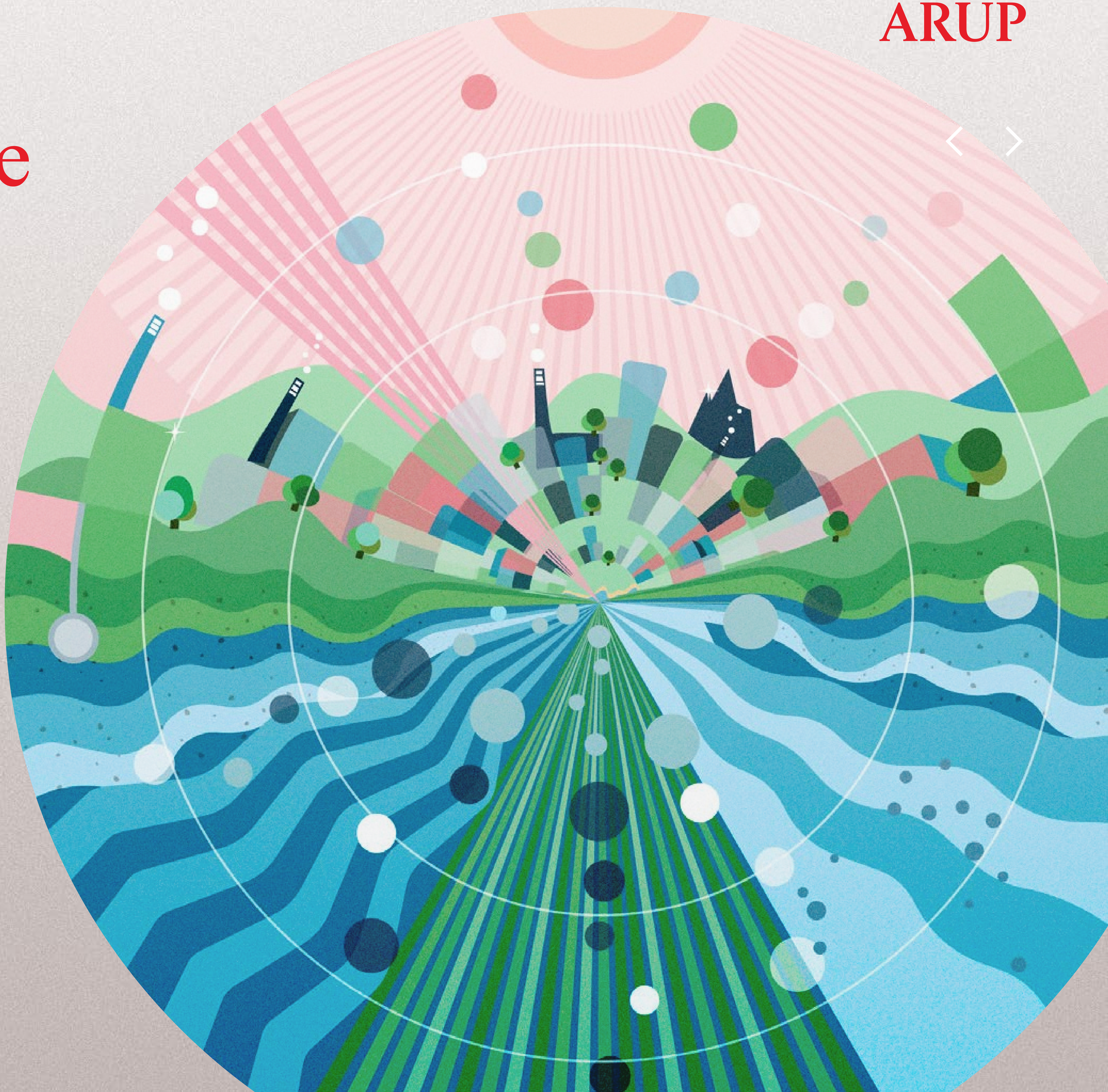
ARUP

Reduce, Restore, Remove

A Call to Action



Contents

Glossary

Carbon: All greenhouse gases, quantified in units of carbon dioxide equivalents (CO_2e) based on global warming potential. Also referring to elemental and 'fixed' carbon.

Embodied carbon: Carbon emissions associated with materials and construction processes throughout the whole lifecycle of an asset, including material extraction, transport to manufacturer, manufacturing, transport to site, construction, maintenance, repair, replacement, refurbishment, deconstruction, transport to end of life facilities, processing, and disposal.

Operational carbon: Carbon emissions associated with energy used to operate a building, infrastructure, or transport.

Whole life carbon: Carbon emissions resulting from the materials, construction and use of an asset over its entire life, including its demolition and disposal.

Built environment: The human-made surroundings that provide the setting for human activity, from buildings and parks to neighbourhoods and cities, including their supporting infrastructure, such as water, transport, and energy networks.

Burden shifting: When lowering environmental impacts in one stage of the life cycle results in counter-acting or negative environmental impacts in another stage of the life cycle, e.g. using a building material with low embodied carbon that has poor thermal performance shifts the burden to the operational stage by increasing energy demand for temperature regulation.

Decarbonisation: Reduction in carbon emissions from an activity or entity, such as the built environment.

Net zero: When the quantity of carbon emitted into the atmosphere equals the quantity of carbon absorbed from the atmosphere.

Foreword

We must repair our climate

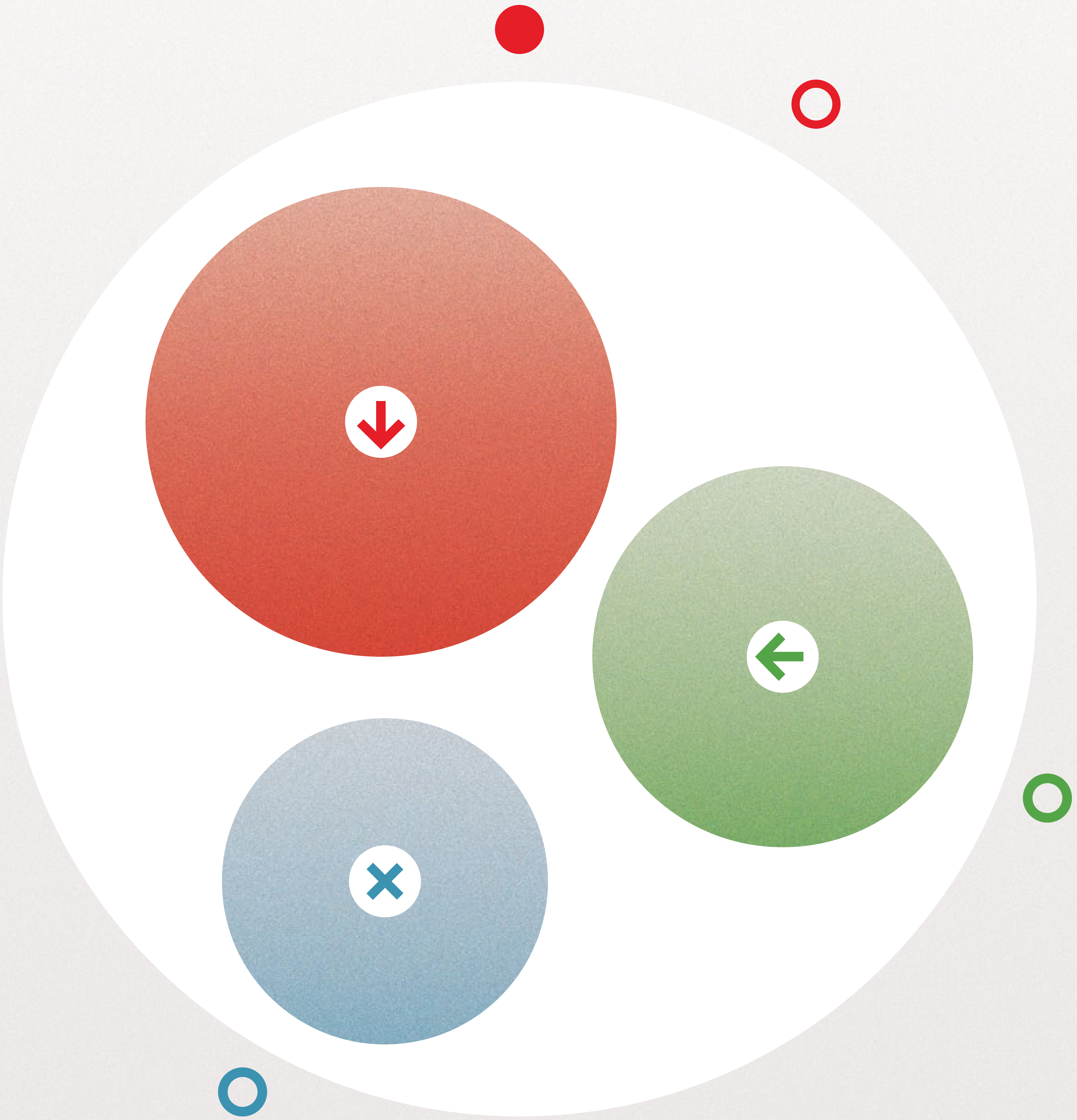
The target of limiting global warming to 1.5°C is almost out of reach. We must, and we can, repair our climate. There is no single quick fix but tackling the root cause comes down to the simple message: reduce emissions, restore the natural environment, and remove carbon from the atmosphere.

We have already put too much carbon into the atmosphere. We need to adapt to the effects we are already feeling and we need to find ways to buy time. But, unless we turn off the taps and widen the plughole at the same time, we are on course for disaster.

The built environment is associated with at least 40% of annual global carbon emissions. Leaders in this sector have not only an opportunity but also a moral duty to take action now that will have a massive impact on the future of our climate. Furthermore, the work we need to do provides a unique opportunity to contribute towards the United Nations' 17 Sustainable Development Goals – we can repair the climate while at the same time growing our economies, reducing poverty, tackling social injustice and reversing biodiversity loss.

I am delighted that Arup have put climate repair and a sustainable future at the heart of their strategy and purpose. The scale of transformation that is needed is unprecedented – to our way of life, our built environment and how we look after and use our natural resources. But the COVID-19 pandemic has shown us what we can achieve, rapidly and on a global scale, when faced with crisis. By working together as scientists, engineers, governments, businesses and communities, we can develop the solutions and take the urgent actions that are needed.

Dr Shaun Fitzgerald OBE FREng
Director, Centre for Climate Repair,
University of Cambridge



Introduction

We must act now

The evidence is unequivocal. Human activity is causing irreversible changes to our climate.

Between 2010 and 2019, average annual carbon emissions were at their highest levels in human history and they are continuing to rise.[1] Heatwaves, floods and droughts are becoming more frequent. Sea levels are rising. Ecosystems and species are being lost. People are being displaced and livelihoods threatened.

To avoid the worst effects of climate change we must limit the global average temperature rise to 1.5°C above pre-industrial levels.[2] However, at current rates of emissions, we will overshoot 1.5˚C by 2030 (Fig. 1) and current policies would see temperatures rise by around 2.7°C by 2100.[3,4] Decades of inadequate climate action mean that the scale of the problem grows as we emit more carbon into the atmosphere, and degrade forests, land and water bodies that act as natural carbon sinks.

The built environment is a major source of carbon emissions. The construction and use of buildings alone contributes around 40% of energy-related CO_2 emissions,[5] and has been a major cause of ecosystem loss. If we are to avoid catastrophe, we must act now. We must radically transform how we plan, design, construct and use buildings and infrastructure this decade. We must halt the loss of biodiversity and repair the damage already caused to ecosystems and the atmosphere.

This report is a call to action for those making or influencing decisions on the built environment and management of nature. It is for practitioners, policy makers, governments and businesses as they tackle the climate crisis. It focuses on three complementary strategies to stop and reverse the rise in atmospheric carbon, whilst acknowledging that other measures to mitigate, and adapt to, the impacts of climate change will be necessary. It provides guidance on the breadth of action needed and solutions that are available already or need to be considered. It emphasises the importance of a whole-system and whole-life approach, and of taking action now.

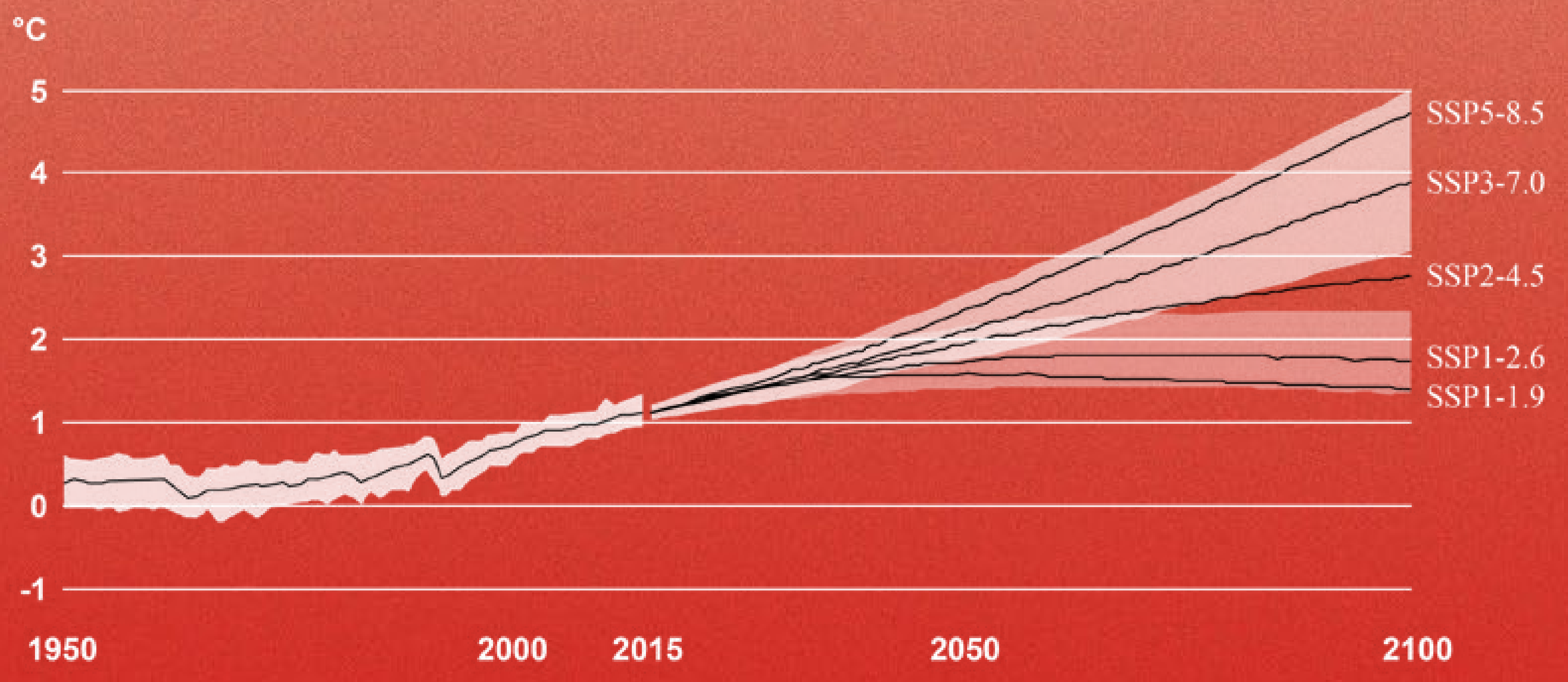


Fig 1. Global average surface temperature change
Relative to 1850-1900 for five emissions scenarios, from IPCC 2021 (figure SPM.8a)[6]

Introduction

A pathway through net zero

To limit warming to 1.5°C (with no or limited overshoot, as per scenario SSP1-1.9 in Figure 1), atmospheric carbon concentrations need to stop rising and go into reverse. They need to fall throughout the second half of this century, from a peak likely to be around 500ppm to 350ppm by 2100.[7]

First and foremost, we must ‘turn off the tap.’ The immediate priority is to slow down and ultimately stop the accumulation of carbon in the atmosphere through deep and rapid reductions in emissions. The trajectory matters; the slower we are to reduce emissions, the greater the warming. We need to achieve a 45% reduction in global CO_2 emissions from 2010 levels by 2030 and net zero CO_2 emissions by 2050, with concurrent deep reductions in emissions of other greenhouse gases, particularly methane.[8,9]

We will continue to add carbon to the atmosphere and what we have already emitted will continue to drive global warming for many years. Therefore, at the same time as reducing emissions, we must ‘widen the plughole.’

We need to restore the Earth’s capacity to draw carbon out of the atmosphere into natural stores such as oceans, lakes and forests. However, deep and rapid emissions reduction and ecological restoration are unlikely to achieve falling atmospheric carbon concentrations by 2050. Consequently, we also need to use technology and engineering to actively remove carbon from the atmosphere and ensure that it is permanently stored.[10]

A 1.5°C-compatible trajectory remains possible, but only with a profound and immediate global effort to decarbonise every aspect of human society, restore the health of our planet and remove carbon from the atmosphere.

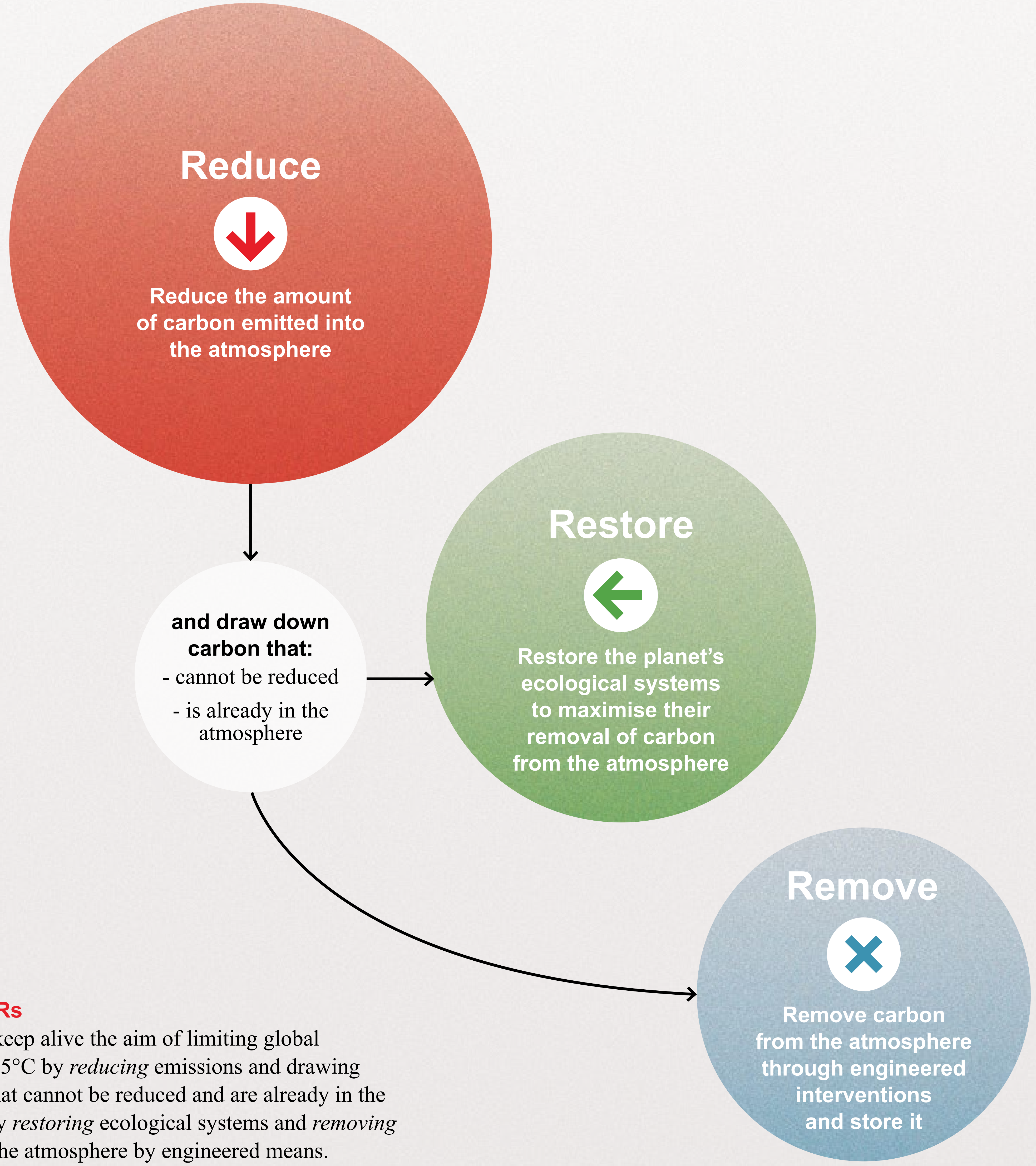


Fig 2. The 3Rs
We can only keep alive the aim of limiting global warming to 1.5°C by *reducing* emissions and drawing down those that cannot be reduced and are already in the atmosphere by *restoring* ecological systems and *removing* carbon from the atmosphere by engineered means.

A pathway through net zero

Due to the urgency and scale of action needed we need to deploy every reduce method in our arsenal now and in parallel scale up eco-sequestration and development of technologies to remove carbon. *Reduce* is essential to reversing the curve; *restore* and *remove* bend it more quickly (Fig 3):

– *Reduce* methods can and must be implemented today to have an immediate impact on the root of the issue

– *Restore* methods can and must be scaled up now so that nature recovers its potential to absorb carbon within a decade

– *Remove* methods must be carefully considered and developed simultaneously with reduce and restore so that the most appropriate methods can start to be deployed and their benefits realised within a decade.

Fundamental to a global reduction in atmospheric carbon concentrations is working at a whole-life and whole-system scale. Methods to reduce emissions or remove atmospheric carbon need to have a permanent impact and must not lead to an increase in emissions at a later date. A reduction in emissions in one sector or geography must not increase emissions in another.

Promoting transparency and accountability for emissions makes it harder to shift responsibility to other parties or into the future. This is vital if we are to achieve global net zero and then net negative emissions within the necessary timescales.

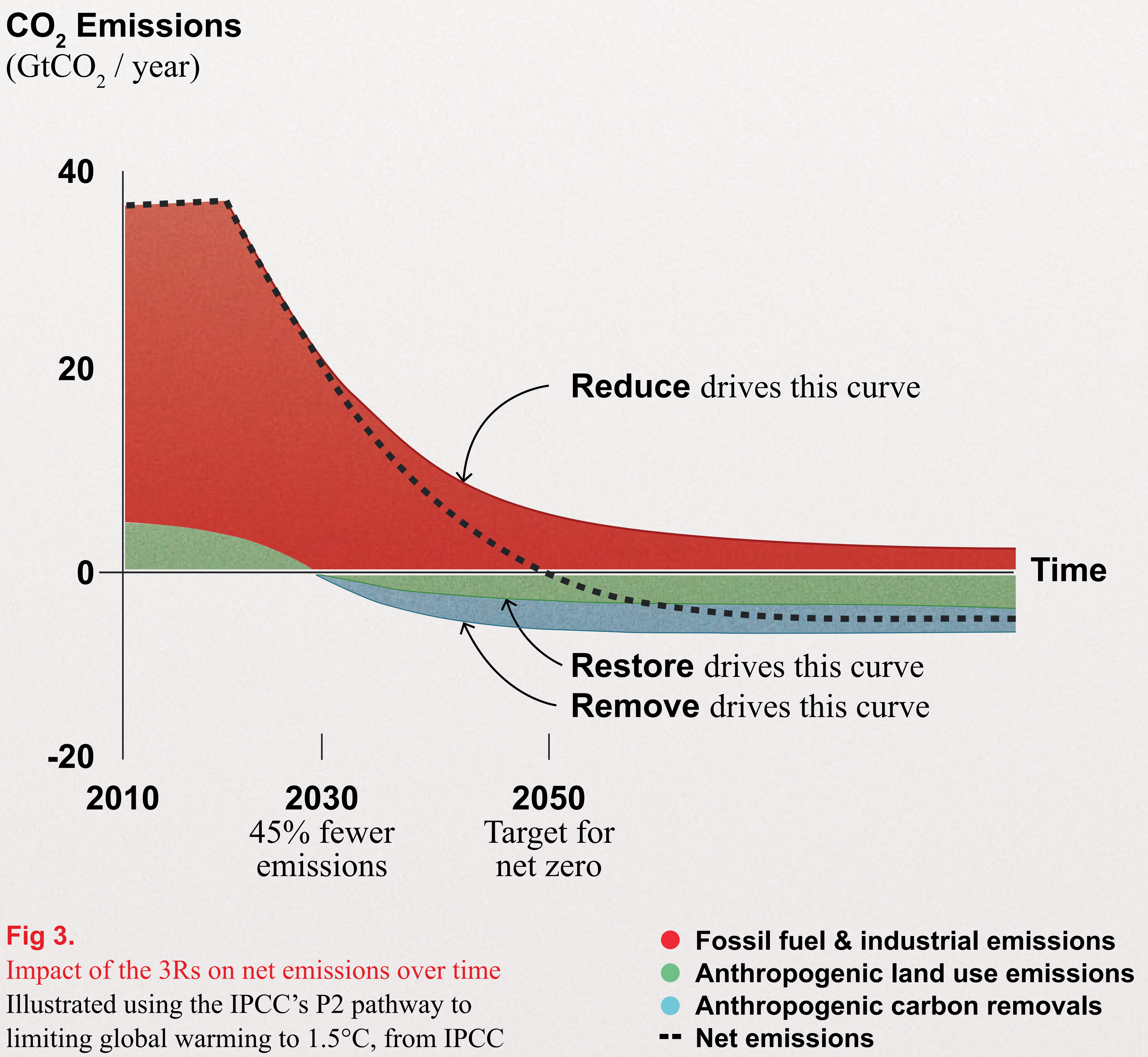


Fig 3.
Impact of the 3Rs on net emissions over time
Illustrated using the IPCC's P2 pathway to limiting global warming to 1.5°C, from IPCC 2018 (figure SPM.3b)[11]

A pathway through net zero

The steps needed to achieve net zero are shown in Figure 4. It is essential that every effort is made to reduce operational and embodied carbon as much as possible. Only then should restoring the natural environment and removing carbon from the atmosphere be used to offset residual emissions.

Policy and finance are now starting to create the necessary conditions to facilitate decarbonisation. Businesses are increasingly setting net zero commitments, transitioning away from use of and investment in fossil fuels, and including climate related financial disclosure in their reporting. Governments are setting ambitious targets driving nationwide action. In June 2017, Sweden became the first country to pass net-zero legislation.[12] 88% of global carbon emissions are now covered by national net zero targets, as is 90% of global GDP*. Simultaneously, advances in enabling technologies – from building and energy solutions to remote sensing and smart systems – are improving efficiency and design based on real-time data and supporting carbon monitoring and validation.

* As of 25 Nov 2021, after COP26. Net zero targets vary in status (10% of emissions are covered by a legally binding national target), date (45% of emissions are covered by a national target of 2050 or sooner), scope, use of offsets and governance.[13]

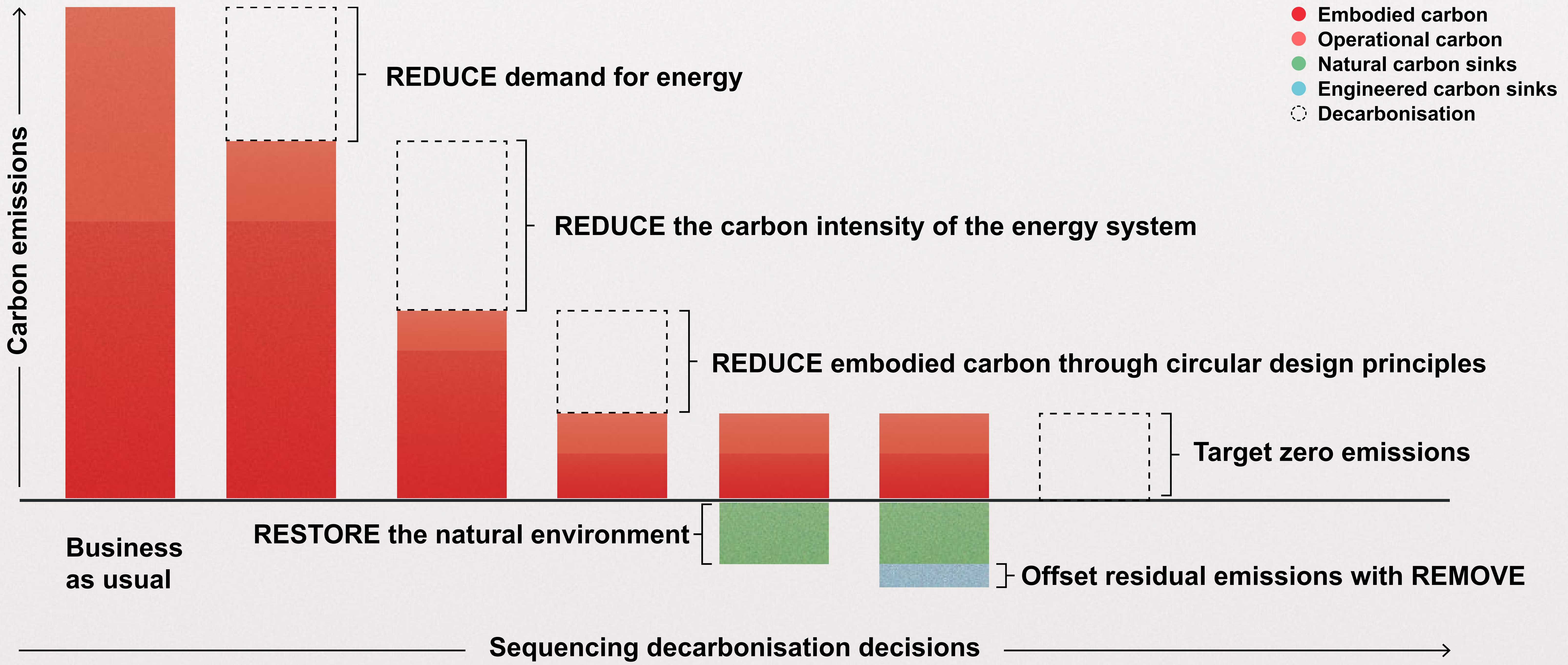
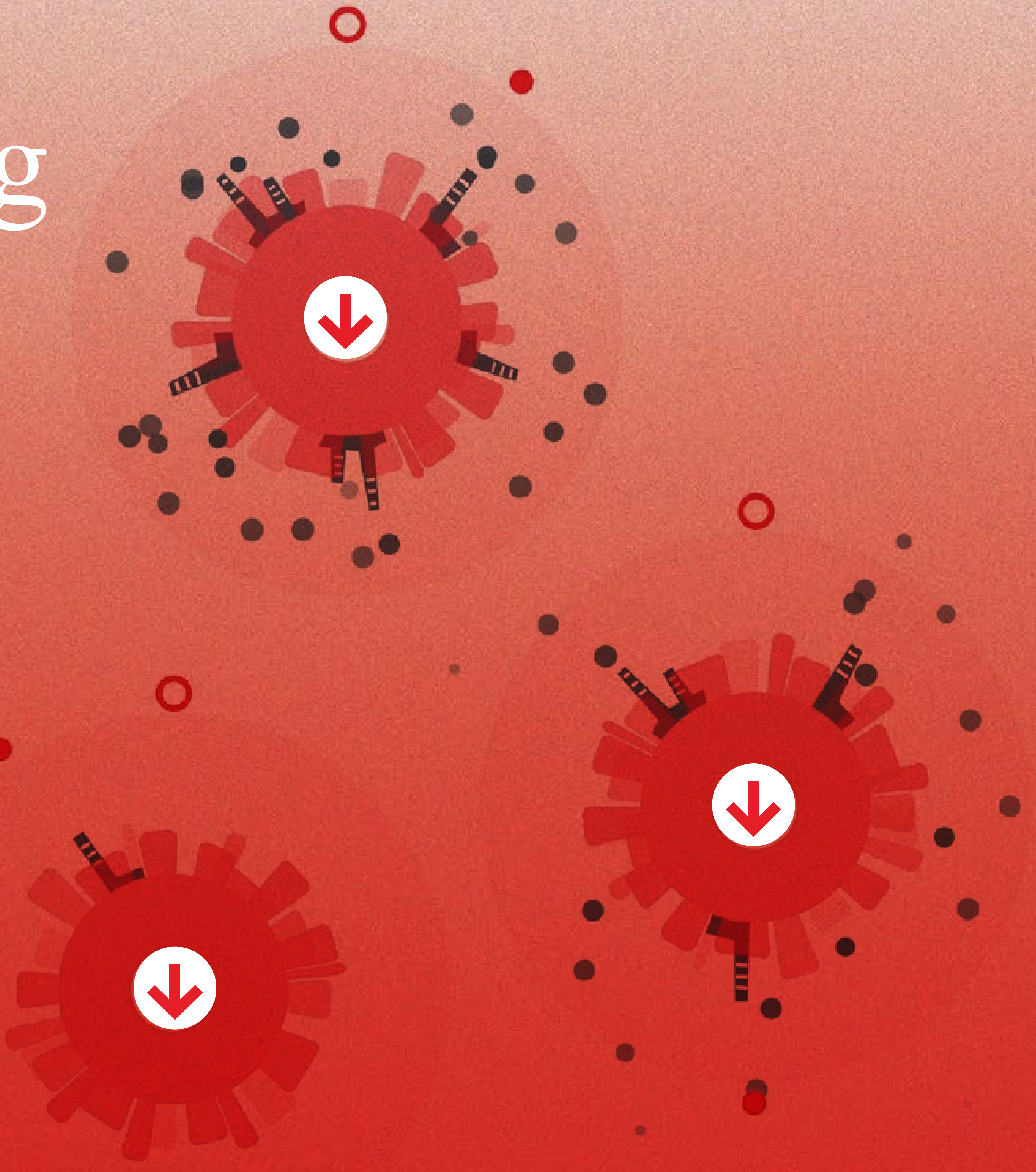


Fig 4.
The approach to decarbonisation in the built environment is important to limiting global warming.

Reduce

Reduce the amount of carbon being emitted into the atmosphere



The global priority for the next ten years is to rapidly and radically reduce carbon emissions in line with a 1.5°C future.

The pace and scale of the required shift will require a fundamental transformation of our systems. The necessary technology, skills and incentives to scale decarbonisation are emerging and financial flows are being redirected to accelerate the transition.

Reducing carbon must be undertaken on a whole-life, systems-level basis, addressing everything from electrification of energy networks to improving circularity of material flows and end of life emissions.

The most effective way to reduce emissions is to eliminate demand for energy by, for instance, using natural ventilation and smart-systems in buildings and shifting to active transport systems such as cycling and walking. We need to reduce overall demand as well as transition energy networks from fossil fuels to renewable energy sources as it is not possible to generate enough renewable energy in the next decades to meet current and rising demand. As operational carbon continues to fall due to advances in efficiency and cleaner energy sources, the relative contribution of embodied carbon will rise due to the challenges of decarbonising steel and concrete.[14]

Reduce

Reduce operational carbon

Addressing operational carbon must begin with reducing energy demand, and energy demand that cannot be reduced must be met with clean sources of generation.

1. Reduce energy consumption

Passive design: Reduce energy demand by optimising design to respond to and leverage local environmental conditions, such as orientation, insulation, ventilation, shading and topography.

Energy conservation and end-use efficiency: Change behaviours to reduce demand and design all systems – from heating and lighting to water distribution – to be as efficient as possible with good controls to maintain effective use. Ensure the operation of an asset is optimised throughout its lifecycle from commissioning, with effective monitoring (measurement and verification) and maintenance.

System of systems efficiency: Minimise wasted energy by optimising resource inputs and outputs at a systems scale. Avoid losses where energy is transferred between systems, such as water and heat. Reduce peaks in demand and ensure a responsive energy system using tools such as smart meters and storage.

Transport efficiency: Decarbonise transport through increased active mobility options and greater passenger efficiency.

2. Reduce carbon content of energy used

Decarbonisation of electricity: Switch to renewable sources of electricity generation to decarbonise grids at scale, such as wind, solar and tidal power.

Decarbonisation of heating and cooling: Reduce reliance on fossil fuels by electrifying heat-based systems powered by a clean grid, using heat pumps and switching to clean fuel sources. Systems should make use of all waste heat from industrial to municipal processes.

Decarbonisation of transport: Increase the penetration of electric vehicles with charging infrastructure and utilise alternative lower-carbon fuels.

Fuel switching: Switch to lower-carbon fuels, such as green hydrogen and biogas, particularly in hard to decarbonise sectors like aviation, shipping, heating and steel.

Carbon capture pre-combustion: Remove CO_2 from fuels before combustion is completed to produce hydrogen.

Oxyfuel: Burn fuel in pure oxygen where virtually all the waste gas is composed of CO_2 and water vapour, which can be condensed out to capture pure CO_2.

Carbon capture post-combustion: Capture CO_2 at the source of combustion from flue gas using solvents.

Reduce

Reduce embodied carbon

Minimising embodied carbon requires a combination of lean construction[15] and adopting circular design principles.[16]

3. Reduce embodied carbon

Build nothing: Challenge the root cause of the need to build and explore alternative approaches to achieve the desired outcome by better utilising existing assets.

Build less: Maximise the useful life of existing assets and optimise asset operation and management to reduce the extent of new construction required.

Build clever: Mitigate the embodied carbon of materials by re-using components and using carbon-storing biomaterials and low-carbon alternatives (e.g. timber instead of cement and steel).

Build efficiently: Utilise efficient design, material and construction processes for optimised performance to reduce material use and waste (e.g. offsite prefabrication, computational design, digital fabrication, advanced materials).

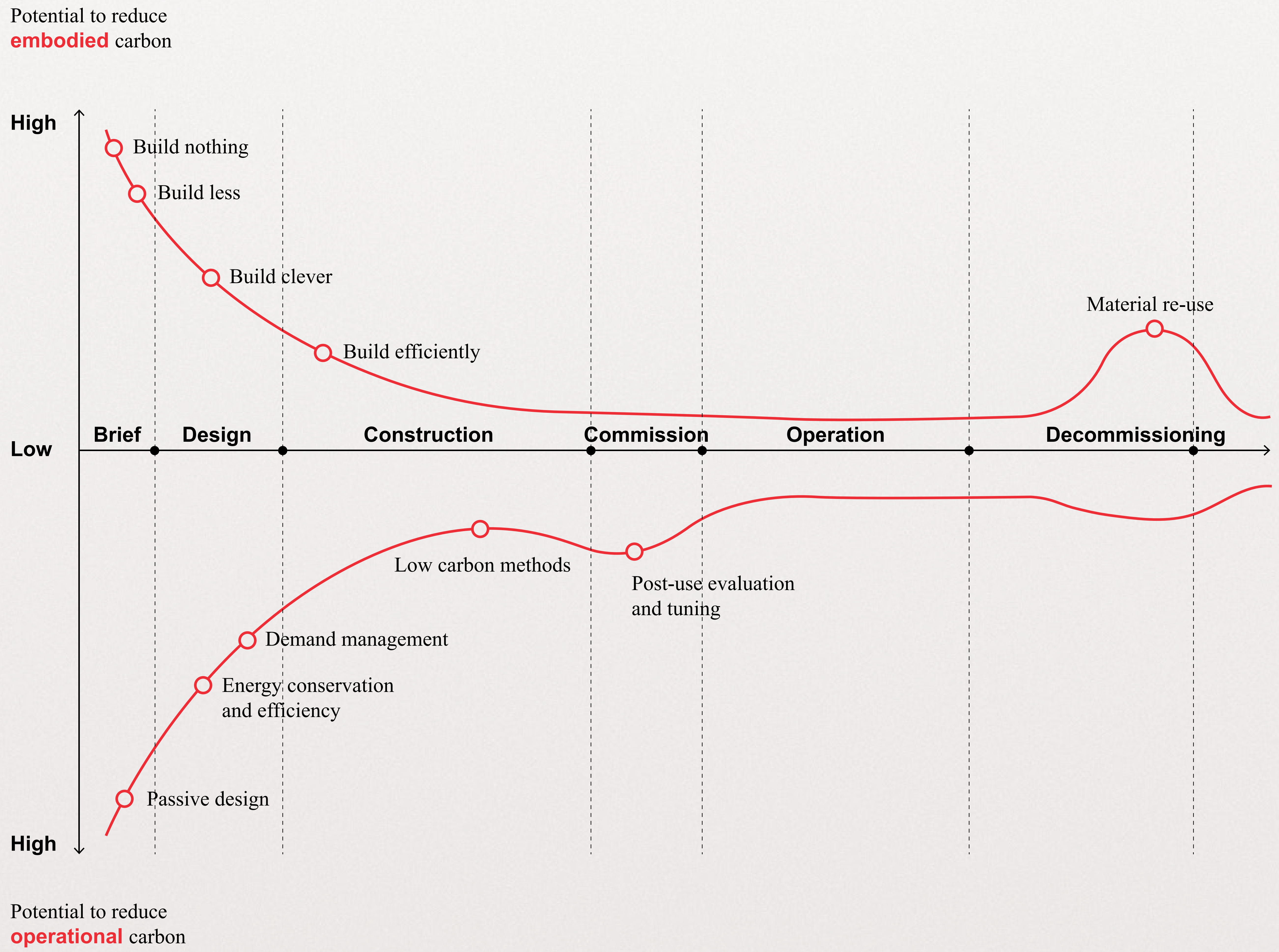


Fig 5.
Potential to reduce embodied and operational carbon through the lifecycle of an asset or system
More opportunities for reductions exist earlier in the project lifecycle. Adapted from HM Treasury / Green Construction Board.[17]

Reduce

Case study: Zero Carbon Building (CIC ZCB)

Onsite renewable energy generation (solar PV and biodiesel tri-generation from waste cooking oil) covers all operational requirements for this sustainable technology demonstrator building.

Surplus energy is exported to the grid to offset the embodied energy of construction and building materials (recycled materials and sustainable timber were prioritised). Passive design strategies, including a cross-ventilated layout, high-performance façade, and daylighting, reduce energy consumption by 20%. Advanced HVAC systems achieve another 25% in energy savings. The property includes Hong Kong's first native urban woodland, which reduces the urban heat island effect, sequesters carbon, and increases biodiversity with 220 native trees of over 40 species and a diversity of shrubs.[18]

Project: Zero Carbon Building (CIC ZCB)

Location: Hong Kong

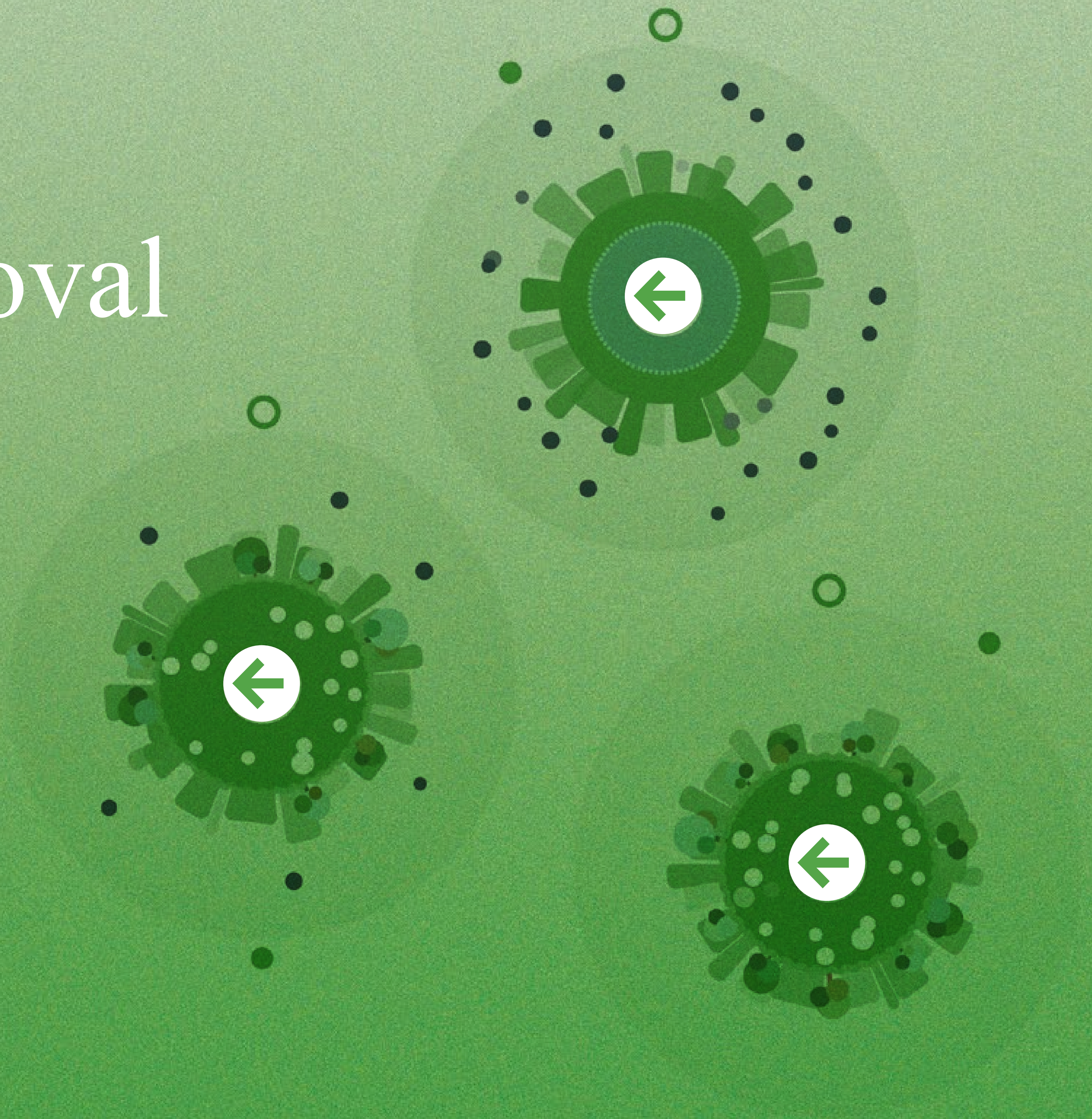
Restore the planet's ecological systems to maximise their removal of carbon from the atmosphere

Climate change and biodiversity loss are two of the most pressing challenges of our time and are intrinsically linked. By restoring nature, we can simultaneously mitigate and adapt to climate change.

Healthy ecosystems capture and store carbon in their biomass and soils – a process known as 'eco-sequestration.' At the same time, they provide resilience to the effects of climate change through increased food security, regulation of water flows and storm surges, reduced soil erosion, urban cooling and more.

Yet, 75% of the land-based environment and 66% of the marine environment have been significantly altered by human actions[19] (such as urbanisation, agriculture and resource extraction), turning many of these sinks into net emitters of carbon. In turn, climate change is accelerating the degradation of ecosystems (e.g. as a result of forest fires, thawing of permafrost, and drying out of wetlands). Approximately 25% of animal and plant species are threatened with extinction, equivalent to 1 million species over the next few decades.[20]

Halting the destruction of natural habitats and restoring nature has a vital role to play in limiting climate change.



Restore

Restore terrestrial ecosystems

Terrestrial ecosystems include forests, grasslands, tundra, peatlands and wetlands. Whilst forests could sequester up to 23% of global annual carbon,[21] some ecosystems, such as peatland and tundra, are even more effective carbon sinks on a per square metre basis. Similarly, soils cannot be overlooked in restoration: three times more carbon is stored in the top metre of soils than in all global vegetation combined.[22] Some of the most effective nature-based solutions to sequester carbon include:

Ecosystem protection: Stop the further loss and degradation of existing carbon-rich terrestrial ecosystems (especially peatlands, wetlands, forests, grasslands and savannahs) and prevent desertification to maintain existing carbon stores.

Reforestation: Restore natural forest habitats by replanting mixed native tree species and other measures to enhance biodiversity, whilst ensuring the involvement and support of local communities.

Peatland restoration: Re-wet degraded ecosystems. Peatlands store more carbon than all other terrestrial ecosystems in the world combined,[23] but they are a source of methane when drained for use.

Soil carbon sequestration and regenerative agriculture: Prevent soil erosion and improve soil quality by building up organic matter (stored carbon) in soil through improved management of cropland and grazing systems, such as soil conservation (e.g. cover crops, crop rotation, conservation tillage) and the reduction of fertilizer use and other chemicals that disrupt the biogeochemical processes of soil that underpin carbon storage.

Restore coastal and marine ecosystems

Around 83% of the global carbon cycle is circulated through the ocean.[24] Over the past 50 years, 20-30% of total anthropogenic CO_2 emissions have been absorbed by the ocean.[25] This has resulted in acidification which, coupled with ocean surface warming, coastal development, and resource extraction (e.g. fishing), has led to extensive degradation of coastal and marine ecosystems. Coastal ecosystems are important carbon stores and provide protection to the coastline from rising sea levels, storm surges and erosion. Consequently, the protection and restoration of coastal and marine ecosystems is a key action in the removal of atmospheric carbon and for climate adaptation.

Ecosystem protection: Avoid further degradation of existing carbon rich ocean sinks, especially coastal ecosystems such as mangroves, salt marshes, kelp forests and seagrass meadows; as well as deep water and polar blue carbon habitats.

Coastal habitat restoration: Restore coastal ecosystems such as mangroves, tidal marshes and seagrass meadows. Coastal habitats cover less than 2% of total ocean area, but account for around half of the total carbon sequestered in ocean sediments.[26]

Wild seaweed restoration and regenerative seaweed farming (restorative aquaculture): Restore seaweed (particularly kelp) forests including cultivation of biomass for carbon benefit, such as biochar or bioenergy with carbon capture and storage or latent transport to deep-sea sediments or coastal blue carbon habitats.[27]

Restore nature within urban areas

Urban areas can be used as catalysts of restoration by creatively incorporating nature into available surfaces and spaces. Reconsidering the design and use of urban environments can maximise carbon sequestration in developed areas from building to district scale. These nature-based solutions also provide wider benefits: they capture and store run-off; facilitate groundwater recharge; and provide cooling services which mitigate the urban heat island effect. They include:

Green infrastructure: Integrate a network of multi-functioning green spaces, including green roofs and walls, parks, and street trees.

Blue infrastructure: Naturalise rivers and restore and create wetlands. These ecosystems provide habitat to a range of photosynthesising organisms with high carbon sequestration rates.

Habitat restoration: Brownfield sites, roadsides, railway corridors, roofs, building facades and gardens all provide opportunities to create new habitat areas that will increase biodiversity and sequester carbon.

Restore

Case study: Community-based mangrove restoration

Mikoko Pamoja is a community-led conservation and restoration project which provides long-term incentives for sustainable mangrove management through community involvement and benefit.

The Gazi Bay mangrove ecosystem had been severely degraded due to demand for building materials and fuelwood. This overexploitation destabilised the surrounding ecosystem, evidenced by dwindling fish stocks, coastal erosion, and declining resilience to extreme weather.

The Mikoko Pamoja Community Organization incentivises improved management by raising income from forest resources, including carbon credits, beekeeping, and ecotourism, thus safeguarding the benefits of the mangroves for future generations. Carbon benefits are conservatively estimated at 2,500 tonnes CO_2/year from avoided degradation and new planting.[28]

Project: Mikoko Pamoja mangrove restoration

Location: Gazi Bay, Kenya

Remove carbon from the atmosphere through engineered interventions and store it

Remove refers to the large-scale removal of carbon from the atmosphere, and its subsequent storage, through technologies or enhanced natural processes.

This approach has been on the international policy agenda since the Intergovernmental Panel on Climate Change's "Global Warming of 1.5ºC" report, published in 2018, which stated that all 1.5ºC pathways would require some degree of large-scale carbon removal.[29]

Removal methods will be necessary in reaching net zero,[30] yet their role may be limited as none have been fully evaluated across their lifecycle nor applied at scale. Whilst some are already in use today, most still require significant development and therefore cannot be relied on as 'silver bullets.' The immediate actions are to invest in research and development to assess scalability, test cost-effectiveness and understand potential unintended consequences.

Remove

There are a range of engineered interventions being explored to remove carbon from the atmosphere. Some of these are illustrated in figure 6. The 'enhanced natural' end of the spectrum has methods which artificially drive or accelerate natural carbon storing processes, on land and in the open ocean. At the other end of the spectrum are technology-based methods centred around mechanical drawing-down and processing of atmospheric air to create a pure CO_2 stream which can be locked-up in products or injected underground. Some methods combine the natural process of CO_2 storage in biomass and technological extraction of this CO_2 to accelerate natural drawdown and increase storage time.

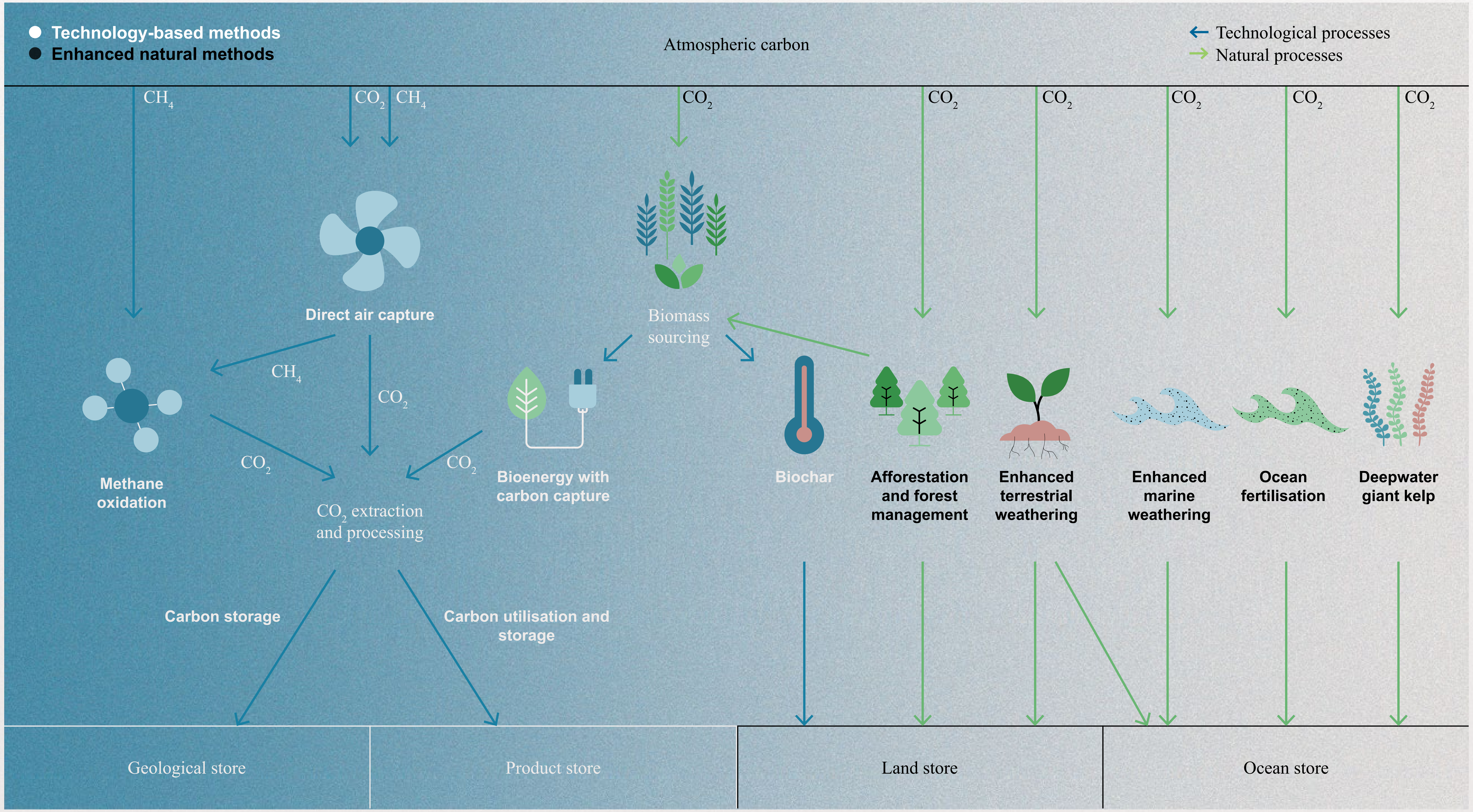


Fig 6.
Removal methods
Mapped across the spectrum from 'technological' to 'enhanced natural' methods. Not all methods, processes and connections are shown.

Remove

Enhanced natural terrestrial carbon removal

The use of land for carbon removal needs to consider trade-offs with food production and development, and potential impacts of land use change on ecosystems, livelihoods and resilience to climate change impacts.

Afforestation: Plant new forests where there was no previous tree cover or where forests have been missing for a long time. This may be detrimental to soil quality and biodiversity so must avoid monocultures and should prioritise native species adapted to the climate and local ecosystem. It may need to be combined with long-term forest management to be effective and to avoid or minimise negative impacts.

Forest management: Ongoing artificial optimisation of existing forests to maximise sequestration and production of biomass through practices such as thinning and rotation.

Enhanced terrestrial weathering: Spread crushed reactive silicate rocks (such as basalt and olivine) on land to accelerate the natural formation of stable carbonate from atmospheric CO_2.[31]

Enhanced natural marine carbon removal

The oceans absorb at least a quarter of annual anthropogenic CO_2 emissions,[32] making them more acidic, but their ability to absorb further emissions is limited.[33] Methods to increase ocean carbon drawdown need to be assessed for potential negative externalities arising from altering ocean chemistry and primary productivity.

Enhanced marine weathering (ocean alkalinisation): Artificially increase ocean alkalinity through the introduction of calcium carbonate to increase carbonate ions lost during ocean acidification. This allows ocean water to absorb more CO_2 while reducing acidity.[34]

Ocean fertilisation: Add nutrients to the ocean in areas of low photosynthetic production to stimulate phytoplankton growth and boost the ocean's carbon drawdown. Phytoplankton absorb CO_2 from surface waters, supporting the regeneration of ecosystems and resulting in carbon export to deep ocean layers.[35]

Deepwater giant kelp (marine permaculture arrays): Use wave-driven pumps to upwell nutrients from cool, deep water and use below-surface platforms to grow giant kelp to rapidly sequester CO_2 at scale and reduce local ocean acidification.[36]

Technology-based carbon removal

There is a range of technologies that have been or are being developed to extract carbon from the atmosphere and use or store it. Combinations of these processes need to be assessed at a whole-system and whole-life scale, in particular the likelihood and timescale of carbon being released back into the atmosphere.

Carbon capture

Direct air capture: Pass atmospheric air through chemical substrates to extract CO_2. See case study on page 18.

Bioenergy with carbon capture: Obtain biomass (which has absorbed CO_2 from the atmosphere) from sustainable sources such as forestry residues, agricultural by-products, and organic municipal waste, and capture the CO_2 produced during combustion for energy.[37]

Non-CO_2 photocatalysis: Draw down non-CO_2 greenhouse gases such as methane and nitrous oxide from the atmosphere and reduce their global warming potential by photocatalysis.[38]

Carbon utilisation and storage

Microalgae: Use microalgae to fix CO_2 at high efficiencies[39] and then process the biomass to make products such as high-value chemicals[40] which store the CO_2.

Building materials: React CO_2 with calcium or magnesium oxide or silicate materials from common industrial residues to produce aggregates, novel cements and in concrete curing.[41]

Polymer processing: Use catalytic processes to convert CO_2 into polymers which can be used in numerous applications, such as thermoplastics, which store the CO_2 as long as the product lasts.[42]

Carbon storage

Rock mineralisation: Inject CO_2 into reactive silicate rocks and minerals (such as olivine and basalt) to provoke mineralisation and permanently fix the CO_2.[43]

Geological storage: Inject CO_2 into porous rock formations deep underground and into depleted oil and gas fields.[44]

Biochar: Store carbon in biochar, a solid, charcoal-like material that can be incorporated into soils, enhancing their quality. Biochar is produced through pyrolysis, the thermochemical conversion of biomass in an oxygen-limited environment, which also generates heat for energy.[45]

Remove

Case study: Direct Air capture technology

Carbon Engineering have developed a method of extracting CO_2 from atmospheric air and delivering it in a pure, compressed form that can then be stored underground or utilised in synthetic products.

A giant fan pulls air into an air contactor, where it passes over thin plastic surfaces that have potassium hydroxide solution flowing over them. This non-toxic solution chemically binds with the CO_2 molecules, removing them from the air and trapping them in the liquid solution as a carbonate salt.

The CO_2 contained in this carbonate solution is then put through a series of chemical processes to increase its concentration, purify, and compress it, so it can be delivered in gas form ready for use or storage. This involves separating the salt out from solution into small pellets in a structure called a pellet reactor. These pellets are then heated in a calciner in order to release the CO_2 in pure gas form. This step leaves behind processed pellets that are hydrated in a slaker and recycled back into the system to reproduce the original capture chemical.[46]

Company: Carbon Engineering

Location: Squamish, Canada

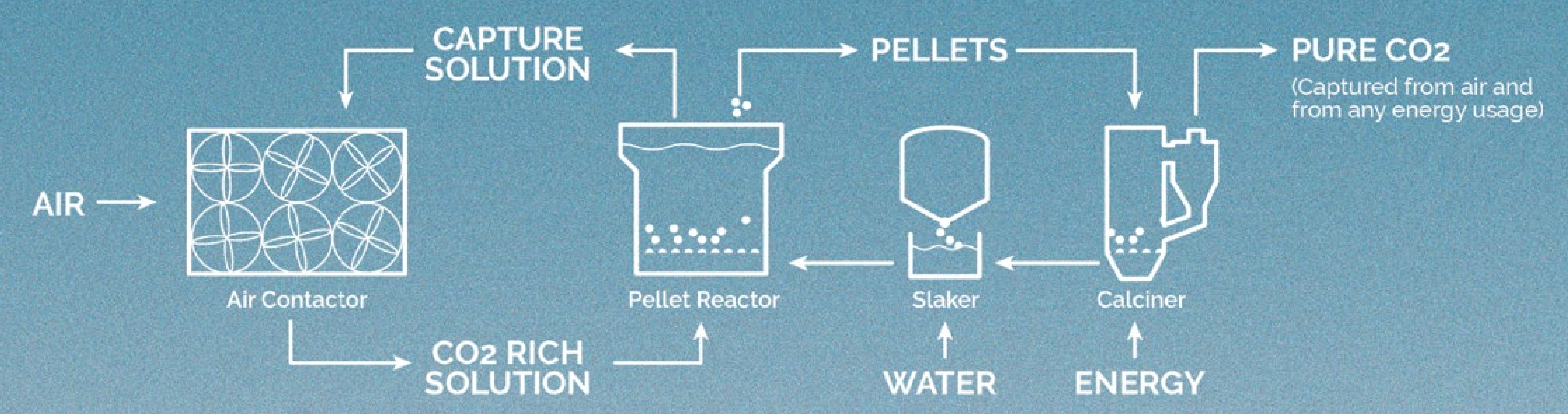


Fig 7.
Carbon Engineering's
Direct Air Capture process[46]

Everyone has a role to play

Use the 3Rs to influence and accelerate action that responds to the challenge of limiting global warming to 1.5°C:

– Ensure that your leaders and stakeholders understand the scale of the challenge and the toolkit of available and prospective solutions;

– Review your strategies, plans and policies to ensure they address the need for simultaneous and immediate action across all 3 Rs;

– Ensure that your decisions maximise deep, rapid and sustained reductions in emissions before seeking to offset residual emissions and that efforts to restore nature and remove carbon are complementary to and do not distract from reducing emissions;

– Analyse the direct and indirect emissions that you control and influence, including mapping stakeholders and interdependent systems, to identify all plausible reduce, restore and remove actions which together lead to an overall reduction in atmospheric carbon;

– Consider the impact of your decisions on atmospheric carbon over the whole life of the change you will enact, to identify and avoid 'burden shifting', and drive a 1.5°C-compatible trajectory;

– Collaborate across skills, sectors and industries to develop and enact the innovations needed across reduce, restore and remove.

Considering the whole life of your project and the change it drives, and all the systems that it affects:

Is your project essential? Can you achieve your desired outcomes with less operational and embodied carbon?

Are you maximising opportunities to restore ecosystems and have a net positive impact on natural carbon sinks?

Can you support the development of carbon removal methods, for example by incorporating trial technology into your process or solution?

Will the project result in a net zero or net negative impact on atmospheric carbon as soon as possible?

Considering the impact that your organisation can have on atmospheric carbon, through its direct operations and including upstream and downstream influence:

Are you maximising deep and rapid reductions in carbon emissions before considering offsets?

Do your activities support the protection and restoration of natural carbon sinks?

Can you support the development of carbon removal methods, for example by providing funding, finance or skills?

We can act now

Limiting warming to 1.5°C is possible, even though some temporary overshoot is likely.[47] The unprecedented change required to achieve this will become easier to implement as we all make commitments and work together to develop innovative solutions. The confluence of enabling factors and technologies is unlocking opportunities at scale: from advances in green finance and tighter regulations to novel applications of satellite imagery and CO_2-based products. Solutions can save money, create new sustainable industries and reshape employment opportunities for many. Rising to this global challenge will result in healthier, more liveable cities, and strengthen the built and natural systems on which the health and prosperity of society and our economy depends.

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Contacts

Jo da Silva
Global Director of
Sustainable Development
e: jo.da-silva@arup.com

Paula Kirk
Global Climate and Sustainability
Services Leader
e: paula.kirk@arup.com

Josef Hargrave
Global Foresight Leader
e: foresight@arup.com

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arup.com

Authors
Lola Bushnell
Owen Jones

Contributors

Full report
Anne Kovachevich
Ben Smith
Heleni Pantelidou
Marcus Morrell
Mark Button
Natasha Connolly
Ros Vose
Sarah Gillhespy
Tim Chapman
Tristan More

Reduce
Chris Carroll
Gigi Kam
Damien Canning
Mel Allwood

Restore
Michael McMullan
Rory Canavan

Remove
Brian Raine
Mike Osborne

Design
Malina Dabrowska
Emily Clements

Copy editor
Len Williams
Julien Clin

Marketing and communications
Alex Mayor
Annabel Rabbets
Eleanor Davis

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