

Building the Road to Greener Pastures¹

How the G20 can support the recovery with sustainable local infrastructure investment

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Executive summary

The economic consequences of COVID-19 have increased the need for substantial infrastructure investment to support the global recovery. This report recommends that the focus should be, in particular, on sustainable investment to help achieve the Paris Agreement climate targets and to avoid more capital becoming stranded as climate policies toughen in the coming decades. Local infrastructure, which accounts for most sustainable infrastructure needs, should be a major target area. Building on the *G20 Principles for Quality Infrastructure*, this report investigates the role that different aspects of predominantly local infrastructure could play in the decarbonisation of the G20 economies.

The economic crisis arising from COVID-19 has led G20 economies to unleash huge volumes of fiscal support. This support has tended to prioritise protection of existing economic structures. As support measures transition into fiscal stimulus, G20 governments must consider the structural impact that measures will have on long-term economic growth. The necessity for fiscal stimulus in the recovery provides a unique opportunity for a sustainable infrastructure strategy aimed at transforming G20 economies into economies fit for the challenges and changes of the twenty-first century.

The global ‘infrastructure gap’ in investment needed to reach sustainable development goals has been estimated at between \$7 trillion and \$8 trillion annually (Bhattacharya *et al*, 2019; OECD, 2017). Priority areas for sustainable infrastructure investment are energy, transport, water and sanitation, and the telecoms/digital sector. About 70% of global greenhouse gas (GHG) emissions come from the construction, development and operation of infrastructure in the energy, buildings and transport sectors. We outline general principles for urgent action that G20 economies should take, whilst being cognizant of the fact that ‘common but differentiated responsibilities’ form the cornerstone of the UNFCCC negotiations resulting in the Paris Agreement of 2015.

In the electricity sector, key priorities are stopping the deployment of new coal-fired power generation plants, and focusing on enabling infrastructure such power grids, which need to become more flexible so they can incorporate decentralised power generation. In the buildings sector, many G20 economies face the challenge of overhauling their buildings stocks to introduce new sources of clean energy while improving energy efficiency. Investment in buildings must also take account of the changing climate and its implications in terms of necessary resilience.

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In mobility, a shift away from the current model of polluting private vehicles is required to decarbonise the sector. Infrastructure deployment should focus on clean charging stations, improved public transport networks, and walking and cycling routes. Increasingly, access to high-speed internet and the deployment of other digital infrastructure is necessary for sustained economic growth. Efforts are still required to improve the disposal and recycling of solid waste and wastewater, both of which contribute to greenhouse gas emissions and to local pollution.

Discussions about sustainable infrastructure normally focus on the end-use. This report instead advocates a lifecycle approach to assessing the sustainability of infrastructure. This must begin by addressing the significant GHG emissions associated with basic construction materials. A number of difficulties associated with decarbonising the production of steel, aluminium and cement make it imperative that the G20 should collaborate to support low-carbon options.

To close the multi-trillion dollar investment gap, new sources of financing must be found. Public investment can provide some of the required infrastructure, but crowding-in of private funds will be crucial to achieve sufficiently high levels of infrastructure investment. The current financial market, with a combination of excess savings and low interest rates, presents an ideal opportunity for doing so.

However, a number of barriers continue to block these flows, particularly to local projects. Local governments find it difficult to access private finance, while private investors often struggle to invest because of a lack of infrastructure opportunities of sufficient size and quality. A final obstacle to private investment is the high risk associated with local infrastructure projects. Infrastructure projects are generally long-term, entailing substantial and costly planning, preparation and construction, while cost overruns and delays are pervasive.

National and international development banks do and must continue to play a critical role in tackling these issues. Development banks are in an ideal position to assess the risks of projects, and simultaneously implement best management practices. Their involvement in a project can reduce the cost of financing for the borrower, in particular when the public sector is ready to assume the greatest funding risk. That would make projects more attractive for private investors.

National governments can play a central role in crowding-in private sector investment by ensuring a supportive and enabling investment environment. This involves addressing macroeconomic barriers and project-specific elements, such as the risk of construction delays, cost overruns and project non-completion.

Establishing a sustainable and local infrastructure strategy is not without challenges, but offers significant economic benefits. A coordinated effort by G20 economies to pursue the approaches outlined in this report, building on previous G20 commitments, can underpin sustainable economic strategies for successful economic recovery in the wake of COVID-19. The report closes with some recommendations to the G20:

- Place climate sustainability at the core of the infrastructure agenda;
- Sustainability plans must start locally;
- Improve access to finance for low-carbon projects;
- Address the shortage of bankable infrastructure projects;
- Commit to supporting bilateral and multilateral development banks;
- Stimulate demand for low-carbon industrial materials;
- Improve cooperation across the G20;
- Focus on lifecycle infrastructure sustainability.

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1. Introduction

The world is in the midst of a global pandemic. The COVID-19 virus has killed millions, led to border closures and nationwide shutdowns, and has driven the world economy into the deepest recession since the Second World War.

Meanwhile, other major global challenges continue to demand attention and action. The past seven years have been the warmest ever recorded (NASA, 2021). Over the past few decades, the world has witnessed extreme weather events of unprecedented scale. The United Nations and the Centre for Research on the Epidemiology of Disaster have reported that major disasters have affected 4.2 billion people, claimed 1.23 million lives and resulted in US\$2.97 trillion in economic losses over the past 20 years (CRED and UNDRR, 2020). It is imperative that G20 governments take more action now to address ever-increasing concentrations of atmospheric greenhouse gases (GHGs) and to protect the world's citizens from the effects of human-induced climate change. This challenge is made more urgent by a growing global population: the world population is projected to reach 8.5 billion people by 2030 and 9.7 billion by 2050 (United Nations, Department of Economic and Social Affairs, Population Division, 2019a). Within the same timeframe, more than two out of three people are expected to live in cities (United Nations Department of Economic and Social Affairs Population Division, 2019b). Today, eight out of the ten most populous cities are located in the G20, where half of the ten fastest growing cities are also found (Satterthwaite, 2020; UN World Urbanization Prospects, 2018).

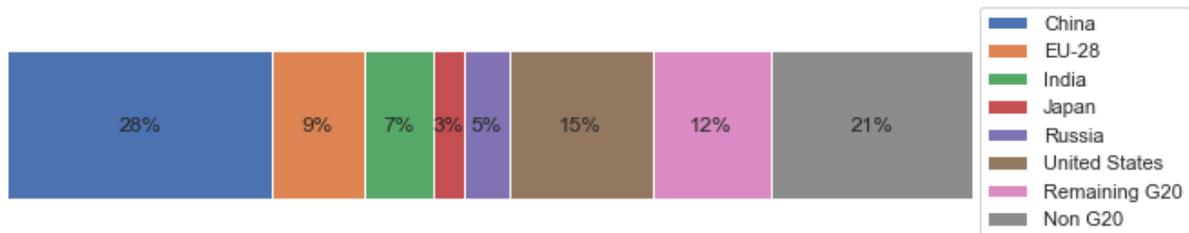
Addressing climate change while enabling sustainable economic growth for a growing and increasingly urban world population will be one of the defining challenges of the twenty-first century. The ongoing economic recession is expected to cause a rise in global extreme poverty for the first time in over 20 years, with an estimated 150 million people being pushed into extreme poverty by 2021 (World Bank, 2020)⁵. If countries fail to address the climate crisis, another estimated 100 million people will fall into poverty by 2030 (Hallegatte *et al.*, 2016). This rapidly urbanising world needs to adapt its infrastructures to reduce the effects of climate change and to deliver prosperity for its citizens. G20 leadership is vital for this.

The G20 economies are responsible for 79% of global CO₂ emissions (see Figure 1). The three largest economies alone – China, the US and the EU – account for over half of global emissions⁶. The decarbonisation of the G20 economies is thus critical for reaching the goals of the Paris Climate Agreement. In the Leaders' Declaration from the 2020 G20 Riyadh Summit, all G20 countries with the exception of the United States reaffirmed their commitment to the full implementation of the Agreement, and US President Biden signed an executive action to re-join the Paris Climate Agreement on his first day in office (G20, 2020a, §33; White House, 2021). Hence, there is now a broad agreement within the G20 about the urgency of addressing climate change.

⁵ Extreme poverty is defined as living on less than \$1.90 per day

⁶ China is the largest emitter of CO₂, with 28% of global emissions, followed by the US (15%) and the EU (9%). In terms of per-capita emissions, Saudi Arabia, Australia and the United States lead the list of emitters among G20 economies. Source: Our World in Data (based on the Global Carbon Project).

Figure 1: Annual CO₂ Emissions by Region



Source: Bruegel representation of Our World in Data for emissions in 2018.

In this report, we look at how the G20 can address one major part of the puzzle: local infrastructure. Approximately 70% of global GHG emissions come from the construction, development and operation of infrastructure in the energy, buildings and transport sectors. Therefore, it is critical that infrastructure investment strategies are underpinned by sustainability considerations. “*Maximizing the positive impact of infrastructure to achieve sustainable growth and development*” is indeed the first of the *G20 Principles for Quality Infrastructure* developed at the 2019 Finance Ministers’ and Central Bank Governors’ Meeting in Fukuoka (G20, 2019). Green infrastructure can reduce local air pollution and GHG emissions, support climate-change adaptation, and contribute to the efficient use of resources (Bhattacharya *et al.*, 2019). Local infrastructure plays a particularly important role in the context of estimates that suggest urban areas are responsible for up to 70% of consumption-based GHG emissions (UN Habitat, 2011).

Building on the *G20 Principles for Quality Infrastructure*, this report investigates the role that different aspects of local infrastructure could play in the decarbonisation of the G20 economies, and develops proposals for a local green infrastructure strategy for the G20. We take into account the global recession caused by the COVID-19 pandemic and our policy recommendations are intended to inform the recovery investment the G20 Finance Ministers and Central Bank Governors committed to in the *G20 Action Plan – Supporting the Global Economy Through the COVID-19 Pandemic* (G20, 2020b, Annex I).

Local authorities build and maintain a large share of infrastructure, for the purpose of serving local communities. Local public transport networks, electricity and energy supply, and water and waste management account for a large share of total infrastructure spending. Increasing the quality of local infrastructure is key to meeting the Sustainable Development Goals in poor communities within the G20, while deteriorating infrastructure that is not well suited to the needs of the modern economy is an impediment to economic growth in industrialised regions.

In light of this challenge, our analysis applies a comprehensive approach to the sustainability of infrastructure following the life-cycle principle regarding environmental costs in the *G20 Principles for Quality Infrastructure* (principle 3.1). Infrastructure affects the carbon footprint of an economy at all three stages of its life cycle: the environmental impacts of the construction of the infrastructure, the emissions generated through its use, and the long-term negative environmental effect of the decommissioning of infrastructure. Additionally, infrastructure has major secondary effects through the type of use it encourages and what existing infrastructure it replaces and complements. Policies aimed at improving the greenness of local infrastructure projects should consider all four aspects. The G20 can play an important role by creating standards and best practices for the assessment of life-cycle costs.

The financing of local infrastructure varies between G20 members and between projects. Local communities have the best understanding of their infrastructure needs but often lack the financial capacity and experience in developing new projects. Sustainable infrastructure should meet local requirements, whilst being financially sustainable. Our recommendations for the G20 local infrastructure strategy will therefore focus on areas where global cooperation between the G20 countries can improve the policy outcomes. This is done with the aim of increasing the efficiency of public infrastructure spending.

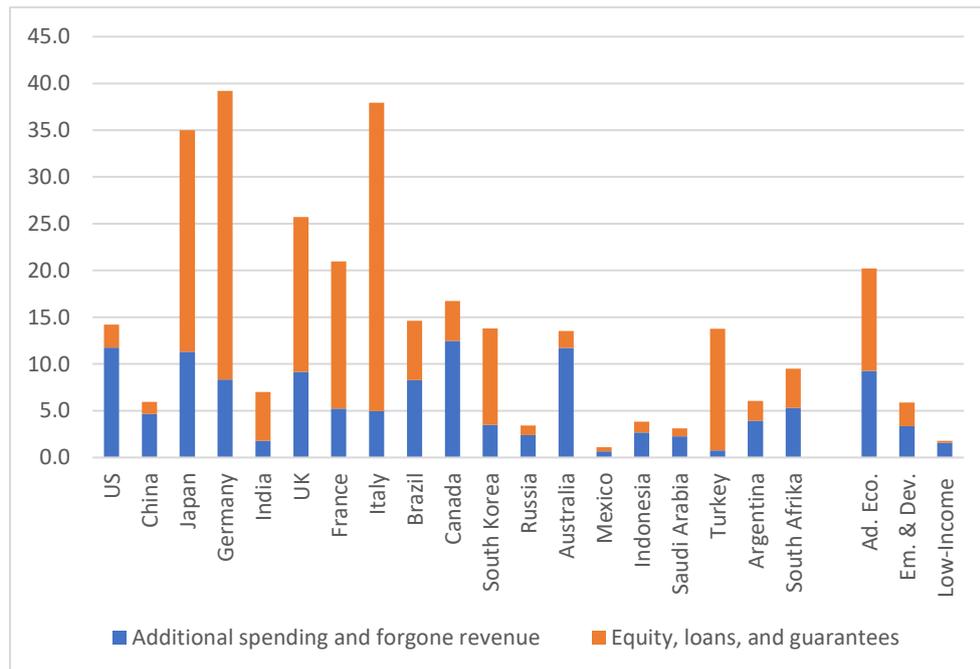
High quality public infrastructure is fundamental for long-term economic growth and productivity (Calderon and Serven, 2014). Under the right conditions, it can boost industrialisation and competitiveness, reduce the costs of connecting people with markets, and improve living conditions while creating job opportunities. These positive economic effects are especially important given the need for economic stimulus created by the COVID-19 pandemic, which we discuss in the next section.

1.1. The COVID-19 crisis and the G20's response

- *Large fiscal stimulus was enacted by developed economies to address the economic fallout of COVID-19, but developing countries had much less fiscal space to support their economies.*
- *Much of the initial stimulus was aimed at preserving existing industries, and as a result had a net negative effect on the environment.*
- *In the recovery phase, fiscal stimulus should be used to address climate change through ecologically sustainable investments.*

The case for a strong investment agenda has become more urgent by the need to address the economic shock caused by COVID-19. The pandemic led to the largest contraction of the world economy since the Second World War. The IMF (2021) estimates that global GDP declined by 3.5% in 2020, more than during the Great Financial Crisis in 2008/2009. While the crisis has been unprecedented, so has been the response. The G20's reaction to the crisis was carved out in its April virtual meeting of Finance Ministers and Central Bank Governors, where the "G20 Action Plan – Supporting the Global Economy Through the COVID-19 Pandemic" was agreed. In this document, the G20 endorsed the importance of economic policy support to businesses and workers and recognised the need to support developing economies through the crisis. In particular in developed economies, there has been massive fiscal support for employees and businesses affected by the economic downturn. According to the IMF (2020b), as of September 2020 fiscal support to businesses and workers in developed economies amounts to around 20% of GDP. This has significantly reduced the impact of the crisis on the economy.

Figure 2: Overview of G20 Fiscal Stimulus as percent of GDP



Source: Discretionary fiscal response as of September 11, 2020, IMF (2020b).

However, there is a substantial gap between high-, middle- and low-income countries. For developing economies and emerging markets, fiscal space is far more limited and as a result, the size of government stimulus packages in developing countries and emerging markets have been far smaller. In emerging markets, fiscal support amounted to approximately 5.5%, and in low-income countries the fiscal stimulus amounted to 1.8% of GDP. As the effect of the economic crisis is more severe in emerging markets and developing countries without significant social safety nets, this development is very worrisome. The IMF warns: “The pandemic will reverse the progress made since the 1990s in reducing global poverty and will increase inequality.” (IMF 2020, page XV).

So far, the most important G20 initiative to address this problem came in the form of debt relief. In April 2020, G20 Finance Ministers and the World Bank’s Development Committee endorsed the DSSI (agreed by the Paris Club) which grants debt service suspension on bilateral loans owed by 73 of the world’s poorest countries in order to enable an effective crisis response. The initiative has been extended by one year, until December 2021, with repayments spread over six years thereafter. However, there has only been limited financial support granted to developing economies through international financial institutions, and more financial support is needed⁷. There should be a strong role for multinational development banks to support developing countries in the G20’s recovery infrastructure agenda.

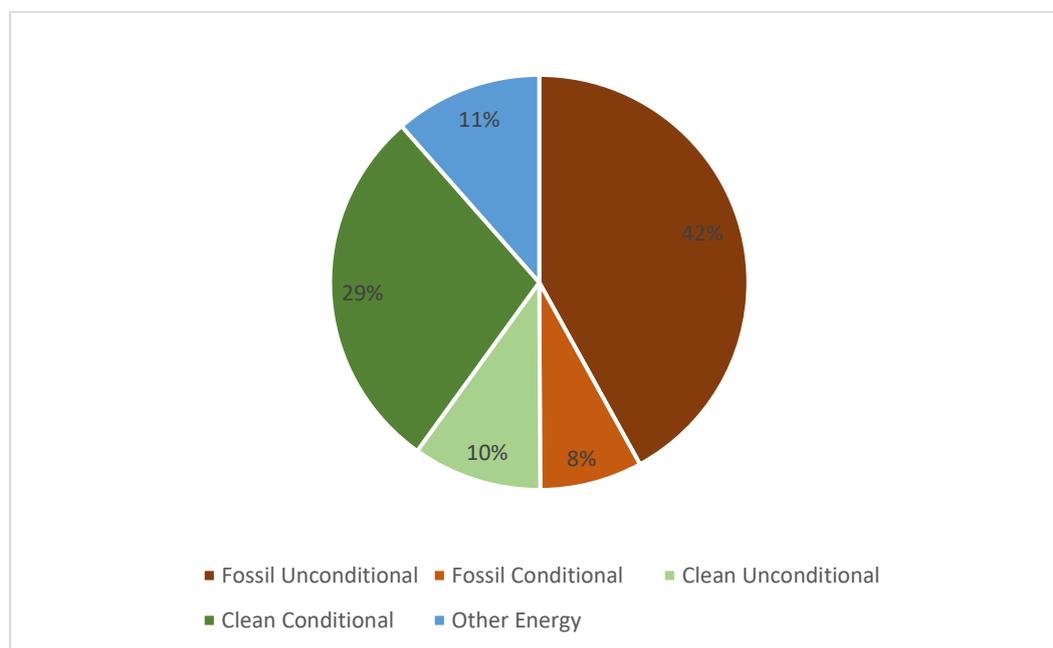
The immediate response to the economic crisis caused by COVID-19 was for governments to protect jobs and existing economic structures and initially little attention was devoted to sustainability issues. As a result, the economic stimulus measures announced by G20 members in response to COVID-19 mostly had a net negative effect on the environment (Vivid Economics, 2020). After the immediate economic shock was contained, and governments began to consider the long-term

⁷ The financial support granted by IFI was around \$ 200 billion, roughly on par with the support during the Global Financial Crisis which affected developing economies only moderately compared to the current recession.

structural growth effect of the stimulus, investments have tended to become more environmentally sustainable (Vivid Economics, 2020).

This becomes particularly clear when considering spending on energy-related investments since COVID-19. Around 73% of global GHG emissions are energy-related, and the majority of sustainably relevant economic stimulus is energy-related⁸. IISD (2020a) provides a breakdown of spending on energy sectors in the recovery packages in the G20 is shown in Figure 3. Governments in G20 countries have committed at least US\$ 485 billion to energy investments. In total, US\$ 242 billion have flown to support fossil fuel energy while only US\$ 187 billion have flown to clean energy. Most worryingly, over US\$200 billion has been unconditional support for fossil fuel energy.

Figure 3: G20 Public Commitments to Energy Stimulus: Fossil Fuel, Clean and other



Source: IISD (2020a) accessed on: 05/02/2021⁹.

Table 1 provides an overview of some of the largest energy-related investments that G20 countries have made between March 2020 and February 2021. Analysis of the complete list of energy-related investments shows that bailouts of aviation companies have been commonplace (IISD, 2020a). A focus on energy efficiency is noted, as well as general investments into the power sector, and support for railways.

⁸ Energy-related emissions are to be understood as emissions derived from the purposeful transformation or use of energy. The notable sectors are electricity production, transport, and buildings.

⁹ The reference is a collaborative effort to compile data from predominantly government sources. Fossil Unconditional refers to policies that support the production and consumption of fossil fuels without any climate targets or additional pollution reduction requirements. Fossil conditional includes such requirements. Clean unconditional spending supports production and consumption of energy that is both low carbon and has negligible effects on the environment. Clean conditional energy intends to support the transition away from fossil fuels, but the effect on the environment is unclear.

Table 1: Recent major energy-related investments in the G20

Policy	Value Committed (USD billions)	Country
Aviation industry bailout	58 billion	USA
Road building and repair	35 billion	UK
Fund for carbon-neutral technology development	19 billion	Japan
National railway deployment	14 billion	China
Electricity price subsidies	13 billion	Germany
Liquidity boost for power distribution companies	12 billion	India

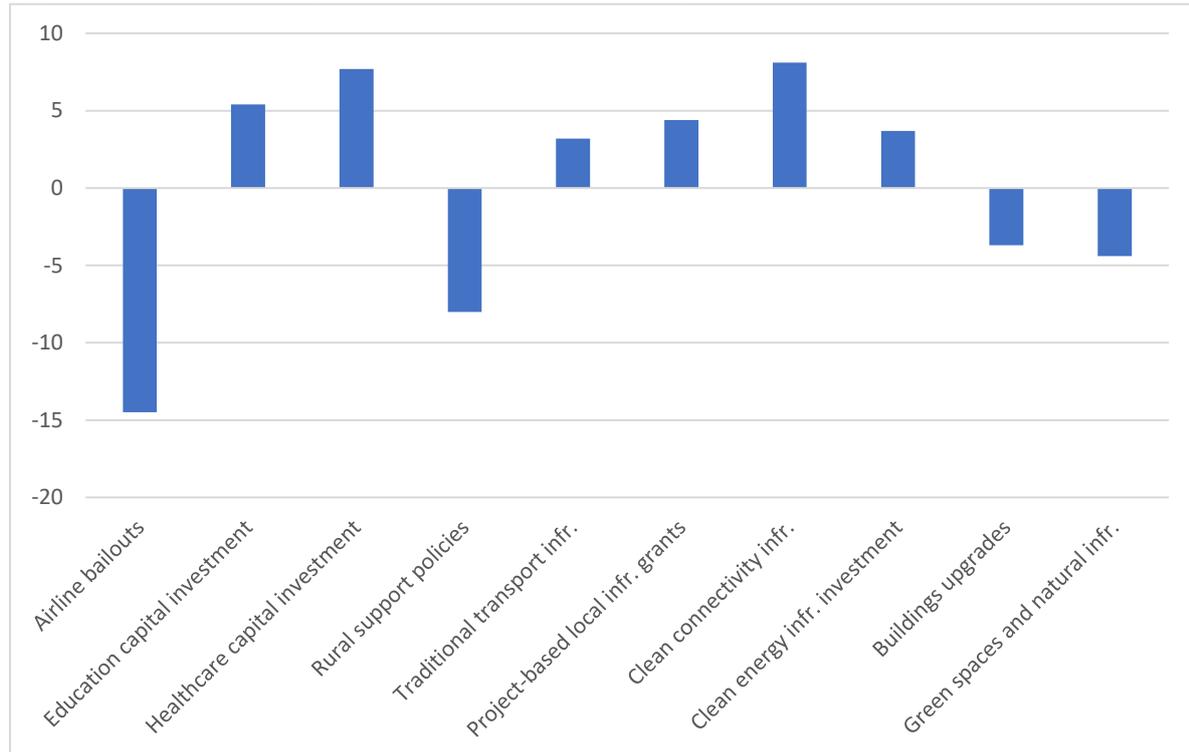
Source: IISD (2020a) accessed on 05/02/2021.

Moving forward, there should be a considerable shift towards sustainable long-term investments in the stimulus and recovery packages. A positive example of such ambitions is the Next Generation EU recovery fund. The Next Generation EU (EUR 750 billion) package comprises EUR 390 billion in grants and EUR 360 billion in loans to support member states. Of this, 30% is committed to ‘fighting climate change’ (European Commission 2021). Under the auspices of the Green Deal, a variety of strategies are being put forward, from hydrogen to biodiversity to agricultural, which provide guidelines for how this ‘green’ money is to be spent.

As fiscal support shifts from emergency liquidity relief towards more structural fiscal stimulus, ambitious global investment programmes should be pursued, and they must be sustainable. As IMF (2020b, chapter 2) argues, investment in the recovery phase will play an important role in ensuring that global economic growth recovers. The case for green infrastructure investment is furthered by survey-based estimates of fiscal multipliers by Hepburn *et al.* (2020)¹⁰. The study provides estimates associated with different kinds of economic recovery policies in the context of the COVID-19 crisis. Airline bailouts, chosen by many G20 countries, are associated with a very low multiplier by respondents. Meanwhile, clean connectivity infrastructure has a larger multiplier than traditional transport infrastructure.

¹⁰ The results are from a survey of 231 finance ministry officials, central bank officials, and other economists, representing 53 countries including all G20 nations. Respondents were asked to assess the fiscal multiplier of each policy in a relative and subjective manner using 100-point sliding scale. Respondents were not homogenous in their use of the sliding point scale and therefore respondents scores were re-based so that the y-axis now records a zero-mean, zero-sum score, i.e. comparable.

Figure 4: COVID Recovery Policies: Relative Fiscal Multipliers



Source: Hepburn et al. (2020)

While research on the employment effects of green infrastructure spending is still inconclusive, most studies point to a neutral or positive effect. Most of the available literature finds that investing in low carbon infrastructure is unlikely to lead to lower levels of job creation than investing in fossil fuel infrastructure (Blyth et al., 2014). Moreover, by tailoring policies to country-specific characteristics, it appears likely that renewable energy projects can lead to a net increase in employment. Meyer and Sommer (2014) and Fragkos and Paroussos (2018) both find larger domestic job creation when compared to fossil fuels¹¹. As with all infrastructure projects, job creation will be particularly large while economies are still experiencing output gaps in the wake of the COVID-19 economic crisis.

2. Scale of the Challenge: Infrastructure Gap

- *Even before the pandemic, a large sustainable infrastructure gap persisted. To reach sustainability goals, annual infrastructure spending in the scale of US\$ 7 to 8 trillion is needed, a gap of 2.1% of GDP.*
- *Local infrastructure in urban areas accounts for 70% of the green infrastructure needed by 2030.*
- *Green infrastructure investment is expected to have a positive fiscal multiplier, especially in the recovery phase after the pandemic has come under control.*

¹¹ Ram et al. (2020) investigates the global job effects in a scenario where accelerated renewable deployment sees the world transitioning to 100% renewable electricity by 2050. Their estimates are such that a scenario would see direct jobs associated with the electricity sector increasing from 21 million in 2015 to nearly 35 million by 2050. Solar PV, wind power, and batteries are the main job creators. On the other hand, a more recent study by Aldieri et al. (2019) assessing literature from 2000-2019 finds that job creation connected to wind power installations is rather limited.

Global infrastructure needs are rising. In order to meet increasing demand from a growing population, accelerating urbanization and technological progress the world will need to invest more than \$90 trillion in infrastructure between 2016 and 2030¹². This is more than the entire existing global infrastructure stock (New Climate Economy, 2016). Bhattacharya *et al.* (2019) estimates that 70% of the infrastructure required by 2050 is yet to be built. This “infrastructure gap” is particularly acute in urban areas. CCFLA (2015) estimates that 70% of the green infrastructure needed by 2030 is to be built in urban areas. Only half of the \$4.5 to \$5.4 trillion annual investment need for low-carbon urban development is currently met (CCFLA, 2015). Many cities in emerging markets and developing countries lack basic water and waste management, reliable transport infrastructure and access to electricity and heating. This includes many citizens of the G20 member states themselves and even in the richest G20 members some poor communities lack access to clean water and public sewerage (Alston, 2018).

Importantly, the type of infrastructure investments that are undertaken in the next few years will lock in technologies for decades to come. Decisions taken now are critical to ensure the world is on path towards a low-carbon and climate resilient future. Infrastructure investment in high- and middle-income regions will need to focus on upgrading and greening existing systems. Low-income economies need to create new infrastructure networks that are sustainable and adaptable to climate, economic and demographic changes, while at the same time providing much needed access to basic services for their citizens. There is the opportunity for them to leap-frog the networks built around carbon-intensive energy production in developed economies. Priority should therefore be given to improving local infrastructure with low-emission technology.

Global annual investment into core infrastructure needed to fulfil expected demand by 2030 is estimated to lie between \$6.3 and \$6.8 trillion annually (Bhattacharya *et al.* 2019; OECD 2017). Core infrastructure includes power generation and distribution, transport, water and sanitation systems and telecommunications. The additional costs of aligning these investments with the Paris goal of limiting global warming to well below 2°C are estimated to lie between \$0.6 trillion and \$1.1 trillion (see Table 2). These additional costs are likely to be offset by reduced expenses for fossil fuels, as well as lower lifecycle costs of sustainable infrastructure in general (OECD 2017).

Table 2: Annual Infrastructure Investment Gap

	OECD	Bhattacharya
	2015 USD trillion	
Energy	2.7	3.9
Transport	2.7	2.0
Water and Sanitation	0.9	0.9
Telecoms	0.6	1.0
Total	6.9	7.9

Source: Bruegel replication of table 1 from Bhattacharya *et al.* (2019)

Most of the investment is needed for energy and transport infrastructure – according to Bhattacharya (2019) US\$ 3.9 trillion and US\$ 2 trillion respectively. Compared to the business-as-usual-scenario, sustainable infrastructure investment will have to shift away from primary energy sources, such as oil, gas and coal, and towards energy efficiency and low-carbon core infrastructure¹³

¹² This estimate by New Climate Economy (2016) includes investments in urban, transport, waste, water, telecommunications and energy infrastructure systems, but excludes investments in natural infrastructure.

¹³ Energy efficiency: in buildings, energy and transportation; low-carbon core infrastructure: renewable energy, nuclear, low-carbon transport, climate-proof water and sanitation, adaptation infrastructure

(NCE 2016). Currently, sustainable infrastructure investments are falling short of the target by US\$ 3.2 trillion per year, or 2.1% of global GDP (Bhattacharya *et al.*, 2019). Local infrastructure will play a key role in this shift, as we will discuss in the next chapter.

Existing foundations for future measures: History of Infrastructure on the G20 Agenda

The Italian G20 Presidency's focus on local sustainable infrastructure continues a decade-long history of infrastructure on the G20's agenda. Future action can build on the foundation of previous initiatives and principles, and leverage existing capacities.

Infrastructure first appeared on the G20's agenda during the 2010 Korean Presidency, when the G20 formally recognised the importance of infrastructure for economic growth (G20, 2010) and outlined concrete measures in a Multi-Year Action plan aimed to address bottlenecks in infrastructure provision in low-income countries. Furthermore, the G20 created a High-Level panel on Infrastructure to mobilise support for scaling up infrastructure financing and tasked MDBs with developing an action plan to increase infrastructure financing and improve project implementation.

The panel's report and the MDBs' action plan were presented and endorsed by the G20 at the 2011 Cannes summit (G20, 2011). Recommendations included creating an enabling investment environment in low-income countries through legal and regulatory reforms, promoting capacities for bankable projects, mitigating risks to increase the availability of long-term funding and expanding the role of MDBs in infrastructure financing. Further measures along these recommendations were concluded at the 2012 Summit in Los Cabos, under the Mexican Presidency.

The 2013 Russia Presidency focused on the role of long-term financing in infrastructure development and took action to attract such investment in the G20. The St. Petersburg Summit endorsed the working plan prepared by the G20 Study Group on Financing for Investment, and the G20/OECD High-Level Principles of Long-Term Investment Financing by Institutional Investors (G20, 2013), and agreed on the implementation of a set of collective and country-specific actions.

During the Australian Presidency in 2014, infrastructure became a G20 priority through the endorsement of the Global Infrastructure Initiative (GII), a multi-year programme to promote quality public and private infrastructure investment. The Group identified guidelines to identify, prioritise, plan and deliver infrastructure projects and established the Global Infrastructure Hub (GIH), a non-profit organization to support the G20 in the implementation of the GII and future infrastructure programmes. As part of this initiative, the World Bank launched the Global Infrastructure Facility (GIF), a global platform that supports the identification, high-quality preparation, financial structuring and procurement of infrastructure projects in emerging markets and developing economies to enable private investment. The private sector was identified as a main stakeholder in mobilising investment in infrastructure (G20, 2014).

Private sector involvement remained the focus of the G20's infrastructure strategy in 2015. The 2015 Antalya Summit developed guidelines and best practices for public-private-partnership (PPP) models as well as country-specific investment strategies to improve the investment ecosystem and foster long-term infrastructure investment. The G20 further worked on toolkits to support countries better prepare, prioritise and finance infrastructure projects (G20, 2015).

During the Chinese Presidency in 2016, emphasis is placed on quality infrastructure investment and the role of MDBs within the infrastructure agenda. Quality infrastructure investment aims to ensure economic efficiency in view of life-cycle cost, safety, resilience against natural disaster, job creation, capacity building, and transfer of expertise and know-how on mutually agreed terms and conditions,

while addressing social and environmental impacts and aligning with economic and development strategies (G20, 2016a). The 2016 Hangzhou Summit encouraged the MDBs to scale up infrastructure investment, attract private finance and strengthen project pipelines through better project preparation (G20, 2016b). Finally, the G20 recognised the importance of infrastructure connectivity, meaning the linkages of communities, economies, and nations through transport, communications, energy, and water networks, for achieving sustainable development and shared prosperity. To this end, it endorsed the Global Infrastructure Connectivity Alliance (GICA), which aims to enhance the synergy and cooperation among various infrastructure connectivity programs in a holistic way.

The 2018 Buenos Aires Summit once again focused on infrastructure for development and members reaffirmed their commitment to attract more private capital to fill the infrastructure investment gap (G20, 2018). To achieve this, the G20 endorsed the Roadmap to Infrastructure as an Asset Class and the G20 Principles for the Infrastructure Project Preparation, and committed to take actions towards greater contractual standardization, reducing data gaps and improving risk mitigation instruments.

At the 2019 Osaka Summit, the G20 established the G20 Principles on Quality Infrastructure as a common strategic direction. Building on the G7 Ise-Shima Principles of Quality Infrastructure, quality infrastructure investment should aim to maximise the impact of infrastructure on sustainable growth and development, raise economic efficiency in view of life-cycle cost, integrate environmental and social considerations, contribute to building resilience against natural disasters and other risks and strengthen infrastructure governance (G20, 2019).

Finally, under the Saudi Arabian Presidency, the G20 endorsed the Riyadh InfraTech Agenda, which provides policy guidance to governments' and international organizations' infrastructure technology strategy. Infrastructure technology refers to the integration of material, machine and digital technologies across the infrastructure lifecycle, including in the design, planning, delivery and in the structures themselves. The Agenda, endorsed at the 2020 Riyadh Summit, aims to harness technology to deliver quality infrastructure investment, promote inclusive, accessible, sustainable, and affordable infrastructure in view of lifecycle costs, mobilise private-sector financing and support the development of infrastructure as an asset class (G20, 2020c).

3. Sustainable local infrastructure

The roll-out of low carbon infrastructure within cities must be at the core of any sustainable development strategy. G20 countries should avoid building new infrastructure that will become obsolete due to its incompatibility with future sustainability goals and needs (“stranded assets”). Without sensible and sustainable infrastructure investment, climate targets will be unattainable.

At the same time, global temperatures are already 1 degree Celsius above pre-industrial times and certain effects of climate change are inevitable. Infrastructure planning must therefore consider not only mitigation of further GHG emissions but also adaptation to a changing environment.

At least 55% of the global population are already living in infrastructure-dense urban areas (cities)¹⁴. Therefore, the roll-out of sustainable infrastructure, both to mitigate emissions and to adapt to a changing climate, will be highly relevant for local communities.

Countries and cities across the G20 differ in their climate, income, urban form and levels of industrial activity. There exists therefore a wide variation in the type of low carbon infrastructure that different cities could use to reduce emissions (Kennedy *et al.*, 2014). For example, colder cities will focus on building construction and renovation for maintaining heat, while warmer cities will focus on urban design to avoid retaining heat, or reducing building exposure to heat in the first place. This report therefore identifies some general themes for low carbon infrastructure.

In the following section we will focus on several areas of local infrastructure investment that are key for reaching these goals: shifting to a zero-carbon electricity (power) sector, energy-efficient buildings, zero-emission mobility, digital infrastructure, water and waste management, as well as low-carbon construction materials. These areas are selected to cover those proposed for sustainable infrastructure by Bhattacharya *et al.* (2019) as well as due to their high contribution to global GHG emissions. Together, the sectors under focus account for over 40% of global GHG emissions¹⁵.

3.1. Electricity Sector

- *Stopping the deployment of new coal-fired power plants should be a priority for infrastructure investment. A significant co-benefit will be improved local air quality.*
- *Renewable electricity generation can be deployed in a decentralised manner allowing for local production, storage and usage of electricity, increasing benefits for local economies. This leads to both economic and health benefits.*
- *G20 infrastructure investment strategies in the electricity sector should focus upon enabling investments which incentivise further private investment.*

3.1.1. Electricity generation

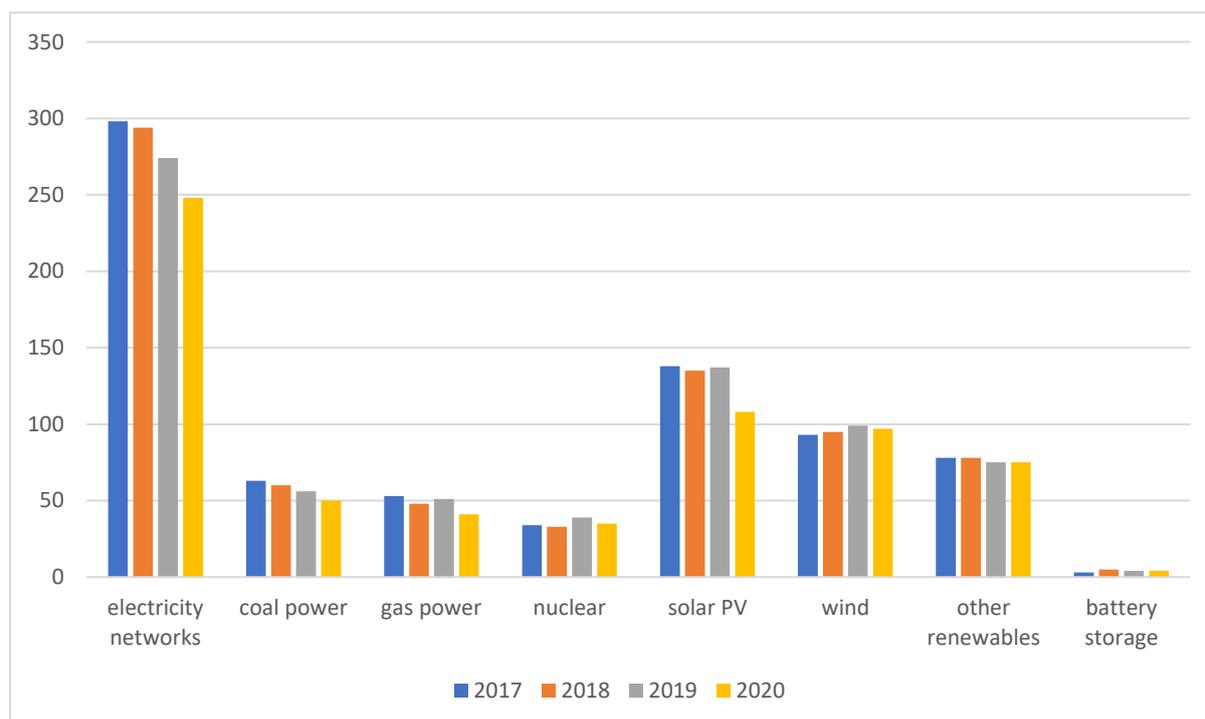
Securing a reliable supply of decarbonised electricity is a fundamental building block for all G20 economies to comply with the goals of the Paris Agreement. GHG emissions from electricity (power) generation accounted for 38% of total energy-related emissions in 2018 (IEA, 2019). Moreover, the decarbonisation of many different end use sectors that currently rely upon alternative fuels, lies in electrification. For example, electrification is seen as key for the decarbonisation of both the road transport and household heating sectors.

¹⁵ Energy use in buildings (17.5%), road transport (11.9%), waste (3.2%), and iron, steel and cement (10.2%) (Our World in Data).

Over the past few years' investment has been significantly larger in solar and wind power compared to coal or gas power, showing that the global power market is already moving in the right direction – albeit at too slow a pace¹⁶. As Figure 5 shows, solar photovoltaic (PV) was the electricity sector technology with the largest annual investment in 2019, with around US\$ 140 billion a year. The investment into solar PV is in fact larger than gas and coal power combined. For projects with low-cost financing which use high quality resources, solar PV is already today the cheapest electricity source in history (IEA, 2020a), and these costs are forecasted to continue decreasing.

In spite of the aggregate global shift toward solar PV, global coal-fired power capacity is set to increase further as certain countries continue to expand their coal-based energy production. A 2019 report shows that G20 economies still provide at least \$48 billion per year to support coal-fired power generation (Gençsü et al., 2019). G20 economies must urgently phase out government support to coal-fired power generation both home and abroad. Higher costs of financing further impede the deployment of renewable power plants which are capital intensive relative to their fossil fuel counterparts. Many of the areas where coal-fired power plants are still being constructed are in developing regions, where access to low-cost finance for the deployment of renewable power can be challenging. A priority for the G20 should be ensuring the access to cheap capital for the deployment of renewable power generation across the world.

Figure 5: Global Investment in the Power Sector by Technology, 2017-2020



Source: Bruegel on IEA (2020a).

Replacing existing coal-fired power plants with low carbon power generation is more difficult than not building them in the first place. Once built, vested interests, incumbents, political opportunism and incumbent employment all create difficulties to shut down a coal-fired power plant. Economically, an already built coal plant is also more competitive when compared with newly built low carbon power. While best avoiding new coal power plant deployment, G20 countries invested

¹⁶ The IEA has recently declared solar the King of electricity markets.

into coal must also begin to plan for the equitable phaseout ('just transition') from coal power generation.

3.1.2. Local and smarter electricity grids

The shift from fossil fuel to renewable power generation holds a significant side-effect which is the shift toward democratisation of energy. Over the past 15 years, a variety of schemes in G20 countries, particularly in Europe, have incentivised consumers to purchase their own solar panels¹⁷. This helped create a worldwide market for household solar PV. Households who invest in their own electricity generation can enjoy significant economic savings on energy bills.

Community schemes which allow groups of households to invest together into small solar or wind plants have also grown in number. Such schemes have the benefit of allowing many households within a community to come together and act as a larger economic agent, investing into larger clean power plants and sharing the economic and energy benefits. The costs are also likely to be lower on average than single household PV (Lazard, 2020). This distributed power generation has the important co-benefits of democratising energy, empowering citizens to feel a part of the energy transition, and potentially positive network spill over effects whereby neighbours adopt solar panels.

Household- or community- level deployment of renewable electricity generation involves private investment into infrastructure which provides a public good, namely the mitigation of GHG emissions, and perhaps more importantly for a local community, the mitigation of local air pollutants that are harmful to human health. Schemes to encourage the growth of such private agent behaviour are attractive options.

Local authorities might consider further subsidy schemes or feed-in tariffs to accelerate the adoption of household solar PV. However, this is an expensive (and regressive) policy and the price of solar PV has already been driven significantly down. A more sensible approach would involve the redesign of electricity markets to allow households to receive fair compensation for the electricity they provide to the grid. An example of this would be the trade of electricity between households at a local level¹⁸, another example is mechanisms designed to encourage flexible household electricity demand depending on current market conditions¹⁹. Such a market mechanism, if well-designed, should incentivise private investment into local renewable power generation, with the important co-benefit of creating a local, shared community spirit of renewable energy.

Moreover, in many developing economies, grid infrastructure has not yet been built to reach all of the population. Here, decentralised renewable electricity generation is an attractive option for providing much-needed electricity to households and communities in rural or other areas without main grid connections.

3.1.3. Enabling Infrastructure Investment

In addition to facilitating the shift in investment toward low carbon power generation, an equally important challenge for G20 countries lies in future-proofing the electricity grids of today. Significant investments are required to upgrade grids for the challenges they will face. These arise both on the supply and demand side.

On the supply side, the challenge will be to successfully incorporate increasing shares of intermittent renewable electricity generation. Grids have traditionally comprised a few central generation units

¹⁷ For example, in the UK (<https://www.ofgem.gov.uk/environmental-programmes/fit/fit-tariff-rates>).

¹⁸ An example can be found in Brooklyn, New York (<https://www.brooklyn.energy/>).

¹⁹ An example can be found in California (<https://www.ohmconnect.com/about-us/news/resi-station>)

which ramp production up and down to distribute power to multiple homogenous end users. The drop in the costs of solar PV has changed this dynamic. It is now possible for households or firms to purchase solar panels, place them on their roof and generate their own electricity. The electricity grid is being forced to adapt toward a situation in which power is being fed into the grid from an ever-growing number of sources, with non-constant supply.

On the demand side, in countries that pursue electrification of non-traditionally electrically-powered sectors, there will be additional strains placed on power grids. This is particularly relevant with the electrification of transport: the charging of large fleets of electric vehicles will put substantial new loads on electricity grids.

Sensible infrastructure projects should prepare electricity grids for this twin challenge. Grids must be reinforced and strengthened in particular areas, whilst the implementation of digital technologies will facilitate smarter grids which are better able to balance fluctuating supply and demand.

The ability of demand response, i.e., rapidly adjusting power demand to accommodate shifts in supply, is one of the most commonly discussed options for integrating higher shares of renewables into power grids. Rapid fluctuations in demand will only be possible with sophisticated digital infrastructure. The roll-out of smart meters, allowing for accurate monitoring of electricity demand on a minute-by-minute basis is an important precursor to a flexible demand-side. Smart charging of electric vehicles, altering demand to match supply, is also an important overlap into mobility infrastructure. This may further include vehicle-to-grid technologies, whereby plugged-in electric vehicles are able to supply electricity to the grid at times of high demand, effectively acting as a large battery for managing grid fluctuations.

Further incentives to develop solutions for the intermittency of renewables will be required. A commonly discussed option is batteries. Figure 5 shows that in comparison with traditional power generation, investments into battery storage technology are still relatively small. Batteries and similar technologies for accommodating renewable power generation will become increasingly imperative infrastructure investments over the coming years.

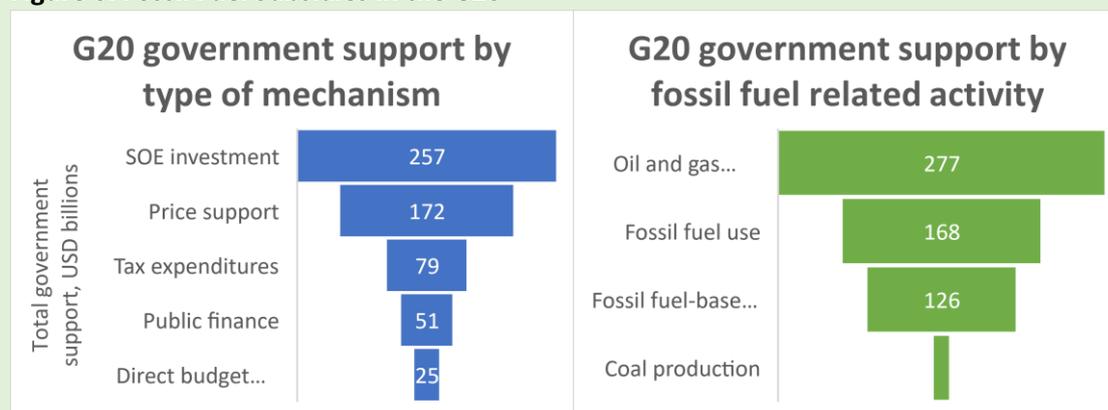
Cities must evolve to become smarter producers and consumers of renewable electricity. Doing so requires significant upfront infrastructure investments. The size of infrastructure investments required in electricity grids is extremely large. G20 countries should therefore focus their strategy upon *enabling investments* which hold a high investment multiplier – their provision and expansion will attract private capital investment into other sections of the grid.

Fossil Fuel Subsidies

Within G20 countries, fossil fuel subsidies are a problem much broader than coal-fired power generation. A failure to shift away from these subsidies undermines commitments to sustainability goals whether they be under infrastructure or not. G20 leaders have recognised this fact and repeatedly pledged to remove fossil fuel support. However, G20 governments provided \$584 billion annually to the production and consumption of fossil fuels at home and abroad (2017-2019 average) (IISD, 2020b). This is down 9% from 2014-2016 values. On aggregate, G20 countries have doubled down on support to fossil fuel industries in response to the COVID-19 pandemic.

IISD (2020b) helpfully distinguish five different forms of government support for fossil fuels. These include direct budget transfers (through spending on R&D fossil fuel exploration, for example), tax expenditures (such as tax breaks), price support (artificially lowering the market price for fossil fuels), public finance (loans and guarantees) and state-owned enterprise investments. The breakdown of both type of mechanism, as well as by fossil fuel related activity is shown in Figure. The majority of support for fossil fuels came through price support and State Owned Enterprises (SOEs) investments and most of it went to oil and gas production.

Figure 6: Fossil Fuel Subsidies in the G20



Source: IISD (2020b).

While not all of these support measures would technically fall under the definition of a subsidy by the World Trade Agreement on Subsidies and Countervailing Measures agreement, direct budget transfers, price support and tax expenditures do. Under this definition, around \$280 billion annually is used by G20 economies to artificially support the competitiveness of fossil fuels. Simply removing these economically inefficient subsidies would have significant environmental benefits, as well as sending a powerful signal to markets. Other forms of subsidies such as SOEs may be more difficult to address, but should still be high on the agenda for any G20 nation looking toward a sustainable infrastructure agenda. Efforts by central government to remove inefficient subsidies will make it easier for local governments to pursue a sustainable infrastructure agenda.

3.2. Buildings and Climate Resilience

- Buildings are an inherently local infrastructure responsible for significant GHG emissions. While for many G20 countries, the challenge lies in redesigning buildings to lower levels of GHG emissions, developing countries are focussed on building new stock.
- For G20 countries, energy efficiency infrastructure should be deployed which is able to reduce the energy consumption of residential and commercial buildings. Construction and renovation are a

labour-intensive process and well suited for government spending with the intention of job creation.

- *Concentrations of GHGs in the earth's atmosphere already guarantee a rapidly changing climate. The effects of this can be highly adverse, and infrastructure planning, particularly for buildings, should consider the increased risk of adverse climate events.*

Buildings are an inherently local infrastructure, clearly affecting the communities which live, sleep and work within them. Buildings are also responsible for a large share of GHG emissions. For many G20 countries, the challenge lies in redesigning buildings to reduce their emissions, while for developing economies, with expanding populations and cities, the challenge is to build in a sustainable manner to begin with. At the same time, countries around the world must recognise the fact of a changing climate and the need for buildings to adapt to this.

3.2.1. Reducing GHG emissions from buildings

Energy usage in buildings today accounts for 18% of global GHG emissions (Our World in Data). Reducing energy demand from residential and commercial buildings is a priority area for green public investment. Energy efficiency measures can greatly reduce building energy demand for cooking, space and water heating and cooling, as well as for electrical appliances. While certain efficiency gains are likely to be driven by public policy and regulation, there is an important role for low-carbon infrastructure. Namely, the renovation of existing buildings to higher standards of energy efficiency through measures such as replacing loft/wall insulation and replacing windows with double glazing. Estimates by the Coalition for Urban Transitions (2019) show that building heating and cooling efficiency could lead to global abatement of 1.44 Gt CO₂ from urban environment by 2050.

The renovation of buildings toward higher energy efficiency standards is a highly labour-intensive task. Roll-outs of renovation infrastructure programmes therefore appear timely as governments respond to the fallout from the COVID-19 economic crisis, particularly looking for investments with high returns in terms of jobs created per dollar spent.

Beyond energy efficiency, fossil fuels are still the largest global source for household heating. There are a variety of options for decarbonising household heating, but G20 countries today should begin sending clear market signals that the future of household heating will be through a non-carbon route. Infrastructure investments must begin here today if they are to be scaled in time to meet Paris Agreement commitments.

3.2.2. Preventing emission lock in for developing economies

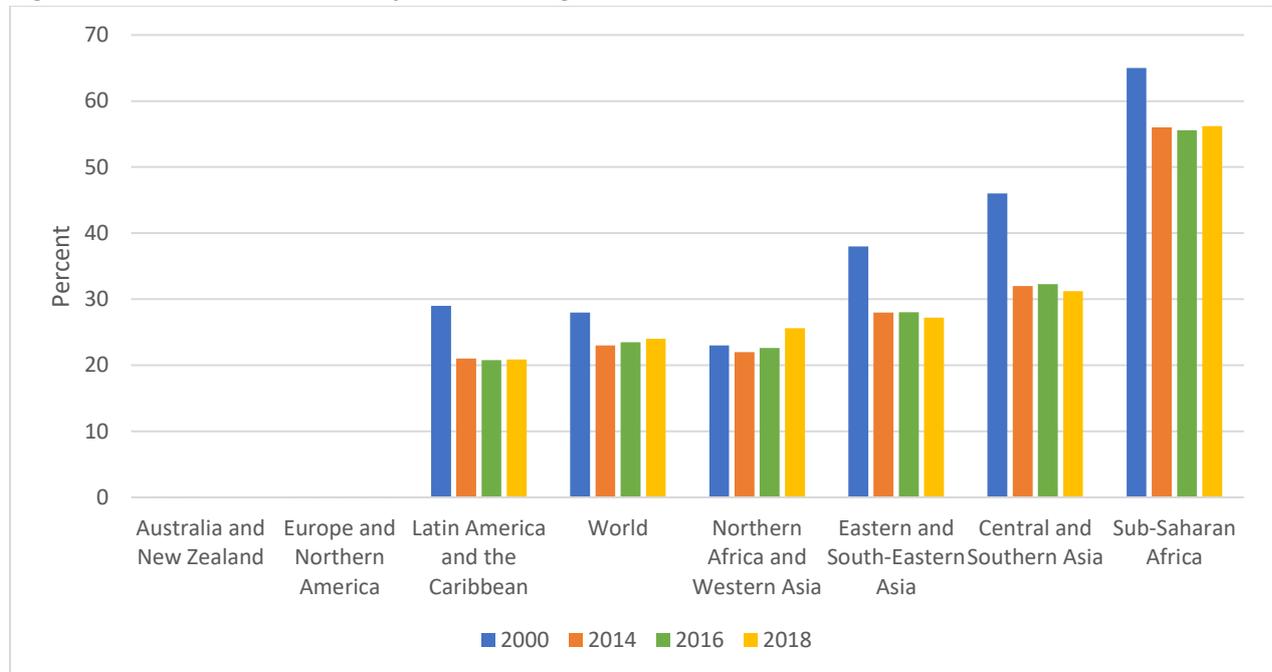
In many parts of the world, the construction of urban housing has not kept pace with population growth and internal migration towards cities. From a GHG perspective, developing countries face a different situation whereby the challenge lies more in rolling-out new sustainable housing rather than retrofitting existing housing to be sustainable.

For example, in sub-Saharan Africa, 55% of the population still live in slums (Figure 7). To achieve the Sustainable Development Goals, a clear first step is building housing which provides the necessary basic amenities for healthy living: clean water, clean cooking facilities, clean heating/cooling equipment, clean lighting. Careful planning is also necessary for facilitating rapid migration into cities to avoid issues such as population build-up in areas vulnerable to hydro-geological hazards, or expansion of cities with a lack of green spaces.

In the context of developing economies, the design of buildings that are low in GHG-emissions is just one among many (at least locally more) urgent considerations. Developed economies have more

capacity to place GHG-considerations higher up the policy agenda when considering the roll-out of new urban infrastructure. There is therefore a risk that developing countries will underinvest into the required steps for low GHG emission buildings, instead building out large new cities that will become responsible for growing shares of the global GHG emissions. Here, there is a role for the G20 to play in providing financial means to encourage the build out of sustainable infrastructure in developing economies from the beginning.

Figure 7: Share of the Urban Population Living in Slums



Source: Bruegel based on United Nations Global SDG Database.

3.2.3. Building sensibly for a changing climate

Mitigation of future greenhouse gas emissions must be central to the debate on sustainable infrastructure. Unfortunately, the existing concentration of GHG emissions in the atmosphere is sufficient to cause adverse climate related events.

Substantial investments will be required to create sustainable and resilient cities and support adaptation to climate change. The UCCRN Technical Report (2018) offers an exploratory analysis on the likely magnitude of these adverse events including heat extremes, water availability, food security and sea level rise. The report is focussed upon adverse climate effects within cities. One key finding is that by 2050, over 1.6 billion people, living in more than 970 cities, will face extreme heat of over 35 degrees Celsius for 3 consecutive months. At the same time, over 800 million people, from 570 coastal cities, will be at risk of flooding due to at least 0.5 metres of sea level rise. Declines in the national yields of major crops, and a decrease in the availability of freshwater will also affect millions of G20 citizens.

Different cities will face different challenges in adapting to climate change. The common theme is that urban planning and infrastructure deployment must be always evaluated against the likely climate change impacts of the area over the coming decades. There is a growing scientific literature offering evidence and advice on this.

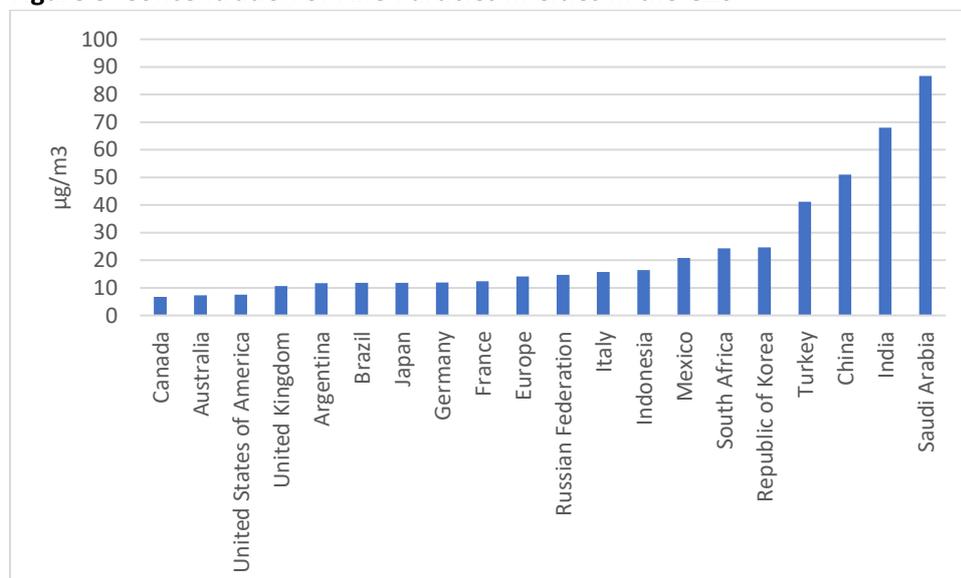
3.3. Mobility

- A shift away from the internal combustion engine is necessary.
- Transitions may occur toward cleaner vehicles or more systematic solutions would see a modal shift away from private road transport and toward walking, cycling, and public transport.
- Through either route, infrastructure requirements are large.

Mobility within cities must change significantly in order to meet goals of the Paris Agreement. A modal shift away from the dominant combination of private and polluting vehicles will be required. Different routes may be taken to achieve this. A technological route sees little consumer change as internal combustion engine automobiles are replaced with electric and other low-carbon vehicles. Other routes may see more significant shifts in consumer behaviours, with increased acceptance of public transport and walking/cycling in place of private automobile journeys.

Regardless of the route taken by individual cities, infrastructure will be key. For example, under scenarios with little behavioural change, an accelerated roll-out of electric charging infrastructure will be required to allow the transformation of most of the global vehicle fleet away from the internal combustion engine and toward electric vehicles by 2050.

Figure 8: Concentration of Fine Particles in Cities in the G20



Note: the figure shows mean annual concentration of fine suspended particles, where the mean is a population-weighted average for urban population in a country. Source: UN Global SDG Database, for 2016.

Alternative strategies with increased behavioural change will require investments into public transport and walking/cycling infrastructure. In particular, investments into city and walking/cycling infrastructure are low in most countries. Increasing the share of citizens travelling by foot or bike reduces GHG emissions, and has alternative co-benefits of exercise leading to a healthier population, reduced air pollution, and reduced noise pollution, see Figure 8.

Public transport infrastructure in most parts of the world needs to be significantly improved such that it more efficiently competes with the automobile for a door-to-door journey²⁰. This is a problem as many cities still lack effective schemes for integrating long and short distance transport means. A modal shift from road to rail will also require investment into high-speed rail. Improving rail connections has been shown to increase demand. For example, when China connected the isolated

²⁰ The absolute time taken to get from departing point to destination point.

Zhengzhou-Xi line, in 2012, to the Beijing High Speed Rail network, passenger volume increased by 43% (Lawrence *et al.*, 2019).

The adoption of multi-modal solutions to effectively integrate the 'last mile' within public transport networks requires systems innovation and infrastructure. For example, in 2015 the Metropolitan Atlanta Rapid Transit Authority (MARTA) announced a partnership with Uber whereby MARTA public transport users can directly link to Uber from the app and request an uber which will be waiting when the passenger arrives. Such "smart city" solutions to transport require adequate telecommunication networks. In the next section we will look at such digital infrastructure.

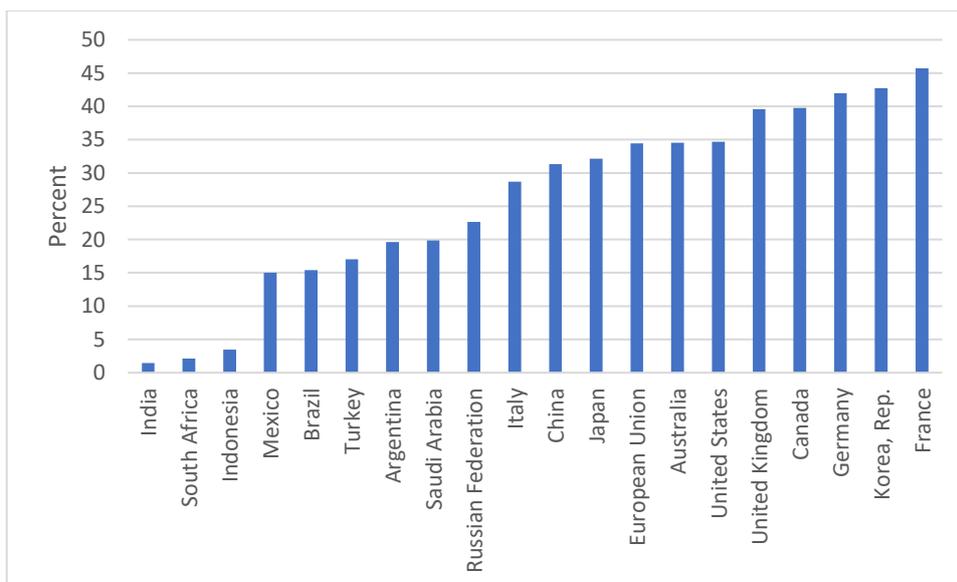
3.4. Digital Infrastructure

- *Digital infrastructure is key for achieving SDGs.*
- *Access to high-speed internet is an important prerequisite for the effective integration of firms and workers into the global economy, and increasingly for citizens into local communities.*

An increasingly important part of connecting local communities with the global economy is digital connectiveness. Investment into digital infrastructure is important for sustainable development. Indeed, target 9c of the SDGs is to significantly increase access to ICT technology and to strive to provide universal and affordable access to the internet globally. The COVID-19 pandemic has further illustrated the importance of digital technologies, not least with regards to achieving other SDG targets involving education, decent work and economic growth, as well as gender equality. Access to reliable internet is increasingly becoming a prerequisite for both workers and firms to participate in the global economy, and for citizens to participate in local or global communities.

A UNCTAD (2017) report lays out key areas for digital infrastructure investment. The report breaks down investment needs for internet availability into three areas: where there is no coverage, where there is cellular coverage, and where cellular coverage has been upgraded to broadband. For different countries, investment needs will differ by the share of these three regions. For some countries, investment needs will be substantial to roll-out out internet infrastructure to current areas of no coverage characterised by high deployment costs and/or low demand. For other countries, mostly G20 countries, where universal cellular connection is already established the challenge is one of upgrading the technology. Infrastructure to improve the speed of internet connection will also have positive economic effects. Figure 9 shows the scale of this challenge across different G20 countries. The figure refers to subscriptions to the public internet at downstream speeds equal to, or greater than, 256 kbit/s.

Figure 9: Share of Population with a Fixed Broadband Subscription in G20 Countries



Source: Bruegel based on World Development Indicators. EU data for 2018, all other data 2019.

Beyond internet access, G20 countries should also look to pursue policies which enable private investment into digital firms as well as encouraging digital adoption by traditionally non-digital firms where appropriate. Digitalisation offers significant development opportunities, in terms of employment and by facilitating new and more efficient business models. Mobile banking, as one example, has provided affordable access to many individuals in situations with difficult access to conventional banking systems. Encouraging investments into telemedicine, online retail, online payments are other examples of likely desirable digital infrastructure policy objectives.

The application of digital technologies to infrastructure, described by the G20 InfraTech Agenda²¹ as “the integration of material, machine, and digital technologies across the infrastructure lifecycle”, will also play a major role in the transition to low- and eventually zero-carbon economies. As a cross-cutting technology, it has the potential to increase efficiency and reduce emissions in many crucial infrastructure systems. One example, discussed above is the digitalisation of electricity grids facilitating more efficient accommodation of renewable electricity sources. Importantly, digital infrastructure also allows environmental data collection, sharing and analysis which can be a major mitigating factor of climate change²².

3.5. Waste and Water management

- *Waste and water management processes contribute significantly to global GHG emissions. Moreover, their effective design is essential for shifting toward a more circular economy.*
- *Sensible water policies will become increasingly important over the next decades with the effects of climate change.*

Waste and water management both directly affect local communities. In certain regions, the burning of waste releases toxic gases which contribute toward air pollution. Moreover, waste which is not properly disposed of can lead to land or water pollution. Securing a fresh water supply to local citizens is a growing problem exasperated by the effects of climate change. Beyond local issues, the

²¹ G20 Infrastructure Working Group (2020).

²² Sarker *et al.* (2020); Gijzen (2013)

treatment of solid and water waste contributes a significant share of global GHG emissions, estimated at 2% and 1%, respectively²³.

3.5.1. Solid Waste

Waste management must be considered central to sustainability goals. The current model of extracting natural resources, consuming them, and then disposing a large proportion in the form of useless waste is, by definition, unsustainable. G20 governments should pursue plans to shift toward the circular economy and zero waste societies. To illustrate the scale of the problem, data from the US show that 50% of municipal solid waste ended up in landfill in 2018²⁴. It is acknowledged that the lack of effective solid waste management as well as unsustainable production and consumption patterns are key to the problem.

From an infrastructure perspective, efforts can be made to improve recycling capacity. This might involve expanding the institutional and logistics chain to better involve consumers in the separation of waste into recyclable components, as well as increasing final capacity for recycling. Another infrastructure option would be increasing capacity to generate useful energy from solid waste, or capturing fugitive emissions from landfills. Such projects should be viewed as a complement to first reducing the volume of waste ending up in landfills in the first place.

3.5.2. Water

As of 2015, 2.1 billion people lacked access to safely managed drinking water services (WHO and UNICEF, 2017). Difficulties in accessing freshwater are set to increase with the effects of climate change. Policy design and infrastructure should focus on managing water resources well, in order to maximise human welfare. On a local level, infrastructure requirements in many countries will be dominated by the need to adapt to a changing climate and provide a secure supply of freshwater. There exists a substantial gap between current financing and required needs for water infrastructure. OECD (2018) outlines some key reasons for this: water is generally an under-valued resource, water infrastructure is capital intensive with high sunk costs and its benefits are of both private and public nature, making it hard to monetise.

The capacity to treat and clean wastewater also needs to be expanded in many regions of the world. United Nations (2017) estimates that high-income countries treat about 70% of the wastewater they generate, but this drops to 8% for low-income countries. Globally, over 80% of all wastewater is discharged without any treatment, which contributes to the spread of water-borne diseases. A key challenge is rolling out further global wastewater treatment infrastructure capacities and best practices. Wastewater treatment plants themselves are also responsible for significant GHG emissions. Options should be explored for decarbonising this process. There are also substantial improvements necessary regarding the effective treatment of water run-off from industry and agriculture.

3.6. Industrial materials

- *Building infrastructure is a resource and greenhouse gas intensive process, responsible for 11% of global GHG emissions²⁵.*
- *Beyond building the infrastructure needed for a low-carbon economy, the construction of the infrastructure itself must become sustainable.*

²³ Our World in Data.

²⁴ EPA, accessed on 02/03/2021.

²⁵ Global Alliance for Buildings and Construction, International Energy Agency and the United Nations Environment Programme (2019) .

- *The G20 should support the commercialisation of low emission technologies for the production of materials used in infrastructure development by creating lead markets.*

Building construction itself accounts for 11% of global GHG emissions (Our World in Data). Before any infrastructure strategy can be deemed truly sustainable the materials used to build with must first be sustainable. Instead, there is significant carbon embedded in the infrastructure projects of the past, and without swift action at the G20 level, this will continue to be the case for almost all infrastructure projects in the future.

An important aspect is therefore developing low carbon technologies for some of the key elements used in manufacturing and construction process: namely, steel, aluminium and cement. All three have proved difficult to decarbonise and still contribute significantly to GHG emissions. Infrastructure lock-in in the form of carbon-intensive production capacity for each of these sectors is a problem. At current trends it is likely that many G20 economies will have to decommission and replace today's fossil fuel intensive production facilities with low-carbon production facilities of the future. While carbon neutral technologies are currently not competitive in prices, the G20 could create markets through public procurement and subsidies that would incentivise investment into research and development of these technologies.

Steel is fundamental to modern life, being used widely in infrastructure, ships, trains, cars, and machines. Steel also has important uses cases for the transition toward low-carbon economies in electric vehicles and wind turbines. Aluminium is used for infrastructure, transportation vehicles, electrical conductors and consumer goods, such as packaging. It has a high strength to weight ratio, great flexibility, and is infinitely recyclable which makes it an attractive material. Cement is used to make concrete, which is a vital building block for infrastructure.

Current methods for the production of steel, aluminium, and cement are both energy and GHG intensive. Estimates suggest that the production of steel, aluminium and cement account for approximately 7%, 2% and 4% of global GHG emissions respectively²⁶. To meet sustainable development scenarios, it is imperative to reduce the carbon emissions associated with the production of these key industrial materials. In all cases, some energy and material efficiency gains may be made, and end-use cases may undergo some substitution toward less carbon-intensive materials. Increased recycling can also play a key role. However, it will still be essential to redesign current carbon-intensive production methodologies. This may involve shifting to new primary production technologies, the consumption of different fuels for energy provision, or the adoption of carbon capture and storage technologies.

OECD (2019) identify some of the key barriers which have so far prevented low carbon innovation and deployment in these sectors. First, steel and cement plants operate with low profit margins in competitive markets. This has led to fears of carbon leakage, and in emissions trading programs such as the EU ETS, the sectors have consequently received a large share of free allowances. As a consequence, innovation in the heavy industrial sectors has remained muted.

Secondly, heavy industry plants operate at very long timescales. They can last for between 25 and 50 years. Much new capacity is being built in developing economies, while developed economies already enjoy an oversupply of production capacity. Moreover, there has so far been no serious attempts to create demand for low carbon heavy industrial materials (OECD, 2018).

²⁶ Our World in Data, Saevarsdottir et al. (2020), and UN Environment and International Energy Agency (2017)

Reducing carbon emissions from heavy industry sectors can be viewed from a supply and demand perspective. From a demand perspective, policy tools should be used to increase material efficiency (i.e., using less material to achieve the same result) and encourage material recycling. From a supply perspective, the challenge is to support low-carbon alternatives. Given the long lifecycles of heavy industry plants, to meet targets of the Paris Agreement, low carbon technologies should already be commercialised by the mid-2030s. It is therefore of fundamental importance for G20 countries to create lead markets and demand for low-carbon steel, cement, and aluminium.

A variety of options can be followed by G20 governments to decarbonise these sectors. One option is green public procurement where governments purchase only low carbon construction materials, or commit to targets for procurement of low carbon materials in the future. Other options are regulations to impose a minimum percentage share of low-carbon materials in any construction project.

Carbon pricing is conventionally seen as driving low-carbon deployment. In construction materials, the problem is that globally carbon prices that exist do not reach the levels required to sufficiently incentivise low-carbon production. Carbon contracts for difference are an option for artificially increasing the carbon price for certain sectors for a period of time. Here, a government guarantees a certain carbon price to, e.g., the steel sector, and pays a steel producer the difference between the existing carbon price and a higher promised carbon price for every tonne of carbon abated. Such a scheme would be implemented for a few years until the price of low-carbon production was driven down to levels whereby a conventional carbon tax can stimulate further demand.

G20 action is vital for the deployment of the technologies for low carbon production in these sectors. Without its leadership in promoting green industrial materials, infrastructure construction will continue being carbon intensive. Infrastructure projects designed for the abatement of GHG emissions or adaption to a changing climate will continue to further exasperate the issue at hand. Successful policy design should allow G20 countries to drive down costs in a manner similar to that in which European lead markets drove down costs for solar and wind power generation in the 2000s. As costs are driven down, it will also become increasingly feasible to bring other global actors on board.

4. Financing sustainable local infrastructure

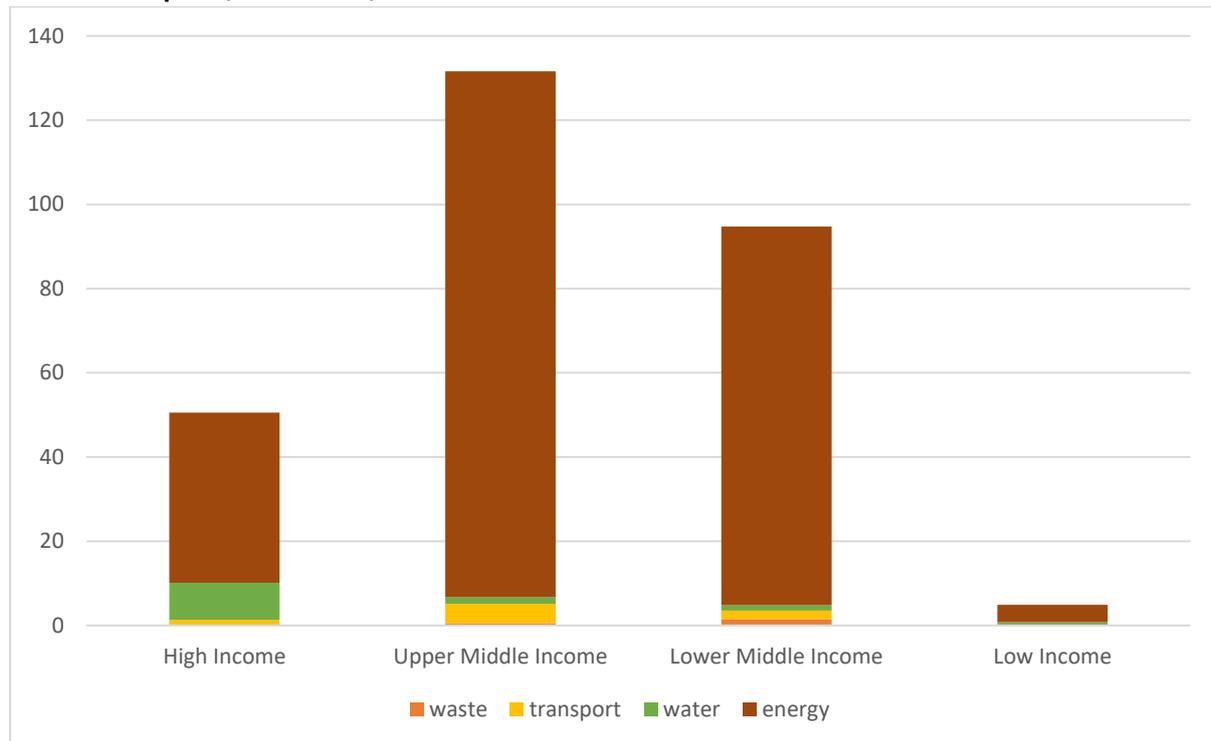
- *Strained public budgets are unable to finance the massive sustainable infrastructure gap, but private sector investment falls short of the needs due to inherent complexities and risks of infrastructure projects.*
- *Local governments face unique challenges in financing infrastructure due to complex decision-making structures, limited access to funding and technical assistance, and the lack of capacity to structure projects for private investment.*
- *Development financing institutions should expand their services to local communities, by providing funding and technical assistance to small-scale projects and to crowd-in private financing.*
- *Pervasive, structural budget overruns and project delays in the infrastructure sector must be addressed by national governments to increase private sector investment.*

Traditionally, infrastructure and the services it provides are managed by the public sector. For many types of infrastructure, governments are the best-suited providers. As a result of a global decentralisation trend in the public sector, today municipalities are frequently in charge of selecting and managing infrastructure implementation (Merk *et al.* 2012). Furthermore, national climate plans are often implemented through local action. In most G20 countries over 50% of investments in infrastructure are made by local governments. In OECD countries more than 60% of climate-smart investments are made at the local level.

To close the multi-trillion-dollar sustainable infrastructure gap discussed in Section 2, which resulted from years of global underinvestment, new sources of financing have to be found. This is especially true for low- and middle-income countries whose public budgets are already stretched thin in the wake of the COVID-19 pandemic. Prohibitively high capital costs often make it impossible to afford the high upfront investments many infrastructure projects require. Hence, there is widespread agreement among policymakers, researchers and climate activists that the infrastructure gap can only be closed with significant private sector investment (Bhattacharya *et al.*, 2019; Grimm and Boukerche, 2020). This will enable governments to allocate scarce public funds more efficiently. The current financial market environment represents an opportunity for sustainable infrastructure investment in developing and emerging economies by the private sector: the combination of excess savings and low interest rates in advanced economies with high foreign investment needs and returns in the emerging economies and developing countries is an ideal setting for more efficient capital allocation.

Most countries are unable to translate the tremendous needs and opportunities for sustainable infrastructure into realised demand, and a significant proportion of investment is not as sustainable as it should be. One good example is FDI flows. Global FDI flows to advanced, as well as emerging and developing economies are dominated by the G20's investments. Bhattacharya *et al.* (2019) analyse these capital flows between 2011 and 2017 with respect to their sustainability. Only 11% of the USD 4 trillion foreign investment by G20 countries was channelled into sustainable infrastructure. As Figure 10 shows, low- and lower-middle income countries make up a disproportionately low share of recipients relative to their investment needs. Similarly, when considering the type of infrastructure that is being funded, the vast majority flows into the energy sector. Local infrastructure, such as water, waste and transport represent an almost negligible share of the G20's FDI in sustainable infrastructure in emerging markets and developing countries. It appears that capital does not flow where it is needed most. This is due largely to the inherent complexities of local green infrastructure development.

Figure 10: Distribution of Sustainable Infrastructure FDI from G20 Countries to EMDCs by Income Level of Recipient, 2011-2017, in USD Billion



Source: Bruegel based on Bhattacharya et al. (2019)²⁷

This firstly relates to funding. In general, cities rely on transfers of federal funds or on reallocation of existing municipal budgets to fund investments in local, green infrastructure. But local governments face unique barriers in accessing private finance, and the ability to do so varies substantially with their size, political autonomy and institutional capacity. Ivanyna and Shah (2012) show that only 16% of countries authorise regional authorities to set local tax rates independently. More so, the majority of national governments either forbid or heavily restrict local authorities' ability to raise money from capital markets and prohibit them from issuing municipal bonds (Ivanyna and Shah, 2012). Among those that are in theory able to issue debt, many have no or very low ratings on credit markets, especially in lower income countries (Carter and Boukerche, 2020).

A second major barrier to local infrastructure investment is the lack of investment opportunities of sufficient quality and appropriate size. This includes both the lack of investible projects and the challenge of matching them with the suitable financier. Much infrastructure does not generate direct and quantifiable returns. In many cases, its aim is to expand the accessibility to the service it provides to the largest possible number of citizens. Even if there are monetary profits, they are generated gradually over long-time horizons. Similarly, one source of private financing that has received a lot of attention in the recent policy discussion are institutional investors. The capital pool managed by such institutional investors in the OECD alone amounts to USD 100 trillion, which would be more than enough to close the sustainable infrastructure gap (Grimm and Boukerche, 2020). However, local infrastructure projects are usually too small for institutional investors. A study by the C40 Cities Finance Facility found that 45% of municipal infrastructure projects are smaller than \$10 million (C40, 2018). Therefore, it is crucial that the source of funding and the specific infrastructure project are efficiently matched. The missing 'pipeline of projects' is a recognised obstacle to

²⁷ Emerging markets and developing countries according to the IMF's country classification, income groups according to the World Bank.

infrastructure investment at all scales and sectors (Bhattacharya *et al.*, 2019), but is exacerbated at lower levels of governments. Most local administrations do not have the resources nor the expertise to identify, design and structure sustainable projects that could attract private investors. Climate-related investments also frequently require technical, feasibility and impact studies which municipalities are unable to afford (Carter and Boukerche, 2020). Access to external, concessional finance for project preparation is scarce at the local level.

A final obstacle to private sector investment in local green infrastructure is risk. Projects are generally long-term and entail substantial and costly planning, preparation and construction phases with no monetary returns for years. Cost overruns and delays are pervasive in the infrastructure sector. Municipal infrastructure projects face additional bureaucratic hurdles due to often complex and opaque decision-making structures between regional and higher-level governments. Due to their cross-cutting impact, infrastructure projects require the involvement of many diverse stakeholders, and a substantial fraction of the funding needs to be paid upfront. This cost structure is exacerbated in sustainable infrastructure, where upfront costs tend to be 5-10% higher while operating and maintenance costs are lower (Bouton *et al.*, 2015). In addition, due to the time-dimension, there is substantial uncertainty related to future regulatory, economic, technological and political developments which is compounded in local projects as regional governments' influence on national strategies is limited. Finally, positive and negative externalities of infrastructure must be assessed and quantified. For example, a desired, if long-term, outcome of investments in green infrastructure is the positive environmental impact and other collective social benefits. But these positive externalities are difficult to quantify in terms of revenue or returns on investment (Carter and Boukerche, 2020). In other words, the lack of appropriate carbon prices makes it impossible to incorporate the negative environmental effects of high-carbon infrastructure into investment opportunities. All this makes green local infrastructure inherently risky for investors.

Local governments' room for manoeuvring these difficulties is relatively scarce. However, they can attempt to strategize their revenue system. Urban administrations are advantaged with respect to their revenue system because the infrastructure sectors with the highest 'greening' potential, such as buildings (energy efficiency), transport (public transport, roads, electric vehicle charging stations), water and waste are the sources of a substantial share of cities' revenues. By setting transport and parking fees, utility charges and possibly property taxes accordingly, local governments are in a unique position to 'green' their revenues by incentivising a more sustainable use of existing resources as well as the transition towards more climate-smart infrastructure (Merk *et al.*, 2012). The purpose of this policy is not to gather additional earnings. On the contrary, if higher parking fees lead to reduced downtown car traffic, revenues may even decline. Instead, it can encourage a shift in the local communities' infrastructure use from dirtier to more sustainable alternatives.

The following sections will expand on the role that development finance institutions and national governments can play in alleviating barriers and crowding-in private investment in local sustainable infrastructure. Finally, we discuss the widespread occurrence of cost overlays and construction delays and non-completion of infrastructure projects.

4.1. Mobilising private funding for sustainable local infrastructure: the role DFIs

National and international development banks (henceforth summarised under the term development finance institutions, or DFIs) will play a critical role in filling the global infrastructure gap, particularly but not only in low- and middle-income countries. Backed by the strong credit ratings of their members, DFIs are able to borrow cheaply from capital markets and thereby bring down the cost of finance for their debtors. According to World Bank estimates, emerging market and

low-income economies alone require annual investments of approximately USD1.5 - 2.7 trillion in sustainable infrastructure until 2030 in order to achieve the SDGs and meet a 2°C climate target (Rozenberg and Fay, 2019). As Table 3 shows, annual investments in sustainable infrastructure in EMDEs by multilateral and national development banks and G20 FDI combined accounted only for 154.8 billion USD between 2011 and 2017.

Table 3: Sustainable Infrastructure Investments in EMDCs by Source of Financing

	Total (USD billion)	Annual (USD billion)	Share of EMDC need	Share of global need
MDBs	180	25.7	1.2%	0.3%
NDBs	621	88.8	4.2%	1.2%
G20 FDI	282	40.3	1.9%	0.5%
Total	1 083	154.8	7.4%	2.0%

Source: Bruegel replication of Table 2 in Bhattacharya *et al.* (2019)

A recent study suggests that MDBs could substantially increase their lending headroom while maintaining their excellent credit ratings (Munir and Gallagher, 2018). Specifically, depending on the scenario considered lending capacity could be increased by between USD 598 billion and 1.9 trillion. While this is noteworthy, it is clear that financing the trillion-dollar yearly gap is well beyond the direct capacity of DFIs. Instead, the primary role of DFIs should shift from providing funding themselves to catalysing private sector investments. The true power of DFIs lies in their project expertise, which enables them to fill two crucial gaps in the local sustainable infrastructure investment system: risk mitigation and project supply.

Thanks to their expertise, DFIs are in the ideal position to assess and ensure appropriate risk sharing among participating investors. As explained above, many factors make local, climate-smart infrastructure projects relatively unattractive for private investors. In addition, for investments in emerging markets and low-income countries risks such as inflation, currency fluctuation and convertibility or expropriation are also present. Thanks to their longstanding experience of successfully lending to and implementing projects in high-risk contexts, DFIs are adept at negotiating with stakeholders, managing risks and monitoring and measuring project impact. Their past relationships with governments reduce political and operational risks of investments, and MDBs have a proven track record of serving as intermediaries between developing countries and investors (Mohieldin *et al.*, 2018). DFIs should increase their participation in blended finance structures for private sector investment, while continuing to engage in institutional strengthening and capacity building and bolstering the fundament of market-oriented growth in the receiving countries.

The second major barrier to be addressed is the lack of investible projects. This is akin to supporting the demand side of infrastructure financing. By providing technical assistance along all stages of preparation, from project identification over feasibility studies to matching with investors, DFIs can contribute to a reliable supply of high-quality, local, sustainable infrastructure investment opportunities. This would not only increase the projects' quality, but also build local capacities and transfer knowledge to municipalities.

For this to have an impact on local infrastructure, it is crucial that DFIs expand their services to lower level of governments. While DFIs are already an important source of funding for urban and sustainable infrastructure, for example through the Global Environment Facility, the Green Climate Fund and the Adaptation Fund (Carter and Boukerche, 2020), they generally work at the national level. This means that the financing provided in the above-mentioned facilities must be accessed

through the national government, which increases coordination needs and bureaucratic load (Alexander *et al.*, 2019). DFIs should cooperate with the G20's Global Infrastructure Facility (GIF), which was established precisely for that purpose and has experience in providing technical assistance to local governments and municipalities in infrastructure project design and structuring in order to attract private sector investment. The World Bank's City Creditworthiness Initiative (World Bank, 2018) is another great step towards this goal. The program aims to improve municipalities' access to financing for sustainable infrastructure by improving their creditworthiness. To this end, the initiative provides a capacity-building 'academy' and a technical assistance program to enhance cities' ability to attract, structure and manage private financing.

4.2. Mobilising private funding for sustainable local infrastructure: the role of national governments

National governments play a central role in crowding-in private sector investment in local, green infrastructure. Their main responsibility is to ensure a supportive and enabling investment environment for sustainable local infrastructure.

Naturally, this means addressing macroeconomic barriers to private-sector investment, such as inflation or currency convertibility. But increasing transparency in terms of climate intentions is also crucial. The central government must be the leader in greening infrastructure investment. This entails aligning national policies and regulatory frameworks with national climate commitments, thereby sending clear signals to markets about infrastructure investment intentions.

Revising assessment frameworks, environmental regulations and infrastructure standards at the national level to reflect sustainability goals facilitates their implementation for local governments. At the same time, central governments could increase municipalities' autonomy over their revenue systems in order to increase their room for policy action. Eventually, they should reassess and revise their institutional framework for municipal financing to ensure efficient allocation of resources while maintaining financial sustainability. In addition, central governments must invest in administrative capacity-building. This should also include increased coordination among higher and lower levels of government, as well as transparent distribution of responsibilities.

4.3. Infrastructure project performance

In order to attract a higher share of private investment in sustainable local infrastructure governments must address the risk of construction delays, cost overruns and project non-completion.

Poor infrastructure project performance, as measured by budget overruns and implementation delays is widespread. The influential study by Flyvbjerg *et al.* (2003) was one of the first to document the pervasiveness and magnitude of the problem. Their analysis of 258 transport infrastructure projects in twenty countries found that almost 90% of projects experienced substantial delays and budget overruns of on average 26%. Among them are, for example, the Channel Tunnel (80% cost overrun) and the Humber Bridge in the UK (175% overrun). Another investigation into the cost burden of large infrastructure projects around the world found that only four of the 52 projects studied remained within the forecasted budget, and cost overruns averaged at 88% (Merrow *et al.*, 1988). Prominent examples of delayed and excessively expensive infrastructure projects abound across the world, and studies investigating this problem in virtually all G20 economies prove that this is still widespread today (See Fiedler and Schuster, 2016, for Germany; Lee, 2008 and Han *et al.*, 2009, for Korea; Pickrell, 1990 and 1992, for the USA; Doloi *et al.*, 2012, for India; Durdyev *et al.*, 2012, for Turkey; Kaming *et al.*, 1997, for Indonesia; Allahaim and Liu, 2015, for Saudi Arabia; Creedy *et al.*, 2010, for Australia; Baloyi and Bekker, 2011, for South Africa; Flyvbjerg *et al.*, 2003, for

France; Huo *et al.*, 2018, for China). Similar findings to those in the transport sector have been found in other sectors of infrastructure and demonstrate considerable differences in average cost and time performance. Sectors such as transmission lines (8%) or solar (1%), wind (8%) and thermal power plants (12%) seem to face fewer unanticipated cost hikes than nuclear power plants and large dam projects, where cost escalation amount to 113% and 96% on average, and the pattern is mirrored in delays in project completion (Ansar *et al.*, 2014; Sovacool *et al.*, 2014). IT and ICT perform comparatively well on average but the sector includes frequent outliers with massively escalated costs²⁸. It is important to note here, however, that national experiences may differ considerably from the averages found in trans-national studies, especially at the subsectoral level²⁹.

Delayed projects that eventually turn into permanent and abandoned construction sites are more prominent in the developing world. Recent evidence suggests that more than one-third of infrastructure projects in emerging markets and developing countries are not completed (Rasul and Rogger, 2018; Williams, 2017). These ‘white elephants’ are a tremendous waste of resources, in addition to presenting a potential danger to the local populations (Bancalari, 2020). The studies estimate that waste of public resources through non-completion of infrastructure projects is of the same order of magnitude as the loss through corruption in infrastructure projects (around 24%³⁰) and is similar to the percentage of government spending that is lost due to politically motivated distortions (around 26%) (Olken, 2007).

Yet, infrastructure non-completion receives much less attention in the development policy discussion and in academic literature than corruption and clientelism, which is why the underlying causes are not yet well understood. The studies that are available identify the drivers of (non-) completion to be specific to the local institutions³¹, and identify a positive effect of budget conditionality on project completion, that is, fund disbursement for a new project to be conditional on the completion of the previous one. Similarly, a striking feature of the existing literature on project cost and schedule performance is that it focuses almost exclusively on large infrastructure projects and megaprojects, which are defined as “...*large-scale, complex ventures that typically cost US\$1 billion or more, take many years to develop and build, involve multiple public and private stakeholders, are transformational, and impact millions of people*” (Flyvbjerg, 2014, p.3) and are managed by central governments. Literature on project performance for smaller infrastructure projects managed by local administrations is still scarce, which is likely due to lack of reliable administrative data on infrastructure projects across levels of governments.

Understanding and mitigating the causes is absolutely vital. By improving infrastructure project performance even marginally, governments have the chance to generate substantial additional economic benefits from their investments in the wake of the current crisis. The magnitude of waste of fiscal resources is substantial and for middle- and low-income countries the social and developmental costs are tremendous. Even a marginal decrease in the cost overruns in infrastructure projects could make billions of USD of public funds available for investment. While an analysis of the underlying determinants is beyond the scope of this report, an assessment of local,

²⁸ Approximatively one out of six IT projects faces cost overruns over 200% (Flyvbjerg and Budzier, 2011).

²⁹ For a discussion of this, and an analysis by sector for Germany see Anzinger and Kostka (2016).

³⁰ Olken (2007)

³¹ Williams (2017) finds that project non-completion is the outcome of a dynamically inconsistent collective choice process among political actors facing commitment problems in contexts of limited resources. Rasul and Rogger (2018) find that the management style of local public offices plays a role, with higher autonomy of contributing to project-completion.

small-scale infrastructure service delivery in G20 countries will be instrumental to identify obstacles to timely and cost-efficient construction, and address them³².

³² For an overview over causes and determinants of project performance see Aljohani *et al.* (2017), Fiedler and Schuster (2016) and Pinheiro Catalão *et al.* (2019).

Recommendations to the G20

The G20 has had considerable success driving infrastructure up the agenda notably following the G20 Principles on Quality Infrastructure adopted at the 2019 Osaka summit, and the InfraTech Agenda adopted at the 2020 Riyadh summit. The time has now come for the G20 to place sustainable and local elements at the centre of the conversation surrounding infrastructure. We outline the key measures that should be taken to do so:

- **Place climate sustainability at the core of the infrastructure agenda.** Infrastructure investments that are made now will lock in technologies for decades to come. It is imperative that these contribute to limiting global warming to 1.5°C, which needs to be emphasised in the G20 infrastructure agenda. The G20 should revise the Principles on Quality Infrastructure to explicitly encompass climate change mitigative, adaptive and resilient infrastructure.
- **Sustainable policies start locally.** Building sustainable cities will be key to solving two of the most pressing challenges of our time: climate change and population growth. Covering only 2% of the planet's surface, cities are responsible for up to 70% of global GHG-emissions and home to the majority of the world's population. The G20 should recalibrate their individual and common infrastructure agendas to prioritise small-scale, local investment that serves local communities.
- **Improve access to finance for low-carbon projects.** Many low carbon infrastructure projects, such as deployment of solar PV, are particularly capital intensive. Higher costs of financing can prohibit ambitious levels of sustainable investment. In order to sustainable infrastructure investment in low- and middle-income countries, the G20 should cooperate to provide cheaper financing. This could be done through blended finance or concessional loan programs by DFIs.
- **Address the shortage of bankable infrastructure projects.** Local administrations lack the capacity to identify, prepare and structure sustainable infrastructure projects for private investment in their communities. The G20 should expand the capacity of the Global Infrastructure Facility (GIF) to provide technical assistance to local governments throughout the project cycle in order to crowd-in private sector investments.
- **Commit to supporting bilateral and multilateral development banks.** DFIs are the key to unlocking large-scale infrastructure investments thanks to their expertise and long-term experience with risky project delivery. With cities at the heart of the global zero carbon infrastructure transition, they are only now beginning to support local governments directly. The G20 should continue to commit future funding to these institutions and promote their engagement at lower levels of government to enable them to provide much-needed support, especially in low- and middle-income countries.
- **Stimulate demand for low-carbon industrial materials.** Industrial materials are essential for sustainable infrastructure are responsible for significant GHG emissions. Addressing this problem is difficult for a number of reasons. The most efficient solution will be a coordinated commitment by the G20 to boost demand for low-carbon options. There are a range of policy options which could be deployed, but whatever route is chosen, it is essential that the G20 commits to this challenge now. Further delays are incompatible with Paris Agreement targets.
- **Improved cooperation across the G20.** Decarbonising economies requires risk-taking, experimenting, and innovation. Certain actions, such as implicit or explicit carbon prices, are essential for encouraging sustainable infrastructure, but difficult for countries to implement

unilaterally. G20 coordination and stronger commitments to decarbonisation can facilitate more ambitious action at the national, and in turn, local level.

- **Focus of lifecycle sustainability.** The G20 should advocate a shift toward a policy-making paradigm where policies are evaluated from a lifecycle sustainability/emissions standpoint. This would involve evaluating the whole chain of an infrastructure project from basic materials construction to recycling possibilities or waste disposal issues. Best practices for this could be agreed at the G20 level.

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