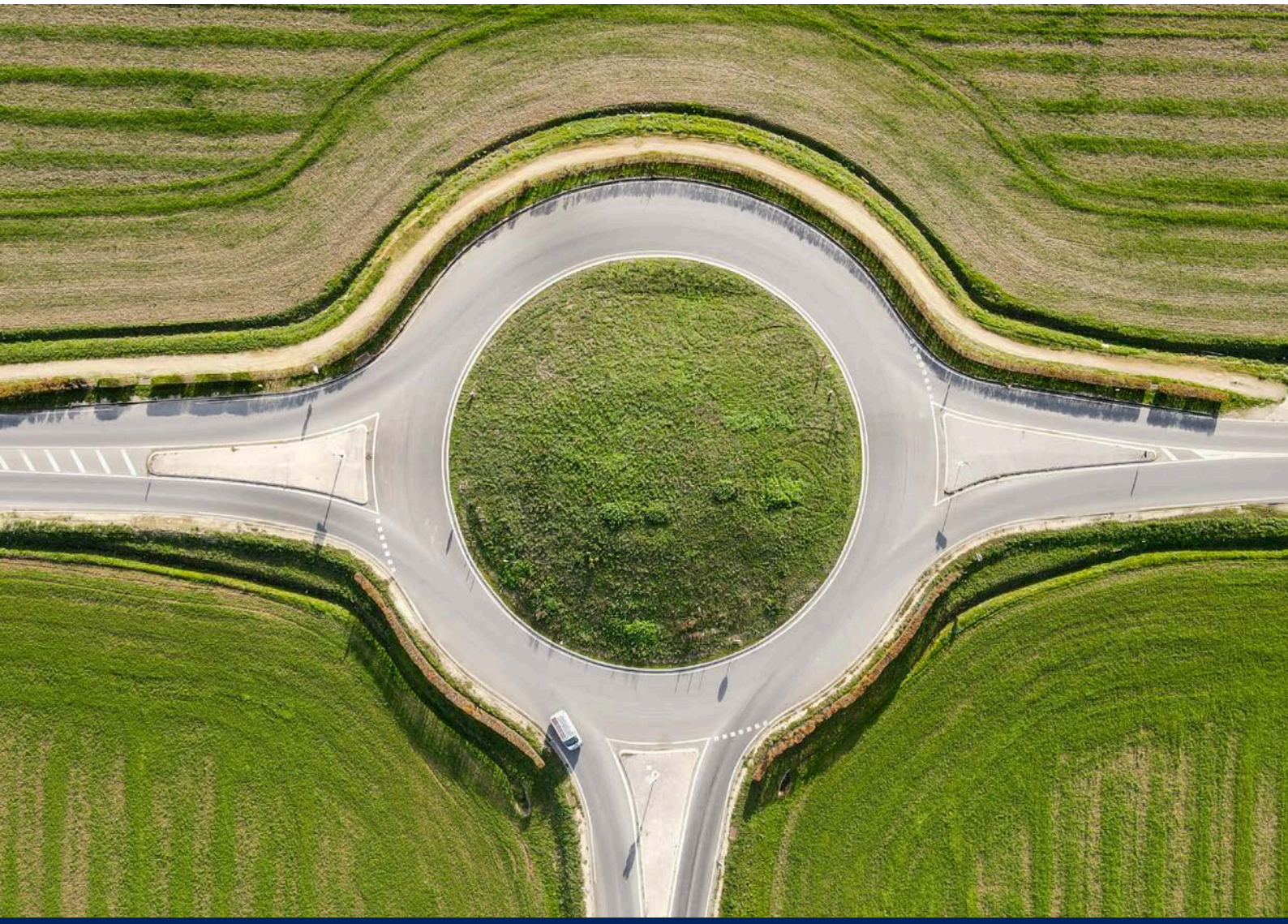
Global Infrastructure Hub

Roadmap for Enabling Circular Economy Potential in Infrastructure



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A G20 INITIATIVE

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This roadmap is designed to build knowledge and an understanding of infrastructure's potential role in enabling the circular economy.

The transition pathways proposed in this roadmap are voluntary and non-binding and intended to be applied taking into consideration specific national circumstances.

1 Introduction

1.1 Background and context

On the 7 April 2021, G20 Finance Ministers and Central Bank Governors reaffirmed the pivotal role of quality infrastructure in the G20 Action Plan for steering economic recovery post COVID-19. The G20 Infrastructure Working Group (IWG) has identified sustainable infrastructure as one of its priorities, and the circular economy as one topic under this priority. To support this agenda, the Global Infrastructure Hub (GI Hub) examined the role that infrastructure can play in advancing the circular economy and identified the knowledge gaps in this subject and how these knowledge gaps can be filled. To date, the initiative has included:

- A thought piece entitled *The Role of Infrastructure in the Circular Economy* (published 16 April 2021)[1]
- A G20 discussion workshop for IWG members to raise awareness of key transition elements (held on 30 April 2021)
- A draft circular economy roadmap, which was presented to the IWG in June 2021 for review and feedback
- The final version of this Roadmap presented to the IWG in September 2021.

Roadmap objectives

To advance the G20's understanding of infrastructure's potential role in enabling the circular economy, in particular the transition pathways that lead to a better knowledge and understanding of its potential for impact.

1.2 What is a circular economy?

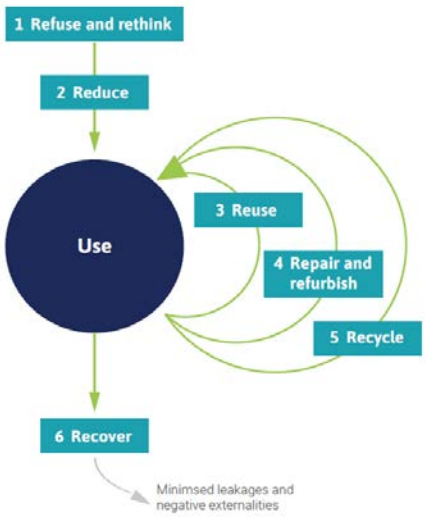
A 'circular economy' is an economic system that organises production, supply and consumption of materials into closed loops, thereby reducing the pressure on the world's finite materials and natural resource depletion. The 6R principles is one example of a 'hierarchy of action' to achieve circularity and is depicted in Figure 1[2].

[1] https://cdn.gihub.org/umbraco/media/3889/gi-hub-thought-piece-infrastructure-and-the-circular-economy-apr-2021.pdf

[2] The circularity diagram for the 6R principles was adapted from PBL Netherlands Environmental Assessment Agency (2019). *Outline of the Circular Economy.* PBL Netherlands Environmental Assessment Agency. Available at: https://www.pbl.nl/sites/default/files/downloads/pbl-2019-outline-of-the-circular-economy-3633.pdf

The 6R principles shows that the aim of the circular economy is to primarily refuse (or significantly reduce) the amount of raw materials entering the system. This is achieved by 'closing the loop' and maximising the amount of materials recovered and subsequently reused, repaired, refurbished and recycled to produce another product of equal or better quality than before. Residual materials are those that can no longer be reused or recycled, and the available pathways are to extract the embedded energy (e.g. through waste-to-energy) or to safely dispose of these.

Figure 1: 6R Principles of circularity



1.3 Why transition towards a circular economy?

It is important to point out that the circular economy presents opportunities for all countries regardless of their level of development, as it has the potential to provide more cost-efficient solutions across many product / asset lifecycles (including infrastructure).

The research and stakeholder consultations undertaken by the GI Hub in the development of this roadmap identified two primary benefits of the circular economy. These are **mitigating climate change** and **mitigating risk of resource scarcity**.

Mitigating climate change

Renewables can address 55% of global greenhouse gas emissions, indicating that the 1.5°C Paris Agreement target can only be achieved by combining current efforts on renewable energy and energy efficiency with other approaches, including circular economy.[3] This implies that better circularity can help economies meet their climate change targets by reducing greenhouse gas emissions associated with the use of materials.

Mitigating risk of resource scarcity

Circularity can reduce supply chain risks and short-term supply shortages by requiring less raw material input and establishing a more local secondary material supply. The COVID-19 crisis has also highlighted the fragility of global trade flows and the need for countries to look at material availability in-country, a secondary material supply could therefore offer some security. Embedding circularity principles into the design of products has the potential to reduce the need for raw material input, thereby mitigating the risk of resource scarcity in the future.

It should also be acknowledged that minimising waste disposal and pollution appeared in the research as another driver for the transition to a circular economy. However, while more sustainable waste management and recycling infrastructure can be an important and necessary part of a transition to a circular economy, waste and recycling is not enough on its own to drive

[3] Ellen MacArthur Foundation (2019). Completing the picture: How the circular economy tackles climate change. Ellen Macarthur Foundation. Available at: https://www.ellenmacarthurfoundation.org/assets/downloads/Completing_The_Picture_How_The_Circular_Economy-_Tackles_Climate_Change_V3_26_September.pdf

circular economy outcomes[4]. A recent study quotes that 80% of a product's environmental impact is determined during the design phase,[5] indicating that a transition to a circular economy requires a transformation of the entire operating system, not just at the end-of-life.

The circular economy can also provide compelling economic, environmental and social co-benefits, as it has been estimated that by 2030, globally the circular economy will create 65 million new jobs[6] or 18 million net jobs[7]. Circular economy also has potential for environmental benefits (beyond mitigation of greenhouse gas (GHG) emissions) by encouraging 'regenerative design'. Regenerative design enables a product to have a positive (rather than a negative or neutral) impact on the environment.[8]

The GI Hub has also seen trends in circularity featuring in COVID-related stimulus, therefore circularity also has the potential to play a role in facilitating recovery from the pandemic[9].

1.4 What impact can infrastructure have in advancing the circular economy?

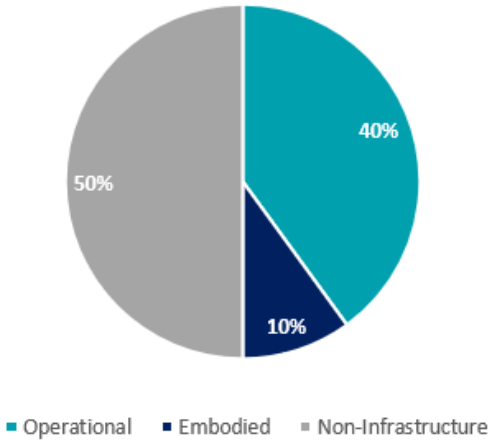
Infrastructure could have a role to play in advancing circular economy outcomes by directly impacting the use and availability of many raw materials that contribute to GHG emissions and that enable economic activity. Infrastructure's contribution to the two benefits of the circular economy (as covered in the previous section) is summarised below. The methodology used in deriving this analysis is provided in the Appendix.

Mitigating climate change

The GI Hub estimates that infrastructure contributes around 50% of GHG emissions as shown in Figure 2. 40% of this relates to operating emissions (emissions from the use of infrastructure) and 10% relates to infrastructure's embodied emissions (emissions from the materials component of infrastructure).

With respect to GHG emissions, the emphasis of circularity is on infrastructure's embodied emissions which can be directly impacted by minimising raw material input in infrastructure. Better circularity in infrastructure can have a direct impact on infrastructure's embodied emissions, but it can also indirectly have an impact on operating emissions by introducing efficiencies through material/design innovations.

Figure 2: Estimate of infrastructure's contribution to global GHG emissions (by operational and embodied GHG emissions) (2018)



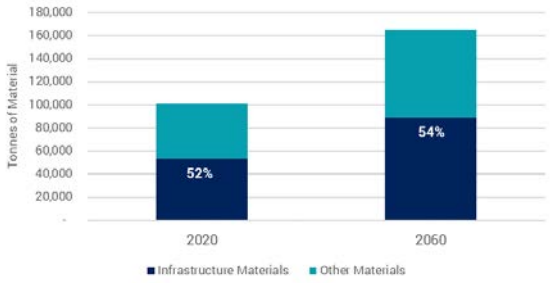
Source: Global Infrastructure Hub analysis

[4] Hanemaaijer et al (2021). Netherlands Integral Circular Economy Report 2021. Available at: https://www.pbl.nl/sites/default/files/downloads/2021-pbl-icer2021_english_summary-4228.pdf
[5] Ellen Macarthur Foundation (2021). Recycling and the circular economy: what's the difference? Available at: https://ellenmacarthurfoundation.org/articles/recycling-and-the-circular-economy-whats-the-difference
[6] Global Commission in the Economy and Climate (2018). The New Climate Economy. Available at: https://newclimateeconomy.report/2018/executive-summary/
[7] IISD & SITRA (2020). Effects of the Circular Economy on Jobs. Available at: https://www.iisd.org/system/files/2020-12/circular-economy-jobs.pdf
[8] Globe Advisors (2012). *British Columbia's Green Building & Energy Efficiency Sector*. Available at: http://globeadvisors.ca/wp-content/uploads/2015/06/Green-Building.pdf
[9] GI Hub 2021, InfraTracker

Mitigating the risk of resource scarcity

Infrastructure consumes over 50% of the world's materials, and the G20 share of this consumption is around 70%[10]. This trend is expected to continue through to 2060 as shown in Figure 3. These materials include carbon-intensive materials such as steel, aluminium and cement (which are covered in the GHG analysis above) but also other economically important materials such as other metals, rare earths, sand, stone, and clay.

Figure 3: Material consumption by the infrastructure sector



Source: Global Infrastructure Hub analysis based on data from the International Resource Panel [11]

A crucial issue is the rapidly increasing demand for materials that enable the clean energy transition. It is anticipated that these materials could become scarce by 2050, meaning that the effort (e.g. energy and cost) needed to extract them would significantly increase.

[10] Data notes: Employing a population, urbanisation and economic growth scenario based on the Socio-Economic Pathways 2 of the IPCC 'Middle of the Road Scenario'; Materials for infrastructure include iron and steel, concrete, bricks, non-ferrous metals, and structural timber; In 2020, infrastructure is expected to consume 52% of the world's resources. This is expected to increase to 54% in 2060. Other major contributors to global material usage include fossil fuel extraction and biomass.

[11] The data presented above (which is explained in more detail in the Appendix) was based on evidence already available in the public domain. It is derived from resource, waste and greenhouse gas emissions models for supply chain activities across a range of sectors. While this pre-existing work is compelling, it does not disaggregate by infrastructure related activities. This is explored further in the next section.

2 Roadmap for Enabling Circular Economy Potential in Infrastructure

2.1 Roadmap overview

Consolidating the evidence presented in previous sections, circular infrastructure includes assets that are developed and delivered to mitigate climate change and resource scarcity by minimising raw material input from carbon-intensive materials and/or economically important materials in adherence with the 6R principles.

This roadmap provides transition pathways to build knowledge and understanding of the impacts of circular infrastructure, linking this with the G20's sustainable infrastructure priorities.

This roadmap is for reference and information purposes only and is voluntary and non-binding. It is acknowledged that different economies will take different approaches to circular infrastructure depending on specific national circumstances.

This final roadmap is a consolidation of the findings from the GI Hub's thought piece (published in April 2021), the G20 workshop (held in April 2021) and G20 IWG and industry feedback following submission of the draft roadmap (June 2021).

As mentioned above, circular infrastructure has potential to mitigate climate change and the risk of resource scarcity. **Circular infrastructure could be a strong enabler in achieving the G20's sustainable infrastructure priorities,** however there are some knowledge gaps that need to be filled before its impact can be fully understood**.**

An overview of the roadmap is shown in Figure 4 below and is summarised as follows:

- Starting in 2020 and continuing through the 2021 IWG Work Plan, one of the IWG's priorities is to promote sustainable infrastructure for decades to come. This includes helping to mobilise private investment to reduce the infrastructure financing gap whilst mitigating the negative consequences that infrastructure can have on people and the planet (in terms of greenhouse gas emissions, land use and degradation, loss of biodiversity, and air and water pollution)[12.]
- In support of this priority, the circular economy has the potential to offer two main benefits: 1) helping to mitigate climate change by reducing GHG emissions, and 2) mitigating the risks of resource availability. This contributes to the G20's sustainable infrastructure agenda, which can be leveraged to attract more private investment into infrastructure.
- Infrastructure can play a key role in advancing the circular economy (and the associated benefits as outlined above). Four transition pathways were developed for this roadmap to help build knowledge around infrastructure's potential impact on the circular economy, and could form the basis of a forward workplan for G20 governments looking to progress their understanding on the topic of the circular economy.

[12] G20 Infrastructure Working Group (2021). *2021 Work Plan*. G20 Infrastructure Working Group.

Figure 4: Overview of the roadmap

2.2 Roadmap transition pathways

The transition pathways, as outlined below, are an evolution of the key elements of transition to a circular economy presented in GI Hub's earlier work[13]. They incorporate the outcomes from the GI Hub's thought piece, the G20 IWG workshop in April 2021 and consultations with industry and circular economy experts and identify gaps in knowledge and how to fill them.

13 Global Infrastructure Hub (2021). The role of infrastructure in the circular economy. Available at: https://www.gihub.org/infrastructure-and-the-circular-economy/

The transition pathways are centred around four key knowledge enablers:

These four transition pathways were developed with public sector leadership in mind, noting that certain actions are enabled through collaboration with the private sector, multilateral development banks (MDBs) and/or international organisations. These transition pathways are all interrelated and interdependent. Each pathway will be reliant on the success of other pathways in order to achieve circular infrastructure. The transition pathways are broken up into short, medium and long-term considerations, which in total aim to achieve the stated benefits of this roadmap.

2.2.1 Data-based evidence

Transitions can start with raising awareness through data-based evidence on the impact of circularity, which can go a long way to making the case for circular infrastructure among policymakers and practitioners, identifying and implementing new and innovative solutions to solving problems. This pathway is centred around three areas:

- Collecting data-based evidence on impact for circular infrastructure
- Aligning circularity principles with existing impact frameworks
- Encouraging data sharing and management.

Strengthening the industry's capabilities around data can also strengthen all other pathways by creating evidence for change, and helping stakeholders make more informed decisions on next steps under this topic.

2.2.1.1 Short Term: Collecting data-based evidence on impact for circular infrastructure

This aims to encourage public and private sector partners to share datasets and data insights on circularity that can be provided on a voluntary and non-binding basis. These frameworks and data sets could help stakeholders better understand how others in the industry have defined circular infrastructure and its desired outcomes.

Example: The World Bank Group

The World Bank Group is currently preparing an assessment of the state of play of circularity in Europe. Using material flow accounting and Computable General Equilibrium modelling they aim to analyse the economic impacts and drivers of achieving circular economy outcomes, for instance through distributional, spatial and labour market effects. The purpose of this work is to inform national decision makers on the potential benefits and costs of circular economy strategies and support the design of effective policy packages. This initial study covers the European Union (EU) with a specific focus on Poland, Romania, Bulgaria and Croatia.

2.2.1.2 Medium-term: Aligning circularity principles within existing impact frameworks

Based on the data sets and data insights uncovered through short-term actions, stakeholders can then understand how to align circularity principles with existing impact frameworks which may be used for

developing infrastructure plans and investments. They can include voluntarily disclosing data on circularity that can be integrated with wider sustainability and climate action disclosure frameworks.

Example: Infrastructure as an Asset Class

As part of a G20 initiative, EDHECinfra sought to develop infrastructure as an asset class when the lack of benchmarks was seen as a key impediment. EDHECinfra surveyed practitioners to define the investment universe as the first step in creating a series of benchmarks to monitor the risk adjusted performance of the underlying assets. EDHECinfra created broad market indices of sovereign unlisted infrastructure equity and private infrastructure debt. EDHECinfra has built a database of underlying infrastructure investments in the world and these benchmarks and databases serve as an important tool in improving transparency and consequently liquidity in the sector.[14]

2.2.1.3 Long-term: Encouraging data sharing and management

At this stage, there would be an internationally accessible pool of data and impact frameworks available to assess the progress of plans and investments towards circularity. The data sharing on projects could now be used to improve the implementation of technologies and policies in order to help establish transparency and accountability, enabling the assessment of the transition's progress with the aim of informing future policy advancements.

Furthermore, the creation of knowledge sharing ecosystems could further catalyse knowledge development and a change in systemic practices. A repository of best practices, use cases, success stories, and lessons learned could transform the industry's capability and support the transition.

Example: Taskforce on Climate-related Financial Disclosure

The Taskforce on Climate-related Financial Disclosure (TCFD)[15] was established by the Financial Stability Board for more effective climate-related disclosures by companies (both in the financial and nonfinancial sector). In 2017, the TCFD published recommendations for climate-related disclosures to inform investment, credit and insurance underwriting decisions. It is now helping companies implement the recommendations as well as promoting advancements in the availability and quality of disclosures. To date, approximately 100 financial institutions have participated in pilots that examine physical and transition risks. This has facilitated the development of tools and frameworks that will help these institutions manage and disclose their climate risks.[16]

2.2.2 Innovative policies

Data-based evidence, as outlined in the previous step, helps to build the case for change. This could lead to the development of national and sectoral strategies for circular infrastructure, and awareness of innovations around policy could help at this stage in the process. A strategy sets a clear direction through a common vision, as well as a set of well-defined objectives. This

14 EDHECinfra (2019). An asset class is born. EDHEC Available at: https://edhec.infrastructure.institute/an-asset-class-is-born/
15 Task Force on Climate-related Financial Disclosures
16 UNEP (2021) TCFD – Task Force on Climate-Related Financial Disclosures. UNEP. Available at: https://www.unepfi.org/climate-change/tcfd/#:~:text=The%20Task%20Force%20on%20Climate,in%20providing%20information%20to%20stakeholders.

leads to a list of prioritised initiatives to guide policymakers and practitioners on key areas to focus on. As there is no precedent for best practice around national strategies for infrastructure in the circular economy, these strategies will need to be tailored to suit specific national circumstances – to tap into strengths and opportunities, and tackle weaknesses and threats. This pathway is centred around three areas:

- Innovative national and sectoral strategies
- Models for policy innovation sandboxes
- Reform around policy and regulation.

An economic case for circular infrastructure can be strengthened through innovative public policy levers to enhance profitability and cost competitiveness, similar to the economic case for renewable energy infrastructure. The guiding principle is to minimise the use of raw materials at the outset and embed circularity considerations across the lifecycle to incentivise uptake of circular solutions by stakeholders in infrastructure.

2.2.2.1 Short-term: Innovative national and sectoral strategies

Raising awareness of innovations around policy could help governments develop national and sectoral strategies for circular infrastructure, which would needed in the short-term to identify and prioritise initiatives. It would also send a signal of commitment to investors, encouraging further investment into circular infrastructure. These strategies would need to be developed through stakeholder consultation and be tailored to suit specific national circumstances, tapping into national or sectoral strengths and opportunities and tackling weaknesses and threats.

Example: A Circular Dutch Economy by 2050

The Netherlands has made a commitment to achieve a Circular Dutch Economy by 2050.[17] The Netherlands has also committed to an intermediate goal that by 2030 there will be a 50% reduction in the use of primary materials. This programme involves collaboration across all actors in the economy, from industry, civil-society organisations and knowledge institutions, to come together to achieve circularity. The Netherlands transition to a circular economy is centred around consuming less, using sustainably produced renewable materials and technological improvements by designing circular products and developing new production methods.

Example: Zero-Waste Nation

Singapore has committed to becoming a zero-waste nation with a masterplan that commits to a 30% reduction in the amount of waste sent to landfill per capita by 2030. This is coupled with their objective to have a 70% overall recycling rate by 2030. This masterplan involves the adoption of a circular economy approach with government taking the lead on the transition and progress being achieved through investments into research and infrastructure

[17] Government of the Netherlands (2016) *A Circular Economy in the Netherlands by 2050*. Available at: https://www.government.nl/documents/policy-notes/2016/09/14/a-circular-economy-in-the-netherlands-by-2050

2.2.2.2 Medium-term: Models for policy innovation sandboxes

Some economies have started developing new policies for circularity and they are being tried and tested through 'innovation sandboxes' (for example, through city transformation programs). Innovation sandboxes are being used internationally to examine real (and perceived) barriers and impacts of new policies through safe, real-world trials. A better knowledge and understanding of how these work can help governments establish and fund policy innovation sandboxes for circular infrastructure to support the evolution of new standards and regulation.

Example: Horizon 2020 – Driving Research and Innovation

In the EU, Horizon 2020 was developed to drive research and innovation. The purpose was to reduce barriers to innovation (red tape) and to facilitate collaboration between the public and private sectors. Its ultimate aim was to ensure "new projects get off the ground quickly – and achieve results faster." [18] Between 2014 and 2020 it provided, early, €80 billion of funding.[19] Horizon 2020 has been used to fund and develop innovative solutions to address circularity, however, it is not used exclusively to facilitate circularity. To date, Horizon 2020 has been used to fund circular approaches to the construction, electronics, waste management, and plastic packaging sectors.[20]

2.2.2.3 Long-term: Reform around policy and regulation

Data on the economic case for circular infrastructure and policy innovation sandboxes would provide the basis to reform policy and regulation. In turn this would support widespread adoption of circularity by changing the behaviour, culture and capability of the industry, and incentivise further investment into this space. GI Hub research has highlighted many opportunities across the infrastructure lifecycle for policy and regulatory interventions, from policies that drive change in infrastructure planning through to innovative funding and financing.

MDBs, and in some cases bilateral lenders can work with national governments to develop innovative blended financing solutions for infrastructure circularity. Due to the relative infancy of the circular infrastructure landscape, these financing solutions are not currently in existence. Based on GI Hub research, there appears to be strong interest from the multilateral community to look at opportunities around this topic.

Example: Green Deal for Circular Procurement

Since 2013 the Green Deal for Circular Procurement in the Netherlands has been stimulating circular economy initiatives. The program encourages collaboration between public and private sector parties to foster a procurement regime inspired by circular principles. In just three years,

18 European Commission (2020). What is Horizon 2020? European Commission. Available at: https://ec.europa.eu/programmes/horizon2020/what-horizon-2020

19 European Commission (2020). What is Horizon 2020? European Commission. Available at: https://ec.europa.eu/programmes/horizon2020/what-horizon-2020

20 European Commission (2021) Circular economy innovations for industrial and urban waste management. European Commission. Available at: https://cordis.europa.eu/article/id/411500-circular-economy-innovations-for-industrial-and-urban-waste-management

> 80 circular economy pilot projects were undertaken with the key lessons learned shared to encourage further uptake. [21]

2.2.3 Models for technological innovation

Technology is essential in the transition to a circular economy as it will fast-track the transition and make circular business models economical at scale. Circular infrastructure technologies are already being developed and implemented by the private sector; albeit on a sporadic and ad-hoc basis. Furthermore, a marketplace for circular products and materials in infrastructure is at a low-level of maturity. However, as determined through the various stakeholder engagements that the GI Hub has undertaken through this initiative, the appetite from the private sector to grow these early stage opportunities is high. The key knowledge gap to be addressed are to identify effective models for technological innovation and how these can be implemented effectively.

Growing these early stage opportunities is where governments can play an active role by incentivising innovation across the lifecycle (e.g. formalising marketplaces for circular materials) through new standards and regulation and by funding innovation sandboxes to test and refine new initiatives. This creates momentum across the industry, leading to the establishment of an innovation ecosystem of experts, suppliers and policymakers collaborating to develop and deliver innovative solutions for circular infrastructure.

The technological innovation transition pathway is explored in more detail below with examples of where countries are successfully implementing a short, medium or long-term objective for infrastructure's transition to a circular economy. This pathway is centred around three areas:

- Supporting the incubation of technology
- Procuring and applying new technology
- Scaling technology through international marketplaces

2.2.3.1 Short-term: Supporting the incubation of technology

Technological innovation is critical to the circular economy transition as it provides the infrastructure solutions that enable the integration of circularity principles across the infrastructure lifecycle.

Circular infrastructure technologies are already being developed and implemented by the private sector; albeit on a sporadic and ad-hoc basis, with some venture capital being invested into technologies supporting the 6R circularity principles[22]. Examples of technology that are facilitating the implementation of circularity principles include fourth industrial revolution, smart infrastructure and green infrastructure technologies. There is appetite from the private sector to scale these early-stage opportunities; however, support is needed from national governments. Governments can play an active role at spurring technology

21 European Commission (2017). Public procurement for a circular economy: good practice and guidance. Available at: https://ec.europa.eu/environment/gpp/pdf/cp_european_commission_brochure_en.pdf

22 The 6R circularity principles refer to the ways that the economic loop can be closed in order to establish a circular economy. The principles are to refuse (1) or significantly reduce (2) the amount of new materials entering the system. This is achieved by 'closing the loop' – by maximising the amount of materials recovered and subsequently reused (3), repaired and refurbished (4) and recycled (5) back into the system. Residual (6) material that can no longer be reused or recycled is that for which the only available pathways are to extract the embedded energy (e.g. through waste-to-energy) or to safely dispose. Further details can be found in our thought piece

research and development to support the scaling up of key technologies across the asset life cycle[23] and knowledge can be built around effective models in achieving this. This would help incentivise the incubation stage, for example through direct fiscal support or dedicated funds, that could leverage blended finance. Blended finance in this context is concessional donor funds that are used to mitigate and reduce certain risks in order to mobilise private investments in certain environments.[24] Governments can also assist through the aggregation of market demand for innovative circular infrastructure solutions. Governments can also assist by adopting technologies across their infrastructure portfolio and by sharing the outcomes and lessons learned through the adoption process to encourage others to do the same.

Example: MDBs financing circularity

MDBs can play a role in helping promote technological innovation. The IFC's Blue Loans to Indorama are an example of MDBs funding circular projects. Reaching financial close in 2020 this USD$300m loan was the first dedicated to diverting waste from the marine environment. The loan is aimed at improving the recycling capability of the world's largest producer of 100% recyclable PET. The loan targeted improvements in the recycling capacity of the organisation in five countries while also faciltiating investments in securing more renewable energy and funding a waste heat recovery project. The IFC's financing package included a USD$150m loan from IFC, and a $150m loan from the Asian Development Bank and the German Investment Corporation (DEG). The loan is an example of how MDBs can promote technological innovation and help fund a transition to a more circular economy.[25]

Example: Waste-to-Wealth Swachh Bharat Unnat Bharat initiative

Through the Waste-to-Wealth Swachh Bharat Unnat Bharat initiative India aims to identify, develop and deploy technologies (national and international) for treatment of waste to generate energy, recycle materials and extract resources for the purpose of creating a viable circular economy ecosystem. Pilot projects are being rolled out in 14 locations across India and they receive professional and technical assistance from state governments, local municipalities and research and development institutions to field test the technologies.[26]

2.2.3.2 Medium-term: Procuring and applying new technology

National governments can play a pivotal role in increasing the adoption of new technologies that will lead to new markets and ecosystems of innovative circular solutions providers. Adoption of new technologies does not necessarily cost more than conventional solutions (in some cases it may even cost less, based on evidence presented at the April IWG workshop). National governments can also advance circularity by taking action to support investment in infrastructure that applies new technology. This can include:

23 G20 Infrastructure Working Group (2020). G20 Riyadh InfraTech Agenda. Available at: https://cdn.gihub.org/umbraco/media/3008/g20-riyadh-infratech-agenda.pdf

24 International Finance Corporation (2021). Blended Concessional Finance. International Finance Corporation. Available at: https://www.ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/bf

25 International Finance Corporation (2020) *New Blue Loan to Help Indorama Ventures Recycle 50 Billion PET Bottles a Year by 2025*. Available at: https://pressroom.ifc.org/all/pages/PressDetail.aspx?ID=26079

26 Invest India (2021) Swachh Barat Unnat Bharat. Invest India. Available at: https://www.investindia.gov.in/swachh-bharat-unnat-bharat

- Governments piloting new technologies within infrastructure portfolios
- Leveraging government buying power to incentivise scalable adoption
- Reforming government procurement processes to be focused on outcomes and by working closely with technology experts to encourage innovative approaches.[23]

To achieve circularity there will have to be a mindset shift amongst those that procure infrastructure. GI Hub research and subsequent rounds of stakeholder consultation has uncovered procurement as one of the more important incentives for driving circular practices in infrastructure.

Example: Technology Commercialisation Fund

Governments around the world established commercial viability of renewable energy technologies through funds and programs that invested in maturation, commercialisation and industry uptake of promising technology solutions. For example, the US Office of Technology Transitions has a Technology Commercialization Fund (TCF), which provides federal research and development investments to technologies that have commercial potential to help them mature and find their way to a viable market. TCF identifies prospective industry partners and helps those partners evaluate those technologies for their business models. This is an example of the work that has driven innovation in the renewables sector. To facilitate innovation in the circular economy space TCF could be expanded beyond renewables. Alternatively, a similar initiative to TCF could be created specifically for circular economy initiatives.

Example: Carbon Circular Economy

Carbon Circular Economy (CCE) forms part of a comprehensive transition to a circular economy through the inclusion of 'remove' to the three 'R' framework. In 2020, the G20 Leaders also supported the circular economy by endorsing the Circular Carbon CCE Economy Platform as a tool to manage emissions and foster access to energy. The Circular Carbon Economy involves the removal of carbon from the atmosphere through direct air capture and sequestration and through natural (carbon sinks) such as mangrove forests.[27] The removal of carbon from the atmosphere is an area that will require the further refinement of technology, particularly in hard-to-abate industries, yet can be 'an essential bridge to a low-carbon future'.[28]

2.2.3.3 Long-term: Scaling technology through international marketplaces

The next step in scaling technological innovation is the aggregation of market demand for innovative circular infrastructure solutions. Governments can influence this outcome by continuing the adoption of technologies across their infrastructure portfolio, and by sharing the outcomes and lessons learned to encourage others to do the same. This would help scale the supply and demand and establish international

27 ARAMCO (2021) The Circular Carbon Economy. ARAMCO. Available at: https://www.aramco.com/en/making-a-difference/planet/the-circular-carbon-economy

28 Mansouri et al (2020) A carbon management system of innovation: Towards a circular carbon economy. G20 Insights. Available at: https://www.g20-insights.org/policy_briefs/a-carbon-management-system-of-innovation-towards-a-circular-carbon-economy/

marketplaces for technological innovation with proven products and services (supported by ongoing research and development) that can be feasibly integrated into the infrastructure lifecycle.

Example: Scottish Material Brokerage Service

The Scottish Government set up the Scottish Material Brokerage Service to aggregate contracts for the three million tonnes of secondary materials collected annually across 200+ public bodies into a robust and cost-effective supply chain.

2.2.4 International collaboration

International collaboration will facilitate better shared knowledge and experiences and help work towards a common goal. International collaborative action can benefit all the transition pathways. Collaboration can speed up technological innovation, ensure more robust national policy and result in the lessons learned from data being more quickly and efficiently assessed. The international collaborative action pathway is centred around three areas:

- Raising awareness on the circular infrastructure benefit
- Developing a collective international vision
- Adopting effective circular frameworks

2.2.4.1 Short-term: Raising awareness on the circular infrastructure benefit

Raising awareness of the cost of inaction and the benefits of circular infrastructure approaches could create a sense of urgency that triggers the transition to circular. Both government and the private sector have a role to play in raising awareness, and the establishment of a taskforce of key stakeholders across the industry can help make this happen.

Example: More Plastic than Fish in the Sea

The Ellen MacArthur Foundation has published evidence of the magnitude of the use of plastic and resulting environmental impacts which captured the world's attention. Analytical studies demonstrated the gravity of the issue and need for action by forecasting the impact of existing trends on natural resources and how a circular approach could limit the adverse consequences[29]. This evidence played an important role in changing the global debate on plastics and delivering effective marketing campaigns. It also helped mobilise a systemic shift towards a common vision for a circular economy for plastic, with both governments and industry reinforcing each other on the path to making it a reality.[30]

2.2.4.2 Medium-term: Developing a collective international vision

Learnings from data disclosure, national strategies and pilots of new technologies could lead to more informed views of the scalable opportunities and next steps needed to advance circularity through infrastructure. This information can be used to develop a collective international vision for circular

29 See the New Plastics Economy reports published in 2016 and 2017, and Breaking the Plastic Wave: The circular economy solution to plastics problem study published in 2020.

[30] Ellen Macarthur Foundation (2018) *The New Plastics Economy: Rethinking the future of plastics & catalysing action*. Available at: https://ellenmacarthurfoundation.org/the-new-plastics-economy-rethinking-the-future-of-plastics-and-catalysing

infrastructure – a role that could be taken on by the G20. In setting a collective vision, international commitment could further support the large-scale adoption of circular practices across regions and the globe.

Example: Make Fashion Circular

Currently there are no collective international visions for circular infrastructure, but the Make Fashion Circular initiative provides an example in another sector (the new textiles economy). In May 2017, Make Fashion Circular was launched at the Copenhagen Fashion Summit. The initiative, led by the Ellen MacArthur Foundation, brings together leaders from across the fashion industry, including brands, cities, philanthropists, NGOs, innovators, and citizens. A vision for a circular economy for fashion was formalised and published in 2020.[31]

2.2.4.3 Long-term: Adopting effective circular frameworks

Research by the International Monetary Fund has shown that a 'synchronised' approach to infrastructure investment across the G20 can achieve two-thirds more growth at the same cost than if a country acts in isolation.[32] Mainstream solutions and international best practices will emerge with the maturity of the circular economy transition in the infrastructure space. The clear 'winners' in terms of solutions are those practices that can be scaled by adapting to a local context. International coordination in the development and implementation of these circular frameworks could amplify the benefits derived from policy reform.

Example: Circular Economy Standards (ISO)

In 2019 the International Organization for Standardization (ISO) established a working group with representatives from 65 countries to create a set of standards for a circular economy. The standards will cover "all aspects of a circular economy including public procurement, production and distribution, end of life as well as wider areas such as behavioural change in society, and assessment, such as some kind of circularity footprint or index."[33]

2.2.5 Pathways forward

Building sufficient knowledge and understanding of the impacts that circular infrastructure can support the transition of infrastructure towards a circular economy.

Transitions can start with raising awareness through data on the economic, environmental and social benefits that circular infrastructure could have. This can lead to further actions in the short-term, including the development of strategies for circular

31 Vision-of-a-circular-economy-for-fashion, Ellen MacArthur Foundation, 2020. Available at URL: Vision-of-a-circular-economy-for-fashion.pdf
32 International Monetary Fund (2020) How a Collective Infrastructure Push Will Boost Global Growth. International Monetary Fund. Available at: https://blogs.imf.org/2020/11/24/how-a-collective-infrastructure-push-will-boost-global-growth/
33 ISO (2019). Connecting the dots in a circular economy: a new ISO technical committee just formed. ISO. Available at: https://www.iso.org/news/ref2402.html#:~:text=ISO%2FTC%20323%2C%20Circular%20economy%2C%20aims%20to%20cover%20all,of%20circularity%20footprint%20or%20index.

infrastructure and the identification of initiatives and innovative technology solutions which can be tested and evaluated in the medium-term.

The actions undertaken in the short-term create the momentum for activities in the medium-term. In the medium-term, it is anticipated that initiatives and innovative solutions can be applied, tested and evaluated to determine the most impactful solutions that would ultimately be scaled and implemented. Furthermore, the data insights uncovered in the short-term would be used to enable alignment with existing impact frameworks and a wider voluntary and non-binding disclosure of data in the medium-term. In addition, policy innovations that support circularity could be explored. Together, this would drive momentum towards an international collective vision for advancing the circular economy through infrastructure.

The long-term actions for circular infrastructure are focused on scaling and replicating the solutions that have been proven in the medium-term. What was once innovative policy and regulation would now be considered as best practice and able to be adapted to a local context. Lastly, the most promising technologies are commercialised and scaled, accompanied by innovative delivery models that disrupt current practices. The result is a global marketplace of established products and services (continuously being developed and improved) that can be feasibly integrated across the infrastructure lifecycle.

The development of data-based evidence, national strategies, knowledge bases, and new innovations are necessary elements of the transition that will set the stage for scaling of circular economy markets and uptake by stakeholders.

3 Conclusions and way forward

The circular economy has potential to address major global challenges such as: 1) mitigating climate change and 2) mitigating the risk of resource scarcity while also generating economic, environmental and social co-benefits. GI Hub research undertaken for this roadmap has shown that infrastructure has a key role to play in advancing those circular economy outcomes and that **circular infrastructure could be a strong enabler in achieving the G20's sustainable infrastructure priorities.**

This roadmap provides transition pathways build knowledge and understanding of the potential impact of circular infrastructure in line with the G20's sustainable infrastructure priorities. Four key transition pathways were identified, centered around:

These four transition pathways were broken up into voluntary and non-binding short, medium and long-term considerations, which aim to achieve the stated objective for this roadmap. The short-term considerations outlined under each of the transition pathways could form the basis of a forward workplan for governments looking to progress their understanding on the topic of circular economy. These short-term considerations include:

- **Data-based evidence: Collecting data-based evidence on impact for circular infrastructure –** This aims to encourage public and private sector partners to share datasets and data insights on circularity that can be provided on a voluntary and non-binding basis to help stakeholders better understand where impact can be achieved and how others in the industry have defined circular infrastructure and its desired outcomes.
- **Innovative policies: Innovative national and sectoral strategies –** Raising awareness of innovations around policy could help governments develop national and sectoral strategies for circular infrastructure, which would needed in the short-term to identify and prioritise initiatives. It would also send a signal of commitment to investors, encouraging further investment into circular infrastructure.
- **Models for technological innovation: Supporting the incubation of technology –** Technological innovation is critical to the circular economy transition and there is appetite from the private sector to scale these early stage opportunities.

Governments can play an active role by implementing national policies aimed at spurring technology research and development to support scaling up of key technologies across the asset life cycle[34] and knowledge can be built around effective models in achieving this. This would help incentivise the incubation stage, for example through direct fiscal support or dedicated funds that could leverage blended finance.

- **International collaboration: Raising awareness on the circular infrastructure benefits -** Raising awareness of the cost of inaction and the benefits of circular economy approaches could create a sense of urgency that triggers the transition. A taskforce of key stakeholders across the industry can help make this happen.

3.1 Next steps

This roadmap was designed to advance the G20's knowledge and understanding of infrastructure's potential role in enabling the circular economy. The transition pathways proposed in this roadmap are voluntary and non-binding and intended to be applied taking into consideration specific national circumstances.

The GI Hub aims for the work on circular infrastructure to be ongoing beyond the submission of this final roadmap at the IWG in September 2021. The GI Hub is planning to assemble a select group of subject matter experts to further develop the data-based evidence around circular infrastructure and to share some of these learnings with the broader industry. The aim of this GI Hub initiative is to gather a pool of evidence in support of circular infrastructure and identify potential strategies for circular infrastructure that could be considered by policymakers and practitioners across the infrastructure lifecycle. G20 members are welcome to participate in this group. To express your interest, please contact Katharina Surikow at Katharina.surikow@gihub.org.

Further to this, the GI Hub aims to develop strategic partnerships with key players within the infrastructure and circular economy sectors to help operationalise this roadmap to suit local requirements and contexts.

[34] G20 Infrastructure Working Group (2020). *G20 Riyadh InfraTech Agenda*. Available at: https://cdn.gihub.org/umbraco/media/3008/g20-riyadh-infratech-agenda.pdf

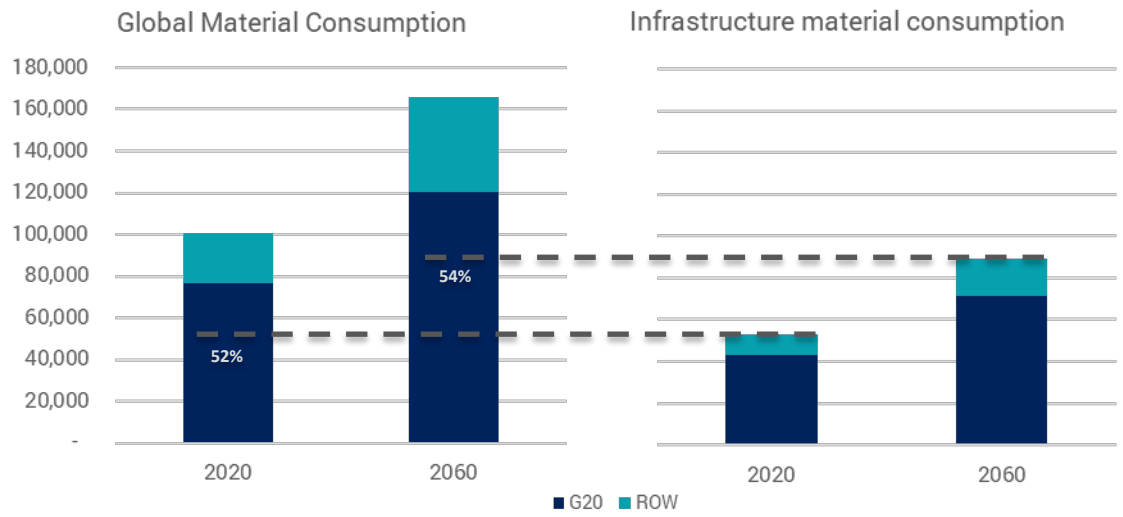
Appendix A - Summary of investment, material demand and GHG emissions in infrastructure

Embedding circularity principles into the design, construction and ongoing maintenance of the world's infrastructure would lessen the demand on materials and address potential resource depletion and regional resource scarcity issues, thereby reducing waste and pollution and the carbon emissions associated with the production and supply of materials.

Globally, across all sectors, 170 billion tonnes of material are expected to be used by 2060.[35] The G20 economies alone are expected to consume 70% of this material within the same period. Infrastructure would consume more than half of this projected material demand. [36,37] The steady increase in material consumption is resulting in natural resource depletion and accumulation of waste and pollution and will contribute further to carbon emissions around the world.

Globally infrastructure is expected to consume 54% of all materials in 2060, a slight increase from a share of 52% in 2020. Infrastructure being such a large consumer of materials has the potential to have a significant impact on future material demand if circular principles are adopted.

Figure 3: Material Consumption: Share of Infrastructure sector



Source: Global Infrastructure Hub analysis based on data from the International Resource Panel [38]

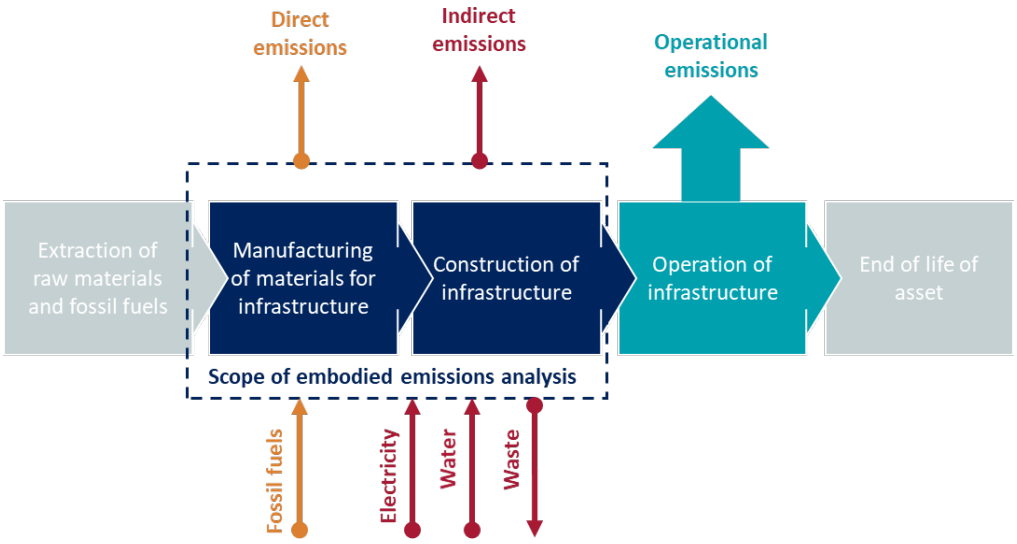
Related to the consumption of materials, infrastructure's contributions to global GHG emissions are also notable both in terms of the operation of infrastructure as well as the embodied carbon contained in its materials. The GI Hub undertook a high level analysis of GHG emissions related to infrastructure to better understand the embodied emissions portion, with the purpose of starting a conversation on areas of the infrastructure lifecycle that could have the highest impact on circularity.

The definitions for operational and embodied carbon in infrastructure for purposes of this roadmap are shown in Figure 5. Operational emissions are GHG emissions from the use of infrastructure (e.g. electricity use in buildings or emissions from

[35] Employing a population, urbanization and economic growth scenario based on the Socio-Economic Pathways 2 of the IPCC 'Middle of the Road Scenario'
[36] Materials for infrastructure include iron and steel, concrete, bricks, non-ferrous metals, and structural timber
[37] In 2020, infrastructure is expected to consume 52% of the world's resources. This is expected to increase to 54% in 2060. Other major contributors to global material usage include fossil fuel extraction and biomass.
[38] The data presented above (which is explained in more detail in the Appendix) was based on evidence already available in the public domain. It is derived from resource, waste and greenhouse gas emissions models for supply chain activities across a range of sectors. While this pre-existing work is compelling, it does not disaggregate by infrastructure related activities. This is explored further in the next section.

vehicles on roads), while embodied emissions are emissions from the materials component of infrastructure, and this includes manufacturing of materials and construction of infrastructure.

Figure 5: Scope of GI Hub's Embodied Emissions Analysis



In order to undertake a high level assessment of the embodied emissions impact of infrastructure, a review of existing literature was undertaken to identify credible sources of the annual contribution of the primary materials infrastructure sectors as well as the relevant GHG emissions / intensity factors for these primary materials under each stage of the lifecycle. This included emissions rates and factors on direct and indirect emissions from various inputs and outputs into the system as shown in Figure 5. The resulting assessment was triangulated to existing global GHG databases (i.e. CAIT Climate Data, EDGAR and Our World in Data) for verification. This triangulation allowed a split between infrastructure operational emissions, infrastructure embodied emissions and non-infrastructure (both operational and embodied) emissions.

Definitions used for this high-level analysis:

- **Infrastructure**: includes public and private, economic and social infrastructure covering roads, bridges, railways, hospitals, schools, communications, electricity generation and transmission, water and waste infrastructure. Vehicles or rolling stock have not been included at this stage.
- **Embodied emissions from infrastructure**: refers to the direct and indirect GHG emissions associated with the manufacturing of materials for infrastructure and its construction. This is shown diagrammatically in Figure 5.
    - **Direct emissions** – these are emissions generated on-site during manufacturing and construction and includes emissions from chemical processes (in the case of cement) and burning of fossil fuels on-site for energy.
    - **Indirect emissions** – these are emissions generated by the off-site production of electricity, water and waste to service manufacturing and construction activities.
    - The focus to date has been on the largest emitters and it was determined that the emissions from the supply of water, wastewater and solid waste services are negligible for embodied carbon. Some of these are covered under operational emissions (see next).
- **Operational emissions**: refers to the GHG emissions associated with the use of infrastructure, including electricity consumed during the operation of the infrastructure asset, vehicle emissions in transport and emissions from water and waste infrastructure.

- **Other emissions**: refers to any GHG emissions within a non-infrastructure sector (see the tables below) that are not infrastructure related
- **GHG emissions**: Expressed as CO_2 equivalent emissions using the definition from the CAIT Climate Data Explorer[39]. This includes Kyoto GHGs (CH4, CO2, N2O, F-gases).
- **Non-infrastructure**: This refers to all other sectors in the economy besides infrastructure

A summary of the outputs from this high-level analysis is included below:

Table 1: GHG Emissions in Mt CO_2e

SECTOR	SUB-SECTOR	TOTAL 2018 EMISSIONS	OPERATIONAL EMISSIONS	EMBODIED EMISSIONS	OTHER (NON-INFRA) EMISSIONS
Energy	Electricity/Heat	15,591	6,855	840	7,896
Energy	Transportation	8,258	8,258	113	-113
Energy	Manufacturing/Construction	6,158	-	2,589	3,570
Energy	Fugitive Emissions	2,883	-	-	2,883
Energy	Buildings	2,883	2,883	-	-
Energy	Other Fuel Combustion	1,452	-	-	1,452
Agriculture	Agriculture	5,818	-	-	5,818
Waste	Waste	1,607	1,584	56	-33
Land-Use Change and Forestry	Land-Use Change and Forestry	1,388	-	-	1,388
Industrial Processes	Industrial Processes	2,903	-	1,401	1,501

Table 2: Percentage of total GHG emissions (% CO2e)[39]

SECTOR	SUB-SECTOR	TOTAL 2018 EMISSIONS	OPERATIONAL EMISSIONS	EMBODIED EMISSIONS	OTHER (NON-INFRA) EMISSIONS
Energy	Electricity/Heat	32%	14.0%	1.7%	16.1%
Energy	Transportation	17%	16.9%	0.2%	-0.2%
Energy	Manufacturing/Construction	13%	0.0%	5.3%	7.3%
Energy	Fugitive Emissions	6%	0.0%	0.0%	5.9%
Energy	Buildings	6%	5.9%	0.0%	0.0%
Energy	Other Fuel Combustion	3%	0.0%	0.0%	3.0%
Agriculture	Agriculture	12%	0.0%	0.0%	11.9%
Waste	Waste	3%	3.2%	0.1%	-0.1%
Land-Use Change and Forestry	Land-Use Change and Forestry	3%	0.0%	0.0%	2.8%
Industrial Processes	Industrial Processes	6%	0.0%	2.9%	3.1%

[39] Total GHG emissions were taken from the CAIT database (for 2018) available through ClimateWatch here

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