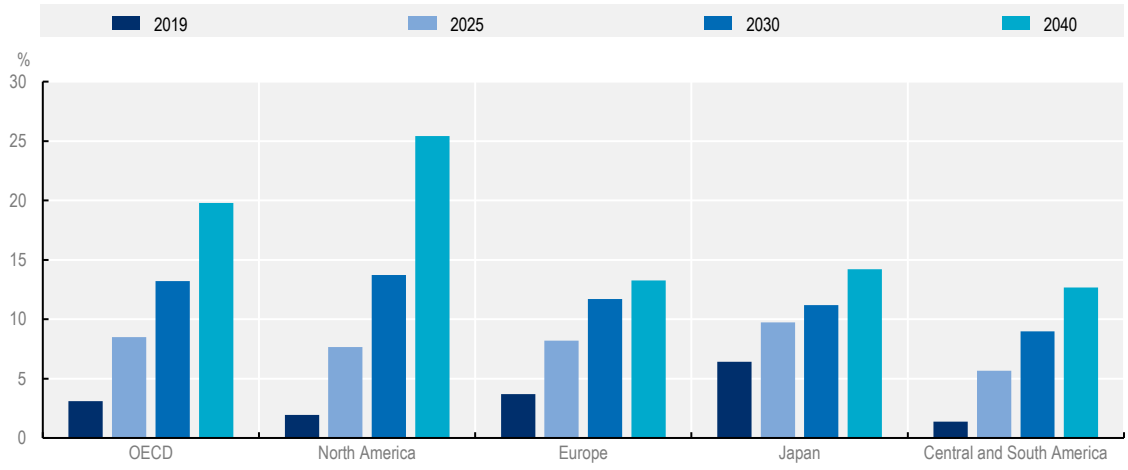
As pointed out in *Regions and Cities at a Glance 2020* (OECD, 2020[88]), regions located further away from metropolitan areas are, relative to their population, larger producers of electricity (Figure 3.27) and produce more from renewables. While metropolitan areas produce less than a fifth of their electricity from renewables, remote rural regions produce over half of their electricity from renewables (OECD, 2020[88]). About 80% of that comes from hydropower. However, the shares of wind and solar power in electricity production also tend to be higher in regions further away from metropolitan areas.

Regions further away from cities are generating more electricity from wind and solar, relative to their size. The generation of wind-based power is especially skewed toward most rural regions (Figure 3.28). Despite being a smaller producer of electricity overall, remote rural regions produce more wind power than large metropolitan regions and almost as much as metropolitan regions. Compared to their contribution to coal and total electricity generation, non-metropolitan regions contribute more to total wind production in the OECD. They also contribute a bigger share to solar electricity generation than to total electricity, except in remote rural regions, which also host most hydroelectric power. OECD countries still produce much more wind than solar power. With utility-scale solar photovoltaic installations continue to produce electricity at a lower cost than rooftop, the strength of solar electricity in non-metropolitan regions may continue to build up. This pattern is already marked in most of the countries with already high wind and solar shares. For example, in Spain, about three-fourths of solar is produced in non-metropolitan regions. This contrasts with the spatial distribution of nuclear or fossil-fuel-based electricity. Overall, the expansion of wind and solar electricity generation and the phase-out of coal will shift electricity generation to more rural regions.

This spatial distribution of electricity generation is likely to be reinforced as progress is made in the zero-emission transition. The IEA Sustainable Development Scenario (IEA SDS) indicates that both solar and wind electricity generation will need to increase a lot, while growth in nuclear and hydro would remain very limited. Average shares in OECD countries will need to increase to 8% and 14% by 2025 and 20% and 30% by 2040 respectively for solar and wind (Figures 3.25 and Figure 3.26). Currently, 73% of small regions (TL3) have smaller shares than the 2025 benchmark in both simultaneously. Of course, the expansion will differ across regions depending on potentials. Globally, full decarbonisation of the electricity system is required for a 1.5°C scenario (Rogejl et al., 2015[5]).

Figure 3.25. Share of solar in the energy mix, according to the Sustainable Development Scenario

Share of solar-powered electricity generation

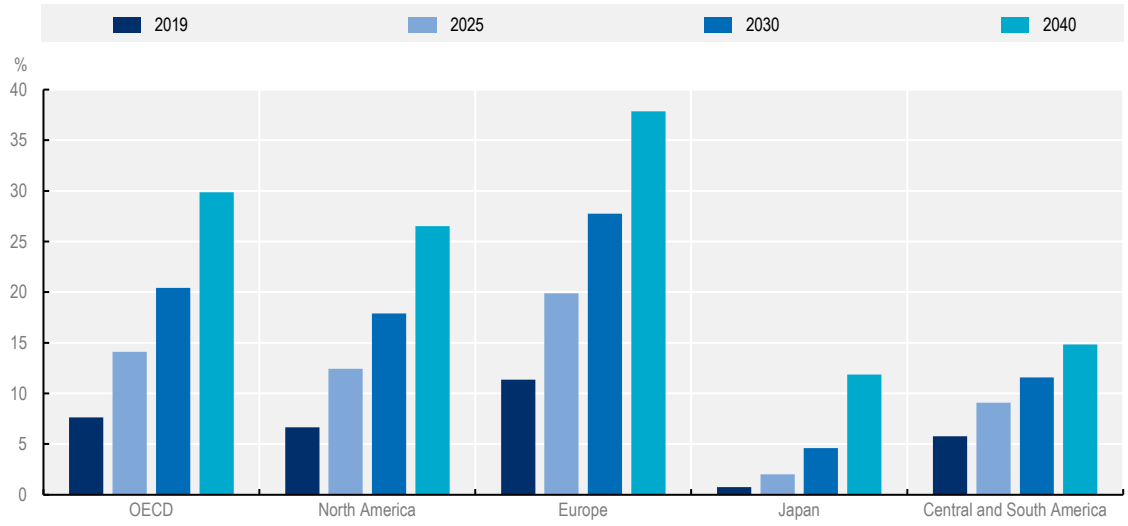


Source: IEA (2020[90]), *World Energy Outlook 2020*, https://dx.doi.org/10.1787/557a761b-en.

StatLink https://doi.org/10.1787/888934236798

Figure 3.26. Share of wind in the energy mix, according to the Sustainable Development Scenario

Share of wind-powered electricity generation



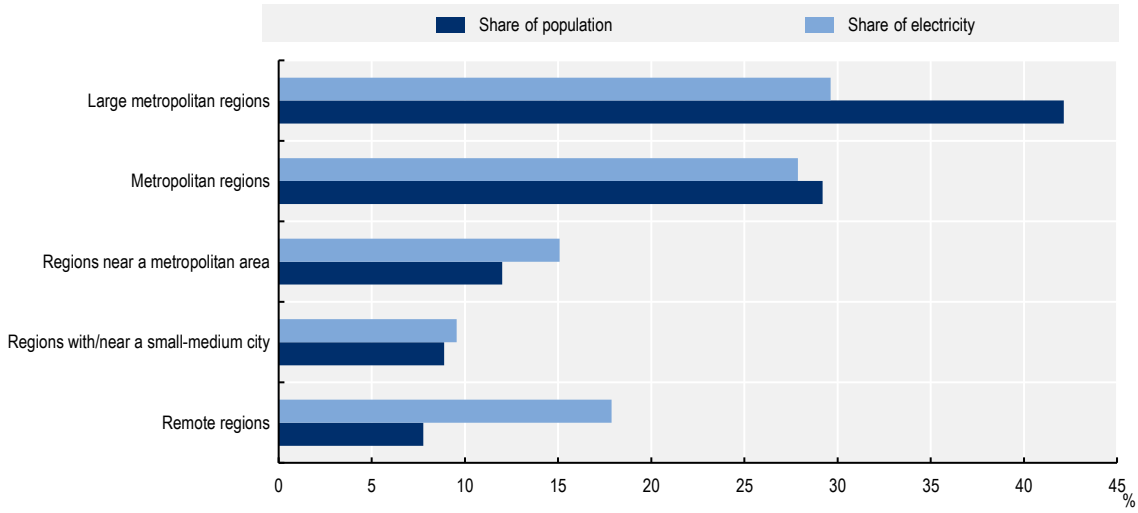
Source: IEA (2020[90]), *World Energy Outlook 2020*, https://dx.doi.org/10.1787/557a761b-en.

StatLink https://doi.org/10.1787/888934236817

These trends will have regional development implications for rural regions. Wind and solar installations are land-intensive. This is one reason why curtailing energy demand growth is important. In addition, shifting electricity generation towards intermittent renewables solar and wind will require a redesign of electricity markets, making room for flexibility in demand, coupled with extensive storage and high-resolution pricing of electricity over time and space. This may reinforce the comparative advantage of high-energy-use sectors in regions with high renewables supply, including the production of hydrogen as well as the production of synthetic fuels on the basis of hydrogen, which will play a crucial role in decarbonising sectors which cannot easily be electrified, such as in industrial applications, road freight, sea and air transport. Taking advantage of intermittent renewable electricity when it is abundant and can be produced at close to zero marginal cost also requires technology adoption, such as responsive charging of electric vehicles or heat pumps. While electricity market design is a central government level task, rural and urban regions can take steps to take advantage of cheap renewable electricity when it is the most abundant, as discussed in Chapter 4.

Figure 3.27. Remote regions, relative to their population, are larger producers of electricity

Contribution to total electricity production by type of region, small regions (TL3)



Note: Data for 2017.
Source: OECD (2020[88]), *OECD Regions and Cities at a Glance 2020*, https://doi.org/10.1787/959d5ba0-en.

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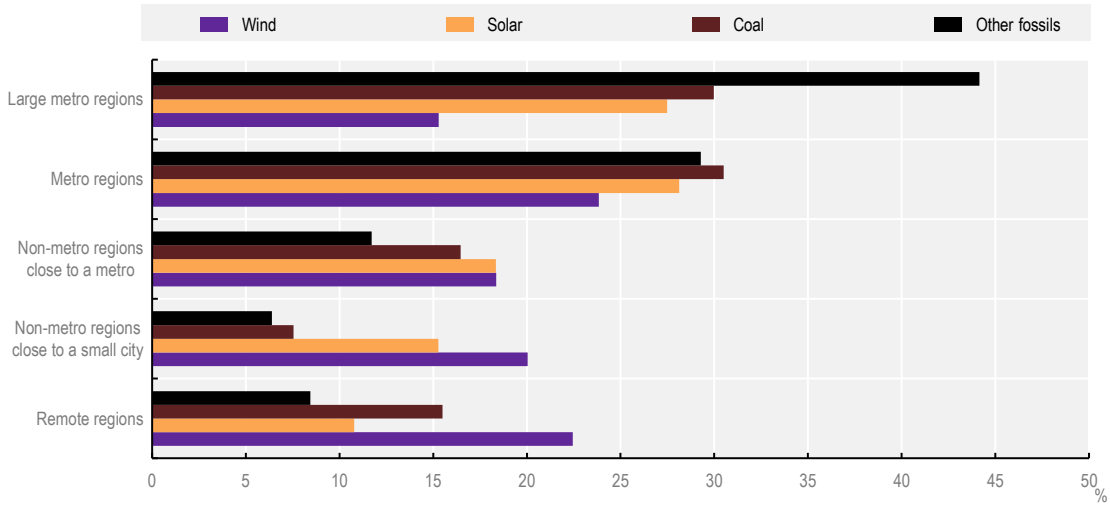
Figure 3.28. Rural regions contribute more to wind-powered electricity than large metro regions

Contribution to electricity production by energy source by type of region, small regions (TL3)



Note: Data for 2017.
Source: OECD calculations based on WRI (n.d.[91]), *Global Power Plant Database*, https://datasets.wri.org/dataset/globalpowerplantdatabase.

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Share of electric powered road motor vehicles

Individual passenger road transport is one of the final energy uses that will need to be decarbonised mostly through electrification, being the lowest cost option for light vehicles. According to the IEA SDS, OECD countries (European Union countries, Japan and the United States), as well as China, should fully phase out conventional car sales by 2040 (IEA, 2020[21]). The global stock of battery electric passenger vehicles should be 29 times the level it is today by 2030 (IEA, 2020[93]). To reach net-zero GHG emission targets by 2050, a phase-out date by 2035 at the latest would be needed. A more cost-effective date from the point of view of users would be 2030 (Climate Change Committee, 2019[2]), even without pencilling in the benefits of such a phase-out in terms of reduced CO_2 emissions, air and noise pollution. With an average useful life of 15 years, a full phase-out would be consistent with the share of electric cars rising by 7 percentage points every year. The roll-out of charging infrastructure is key to bring this about.

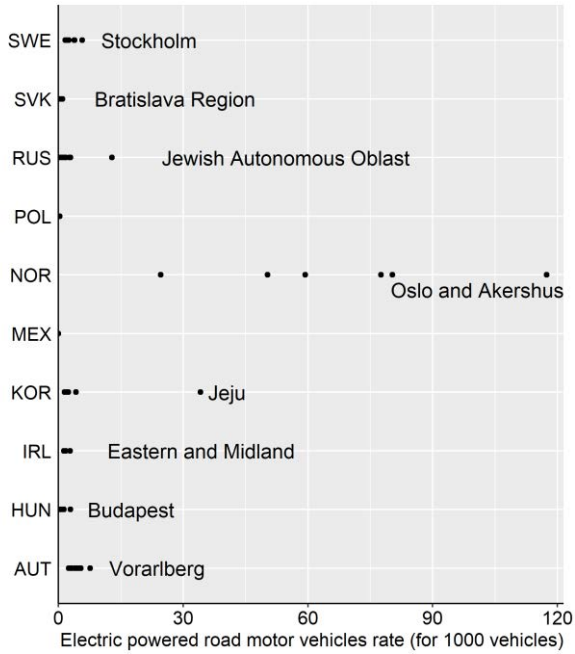
Few countries currently provide data on the number of electric vehicles. Norway, which currently is the only country in the world where the majority of new vehicles sales are electric (including battery and plug-in hybrid), has the most regions with the highest share of electric passenger vehicles. Oslo and Akershus is the only large region (TL2) with over 10% (Figure 3.29). In most regions, the share is below 1%. However, Germany, the Netherlands, the UK and the US are not included in the sample. In Korea, Jeju Island has a much higher share of electric vehicles in stock than any other Korean large region (TL2). Jeju's share grew faster because its regional government expanded its public charging infrastructure and offered incentives added to the ones provided by the national government (Kwon, Son and Jang, 2018[94]).

Electric vehicles are most common in medium-sized metropolitan areas, followed by remote rural regions. In Norway, electric cars (both full and hybrid) accounted for more than 40% of vehicle purchases in all small regions (TL3), rural and urban alike (Hall et al., 2020[95]). Electric vehicles already have lower operating costs than petrol-fired cars and purchase prices of electric vehicles are expected to fall. Reaches of new electric cars typically exceed 400 kilometres, covering almost all trips. Low operating cost makes electric cars particularly attractive for more intensive use in rural areas and shared use. As petrol tax revenues vanish, they will need to be placed with road use charging (OECD/ITF, 2019[96]). This offers the opportunity to charge higher charges in urban areas, where the external costs from vehicle use in terms of air pollution (including from tyres, also from electric vehicles), congestion and public space use are higher (OECD, 2018[97]), allowing rural regions to benefit from the low operating costs of electric vehicles.

To date, 17 countries have announced the phase-out of sales of cars with internal combustion engines (ICE) vehicles through 2050. France put this intention into law for 2040 (IEA, 2020[93]). Norway has the earliest phase-out commitment in 2025 including light vans. The UK will phase out ICE and hybrid cars by 2035. Some cities within countries with targets are setting additional targets. For example, London wants to phase out fossil fuel vehicles by 2025 (ICCT, 2020[98]).

Figure 3.29. Norway's capital region is miles ahead of any other OECD region

Number of electric vehicles per 100 vehicles, large regions (TL2), 2018



Note: Selection of European countries (Austria, Hungary, Ireland, Norway, Slovak Republic and Sweden) and Korea, Mexico and Russia.
Source: OECD Statistics.

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The best-documented well-being gains from the net-zero-emission transition are from lower air pollution

Policies towards net-zero GHG emissions can bring many benefits beyond halting climate change, which often accrues locally, and can therefore also serve to encourage local climate action (Box 3.8). Air pollution is among the greatest environmental health threats across the world. This is particularly true for cities, where the higher concentration of people, transport and economic activity compared to less dense areas make them more exposed to air pollution (OECD, 2020[88]; OECD, 2020[14]). The most relevant is exposure to fine particulate matter (PM2.5). Air quality is also a source of health resilience. Air pollution contributes to the airborne transmission of SARS-CoV-2 and a higher risk of mortality due to COVID-19 (Comunian et al., 2020[99]; Cole, Ozgen and Strobl, 2020[100]).

A large majority of the population in OECD countries is exposed to small particle pollution above the World Health Organization (WHO)-recommended threshold of 10 micrograms per cubic metre and virtually all populations in enhanced engagement countries (Figure 3.30). As pointed out in *Regions and Cities at a Glance 2020* (OECD, 2020[88]), most cities together with their commuting zones are on average exposed to PM2.5 above the threshold. South Asian functional urban areas (FUAs) have the lowest air quality. Air pollution has been on the rise in the last 10 years in low-middle countries and has fallen little in high-income countries.

Most air pollution results from the burning of fossil fuels in transport, industry and heating. In the EU, the highest PM2.5 concentrations are measured in stations close to urban contexts and in proximity to major roads (EEA, 2020[101]). Close to half of transport emissions comes from tyre use. In some countries, agriculture and the burning of waste also contribute significantly, for example through tilling and the burning

of agricultural waste. In some locations, in particular those exposed to desert winds, natural sources contribute too. Moving towards zero CO_2 emissions will reduce most air pollution. Reducing the circulation of cars (especially, but not only, fuel-fired cars) can also lower energy consumption, pollution (including from vehicle tyres) and congestion, while improved agricultural practices can reduce agricultural emissions from fertilisation, both with benefits for the zero-emission-transition.

In most OECD countries, all large TL2 regions have at least 25% of the population exposed to pollution above the WHO-recommended threshold (Figure 3.31). Some more coal-dependent economies, on the other hand, have more regions exposed to air pollution. Of the 23 regions where at least some population is exposed to 3.5 times the safe level of PM2.5, 13 are Turkish. By far the worst region in terms of air quality is Chile's most sparsely populated region Aysén. Regions with higher PM2.5 levels tend to have a lower average life satisfaction compared to their country's average.

Box 3.8. Key local well-being benefits from a zero-emission transition

Adopting policies that are consistent with achieving the Paris Agreement objectives and prioritise health, could annually save 6.4 million lives due to healthier diets, 1.6 million lives due to cleaner air and 2.1 million lives worldwide due to increased physical activity, compared to policies that follow the NDCs, which are not yet ambitious enough to be consistent with these objectives (Hamilton et al., 2021[102]).

Reduced air pollution

Small particulate matter (PM2.5) is the biggest cause of human mortality induced by air pollution. Outdoor particulate matter causes about 422 000 premature deaths in OECD countries every year, a number which has barely fallen over the last 30 years with an equivalent estimated welfare loss of around 3% of GDP. The marginal benefit of pollution abatement on reducing mortality is high at relatively low levels around and even below the WHO-recommended threshold of 10 micrograms (Roy and Braathen, 2017[103]). For regions and cities where small particle pollution is much higher, often in middle-income countries, zero-carbon policies are therefore attractive from a local well-being-perspective, with a need to reduce pollution substantially and sustainably, with expanding economic activity.

Major disease effects include stroke, cardiovascular and respiratory disease. Air pollution amplifies respiratory infectious diseases such as COVID-19. It affects children's health the most (WHO, 2018[104]). Education outcomes for young children exposed to higher air pollution are substantially and lastingly lower, even if exposure is temporary and even in a high-income region such as Florida in the US (Heissel, Persico and Simon, 2019[105]). Air pollution reduces worker productivity, reflecting illness and absence but perhaps also cognitive performance (Dechezleprêtre, Rivers and Stadler, 2019[106]). Worker productivity could be at least 5% higher if average exposure was below the WHO threshold: for example in Israel, productivity effects can be attributed to cognitive effects and illness. Air pollution also appears to contribute substantially to the incidence of old-age dementia (Bishop, Ketcham and Kuminoff, 2018[107]).

For instance, Schucht et al. (2015[108]) estimate at least 85% of mitigation costs are covered by co-benefits from decreased particle and ozone levels. An empirical analysis by Chapman et al. (2018[109]) of several active travel interventions (e.g. walking and cycling) in two provincial cities in New Zealand also shows clear parallel reductions in diseases and emissions, amounting to an 11:1 benefit-cost ratio.

Reduced noise pollution

Noise pollution, especially from transport, is a growing health risk. Persistent exposure to high levels of noise can have both physical and mental health consequences. The main health threats for which

causal associations have been found are cardiovascular disease, hearing and cognitive impairment, sleep disturbance, tinnitus and annoyance (WHO/JRC, 2011[110]). In addition, noise exposure has been found to affect patient outcomes and staff performance in hospitals as well as impair cognitive performance in schoolchildren (Basner et al., 2014[111]). Electric vehicles reduce noise especially at modest speeds when motor noise dominates noise from movement. Moving to active mobility and urban transport in cities can also reduce noise.

In the EU, at least 20% of the population are exposed to harmful levels of traffic noise. Chronic exposure to noise levels above the WHO standard causes 12 000 premature deaths per year worldwide and contributes to 48 000 cases of ischaemic heart disease. In addition, 6.5 million people suffer from chronic high sleep disturbance and 22 million people from "prolonged high levels of annoyance" due to noise pollution from transport or industry (EEA, 2020[112]).

Traffic congestion

The cost of traffic congestion includes time loss as well as productivity losses from higher costs in the exchange of goods and services, especially within highly productive FUAs. The productivity impact of congestion is magnified because productivity is intermediate service, affecting productivity in all sectors where transport is an input. Congestion hinders the region's economic and social development, raises the cost of doing business and makes it harder to attain environmental goals. Costs in high-income economies are estimated: for example 1% is usually cited for the average cost of congestion in Europe and between 0.7% and 0.9% in the US. However, cities in middle-income countries appear to be substantially more congested. Congestion is increasing in most cities.

Healthier diets

The EAT-Lancet Commission on Food, Planet, Health (2018[113]) recently reported that reaching a healthy diet globally would require dividing the global consumption of red meat (beef, lamb and pork) by nearly three (more than six in North America). A change in dietary patterns would also mitigate climate change through two distinct channels: first, it would reduce direct emissions from animals; second, it would ease pressure on land use, since a large proportion of crops are grown to feed livestock. In its report on climate change and land (IPCC, 2019[8]), the IPCC estimates that changing diets have a major GHG reduction potential.

Active mobility

It is estimated that if all Londoners walked or cycled for 20 minutes a day, public health spending could be close to 0.1% of GDP lower and add 60 000 years of healthy life per year thanks to prevented illness and early death. Typically, policies that encourage active mobility also increase road safety, as it is safer roads that encourage walking and cycling.

Thermal insulation

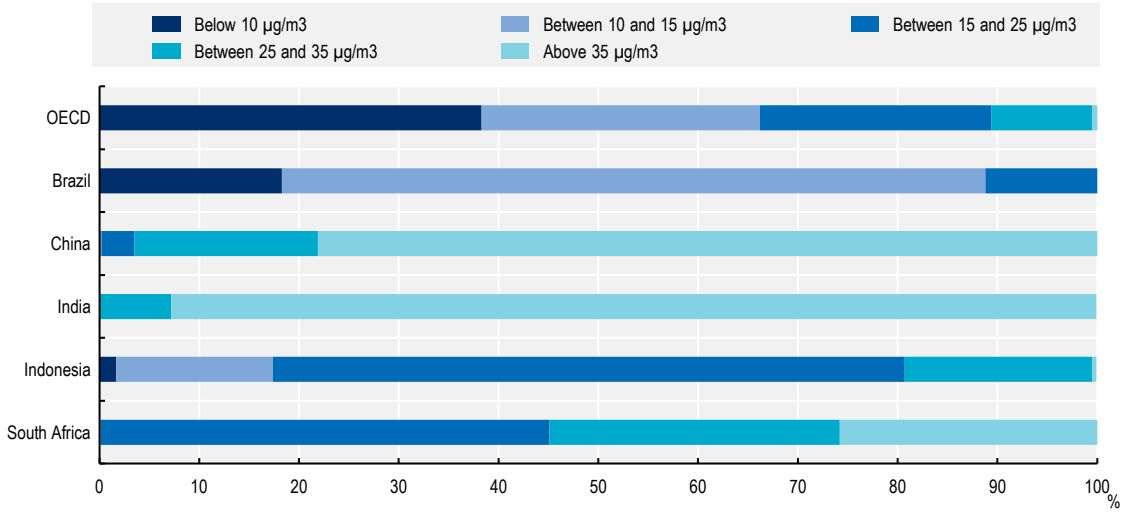
Health benefits of building energy efficiency investment subsidies in New Zealand have been estimated to pay off the costs alone, even with high discount rates (Grimes et al., 2012[114]). In the presence of energy poverty, the health benefits of loft insulation have been estimated to exceed the costs by a multiple and be almost equal to the cost for wall insulation (Frontier Economics, 2015[115]). However, if thermal insulation employs toxic materials or leads to poor ventilation, it can also result in health costs.

Improved water, soil and biodiversity protection

Reducing fertiliser use could result in reduced nutrient runoff and water pollution, leading to healthier aquatic ecosystems. It also reduces ammonia volatilisation, which participates in the formation of particulate matters and therefore improves air quality. Low-emission farm practices which strengthen CO_2 sinks also protect biodiversity.

Figure 3.30. Most population in OECD and BRIICS countries is exposed to air pollution above the WHO-recommended threshold

Percentage of the population exposed to a certain level of PM2.5, 2019



Note: OECD countries, Bulgaria and Romania. BRIICS: Brazil, Russia, India, Indonesia, China and South Africa.
Source: OECD Statistics.

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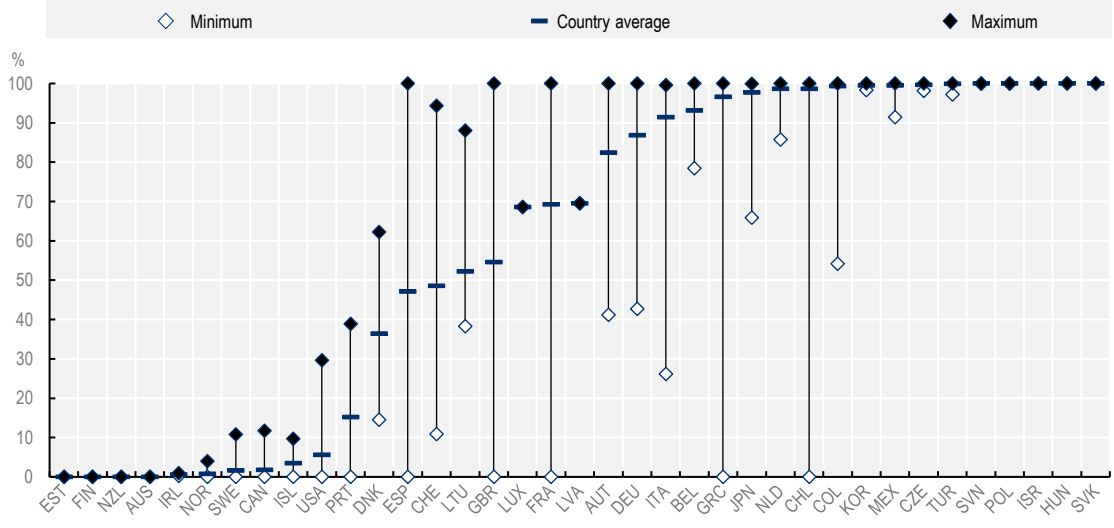
Figure 3.31. In most OECD countries, all large regions have at least 25% of the population exposed to pollution above the WHO-recommended threshold

Percentage of the population exposed to above 10 µg/m3 PM2.5, large regions (TL2), 2019



Note: OECD countries, Bulgaria and Romania.
Source: OECD Statistics.

StatLink https://doi.org/10.1787/888934236912

Employment risk from the transition appears limited

The transition to net-zero emissions will bring economic restructuring. Some sectors will shed employment. Others may be transformed substantially. This section provides an economic analysis of such risks. It uses employment data only, as regional value-added data are not available at a sufficiently detailed sectoral level. An OECD general equilibrium model, ENV-Linkages, is used to identify employment impacts across sectors of economic activity that would result from the IEA SDS, which describes an emissions pathway consistent with the Paris Agreement.

Employment data for subnational regions are only available for broad, two-digit economic sectors. The data allow identifying future regional sectoral employment in a few cases with precision but only in a few sectors, notably employment in the extraction of coal. For example, the data do not allow to distinguish employment in renewable electricity generation, which will increase, from employment in fossil fuel electricity generation, which will fall. In any case, electricity generation employs few workers. The analysis below considers employment in sectors where general equilibrium modelling suggests some employment loss will occur. These sectors may however also include activities that may not lose employment. Conversely, it may not include employment in activities that may lose employment, if these activities are in sectors in which some activities may experience employment gains (Box 3.9). Moreover, local employment risks differ depending on production costs. For example, as decarbonisation is expected to depress oil prices, production will disappear first in those regions where extraction costs are highest. In these regions, the stranded asset risk from investment in these activities is highest. Regional policymakers in member countries need more precise data to assess place-based employment at risk.

Box 3.9. The impact of the net-zero carbon transition on regional employment: Methodological approach

The selection of sectors where regions are experiencing (both direct and indirect) employment losses as economies move towards net-zero GHG emissions is based on a simulation with the OECD ENV-Linkages model. However, the sectoral employment data is only available for the large OECD TL2 regions and the sectoral data available for these regions is coarse. The selected sectors are therefore broader than those identified in ENV-Linkages.

OECD ENV-Linkages is a dynamic general equilibrium model that allows illustrating economic impacts of climate mitigation policy scenarios several decades into the future, linking activity and employment to GHG emissions (Château, Dellink and Lanzi, 2014[116]). This *Regional Outlook* report uses sectoral employment outcomes of a scenario that allows the goals of the Paris Agreement to be reached, following the IEA SDS. It compares employment in this scenario with employment in a baseline scenario of no further climate policies. Table 3.1 shows sectors that lose at least 3% of employment in OECD countries by 2040. This is the threshold chosen to identify sectors with regional employment risks. Employment changes in the EU (EU17) and individual economies, such as Canada, Japan and the US, are largely similar to those of the OECD as a whole. In some cases, the reduction in employment due to the zero-carbon transition is not as large for the OECD as a whole but exceeds 6% in EU17, Canada, Japan or the US. Based on this criterion, air and water transport and manufacture of other transport equipment were also included.

Matching sectoral modelling outcomes to available regional data results in a broad classification of employment risks

Regional employment data covering a selection of OECD countries is only available for broad two-digit sectors in the International Standard Industrial Classification of All Economic Activities (ISIC). These are considerably less granular than the Global Trade Analysis Project (GTAP) sectors in the

ENV-Linkages model. Unlike GTAP data, they are also not defined for the purpose of climate policy analysis.

Table 3.1. Employment changes from worldwide emission reductions consistent with the Paris Agreement, by sector

Deviation of sectoral employment from baseline in 2040, in percentages

Economic sectors	OECD	EU17	United States	Canada	Japan
Coal powered electricity	-88	-89	-89	72	-90
Coal extraction	-74	-80	-86	-35	-100
Gas powered electricity	-45	-40	-41	-69	-59
Natural gas distribution	-30	-27	-37	-49	-10
Natural gas extraction	-30	-24	-37	-29	0
Oil powered electricity	-28	52	18	65	-64
Petroleum and coal products	-21	-32	-30	-17	-27
Electricity transmission and distribution	-7	-1	-6	-17	-15
Secondary zinc, lead, gold and silver production	-6	-13	-6	2	-9
Fibre crops	-5	-3	1	-7	-4
Other crops (forage products, plants used in perfumery or for insecticidal purposes, etc.)	-5	-7	1	-6	-3
Primary aluminium production	-4	-5	-6	3	-7
Secondary aluminium production	-4	-5	-6	2	-6
Primary copper production	-4	-5	-6	0	-6
Primary zinc, lead, gold and silver production	-4	-4	-6	1	-6
Mining of metal ores; other mining and quarrying	-4	-4	-3	-7	-7
Secondary copper production	-4	-4	-5	-1	-5
Textiles	-4	-5	-3	-5	-4
Maize, sorghum, barley, rye, oats, millets, other cereals	-3	-5	-3	-6	-1
Oil seeds and oleaginous fruit	-3	-7	-1	-5	-1
Electronics	-3	-1	-5	-5	-4
Chemicals, rubber, plastic products	-3	-7	-1	-11	-1
Secondary iron and steel production	3	8	2	4	3
Crude oil extraction	11	30	11	9	51
Solar power	74	69	142	61	70
Other power (biofuels, waste, geothermal, tidal technologies)	75	61	113	21	95
Wind power	78	45	141	39	323

Source: OECD calculations based on the ENV-Linkages model; Bibas, R., J. Chateau and E. Lanzi (2021[117]), "Policy scenarios for a transition to a more resource efficient and circular economy", https://doi.org/10.1787/c1f3c8d0-en.

Most GTAP sectors correspond to three- or four-digit ISIC sectors, which are more granular than two-digit sectors. The chosen two-digit ISIC sectors therefore often also include employment the modelling does not identify as being subject to employment loss. In a few cases, two-digit ISIC sectors include GTAP sectors with both gains and losses. In these cases, potential employment losses cannot be taken into account. This applies in particular to employment in fossil fuel-fired and renewable electricity generation which are part of a single two-digit ISIC sector ("electric power generation, transmission and distribution"). Moreover, sectoral employment risks can differ across regions for other reasons that cannot be taken into account. For example, climate mitigation policies should depress fossil fuel prices, resulting in the phase-out of production in those regions first where production cost is highest.

Overall, the two-digit ISIC sectors identified as being at risk of employment losses due to the net-zero carbon transition include: Mining of coal and lignite; Other mining and quarrying; Manufacture of textiles; Manufacture of coke and refined petroleum products; Manufacture of chemicals and chemical products; Manufacture of rubber and plastics products; Manufacture of other transport equipment; Water transport; Air transport. The petrochemical sectors contain most of the employment in sectors likely at risk of employment losses due to the net-zero carbon transition in OECD and partner countries: 32% of employment in sectors at risk is employed in the manufacture of rubber and plastics products and 20% is employed in the manufacture of chemicals and chemical products.

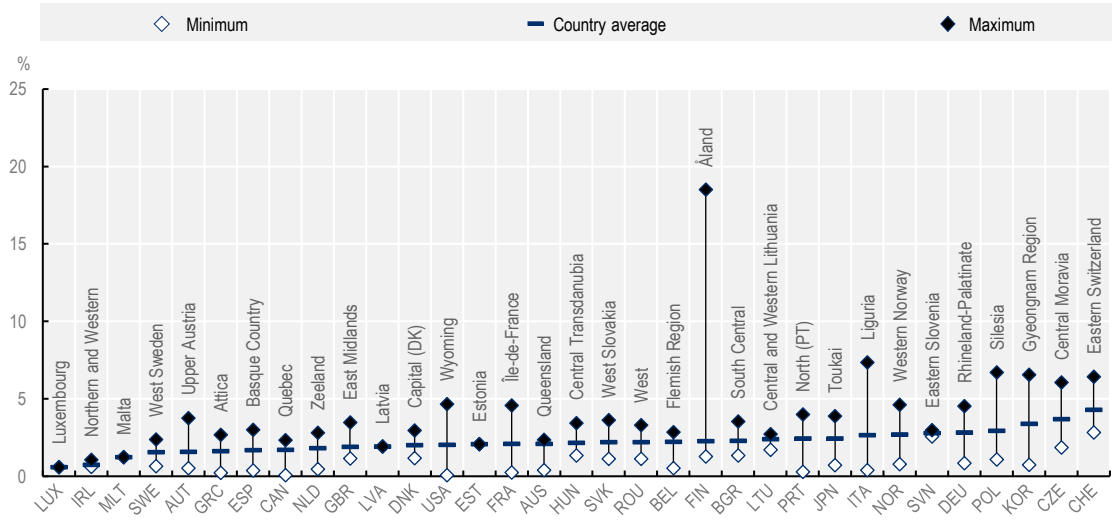
Data are available for the large regions (TL2) in 30 OECD member countries and 3 partner countries (Bulgaria, Malta and Romania). The OECD countries that are not currently included are Chile, Colombia, Iceland, Israel, Mexico, New Zealand and Turkey. For all countries except Australia and Japan, the data is for 2017. For Australia, the data is from 2019 and for Japan, the data is from 2016.

There will be both employment losses and gains due to the net-zero transition. Relative employment gains are estimated to be the largest in renewable power production and recycling of materials (Box 3.9, Table 3.1). Policies to promote renewable energy and other low-carbon activities will create demand for new service jobs (Rydge, Martin and Valero, 2018[118]). Overall, renewable energy is expected to be more employment-intensive than the fossil-fuelled energy it replaces (EC, 2018[25]). Other employment gains may come from the electrification of passenger vehicles and from early-stage innovation to diffusion for example (Unsworth et al., 2020[119]). Employment gains from the transition are difficult to project at the regional level. In any case, they may not coincide with the spatial distribution of employment losses, Employment losses are regionally concentrated and thus need place-based policies to ensure that no region is left behind. Policies to avoid regional decline and ensure a just transition for workers and local communities are discussed in Chapter 4.

Only 2.3% of employment is in sectors that are at risk of some employment loss across all countries included in the analysis. This is in line with earlier analysis, which indicates that decisive climate policy produces modest sectoral reallocation in comparison to historic sectoral job reallocation patterns (OECD, 2017[26]), although the two-digit sectoral data suggest that the Czech Republic, Germany, Korea, Poland and Switzerland might be hit slightly harder. Not a single country for which data are available has more than 4.5% of employment in sectors that on average are most at risk of employment loss. The Czech Republic, Finland, Italy, Korea, Poland and Switzerland all have at least 1 riskier region where more than 5% of employment are in sectors at risk of employment losses (Figure 3.32).

Figure 3.32. Few countries have regions with over 5% of employment in sectors at risk of employment losses due to the net-zero carbon transition

Share of employment in sectors with employment at risk, large regions (TL2), 2017



Source: OECD Statistics.

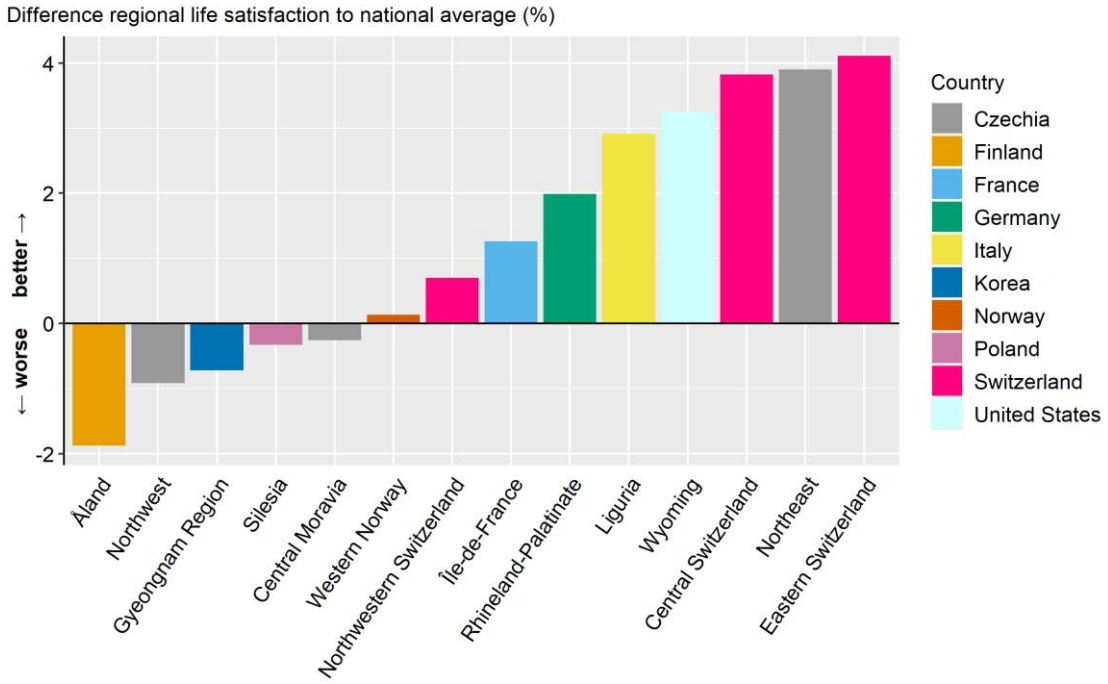
StatLink https://doi.org/10.1787/888934236931

At 18%, Finland's Åland Islands are by far the large region (TL2) with most employment in sectors at risk. This region is small in population. Italy's Liguria and Poland's Silesia follow with 7%. In Liguria, most are in water transport and some in the manufacture of other transport equipment. In the Polish region of Silesia, more than half of employment in sectors at risk is from employment in the mining of coal and lignite, and a quarter from employment in the manufacture of rubber and plastics products. Further, Korea's second most populous region, Gyeongnam, and Eastern Switzerland have 6.5% of their employment in industries at risk of employment losses. For the former, about half is in the manufacture of other transport equipment, while for the latter, it is concentrated in the manufacture of chemicals, rubbers and plastics. Finally, the Czech Republic has 3 regions with over 5% of employment in industries at risk of employment losses, mostly in the manufacture of rubber and plastic products. Its Northwest region also has substantial employment in the mining of coal and lignite. Some major regions stand out compared to their national average. For example, Île-de-France has the highest employment in sectors at risk in France. This includes mostly employment in the manufacture of other transport equipment, chemicals and chemical products. The estimations consider the sectors of employment only and not the occupations of workers. Headquarters of, for example, large petrochemical companies are often in capital regions. This explains the larger measured share of employment at risk in Île-de-France. In Germany's Rhineland-Palatinate, about 90% of employment at risk is in the manufacture of chemicals, chemical products, rubber and plastic products.

The regions with the highest shares of employment (over 4.5%) in industries at risk of employment loss are not generally regions with lower life satisfaction (Figure 3.33) or income (Annex Figure 3.A.4), nor do they significantly differ in terms of long-term unemployment rates or poverty risk, as the country notes will show. Thus the regions are not generally in a position which would make them particularly vulnerable to adverse regional developments that could result from structural change. However, some of these regions do have higher poverty risks and higher long-term unemployment and are well worth identifying. For example, for the three coal-mining regions in the Czech Republic, all are regions with a lower GDP per capita. By contrast, the Polish region has a GDP per capita higher than the national average.

Figure 3.33. Life satisfaction of regions with the highest share of employment in sectors at risk is not necessarily lower than the national average

Relative difference to country means (in %), large regions (TL2) with over 4.5% of employment in sectors at risk



Source. Gallup World Poll, 2014-18.

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Employment in coal mining and agriculture is often in regions with lower GDP per capita

According to the IEA Sustainable Development Scenario (SDS), coal in OECD countries will contribute less than 3% of the primary energy supply by 2040. The shares of oil and gas will also decline, though more gradually (IEA, 2020[90]). Employment in these sectors is at most about 1% of national employment. Employment in coal, oil and gas extraction and refining is above 4% in Alberta in Canada as well as in Agder and Rogaland in Norway and Wyoming in the US (Figure 3.34).

Countries analysed include Australia, Canada and the US, which are among the leading coal, oil and gas exporting countries in the world, as well as Poland. Regional employment in coal mining exceeds 1% in OECD large regions (TL2) only in the Northwest in the Czech Republic, Silesia in Poland, South-West Oltenia in Romania and West Virginia and Wyoming in the US (Figure 3.35). The Polish region of Silesia has 67 000 employees in coal mining, followed by Germany's North-Rhine Westphalia with 13 000 workers. However, within large regions, employment at risk can be further concentrated in subregions and communities. For example, in Lesser Poland, coal mining employment is in the small region (TL3) of Oświęcimsk (ESPON, 2020[120]). Countries where regions employ more workers in coal mining have committed to later coal phase-out dates in electricity generation or have not yet committed to a phase-out (Figure 3.36).

Regions with a relatively large share of the population employed in coal mining tend to have a lower per capita GDP compared to the national average (Figure 3.37). However their position is less unfavourable when looking at household income. Indeed, the negative relation is less clear with respect to equalised disposable household income. Regions with employment in coal do not systematically differ from other regions in their respective countries in terms of average life satisfaction or long-term unemployment,

though in a few countries, some regions with coal employment have more poverty, as the country notes show. Regions with oil and gas employment are not statistically different in terms of GDP per capita, relative poverty, long-term unemployment and life satisfaction.

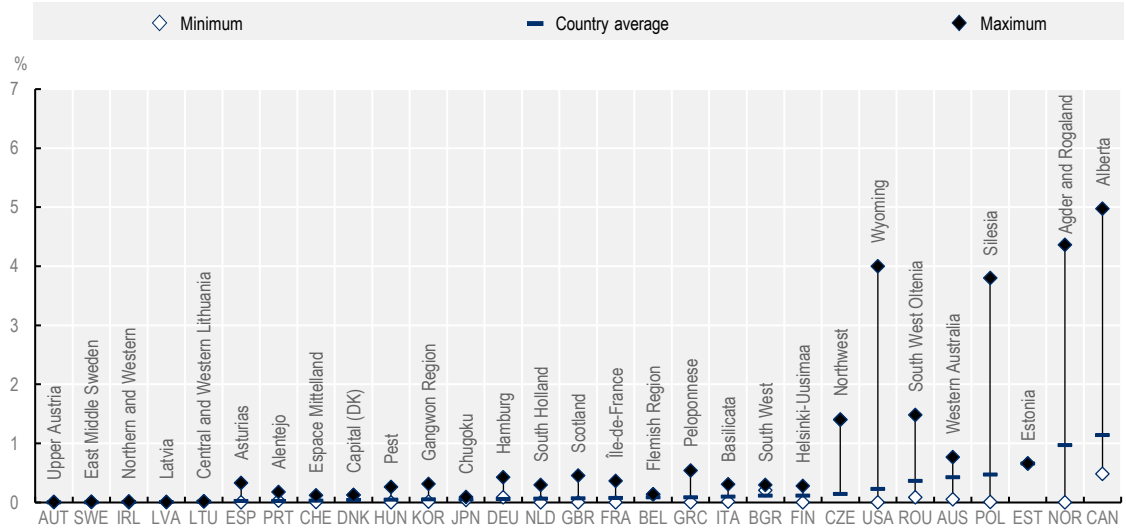
While agriculture is not a sector that can be broadly identified as being subject to employment risks, it will be subject to important transformations, for example with respect to agricultural practices to reduce fertiliser use and carbon sequestration, including through afforestation. An avenue for climate change mitigation is from consumption habits with lower emission footprints, shifting diets away from meat and milk products of ruminant animals in high-income countries and reducing food waste (OECD, 2019[121]). These would result in health benefits but would impact related food production, especially likely so in high-cost regions. Employment in agricultural activities is very limited in OECD countries. Regions in Greece, and to a lesser extent in Australia and Finland, have higher employment shares. Ten Greek regions have over 10% of their employment in agricultural activities.[2] Moreover, these regions represent 60% of its population. However, these regions also have the lowest per capita emissions related to agriculture among OECD countries with high employment in this sector. Hence, their transition risk is likely limited.

For regions where more than 2% of employment is in crop and animal production, hunting and related service activities, GDP and household income per capita tend to be lower than the national average (Figure 3.38) although the differences are not always statistically significant. Relative poverty[3] is often higher in regions of Australia and Finland but not in Greece (Figure 3.39). There is no systematic difference in life satisfaction and unemployment. In any case, GHG emissions appear to be low in Greek regions but are substantial in Australian regions, suggesting that employment risks in Australia are higher.

Colombia, Ireland and New Zealand have a relatively large proportion of national employment in agricultural activities but regional employment data is not currently available. They also tend to have higher per capita emissions related to these activities, especially New Zealand – indicating a higher transition risk. Within these three countries, regions with higher agricultural emissions per capita are not poorer in terms of GDP per capita, disposable household income and relative poverty.[3] However, in New Zealand in particular, regions with higher agricultural emissions per capita do tend to be poorer regions (Figure 3.40). These regions tend to have lower disposable income and higher relative poverty. In Ireland, we find that the regions with the highest emissions per capita also have a lower disposable income.

Figure 3.34. Employment in coal, oil and gas extraction and refining sectors is at most about 1% of national employment

Share of employment in the mining of coal and lignite, and oil and gas extraction and refining, large regions (TL2), 2017



Source: OECD Statistics.

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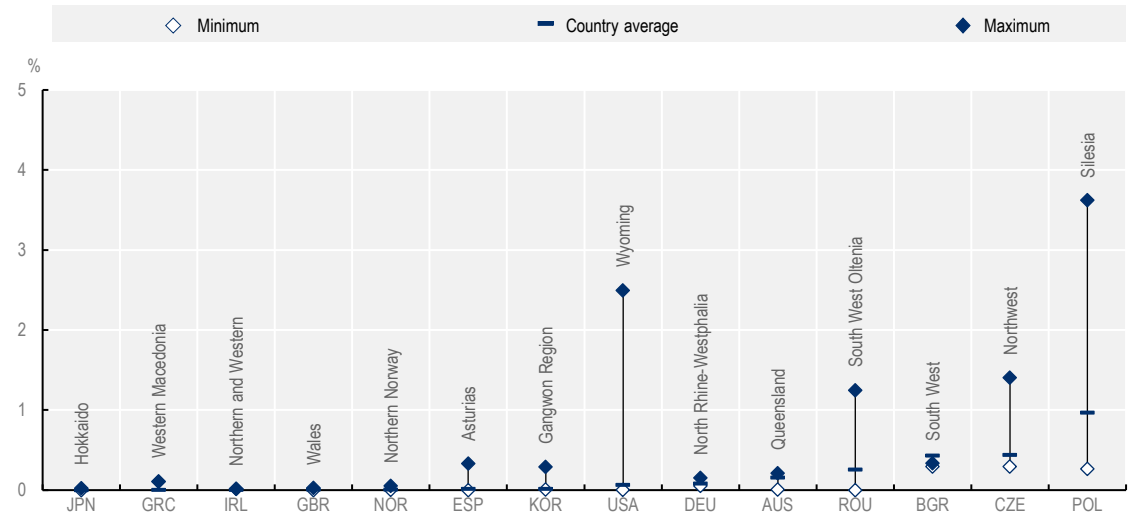
Figure 3.35. Regional coal mining employment exceeds 1% only in Northwest Czech Republic, Silesia, South-West Oltenia, West Virginia and Wyoming

Share of employment in the mining of coal and lignite, large regions (TL2), 2017

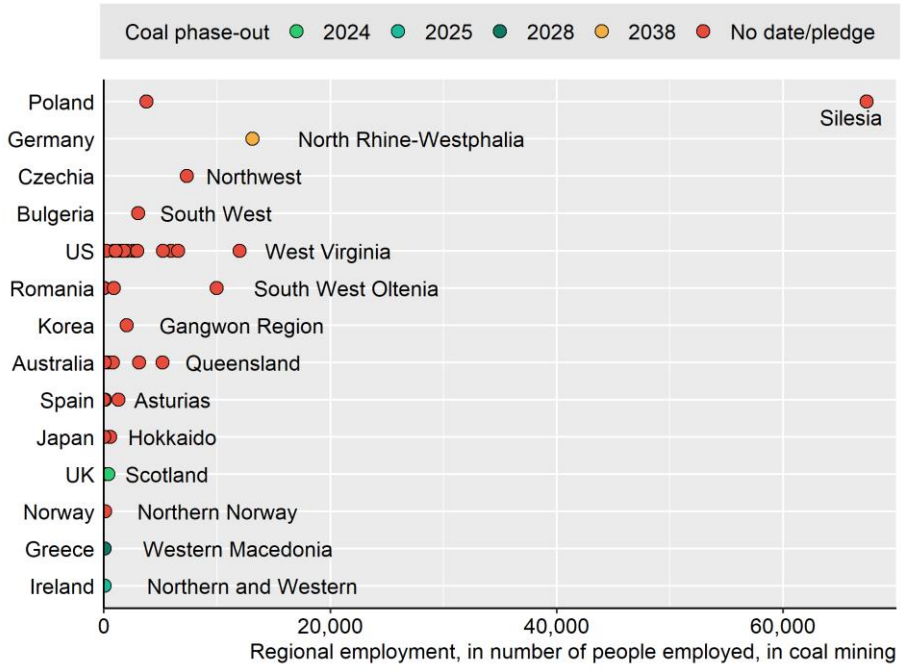


Source: OECD Statistics.

StatLink https://doi.org/10.1787/888934236988

Figure 3.36. Countries with more coal mining employment have no or later coal phase-out dates in electricity generation

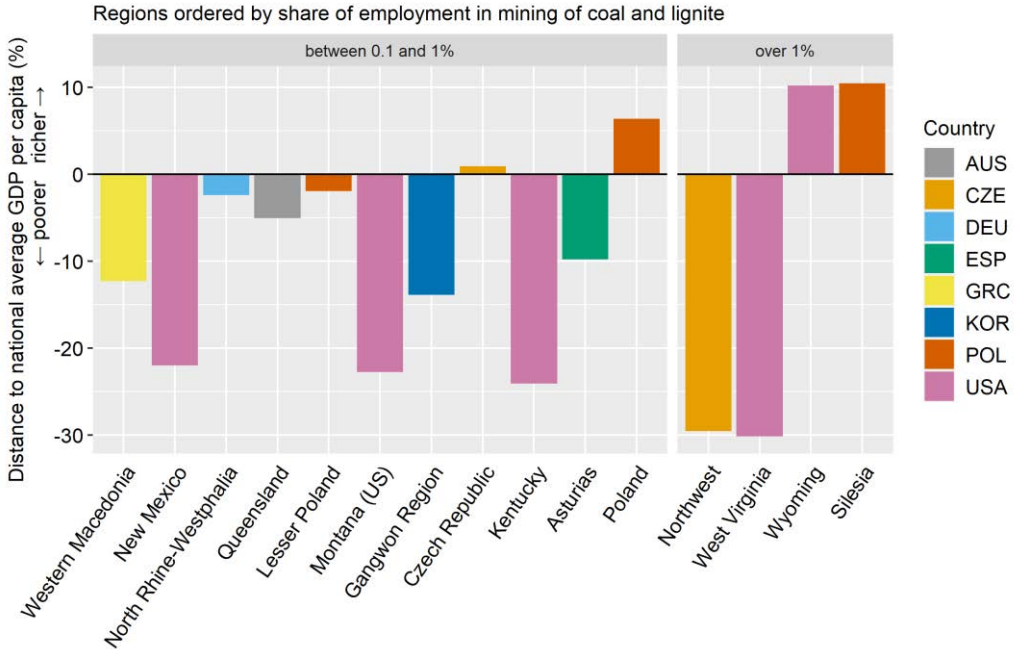
Share of employment in the mining of coal and lignite and coal phase-out pledge date, large regions (TL2), 2017



Source: OECD Statistics and Powering Past Coal Alliance.

Figure 3.37. Regions with the highest shares of the population employed in coal mining tend to have a lower per capita GDP compared to the national average

Relative difference to country means, large regions (TL2)

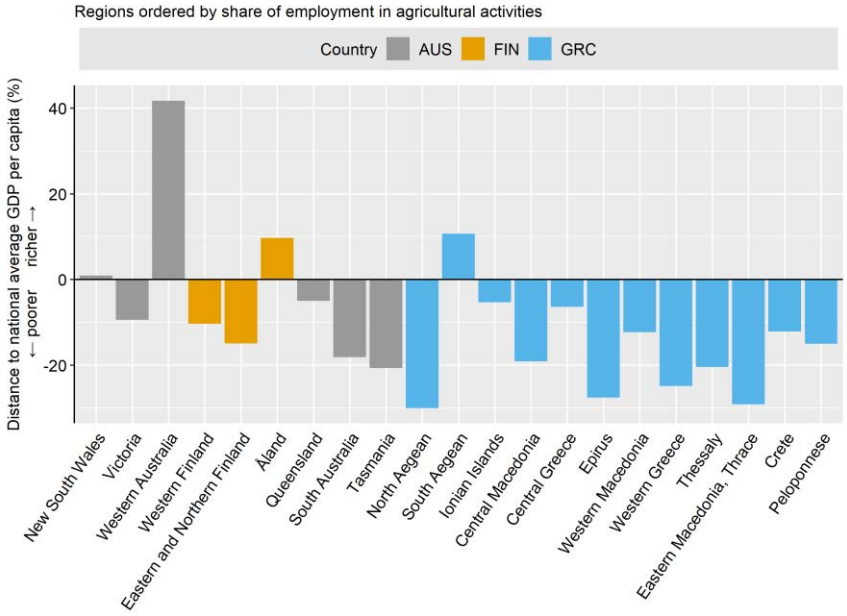


Note: Data for 2018 or most recent year available, no data for Bulgaria and Romania, GDP per capita is USD per capita, PPP, prices from 2015.
Source: OECD Statistics.

StatLink https://doi.org/10.1787/888934237007

Figure 3.38. Some regions with over 2% employment in agriculture have lower GDP per capita than the national average

Relative difference to country means, large regions (TL2) with over 2% of employment in agriculture



Note: Data for 2018 or most recent year available, GDP per capita is USD per capita, PPP, prices from 2015. Agriculture is defined as crop and animal production, hunting and related service activities.
Source: OECD Statistics.

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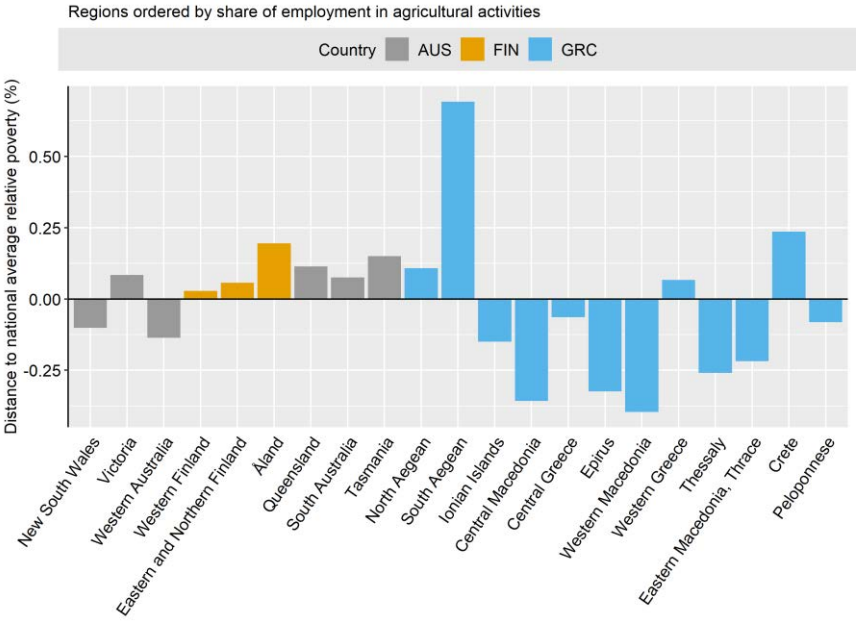
Figure 3.39. Poverty is often higher in regions with over 2% of employment in agriculture in Australia and Finland but not in Greece

Relative difference to country means, large regions (TL2) with over 2% of employment in agriculture

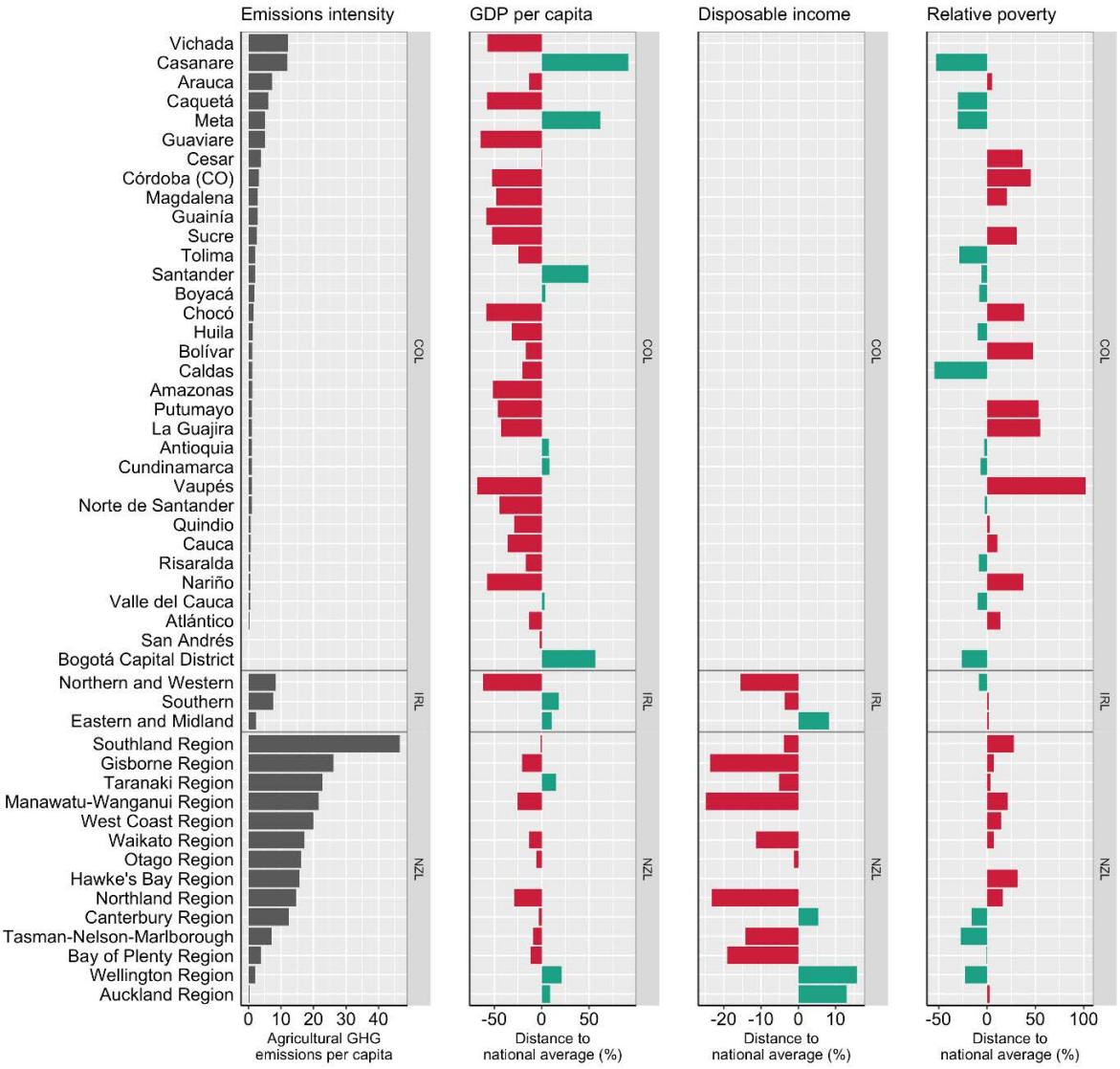


Note: Data for 2018. Agriculture is defined as crop and animal production, hunting and related service activities.
Source: Gallup World Poll, 2014-18.

StatLink https://doi.org/10.1787/888934237045

Figure 3.40. In New Zealand in particular, regions with higher agricultural emissions per capita do tend to be poorer regions

GHG emissions from agriculture per capita and relative difference to country means for GDP per capita, disposable income and relative poverty, large regions (TL2) in Colombia, Ireland and New Zealand, 2018 (or latest available data year)



Source: OECD calculations based on EC (2020[84]), *EDGAR - Emissions Database for Global Atmospheric Research*, Joint Research Centre, European Commission; Gallup World Poll, 2014-18; OECD Statistics.

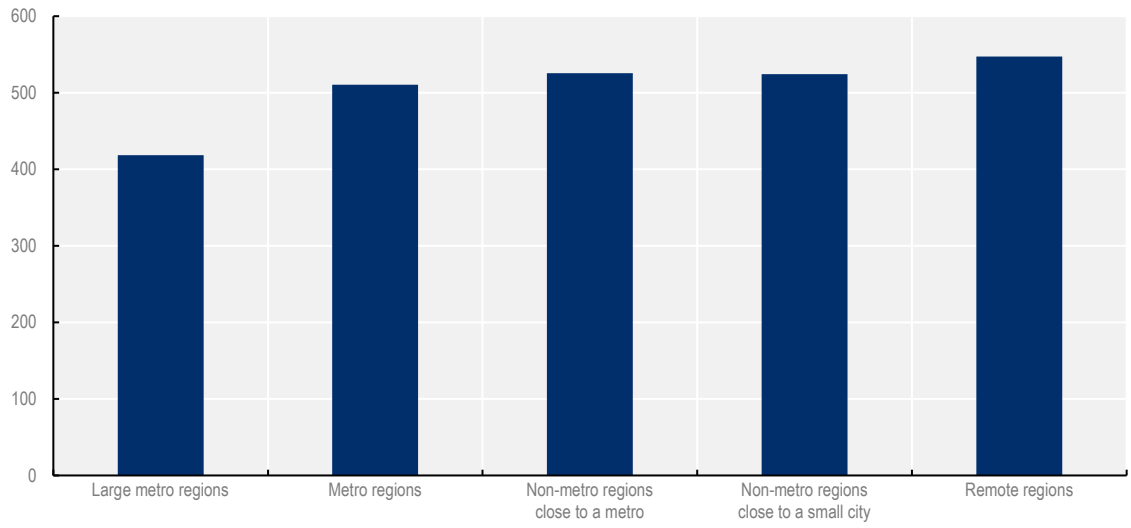
Rural regions and poorer metropolitan areas are more car-dependent

Transitioning to a net-zero GHG emission economy requires a shift away from fossil-fuel-powered cars. Governments may decide to implement policies to move to zero-carbon cars and reduce car use. The latter can offer additional benefits, notably lower energy consumption, a bigger reduction in air pollution, lower traffic congestion, more room for active mobility and other use of urban space taken up by cars. Regions with high use of fuel-powered cars are more sensitive to potential costs and perhaps also to the benefits. Traffic congestion, air pollution from traffic and space constraints are less important in remote rural regions,

however. More rural regions tend to be more car-dependent (Figure 3.41). Policies to price fossil-fuel-fired cars out of use would have strong welfare consequences among car-dependent communities, where the elasticity of car use with respect to the price is low. Compensation would have to be precisely targeted but the low operating cost of electric cars can make their phase-in attractive.

Figure 3.41. Rural regions are more car-dependent

Average number of private vehicles per 1 000 inhabitants by type of region, weighted averages of small regions (TL3)



Note: Latest available data year from 2010 onwards, for 24 OECD countries. Definitions of private vehicles differ across countries. For example, the EU defines passenger vehicles as vehicles "designed...for the carriage of passengers and not exceeding eight seats". The US, on the other hand, defines passenger vehicles primarily based on weight. Consequently, sport utility vehicles (SUVs) are not classified as passenger vehicles, although they are often used this way in the US. Hence, if it were included, US rates would be higher.
Source: OECD Statistics.

StatLink https://doi.org/10.1787/888934237064

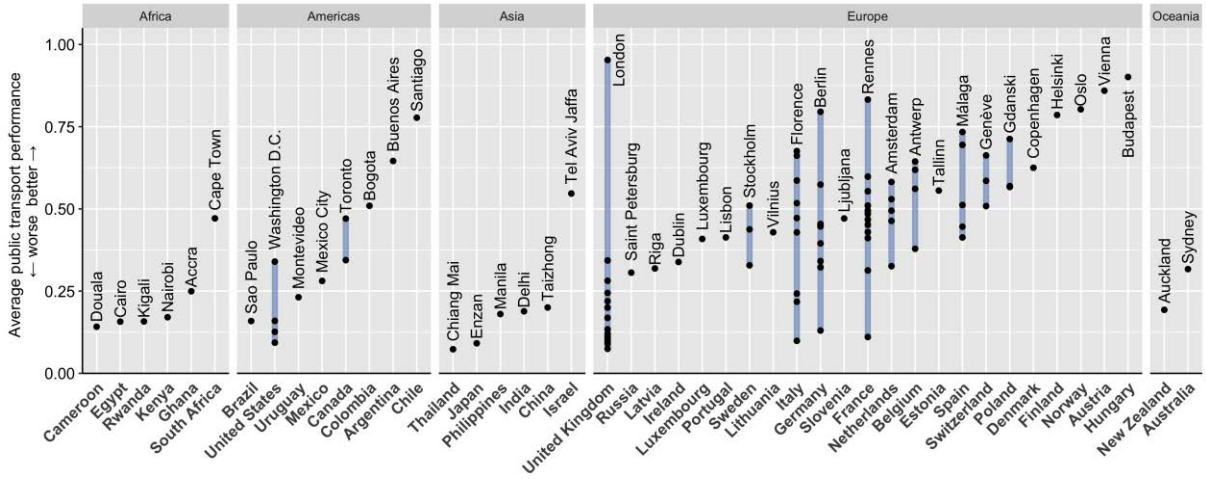
Public transport performance needs large improvements to encourage a modal shift

A shift to public transport and active mobility needs to be part of the net-zero GHG emission transition. Additional to electrifying light transport in general, a shift away from cars towards public transport and active mobility can ease the transition by reducing energy demand and the infrastructure needs related to electrification. It can also provide substantial well-being benefits from reduced congestion, air and noise pollution, increased safety and public space, as well as health benefits from active mobility. It can even reduce pollution when road transport is entirely decarbonised, as particles of rubber from tyres are currently responsible for nearly half of road transport particulate emissions.

Across countries, public transport performance is typically higher in European and South American FUAs, which include cities and their surrounding commuting areas (OECD/EC, 2020[40]). Public transport performance measures how well it gets people to destinations (Box 3.10). Within-country comparison of cities is currently only possible for Europe and to some extent North America (Figure 3.42). In Europe, variances in performance within-country are large, especially in the UK. This may allow setting benchmarks and improve performance in cities with poor public transport performance.

Figure 3.42. Where within-country comparison is possible, regional differences in public transport performance are clearly large

Public transport performance, 30 minutes/8 km, 2018



Sources: OECD Statistics and International Transport Forum.

Box 3.10. Defining public transport performance

Public transport performance measures the ratio between accessible destinations within a certain distance and nearby destinations for different transport modes within a set period of time. The destinations can be facilities, schools, hospitals or other people. In this report, the chosen destination is other people. The indicator captures many aspects of the effectiveness of a transport mode in providing access to destinations. For example, public transport performance depends among other things on how many people live close to a stop, the frequency and the speed of public transport vehicles and the design of the network (ITF, 2019[122]). Analysis in this section is based on 30 min/8 km. The index reaches one when all destination within 8 km can be reached within 30 minutes. When more people can be reached than are proximate, the ratio will be larger than one. If fewer people can be reached in 30 minutes than are proximate in an 8 km radius, the ratio will be between 0 and 1.

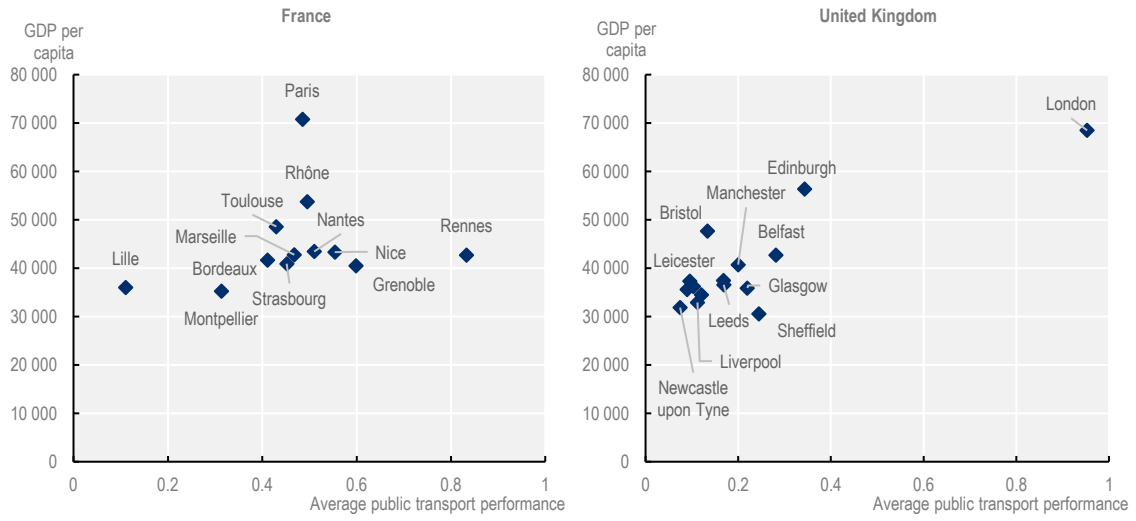
Smaller cities are less prepared to follow a decarbonisation pathway via modal shift. Public transport performance tends to be higher for larger cities, in terms of population, in each country. This is especially true for most of the large capital cities. While mass transit can be deployed with more frequent service and lower cost in denser cities (ITF, 2019[122]), currently, denser cities are not more likely to have a higher public transport performance in all countries. Cities with a lower GDP per capita tend to have a worse public transport performance score in some countries, such as in France and the UK, and are thus more car-dependent. This suggests national policies are needed to improve public transport in the poorest cities. It may also reflect higher productivity performance in cities as a result of better public transport performance (Figure 3.43).

FUAs with better accessibility by car than by public transport are likely to need more investment to achieve modal shift. For all FUAs except London, accessibility is better by car than by public transport (Figure 3.44). For the vast majority, taking the car even offers twice the level of accessibility. London has both the best public transport and worst car performance accessibility in Europe. This is a consequence of legacy

decisions against building express roads through central London and more recently deliberate policies to reallocate road space to public transport and cycling (ITF, 2019[122]). London also has developed a system to measure the accessibility of residents to jobs and key facilities, so transport infrastructure and urban planning can serve to improve accessibility, as well as a congestion charge. London's performance notwithstanding, generally public transport performs particularly poorly compared to cars (Figure 3.44).

Figure 3.43. Cities with a lower GDP per capita tend to have worse public transport performance

Correlation between public transport performance score and GDP per capita, large regions (TL2), 2018



Sources: OECD Statistics and ITF.

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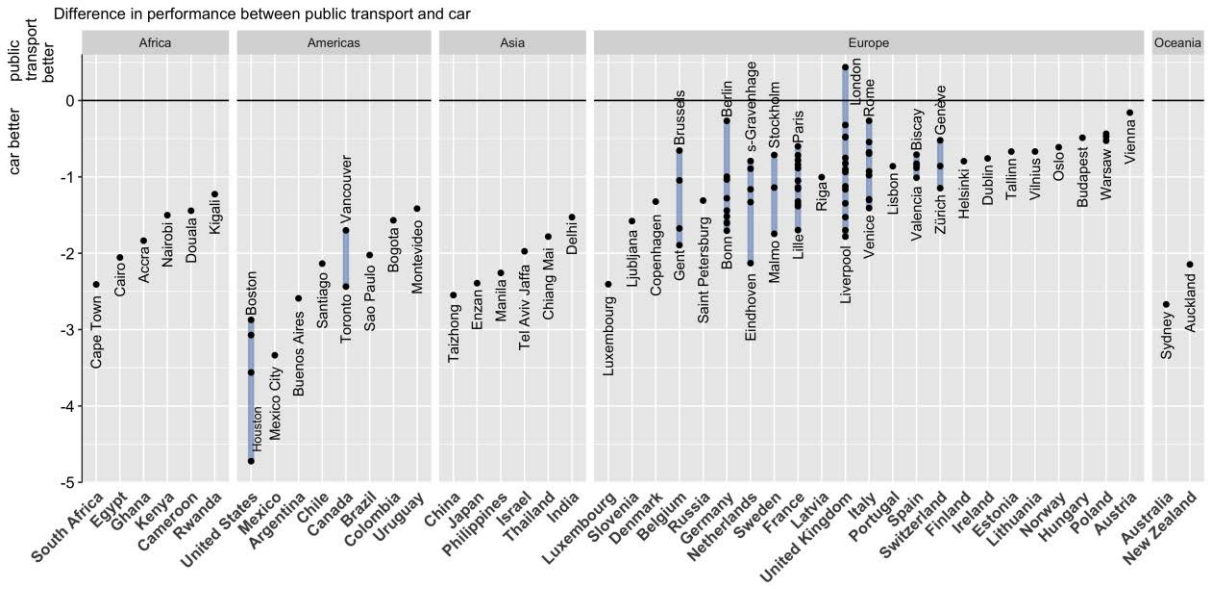
Road freight hubs need to engage with the zero-carbon transition

Heavy-duty road freight accounts for 22% of transport-related CO_2 emissions and over 5% of total energy-related CO_2 emissions worldwide. Decarbonisation in road freight is less advanced than passenger transport, as zero-carbon technologies to be deployed at scale have not yet been chosen. However, deployment of such technologies is a near-term priority to move road freight towards net-zero emissions (IEA, 2017[123]).

Railways and inland waterways could take a larger share but the infrastructure is not always in place and it is costly and not always feasible to build (IEA, 2020[21]). For example, the EU aims to shift 50% of medium-distance freight journeys to rail by 2050. Better multimodal solutions for long-distance transport of goods are needed (EC, 2018[124]). In any case, a segment of the deliveries (e.g. port to road, road to rail) almost always requires road haulage. To decarbonise these, zero-emission technologies need to be deployed, going beyond battery electric vehicles, which may not be suitable for heavy loads. These could be hydrogen and synthetic fuels. Infrastructure investments by governments and industry are needed with synergies for battery electric and hydrogen fuel cell buses (ICCT, 2017[125]). The majority of alternative fuels require new distribution networks and refuelling or recharging stations. All of these bring challenges for infrastructure supply and management (ITF, 2018[126]).

Figure 3.44. Public transport performs poorly compared to cars

Comparison of accessibility by mode, difference in transport performance between public transport and car, 30 minutes/8 km, 2018



Note: The difference in transport performance is calculated as the car transport performance score minus the public transport performance score.
Sources: OECD Statistics and ITF.

Regional challenges from freight transport decarbonisation include these large infrastructure investments. Some standardisation of truck technology and infrastructure systems (for electric vehicles that are dynamically charged) across regions might be necessary for long international routes (ICCT, 2017[125]). In the near term, reducing emissions from trucking will require systemic improvements in supply chains, logistics and routing, supported by new technologies, improved vehicle utilisation, backhauling, last-mile efficiency measures and re-timing urban deliveries. Regulation will need to enable many of these systemic changes with substantial efficiency gains (IEA, 2017[123]). Finally, there will likely be net employment and gross value-added gains as well as changes in qualification requirements and wages when shifting from road to rail and possibly waterborne transport, as well as towards zero-carbon technologies. But overall, the economic and labour market impacts are small (Doll et al., 2019[127]).

The introduction of new logistics, technologies as well as the shift to multimodal transport may particularly affect regions with large volumes of transport loading and unloading. The three regions with the highest tonnage of freight loading are Spanish – Barcelona, Madrid and Valencia – followed by Sweden's second-largest county Västra Götalands län, the major port city in northern Germany Hamburg and regions in France (Figure 3.45). Most goods are loaded in intermediate to urban areas (Figure 3.46).

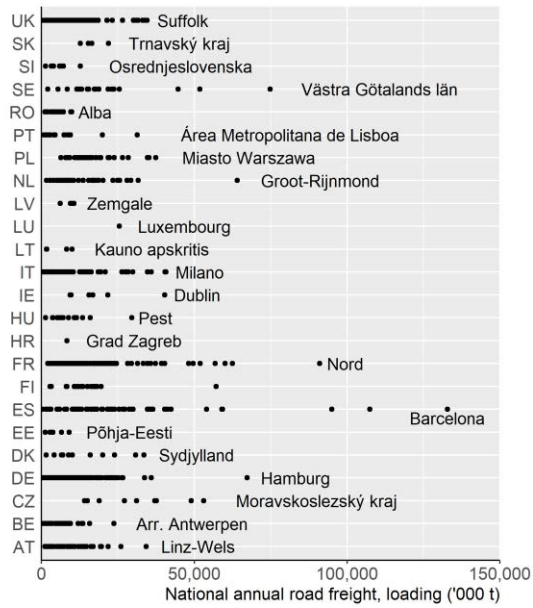
Climate models provide insights into future regional hazards

High-resolution climate models can provide indicators of climate hazard at regional and local scales that can contribute to preventive adaptation and build a more resilient society, for different global warming or emission scenarios. The following section illustrates place-based modelling results and their use to integrate adaptation in regional development policy. Spatial variations in climate hazards are substantial even within subnational regions. But there are also substantial variations across models and scenarios

especially for projected climate hazards (Schoof and Robeson, 2016[128]). Ensemble of models can improve the robustness of the results but may also risk averaging out extreme outcomes.

Figure 3.45. Spanish regions have the highest tonnage of road freight loading

National annual road freight in 1 000 tons, locations of loading, small regions (NUTS3), 2019



Note: EU countries.
Source: Eurostat.

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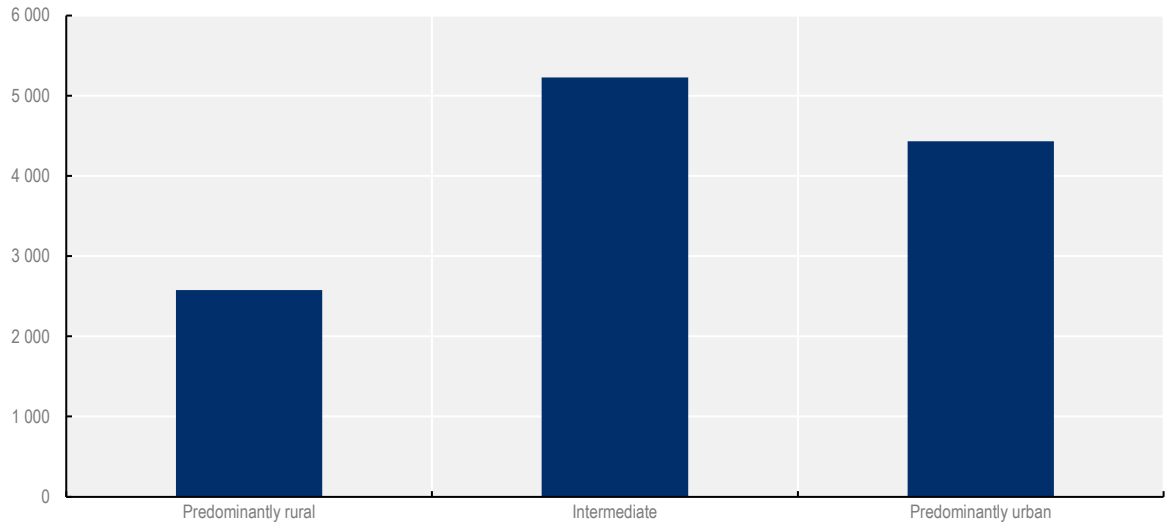
Figure 3.46. Most road freight goods are loaded in intermediate to urban areas

National annual road freight in 1 000 tons, locations of loading, weighted averages of small regions (TL3), 2019



Note: EU countries.
Source: Eurostat.

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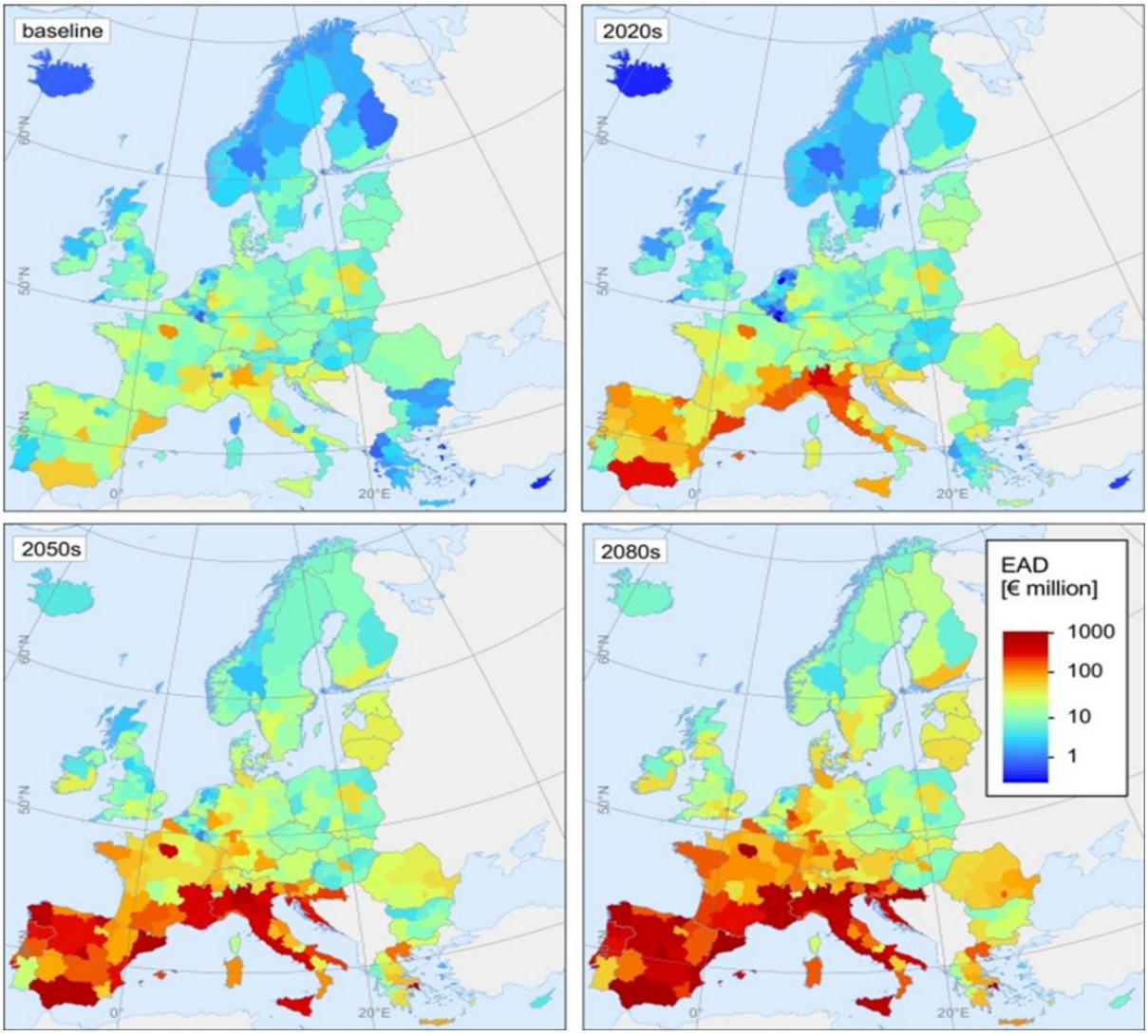
Climate hazards in European regions

Climate-induced hazards including heatwaves, cold waves, river and coastal floods, wildfires, droughts and windstorms. Windstorms and flood are dominant hazards today but, in the future, drought and heatwaves will dominate. Under a "business as usual" scenario (no further climate change mitigation), they are expected to rise tenfold with significant spatial variations across Europe (Figure 3.47).

Figure 3.47. Cost of multi-hazard damages across Europe to 2080 assuming no further climate change mitigation action

Baseline 1981-2010



Note: EAD denotes expected annual damage over the period under consideration. Multi-hazard includes heatwaves, cold waves, floods, wildfires, droughts and windstorms. Hazard and associated losses were obtained from the Emergency Events Database. Climate scenario SRES–A1B consistent with "business as usual".
Source: Forzieri, G. et al. (2018[38]), "Escalating impacts of climate extremes on critical infrastructures in Europe", https://doi.org/10.1016/j.gloenvcha.2017.11.007.

Flood hazard in Japan

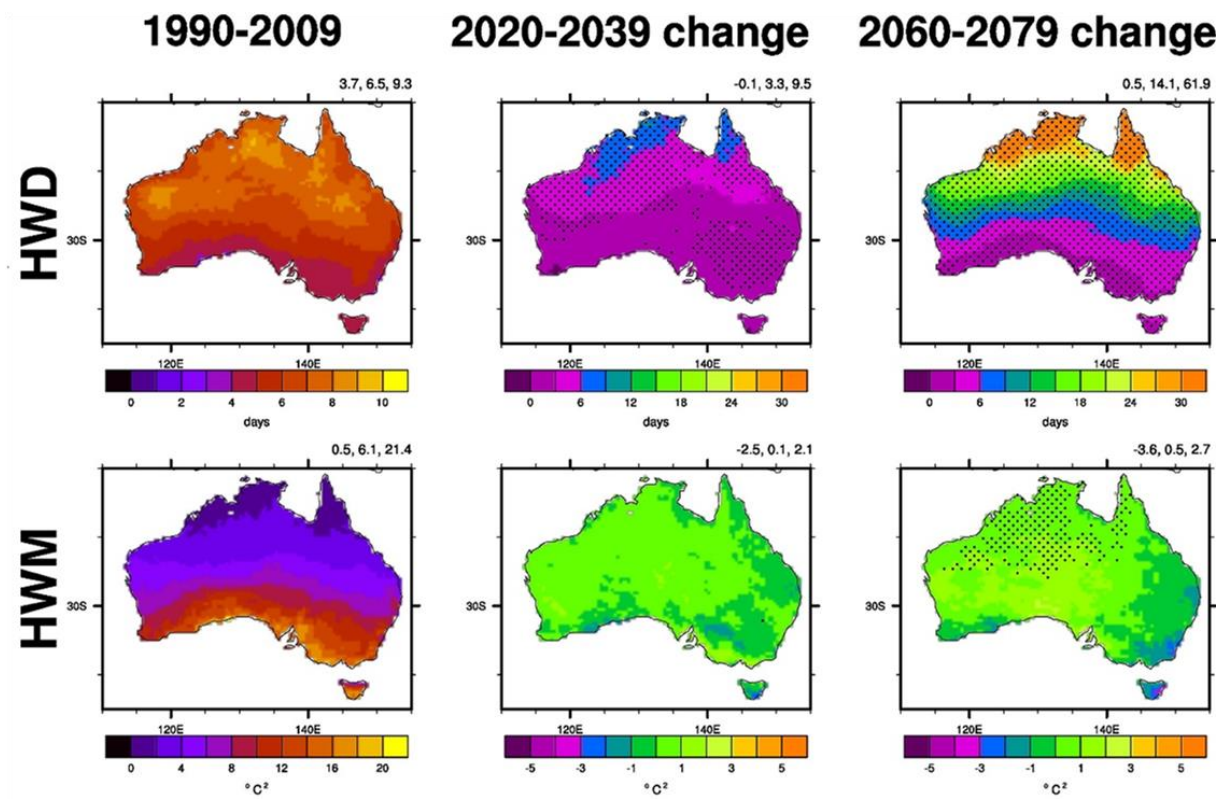
Japan has a long history of typhoons, flooding and heavy rainfall and has a well-formulated flood risk reduction strategy (Fan and Huang, 2020[129]). Flood fatalities trend downward in Japan. Nonetheless, 50% of the population and 75% of national assets are concentrated in flood-prone areas (Fan and Huang, 2020[129]). Flooding from extreme rainfall is expected to increase and inflict economic losses. Precipitation is expected to increase significantly with large regional differences (Tezuka et al., 2014[130]). One finding of this modelling is that the flood protection suitable for floods of a strength that may only occur every 50 years will only protect against floods that are likely to return every 30 years by 2050.

Climate hazard across Australia

Global warming has inflicted longer periods of drought, heatwaves, wildfires or bushfires. The likelihood of fire risk is increasing with rising temperature and heatwaves. Heatwaves are the deadliest natural hazard with detrimental impacts on coral reefs, native fauna, human health, infrastructure and agriculture (Alexandra, 2020[131]). They are projected to triple in the future with spatial variation between regions and cities measured in terms of different heatwave indices (Herold et al., 2018[132]) (Figure 3.48).

Figure 3.48. Heatwaves across Australia relative to recent past

Heatwave duration (HWD), HWM – heatwave magnitude (HWM)

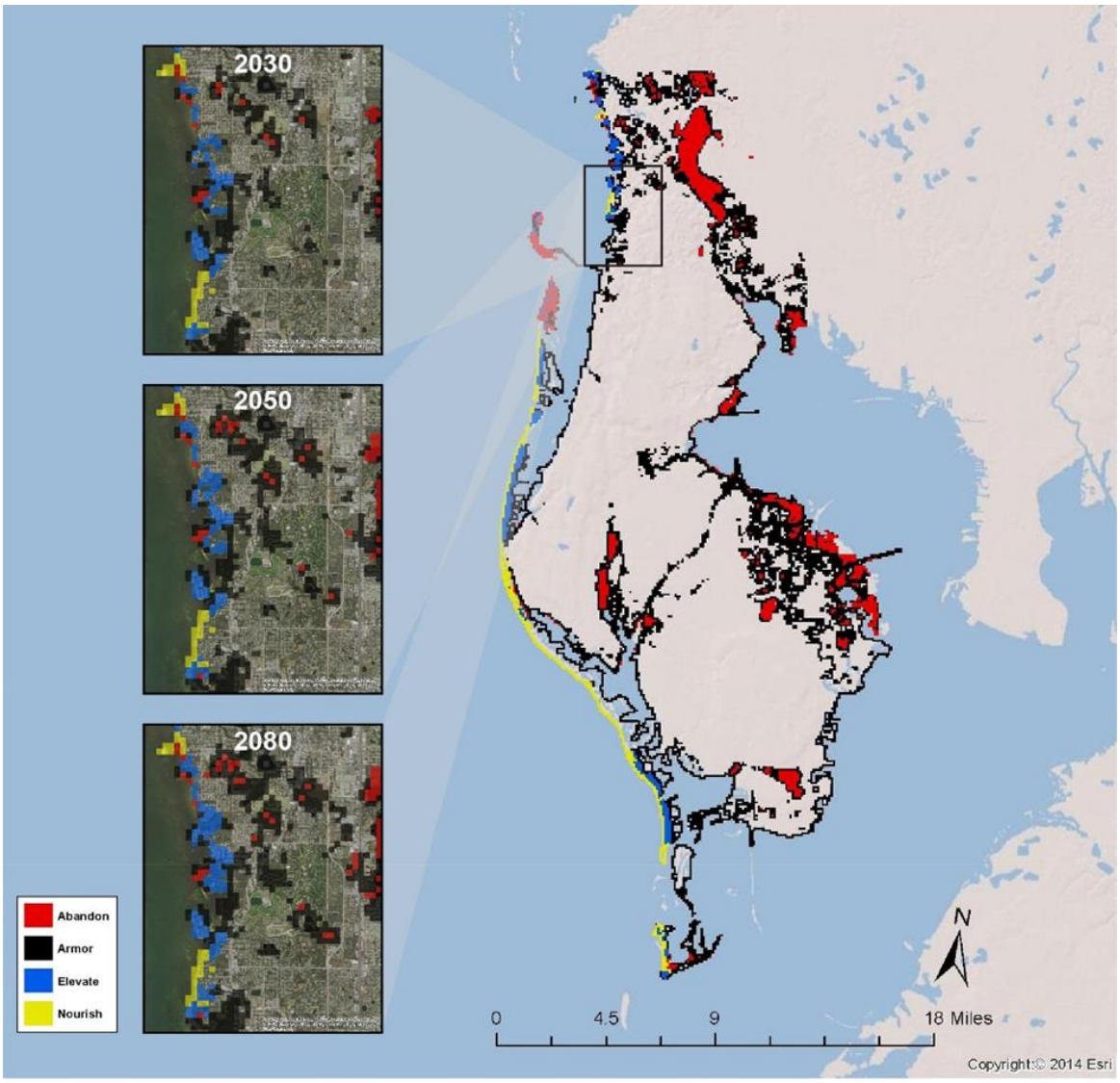


Note: HWD in days, HWM expressed as excess heat in °C. SRES A2 scenario consistent with about 3.5-degree global warming by 2100.
Source: Herold, N. et al. (2018[132]), "Australian climate extremes in the 21st century according to a regional climate model ensemble: Implications for health and agriculture", https://doi.org/10.1016/j.wace.2018.01.001.

Climate hazard in the US

In the US, hurricanes are the most destructive climate hazard. Hurricanes have increased in intensity as well as in the frequency of occurrence between 1900 and 2018, which is attributed to global warming (Grinsted, Ditlevsen and Christensen, 2019[133]). Global warming will increase storm tide heights. Coastal floods are hence expected to increase, which will require a combination of several adaptation measures such as armouring floodwalls, elevating structures, shoreline nourishment (increasing amount of sand to replenish beach profile) and abandoning property (Lorie et al., 2020[134]). Scenarios of sea level rise at 0.5 m, 1 m, 1.5 m and 2 m by 2100 were assessed for the coastal regions of Tampa, Florida, for example. For the case of Pinellas County in Tampa, a combination of the four adaptation approaches is expected to minimise economic damage and loss of human lives (Figure 3.49). This exercise can illustrate how regional policymakers can work with modellers. They can provide policy questions as inputs to deploy modelling work, which can protect valuable local physical and social infrastructure, drawing on local knowledge.

Figure 3.49. Projected mix of adaptation approaches under sea level rise in Pinellas County, Florida, US



Source: Lorie, M. et al. (2020[134]), "Modeling coastal flood risk and adaptation response under future climate conditions", https://doi.org/10.1016/j.crm.2020.100233.

Climate impacts include the number of days with minimum temperature above 20°C (Schoof and Robeson, 2016[128]) indicating more chances of heatwaves. Also, there will be a net reduction in agricultural yields by 9% per 1°C rise in warming after accounting for yield increase from CO_2 concentration in cold places (Hsiang et al., 2017[47]).

Road infrastructure damage in Mexico

Mexico is vulnerable to drought as most of its territory is arid or semi-arid (Soto-Montes-de-Oca and Alfie-Cohen, 2019[135]). The drought risk is expected to increase. For example, by 2080 (in a scenario consistent with global warming of 2°C), dry events will increase by 175%, whereas wet periods will decrease by 86%, aggravating scarcity of water (Herrera-Pantoja and Hiscock, 2015[136]). Some local communities will need to anticipate human and livestock morbidity, discomfort in working outside and the likelihood of abandoning agriculture (Soto-Montes-de-Oca and Alfie-Cohen, 2019[135]).

Changing temperature and precipitation are also projected to inflict damage to the road infrastructure. The cost of repairing and maintaining roads' functionality may range between USD 1.3 billion to 4.8 billion at the national level during the period 2015-50 (Figure 3.50). These costs vary from 1% of road inventory for the least vulnerable state to 100% for the most vulnerable state under severe climatic change. The modelling work provided vital information such as in terms of the future cost of damage on road networks, which can inform science-based decision-making to integrate adaptation actions in road infrastructure planning.

Figure 3.50. Climate-change-induced road maintenance costs vary strongly across Mexican regions

Cumulative cost (in million USD) from road infrastructure damage across states in Mexico between 2015 and 2050

Note: Scenario corresponds to 2°C warming by the end of the 21st century.
Source: Espinet, X. et al. (2016[137]), "Planning resilient roads for the future environment and climate change: Quantifying the vulnerability of the primary transport infrastructure system", https://doi.org/10.1016/j.tranpol.2016.06.003.

Summing up: Policy conclusions from Chapter 3

Climate change is a global challenge requiring local action. Reaching the objectives of the Paris Agreement will prevent major threats to the foundations of human well-being. These are substantially worse under 2°C of global warming than under 1.5°C. Most OECD countries, therefore, aim at reaching net-zero domestic GHG emissions in 2050. Deep transformations of unprecedented breadth over a short period of time are needed to reach this target. There is a need for place-based policies that align with national and global objectives to address climate change mitigation and adaptation.

- **Well-being benefits beyond the protection of the climate can more than offset the cost of climate action** in many regions. A large majority of the population in OECD regions and cities is exposed to unhealthy levels of small particulate pollution, with negative effects on mortality, disease, vulnerability to COVID-19, child health, education and worker productivity. Other well-being gains include reduced noise pollution and traffic congestion, healthier diets, enhanced health due to increased active mobility, health benefits through thermal insulation and improved water, soil and biodiversity protection. Negative GDP effects of the transition are more marked in fossil-fuel exporting regions. Some regions with intensive coal use do much more poorly than their national averages, especially with respect to GDP per capita, and need support not to be left behind.

Delayed action raises costs substantially, including in the cities and regions where they occur. Anticipation and support for vulnerable local populations are critical. Anticipation prevents potentially disastrous climate impacts which hit the vulnerable the most in their livelihoods. Adequate income and access to key services, such as healthcare and water, are key for the vulnerable to be resilient to climate-change-related impacts.

Subnational governments need to play a key role in the net-zero transition:

- Local conditions are critical for defining net-zero-emission strategies, for example for connecting people to jobs, for the specific industrial mix and enterprise fabric of cities and regions.
- Subnational governments have key relevant competencies for climate policy. The three pillars of climate mitigation action – energy, land use, urban policy – are at the heart of regional development. Local and regional governments play an essential role in supporting the most vulnerable as they understand the local issues.
- Governments at all levels should assess all their investment decisions against the net-zero-emission transition. Some regions heavily invested in fossil fuel extraction and transformation are particularly at risk from losses if investment in these activities continues.
- Well-being benefits beyond climate often arise regionally in the near term and require local and regional action to harness them.
- The impacts, exposures and vulnerabilities to climate change differ across locations and need to be identified and addressed locally and regionally.

Indicators to measure regional progress on the net-zero-emission transition have shown that:

- GHG emissions vary hugely across territories and degree of rurality:
  - Regions with different production-based emissions will have different transition pathways.
  - While metropolitan regions contribute most to total GHG emissions (about 60%), rural regions' emissions per capita are higher.
  - Within-country variation in emissions is higher than between countries.
  - Regions with higher production-based emissions per capita tend to have higher GDP per capita.
- Most OECD countries still have regions that rely on coal-fired electricity generation:

  - Coal in electricity generation should be largely phased out by 2030 but the transition to zero-carbon electricity remains unequal across regions.
  - Some regions in Australia, Colombia, Greece, Japan, Korea, Poland and Turkey are still planning or adding new coal-fired electricity generation capacity, which exposes them to losses on the investment.
- Regions need to move more decisively to renewables:
  - Remote regions produce the most electricity, per capita, using renewables. The generation of wind-based power is especially skewed toward most rural regions.
  - Overall, the expansion of wind and solar electricity generation and the phase-out of coal will shift electricity generation to more rural regions as progress is made in the zero-emission transition. These trends will have regional development implications for rural regions.
  - While electricity market design is a central government level task, rural and urban regions can take steps to take advantage of cheap renewable electricity when it is the most abundant, as discussed in Chapter 4.
- Electric cars, public transport and active mobility need to grow more rapidly:
  - A cost-effective date for phasing out the sale of new fossil-powered cars is 2030.
  - Regional governments can encourage electric vehicle uptake by expanding public charging infrastructure and offering additional incentives. Shifting mobility towards public transport and active mobility can ease the transition by reducing transport energy demand as well as infrastructure and material needs. Policies to encourage such a shift are described in Chapter 4.

These indicators are also examined for each country in the online country notes. However, across the OECD, regional data to measure transition progress is lacking. For example, regional progress in making energy use in all buildings consistent with net-zero emissions and required renovations cannot be tracked.

Employment losses from the transition appear limited:

- The employment risks are modest compared to historical job allocation and anticipated restructuring due to digitalisation. On average, 2.3% of employment is at risk in OECD regions.
- Job losses are regionally concentrated. Some of the regions with over 5% of employment at risk have higher poverty risks and higher long-term unemployment. Polices to ensure that no region is left behind are further discussed in Chapter 4.
- There will also be employment gains from the transition.

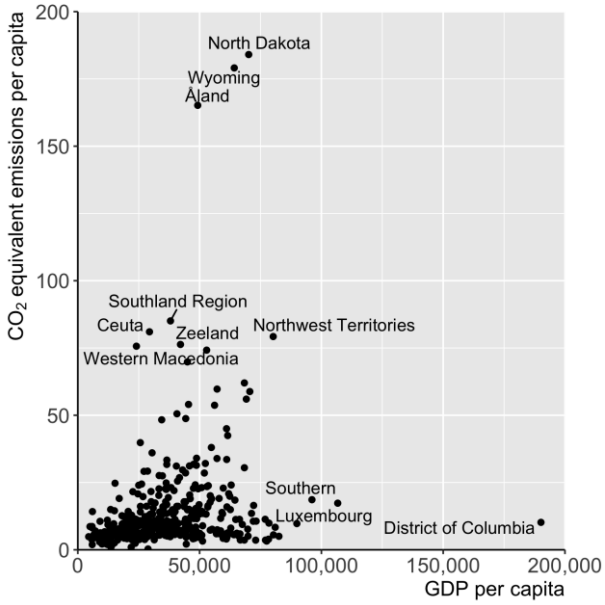
Place-based **adaptation** needs to complement decisive mitigation:

- Regional policymakers can work with modellers to identify exposures and vulnerabilities to protect valuable local physical and social infrastructure, drawing on local knowledge.

Annex 3.A. Annex charts

Annex Figure 3.A.1. Regional emissions per capita and GDP per capita are positively correlated

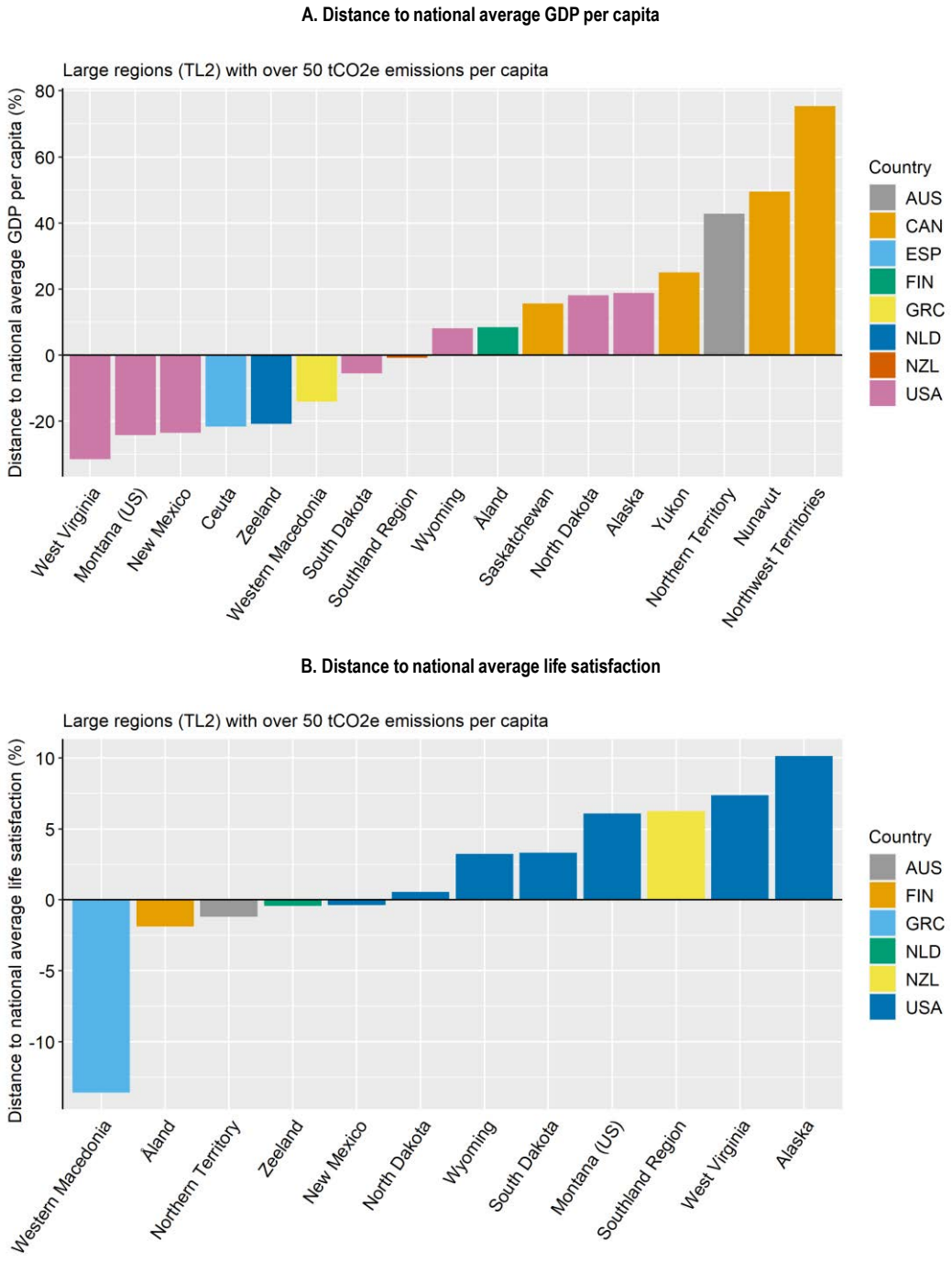
GHG emissions per capita and GDP per capita, large regions (TL2), 2018



Source: OECD calculations based on EC (2020[84]), *EDGAR - Emissions Database for Global Atmospheric Research*, Joint Research Centre, European Commission; OECD Statistics.

Annex Figure 3.A.2. In some top-emitting regions, GDP per capita is very high with little difference in life satisfaction

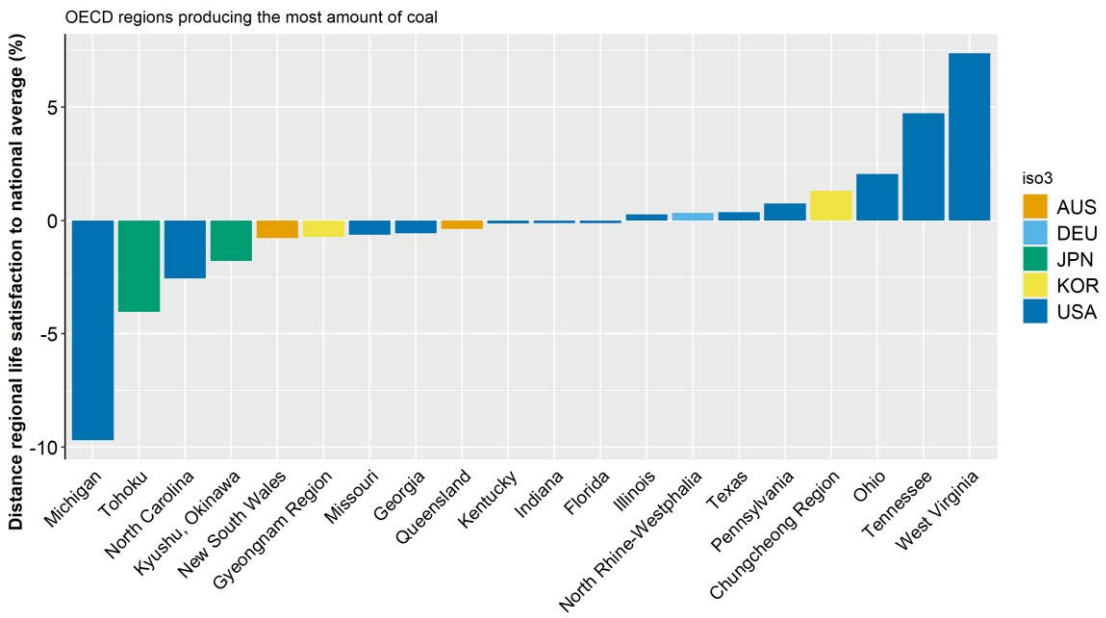
Relative difference to country means, large regions (TL2), 2018



Note: Panel B: No data for Canada and Spain.
Source: Panel A: OECD Statistics; Panel B: Gallup World Poll, 2014-18.

Annex Figure 3.A.3. Difference between regional life satisfaction and national average for regions with largest coal-fired electricity production

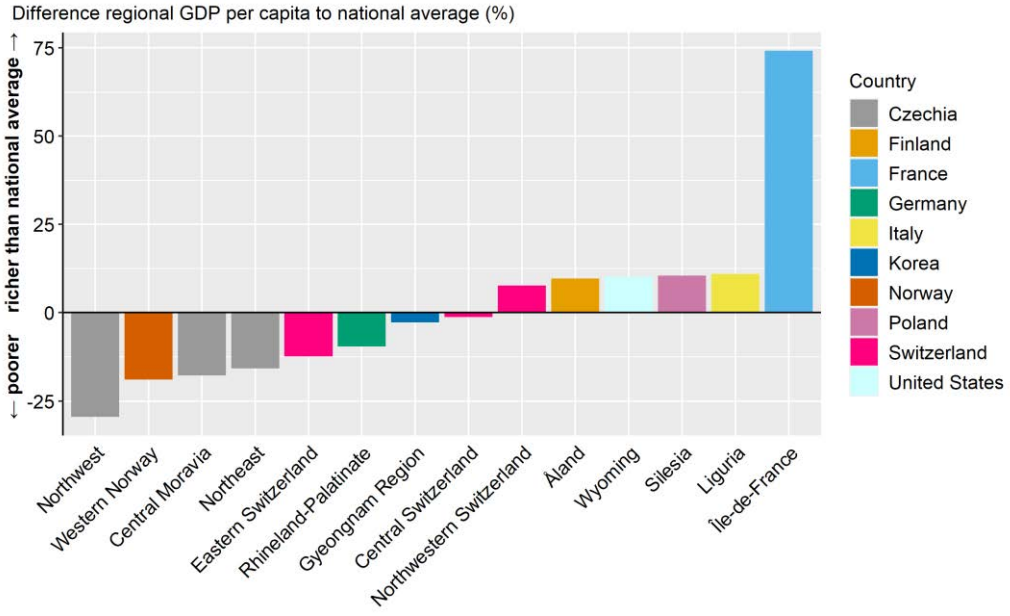
Relative difference to country means, large regions (TL2) most coal-fired electricity generation, 2017



Source: Gallup World Poll, 2014-18.

Annex Figure 3.A.4. Difference between regional GDP per capita and the national average for TL2 regions with highest shares of employment in sectors with employment at risks

Relative difference to country means, large regions (TL2) with more than 4.5% of employment in sectors with employment at risks, 2017



Source: OECD Statistics.

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Notes

[1] See https://edgar.jrc.ec.europa.eu/overview.php?v=verify_h2020.

[2] Defined as crop and animal production, hunting and related service activities.

[3] Relative poverty is defined here as the percentage of people having experienced times in the past 12 months when they did not have enough money to buy food that they or their family needed

4 Selected policy avenues

Climate change is a global challenge requiring local, inclusive, early action. Subnational governments need to play a key role. Multi-level governance and finance should identify the steps to take by all government levels. Transfers between subnational governments need to be linked to climate policy goals. Integrating scientific advice improves success. Cities can adopt policies that reach net-zero emissions and improve urban living. Metropolitan regions contribute more than 60% of production-based greenhouse gas (GHG) emissions. Urban policies should co-ordinate sectoral policies, such as transport and housing, to reach net-zero emissions. Cities hold large potentials for modular technologies to integrate renewables, heat pumps or green infrastructure. Circular economy initiatives can make consumption more consistent with net-zero emissions. Rewarding ecosystem benefits boosts emission reductions and rural development. Participation in profits and decision-making makes renewable projects more attractive. Ageing, lower education levels and less diversified economic activity put rural regions with carbon-intensive industry at bigger risk and per capita emissions are often higher than in metropolitan regions. In regions at risk of losing employment in emission-intensive economic activity, building consensus early among local stakeholders from education, innovative business, regional and local governments is key to make best use of local assets.

Integrating subnational governments in climate policy governance and financing

Subnational governments are central for the net-zero greenhouse-gas-emission transition by 2050. As highlighted in paper "Financing climate objectives in cities and regions to deliver sustainable and inclusive growth" (OECD, 2019[1]), in 2000-16, subnational governments were responsible for 55% of public spending and 64% of public investment in sectors having a direct impact on climate change and other environmental issues. Yet, subnational climate-related spending and investment represented, on average, only around 1.3% and 0.4% of gross domestic product (GDP) respectively in that same period (OECD, 2019[1]).

Cities and regions provide critical emission reduction opportunities, as they often have jurisdiction over key sectors for climate action. They are also motivated to act because many of the well-being gains of the net-zero-emission transition, such as improved health outcomes, accrue locally (Chapter 3). As Chapter 3 has also shown, regions differ enormously in terms of activities generating emissions and potential socio-economic impacts and, therefore, in the actions needed to move to net-zero emissions. Since local governments are in close contact with citizens and local businesses, local governments are generally in a better position to influence behaviour by implementing emission-reduction policies based on their knowledge of local conditions and capabilities.

Subnational governments will not be able to manage the net-zero transition on their own. Reaching national net-zero emission targets requires co-ordinated action across regions and a massive upscaling of subnational climate finance. Ensuring effective multi-level governance systems are needed to optimise regional and local policy, programming and investment contributions. This becomes even more urgent after the COVID-19 pandemic, which has further weakened subnational spending abilities.

One important policy avenue to manage the net-zero transition will be creating incentives for subnational governments to focus spending and investment on the net-zero transition. These incentives can be broadly understood as combining different types of financial transfers from national to subnational governments, such as grants, subsidies, contracts, etc. with specific objectives towards reaching the net-zero transition. One example of such an incentive is conditionalities. Several countries have introduced environmental conditionalities in the allocation of their grants and subsidies for infrastructure projects to make sure that the project is consistent with the objective of the net-zero transition. Sound multi-level governance of climate policy means managing interactions and financial flows at and among different levels of government – from the global and supra-national level to the national, regional and local levels. The first part of this section highlights governance challenges associated with co-ordinating and financing the net-zero transition and presents a range of instruments to overcome these. The second part of the section explores how subnational governments can scale up and deploy different climate finance instruments.

Subnational governments need to be integrated into climate policy governance

A successful net-zero transition requires multi-level governance systems that are "fit for purpose" and can support integrated or synchronised government actions across policy sectors and actors, in order to:

- Help different levels of government navigate the complex and dispersed processes that generate net-zero transitions.
- Ensure coherence across policy sectors, build an appropriate scale for intervention and optimise climate finance initiatives.
- Maximise well-being gains while minimising the trade-offs associated with climate policy implementation.

Several factors can make or break subnational climate governance:

- *The political and legal context*: The extent to which subnational governments govern climate action depends on and is affected by the national and international political and legal contexts. Results of a survey conducted by the European Environment Agency (EEA) show that cities identify national laws, standards and regulations, the distribution of state powers and actions, and national-level policy objectives as drivers of sustainability transitions. Despite the increasing number of regional and local climate initiatives, current efforts to tackle climate change at the subnational level remain poorly recognised and not well integrated into national policy frameworks. Approximately one out of four countries that recently submitted nationally determined contributions[1] (NDCs) do not consider subnational governments in their effort to reduce national emissions and adapt to the impact of climate change (Hsu et al., 2018[2]; Matsumoto et al., 2019[3]).
- *The degree of autonomy and decentralisation*: In two-thirds of OECD countries, the economic importance of subnational governments has increased between 1995 and 2016, measured as a spending share of GDP and total public spending. Decentralisation may expand citizen participation by bringing government closer to citizens and by better targeting public service provision to local needs. This can also help meet regionally and locally identified climate priorities. Yet, a lack of administrative, technical or strategic capacities, limited resources or limited clarity in the assignment of responsibilities can be barriers to effective local action and can result in poorly co-ordinated investments. Decentralisation can result in geographical fragmentation and poorly co-ordinated investment. To avoid and overcome these barriers, the OECD report *Making Decentralisation Work: A Handbook for Policy-Makers* offers guidance on designing and implementing effective decentralisation systems to optimise the associated potential advantages, such as greater accountability and more efficient, better targeted public service delivery (OECD, 2019[4]).
- *Access to finance for climate action*: The extent to which subnational governments have access to funding and can optimise its use for climate-related investment and spending is a key factor in climate governance. Subnational governments need more financial support from the international community and national governments, just as they need more incentives to apply their own revenues towards the net-zero transition. Multi-level governance mechanisms are essential for planning and co-ordinating the net-zero transition.

Applying a place-based approach to the net-zero transition requires ongoing and productive dialogue among different levels of government. This can embed climate change action in regional development policy across diverse sectors and activities, such as energy, urban planning and sustainable land use. It also demands a seamless flow of information and resources. The transition comes with unintended consequences and trade-offs among social, economic and environmental sustainability outcomes. Managing these calls for continuously identifying and evaluating the risks and opportunities associated with transitions. Foresight exercises and backcasting policy actions from them can be useful techniques. They help policymakers develop timelines for technology and investment decisions. Progress towards the goal of net-zero emissions in 2050 should be measured by setting clear and realistic short- and medium-term targets, bearing in mind the economically useful life of assets and the availability of zero-emission consistent alternatives. Such targets include, for example, sustaining the current growth rate of renewables and increasing the annual refurbishment rates of existing buildings to close to 5%, so all buildings are refurbished consistent with net-zero emissions before 2050.

Successful climate policy governance relies on multi-level governance systems that can identify and broker an agreement on long-term strategic goals to set coherent policy priorities at different government levels. It also relies on monitoring and evaluation systems that first allow governments to identify whether they are reaching their aims and do so in a cost-effective way, taking into account well-being impacts and, second, serve as an accountability mechanism to stakeholders and citizens. While climate-related objectives, strategies and policies may be set at the international and national levels, implementation by

subnational governments can generate action that is more appropriate to local characteristics. Regions can also play an important role as a co-ordinator of climate action undertaken at the local level. A periodic review helps policymakers adjust and enable policy learning. Scientific advisory bodies can help regions and cities to define and monitor a range of short-term sectoral benchmarks and their contribution to the long-term objective of net-zero emissions. Integrating an autonomous scientific advice body in political decision-making at the central government level has made a substantial difference in reducing emissions cost-effectively, as the United Kingdom (UK) has shown (Box 4.1). This includes a single advisory body involved in setting medium-term and long-term objectives, the evaluation of policies *ex ante* and *ex post* against objectives, as well as the approval of policies and objectives by parliament. The central role of place-based policies argues in favour of extending this approach to regional and urban climate action. The climate challenge and the COVID-19 crisis have common characteristics. Countries can therefore learn from the multi-level governance arrangements in the course of the COVID-19 crisis. For example, associations of regional and local governments are playing an important role to support vertical co-ordination during the pandemic (Chapter 2).

Box 4.1. Integration of scientific advisory bodies

National and regional scientific bodies provide independent advice to governments on setting and meeting greenhouse gas (GHG) emission targets. They also help subnational governments understand whether current decisions, especially on infrastructure investment, are compatible with carbon budgets and the emission reduction trajectories of long-term plans. This creates the necessary link between scientific knowledge, national long-term targets and the decision-making process. Many countries have introduced such bodies. Given the strong case for place-based climate action, regional policymakers should incorporate scientific advisory bodies as knowledge and evidence channels within the multi-level governance system supporting the transitions.

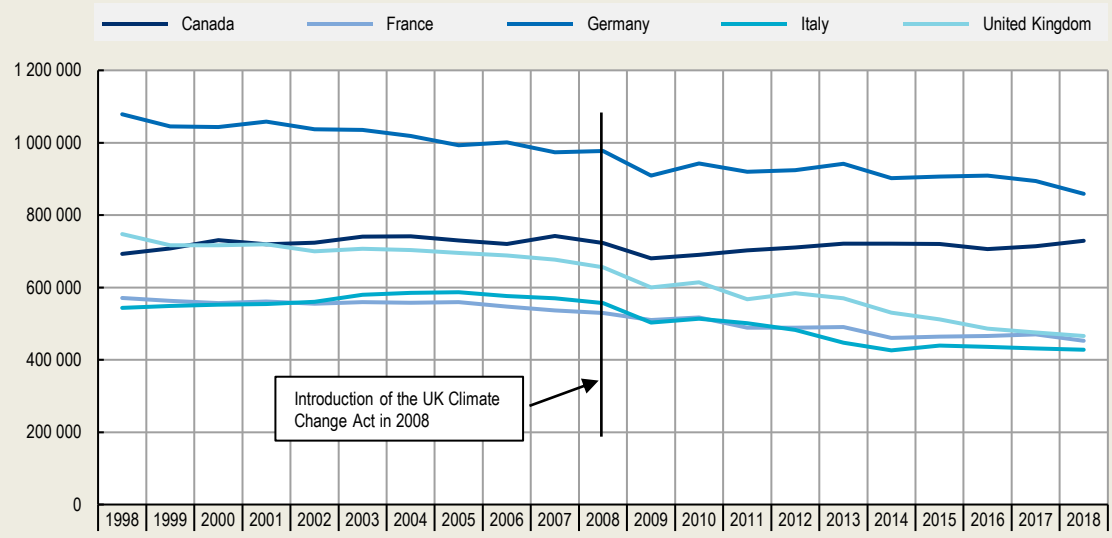
The UK Climate Change Committee

In the UK, parliament sets legally binding five-year emission-reduction budgets and the government is required to propose policies to meet them. The Climate Change Committee evaluates and monitors the government's policies *ex ante* and *ex post* and makes concrete recommendations for these five-year budgets. The government is legally obligated to respond to the committee's annual reports. Reporting to parliament also occurs annually and all views are made public, stimulating public debate and engagement with a science-based policy programme. The Climate Change Committee comprises 8 experts on climate change, science, economics, behavioural science and business administration, with the additional support of a secretariat of approximately 30 professionals and an annual budget. The committee is also the only scientific advisory body in the UK that gives a single voice to climate advice.

The UK's experience underscores how the advice that is integrated into decision-making can help achieve lasting emission reductions that are sustained by broad consensus, although it has not yet included subnational government levels. Emission reduction in the UK is greater than in other large OECD economies, and emissions have fallen considerably since the introduction of the UK Climate Change Act in 2008 (Figure 4.1). Emissions in electricity generation fell by 58% since 2012, as the share of coal in electricity generation dropped from around 40% to less than 8% in 2017 without negative impacts on supply or costs (Newbery, Reiner and Ritz, 2018[5]).

Figure 4.1. Reductions in greenhouse gas emissions in selected major economies

Total emission reduction over the period 1998-2018 excluding land use, land-use change and forestry (LULUCF), thousands of tonnes of CO_2 equivalent



Source: OECD ENV Database

Co-ordination and integration across sectors and among levels of government

Governing net-zero emissions require horizontal and vertical policy co-ordination. Policymakers should actively seek to identify and correct existing policy misalignments. This can mean moving from a patchwork of individual policies designed and pursued in a sectoral manner to developing an integrated policy approach. Policy coherence and co-ordination towards the objective of net-zero emissions also helps create the necessary links between sectors. For instance, reaching net-zero consistent mobility requires changes in land use and spatial planning.

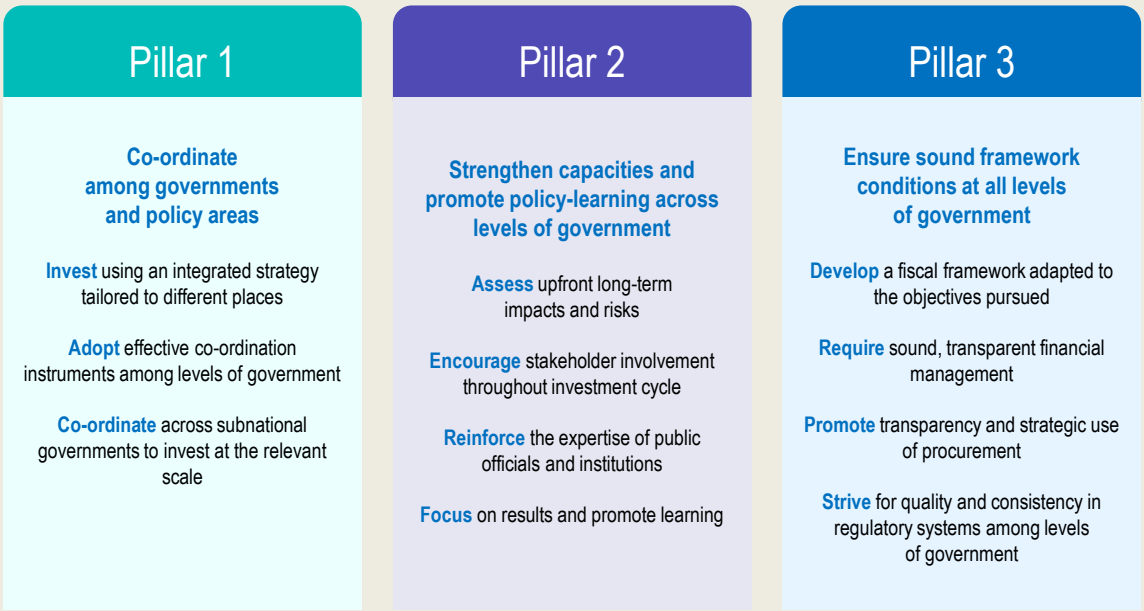
Several countries are developing governance platforms to co-ordinate transport and land use development policies among national, regional and local governments with the objective of climate-neutral transport. The Norwegian Urban Growth Agreement and the Swedish Urban Environmental Agreements are both examples (Westskog et al., 2020[6]). Finally, dialogue among levels of government supports strong climate governance. Platforms for knowledge sharing among local and regional governments provide an opportunity to empower local actors. Networks such as the Covenant of Mayors for Climate and Energy and the ICLEI Green Climate Cities Programme help identify and share best practices internationally.

In addition to effective co-ordination as discussed above, subnational governments will also benefit from additional financial resources to effectively redirect their expenditure towards climate-neutral assets and scale up investment. The OECD Council adopted a Recommendation on Effective Public Investment Across Levels of Government (OECD, 2014[7]), which is organised around three pillars (Box 4.2).

Box 4.2. OECD Principles on Effective Public Investment Across Levels of Government

Across the OECD, subnational governments are responsible for about two-thirds of direct public investment. Well-managed public investment can be growth-enhancing and contribute to higher levels of productivity growth. Poor investment choices, on the contrary, may not only waste public resources but also hamper future growth. In 2014, the OECD Council adopted the Recommendation on Effective Public Investment Across Levels of Government. The principles set out in the recommendation are meant to help governments assess the strengths and weaknesses of their public investment capacity and set priorities for improvement. The 12 recommendations are grouped into 3 pillars representing multi-level governance challenges to public investment:

Figure 4.2. The 12 Principles on Effective Public Investment Across Levels of Government



Source: OECD (n.d.[8]), *Effective Public Investment Toolkit*, http://www.oecd.org/effective-public-investment-toolkit/.

Incorporating non-state actors into multi-level governance for climate policy

The effective governance of complex sustainability issues relies on new forms of collaboration with actors from government, science, business and civil society (Ehnert et al., 2018[9]). A broad actor set can help strengthen the participation of civil society and local communities in climate governance and advocate for partnerships with subnational and national governments on local climate action. They can also provide policy and technical advice to local governments.

Making the most of contractual instruments to deliver on climate objectives

Formal instruments such as intergovernmental "contracts" or agreements can help foster harnessing place-based action for reaching national and international climate objectives. Several examples of "deal-making" or contractual arrangements are found in OECD countries: France, especially, has a long tradition of State-Region Planning Contracts but also Australia (city and regional deals), Italy and the Netherlands (City deals) (Box 4.3).

Box 4.3. Making the most of multi-level governance tools to reach net-zero emissions by 2050

A number of countries have designed intergovernmental agreements linked to promoting and achieving climate objectives.

- In **France**, the State-Region Planning Contracts launched in 1984 have played a critical role in shaping autonomous policymaking among regions. The 6th generation of contracts (2015-20) includes transport, the environment and energy transition. The contracts provide regions with 8.5% of their budget. Co-funding varies across regions and according to the priorities.
- In **Italy**, the Italian Pacts for the South (2016) support economic growth, employment and environmental sustainability goals in the southern regions. They define priorities, actions for implementation and responsibilities of parties.
- In **the Netherlands**, the Climate Adaptation City Deal was signed in 2016 between the Ministry of Infrastructure and the Environment, three regional water authorities, five cities (Dordrecht, Gouda, Rotterdam, The Hague and Zwolle) and other partners (research centres and companies). The aim is to create a learning environment for climate adaptation at the urban level for the next four years.

Source: OECD (2018[10]), *Rethinking Regional Development Policy-making*, https://dx.doi.org/10.1787/9789264293014-en.

Financing instruments for the transition to net-zero emissions

Subnational governments are major spenders and investors in the transition to net-zero emissions and particularly in the infrastructure that will be required to meet the ambitions of the Paris Agreement. However, the COVID-19 pandemic is placing significant pressure on subnational government finance. Shrinking revenues could lead the subnational government to restrict their expenditure to mandatory and the most pressing areas, including staff costs, debt obligations, social benefits and services and support to the most vulnerable population and businesses. This may come at the expense of environmental and climate-related operating and capital expenditure. To preserve fiscal capacity for investment, all potential internal and external financing sources need to be mobilised to cover green investment needs. Subnational governments should make full use of their traditional budget instruments to reach the net-zero emission target by 2050. There are different sources of subnational government revenue that could be designed to foster and help finance the net-zero transition. These include grants and subsidies, as well as own-source revenues such as subnational taxes, user charges and fees, and income from assets, which tend to be under the direct control of subnational governments (although often constrained).

The following sections address the following four challenges:

1. How to make the most of grants and subsidies to deliver on climate objectives.
2. How to develop and optimise taxation, user charges and other revenues to support climate objectives.
3. How to make use of external finance mechanisms and attract private investors for subnational climate-related projects.
4. How to better align subnational government expenditure with net-zero emission objectives and direct subnational spending and investment towards climate priorities.

Making the most of grants and subsidies to deliver on climate objectives

In OECD countries, grants and subsidies to subnational governments represent around 37% of their revenue, around USD 3.5 trillion in 2018 (OECD, 2020[11]). Grants and subsidies may be unconditional (block grants) or earmarked to finance subnational government responsibilities in a wide range of sectors (education, social protection, health, environment, etc.), covering current or capital expenditure needs. They may be allocated by international organisations (including the European Union), national governments as well as state governments in federal countries. Through their grants and subsidies policies, international organisations, national and state governments are already influencing subnational spending and investment towards climate priorities. They can serve climate objectives in two ways:

- Environmental and climate considerations should be integrated into national transfer policies to subnational governments, including for general and earmarked grants, to provide incentives and resources to contribute to the net-zero emissions target.
- Specific earmarked grants and subsidies could be additionally introduced to finance targeted policy instruments to reach the net-zero policy target.

Making the most of grants and subsidies to deliver on the objectives of the net-zero transition implies that these grants and subsidies need to be designed to provide incentives for subnational governments to deliver on the objective of the net-zero transition. There are several ways to do this. For example, governments could review their entire intergovernmental grant system through a climate lens. As stressed in the *Chicago Proposal for Financing Sustainable Cities* (OECD, 2012[12]), grants can be used to correct incentives for unsustainable behaviour and reward subnational governments that create environmental benefits through their policies. Climate objectives and indicators, as well as an assessment of climate change impacts, should be more systematically integrated into intergovernmental transfers. The national system of grants should also ensure cross-sectoral policy coherence (e.g. with the energy, agriculture, transportation and land use planning sectors) with climate objectives. How to best design the incentives for subnational governments to prioritise investments and expenditures that support the objective of the net-zero transition will depend on the type of region. For some regions, the transition might require specific objectives with regard to afforestation; for others the transition to renewable energy production and use or sustainable transport provision might be most feasible. Incentives for subnational governments need to be consistent with predictable provision to foster the net-zero transition, so local governments steer the transition and send the right signals locally, especially for investment decisions that need to be taken now.

When conditionalities are attached to grants, they are primarily used to align national and subnational spending priorities, to promote subnational spending in particular areas, to address fiduciary and accountability concerns and to promote minimum public service standards (OECD, 2018[10]). This mechanism, which can support environment- and climate-friendly practices and standards, may be further promoted in the context of the green recovery plans.

The European Union (EU) has considerably extended the use of conditionalities in its cohesion policy in the 2014-20 period. These include *ex ante* conditionalities (general and thematic), macroeconomic conditionality and the link to country-specific recommendations (OECD, 2018[10]). Environmental conditionalities are now an integral part of many policy areas.

Some countries have also introduced environmental conditionalities in the allocation of their grants and subsidies for their infrastructure projects. In Canada for example, the Climate Lens programme is a requirement for projects seeking funding through the Investing in Canada Infrastructure Program, Disaster Mitigation and Adaptation Fund, and Smart Cities Challenge (see Box 4.4).

Box 4.4. The Climate Lens in Canada

The Climate Lens encourages consideration of climate impact and low-carbon options in the planning of infrastructure projects. Launched in June 2018, the Climate Lens was updated in September 2019 to clarify requirements and add a reference to additional external resources, such as the Canadian Centre for Climate Services. The Climate Lens has two components: the GHG mitigation assessment, which measures the anticipated GHG emission impact of an infrastructure project, and the climate change resilience assessment, which uses a risk management approach to anticipate, prevent and adapt to any climate change-related disruptions or impacts related to an infrastructure project. In 2019, 70 projects funded under the Investing in Canada Infrastructure Program were required to complete Climate Lens GHG mitigation assessments and 65 were required to complete climate change resilience assessments.

Source: Government of Canada (2020[13]).

The use of conditionalities is not without controversy. Some evidence suggests that the use of conditionalities has not always been effective in improving economic policies in recipient countries. There are different inefficiencies associated with the uptake of conditionalities (OECD, 2018[10]). Some particular issues are crucial for the effectiveness of conditionalities, which should be taken into consideration when designing and implementing a grant system using conditions (see Box 4.5).

Box 4.5. How to best use conditionalities?

Designers of conditionality-driven agreements need to have a clear understanding of the trade-offs and consequences of their design. This needs to take into account objectives, choice of instruments, degree of administrative burden and capacity of all parties to implement the agreement and realise the desired objectives. The lack of adequate capacities and skills may partially explain why conditionalities have not necessarily reached the expected outcomes. There is also a need to ensure ownership and legitimacy by establishing mutual accountability, especially to ensure that the application of conditionalities to different recipients is fair, consistent or even relevant. There is thus increasing pressure for transparency and accountability as well as programme evaluation and monitoring. The system should also be kept simple. An excessive amount of legislation and guidance or the proliferation of multiple conditions coupled with weak capacities may lead to inefficient or low use of funds by subnational governments. Simplicity also comes with the need for greater flexibility to adapt programmes to specific local circumstances and development needs.

Linking conditionalities to outcomes is ideal but is very difficult to put in practice. For example, the United States (US) applied this mechanism in environmental grant programmes and performance partnerships where outcome measures for pollution levels were negotiated with individual states. The government faced significant difficulties in negotiating the exact outcome(s) on which to link the conditionality because the states did not feel they had enough control over all of the contributing factors. Outcomes are often uncontrollable. The challenge is designing indicators that are objective, measurable, timely, meaningful, comprehensible, well documented and widely disseminated. For performance-based management to support greater accountability in the application and uptake of conditionalities, all parties must subscribe to human resource management frameworks that espouse results-based management and evaluation. In addition, having independent evaluation is important, i.e. undertaken

by outside actors, as the incentive structures in donor institutions do not often support truly objective and independent evaluation.

Source: OECD (2018[10]), *Rethinking Regional Development Policy-making*, https://dx.doi.org/10.1787/9789264293014-en; Berkowitz, P., Á. Rubianes and J. Pieńkowski (2017[14]), "The European Union's experiences with policy conditionalities", Background paper prepared for the Seminar "Conditionalities for More Effective Public Investment" held 28 April 2017 at the OECD Headquarters, Paris.

Establishing and developing specific climate funds targeted at subnational governments

The international community and national/state governments could further develop specific or matching grants to support climate-related projects developed by regions and municipalities. The international community (multilateral banks such as the World Bank, as well as bilateral banks, the United Nations Development Programme [UNDP], the Global Environment Facility, etc.) has established a series of funds providing support from developed countries to developing countries. These funds are earmarked for environmental protection and climate action. While a large part of these funds provides loans, in 2018 around 20% were allocated as grants (OECD, 2020[15]). While subnational governments can benefit from these multilateral funds, in reality, there is limited access for regional and local governments. Few donors are permitted to work directly with subnational governments and most resources are channelled through international implementing entities and the national governments of recipient countries. Even when subnational governments are accredited as intermediaries, they often face capacity challenges. Subnational governments willing to benefit from these funds will have to negotiate access with their national government and ensure compatibility with bilateral agreements negotiated between the fund and the government (OECD, 2019[1]; Colenbrander, Lindfield and Lufkin, 2018[16]).

At the European level, in the context of the Green Deal and the post-COVID-19 recovery measures, there is a new impetus for climate action at the national and subnational levels. The European Green Deal, adopted by the European Commission (EC) in December 2019, aims to make the EU climate-neutral by 2050.

Some national and state governments have also established dedicated funds to finance subnational government projects (Canada, Germany, the state of Jalisco, Mexico, the state of California in the US, etc.) but much more could be done to really foster climate priorities at the subnational level (see Box 4.6).

Box 4.6. Multilateral, European and national/state climate funds

Multilateral climate funds

Multilateral climate funds play an important role in supporting developing countries to adopt low-emission, climate-resilient development trajectories through loans, guarantees, grants et equity investment. They also have a role in capacity building, research, piloting and demonstrating new approaches and technologies, and removing barriers to other climate finance flows (Climate Funds Update, 2020[17]). Among the most important in terms of the pledge are the Green Climate Fund (GCF), the Clean Technology Fund (CTF), the Amazon Fund, the Least Developed Countries Fund (LDCF) and the Global Climate Change Alliance (GCCA), the Pilot Program for Climate Resilience (PPCR) and the Adaptation Fund (Climate Funds Update, 2020[17]). There are several estimates concerning the global amount mobilised by multilateral climate funds, depending on the source. A recent OECD estimate from 2020 puts the public and private climate finance flows provided by developed countries to developing countries in the context of the United Nations (UN) Framework Convention on Climate Change (UNFCCC) at USD 78.9 billion in 2018. In 2018, 21% of all climate finance was for adaptation, 70% for mitigation and 9% were cross-cutting. Over 2016-18, Asia benefitted from the largest share

(43%) of total climate finance, followed by Africa (25%) and the Americas (17%) (OECD, 2020[15]). The GCF and the Adaptation Fund have introduced a number of relatively new institutional features with the aim of channelling a larger share of climate finance to the local level. However, local government participation remains low (Colenbrander, Lindfield and Lufkin, 2018[16]).

- **EU cohesion funds, the Green Deal and EU funds for climate action**:
  - EU cohesion policy provides a key source of financing that member states have employed for environmental investments, in particular through the European Regional Development Fund (ERDF) and the Cohesion Fund (CF), which primarily finance infrastructure and physical investments. Going forward, a large part of the funding provided in 2021-27 will have to contribute to achieving the Green Deal objectives. In addition to cohesion policy, the EU plans to finance the policies set out in the Green Deal through an investment plan, InvestEU, which forecasts at least EUR 1 trillion in investment, and the Just Transition Fund, which provides EUR 40 billion to support economic diversification and reconversion in regions and sectors that are most vulnerable to the transition towards the green economy.
- **National and state climate funds supporting subnational climate-related projects**:
  - In **Canada**, in 2019, the federal government announced CAD 1.01 billion in endowment funding for the Federation of Canadian Municipalities' Green Municipal Fund, for 3 programmes: Sustainable Affordable Housing Innovation, Community EcoEfficiency Acceleration, and Low Carbon Cities Canada (LC3). These programmes support local actions to improve the energy efficiency of homes and community buildings and reduce GHG emissions. In summer 2019, seven LC3 Urban Climate Centres were announced in Canada's seven largest urban environments: Calgary, Edmonton, Halifax, Hamilton, Montreal, Ottawa, Toronto and Vancouver (Environment and Climate Change Canada, 2020[18])
  - In **Germany**, the National Climate Initiative (NCI) is the main instrument to support subnational green finance across a range of sectors, such as transport, energy and sanitation services. However, the capacity of the fund is likely insufficient. In the 2008-19 period, the NCI invested EUR 1.07 billion in over 32 450 projects domestically, which leveraged a total of EUR 3.5 billion in investment.
  - In **Mexico,** the state of Jalisco has created a framework to provide funds to municipalities as well as to associations of municipalities to implement climate protection projects. In addition, an environmental fund opens up further financing opportunities for climate change projects by municipalities. Funds are allocated via calls for proposals, where councils may apply based on their climate action plans (OECD, 2020[19]). Since 2015, the state of Jalisco adopted its Law for Action on Climate Change (LACC) that requests all municipalities to have a Municipal Climate Change Programme (*Programa Municipal de Cambio Climático*, PMCC).

Developing and optimising tax revenues, user charges/fees and other revenues to support climate objectives

Developing and optimising subnational government tax revenue instruments

In 2018, tax revenues (shared and own-source taxes) accounted for a large share of subnational government revenues on average in OECD countries (44%). However, as the share of tax in subnational revenues varies greatly from one country to another – from 3% in Estonia to 79% in Iceland – the potential of subnational tax systems to foster environmental and climate priorities also varies greatly across countries.

There are different ways to green subnational tax systems, including eliminating the anti-green bias of existing subnational taxes, using local taxes to foster green practices and developing subnational environmental taxes. This could also imply providing subnational governments with more taxing powers.

National and subnational governments should screen and audit their subnational tax systems to identify taxes, tax provisions and tax incentives that could favour non-environmentally friendly green and climate practices. A classic example is property tax on land and buildings. Depending on how they are designed, property taxes can encourage urban sprawl or by contrast, favour the development of urban cores and transport linkages. Reforming property taxation may therefore be a valuable tool to achieve more sustainable urban development patterns. For example, split rate property taxes, whereby higher tax rates are set on the value of land than on the value of buildings and other improvements, can promote denser development and give rise to more compact cities. Lower tax rates on the value of buildings and other improvements can encourage owners to build more intensively or renovate their properties to increase their value (OECD, 2018[20]). Tax incentives for the development of land on the outskirts of cities can be also eliminated to prevent the conversion of farmland and forests into urban land (OECD, 2018[20]).

Taxes that specifically target regional environmental impacts could be further developed at the subnational level. Many of them would also contribute to GHG emission reduction or climate adaptation. Environmental taxes include tax transport (cars sales/registration taxes, annual vehicle circulation taxes), pollution (including waste taxes and taxes on the use of pesticides and/or fertilisers) and taxes on water abstraction and resources extraction. Environmental taxes, which are already well developed at the subnational level in several OECD countries, offer a potential source of expanded revenue for subnational governments. Waste taxes, for example, can encourage emission reduction by encouraging circular economy practices, helping to reduce high demand-based emissions in high-income cities for example. Cost-reflective water chargers will be important in the context of climate adaptation, as many regions will face rising draught risk as well as increasing water demand in agriculture.

Subnational governments' powers of taxation are limited, however. Reforming tax systems at a subnational level mostly depends on the decision of central or federal governments. While subnational governments have taxing power on their own-source tax system (ability to modify rates and bases), tax provisions are framed by national regulations and subnational tax power on rates and bases may be constrained and limited. National governments could allocate the full benefit (or a share) of certain national environmental taxes to subnational governments and also provide them with more flexibility and taxing power to implement a regional or local climate-friendly tax policy. This can be done through rates and bases but also by creating local ecotaxes. Some of these tax arrangements are linked to land value capture and further developed below.

Enhancing the potential of user charges and fees for climate objectives

User charges and fees can raise revenue that supports the transition. These include congestion charges, parking fees, high occupancy toll lanes, water and wastewater user fees, urban tolls or utility fees (water, waste and energy) (Merk et al., 2012[21]). Road user charges will need to replace fossil fuel taxes when fossil fuel vehicles are phased out, both to replace revenue streams from fossil fuel taxes as well as price negative externalities related to vehicle use such as congestion, accidents and noise. Moreover, road use charges that are time- and place-contingent can price externalities more efficiently, especially in urban areas, where external costs are much higher than typical fuel tax rates today (OECD/ITF, 2019[22]). However, road use charges in urban areas need to be embedded in an overall urban transport strategy as argued in the urban policy section below.

In London, Milan, Singapore and Stockholm, congestion charges have resulted in reduced carbon emissions. In the case of Milan and Singapore, this drop has been linked to the level of pollution emitted from vehicles (OECD, 2019[1]). Oslo, Norway, has become one of the world's electric vehicle (EV) capitals. It has developed a series of proactive measures that encourage the development of

EVs that include road tolls and municipal parking fees that only apply to fossil fuel vehicles (since the late 1990s). In the waste sector, Seoul, Korea, has developed and continuously improved a pay-as-you-throw system since the 1990s. General waste is charged on a volume-based fee (VBF) system for households, businesses and office buildings instead of a disposal bill based on building areas or property taxes. However, there are several limitations attached to the development of user charges and fees, including the legal ability of subnational governments to create and determine the level of such fees, in particular in areas considered as essential (e.g. energy sector), the capacity and willingness to pay of users and capacity management (OECD, 2019[1]).

Developing property income and land-based financing instruments

Local authorities can reclaim gains from investments or changes in land regulations, thereby generating revenue that can be used to close some of the funding gaps of the transition. This also includes funding infrastructure through land value capture, enabling communities to recover and reinvest land value increases resulting from public investment and other government actions (Lincoln Institute, 2018[23]). For example, local governments in Japan use land readjustment, a form of joint development, to finance infrastructure improvements. While these have not specifically funded green investments, many have funded passenger rail development, thereby reducing travel-related emissions compared to car travel. Land value capture instruments are useful in the context of zero-carbon transitions because they require substantial investment, for example in public transport, which raises real estate prices. Land value capture instruments can therefore serve to fund investment as well as limit rents from higher real estate prices.

Emissions trading systems (ETS)

Cap and trade is a policy mechanism to reduce GHG emissions. High polluting industries are required to pay when they exceed predetermined emission amounts. In order to emit over the prescribed amount, companies are forced to purchase emission allowances. While many ETS operate at the national level, some subnational governments operate their own (OECD, 2019[1]). For example, in the US, the Regional Greenhouse Gas Initiative (RGGI), launched in 2012 as a co-operative effort among several US states (as of today 11 states: Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, Vermont and Virginia), was the first mandatory market-based programme to reduce GHG emissions from the power sector. Another example is the California Cap-and-Trade Program, which is the main source of funding for the state of California's climate investments. At the city level, as part of a local law that sets emission intensity limits for most large buildings starting in 2024, the New York City government is required to study the feasibility of a citywide ETS for the buildings sector and release its findings by 2021 (World Bank, 2020[24]).

Globally, there are now 61 carbon pricing initiatives in place or scheduled for implementation, consisting of 31 ETS and 30 carbon taxes, covering 12 gigatons of carbon dioxide equivalent (GtCO2e) or about 22% of global GHG emissions (versus 20% in 2019). These initiatives cover 46 national and 32 subnational jurisdictions, the latter being mainly in North America (see Canada and the US above). Governments raised more than USD 45 billion from carbon pricing in 2019. Almost half of the revenues were dedicated to environmental or broader development projects and more than 40% went to the general budget (World Bank, 2020[24]).

Despite the increase of carbon prices in many jurisdictions, they remain substantially lower than necessary to be consistent with the Paris Agreement (World Bank, 2020[24]). In addition, carbon pricing comes with social limitations that need to be addressed. Some jurisdictions have delayed measures to strengthen their carbon pricing instruments and have extended compliance deadlines due to the restrictions (World Bank, 2020[24]). For efficiency adequate carbon pricing should be as uniform as possible, and therefore preferably be set at international or at least national, rather than subnational, level.

Making use of external finance mechanisms and attracting private investors for subnational climate-related projects

A number of potential instruments exist for mobilising external financing for the net-zero transition, including debt financing, subnational public-private partnerships (PPPs) and equity funds.

Developing debt financing for green and climate-related projects

Debt financing is used to complement self-financing and capital transfers to finance investment projects. This is especially true at the local level where borrowing is allowed only to finance capital expenditure. However, some subnational governments may face difficulties in borrowing because of strict prudential rules, among other constraints such as the lack of creditworthiness. Estimates suggest that around 20% of the largest 500 cities in developing countries are deemed creditworthy in international markets (OECD, 2019[1]). It may be even more difficult to borrow on capital markets (bond financing). In a large number of countries, subnational governments, or certain categories of subnational governments, are not allowed to issue bonds on capital markets. This said, even in countries where subnational governments are allowed to issue bonds, the practice is not widespread.

In Japan and North America, bond financing is widespread while loan financing is predominant in Europe, except at the state government level in federal countries (such as Germany, Spain and Switzerland). In Canada and the US, bonds represent more than 90% of the subnational government debt stock (OECD/UCLG, 2019[25]).

Borrowing frameworks could be adapted to allow borrowing for subnational government investments, especially if investments support the net-zero transition. National governments could also facilitate local government access to capital markets. National and/or regional governments could actively assist local governments by providing technical assistance for project appraisal and implementation, and assist local governments to explore joint borrowing across jurisdictions. They also help by setting up specialised agencies to pool local debt, thereby facilitating access to lower-cost capital finance for infrastructure investment such as in Nordic countries. In Sweden for example, the local government funding agency Kommuninvest makes use of the high creditworthiness of Swedish municipalities to help them raise capital through the issuance of bonds, which it places in Europe, Japan and other countries (OECD, 2020[26]).

Some promising debt instruments to mobilise private finance could be further promoted, in particular green and climate bonds. Targeted at financing environment-related investments, green and climate bonds must meet the eligibility criteria determined by the Green Bond Principles (GBP) or the Green Loan Principles (GLP). Despite rapid growth (USD 754 billion of cumulative issuance since inception in 2007, including USD 259 billion issued in 2019), green bonds still account for a small share of the global bond market. Subnational governments are increasingly active in the green bond market (USD 11.6 billion issues in 2019 by local governments vs. USD 3.7 billion in 2014) but there is significant room for scale-up. The share of subnational government accounted for only 4.4% of green bond issuance in 2019. In some countries (e.g. France, Japan, Sweden and the US), subnational governments are becoming significant issuers of green bonds or climate bonds, yet there is still significant scope for improved use of these instruments.

Scaling up the use of green bonds is especially difficult in countries where subnational governments are restricted from borrowing on capital markets. In addition, to establish an enabling environment for allowing and facilitating the subnational governments' access to capital markets, governments could also develop guidelines, standards, reporting and certification practices to create the foundation for a green bond market. They could also provide technical assistance to develop bankable green projects and support for capacity building at the local level. Another way to support the development of a local green bond market is credit enhancement from governments/multilateral institutions, possible provision of tax incentives for an initial period to foster market development and the development of green banks and green funds (Climate Bonds Initiative, 2015[27]).

Mobilising public-private partnerships (PPPs) to foster climate objectives

PPPs may also be an interesting mechanism to support green growth projects at the subnational level. PPPs are a long-term contract between a private party and a government entity for providing a public asset or service, with some of the risk and management responsibility shifted to the private party. Although the average value of PPPs is generally higher at the national level, the number of PPPs may be greatest at the subnational level in some countries. For example, in Germany, subnational PPPs constitute approximately 80% of PPP investment. Green PPPs may offer added value. For example, in Slovenia, the city of Ljubljana developed two PPPs through energy performance contracting (PPP EPC). These are recognised as the most successful PPP EPC in the country and in the EU, and have been replicated by other Slovenian cities. These projects are based on the principle of EPC within which the majority of building stock (schools, cultural centres, sports and healthcare facilities, etc.), owned by the city is being deeply energy retrofitted and, where possible, renewable energy sources are being introduced. Consequently, their GHG emissions are being reduced. For the first project (EOL1), the 25 deeply retrofitted buildings received 51% of their funding from private partners, 40% from cohesion policy funds and 9% from the city (OECD, 2020[19]).

Subnational PPPs are however not without risks. Challenges emerge in areas such as financing and funding. Private borrowing costs might be higher than public ones, for example, raising the costs of the PPP project overall. PPPs require intergovernmental regulatory coherence, cross-jurisdictional co-ordination, economies of scale and asymmetric information between the contracting parties, which may put local governments at a disadvantage. It also requires management capacity in subnational governments (OECD, 2019[1]).

Attracting private sector financing through equity funds

Private institutional investors, such as pension funds and insurance companies, have some USD 70 trillion in assets under management in OECD countries and could invest more in climate-neutral projects. Such actors are currently investing very little in climate-related projects at the subnational level. Yet, there are at least two barriers to overcome. These relate to inadequate international and national legal frameworks for private long-term investments and public-private co-investments rules, as well as the size of urban projects, which increases the cost for private investors. Successful experiences of mobilising institutional investor capital for climate-friendly investment projects do exist. In particular, investment can take place through specialised infrastructure equity funds, which may also involve other private investors, such as urban developers (OECD, 2019[1]).

Aligning subnational government expenditure with net-zero-emission objectives and direct subnational spending and investment towards climate priorities

Subnational governments can set climate targets and incorporate them into their spending policies and budget priorities. Greening expenditure applies to both current and capital expenditure. It is important to recall that, on average in the OECD, investment expenditure represents around 13% of subnational expenditure while current expenditure represents the remaining part. Therefore, a comprehensive review of the budget should be conducted for both current and capital expenditure (OECD, 2020[11]).

Several tools can be mobilised to direct spending and investment towards environmental and climate objectives. They include: i) providing climate-related financial support to firms and households; ii) integrating environmental benefits in costs analysis; iii) developing the use of green public procurement; and iv) developing subnational green budgeting.

Providing climate-related financial support to firms and households through dedicated regional and local climate funds

At a regional level, several states, provinces and regional governments operate their own dedicated green and climate funds. At the local level, some cities have also used their power to establish climate funds to finance sustainable and climate-friendly projects within their city. These funds are derived from different sources, including the proceeds from the sale of emission allowance and support projects in many areas: energy efficiency, renewable energy, affordable housing, public transportation, increased mobility options through transit, walking and biking, zero-emission vehicles, environmental restoration, water savings, more sustainable agriculture, recycling, etc. Support is provided in different ways, including direct investment in projects, subsidies, loans, credit enhancement solutions, guarantees, equity, etc. Creating such funds has three main advantages for subnational governments, in addition to supporting climate objectives. The first is giving a clear signal to citizens, businesses and investors regarding the region or city's ongoing commitment to support projects that reduce emissions and increase resilience. Second, they can help de-risk finance from more conventional sources. Finally, by acting as a guarantor or an underwriter, climate funds can entice more private sector actors or other commercial lenders to invest in cities' projects and allow the region or the city to invest and have a stake in their own projects (C40 Cities, 2016[28]).

Box 4.7. Regional and local climate funds targeted at firms and households

Many regions and cities, using different sources of revenues, have established climate funds directed to businesses, households and non-governmental organisations (NGOs) to support green and climate-related projects.

- In **California**, the Greenhouse Gas Reduction Fund (GGRF) is funded by the proceeds from the Cap-and-Trade Program (see above). The fund support programmes and projects that reduce GHG emissions in the state in application of the California Global Warming Solutions Act of 2006. As of 2020, more than USD 11 billion have been appropriated by the legislature to state agencies implementing GHG emission reduction programmes and projects. As of March 2020, cumulatively, USD 5.3 billion in projects have been implemented across the state, with 57% of those investments benefitting California's priority populations, with more than 428 000 individual projects implemented (OECD, 2020[29]).
- In **France**, the city of Paris launched in 2018 the Paris Green Fund (*Paris Fonds Vert*) to support private innovation and small- and medium-sized enterprises (SMEs) in support of the ecological transition of Paris. The city of Paris allocated EUR 15 million into the fund initially, with a first target to reach EUR 200 million thanks to the involvement of private investors. The fund has three main functions: first, to serve as a growth equity fund aiming at financing companies that are already in a growth phase and/or at a more mature stage in their development; second, to serve as a green fund to invest in several sectors transport, energy, energy efficiency, waste management, buildings and digital innovation; and third, to serve as a territorial fund. All activities funded through the Paris Green Fund must demonstrate a positive impact on the ecological transition of the city of Paris. The territorial impact of the fund will be evaluated by an external body according to six main metrics: carbon impact (induced and avoided emissions); energy impact; impact on air quality; overall economic impact and just transition; resilience to the consequences of climate change; recycling and waste reduction (OECD, 2019[1]).

- In **the Netherlands**, the Amsterdam Climate Fund, established by the city in 2019, is intended to encourage residents, businesses and institutions to take significant measures to reduce carbon emissions, including disconnecting buildings from natural gas. In the case that projects do not pay for themselves (inevitable losses), initiators can apply for a contribution from the fund (City of Amsterdam, 2020[30]).

Developing green public procurement

Public procurement needs to be consistent with the net-zero emission transition. On average in the OECD, public procurement represents 12% of GDP and 29% of government expenditure; subnational government's procurement represents more than half of this expenditure. In addition to greening public consumption and investment policies, green public procurement (GPP) can provide industry with incentives for developing environment-friendly products and services, particularly in markets where public purchasers represent a large share, such as construction or public transport. GPP covers: i) gross fixed capital formation; and ii) intermediate consumption, such as energy-efficiency light bulbs, recycled paper, etc. (OECD, 2015[31]; 2019[32]).

GPP is most effective when integrated into broad subnational emission-reduction strategies with concrete net-zero benchmarks. These benchmarks provide the framework for public procurement. In the pre-procurement phase, subnational governments that engage in preliminary market consultation improve their understanding of existing technologies. During the procurement process, subnational governments can formulate minimum and binding requirements for the tender. Environmental certification (e.g. EU Ecolabel, Energy Star, etc.) and other performance specifications are useful and can be defined in multi-level governance arrangements. Additionally, ESG criteria should be defined and implemented in public procurement as in private finance. For example, the EU Taxonomy defines economic activities that contribute towards climate neutrality by 2050 and argues for more consistent reporting (EC, 2021[33]). Another example is the Glasgow Financial Alliance for Net Zero which brings together large firms across the financial sector to co-ordinate short-term targets towards net-zero emissions by 2050 (UNCC, 2021[34]). Continuous monitoring and evaluation are key. This should be integrated into policy and regulation (EC, 2014[35]; OECD, 2015[31]). For instance, the Italian city of Rome has integrated a monitoring system into its green procurement tool (see Box 4.8).

Box 4.8. Green public procurement in Cities

- In 2006, **Denmark**'s Ministry of the Environment and Food, together with the three largest cities (Aarhus, Copenhagen and Odense) established the Danish Partnership for Green Public Procurement. Since then, this initiative has expanded to 12 municipalities, 2 regions and 1 water supply company, representing 13% of Denmark's annual public procurement in Denmark (approximately EUR 5.5 billion) and 30% of the total procurement volume of Danish local governments. The partnership aims to develop joint, mandatory procurement objectives and criteria that have major positive impacts on the environment, ensuring a certain level of co-ordination in GPP actions from the largest public sector procurers. These criteria can also function as a guide for municipalities where incorporating environmental requirements in the procurement process is less developed. Furthermore, the partnership also establishes working groups that share knowledge between the cities to solve joint procurement challenges and develop specific criteria within different product areas. Relevant materials are available on an online platform for easy peer learning. In addition, by sharing consistent sets of green criteria, the partnership makes it easier for the market to respond to sustainability demands from public purchases. Finally, the national government has developed a webpage, the Responsible

Procurer, where procurers can find green criteria, based on EU GPP criteria and other national recommendations, ready to copy and paste into tender documents for a number of product areas and Total Cost of Ownership tools for selected product areas.

- In Frankfurt, **Germany**, new buildings must meet strict energy use standards. Several environmentally harmful materials are forbidden. Based on tenders, subnational governments analyse and evaluate the life cycle environmental impact and costing of the product.
- In 2009, the **Italian** Metropolitan City of Rome developed its first action plan for GPP with a manual monitoring system. The city reduced CO_2 emissions by 749 tonnes between 2011 and 2014. However, many procurement forms were incomplete or inaccurate. To improve data collection and reporting, in 2014, the city integrated GPP monitoring into its accounting system and, in 2016, launched a digital version. The new monitoring helps municipal staff to verify the completeness and quality of GPP tenders. The city has also set up a telephone help desk, an updated online library of laws and regulations regarding GPP, a support guide and training for staff across departments.

Source: Ministry of Environment and Food of Denmark (2020[36]), *Sustainable Procurement*, https://eng.mst.dk/sustainability/sustainable-consumption-and-production/sustainable-procurement/; City of Frankfurt (2014[37]), *European Green Capital Award*, https://www.frankfurt-greencity.de/de/vernetzt/auszeichnungen/european-green-capital-award/; EC (2016[38]), "Strategy and approach to SPP in the municipality of Copenhagen", https://ec.europa.eu/environment/gpp/pdf/news_alert/Issue64_Case_Study_130_Copenhagen.pdf; C40 Cities (2019[39]), "Cities leading the way: Seven climate action plans to deliver on the Paris Agreement".

Developing subnational green budgeting to align revenue and expenditure with zero emissions

Green budgeting can support subnational governments to better align their expenditures and revenues with climate objectives. It requires a systematic examination of existing and potential budget measures and policies, their interdependencies, externalities and joint benefits, and mainstreaming an environmentally informed approach to the national and subnational budgetary frameworks. It provides decision-makers with a clearer understanding of the environmental impacts of budgeting choices. Green budgeting can help regions and cities to identify spending that is inconsistent with the net-zero-emission transition and helps prioritise net-zero-consistent spending. This type of budgeting is still rare. Budgetary practices tend not to fulfil their potential to make revenues and spending consistent with national or regional climate objectives (OECD, 2020[40]; forthcoming[41]).

Four types of green budgeting exist and can be applied by subnational governments. First, monetary budgeting can be related to carbon budgeting. Carbon budgets identify the target carbon emissions. Based on their carbon budgets, subnational governments can develop short-term and long-term targets towards net-zero emissions (see section on subnational governments need to be integrated into climate policy governance). Second, environmental budgeting and reporting enable governments to track the emission impact associated with each budget line item, to align budget priorities with the carbon budget. Third, green accounting expresses environmental externalities in monetary terms, i.e. by attributing a price to carbon. It can also price other environmental impacts such as biodiversity, clean air, etc. Fourth, "common good" balance sheets aim at gathering the scores for performance indicators related to the environment but also to social justice, human dignity, solidarity and democratic governance. This adds complexity but provides a valuable opportunity to identify the multiple non-climate benefits climate action can bring and which often arise locally (EnergyCities, 2019[42]; OECD, 2020[43]).

Urban policies are central to climate change mitigation and regional development

Cities are hubs for high-productivity activity in close integration with surrounding low-density areas. On the path towards 2050, when many countries aim at reaching net-zero GHG emissions, cities will play a key role. More than half of the world population lives in metropolitan areas. They account for 70% of GDP and about two-thirds of energy demand. This will require different and more investment but could also lead to many positive impacts in urban areas. These can include business opportunities, health benefits from lower air and noise pollution, as well as productivity gains from lower air pollution, congestion and improved accessibility (Box 4.9). Taking advantage of zero-emission innovations in energy, mobility and buildings, cities can lower public service provision cost and provide healthier and more climate-resilient urban environments. Moving ahead early will provide competitive gains for cities, as well-being gains make cities more attractive to mobile workers and productivity gains attract knowledge-intensive business. Moreover, moving early will save costs from avoiding transition-inconsistent investment.

In cities, CO_2 emissions predominate. As highlighted in Chapter 3, reaching net-zero GHG emissions will imply reaching net-negative CO_2 emissions by 2050 and net-zero CO_2 emissions several years earlier. CO_2 emissions should reach zero particularly quickly in the electricity sector, where technology is readily available and cheap, to allow cost-efficient decarbonisation of energy end-use sectors, including passenger and light road freight transport.

Metropolitan regions may account for more than 60% of production-based GHG emissions in OECD countries. The contribution of metropolitan regions to emissions is particularly large in North America and OECD Asia (Figure 4.3). In Japan and Korea, populations are particularly concentrated in metropolitan areas. In North American metropolitan regions, per capita emissions are particularly high (Figure 4.4). Per capita emissions are lowest in European and South American metropolitan regions, mostly on account of transport. This highlights the importance of public transport in controlling emissions, with many European cities doing better (Chapter 3). In Australian and East Asian countries, electricity generation and industry also contribute substantially to emissions because of coal use. In these metropolitan regions, local well-being gains from exiting coal are particularly likely to be large as air pollution would decline, saving a substantial number of premature deaths. Across all continents, OECD large metropolitan regions have lower per capita emissions than their smaller peers. Moving to net-zero emissions in an urban context requires an integrated approach to urban land use, housing and transport and is one of three pillars of climate action.

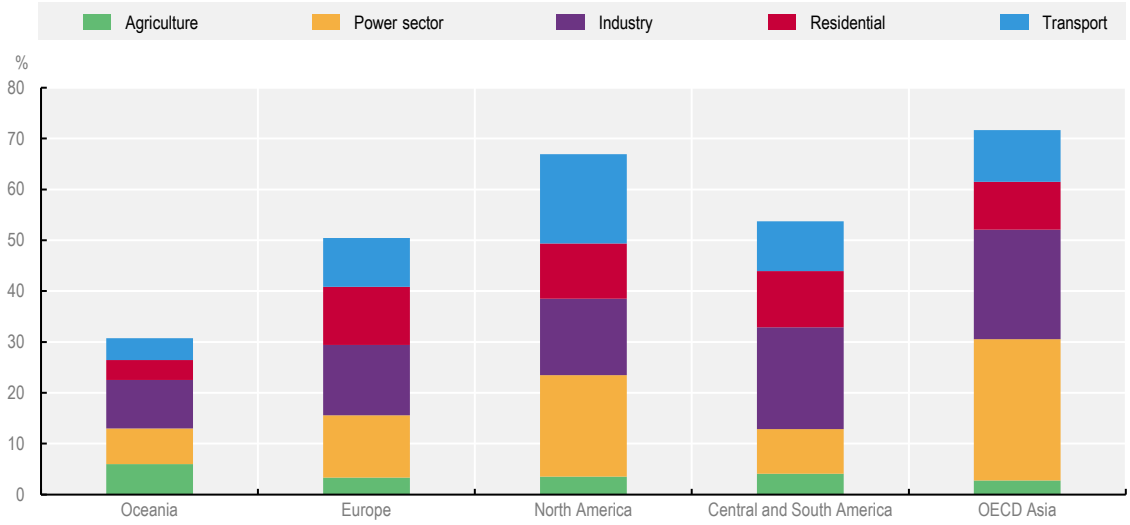
In some middle-income countries, the share of urban CO_2 emissions is much higher than in OECD countries. In China, India and Indonesia, urban centres contribute more than 40% to national CO_2 emissions, compared to 20% in most OECD countries (Crippa et al., forthcoming[44]). Between 2015-50, the world's city populations are projected to grow from 48% in 2015 to 50%, mostly in middle-income countries as reported in *Cities in the World* (OECD/EC, 2020[45]). Urbanisation in these countries is a key driver of world energy demand and emissions growth, as workers migrate to cities with high or rising emissions to take up jobs in more energy-intensive industries, adopt more energy-consuming lifestyles and earn higher incomes. Zero-carbon-consistent urbanisation, with support from high-income countries, is a key challenge but also an opportunity. For example, zero-emission-consistent transport infrastructure can be developed at a lower cost than conventional infrastructure if integrated from the onset (OECD, 2017[46]). It also allows the decoupling of air pollution from economic production.

In high-income cities, consumption-based emissions are typically much higher than production and location-based emissions, as they consume many goods produced elsewhere (Box 4.9). Consumption-based emissions in cities may or may not be production-based in their country, depending on whether the goods and services consumed in the city are imported. In any case, cities have options to reduce consumption-based emissions such as reducing waste and encouraging the circular economy, some at particularly low cost, as described below. Policies to lower consumption-based emissions also offer the advantage that they do not result in displacement of production and emissions, especially if the emissions'

content of the consumed goods is easily established. Reducing consumption-based emissions can also contribute to a more equitable sharing of the carbon burden.

Figure 4.3. Metropolitan regions contribute the most to greenhouse gas emissions in North America and OECD Asia

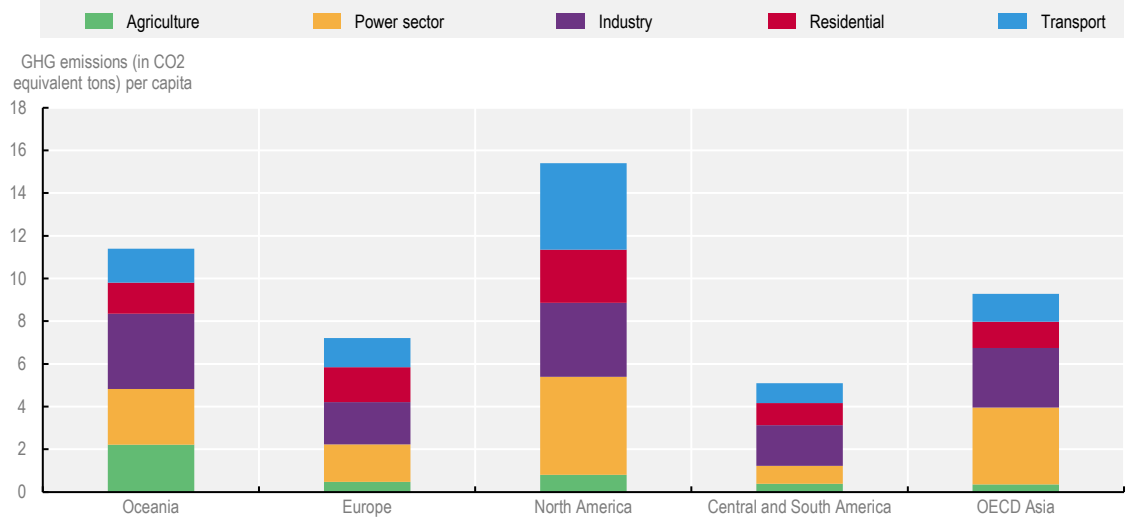
Contribution to total GHG emissions across continents, 2018



Note: OECD countries, Bulgaria and Romania. GHG emissions excluding emissions from land use and land use change.
Source: OECD calculations based on EC (2020[47]), *EDGAR - Emissions Database for Global Atmospheric Research*, Joint Research Centre, European Commission.

Figure 4.4. Per capita emissions in metropolitan regions are particularly large in Australia, North America and OECD Asia

GHG emissions per capita, 2018



Note: OECD countries, Bulgaria and Romania. GHG emissions excluding emissions from land use and land use change.
Source: OECD calculations based on EC (2020[47]), *EDGAR - Emissions Database for Global Atmospheric Research*, Joint Research Centre, European Commission.

Box 4.9. Consumption-based greenhouse gas emissions in cities

Consumption-based emissions rise more strongly with city per capita income than production-based emissions (Sudmant et al., 2018[48]), reinforcing the case for monitoring consumption-based emissions. In Bristol, for example, the city's consumption-based emissions are three times the production-based emissions, largely due to the impacts of food and drink. In other UK cities, they may be twice as high (Sudmant et al., 2018[48]). Cities in America and Europe produce consumption-based emissions thrice that of production-based emissions. A study on 10 European cities projected consumption-based emissions to increase by 35% by 2050. Across 79 C40 cities, consumption-based emissions were higher by 60% on average compared to emissions generated locally from production-based emissions (e.g. from economic production, transport or the heating of buildings) (C40 Cities, 2018[49]).

Taking into account consumption-based emissions provides additional opportunities for reducing emissions and supporting a more circular economy, for example by reducing consumption of goods that generate substantial emissions where they are produced. This can help accelerate the transition at a lower cost. City action to transform consumption habits can reduce these emissions at low cost (Millward-Hopkins et al., 2017[50]). In Bristol, investments of approximately GBP 3 billion in low-carbon infrastructure, such as buildings, could reduce production-based emissions by 25% in 2035. Eliminating the city's current levels of food waste would reduce emissions by a similar amount but with little investment or other costs (Millward-Hopkins et al., 2017[50]). Policies that can tackle consumption-based emissions include product and procurement standards, city and infrastructure planning, and economic measures to incentivise product longevity and a sharing economy.

The commitments to address climate change varies strongly across cities. Some cities have taken strong leadership in GHG emission targets, aiming for net-zero emissions well before 2050. The city of Bristol, UK, has adopted a net-zero emissions target for 2030, including consumption-based emissions. But across 327 European cities, for example, reduction targets for 2050 range from a mere 3% to 100%, giving an average emission reduction of 47%, which acutely falls short of the EU target to reach net-zero GHG emissions overall by 2050 (Salvia et al., 2021[51]). Most cities with over 500 000 inhabitants have comprehensive standalone mitigation or adaptation plans. Where local climate change planning is required by national governments (Denmark, France, the Slovak Republic and the United Kingdom), cities have been nearly twice as likely to produce local mitigation plans (OECD, 2020[26]). Moreover, setting targets for emissions is not enough. For example, cities that do not host power plants and where energy use in buildings is electric may have low production-based emissions but will still need to contribute to energy efficiency targets and renewables deployment to contribute to national targets.

Effective metropolitan governance is critical for integrating climate policy

A key message from the UN New Urban Agenda (OECD/UN-Habitat, 2018[52]) is that urban CO_2 emissions and air pollution are best addressed at the metropolitan level. Tackling climate change while achieving the other Sustainable Development Goals (SDGs) requires urban governance, building competencies and technical capacities to redirect and unlock investment for sustainable infrastructure.

Urban areas sometimes extend across regions and hundreds of municipalities. The socio-economic flows, notably travel-to-work, exchanges and services provision, which need to be decarbonised, do not match administrative boundaries. For example, in the metropolitan area of Mexico City, Valle de México, two-thirds of GHG emissions and 80% of particulate matter pollution come from outside the administrative borders of the city (OECD, 2015[53]) and more than 40% of residents commute across a municipal boundary to get to work or school and access services (OECD, 2015[53]). In the Hamburg Metropolitan Region,

350 000 out of 760 000 commuters enter the city on a daily basis (OECD, 2019[54]). The region brings together 20 districts and more than 1 100 municipalities from 4 federal states including the city of Hamburg itself (OECD, 2019[54]).

Metropolitan areas, therefore, need to be governed with respect to the delimitations of travel-to-work areas. Metropolitan governance for urban planning, transport and housing will allow the residents to benefit from public transport and housing co-ordinated throughout commuting zones, while improving accessibility of jobs and services, reducing air pollution and congestion as well as eliminating GHG emissions. The benefits of such co-ordination are large. Metropolitan areas without their own governance tend to have more emissions and air pollution as well as lower levels of productivity (OECD, 2015[55]). Metropolitan governance also results in denser and more contiguous residential development, which helps reduce emissions and higher satisfaction of residents with public transport. The experience of OECD countries offers lessons for metropolitan governance reforms (OECD, 2015[56]). They are complex processes, requiring political support, effective co-ordination and reliable funding (Box 4.10).

Box 4.10. Governance lessons from several metropolitan areas across the OECD

Motivate collaboration by identifying concrete metropolitan projects

Kick-starting initiatives around tangible projects can help rally forces. For example, in the Øresund metropolitan region in eastern Denmark and southern Sweden, the opening of a bridge between Copenhagen and Malmö in 2000 stimulated integration. Municipal and regional authorities form the Øresund Committee, its main cross-border governance body. The bridge has opened job opportunities for the benefit of both sides. In the Hamburg Metropolitan Region in Germany, improving environmental sustainability and harnessing the potential of renewable energy production reinforced metropolitan governance, as this requires co-operation among the different local-level actors in policy domains such as housing and transport (OECD, 2019[54]).

Build metropolitan ownership among local stakeholders

Metropolitan governance reform needs strong advocates. For example, in 2015, the Dutch national government undertook a series of institutional reforms that led to the creation of the metropolitan regions of Amsterdam and Rotterdam-The Hague (OECD, 2016[57]). In the US, the metropolitan land use and transport planning agency for the Chicago metropolitan area was the product of a two-year campaign initiated by a regional non-profit organisation representing the business community (OECD, 2012[58]). In the UK, the government gives metropolitan areas specific powers through the City Deals initiative. Under City Deals, local governments decide what needs to be done locally and set targets in areas such as jobs, affordable housing and emissions reduction. In Valle de México, the Environmental Commission for the Megalopolis co-ordinates decision-making and provides a vision for air quality improvement across local governments. It promotes an integrated approach for diagnostics, analysis and actions (OECD, 2015[53]). Co-operation among municipalities works best on a voluntary basis with incentives from the top but also with a strategy to engage those who feel threatened, sometimes by giving compensation.

Tailor reliable sources of metropolitan financing

A key element for metropolitan areas is to secure an appropriate, reliable stream of funding to facilitate collaboration. They generally face problems related to disparities in revenue-raising potential, expenditure needs and investment capacity. Financial resources need to match the new governance structure's responsibilities. Property tax is the main source of income of metropolitan areas as it provides stability to revenue. In Mexico, the national government contributes to the funding of

infrastructure projects in metropolitan areas to complement local resources. Metropolitan areas and the municipalities in them apply together providing incentives to create metropolitan areas (OECD, 2015[53]).

Design incentives and compensation for metropolitan compromises

Effective metropolitan governance requires clear communication around the costs of maintaining business as usual and the long-term gains of reforms. Co-operation among municipalities tends to work best on a voluntary basis with incentives from the top, while also having a strategy for engaging those who feel threatened by the reform and leveraging their buy-in. Examples of such incentives are devolution and financial incentives. For instance, for the City Deals in the UK, the government gave a range of new powers to cities that committed to strengthening collaborative governance in their area.

Implement a long-term process of monitoring and evaluation

Metropolitan governance requires continuous improvement through strong, reliable instruments for monitoring and evaluation. In Toronto, Canada, for example, the city authorities set up mechanisms to gather feedback from citizens and other stakeholders on metropolitan issues on a regular basis. One such mechanisms is the Greater Toronto City Summit Alliance, which convenes members of the three levels of government with business, labour, academic and non-profit sectors every four years to drive collective action for example in transport, energy, socio-economic inclusion. In Perth, Australia, an independent expert panel conducts a metropolitan review to examine the city's social, economic and environmental challenges and formulate reform proposals. Reforms may take the form of incremental experimentation through the implementation of pilot projects. In Sweden, governance reforms aimed at merging counties with a directly elected regional assembly and responsibility for regional development were first tested in two pilot regions (Västra Götaland around Gothenburg and Skåne around Malmö) with multi-annual evaluation before extending it to other counties.

Source: OECD (2015[56]), *Governing the City*, http://dx.doi.org/10.1787/9789264226500-en.

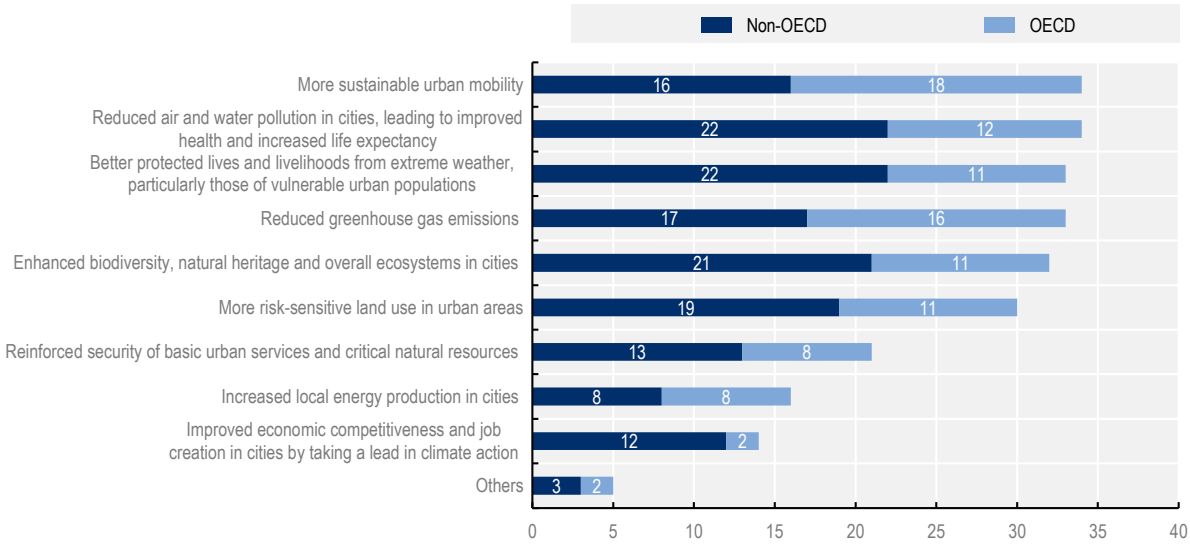
National urban policy frameworks are beginning to integrate climate policy

National urban policies (NUPs) can co-ordinate sectoral policies relevant for the net-zero-emission transition in cities. A NUP is a government-led, coherent set of decisions to co-ordinate actors in order to promote more productive, inclusive and resilient urban development consistent with environmental goals (UN-Habitat, 2014[59]). A NUP must be accompanied by an effective institutional framework and governance that allow for co-ordination and collaboration with urban stakeholders (OECD/UN-Habitat, 2018[52]). NUPs can cover a wide range of national policies with a profound effect on urban development. They can help deliver climate change mitigation and adaptation responses and achieve cross-sectoral synergies. Land use zoning, for instance, impacts sectors such as transport, housing, energy, natural resources, water and waste. For example, national ministries have often pursued housing programmes without subnational governments and without co-ordinating the housing programme with local transport (OECD, 2015[60]; Rode et al., 2017[61]). This often results in low-cost urban periphery construction, more car dependence, a higher carbon footprint and emissions from a land use change such as deforestation. This ultimately results in higher costs from connecting housing to infrastructure, aggravated by congestion (Moreno Monroy et al., 2020[62]) as recently illustrated in a case study of Ethiopia (OECD, forthcoming[63]). The location of housing developments at urban peripheries can also result in high home vacancy rates, as in Mexico (OECD, 2015[60]). National governments can improve local capacity to implement national development plans, consistent with climate objectives, and establish a central body responsible for cross-sectoral co-ordination of key policy areas, such as in Colombia's interagency commission (Rode et al., 2017[61]).

Among 65 countries that have participated in a survey of NUPs, including 22 OECD countries, most, but not all, have integrated climate action. According to preliminary survey findings (OECD/UN-Habitat, forthcoming[64]), 51 country NUPs addressed adaptation and mitigation, while 13 reported that their NUP did not address climate change at all. Some countries have identified related co-benefits in their NUPs (Figure 4.5). Half of the countries (26) identified "enhanced urban biodiversity and ecosystems" and "better protected lives and livelihoods from extreme weather". These allow nature-based urban solutions to provide wider ecosystem services and protect against extreme heat or flooding. "Increased local energy production in cities" was a key objective for only 16 respondents. Only 14 national governments – 2 of which are from OECD member countries – regard economic competitiveness and job creation as a reason to integrate climate change into NUPs.

Where climate action is included in NUPs, the survey results do not allow us to assess whether they are consistent with national or Paris Agreement emission reduction objectives. To deploy sectoral policies consistent with net-zero GHG emissions in 2050 in housing, for example, national governments will have to integrate the refurbishment of the entire buildings stock. This is likely to require refurbishing around 5% of cities buildings per year. NUPs can also integrate scenario analysis to set benchmarks for urban renewable electricity generation, transport and the reduction of consumption-based emissions as discussed below.

Figure 4.5. Key objectives identified by national governments to mainstream climate action in their NUPs



Note: 52 respondents (22 OECD member countries) reported their NUP addressed climate change through mitigation, adaptation or both.
Source: OECD/UN-Habitat (forthcoming[64]), *Global State of National Urban Policy: 2nd Edition*, OECD Publishing, Paris/United Nations Human Settlement Programme, Nairobi.

Networks of cities and their metropolitan areas must also be supported, as highlighted in the report *Managing Environmental and Energy Transitions for Regions and Cities* (OECD, 2020[26]). They in turn can support the replication, scaling up and mainstreaming of successful experiments. Urban pilot projects to introduce novel transport systems that contribute to the net-zero-emission transition in a city, such as digital-based ride-sharing described below, can serve rapid diffusion and should also be integrated into NUPs.

There are two main ways to support more structured learning in and between cities:

- **Intracity learning** focuses on the exchange of information and knowledge between initiatives and actors within the boundaries of a particular city or region. Urban policymakers can promote knowledge exchange and collaboration (Bulkeley and Castán Broto, 2013[65]).
- **Intercity learning** focuses on the exchange of information and knowledge about practices, experiences and knowledge between cities via networks. City networks, such as C40 and Champion Mayors, can help spread urban innovation by transferring lessons across localities. Members of climate networks such as C40 cities adopt more ambitious climate targets and actions (Salvia et al., 2021[51]), although this may in part be because cities with relatively ambitious climate action may wish to showcase it through membership. C40 Cities have committed to zero location and production-based emissions by 2050 (C40 Cities, 2016[66]).

Knowledge about how successful experiments and innovation travels across contexts and how they are transferred is still limited but knowledge-sharing initiatives have an important role (Lee and Jung, 2018[67]). National city and municipality networks, such as the Dutch Klimaatverbond, Sweden's Klimatkommunerna and Finland's KINKU network, may play this role (Hakelberg, 2014[68]). These networks still generally appear to be financed by member cities themselves.

Preparing the "net-negative electric city" by 2050

Scenario analysis for 2050 net-zero GHG emission targets has called for reaching 100% renewable energy by 2030 (C40 Cities, 2016[66]). Half of the around 300 cities studied do not have renewable energy targets in their climate mitigation plans (Salvia et al., 2021[51]). Only a few cities have achieved 100% electrification of non-residential buildings. For residential and transport sectors, electrification is well below 50% (C40 Cities, 2016[66]). Yet 100% must be reached well before 2050. This suggests the need to ramp up the use of electricity in end-use energy demand, which need to be coupled with energy efficiency programmes to achieve "net-negative electric cities". Net-negative electric cities sequester more carbon than they emit in total (Kennedy et al., 2018[69]), thereby achieving net-negative CO_2 emissions. They are developed by decarbonising electricity generation, electrifying most energy end-use (such as transport) and reducing energy consumption to reach net-negative emissions. Modular technologies such as rooftop solar or photovoltaic electricity (PV) panels, small-scale wind turbines, batteries and heat pumps allow the harnessing of renewable energy sources. These distributed energy systems may avoid costly and extensive electric transmission lines.

Conducive regulation at the national level is important. For example, in Spain, permitting shared electricity generation among neighbours increased the profitability of solar panels, thereby boosting uptake (López Prol and Steininger, 2020[70]). The C40 cities express concern that without national-level support for the electric grid renewables targets could be missed. Small-scale urban-distributed renewable electricity generation requires co-ordination within the overall electricity system, for example, to avoid oversized batteries that raise the costs exponentially (Green and Newman, 2017[71]; Quoilina and Zucker, 2016[72]). Cities can initiate dialogue between regulators, utilities and "prosumers" (small-scale producers and consumers) for an optimal mix of scales and technologies to minimise costs. White Gum Valley in Western Australia demonstrates the supporting role played by local actors including the city (Hojckova et al., 2020[73]).

Emerging technologies such as blockchain-based energy services facilitating peer-to-peer (P2P) trading, such as those operational in Brooklyn, US, and White Gum Valley, Western Australia (Hojckova et al., 2020[73]), can boost distributed renewable energy deployment, adjusting electricity supply and demand to the intermittent nature of solar and wind. In fact, blockchain-based energy systems could be a cornerstone for a wholly decarbonised energy system (Ahl et al., 2020[74]). Cities can foster blockchain technology to meet their renewable energy and emission-reduction targets through P2P or peer-utility-peer trading. For example, where there are shared solar panels and batteries in multi-unit apartments under common property, trading can be done between those multi-unit apartments. Batteries and hydrogen storage will

be critical for electric network stability under a 100% renewable energy system. These clusters of technologies need to be integrated to deliver a zero-carbon city (Newman, 2020[75]).

Bottlenecks in the electric distribution networks could be an emerging issue for electrification of end-use energy services as well as to accommodate a rising number of renewables prosumers. For example, the city of Bristol projects its electricity demand to increase by 50% by 2030 to electrify its heat and transport energy demand (City of Bristol, 2020[76]). These suggest the need to upgrade local distribution networks (Green and Newman, 2017[71]). Cities' vertically integrated electric utilities may also face conflicting interests as upgrading the network will allow more prosumers to sell their excess electricity to the grid to the detriment of their own sales of utilities (Green and Newman, 2017[71]).

Electric heat pumps will be the major technology to be employed for heat in residential, commercial and some industrial uses while improving energy efficiency. These are available in a range of different technologies, which may require collective decisions. For example, heat pumps themselves can be provided for individual housing units or collectively. Where natural gas has been widely employed and infrastructure exists, hydrogen use could be an option (Climate Change Committee, 2019[77]). Biomass-based combined heat and power (CHP) plants can decarbonise both power and heat end-use demand without electrifying heat. Electricity generation with sustainably sourced biomass, combined with carbon capture and storage (BECCS) can generate net-negative emissions (Kennedy et al., 2018[69]), and could be of interest to cities where such power plants have access to eligible storage sites and CO_2 transport infrastructure. Coupling PV installation with desalination to produce energy and water contributes to alleviating water scarcity (Shannak and Alnory, 2019[78]). Local and regional governments and their citizens will need to get involved in these decisions as soon as possible for needed infrastructures to be laid out and industry capacity to produce it to be deployed at sufficient scale.

The biophilic design of the urban environment considers green spaces, hanging gardens and green roofs among others. These contribute to climate mitigation (Newman, 2020[75]) and can damp heat waves. Such heat waves will become common in many cities, which are still in temperate climates today. It can improve well-being in contemporary cities (Totaforti, 2020[79]). Urban land management that adopts arrangements observed in natural ecosystems, including for agricultural production ("permaculture") in cities can reduce, albeit modestly, energy use in the food system while also strengthening resilience and well-being (Morel, Léger and Ferguson, 2019[80]). The plants and crops can also provide some carbon sequestration. Urban permaculture can contribute to reducing waste, eliminating emissions through circular economy practices, as described below (C40 Cities, 2016[66]).

Prioritising solar energy in cities

Prioritising photovoltaic electricity generation is indispensable to achieve climate targets with massive installation to be undertaken within a period of 10 years (Jäger-Waldau et al., 2020[81]). While potentials vary depending on sunshine and other geographic factors (see the online country notes to this *Regional Outlook* report), there are huge untapped potentials for cities. For example, in US cities, the share of suitable rooftops ranges from 15% in Washington to 55% in Chicago, 84% in San Bernardino and 85% in Riverside. But actual rooftop solar penetration ranges from 0.3% in Chicago, 7% in Riverside, 8% in San Bernardino and 12% in Washington (Reames, 2020[82]). This reinforces the need to legislate, for example new house construction to install solar panels. Such legislation can be at the city or regional level, as in California. Australia is the world leader in this domain. More than 2 million houses have rooftop solar panels with a combined capacity of 7 GW, contributing 62% of total PV capacity, although this may also reflect lagging policy support for large, utility-scale installations. Rooftop PV technology is continuing to expand (Say, Schill and John, 2020[83]).

Beyond electricity market regulation, which is mostly national, city governments can influence the uptake of solar panels by households.

- In the US city of Riverside, for example, socio-economic factors such as lack of Internet access and older housing stock were found to reduce solar panel adoption. Low-income reduces solar panel penetration in both Chicago and San Bernardino. Language barriers also reduced the adoption of solar panels in San Bernardino. This calls for cities to proactively engage with the communities. This is particularly important as subsidies for solar panels risk otherwise being regressive.
- Regulation of multi-apartment shared property matters. In Australia, residents in multi-unit apartments can install shared batteries and solar panels on the roof of a common property, which can be managed by owners' corporations without the involvement of utilities (Roberts, Bruce and MacGill, 2017[84]). This shared system can reduce load variability, reduce costs compared to standalone systems, whilst providing 60% self-sufficiency to residents (Syed, Morrison and Darbyshire, 2020[85]).
- Cities can promote large-scale solar panels alongside other renewables outside city borders, as is the case of the city of Adelaide in South Australia in its pursuit of carbon neutrality by 2023 (City of Adelaide, 2019[86]).
- Cities can stimulate investment through incentive schemes. For example, in Adelaide, one Australian Dollar (AUD) of city-provided funding generated AUD 6.45 in investment in sustainable technologies such as light-emitting diodes, solar hot water systems and electric vehicle charging stations among others (City of Adelaide, 2019[86]).

Sustainable urban mobility

As highlighted in *Managing Environmental and Energy Transitions for Regions and Cities* (OECD, 2020[26]), transport emits around 23% of energy-related CO_2 emissions, mostly in road transport. Around half of passenger transport takes place in urban areas and urban transport accounts for about 40% of transport energy use (IEA, 2016[87]). It is the sector with the highest growth in GHG emissions (ITF, 2019[88]). Demand for transport may continue to grow, driven by urbanisation, population growth and rising incomes, especially in middle-income countries.

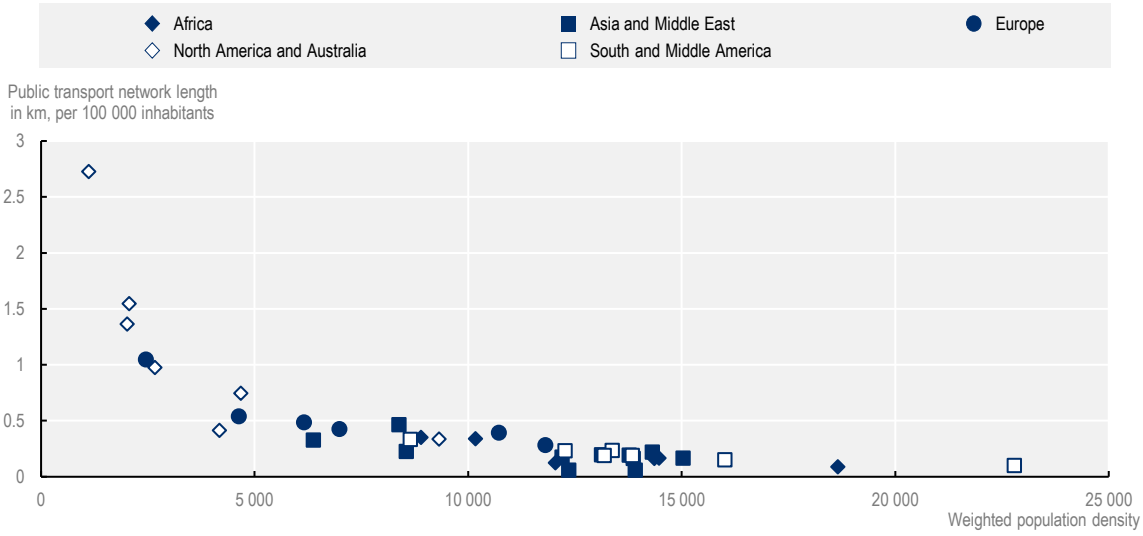
Transport accounts for much local air pollution, noise and accidents and uses up much precious urban space, especially from car parking, whilst generating congestion and delays (EEA, 2019[89]). Urban policy can seek synergies between emission reduction and reducing all these urban ills. For example, policies to reduce individual car use through improved local accessibility, transport-oriented development, public transport improvements and digital-based ride-sharing (see below) could harness these benefits more than solely relying on electric cars, while also reducing energy consumption.

The spatial distribution of population within a city or metropolitan area can have a strong influence on the cost of providing public transport

As shown in the *Cities in the World* report (OECD/EC, 2020[45]), there is a clear link between cities' shape and the needed length of its public transport network to provide the same quality of service. Cities such as Hong Kong, China, or Mumbai, India, which have a very strong concentration of their population in the central part of the city, can provide public transport to 80% of its residents with a network of only 6 km per 100 000 inhabitants. Houston needs a 26-fold and Atlanta a 45-fold longer network than Hong Kong, China, to provide the same access. In practice, this usually means that a much lower share of the population has access to public transport in cities like Atlanta and Houston. Thus, as neighbourhood density falls, the total network costs increase. For example, reducing the density from 15 000 to 12 000 increases costs by 30%, while reducing it from 6 000 to 3 000 increases costs by 120%.

Across the globe, the conditions of providing public transport in metropolitan areas differ widely between world regions (Figure 4.6).

Figure 4.6. Simulated public transport network length in 37 metropolitan areas, 2015



Source: See Jacobs-Crisioni, C., L. Dijkstra and A. Kucas (2020[90]), "Does density foster efficient public transport? A network expansion simulation approach", Manuscript submitted for publication. Work is based on the boundaries of Moreno-Monroy, A., M. Schiavina and P. Veneri (2020[91]), "Metropolitan areas in the world. Delineation and population trends", https://doi.org/10.1016/j.jue.2020.103242.

Cities need to support urban mobility in several ways, including shared mobility, electric mobility and active mobility. The integration of walking, cycling, bus, e-rollers, subway and railway regimes into an intermodal transport system could also make a modal shift to public transport more attractive, as happened in London, where car use declined by 25%-35% between 1995 and 2015 (Cass and Faulconbridge, 2016[92]). Additionally, public transport systems need to be sufficiently accessible to offset a potential growth in inequality as a consequence of price-based instruments, such as carbon taxes or congestion charges (OECD, 2020[93]). Such policies can have negative distributional effects when individuals being taxed do not have alternative means of transport to turn to. Steps to meet connection and access needs with fewer vehicle kilometres will be particularly effective in reducing multiple negative impacts of road transport. Such an approach will also help lower energy demand, a key priority on the way to net-zero emissions (Chapter 3). A transition with radical systemic innovation in road transport is therefore necessary (Frantzeskaki et al., 2017[94]). Such a transition will require both technological and institutional changes.

The development of location-based connectivity and accessibility indicators for all residential areas helps to guide cost-effective decisions for housing development or improve accessibility and connectivity through walking, cycling and public transport use. It ensures that people are easily able to reach jobs or everyday public services with sustainable transport modes, such as walking, cycling or public transport. This can include, for example, steps to make pedestrian and cycling access to public transport hubs quicker and safer. Transport-oriented development requires integrated accessibility and connectivity for commercial and residential development (OECD, 2019[95]). Complementary policies, such as increased housing supply through the densification around transport links or dedicated affordable housing, are needed to ensure accessibility is improved for everyone (OECD, 2020[96]).

Shared mobility solutions

Digital-based ride-sharing can lower CO_2 emissions sharply and deliver large reductions of traffic, eliminating congestion, freeing expensive urban space while improving connectivity and accessibility, provided it replaces individual car use. It improves connectivity and accessibility especially for low-income households and households in suburban areas, which are often less well connected to public transport. In such ride-sharing models, individual private car rides and ideally all rides in an entire metropolitan area are replaced by rides in shared taxis or minibuses. These services are modelled to be available on demand, at the doorstep or at the next street corner. Supply and demand of on-demand services are co-ordinated by a digital platform, which optimises routing (Box 4.11). Professional staff drive the vehicles.

Recent modelling for the daily mobility patterns of metropolitan area Dublin, Ireland, shows that the number of vehicles, traffic, CO_2 emissions and congestion would be reduced by up to 98%, 38%, 31%, and 37% respectively (ITF, 2018[97]). Broadly similar results have been obtained for other cities, such as Auckland, Helsinki, Lisbon and Lyon (ITF, 2020[98]). Ride-sharing is also low-cost. For Dublin, the cost of shared minibus services would be less than the price of a public transport ticket, yet would not need to be subsidised. Shared rides could substitute inefficient bus lines and provide feeder service to rail. Further benefits would include substantially lower pollution and freeing up space occupied by parked cars, for example, for active mobility. Emission reductions are larger if the shared vehicle fleet is electric.

Survey results suggest that 20% of car drivers would be willing to switch to shared rides in Dublin, although this share could be substantially higher if more information about the ride-sharing system (e.g. example about the lower cost of ride-sharing for users compared to using and operating private cars, for many, incentives to switch, such as lower prices for early adopters) are provided. If 20% of private car trips were replaced with shared modes, shared services could still be provided at a sufficiently low cost to ensure uptake. Emissions could fall by around 20% and congestion by 7%. Survey results for Lyon suggest that most citizens are willing to use shared modes.

Relying on on-demand ride-sharing also reduces the cost of electrifying transport. By reducing the number of vehicles and using them more intensively, ride-sharing would take advantage of the low operating costs of electric vehicles, while limiting electricity demand, material used for battery and car production and infrastructure needs. At the same time, more intensive vehicle use results in more frequent renewal and therefore quicker technology diffusion (ITF, 2018[97]; 2020[98]). Digital-based sharing models and multimodal transport systems require steps to regulate smart mobility and the role of data (Box 4.11).

Box 4.11. Regulating smart mobility and the role of data

Smart mobility can contribute to the net-zero emission transition by fostering ride-sharing, multimodal public transport combined with active mobility and shared micromobility. Each of these requires an adapted regulatory framework that enables innovation to further the net-zero-emission agenda without hindering equity, safety, flexibility or efficiency (ITF/OECD, 2020[99]). The regulatory framework should be transparent, agile and linked to over-arching public policy objectives. For example, the city of Paris re-assessed its shared micromobility based on a voluntary charter signed by e-scooter companies (ITF/OECD, 2020[99]).

Transport systems and their users generate an increasing amount of data, representing a source of improvement in transport system performance. City authorities may adopt frameworks that enable targeted data sharing that respect privacy, operational needs and commercial sensitivities, while guaranteeing cyber-resilience (ITF/OECD, 2020[99]), provided they serve policy objectives, such as accessibility, environmental outcomes, equity and safety. Finland's National Transport Code (NTC) lays the groundwork for data sharing in support of Mobility as a Service (MaaS). The aim is to create an

open and level playing field where operators can co-ordinate their services and create new applications (Finnish Ministry of Transport and Communications, 2019[100]). In 2019, France approved the National Mobility Law (*Loi d'orientation des mobilités 2019*) that sets out requirements regarding data sharing in support of smart and sustainable mobility. These requirements concern public transport operators and all other providers of mobility services (Assemblée Nationale française, 2019[101]).

Source: ITF/OECD (2020[99]), *Leveraging Digital Technology and Data for Human-centric Smart Cities: The Case of Smart Mobility*, https://www.itf-oecd.org/sites/default/files/docs/data-human-centric-cities-mobility-g20.pdf.

Fostering active mobility

Cycling and walking are low-cost means of transport to users and taxpayers alike. To users, they provide the health benefits from regular exercise on daily trips they need to undertake anyway. To governments, infrastructure is cheap to build. Facilitating cycling and walking benefits low-income households. For example, cycle-hire facilities increased cycling substantially, in particular in low-income areas of London (Lovelace et al., 2020[102]). The reach of cycling as a means of transport can be extended to 20 kilometres with electric bicycles. Fostering active mobility should be seen as a complement to public transport. Low-cost options for cities to facilitate walking typically also facilitate public transport use.

City governments have redistributed street space to pedestrians and cyclists as part of their post-lockdown COVID-19 strategies (Kraus and Koch, 2020[103]). On average 11.5 kilometres of provisional pop-up bike lanes have been built per city in 106 European cities. Each kilometre may have increased cycling by 0.6%. The new infrastructure could generate USD 2.3 billion in health benefits per year. This suggests that every kilometre of cycle land produces annual health benefits of about USD 2 million, so the investment may often pay off in less than a year.

The application of a broad range of ethical fair allocation principles also argues in favour of moving street space from cars to pedestrians and cyclists on a larger scale (Creutzig et al., 2020[104]). For example, it would improve the safer, more autonomous use of streets for the least able, in particular children, the elderly and the disabled. Especially the allocation of curbside space to car parking appears difficult to justify on any fair allocation principle. In Berlin, for example, parked cars hold 22% of street space but only a 5% share of users (Figure 4.7). Cycling, on the other hand, uses less than 10% of space for 16% of users. A fairer allocation would reduce the space allocated to car parking by more than half while increasing the street space allocated to biking, walking and public transport. Some of the allocation mechanisms and principles considered include well-being, environmental efficacy, economic efficiency and intergenerational justice.

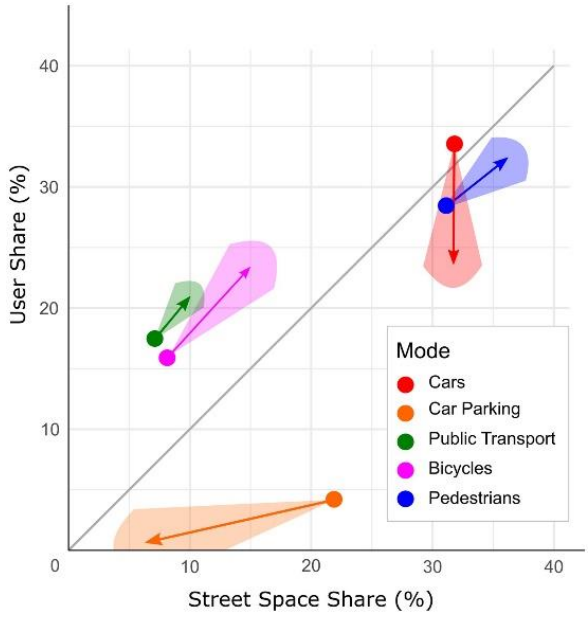
Road use charges need to complement the widespread uptake of electric vehicles

As highlighted in *Managing Environmental and Energy Transitions for Regions and Cities* (OECD, 2020[26]), electric vehicles (EVs) have great potential as a way for cities to reduce local air pollution and GHG emissions. However, they still contribute to congestion and air pollution due to particles released from tyres and braking. Therefore, a shift to EVs should be positioned within a wider plan for city journeys to be made by public transport, ride-sharing, bike or on foot. Some cities have announced specific goals for EVs (Table 4.1).

Little is known if and how local policies and strategies affect EV usage and its supporting infrastructure (Roelich et al., 2015[105]). One successful policy has been to invest in public charging infrastructure. The need for public charging varies based on housing stock, private charging availability and commuting patterns.

Figure 4.7. Fair street space allocation provides more space for biking, walking and public transport while significantly reducing the space for parking

Street space by usage and space allocation for five transport modes, Berlin, Germany



Note: The arrows show the suggested direction of change from considering a range of ethical principles. Cones represent uncertainty values.
Source: Creutzig, F. et al. (2020[104]), "Fair street space allocation: Ethical principles and empirical insights", http://dx.doi.org/10.1080/01441647.2020.1762795.

Table 4.1. Electric vehicle goals announced by selected major cities

City	Target
Amsterdam (NL)	Zero-emissions transport within the city by 2025
London (UK)	70 000 ultra-low-emission vehicles sold by 2020; 250 000 by 2025
Los Angeles (US)	10% of vehicle stock electric by 2025; 25% electric by 2035
New York City (US)	20% EV sales share by 2025
Oslo (NO)	Zero-emission transport within the city by 2030
Shenzen (CN)	120 000 new energy vehicles sold by 2020
Tianjin (CN)	30 000 new energy vehicles sold by 2020

Source: OECD (2020[26]), *Managing Environmental and Energy Transitions for Regions and Cities*, https://doi.org/10.1787/f0c6621f-en; Hall, D., H. Cui and N. Lutsey (2017[106]), "Electric vehicle capitals of the world: What markets are leading the transition to electric?", http://www.theicct.org/EV-capitals-of-the-world (accessed on 22 May 2020).

Electric cars already have lower operating costs than cars with internal combustion engines and they are likely to become cheaper for most users within this decade, even including the purchase price. The diffusion of electric cars could therefore risk intensifying car use in cities, aggravating congestion. Automated driving adds to these risks, as it will reduce the opportunity cost of the time spent in the car. Fuel taxes have priced only a fraction of the full external costs in cities, where they are particularly high. In any case, fuel taxes disappear with net-zero-emission policies and EV use. Electrification of car use will need to come with the adoption of road use charges in order to replace fuel taxes also for revenue (Atkinson, 2019[107]). This will lower excess driving demand and shift mobility to other modes of transport (OECD/ITF, 2019[22]).

Cities will have an important role to play in setting road use charges. Introducing road use charges also offer the opportunity to price external costs more precisely, by varying them over time and place. Lessons from the London Congestion Charge show that attitudes change in favour of policies to reduce car demand after their successful introduction as the benefits of less car use materialise (Downing and Ballantyne, 2007[108]). Pricing of mobility will also be important when accessibility and connectivity improve, for example as a result of digital-based ride-sharing. Such improvements would lower the cost of mobility, raising the demand for it, including by encouraging urban sprawl.

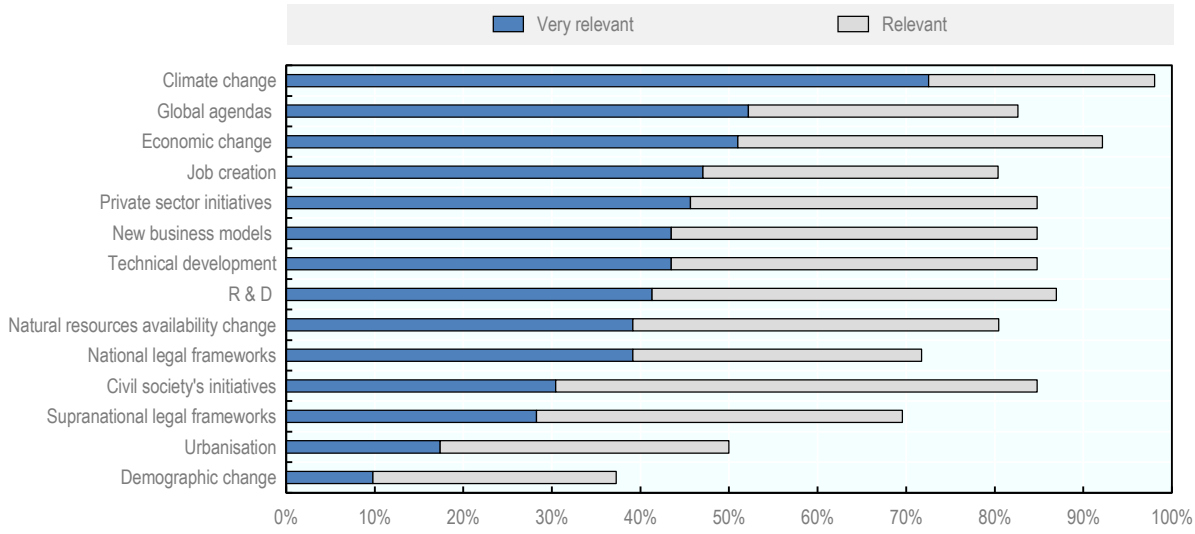
Reducing emissions with circular economy policies

The adoption of a circular economy framework in 5 key areas for cities (steel, plastic, aluminium, cement and food) could achieve a reduction of a total of 9.3 billion tonnes of GHG in 2050 (Ellen MacArthur Foundation, 2019[109]). By 2060, total worldwide emissions are projected to reach 75 Gt CO_2-eq. without any further climate action. Materials extraction and processing, directly and indirectly, may contribute approximately 50 Gt CO_2-eq (OECD, 2019[110]). Emissions from solid waste management account for about 5% of these (Kaza et al., 2018[111]).

Economic activity and consumption in cities, especially high-income cities, are based on the use of these materials. In high-income countries, healthier diets would also reduce emission-intensive meat and dairy production. Regions and cities can invest in consumer education and awareness, create clear dietary guidelines and leverage public channels to deliver healthier products (e.g. school canteens). They can also opt for reused or reusable products and develop recycling streams, for example for electronics or office furniture. The Amsterdam Metropolitan Area, for example, has set a target of 50% circular procurement by 2025 (Amsterdam Smart City, 2017[112]).

Many strategies at the regional and local levels highlight the role of the circular economy to fight climate change (Figure 4.8). For example, London is pursuing circularity in order to make a substantial contribution to the mayor's aspiration to become a zero-carbon city by 2050. The city of Joensuu, Finland, is planning circular economy actions within the ongoing climate programme that aims to transform Joensuu into a carbon-neutral city by 2025.

Figure 4.8. Drivers of the circular economy in surveyed cities and regions



Note: Results based on a sample of 51 respondents that indicated the drivers being "Very relevant" and "Relevant".
Source: OECD (2020[113]), *The Circular Economy in Cities and Regions: Synthesis Report*, https://doi.org/10.1787/10ac6ae4-en.

Often the circular economy in cities and regions is seen as synonymous with recycling but it goes beyond. A circular urban economy is one where waste is prevented; goods are used for longer; the disposable model is replaced by a recovery one; a market for secondary raw materials is in place and secondary materials would satisfy a prominent percentage of the demand of materials for goods production. A circular waste system would develop and commercialise technology to identify, sort and deliver high-quality secondary material. Digitalisation and data management should connect products with waste handling and the design and production phase should take into account feedback from waste handling and extend the life of products and goods.

Many cities are putting in place initiatives to support product design, reuse and recycling. The city of Helsinki, Finland, launched in 2019, the Closed Plastic Circle to develop tendering processes that include criteria to promote plastic recycling (Smart Clean, 2019[114]). In the US, Austin is advancing towards zero waste through the Austin Resource Recovery Master Plan; San Francisco aims by 2030 to reduce municipal solid waste generation by 15% and reduce disposal to landfill and incineration by 50%. While recycling is projected to grow, the share of landfill in municipal waste treatment remains high in OECD countries. It decreased from 63% to 42% between 1995 and 2018 but still accounts for most of the waste management related emissions (OECD, 2019[115]).

Some sectors are key to cut carbon emissions in cities following a circular economy approach, such as the built environment. The building sector is responsible for about a third of all carbon emissions worldwide (World Green Building Council, 2017[116]; Ellen MacArthur Foundation, 2020[117]) (Box 4.12). The circular economy can contribute to reducing the sector's CO_2 emissions by minimising material use and maximising reuse. Applying circular economy principles to the built environment would imply rethinking upstream and downstream processes. It also implies new forms of collaboration amongst designers, constructors, contractors, real estate investors, suppliers of low- and high-tech building materials and owners, while looking at the life cycle from construction to end of life. Key phases can be identified as planning, design, construction, operation and end of current life (Stronati and Berry, 2018[118]):

1. **Planning** in a circular way implies considering the entire lifecycle of the asset. Examples are modular approaches so that materials and buildings' blocks can be easily dismantled and reused.
2. A proper **design** in the project phase takes into account the material choice, the consumption of water and energy in buildings to reduce consumption and minimise waste and allow reuse of buildings.
3. The choice of materials for the **construction** phase entails identifying more sustainable materials and minimising the variety of materials used. Material passports and material banks can foster reuse.
4. The **operation** phase concerns the use of energy and technologies for resource efficiency. The operation also includes data and innovative technologies as enablers to extending building life.
5. The **end life** of a building would create a new life for the waste material produced (Stronati and Berry, 2018[118]). In Groningen, Netherlands, a project using the disused sugar factory aims to create a "zero-waste" neighbourhood: De Loskade is projected to be a "removable" and "short-stay" neighbourhood. Temporary properties will be dismantled after the rental period that ends in 2030 and rebuilt in other areas. Extensive pilots and testing are taking place at De Loskade, for example gas-free installations and energy-efficient homes (Municipality of Groningen, 2019[119]; Van Wijnen, 2019[120]).

Box 4.12. The key role of cities and regions in low-carbon transition in buildings

While buildings account for nearly a third of energy-related GHG emissions globally, these percentages reach roughly 70% in cities like London, New York and Tokyo (Greater London Authority, 2018[121]; Bureau of Environment, 2018[122]; New York City Mayor's Office of Sustainability, 2017[123]).

Energy efficiency improvements in buildings will generate numerous co-benefits, including job creation, health improvements and increased energy affordability, which can all contribute to a green and inclusive recovery from the COVID-19 crisis. Building works are particularly suitable for a rapid employment-intensive recovery.

- The potential for job creation is estimated to be from 8 to 27 working years per EUR 1 million spent on energy efficiency measures depending on a country's economic context (IEA, 2014[124]). They include low- to medium-skilled jobs (OECD, 2013[125]).
- The health benefits reduced respiratory and cardiovascular conditions due to improved indoor air temperature, as well as improved mental health such as reduced depression. A Japanese survey found a significant reduction in blood pressure (MLIT, 2019[126]). Public health spending could be substantially lower (IEA, 2014[124]).
- Energy efficiency improvements of housing can also lead to increased energy affordability especially among low-income households, provided they do not bear the cost of the capital outlays when they arise initially. For example, the study on Cincinnati's low-income weatherisation programme found that the average arrears of households joining the programme fell by more than 60% after energy efficiency improvements (IEA, 2014[124]).

Action needs to sharply accelerate to meet the net-zero domestic GHG emission targets. Virtually all existing buildings will need to be renovated in-depth to be consistent with net-zero emission. The rate of building energy renovations needs to increase considerably, from rates of 1%-2% of existing stock today to ideally 5% per year as soon as possible to meet net-zero-emission targets by 2050 (OECD, 2020[127]). his will also imply equipping them with energy-saving heating equipment. In the EU, buildings built before 1945 still account for 23% of all building stock and their average insulation level (of external walls) is more than 5 times lower than that of buildings built after 2010 (EC, n.d.[128]), which suggests they should be renovated first.

In order to avoid lock-in of inefficient building stock and costly future renovations, net-zero-emission standards should already apply to new buildings. In the EU, the Energy Performance of Buildings Directive requires all new buildings to be nearly zero-energy buildings from 31 December 2020 (EC, 2019[129]). However, implementation will depend on member countries.

Decarbonising the existing building stock requires a co-ordinated approach across levels of government. In view of multiple market failures, including split incentives between owners and tenants, capital market imperfections and too-short-time horizons in investment decisions, compulsory energy standards to reach standards at set dates may be best suited (Deasley and Thornhill, 2017[130]). Such an approach would also allow governments to target financial support to those households and firms which need the most support. For cost-effectiveness, it will be important for renovation programmes to incorporate consistency with the net-zero emission objective from the outset.

Cities and regions have a unique ability to promote the decarbonisation of building stock through effective implementation, prioritisation and effective engagement of citizens and local businesses. This includes gathering information on renovation needs, taking advantage of public building procurement and certifying energy efficiency standards.

Applying circular economy principles to food production and consumption can contribute to reducing GHG emissions at a low cost. Cities are major food consumers. A total of 2.9 billion tonnes are annually destined to cities with 0.5 billion tonnes wasted (Ellen MacArthur Foundation, 2019[131]) Achieving a regenerative food system in cities will entail an annual reduction of GHG emissions by 4.3 billion tonnes of CO_2-equivalent and the generation of annual food benefits worth USD 2.7 trillion by 2050. By 2050, cities will consume 80% of food (FAO, 2020[132]). Circular food systems in cities and regions are based on strengthening synergies across the food value chain, from production to distribution, consumption and waste handling.

In a circular economy, food waste should be reduced as much as possible or transformed into usable products for agriculture. For example, the city of Groningen, Netherlands, launched Food Battle Groningen to raise awareness on reducing food waste. Local not-for-profit organisations are taking the lead by pushing the demand towards local food consumption, reducing food waste and promoting urban agriculture. The city of Toronto, Canada, has put in place the Urban Harvest programme to help reduce food waste and benefit the broader community by collecting surplus fruit and vegetables from residents' backyards and redistributing them to local food banks and programmes. The city of Guelph aims to become Canada's first technology-enabled circular food economy, reimagining an inclusive food-secure ecosystem that by 2025 increases access to affordable, nutritious food by 50%, where 50 new circular businesses and collaborations are created and circular economic revenues are increased by 50%. The programme aims to make the most of its distinctive characteristics (the presence of major agri-food industry players, agriculture research institutions and a developed household organic waste collection scheme) to: grow food regeneratively and locally when possible; minimise food waste; and design and market healthier food products (Government of Canada, 2020[133]).

The transition to a circular economy does not come without obstacles. Matching biological and technical cycles of cities and regions and the various ways in which resources can be repurposed and reused, from water to energy and mobility, is a complex task. From a business perspective, there is no efficient secondary market for most of the collected household waste. Still, virgin materials are less expensive than secondary products. Collaboration along a value chain can be best established at a regional and urban scale. Insufficient financial resources, inadequate regulatory frameworks, financial risks, cultural barriers and the lack of a holistic vision are amongst the major obstacles identified by more than one-third of the interviewed stakeholders in the OECD survey (2020[134]).

The circular economy can be implemented if proper governance conditions are in place. The OECD (2020[134]) identified three clusters corresponding to the complementary roles of cities and regions as promoters, facilitators and enablers of the circular economy:

1. **Promoters**: Cities and regions can promote the circular economy acting as a role model, providing clear information and establishing goals and targets, in particular through: defining who does what and leading by example (*roles and responsibilities*); developing a circular economy strategy with clear goals and actions (*strategic vision*); promoting a circular economy culture and enhancing trust (*awareness and transparency*).
2. **Facilitators**: Cities and regions can facilitate connections and dialogue and provide soft and hard infrastructure for new circular businesses, in particular through: implementing effective multi-level governance (*co-ordination*); fostering system thinking (*policy coherence*); facilitating collaboration amongst public, not-for-profit actors and businesses (*stakeholder engagement*) and adopting a functional approach (*appropriate scale*).
3. **Enablers**: Cities and regions create the enabling conditions for the transition to a circular economy to happen, e.g.: identify the regulatory instruments that need to be adapted to foster the transition to the circular economy (*regulation*); help mobilise financial resources and allocate them efficiently (*financing*); adapt human and technical resources to the challenges to be met (*capacity building*);

support business development (*innovation*); and generate an information system and assess results (*data and assessment*).

Cities need to address specific adaptation challenges

Climate change poses unique challenges for adaptation in cities. Prolonged extreme temperature events will increase energy demand and exacerbate inequalities in access to cooling at work and in homes, especially in cities because of the heat island effect of built environments (IEA, 2016[87]). Urban areas are expected to experience major impacts on water availability and supply with potential changes in water quality and quantity, potentially resulting in fierce competition (OECD, 2016[135]).

Extreme precipitation and related storms, floods, torrents and landslides will increasingly damage critical urban infrastructure as well as private assets. One in 5 urban dwellers, representing 613 million people, is currently exposed to a 100-year flood and up to 6% of cities are at risk of being entirely flooded (OECD/EC, 2020[45]). By 2030, urban property damaged by riverine floods is estimated to increase threefold, from USD 157 billion to USD 535 billion annually (WRI, 2020[136]). The US, for example, may experience an additional USD 16 billion in annual flood damages to urban property by 2030 (WRI, 2020[136]). Sea level rise poses further risks, albeit arising with more delay: 14% of all urban dwellers (as well as 11% of dwellers of towns and semi-dense areas) live in low-lying coastal areas (OECD/EC, 2020[45]). Urban property damaged by coastal storm surge and sea level rise is estimated to increase tenfold by 2030, from USD 17 billion to USD 177 billion annually (WRI, 2020[136]). OECD modelling projections for a sea-level rise of 1.3 metres by 2100 indicate that without adequate adaptation measures coastal flooding may cause global annual damage costs up to USD 50 trillion – nearly 4% of global GDP – by the end of the century (OECD, 2019[137]).

The impacts of climate change vary widely across cities. Climate models have greatly improved in precision and scale, with spatial resolutions on the order of 100 km, yet this scope remains much too large for most cities (Shepherd and Sobel, 2020[138]). Climate modelling at lower resolutions may magnify uncertainties. To know the exact future impacts of climate change at local urban levels is unfeasible and can be a problematic expectation if policymakers defer action. Rather, policymakers should implement measures to reduce overall risk exposure – that is to say, by minimising vulnerability tied to social, economic, environmental and physical factors or processes, which can compound hazards, long-term stress (economic decline, natural resource degradation) and sudden disastrous shocks (drought, flood) (OECD, 2018[139]; Figueiredo, Honiden and Schumann, 2018[140]).

National and local policymakers can jointly undertake measures to reduce risk exposure and enhance the adaptability and resilience of cities. The OECD has developed a set of recommendations on urban resilience and disaster risk management. A vulnerability risk assessment (VRA) and, building on it, a local resilience action plan (LRAP) forms the basis of policy and financing priorities (Box 4.13). NUPs can be a good platform to foster a national-local relationship. They can provide a general implementation roadmap and unlock financing and capacity building. Preliminary survey results from the 2nd edition of the *Global State of National Urban Policy* (OECD/UN-Habitat, forthcoming[64]) reveal that the 2 most common adaptation measures in NUPs are to “conduct a comprehensive VRA focusing on urban areas” (65% of respondents) and “adopt risk-sensitive land use policies” (62% of respondents).

Box 4.13. Key recommendations on urban resilience and disaster risk management

The OECD report *Building Resilient Cities: An Assessment of Disaster Risk Management Policies in Southeast Asia* (2018[139]) provides a general framework for assessing disaster risk management policies and resilience in cities as well policy recommendations for five cities in Southeast Asia: Bandung (Indonesia), Bangkok (Thailand), Cebu (Philippines), Hai Phong (Viet Nam) and Iskandar (Malaysia). City governments can conduct VRAs and LRAPs with a high degree of autonomy. They are also typically in charge of adopting risk-sensitive land use policies. Many measures to improve urban resilience are most effectively achieved when national and local governments work hand in hand.

The main recommendations in the report are the following:

1. *Conduct a comprehensive VRA in each city in order to develop an LRAP*. A VRA identifies and locates people, places and assets that are expected to be most exposed to natural hazards risks. Next, the vulnerability and adaptive capacity are estimated. VRAs and asset inventory practices form the basis of an LRAP, which should work as an interface with other urban policy.
2. *Adopt risk-sensitive land use policies combining regulatory and fiscal instruments* to guide urban development away from risk-prone areas.
3. *Integrate disaster risk management policies and urban green growth policies*, especially in the infrastructure sector, to generate "co-benefits". Property taxes, fees, tariffs and land value capture mechanisms can provide funding, drawing on the benefits.
4. *Develop disaster risk financing (DRF) mechanisms*. Typically, *ex ante* disaster risk financing tools involve significant opportunity costs, especially in terms of investment potential.
5. *Promote the use of information and communication technologies*. Key tools include early warning systems, emergency services and other disaster response efforts in sectors such as transport, energy, water and solid waste.
6. *Foster vertical and horizontal co-ordination*. National governments have an important role in aligning national and subnational risk management policies and creating an enabling environment that allows local governments to act more effectively and efficiently. Establishing a dedicated agency on climate risk/adaptation can help to facilitate co-ordination among sectoral departments as well as vertical coherence across levels of government. Conducting in-depth country reviews of urban risk management policies can also be useful to guide public action and decisions.
7. *Engage with stakeholders to promote inclusiveness*. Co-ordinated response mechanisms between civil society and local governments as well as public awareness campaigns targeting citizens who are at the greatest risk and financially vulnerable are critical to enhancing urban resilience. Local authorities can encourage the private sector, notably SMEs, to design business continuity and recovery plans to reduce economic disruption.

Source: OECD (2018[139]), *Building Resilient Cities: An Assessment of Disaster Risk Management Policies in Southeast Asia*, https://dx.doi.org/10.1787/9789264305397-en.

Improving the resilience of rural regions in the net-zero-emission transition

Rural regions are pivotal in the transition to a net-zero-emission economy and building resilience to climate change because of their natural endowments. Rural regions are home to around 30% of the OECD's population and cover approximately 80% of its territory, containing the vast majority of the land, water and

other natural resources. These lands are needed for food and renewable production from wind, water and biomass. They are also where we find natural beauty, biodiversity and ecosystem services that produce clean air, detoxify waste, clear water, sequester carbon and allow for recreation. Forests and wetlands, for instance, function as natural carbon sinks – trees and other vegetation sequester an amount equivalent to roughly one-third of global emissions (IPCC, 2019[141]). Wind, water, biomass and waste present in rural lands are used to create clean energy. These fundamental values to our well-being are increasingly recognised, as is the duty to protect them for current and future generations.

The specialisation of rural areas in resource-based industries makes them a contributor to climate change. Rural economies produce almost all of the food, energy, lumber, metals, minerals and other materials that make our way of life possible. Population growth and increased living standards have enlarged the demand for many of these materials. This has put strong pressures on extraction and production, often leading to increasing emission and depleting the earth's ability to absorb CO_2. Agriculture and forestry, for instance, are responsible for around 25% of global GHG emissions when emissions from land use and land use change are included (OECD et al., 2015[142]). GHG emissions per capita in remote rural regions are particularly high (Chapter 3). The extraction and primary processing of metals, which largely happens in rural regions, further accounts for 26% of global CO_2 emissions (UNEP, 2019[143]). In the light of the growing demand for minerals and metals – the world consumption of raw materials is set to double by 2060 – the extractive industry is required to contribute to the mitigation of climate change and become more sustainable.

Many rural economies (e.g. agriculture, forestry, fisheries, mining and energy, etc.) are already suffering from the increased frequency and intensity of extreme weather events such as storms, floods, torrents and landslides. In many rural regions across the world, increasing heat waves will contribute to water scarcity, with risks to food production. As nature loses its capacity to provide important services, rural economies will suffer significant losses as they rely on the direct extraction of resources from forests, agricultural land and oceans or the provision of ecosystem services such as healthy soils, clean water, pollination and a stable climate (WEF/PwC, 2020[144]).

Rural communities often struggle to adapt and prepare for transformational challenges required to move to net-zero emissions. Over the past decades, the benefits of globalisation and technological change have not reached many rural places and regional inequalities have grown. Rural economies are experiencing increased competition from less developed counties. The shift to a service economy has largely benefitted cities and important infrastructure including broadband is missing. Population ageing, limited economic diversity and dependence on external markets and transport often accelerate their vulnerability. Consequently, many rural communities feel left behind and exposed to a range of challenges they have to deal with (OECD, 2020[19]). Rural regions and their workers specialised in economic activities which need to be phased out in the transition to net-zero emissions will need dedicated support.

While rural places are not without their challenges, they are also, unquestionably, places of opportunity that are key in delivering wider well-being to current and future generations. Rural policies have an important role to play in reaching net-zero GHG emission targets, while also generating benefits for rural communities. This can happen through more sustainable land management, higher valorisation of ecosystem services, making use of innovative production processes around agriculture, mining and renewable energies and new modes of transportation. At the same time, this requires a fundamental transformation to rural economies and societies. This section shows opportunities for rural development by making rural regions more resilient to climate change and in the net-zero-emission transition.

Rural regions come in different shapes and forms: policies need to reflect this diversity to be effective. In place of an urban-rural dichotomy, the Rural Well-being Policy Framework (OECD, 2020[19]) identifies three types of rural regions on a rural-urban continuum: i) rural inside functional urban areas (FUAs); ii) rural close to cities; and iii) remote rural. The framework identifies the interactions between the three types of rural places and cities, each with stark structural differences, and distinct challenges and opportunities.

Understanding this diversity helps to shape policy responses for the transition to a net-zero-emission economy. Rural regions close to cities, for instance, can substitute carbon-intensive car use more easily than remote regions. Remote regions on the other hand have an advantage in providing renewable energy but are less economically diverse.

Land use is key in directly contributing and removing GHG emissions, mostly through agriculture and forestry

Current and predominant forms of land use in rural regions are a large direct contributor to GHG emissions as well as land and biodiversity degradation, notably through agriculture and forestry. Today, 70% of the global, ice-free land surface is affected by human use (IPCC, 2019[141]). The food system is responsible for around 30% of global GHG emissions. Of this total, 46% come from direct production (largely methane from enteric fermentation of ruminants), 36% from land use change (deforestation), 13% from post-production (processing, storage, transport, waste disposal) and 5% from pre-production (animal-feed production, energy use, fertiliser manufacture) (OECD, 2019[95]). In addition, agriculture also puts pressure on resources such as water, soil quality and other ecosystems and biodiversity. Many of these are linked to the intensification of farming practices to meet growing food demand (e.g. excessive use of fertilisers, pesticides and antibiotics, industrial livestock systems and unsustainable grazing, specialisation and uniformity of landscapes, and land conversion) (OECD, 2019[95]; Hardelin and Lankoski, 2018[145]). Today, around 25% of animal and plant species are threatened with extinction (IPBES, 2019[146]). The link between biodiversity loss and climate change is well documented. It is estimated that 5% of all species are threatened with extinction by 2 degrees Celsius (°C) of warming above pre-industrial levels, while the earth could lose a staggering 16% of its species if the average global temperature rise exceeds 4.3°C. This loss of diversity poses a serious risk to global food security by undermining the resilience of many agricultural systems to threats such as pests, pathogens and climate change (IPBES, 2019[146]). To address this, local efforts including knowledgeable local actors plays a key role.

Land use offers great potential to reduce emissions and increase the removal of GHG emission from the atmosphere. Agriculture and forestry have the potential to do this, including through afforestation, reforestation, bioenergy use with carbon capture, use and storage. Afforestation, reforestation and peatland restoration are near-term priorities if their potential is to be fully utilised for reaching net-zero GHG emission objectives by 2050. Countries will require net-negative CO_2 emissions in order to reach net-zero GHG emissions by 2050 with CO_2 emission falling lower in net-negative territory beyond 2050. Rural regions will be key for the potential for carbon dioxide withdrawal.

Decisions on land use are currently largely defined by short-term economic criteria, while wider environmental and social aspects are left aside (OECD, 2019[95])**.** In light of the ongoing climate crisis and the fundamental role land use plays in the net-zero emission agenda, there is a clear need to transform land use to a more sustainable model that works towards multiple well-being objectives. Yet, the potential for rural development from more sustainable land use still needs to be unlocked. There is a range of instruments policymakers can use to reduce emissions from land use, including standards and rules for land management, increasing investments in technologies and research, targeting environmental outcomes or production practices and payments for the provision of ecosystem services. This section discusses what rural places can do to manage the opportunities and challenges that follow from transitioning to more sustainable land use processes and what options arise for rural development in the process.

Current approaches

There is a range of policy instruments that aim to address climate change and ecosystem degradation on the land use side. The most common policies can be organised around the categories of regulatory approaches, i.e. rules and standards for land use planning, economic instruments (taxes, abatement

payments and subsidies), information instruments (ecolabelling, green procurement) and other (knowledge transfer and research). Information instruments are particularly important to ensure a level playing field where goods are internationally tradeable and low-emission production entails higher market costs, for example because GHG emissions cannot be priced or where regions are progressing unevenly in their low-emission pathways. Overall, these policies and the change they entail does not happen in a vacuum but tend to play out and affect the local realities of people on the ground. Most importantly, they need to be economically viable to be able to be accepted and successfully implemented. Some offer important development opportunities for rural areas. Table 4.2 summarises the most common policy instruments and their considerations for rural development.

Table 4.2. Policy instruments to address climate change and ecosystem degradation in the agriculture and forestry sectors and considerations for rural development

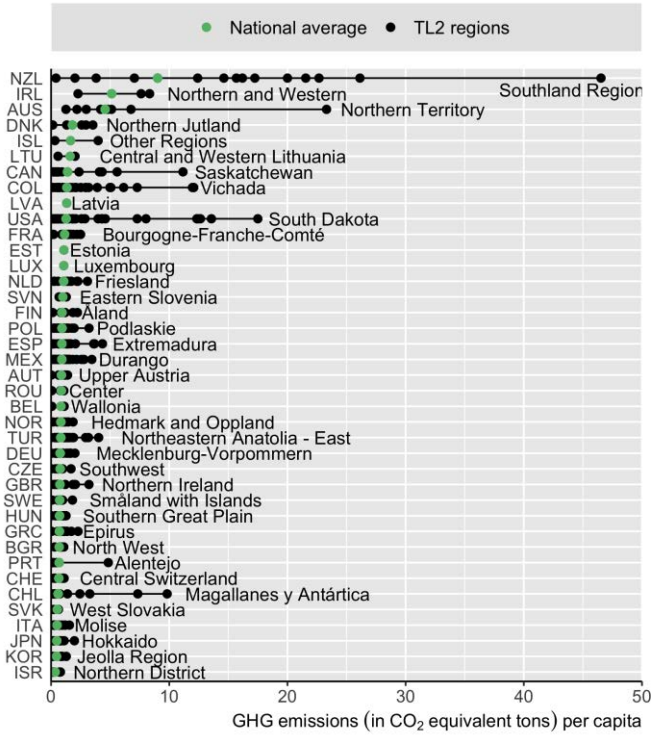
Policy instruments	Regulatory approaches	Economic instruments	Information and voluntary instruments	Other
	Land use/special planning tools and requirements (e.g. environmental impact assessments [EIAs] and strategic environmental assessments [SEAs]).	Taxes (e.g. on carbon, and fertiliser use). Charges/fees. Subsidies to promote green technology.	Ecolabelling and certification (e.g. organic agriculture labelling schemes; sustainable forest/timber certification).	Trade measures, such as lowering tariffs on climate-friendly and/or biodiversity-friendly products, reduce export subsidies.
	Rules and standards for water, soil quality and land management. Standards and controls on the overuse of agrochemicals and fertilisers in production.	Reform of environmentally harmful subsidies (e.g. decouple farm support from commodity production levels and prices).	GPP (e.g. ensuring government procurement is from sustainable sources).	R&D, e.g. to decouple GHG emissions and food production, biomass energy carbon capture and storage.
	Restrictions or prohibitions on use such as moratoria on deforestation (e.g. as used successfully by Brazil to slow deforestation); protected areas.	Payment for ecosystem services and agri-environmental measures (e.g. retirement of degraded cropland or subsidisation of conservation-friendly production practices).	Voluntary approaches (e.g. negotiated agreements between businesses and government for nature protection or voluntary offset schemes).	Inclusive national planning, incorporating climate and biodiversity concerns, national and local governments, non-party stakeholders.
	Concessions for sustainable forest management.	Biodiversity offsets/biobanking (e.g. payment-in-lieu or project-based offsetting). Tradeable permits (e.g. carbon emissions, water rights).	Fiscal transfer schemes (e.g. transfer of resources between different governments in the same country).	Development assistance (e.g. coherent consideration of nexus areas in Natural Resource Management, forestry and biodiversity projects).
		Property rights and secure and tenure. Liability instruments. Non-compliance fines.		Capacity building (including education and training).
Considerations for rural development	Regulations bear the challenge of being one-dimensional and not looking at cumulative impacts on landscapes. They can also lack economic and social aspects. For better rural development these should	The introduction of taxes can have uneven effects across territories. Some rural areas might be disadvantaged based on their economic profile, tailored responses are needed. Subsidies for innovations,	Certifications can be linked to local branding and agro-tourism, shaping the image and economic profile of a region. GPP schemes specific to rural regions, supporting rural businesses to access	Lower tariffs can increase profits for rural areas based on sustainable tradeable goods. R&D relevant to green rural economies collaboration with research institutions to

Policy instruments	Regulatory approaches	Economic instruments	Information and voluntary instruments	Other
	be included. Protecting areas can contain other development opportunities i.e. for recreational or touristic activities.	payment schemes, tradeable permits offer opportunities for rural development, they require a change in valorisation, knowledge of opportunities, new sets of skills are needed. Land rights are the basis for economic development in rural areas.	these funds.	work onsite. Involvement of local (rural stakeholders in policymaking). Capacity building of local administrations on sustainability issues and for businesses and landowners.

Source: Own elaboration based on OECD (2020[147]), *Towards Sustainable Land Use: Aligning Biodiversity, Climate and Food Policies*, https://doi.org/10.1787/3809b6a1-en (accessed on 11 September 2020).

Agriculture emissions per capita across regions vary enormously and are highest in regions with high meat and milk production, for example in Ireland or New Zealand (see Figure 4.9). So-called "hot spot areas" are associated with intensification. Examples from France show nitrogen surpluses range from 16 kg to 69 kg per hectare of agricultural land (Hardelin and Lankoski, 2018[145]). These contribute to emissions as well as water pollution. This uneven distribution of emissions highlights that place-based approaches are needed to address individual challenges.

Figure 4.9. Agricultural emissions per capita for each TL2 region, sorted by national average, 2016



Note: Does not include emissions from land use and land use change.
Source: OECD calculations based on EC (2020[47]), *EDGAR - Emissions Database for Global Atmospheric Research*, Joint Research Centre, European Commission.

Housing, transportation, energy, water, agriculture, tourism and economic development all make demands on how land is used. For instance, maximising food production without regard to environmental impacts can raise GHG emissions and negatively impact habitats (and biodiversity), while increasing carbon sequestration from afforestation and bioenergy use combined with carbon capture, use and storage (CCUS) can reduce arable land. Likewise, extending protection in one area might shift deforestation but can also generate income. Consequently, sustainable land use presents a complex governance challenge that has to deliver simultaneously on social, economic and environmental policy outcomes as well as a large number of stakeholders (OECD, 2020[147]). Sectoral policies dealing with only one aspect are usually not suitable to address interconnected needs. The OECD Principles on Rural Policy stress the need to promote integrated spatial planning with Principle 4: "Set a forward-looking vision for rural policies", requiring land use planning to consider multiple aspects such as environmental quality, waste management, natural resources development, community attractiveness, climate change mitigation and adaptation as well as population ageing and out-migration (OECD, 2019[148]).

Regional governments have significant roles to play in transitioning to more sustainable land use, but co-ordination is needed. While the national governments generally set the over-arching framework, subnational governments, in particular at the local level, are in charge of spatial planning and land use policies. In order to co-ordinate well, national and regional governments can establish frameworks to support integrated planning across functional territories. The Austrian Conference on Spatial Planning, for example, provides effective co-ordination across levels of government and across policy sectors. Better integration and co-ordination of policies is particularly important if a wider range of policy instruments is used to steer land use. Without better co-ordination mechanisms, it will not be possible to align an even more diverse set of policies to influence land use effectively (OECD, 2017[149]).

Land use policies must pay greater attention to the incentives that other public policies provide to use land. Whenever possible, policies unrelated to land use should not provide incentives that contradict spatial objectives. For example, countries that wish to restrict urban sprawl should not provide greater tax incentives for ownership of single-family homes over multi-family homes. More generally, policies outside of the planning system should be used to encourage desired forms of spatial development. Tax policies are of particular importance; higher transport taxes, for example, increase the costs of commuting and thus provide incentives to live closer to employment centres, in turn encouraging compact development (OECD, 2017[149]).

Managing rural land use change through landscape approaches

Landscape planning approaches can help regional policymakers balance the social, environmental and productivity goals in their regions. These approaches offer an alternative to siloed measures focusing on production sectors or farm-level and consider the social, economic and ecological functions of an area holistically to develop spatial and development plans. They offer an organising framework, facilitate the investigation of different courses of action and are increasingly being used, for example as part of the World Bank Forest Action Plan FY16-20 (OECD, 2020[147]). Most importantly, however, they give practitioners a tool to adapt to local conditions (Sayer et al., 2014[150]).

Supporting landscape approaches in rural regions:

- **Introduction of new decision-making tools that incorporate non-market values**. Multi-criteria decision analysis (MCDA) is a method that can combine ecological objectives with social and economic criteria and is able to consider non-market values of ecosystem services. It has been developed to allow the inclusion of data from various sources (e.g. economic, ecological, stakeholder opinions) into quantitative decision-making models and has been used extensively for land use. Multiple Danish studies have shown that the tool is useful to identify areas for land use improvements through scenarios that allocate weights to environmental services (Vogdrup-Schmidt, Strange and Thorsen, 2017[151]; 2019[152]). MCDA requires sound sociotechnical design,

reflecting both the social (who participates, when and how) and technical (which methods, which software) considerations. Overall, MCDA is made up of the following participants: decision-makers who choose between alternatives; stakeholders who are the source of scores and weights; analysts who are responsible for design and implementation; and experts who provide advice. Generally, the method relies heavily on the weights used by the decision-maker and/or relevant stakeholders (Kennedy et al., 2016[153]).

- **Improve local data availability**. Data can strengthen the design, implementation, monitoring and enforcement of landscape approaches. Data availability, however, is often a challenge, especially in rural places. Geographic information systems (GIS) are fundamental tools of local land use planning. The use of satellite spatial data can provide important insights on land use change, land degradation and waste. In Europe, the European Environment Agency (EEA) is an important source of open data on land use, including the CORINE Land Cover (CLC) dataset, which provides land cover information at a resolution as fine as 100 m. Further, the INSPIRE Directive aims to create a new EU-wide spatial data infrastructure (Weber, Eilertsen and Suopajärvi, 2017[154]). Apart from ecological information, cultural, historical and visual aspects are much more difficult to capture through data.
- **Landscape approaches can and should integrate regional climate adaptation challenges**. Regional climate modelling can provide important insights into local adaptation challenges. Future climate-change-induced extreme weather events will get worse in many regions but will also change in nature. Heat waves and drought will become common in many regions where they have not been so far. Regional policymakers need to work with climate modellers and local authorities to harness local knowledge and define potential socio-economic vulnerabilities, on which regional climate models can provide further insights.
- **Support through larger rural policy agendas**. Rural policy across OECD countries is currently undergoing a paradigm shift from a sectoral focus to a more place-based approach, underpinned by the recognition that rural places are diverse and structural changes, such as climate change, need to be addressed through a multidimensional multi-stakeholder approach (OECD, 2020[19]). New rural policy approaches can work to support local landscape approaches by giving them the needed validation and authoritative support recognising the value of working across policy and administrative barriers. A first step in the right direction is that a number of countries already embed climate change objectives in local economic development strategies and programmes and seek to break up silos this way (OECD, 2013[155])**.** While the EU Rural Development Programme (RDP), under Pillar II of the Common Agricultural Policy (CAP), is still largely focused on funding individual actors who undertake different actions (Rega, 2014[156]), its LEADER programme, albeit small, seeks to address aspects of territorial governance, so important for the implementation of landscape processes, and the co-ordination of actors that undertake individual actions.

Creating value from ecosystem services

In rural communities, policy drivers and market incentives are still forcing land users to prioritise unsustainable economic development over climate protection. Market values only capture provisioning ecosystem services such as the production of food, wood and energy, rather than the full range of supporting, regulating and cultural ecosystem services, including nutrient cycles, pollination, water filtration, biodiversity, disaster prevention (i.e. floods), recreation and cultural heritage (Natural Capital Germany, 2016[157]). In this context, policymakers must find ways to reward the provision of supporting, regulating and cultural ecosystem services. For instance, in agriculture, market price support is currently based on crop-specific area payments. Commodity production increases but often at the expense of higher GHG emissions and a lower capacity of vegetation and soils to absorb carbon. Biodiversity and water quality may also worsen (Hardelin and Lankoski, 2018[145]) Yet, land use practices consistent with climate objectives must be scaled up sharply. Redirecting subsidies for agriculture to payments for ecosystem

services, to strengthen CO_2 sinks by preserving carbon-rich soils and vegetation and encourage emission reduction, is one policy option to scale up climate action in rural regions (Box 4.14).

Box 4.14. Ecosystem service payments to integrate GHG reduction in rural regional development

Payments for ecosystem services (PES) can mitigate climate change through increased carbon sequestration and reduced emissions. They are most likely to be effective in intensive farming and if they are outcome-oriented (OECD, 2020[26]). Redirecting subsidies for agriculture in this way would also remove environmentally harmful subsidies. These actions need to be scaled to reach net-zero GHG emission objectives for 2050. Options with the highest potential include afforestation, conversion of cropland to grassland and reduced tilling. Payments per ton of sequestered carbon below estimated climate costs have induced conversion of agricultural land to forest land, changes in tillage practices and crop mixes on remaining agricultural land, and changes in livestock management. They often also contribute to climate adaptation and substantial further climate and well-being benefits.

- The conservation of high-carbon ecosystems, such as peatlands, wetlands, mangroves and forests, has an immediate impact on carbon emissions from land use and multiple benefits for the conservation of water resources, thereby reducing draught vulnerability, biodiversity, flood control and halting land degradation recreational benefits (IPCC, 2019[141]). Costa Rica established a programme of PES that compensates farmers and landowners for forest conservation (OECD, 2020[26]).
- Afforestation, reforestation and peatland restoration require more time to deploy their potential. The need to be scaled up quickly so they can still contribute in time for net-zero emission objectives by 2050. For example, in the UK, afforestation should rise from below 10 000 hectares per year to 27 000 hectares by 2025 rewarded (Climate Change Committee, 2019[77]). Small-scale deployment with a broad variety of native species, involving local stakeholders, afforestation in degraded areas can minimise trade-offs for food production and make the most of co-benefits, notably the protection of biodiversity, resilience against extreme weather events or wildfires and the protection of soils (IPCC, 2019[141]). The protection of soils and biodiversity in particular are, alongside climate change, key global environmental challenges. Protecting them is also important to reduce the risk of future pandemics, as pointed out in Chapter 1.
- Sustainable management of forests and biofuel crops can play an important role in reducing emissions by allowing the use of biomass firing and timber. This requires managing the carbon stocks in plants and soils. Performance over and above established thresholds can be rewarded. Firing of biomass from sustainably managed forests and biocrops can also contribute to negative emissions if combined with carbon capture, use and storage (BECCS). Access to CO_2 storage and the most suitable sites for BECCS plants is key for this purpose (Climate Change Committee, 2019[77]).
- Farming practices such as reduced tillage, permanent soil cover, use of organic products, diversified cropping systems and agroforestry can sequester carbon and reduce GHG emissions from fertilisers and animal farming. Growing leguminous crops can be used to fertilise the soil and therefore limit the use of chemical fertilisers. These practices generate further environmental benefits. The adoption of reduced tillage also reduces soil erosion and has the potential to significantly improve water quality, aquatic ecosystems and lower air pollution. Farmers in the Canadian province of Alberta, Canada, can earn carbon offset credits with carbon saving practices (OECD, 2020[26]).

Result-oriented payments require monitoring with satellite imagery, sensors or other digital tools. Such tools may also be needed to identify where particular practices, such as afforestation, have the desired benefits. Policy must support land managers with skills, training and information. Payment schemes may also need to deal with the caveat that sequestration could be reversed if farmers switch back to conventional practices or forest cover is lost (IPCC, 2019[141]; OECD, 2020[26]).

Understanding and rewarding the true value of ecosystem benefits, including GHG emission reductions, offers potentials for rural development – but also holds challenges. A key challenge for policies to protect ecosystem services, such as ecosystem service payments, is the difficulty to measure and manage them. Currently, measurements and metrics largely depend on multidimensional spatial and temporal variations. Furthermore, ill-defined payment schemes can lead to unintended consequences, for instance through the introduction of fast-growing (often non-native) trees that satisfy carbon sequestration but also consume much water or cause soil loss (Chan et al., 2017[158]). Hence, while ecosystem service payments can make sustainable land use practices economically viable, they cannot regulate such practices alone through the incentives they provide. Other challenges relate to building the required local scale and limited understanding of and inhibition in switching behaviours. This means that smart policy design needs to integrate economic incentives as well as potential social and cultural barriers and ecologic consequences.

PES are used to incentivise land managers to provide certain services (conservation and restoration, water, carbon and biodiversity purposes) in certain regions. Payment schemes related to ecosystem services often do not pay for the service itself but cover the cost of adopting certain practices to increase the provision of ecosystem services. This approach may miss rewarding those who already protect ecosystem services at the time of introduction. Alternative approaches seek to involve producers, extractors and the supply chain in mitigating impacts, for instance through paying ecosystem "stewards" (i.e. the land users who are already undertaking positive actions) (Chan et al., 2017[158]). Overall, PES programmes are diverse and can be public, private or a combination of both, voluntary or mandatory, as well as small or large in monetary and geographical scale (OECD, 2013[159]; Hardelin and Lankoski, 2018[145]).

The following considerations may serve to link rural development and PES:

- **Regional policy and linked fiscal transfers need to recognise the fundamental benefit of ecosystem services from natural asset protection**. Assessing, measuring and communicating positive externalities of ecosystem services can help to promote understanding and inform regional policymaking. In the UK, the National Ecosystem Assessment framework considers economic value, health value and shared social value when evaluating changes in ecosystems (UK National Ecosystem Assessment, 2011[160]). Other examples include the EU Mapping and Assessment of Ecosystems and their Services (MAES), which aims to build a coherent analytical framework as well as common typologies of ecosystems for mapping across the EU. As part of this initiative, the EFESE (*L'évaluation française des écosystèmes et des services écosystématiques*) in France has produced six assessments of different ecosystems (OECD, 2020[147]). Despite some success in using the results of MAES in policy design, a recent EU assessment suggests that unclear relationship of results and regulatory frameworks in respect to land use/landscape planning, lack of human and financial resources to make results operational and rigid national legislation not open to incorporation of the ecosystem services concept hamper the process (Ling et al., 2018[161]).
- **The geographical scope is an important element for successful PES**. The application of PES is often heterogeneous with a wide variety of approaches, low availability of information and inconsistent monitoring and evaluation. This limits the needed geographical scope to improve the sustainability of larger land use systems as participation is often split among small land parcels and does not correspond to the spatially dependent nature of ecosystem services. National systems like the one in Mexico (the world's first) can help address fragmentation. Mexico's PES

scheme was introduced in 2003, mainly targeting forest ecosystems. The scheme avoided 18 000 ha of deforestation between 2003 and 2007 and reduced forest fragmentation (OECD, 2020[147]). More local approaches to build scale include stimulating co-ordination between land users across parcel or farm boundaries. One option to incentivise this includes agglomeration bonus payments for participants co-operating cross-boundary (Wätzold and Drechsler, 2014[162]).

- **PES should seek to contribute to economic development opportunities more broadly**. This can include driving regional innovation, diversifying the economic base or adding to community well-being. In Australia, PES are linked with the economic development of Indigenous communities. One example is earning revenues from carbon credits. Indigenous fire management practices have reduced the intensity of bushfires, limiting carbon release. Roughly 118 ranger groups exist across the country and employ over 2 900 Indigenous Australians. Overall, rangers reported they felt greater individual and community well-being, including self-worth, health, closer connections to family and country as well as safer communities, strengthened culture, ability to find meaningful employment, increased respect for women and more role models for younger people (NIAA, n.d.[163]). These land management practices have also driven technological innovation. For example, the Yawuru Indigenous community in Western Australia is developing capability in GIS mapping to support their land and water management (Raderschall, Krawchenko and Leblanc, 2020[164]). Other local benefits from PES can include the development of new leisure services, as research has shown that tourists prefer rural landscapes of forest patches interlinked with hedgerows, rather than open landscape dedicated to agriculture or only forest (Hardelin and Lankoski, 2018[145]). Further benefits can include local branding of the products and advertising from sustainable land use.
- **Regional institutions can offer support, provide information, raise awareness and promote social inclusion**. Existing power structures and inequalities can easily undermine equitable access to PES. In Costa Rica's national PES programme for instance, participants continue to be wealthier and more educated landowners, despite the addition of explicit social goals and associated requirements to include less wealthy and more vulnerable people (Chan et al., 2017[158]). A review in Indonesia highlighted the importance of local-level working groups to improve programme uptake, provide information and promote co-ordination between beneficiaries and other stakeholders (OECD, 2020[147]).
- **Make PES attractive for land users**. Inflexible programmes targeting only one ecosystem service are often not successful because ecosystem services function as bundles. So-called stacking approaches allow land managers to receive payments for different ecosystems services provided in the same area, thereby increasing the cost-effectiveness (Lankoski et al., 2015[165]). Also, stacking can be used to incentivise the development of higher-quality projects, such as restoring a wetland instead of simply planting a vegetative buffer. Similarly, bundled payments describe programmes where participants receive single payments for multiple ecosystem services (Cooley et al., 2011[166]). The French Flowering Meadows agri-environmental measure (AEM) is known for its flexibility: the results-oriented scheme allows farmers to choose how they achieve the desired result. Farmers commit to ensuring that at least four plants from a reference list of 20 species with high ecological value are in their meadows. The reference list was drafted by a range of stakeholders, including farmers. Acting in collaboration with other stakeholders to define the goals and means may also increase motivation (Fleury et al., 2015[167]).
- **Clearly defined and enforced land tenure is a prerequisite for sustainable land use**. If land users have sufficient certainty over land tenure and clarity about who owns or has the rights to manage land, they will be more willing to plant trees or restore peatland (Wreford, Ignaciuk and Gruère, 2017[168]). Lack of clarity can also lead to illegal logging, mining and agricultural activities, in Brazil, Indonesia and Mexico for example. Supporting and intensifying ongoing land reform efforts is essential for effective land use policies (OECD, 2020[147]).

- **Identify land use incentives that are inconsistent with the net-zero-emission transition and ecosystem services**. Switzerland, for example, has reformed its direct payment system by removing direct payments to livestock farmers and increasing payments to farmers engaging in extensive upland grazing. Transition payments were used to minimise negative impacts on farmers and environmental groups helped make sure that potential beneficiaries were informed (OECD, 2017[169]).

Rural regions need to take an active role in the energy and industrial transition

The territorial impact of the energy transition is already present today but will need to increase sharply in scale. Wind and solar energy make up roughly 11% of total electricity generation today in OECD countries but their share will have to increase to 50% by 2040, much of it in rural regions (Chapter 3). Remote regions record a higher share of renewables (51% of total production) than regions that are close to a small or medium city (33% of total production, Figure 4.10) This means that some rural areas have a clear comparative advantage in producing renewable electricity, largely because of their favourable geographies such as elevated and open spaces, biomass availability and low population density. However, not all rural geographies offer equally favourable conditions. It is therefore important to identify potential based on a place-based analysis (Phillips, 2019[170]; OECD, 2012[171]; Poggi, Firmino and Amado, 2018[172]). Some regions, especially those that rely on traditional energy industries, may lose activity to renewable energy (RE) generation locations, leading to economic losses. In this context, energy transition also needs to enable economic development through economic diversification and job creation where possible. This section will outline how rural regions can best benefit from their comparative advantage in RE and which barriers need to be overcome.

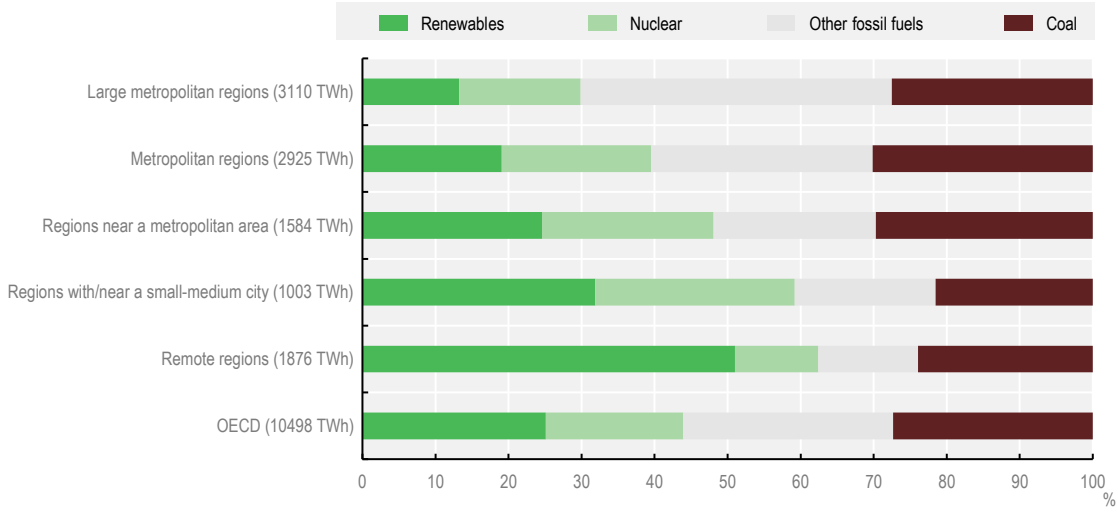
Rural regions have a comparative advantage in producing renewable energy

Rural regions, especially remote ones, are leading in renewable electricity production. Overall, rural regions account for 43% of the electricity produced in OECD countries, generate 38% of their electricity using renewable sources. In total, regions far from metropolitan areas account for around half of the total electricity produced from renewable sources in the OECD, with hydropower being the most used renewable source (OECD, 2020[173]).

Cost reductions in renewables and innovations have opened up new possibilities for rural areas. Since 2010, the cost of investment for photovoltaics decreased by 82%, for onshore wind by 39% and offshore wind by 29%. These falling costs have enlarged the possible group of owners with raising the potential for profit margins. In terms of innovations, offshore wind, in particular, has high potential to meet electricity demand, offering higher capacity factors due to ever-larger turbines that tap higher, more reliable wind speeds and floating turbines that open up possibilities for new locations for instance in the North Sea (IRENA, 2020[174]; IEA, 2019[175]).

Renewable energy can have positive effects on the job market but aspects such as technology type and regional fit matter. For example, in EU countries, under the scenario of 80% emission reduction by 2050, deploying wind and solar panels may create one million jobs (direct and indirect) between 2014 and 2050. The share of jobs across three stages of wind and solar panel deployment will be 40% at the manufacturing stage, 23% at the installation stage and 37% at the operations and maintenance stage. Estimates however vary, depending on the learning rate of the technology, fossil fuel prices, energy demand and policy initiative among others (Ortega et al., 2020[176]).

Figure 4.10. Sources of electricity production, 2017



Note: Renewable energy sources include hydropower, wind, waste, biomass, wave and tidal, geothermal and solar. Fossil fuels are divided into two subcategories: coal, which corresponds to the most carbon-intensive energy source; and the other fossil fuels, including oil, petroleum, coke and gas.
Source: OECD (2020[173]), *Regions and Cities at a Glance 2020*, https://doi.org/10.1787/959d5ba0-en.

StatLink https://doi.org/10.1787/888934237140

Box 4.15. Key factors for successfully linking renewable energy to rural development

- Embed energy strategies in the local economic development strategy so that they reflect local potential and needs.
- Integrate renewable energy within larger supply chains in rural economies, such as agriculture, forestry, traditional manufacturing and green tourism.
- Limit subsidies in both scope and duration, and only use them to encourage renewable energy projects that are close to being viable on the market.
- Avoid imposing types of renewable energy on areas that are not suited to them.
- Focus on relatively mature technologies such as heat from biomass, small-scale hydro and wind.
- Create an integrated energy system based on small grids able to support manufacturing activities.
- Recognise that renewable energy competes with other sectors for inputs, particularly land.
- Assess potential projects using investment criteria and not on the basis of short-term subsidy levels.
- Ensure local social acceptance by ensuring clear benefits to local communities and engaging them in the process.

Source: OECD (2012[171]), *Linking Renewable Energy to Rural Development*, https://dx.doi.org/10.1787/9789264180444-en.

Developing renewable energy projects to the advantage of rural development is not straightforward. Evidence is mixed on whether construction, operation and maintenance activities from renewable energy projects actually support long-term rural development (Clausen and Rudolph, 2020[177]; OECD, 2012[171]). While there is an indication that renewable energy creates jobs, for instance from operation and maintenance of equipment, studies suggest that the largest potential for employment is rather indirect and can develop along the value chains, the reallocation of abandoned facilities or more affordable local energy can make other production activities possible, including food processing, storage and transport (European Court of Auditors, 2018[178]; OECD, 2012[171]; ILO, 2019[179]). In addition, considerations on how profits of local resource use are distributed and retained locally to benefit social and economic development is a central question (OECD, 2020[26]). Experience with other types of resource extraction including mining has demonstrated the importance of assuring local community benefits and local participation in resource development projects to ensure community ownership and acceptability.

Regional level governments play an essential role in decision-making for renewable energy. While national-level governments are important to establish legal frameworks and supply financial support for technological innovations, the final decisions about renewable energy deployment are better placed at the local or regional level. This is because potentials for renewable energy development are unevenly distributed across countries and closely linked to spatially diverse natural conditions (OECD, 2012[171]). Conducting economic and social benefits assessments can help decision-makers to understand what kind of impact renewable energy deployment can have in their regions and help to illustrate regional benefits to the population (Jenniches, 2018[180]).

Making use of renewable potentials for the benefit of rural regions

Enhance innovation potential

RE deployment can generate innovation (in products, practices and policies) that result in new business opportunities in rural regions (OECD, 2012[171]). Rural communities can and do engage in R&D related to RE. Lately, innovations have developed specifically around: transmission and storage (smart grids, batteries, hydrogen); applications (e-mobility, green ports); and administration and service (legal, consulting, supply chain, financial service, etc.). Nord-Norge, in Norway, for instance, is drawing on what it has in abundance – water and energy – in order to produce green hydrogen (IEA-RETD, 2016[181]). Hydrogen can be used for fossil-free fuel for transportation in shipping and heavy road transport and in manufacturing, provided it is produced with renewable electricity. As governments seek to increase hydrogen production, they should involve rural areas.

Other rural regions have engaged in specific RE projects to push the technological frontier towards new technologies. In Canada, Nova Scotia, one of the poorest Canadian provinces, has started to generate, store and export tidal energy. As tidal energy is still in the early stages of development, the region seeks to utilise the early adopter advantage in this industry to develop services exportable to other parts of the world. To this end, it has set up consulting businesses that support other rural communities with tidal power potential (IEA-RETD, 2016[181]). In September 2020, the Canadian government announced major investment in four tidal energy projects – two of them located in Nova Scotia – to build a tidal turbine array using subsea tidal technology in the Bay of Fundy and research environmental effects at the local university (Government of Canada, 2020[182]).

Networks are key to foster innovation around RE. Innovations are recognised as co-learning and a co-creation process, involving many other actors rather than a single “inventor”. Specifically, innovation normally involves joint and mutually supporting activities that involve regional and local governments, enterprises, universities and research institutions and users. Key ingredients for regional innovations are related to building and fostering this network, through good external and internal linkages, local decision-making power and ownership but also the support at the structural level with regards to investments and regulatory frameworks (OECD, 2012[171]).

While electricity markets are increasingly integrated as renewables expand, stronger local production of renewable electricity may support the creation of new forms of activity, complementing present activities such as agriculture. Examples include processing, storage and transport in food systems. Particular benefits can be overserved in remote regions that are poorly integrated into energy networks. On the Scottish Isles, for instance, the installation of local grids has freed residents from dependence on diesel generators and supported drinking water and heating as well as several new businesses in the tourism and leisure industry such as restaurants, shops, guest houses and self-catering accommodation (Chmiel and Bhattacharyya, 2015[183]).

Revive existing facilities

Existing infrastructure and buildings can constitute an opportunity for new companies in the RE sector. Economic transition and population decline can render existing facilities in rural regions unused. Reappropriation of existing building and infrastructure for renewables-related businesses can bring these abandoned places back to life. A factory in Trenton, Nova Scotia, formerly used to build locomotives and train wagons, is now being used to build windmill pylons. In other countries such as Norway, unused water distribution pipes and storage find additional usage to drive turbines and generate electricity.

Rural regions which have been involved in carbon-intensive industries might have opportunities to reuse existing spaces and knowledge for RE development. A recent report attests a significant potential for RE development in previous coal regions. It states that the deployment of renewable energy technologies in the coal regions can create up to 315 000 jobs by 2030 and up to 460 000 by 2050 in the EU and that investments significantly benefit from the availability of infrastructure, land, skills and industrial heritage already in place. In the region of Visonta, Hungary, 72 500 solar panels have been installed on coal mine sites, as well as in Klettwitz, Germany, where wind farms are placed on similar sites (Kapetaki and Ruiz, 2020[184]).

Ensure community involvement and benefits

Community ownership and participation in benefits and decision-making support rural development. A case study from rural Sweden, for instance, found that in the absence of community benefit schemes, employment opportunities are modest and depend on the presence of local manufactures (Ejdemo and Söderholm, 2015[185]). Across many OECD countries, there has been resistance to the siting of renewable energy developments in rural areas. Reasons for these are varied and include biodiversity loss, competing land use (such as agriculture), as well as visual impacts. Loss of view or increased noise might reduce property values or opportunities for the tourism industry (Phillips, 2019[170]; Poggi, Firmino and Amado, 2018[172]). To address these issues, two aspects are important: i) procedural fairness, i.e. the ways in which communities are involved in the RE development decision-making leading to implementation; and ii) distributional fairness, i.e. fairness in the benefits communities receive from installation as well costs and risks (González et al., 2016[186]).

Procedural fairness improves trust with large companies or developers. Trust has been highlighted as one of the most important factors needed to gain the acceptance of RE development by communities (González et al., 2016[186]). Trust can be increased if residents feel the information is handled with transparency and accuracy throughout all stages of the project and their concerns are reflected in prospected operations. Communities who perceive that decisions are made to benefit all as opposed to only a few also display more trust. Options to improve trust include setting in place inclusive and sufficient mechanisms for dialogue and consultation as well as ensuring concerns are taken into account in decision-making (Moffat and Zhang, 2014[187]). This, however, is often lacking because of unbalanced power relations, limited community capacity and funds (rural communities often have small administrations and tight budgets in comparison to large energy companies), missing guidance or legal frameworks.

Regional and national policymakers are responsible for clarifying planning and permission processes and act as mediators. The state of North Rhine-Westphalia, Germany, for instance has set up state-wind energy dialogues and mediation on renewable energy projects at the local level. The process includes information, consultation and expert advice as well as round table discussions and an interactive website with information on planning and permission processes, conducted by an independent agency to ensure neutrality and unbiased support. Mediations include targeted problem-solving within municipalities and help negotiate positions, ideas and interests directly. Other German state governments have established similar platforms. Between them, they exchange ideas, latest developments and experiences (The Climate Group, 2016[188]).

Benefit-sharing agreements and funds can be critical tools to support rural development from renewable energy. Such agreements and funds can set rural communities on a path of sustainable development and increase social acceptability. But the extent to which benefit-sharing agreements and funds deliver robust results for rural communities differs considerably. Much comes down to the nature of the benefits and ownership regimes and how they are implemented. The mining industry has a long tradition of benefit-sharing agreements (Raderschall, Krawchenko and Leblanc, 2020[164]). These can be instructive for renewables deployment. Local-level benefit-sharing approaches can take a range of forms, including:

- Financial payment into some form of "community fund" that can be used for the benefit of local residents.
- The delivery of some form of community "benefit in kind", such as a facility or infrastructure improvement.
- "Share ownership" or "profit sharing" where residents of an area receive a stake in an energy development such that community benefits are tied to its performance (Phillips, 2019[170]; Kerr, Johnson and Weir, 2017[189]).

Among these options, community ownership or co-ownership offer the greatest potential and have achieved promising results. This increases the potential for benefits (in this case revenues) to be retained and reinvested in a way that allows for local enhancements of rural communities, reducing dependence on outside investments or grants. Greater community involvement also fosters the creation of new capacities and skills, mobilises local skills for renewables deployment, increases local identification and community cohesion and empowerment (Clausen and Rudolph, 2020[177]). The REScoope MECISE project showed that a stronger involvement of European citizens is needed to achieve the transition to renewable energy. Decentralised ownership of projects encourages greater acceptance of renewable energy and benefits local communities. Renewable energy communities can be made up of natural persons, local authorities (including municipalities) and SMEs (OECD, 2020[190]). The following mechanisms can help to enable communities to better exploit these opportunities:

- **Rural regions and communities might require access to professional/technical skills and capabilities in order to effectively engage with renewable energy proponents**. Power and information asymmetries can be barriers to community ownership models. In order for smaller administration or communities to make informed decisions regarding RE developments, they require access to various expertise including commercial, legal, financial, land use and geological expertise and data. In some cases, these skills can be developed, in others, they need to rely on external experts. This advice is expensive and the costs should not be the sole responsibility of the rural region but part of the project cost. Information sharing platforms and peer learning between rural regions can further improve capacity building and support peer learning.
- **Governments set the rules – they must acknowledge capacity and power imbalances and set fair and transparent processes**. Small-scale RE developments still face obstacles including legal restrictions, disproportionate administrative and planning procedures, lack of finance and punitive tariffs that inhibit investments – these need to be identified and removed. This happens for instance because small initiatives do not have the same means to deal with documentation

required in permitting granting procedures. Access to one-stop-shops where small initiatives can easily submit relevant documentation, have access to technical information and can expect clear waiting times to get projects approved can be an opportunity to support processes. Targeted financial tools, revolving funds or favourable loans, grants or tax reductions for investments by small energy projects can also help. Governments are also crucial in setting up engagement and consultation (OECD, 2020[190]). This can happen through the provision of guidelines, dialogues, mediation as well as setting the rules and regulations by which industries operate.

- **Local benefit-sharing approaches should be guided by a coherent regional policy framework**. Funds should be distributed to meet specific objectives and funding amounts should be related to these policy aims. Furthermore, local planning can facilitate communities to identify their assets and opportunities and determine their development priorities through locally-led governance.

A prominent example that demonstrates the regional and local effects of the energy transition are coal regions. As coal is often geographically concentrated, highly specialised local economies and strong cultural identities linked to the industry have developed in these territories. Research on transitioning coal regions shows that, in the past, policy approaches to phasing out lack coherent long-term visions and strategies for dealing with unemployment and loss of income. To enable a just transition,[2] programmes need to be carefully designed and adjusted to local contexts. Countries are seeking solutions to these challenges in different ways and have started initiatives to assist regions with structural changes. In Germany, the Commission on Growth, Structural Change and Employment suggested steps to address the impact of the energy transition on mining communities (BMWi, 2019[191]). Further, the EC Coal Regions in Transition Platform is preparing a roadmap for the phase-out of coal, with a special focus on strengthening growth and employment for the people living and working in affected regions (EC, 2019[192]). A promising example is the Latrobe Valley in the state of Victoria, Australia. The region will have to close all 4 coal power stations over the next 27 years. To secure the economic, social and environmental future of the region the Victorian Government has established an authority to co-ordinate the transition and has endowed it with roughly AUD 300 million to promote economic diversification, growth and resilience through a range of projects (Cain, 2019[193]).

Rural regions face specific challenges and opportunities in the context of decarbonising transport

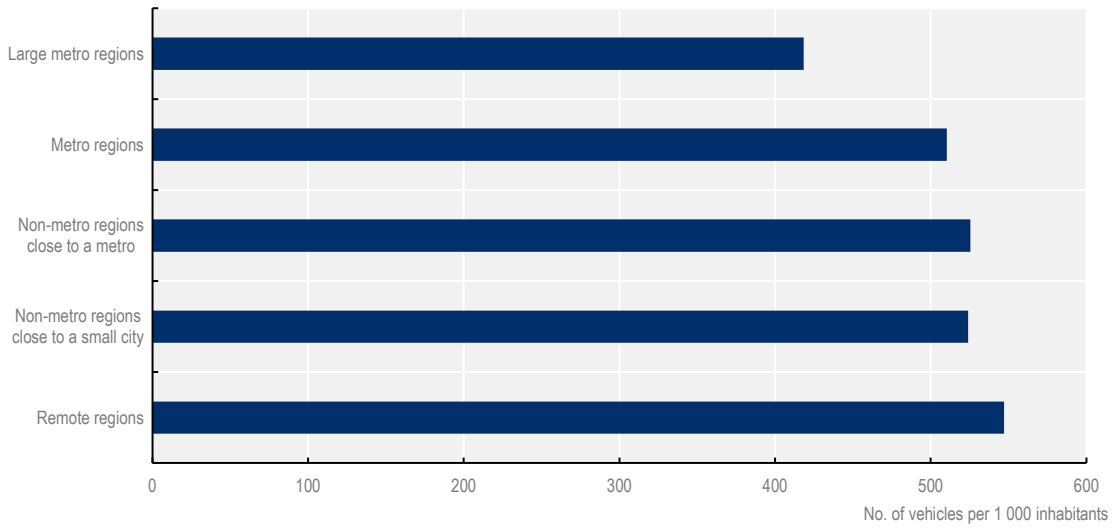
Globally, transport accounts for one-quarter of total CO_2 emissions, largely driven by freight and rural passenger transport. Over the past 50 years, CO_2 emissions from the transport sector have grown faster than any other sector (OECD, 2019[95]). Furthermore, worldwide transport CO_2 emissions are projected to grow by 60% by 2050 (ITF, 2019[88]). While eliminating transport emissions is crucial for rural and urban areas alike, a strong policy focus on urban passenger transport shows results with a projected decrease of 19% by 2050. Freight and non-urban passenger transport, on the other hand, are projected to increase in demand – 225% by 2050 (ITF, 2019[88]). This demonstrates the significant policy action needed to decarbonise rural transportation in order to reach the Paris Agreement.

Overall, policies can reduce emissions from the transport sector through multiple channels:

- Reducing the *emissions intensity per passenger kilometre* travelled, by encouraging a shift from private vehicles to public transport, biking or walking and by incentivising carpooling or car sharing.
- Reducing the *emissions intensity per vehicle kilometre* travelled, through measures that encourage shifts from fossil fuel-powered cars to more energy-efficient vehicles such as EVs and increasing and investing in opportunities for less carbon-intensive energy generation.
- Reducing the *total number of kilometres travelled*, by encouraging fewer trips, for instance by making increased transportation cost and by incentivising teleworking (OECD, 2020[190]).

Policy solutions for decarbonising transport need to account for spatial configurations. Predominantly rural and intermediate regions are especially car-dependent. Measures to punish high CO_2 emissions, for instance by increasing tax on fuel to disincentive car use, disproportionally affects rural dwellers. Redistributive policy from urban to rural areas or differential taxation of car usage, depending on whether it takes place in rural or urban areas, are solutions to this problem (OECD, forthcoming[194]). In addition, in places close to cities, improved bicycle infrastructure and service offers as well as improvement in public transport (express lanes and optimisation of train lines) are important to offer alternatives to car use (The Shift Project, 2017[195]). Also, electric bicycles can increase the reach of cycling substantially. In remote places, improving the safety of roads for soft transport can also increase walking and cycling in rural areas, with important health benefits. In addition, solutions need to focus on zero-carbon engines and technological innovations to reduce emissions. Low-income households should not be left behind (Kamruzzaman, Hine and Yigitcanlar, 2015[196]). This section will present key policy consideration for decarbonising transport in rural regions.

Figure 4.11. Average number of private vehicles per 1 000 inhabitants, by type of region



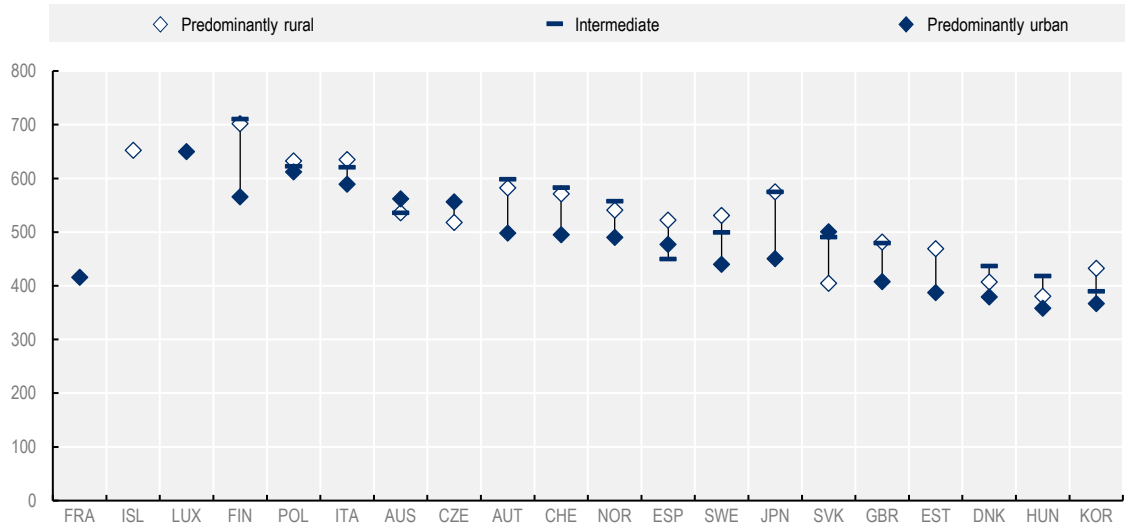
Note: Latest available data year from 2010 onwards. Definitions of private vehicles differ across countries. For example, the EU defines passenger vehicles as vehicles "designed...for the carriage of passengers and not exceeding eight seats".[3] The US, on the other hand, defines passenger vehicles primarily based on weight.[4] Consequently, sports utility vehicle (SUVs) are not classified as passenger vehicles, although they are often used this way in the US. Hence, if they were to be included, US rates would be higher.
Source: OECD Statistics.

StatLink https://doi.org/10.1787/888934237159

Multimodal transport has climate benefits and systems foster rural-urban linkages but require integrated planning. Multimodal systems enable residents to move around by using a combination of walking, cycling and public transportation. While these are already widely applied in cities, there are also opportunities for rural places and small towns, especially those in proximity to urban areas (Porru et al., 2020[197]). Multimodal transport infrastructure that integrates rural regions into the local labour market of cities located in their proximity, creates a greater variety in job opportunities and raises the living standards of inhabitants. In addition to these benefits, multimodal transportation also provides more inclusive mobility by increasing affordability and adding options for non-divers (i.e. elderly, people with disabilities and youth) (OECD, 2020[198]). Well-designed multimodal transport requires integrating different modes of transportation and facilitating the switch between transport modes. Unique ticketing systems and other accommodations for travellers, such as public transport vehicles with space for bikes or scooters, can favour these systems.

Finally, intermodal trips can be encouraged by making walking and cycling more amenable transport mode choices for short journeys, for instance through policies making walking and cycling infrastructure safer and more comfortable to use (OECD, forthcoming[194]). Overall, comprehensive planning strategies resulting from the objective to foster accessibility within regions (i.e. maximising the access to opportunities such as workplaces, services, entertainment, education, goods and culture) can be used as a policy design tool to pursue economic, social and environmental goals simultaneously (OECD, forthcoming[194]).

Figure 4.12. Average number of private vehicles per 1 000 inhabitants, by type of region in each country



Note: Latest available data year from 2010 onwards. Definitions of private vehicles differ across countries. For example, the EU defines passenger vehicles as vehicles "designed...for the carriage of passengers and not exceeding eight seats".[5] The US, on the other hand, defines passenger vehicles primarily based on weight.[6] Consequently, SUVs are not classified as passenger vehicles, although they are often used this way in the US. Hence, if they were to be included, US rates would be higher.
Source: OECD Statistics.

StatLink https://doi.org/10.1787/888934237178

On-demand transport and pooling solutions are promising solutions for lower-density areas. In some cases, classic modes of public transportation become uneconomical as regions undergo demographic change (de Jong et al., 2011[199]). On-demand pooling can address this problem while securing important public service for the local population. In Spain, on-demand pooling transport services have been introduced in the municipalities of Sant Cugat del Vallès and Vallirana. The services replace former regular services introducing a technological pooling platform with positive results in terms of occupancy and cost. In Sant Cugat, the average occupancy of vehicles increased from 6 passengers per trip to 16 with the new service and the flexible service's operational costs are 15% less than the former conventional line (OECD, 2020[190]).

The electrification of personal mobility constitutes one of the most effective ways to reduce CO_2 emissions from passenger transport and offer significant co-benefits in rural regions if renewable energy is used to power them and negative effects of sourcing rare earth metals are mitigated. While the lifetime costs of EV is currently higher than that of cars with internal combustion engines (gasoline or diesel), a break-even point might be reached as soon as 2023 (OECD, 2020[19]). For many rural residents, the break-even point may therefore well be reached before 2023: because they drive more, they can benefit more from lower operating cost of EVs – the cost for EVs can be less than half as much as fuel-powered cars due to fuel

savings and less maintenance (McMahon, 2018[200]). While important, price incentives are not sufficient from a rural development perspective. The use of EVs in rural regions offers important opportunities for rural economies in the context of the needed large-scale deployment of renewables. Sector coupling links renewable energy production with local consumption closing resource loops. Smart charging of vehicles, for instance, could be used to absorb electricity produced at almost no cost at moments of abundant renewable supply and vehicles can provide electricity back to the grid in times of peak demand. Rural development policymakers should therefore support regulatory policy reforms which foster the integration of renewables in the electricity market, including high-resolution pricing over time and space, and flexible demand response, facilitating sector coupling. Further, the sourcing of rare earth metals such as lithium, graphite and cobalt for the production of EV has reportedly significant negative externalities on local rural communities and ecosystems (Ballinger et al., 2019[201]). Promoting EVs in one rural region should not come at the expense of another. Hence, it is important for policymakers to assure that the extraction of natural resources generates improved and sustainable well-being for producing regions and those local communities receive adequate benefits.

Uptake of EVs requires investments in charging infrastructure, especially in rural regions. While, new electric cars typically offer ranges of 400 km or higher, lack of charging stations can pose barriers to rapid EV adoption. Most governments continue to provide financial incentives to increase demand rather than investing in charging infrastructure (ITF, 2019[88]). In rural regions, the dispersed nature of residences and infrastructure requires recharge points to be placed strategically, for instance at supermarkets and schools. Governments also need to consider increasing demand for total electricity with increasing market penetration of EVs, which calls for more co-ordinated charging and local reinforcements of grids. Investing in the construction and upgrading of transport infrastructure is also important to improve the connectivity between rural and urban areas and boost local economies (OECD, forthcoming[202]). A leading example of investments in EV infrastructure can be found in Southern Alberta, Canada. In the province, civil society groups, local businesses and local and regional governments collectively invest in EV charging infrastructure to facilitate emission reductions, economic development and tourism. The project has installed 22 charging stations, powered using renewable energy sourced from the region (Peaks To Prairies, 2019[203]).

Green hydrogen production can offer rural regions specialised in renewable energy an opportunity for economic development. Many rural economies require heavy-duty transport including trucks, maritime and aviation to export their tradeable goods. At the same time, projections see road freight activity at least doubling by 2050, offsetting efficiency gains and increasing road freight CO_2 emissions (ITF, 2018[204]). Green hydrogen can be used to produce alternative fuels for heavy-duty transport and decarbonise industrial processes at the same time. The first hydrogen-fuelled trucks have recently been put onto the road and governments start to invest strategically in this technology. Portugal is planning a new solar-powered hydrogen plant, which will produce hydrogen by electrolysis by 2023. The Netherlands unveiled a hydrogen strategy in late March, outlining plans for 500 megawatts (MW) of green electrolyser capacity by 2025 (EBRD, 2020[205]). While prices are not competitive yet, increased demand could reduce the cost. The fact that renewable energy is required for zero-carbon hydrogen production makes rural regions a key player in the development of this technology and would allow them to sell it to regions with limited potential or higher costs of renewable power generation.

Reducing travel demand in rural places can save emissions and has the potential to (re)vitalise local business and services. Business and service availability play a role in reducing transport-related CO_2 emissions in rural regions. The decline in local service provision in areas outside cities often results in the need for longer trips. Rural people also prefer to use local services. Temporarily subsidising local services can result in long-term financial viability, while at the same time reducing emissions (Kamruzzaman, Hine and Yigitcanlar, 2015[196]). Further, innovations such as the collective distribution of e-commerce purchases to reduce individual travel can be used to support local businesses, as they function as order and receipt points (The Shift Project, 2017[195]). Other possible interventions involve aspects such as increasing scope

for telework. These can reduce travel and induce local interaction, for instance, if telework is located in rural co-working places. Germany's first rural co-working space is situated in Bad Belzig, Brandenburg. The Community and Concentrated Work in Nature (Coconat) is a temporary work station in a remodelled estate. Since 2017, it has become a meeting place for digital nomads, urban working tourist and regional dwellers working for the digital and knowledge industry (Coconat, 2020[206]).

Leaving no region behind

Regions facing job losses in the net-zero-emission transition need to attract new economic activity

The analysis in Chapter 3 suggests that in most large TL2 regions, employment in sectors at risk of job loss from the net-zero-emission transition is modest. However, there are significant differences between regions and some of this employment is geographically concentrated even within these regions. The socio-economic characteristics of these regions are diverse. As shown in Chapter 3, some regions with particularly high emissions in industry or power generation have unusually high GDP, though this does not translate into equally high subjective well-being. In some of these cases, high GDP per capita may relate to the economic rents from the extraction and processing of fuels and materials. In others, including coal regions, GDP per capita is below average and poverty and unemployment may already be high. Rural regions can be particularly vulnerable because economic opportunities are scarcer and life satisfaction tends to be lower (Box 4.16). Especially for these regions, digitalisation can help overcome some traditional rural challenges, such as low density and shrinking local markets. However, rural communities often face more of a lack of digital connectivity than urban areas, reflecting a need to strengthen technological and civil infrastructure, quality education and skills training (OECD, 2020[19]). For all regions, it is important to find ways to benefit from the transition to a net-zero-emission economy, attracting new activity that is consistent with this transition. Doing so in a way that harnesses skills and assets rooted in these regions, including those inherited from industries that are set to disappear in the transition, can help avoid protracted regional decade-long decline, often characterised by self-reinforcing emigration of businesses and workers.

Box 4.16. Economic opportunities tend to be weaker in rural regions

Economic opportunities follow a clear urban gradient

OECD analysis in *Cities in the World* (OECD/EC, 2020[45]) based on a consistent definition of human settlements and data from the Gallup World Poll shows that economic opportunities follow an urban gradient across the world. Some rural regions face difficulties in generating employment and high-income jobs, which helps explain domestic migration to large cities (OECD/EC, 2020[45]). For example, regular employment opportunities are significantly more common in cities than elsewhere.

Local conditions for starting a business offer one pathway for economic mobility and renewing economic activity (OECD/EC, 2020[45]). On average, they tend to be slightly better in more densely populated areas. In some countries, entrepreneurship-friendly local conditions differ significantly across space. Rural areas in countries in Central Asia and Eastern Europe especially struggle to provide adequate conditions for business creations with the share of rural residents believing that their area is a good place to start a business falling 20-30 percentage points below that of city residents in Bulgaria, Lithuania, Poland or Russia.

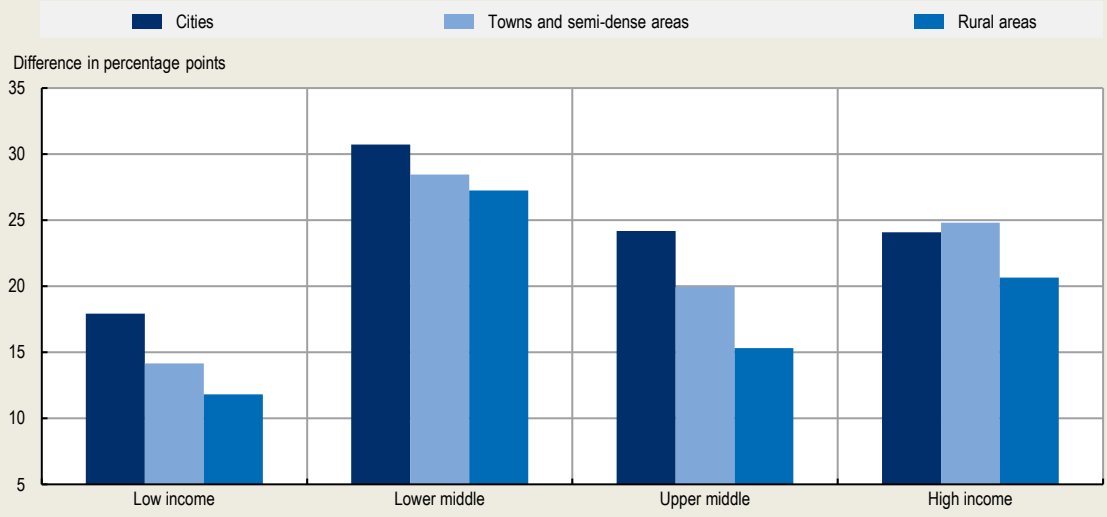
Differences in subjective well-being across the degree of urbanisation

Economists and policymakers are increasingly going beyond GDP by using a multitude of well-being indicators. Self-reported life satisfaction can encompass many aspects of quality of life. As highlighted in *Cities in the World* (OECD/EC, 2020[45]), in general, life satisfaction appears to be somewhat higher in densely populated areas for a sample of 111 countries across the world.[7] Life satisfaction in towns and semi-dense areas is lower than in cities but higher than in rural areas. For a sample of 13 OECD countries, the difference between cities (28.7% satisfied with their lives) and rural areas (24.4% satisfied with their lives) amounts to more than 4 percentage points.[8]

Living in a city is not only associated with higher life satisfaction but also with more positive expectations. While residents are generally more optimistic about their future than about their present, residents in cities tend to be the most optimistic (Figure 4.13). This difference is the biggest in the poorest countries.

Figure 4.13. Difference between future and current life satisfaction

Expected increase in life satisfaction across income and degrees of urbanisation, in percentage points, five years from the present



Note: The figure presents the percentage point difference between current and future life satisfaction by country income class across the degree of urbanisation.
Source: OECD/EC (2020[45]), *Cities in the World: A New Perspective on Urbanisation*, https://dx.doi.org/10.1787/d0efcbda-en.

Even so, industrial renewal will raise the demand for some occupations while reducing it for others (OECD/Cedefop, 2014[207]). The transition to net-zero emissions will also change the way tasks are done within occupations (Cedefop, 2012[208]). New “green” skills can help local economies secure employment for workers losing out from the transition. Local policymakers are at the forefront of this change in the world of work due to their responsibilities in active labour market policies, training and a number of public services (Martinez-Fernandez, Hinojosa and Miranda, 2010[209]).

Place-based innovation policies need to support and direct structural change

As shown in *Regions in Industrial Transition* (OECD, 2019[210]), industrial innovation policies based on the concept of smart specialisation aim to boost economic activity through economic diversification and by connecting new activities to established local businesses and worker skills. This avoids employment loss and the emigration of businesses, firms and workers, which tend to characterise persistent regional decline. Establishing clear priorities in the regional development policy agenda according to this principle facilitates the allocation of available resources in the face of industrial transitions (McCann and Ortega-Argilés, 2015[211]). The approach helps avoid spreading public support thinly across a wide spectrum of activities or to copy experiences that may have been successful elsewhere with no real regard for regional context. Both have resulted in proliferating small-scale initiatives incapable of exploiting the full benefits of the positive network externalities characterising industrial clusters that help establish an industrial fabric that will prevent regional decline (Foray, 2017[212]).

Unlike previous shocks to the industrial fabric of regions, the net-zero-emission transition allows identifying economic activities that are likely to suffer employment losses or substantial technological or business model transformations well in advance, making this approach particularly useful to prepare regional transitions. To be able to anticipate the transition, a clear timetable for phasing out industrial activities that are inconsistent with the transition or require a major transformation is useful. Such a timetable can remove uncertainty, avoid risks of stranded assets and can be based on scenario analysis. For example, countries in the Powering Past Coal Alliance, committed to exiting coal use in electricity generation by 2030, argue that this was a cost-effective date for high-income countries to pursue efforts to limit global warming to 1.5°C.

Smart specialisation has two main characteristics:

- First, a smart specialisation strategy (S3) consists of identifying the economic activities that have potential, based on established local resources, including worker skills, infrastructure, local technology and other comparative advantages, and prioritise the development of these sectors through innovative activities or technologies. Selection criteria can include a critical mass of companies in a specialisation, innovation capacity, clustering and entrepreneurial dynamics. The consistency of smart specialisation with the net-zero emission transition is critical (Asheim, Grillitsch and Trippl, 2017[213]).
- Second, the choice of the activities that will receive government support should be based on the evidence collected through the interaction of key stakeholders (central, regional and local governments, businesses and higher education institutions). The aim is to explore and assess new activities and their possible development trajectories as well as their policy needs. The search for and discovery of new activities is known as the entrepreneurial discovery process (Foray, David and Hall, 2009[214]).

Successful industrial transformation needs to rest on the participation of local actors and an evidence-based approach

Engaging stakeholders to identify investment priorities for smart specialisation requires an inclusive and interactive bottom-up process in which participants from different environments uncover and produce information about potential new activities. Most regions are endowed with important innovation actors, such as higher education institutions, innovative businesses, the regional and local governments and civil society. Their knowledge is however often fragmented over sites and organisations. Smart specialisation processes, therefore, introduce a range of tools to foster collaboration, such as working groups, advisory boards, partnerships and public-private committees. Recent approaches argue that stakeholder engagement should be built together with evidence-based analyses, such as studies relating local to global scientific, technological and economic trends (Kroll, 2015[215]).

A key question is whether governments have the right governance mechanisms to build long-lasting broad partnerships with private sector actors. Arguably, the process of smart specialisation has been most successful in the Northern countries, e.g. Sweden, home to high-quality institutions and strong existing innovation networks. Leveraging multi-stakeholder networks to identify future-oriented priority areas can however also work in moderately innovative regions. The Pomorskie region in Poland provides an example of a well-designed entrepreneurial discovery process within an environment that lacks a legacy of strong collaborative ties (Box 4.17).

Box 4.17. Stakeholder engagement for smart specialisation in Pomorskie, Poland

The Pomorskie regional government took a collaborative approach to the development of smart specialisation priorities through the entrepreneurial discovery process. Smart specialisation investment priorities in Pomorskie were identified largely through a bottom-up process entailing the following main steps:

- Step 1: An economic diagnostic of key regional strengths and weaknesses, accompanied by public consultation and the formation of partnerships.
- Step 2: A call for proposals to research and industry stakeholders for joint smart specialisation projects.
- Step 3: An initial assessment of proposals by a selection board composed of national and international experts and a public hearing. The selection took into account global trends, market potential, economic and technological potential, a domestic and international benchmarking, the proposed strategy and action plan, and the potential of the partnership. This led to a narrowing down to six specialisations and partnerships.
- Step 4: Four smart specialisations were selected.
- Step 5: An implementation plan was set up for each specialisation.
- Step 6: Partnership agreements with priority access to EU funding were established for each specialisation.

Source: OECD (2019[216]), "Local entrepreneurship ecosystems and emerging industries: Case study of Pomorskie, Poland", https://doi.org/10.1787/8fd63992-en (accessed on 30 November 2020).

The OECD report on *Broad-Based Innovation Policy for all Regions* (OECD, 2020[217]) has shown that regional development agencies can play an important role in fostering innovation. In Andalusia, Spain, for example, the regional Innovation and Development Agency (IDEA) has been instrumental in strengthening the capacities of the aerospace industry. It provided a platform for universities and companies to realise that researchers could develop prototypes with local SMEs. With the Centre for Technological Innovation and Advanced Aeronautical and Naval Manufacturing (CFA), the region then provided a place and infrastructure where collaboration can take place (OECD, 2020[217]).

Building consensus around future specialisations can help target policy instruments better to serve transition-consistent structural transformation. These policy instruments include support for firms to become more innovative and to encourage knowledge exchange and collaboration. University-industry partnerships can be supported through collaborative research tools such as grants and innovation vouchers. The OECD evaluation of the smart specialisation academy in Värmland has indeed shown that the co-operation between the regional government and the local university – in this case with a formal agreement – has been important to identify future activities that build on regional strengths and research and development capacities.

Regulatory or fiscal incentives strengthen the engagement of local actors for regional innovation and collaboration. Examples are direct funding to businesses for R&D or R&D tax credits, which are mostly provided at the national level. At the regional level, R&D contract opportunities can help develop innovative products or organisational practices that can increase productivity. Universities can also receive funding from the government to support spin-offs and academic entrepreneurship, one good way to spur entrepreneurial dynamism in the region. Open research laboratories or student hiring are additional instruments to support exchange between industry and university. Important preconditions to make collaboration instruments work are adequate and sustainable funding, clear rules on property rights and confidentiality issues, and sufficient trust among actors. An example of a university taking a leadership role in local industrial transitions comes from Northeast Ohio in the US (Box 4.18).

Regions that transform their industries to become consistent with the net-zero GHG emissions need to take into account international contexts when activities are subject to international competition. For example, zero-emission consistent steel production faces higher costs than conventional steel production. Carbon border adjustments are one option (OECD, 2020[218]); integrating trade agreements could include environmental criteria while minimising compliance costs (Bellmann and van der Ven, 2020[219]). Else, government incentives to decarbonise these industries may need to be designed to keep them competitive (DIW, 2018[220]). Another approach may be for regions hosting similar activities to work together across international borders, for example in maritime port regions.

Box 4.18. How higher education institutions play a role in industrial transition

In Akron, Ohio, in the US, a university mobilised its industrial heritage to build an advanced research centre

In the 1970s and 1980s, large tire companies based in Akron struggled with international competition, leading to closures and layoffs. Due to the large share of jobs represented by the rubber and tire manufacturers, plant closures had a severe effect on the city's and the region's well-being. Although the government, businesses and citizens also played important roles, the University of Akron played a key role in attracting new employment by further developing its polymer and material science labs. These labs were still intact from Akron's industrial period.

The university began expanding the number of students and making partnerships with innovative industries and the Ohio government. The latter invested an initial USD 2.1 billion into funding technological companies' partnerships with research institutions. One major outlet of university research has been in technologies relevant for the green transition yet drawing on established skills, such as pollution measurement instruments, clean energy sensors and fuel-cell polymer development.

Source: OECD (2018[221]), *Job Creation and Local Economic Development 2018: Preparing for the Future of Work*, https://dx.doi.org/10.1787/9789264305342-en; Ledebur, L. and J. Taylor (2008[222]), "A restoring prosperity case study: Akron, Ohio", https://www.brookings.edu/wp-content/uploads/2016/06/200809_Akron.pdf; Van Agtmael, A. and F. Bakker (2016[223]), "How cities can use local colleges to revive themselves", https://www.theatlantic.com/business/archive/2016/03/cities-colleges-akron-polymers/472881/.

As outlined in the OECD report *Regions in Industrial Transition* (2019[210]), policymakers can support digital take-up by people, firms and local governments. They can help firms and their workers acquire digital competencies and support business innovation networks. Policy instruments can include targeted loans and vouchers to small firms. Training support can include a mix of support activities, events, webinars, counselling and training programmes to foster digital competencies. These programmes often have a specific focus on SMEs, as they frequently lag in the adoption of digital technologies.

Prompt remediation and restoration of contaminated sites, especially when mining activities are abandoned, support ecological redevelopment as well as economic development on brownfield sites with access to infrastructure and increase the local economic attractiveness for new business development (Sartor, 2018[224]). Mining companies should establish appropriate financial mechanisms for the remediation of past damage to land and water resources. If individual companies' resources are insufficient, this should be financed by revenues from a charge on the mining industry as a whole (OECD, 2013[225]).

Skills mapping can help identify skill needs for industrial transitions

Skills anticipation and assessment help identify skill needs in future investment priority areas in regions in industrial transition and in accordance with projected labour market trends by sector, local area and/or occupation. Indeed, in regions facing industrial transition, it is often uncertain how the skills of former "brown" workers are transferable to emerging jobs, particularly those in low-carbon sectors (OECD, 2019[210]). Skill mapping does not always require new institutions, as many OECD countries already have sectoral skills councils, observatories and skills advisory bodies that could play the role (OECD/Cedefop, 2014[207]). The region of Wallonia, Belgium, has entrusted detailed skills mapping exercises to the region's public employment service (Box 4.19).

Box 4.19. Industry and skills mapping by the Public Employment Service in Wallonia

Wallonia's Public Employment Service is undertaking a prospective analysis – the Le Forem study – to identify local skill needs in strategic business areas. The objective of the exercise is to develop appropriate training offers for Wallonia's strategic and future-oriented economic activities and to communicate the identified skill needs to relevant audiences. The analysis first classifies future occupations and associated core skills in eight sectors. It then identifies a set of related skills that could subsequently arise from developing the sectors. The approach follows a four-step qualitative process:

1. Analytical staff from the Public Employment Service produce reports to identify the sectors in which economic activities of strategic future importance take place.
2. A panel of experts consisting of directors of local skills centres, firm managers, Le Forem account managers and representatives of sector associations answers to a set of questions that are then included in the sector reports. The objective is to detect activity/sectoral trends in the chosen eight sectors and their effects on occupations.
3. Based on the received inputs, the skills required for each occupation are identified. To this end, expert workshops, organised by occupation, identify key evolution factors and the potential evolution scenarios. They then select the most likely (or desired) scenario, also identifying the associated skill needs.
4. The local training department receives the results of the analysis in order to start designing appropriate training programmes. The results are also published and sent to the education authorities.

The sectors and associated industries value the programme since they themselves do not have the capacity or resources to undertake such an extensive study.

Source: OECD (2019[210]), *Regions in Industrial Transition: Policies for People and Places*, https://dx.doi.org/10.1787/c76ec2a1-en.

On-the-job training helps laid-off workers to settle in new employment structures

Reflecting strategically on existing skills and making use of them to transform local industrial specialisation so it becomes consistent with the net-zero-emission transition can help avoid depreciation of skills and make training in green skills correspond with local job creation (OECD, 2019[210]). The OECD Programme on Local Economic and Employment Development (LEED) has highlighted that green skills can take the form of industry-specific technical skills as well as transversal skills. Transversal skills include technological knowledge (e.g. energy efficiency), innovation management as well as "transversal generic skills" to support worker transitions (OECD/Cedefop, 2014[207]; OECD, 2017[226]). Green skills will be required across occupations and economic sectors, and play an important role in local industrial transitions (OECD, 2017[226]). "Greening" of skills is likely to require upskilling, as low-carbon sectors are estimated to require more skills than carbon-intensive industries. It can help accelerate transitions, for example in waste management systems. It has been highlighted that transferring workers to new jobs and providing on-the-job training at a new place of employment should be given priority over external and/or additional retraining programmes to avoid large-scale training programmes being set up without a connection to job prospects. Such on-the-job training may therefore be a good candidate to receive government funding and facilitate the transition (IDDRI, 2017[227]).

Policies to support redundant workers may include entrepreneurial training. However, it should be noted that only a limited share (2%-3%) of displaced workers typically return to work by starting a business (OECD/EC, 2017[228]). Although findings vary, overall, start-ups supported in this way have relatively high survival rates, though they require multifaceted support, including coaching (Caliendo, 2016[229]).

Governments can tailor local employment services to the needs of regions in industrial transition

Several regions across the OECD have supported workers in transitioning to quality employment in other more sustainable sectors or production methods. In Flanders, Belgium, the Public Employment Service has given discretion to local employment offices to create partnerships with local labour market actors as highlighted in the OECD report *Boosting Skills for Greener Jobs in Flanders, Belgium* (2017[226]). The Flanders Public Employment Service has developed a green transition plan that has integrated sustainability principles and green skills in training programmes to tackle some of the region's sustainability risks (Box 4.20). Paired together, local delivery flexibility and green Active Labour Market Policy (ALMP) strategies can help vulnerable workers from "brown" industries benefit from locally relevant ALMP packages.

Box 4.20. Employment services in Flanders, Belgium, gear programmes to green transitions

VDAB is introducing sustainability principles across ALMPs and giving local offices policy discretion

VDAB, the regional public employment service of Flanders, has developed an array of ALMPs focused on the green transition. Training modules have started integrating relevant skills. For instance, in the construction sector, programmes have begun integrating sustainable building and energy efficiency methods. VDAB has also developed a building centre to co-ordinate with actors in the sector and develop training curricula.

VDAB has also given more flexibility to its regional employment offices to deliver services. District offices can forge their own partnerships with local labour market actors and develop their own strategies based on local realities. The OECD has highlighted that multiple sectors in the region, such as chemical product manufacturing, basic metal manufacturing and energy production may face pressure. In 2010, these sectors represented 16.7% of employment in Flanders and upwards of 18% in West Flanders.

Local offices can anticipate these risks and develop strategies with local companies and unions to ensure processes and workers adopt more sustainable methods. These partnerships complement VDAB's large-scale job matching programme and Flanders-wide programmes, as well as VDAB's links with Belgium's federal employment service.

Source: OECD (2017[226]), *Boosting Skills for Greener Jobs in Flanders, Belgium*, https://dx.doi.org/10.1787/9789264265264-en; OECD (2018[221]), *Job Creation and Local Economic Development 2018: Preparing for the Future of Work*, OECD Publishing, Paris, https://dx.doi.org/10.1787/9789264305342-en.

Engaging employers – and SMEs in particular – is essential for training success and lifelong learning in the workplace

Engaging employers in skills development programmes can help align skills programmes with industry needs. Subnational leadership can play a role in reaching out to employers to promote awareness and participation in training (OECD/ILO, 2017[230]). Regions undergoing sharp employment transitions can liaise with firms to understand their skill requirements. For example, OECD firm interviews conducted in Pomorskie, Poland, found the training system may not dispense the green economy skills needed in the local labour market (OECD, 2017[231]). Training systems may benefit from greater knowledge of local skill needs, particularly in emerging green industries or occupations, so that they can be integrated into their learning programmes.

The OECD has highlighted that governments should encourage firms to support their workforce through lifelong learning (OECD, 2018[221]). This can take the form of workplace or offsite training and education, ensuring workers both grow professionally and absorb skills needed to green production processes (OECD/Cedefop, 2014[207]). Production methods will need to become more energy and resource-efficient, calling for upskilling. Development training subsidies, training vouchers and tax incentives can encourage upskilling.

Given the strong presence of small firms in regions in industrial transition, it is important to involve SMEs in skills planning. This can take the form of encouraging their participation in regional employer councils or co-designing and co-delivering training initiatives with vocational colleges, universities and large firms. The OECD has highlighted the role of integrating SMEs into such networks to foster trust-based relationships among firms, knowledge sharing and generate opportunities to pool training costs and resources.

Compensation policies

As regional industries face sustainability risks, some workers will be able to retrain and find gainful employment, while others will be unable to find work with equal pay and conditions. Some workers will require prolonged economic support. Specific economic compensation for laid-off workers supports the well-being of communities during transitions. In economically undiversified regions, tax revenues and local incomes can be heavily reliant on high emission companies and their employees (OECD, 2019[210]). Worker compensation policies specific to industrial transitions support workers financially in addition to unemployment benefits and compensation rights established in national labour law. Compensation can range from temporary unemployment schemes to early retirement.

Extensive case studies in France, Germany, Italy, Slovenia and Sweden found that policy co-ordination, stakeholder involvement, rapid and appropriate taking of action, comprehensive communication to workers and adequate financing are key (OECD, 2020[190]). Many workers were largely hesitant to travel for work or relocate, highlighting the relevance of local labour market solutions. Younger or higher skill workers are more willing to move for work and find employment more easily. Companies, unions and governments need to take into account the preferences and situations of workers with widely different backgrounds, as well as local labour market realities.

Summing up: Policy conclusions from Chapter 4

While climate-related objectives and strategies are largely international and national, subnational governments need to take the action that is appropriate for local characteristics.

Multi-level climate governance and finance need to identify goals for government levels and regions to reach national 2050 net-zero emission targets. Subnational governments are responsible for most of public spending and investment in sectors with a direct impact on climate change and other environmental issues.

- *Transfers between subnational governments* need to be linked to climate policy goals, so subnational governments have the incentives and resources to make all their policy actions consistent with reaching net-zero emissions.
- *Revenue and spending systems* should be overhauled, including subnational green budgeting and GPP and by eliminating environmentally harmful subsidies. For example, property taxes on land and buildings and land value capture mechanisms can be designed to avoid urban sprawl and finance infrastructure.
- *Borrowing frameworks* should make room for investment serving the net-zero emission transition.

Cities account for most energy consumption and emissions. In high-income cities, emissions inherent in the consumption of goods and services are often a multiple of locally generated emissions.

- *Effective governance* integrates climate policy at three levels:
  - National – National urban policy (NUP) frameworks need to co-ordinate sectoral policies to make them consistent with net-zero emissions and improve well-being.
  - Metropolitan – metropolitan governance can enable coherent urban planning, housing and transport policies towards the 2050 net-zero GHG emission target, while improving well-being, across municipalities belonging to the same travel-to-work area.
  - Intracity – policies to decarbonise urban planning, transport and housing should be co-ordinated across municipalities belonging to the same commuting areas.
  - Intercity – networks of cities should be supported to share knowledge across cities.
- Cities hold large potentials for *modular technologies* to integrate solar rooftop photovoltaic panels, small-scale wind turbines and heat pumps. Regulating energy markets is at the national level but cities can influence uptake.
- Encouraging walking, cycling and public transport to substitute individual car use, in addition to electrifying passenger transport, reduces materials needs and can avoid inequality, as well as deliver broad well-being benefits. Location-based connectivity and accessibility indicators can guide cost-effective improvements.
- The spread of low-density neighbourhoods should be avoided to reduce network costs.
- Provided it replaces individual car use, digital-based *on-demand ride-sharing* lowers CO_2 emissions, energy consumption and congestion while saving on costs and boosting innovation.
- The adoption of the *local circular economy* framework can help accelerate reaching the net-zero transition at a lower cost, for example in building materials, by eliminating food waste and by encouraging a sharing economy.
- Cities should address specific *adaptation* challenges with vulnerability risk assessments (and local resilience action plans).
- Road use charges need to replace fuel taxes as fossil fuels are phased out and reflect mobility costs, such as congestion.
- All new buildings must be consistent with net-zero emissions in energy use and all existing buildings refurbished to such standards within 25 years.

Because of their natural endowments, **rural regions** are pivotal in the transition to a net-zero-emission economy and in building resilience to climate change.

- Decisions on *land use* are still largely defined by short-term, sector-specific production objectives. Integrating social, economic and ecological impacts is key.
- Ecosystem services in rural regions are key to the foundations of well-being in urban and rural regions alike. Understanding and rewarding *ecosystem benefits*, including for GHG emission reductions, for example through afforestation that is respectful of local biodiversity, offers potential for rural development.
- Rural regions need to take an active role in the *energy transition* to benefit from renewables potentials. Through rural community participation in benefits and decision-making, trust can be built to support the needed expansion of renewables.
- Rural regions may benefit the most from the low operating costs of EVs but need to pay particular attention to *charging infrastructure* and affordable vehicles. On-demand shared transport and pooling solutions are also promising solutions.

Smart specialisation can help **leave no region behind** as high-carbon activity is phased out. It aims at connecting new activities to established local businesses, worker skills and assets, involved in activities that need to be phased out and beyond.

- Regions facing job losses in the net-zero-emission transition need to attract new economic activity that is consistent with this transition. Building consensus around future specialisations through early local stakeholder involvement, such as from higher education, innovative businesses, regional and local governments, is key.
- Skills mapping can help identify future occupations and associated skill needs for industrial transitions. Engaging local employers in skill development programmes can help align them with industry needs for the net-zero-emission transition.
- Ageing and less-educated populations, as well as less diversified economic activity, put some rural regions at particular risk. Innovative processes around agriculture, reinforcing regional urban-rural connections, for example in food markets, renewable energies and new modes of transportation, can be attractive options to diversify.

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Notes

[1] The Paris Agreement (Article 4, paragraph 2) requires each party to prepare, communicate and maintain the successive nationally determined contributions (NDCs) that it intends to achieve. Parties shall pursue domestic mitigation measures, with the aim of achieving the objectives of such contributions.

[2] In 2015, the International Labour Organization (ILO) adopted a set of guidelines based on inputs from governments, businesses and trade unions to ensure "A just transition". These guidelines highlight the need for policy coherence between actions taken on climate change and economic development, industrial, labour market and enterprise policies. They emphasise the need to pay special attention to regions and workers that could be negatively affected. The guidelines recommend action to anticipate adverse effects of the transition, implement international labour standards and actively promote social dialogue (ILO, 2015[232]).

[3] See https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32009R0443.

[4] See https://www.epa.gov/emission-standards-reference-guide/epa-emission-standards-light-duty-vehicles-and-trucks-and.

[5] See https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32009R0443.

[6] See https://www.epa.gov/emission-standards-reference-guide/epa-emission-standards-light-duty-vehicles-and-trucks-and.

[7] Data come from Gallup World Poll and consist of countries from all world regions and all country income groups. In total, 13% are high-income countries, 65% middle-income countries (32% upper and 33% lower middle income) and 22% low-income countries.

[8] All reported averages for the Gallup data by income group or world region are unweighted country averages.

OECD Regional Outlook 2021

ADDRESSING COVID-19 AND MOVING TO NET ZERO GREENHOUSE GAS EMISSIONS

The COVID-19 crisis has revealed the close relationship between environmental risks and those to the foundations of human well-being – and the cascading effects on the economy and society. It has also highlighted the importance of anticipation and early action. These are also key to integrating climate policy into regional development, albeit on a larger scale. As with COVID-19, the climate challenge is global, but the response needs to build on regional and local actors, natural environments, geographies and infrastructures.

The 2021 edition of the *OECD Regional Outlook* shows that a place-based approach is vital for resilience in the face of both these challenges. It analyses the different territorial impacts of COVID-19 on health and economy, as well as policy responses. The report explores the different territorial implications of moving to net-zero greenhouse gas emissions by 2050 whilst adapting to inevitable climate change, and provides fresh analysis of regional data. It provides insights for integrating the climate challenge into multi-level governance, urban and rural development so as to leave no region behind. It highlights the opportunity we have to draw lessons from COVID-19 for a place-based response to the climate challenge.

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