
**Partners Group Infrastructure Thematic Research** March 2022

# The next generation of decarbonization infrastructure

Partners Group
REALIZING POTENTIAL IN PRIVATE MARKETS

## Important information

# Contents

# Executive summary

## Combatting climate change is one of the greatest humanitarian and economic imperatives of our time.

The increased frequency and intensity of natural disasters costs nearly USD 250 billion per year; this is a cost increase of around 600% since the 1980s[1]. With a global consensus that man-made greenhouse gas (GHG) emissions are overwhelmingly responsible for climate change, we are witnessing mitigation efforts from both governments and corporates across the world on an unprecedented scale. There is also a growing recognition that efforts to tackle climate change must extend beyond the electric power sector to address the more challenging decarbonization of industry, transportation, and buildings. Today, decarbonization is about far more than just renewables and the breadth and depth of decarbonization investment opportunities is, therefore, growing at speed.

'Decarbonization' is one of the giga-themes guiding Partners Group's thematic investing across asset classes, in line with the strategic asset allocation described in our Climate Change Strategy. In this paper, we will discuss the significance of decarbonization for infrastructure investors and why we believe it offers compelling investment opportunities both today and for decades to come.

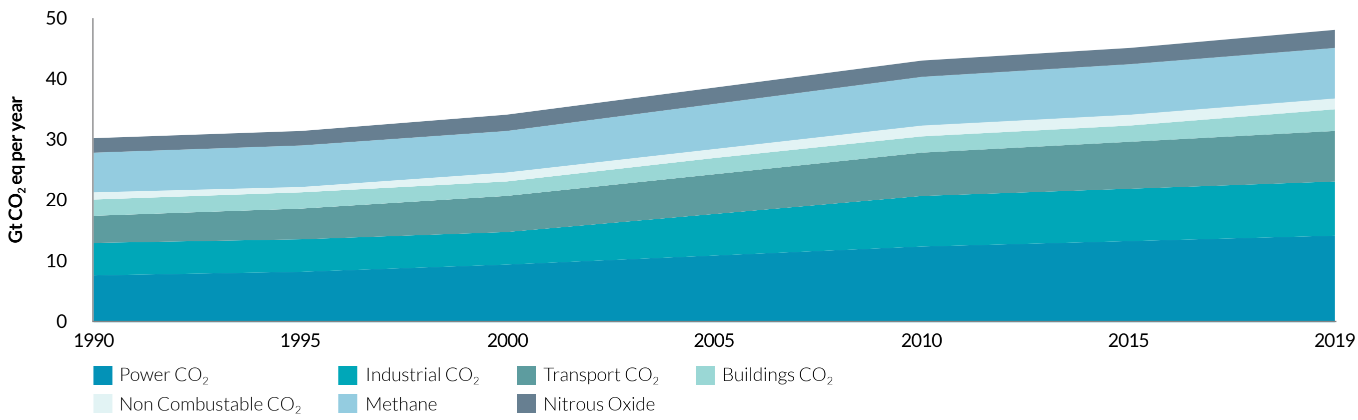
## Beyond clean power

Partners Group has invested in over 8.4 gigawatts (GWs) of renewable power generation assets to date. In fact, the development of incremental clean power, as well as reliability and flexibility assets that address renewable power intermittency, remain vital to achieving Paris Agreement goals. But the power sector accounts for just 39% of direct carbon dioxide ($CO_2$) emissions. Transportation and industrial sources are each responsible for around a quarter, with buildings and non-combustible sources, such as agriculture and waste, contributing between 5% and 10% of the total.

In other words, over 60% of $CO_2$ emissions stem from outside the power sector. And, of course, $CO_2$ is not the only GHG to be considered but it is the largest volumetric contributor, which is why GHG emissions are typically referred to as gigatons of carbon dioxide equivalent (Gt $CO_2$eq). Prior to the Covid-19 pandemic, $CO_2$ was 74% of the 50 Gt $CO_2$eq of total GHG yearly emissions. Other GHGs such as methane, nitrous oxide, and several fluorinated gases account for the remaining 26%. These other gases are mostly created from agriculture, land use, waste and fugitive emissions from hydrocarbon production, and they typically do not reflect the characteristics for stand-alone infrastructure investment (outside of waste management or waste-to-value). Because of this, they will not be the primary focus of this paper.

1 Source: Munich RE (2020).

**Figure 1 – Historical source of global man-made greenhouse gas emissions, 1990-2019**




Source: International Energy Agency (2021), BP Energy Outlook (2020), World Resource Institute (2020), Global Methane Initiative (2021).

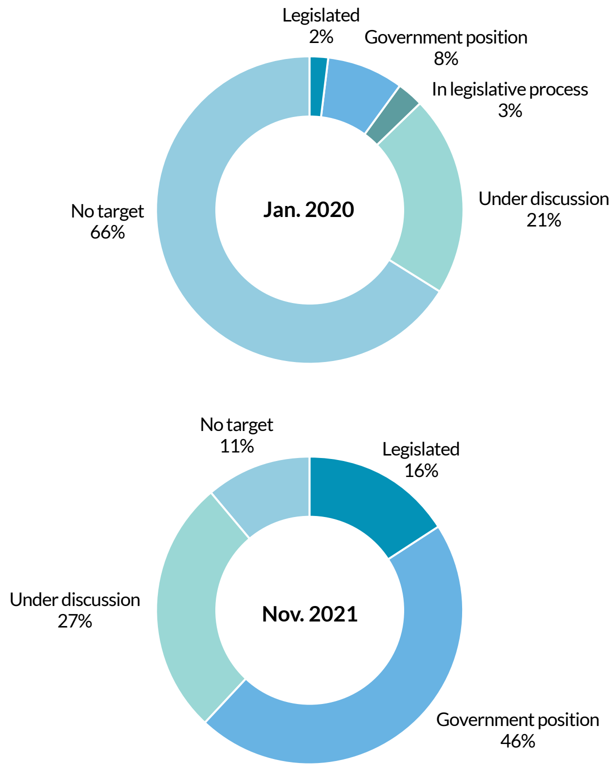
## Why now

Policymakers are deploying direct investment, economic incentives, and regulatory frameworks with unprecedented vigor to expand decarbonization and reach net zero carbon goals, with an increased focus on 'hard to abate' sectors. The United Nations Climate Change Conference (COP26), which was held late last year in Glasgow, was the first opportunity for governments to outline their 'Nationally Determined Contributions' for reaching the 2015 Paris Agreement goals. While the submitted contributions do not fully achieve the reduction goals, they are moving in the right direction and 62% of global man-made GHG emissions are now covered by law or official government policies, compared to only 10% at the beginning of 2020[2].

To meet Paris Agreement objectives, we estimate that **USD 20 trillion of decarbonization infrastructure investment will be required by 2030**; around half of this will go beyond renewable power and electrification. Several investment and policy goals already extend to at least 2070, offering a uniquely long runway of investment opportunities. While the volume of capital deployed behind decarbonization is expanding dramatically, we believe that the more complex investments required for 'hard to abate' sectors offer compelling returns for private capital.

2 Source: Bloomberg New Energy Finance (2021).

**Figure 2 – Share of global emissions covered by net zero carbon targets**




Source: Bloomberg New Energy Finance (2021).

## The decarbonization investment spectrum

According to our research, decarbonization investment opportunities broadly fit into three categories:

**Figure 3 – Categories of decarbonization**

| | Replacement | Conservation | Carbon management |
|---|---|---|---|
| **Function** | Replacing high emission fuel sources with lower emission alternatives | Reducing emissions by improving processes or tools without replacing the high emission source | Capturing and removing produced emissions |
| **Related investment themes** | **Clean power**<br>• Renewables<br>• Reliability & flexibility<br>• Electrification<br>• Power storage<br>**Low carbon fuels**<br>• Natural gas<br>• Bioenergy<br>• Synthetic fuels<br>• Hydrogen | **Energy & resource efficiency**<br>• Process gains<br>• Efficiency gains<br>• Heat exchange<br>**Circular economy**<br>• Recycling & re-use<br>• Waste-to-value<br>**Agriculture & forestry management** | **Carbon capture, utilization, and sequestration (CCUS)**<br>• Natural sinks<br>• Underground sequestration<br>• Direct Air Capture (DAC)<br>• Carbon transportation<br>• Carbon use |

## Replacement

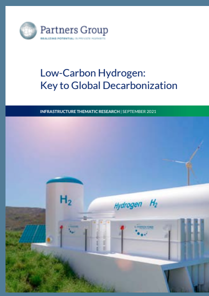
Carbon replacement covers renewable power generation and the use of natural gas as a complementary fuel to support grid reliability and flexibility. Replacement also spans the growing bioenergy industry and, in the longer-term, synthetic fuels and hydrogen.

The replacement of high emission fuels represents the largest opportunity for decarbonization and investment in the near-term. It holds the potential to lower $CO_2$ emissions by up to 5.5 Gt $CO_2$ per year beyond current policy levels and requires USD 14 trillion of capital by 2030. For now, this category remains focused on **clean power**, where business models are relatively well established, while low carbon fuels develop further.

The clean power investment theme includes the development of renewable power generation; infrastructure that enables power distribution and electrification; and reliability and flexibility assets, including batteries. Reliability and flexibility assets support renewable power growth while maintaining power resiliency during periods of low renewable utilization.

While we expect renewable power generation investment will remain high and relatively stable for at least the next twenty years, **the focus on removing 'hard to abate' emissions will accelerate later this decade**. We believe there will be increased spending on downstream electrification in industry and buildings, and the use of more **low carbon fuels**. Currently, more than half of the investment flow in low carbon fuels is targeted at natural gas power generation and midstream transportation. But we expect this will decline to around a third in the next decade as new solutions, including bioenergy, hydrogen, and synthetic fuels, become more investable.

Partners Group has been an active infrastructure investor in the replacement of high carbon emission fuels through renewable clean power, natural gas, and bioenergy infrastructure, with over USD 6.2 billion invested in 28 assets since 2001.




**To learn more about Low-Carbon Hydrogen, see our recent thematic report published in September.**

Low-Carbon Hydrogen: Key to Global Decarbonization

### Select Partners Group investments in Replacement

DIMENSION RENEWABLE ENERGY — A platform to develop over 800 MWs of community-based solar parks and accompanying battery storage across the US. The company provides direct access to locally-generated renewable power for historically underserved households and businesses.

Gren — District heating, cooling, and power assets across 375 km of pipelines in the Baltic region of Europe, using sustainable biomass and waste as fuel to reduce the impact of carbon intensive fuels used heavily in this region.

CWP Renewables — One of the largest integrated renewable platforms in Australia that develops, owns, and operates wind and storage assets across the country. The company aims to develop more than 2 GWs of power generation within the next five years.

### Conservation

This refers to **energy and resource efficiency** projects in industry, buildings, and transportation, including improvements in processes and the adoption of productivity tools and devices. Although the spectrum of investable assets is more limited, certain niches, including tech-enabled infrastructure services, are creating compelling investment opportunities. **Circular economy** developments, which can help support a closed loop carbon economy, are also drawing attention; for example, efforts to convert waste to valued products, including energy. Meanwhile, innovative sub-sectors, like chemical recycling and the burgeoning electronic waste (e-waste) industry, are also poised for growth.

Conservation will have the largest impact on reducing carbon emissions over this decade in every sector except power. This could lead to a 3.7 Gt $CO_2$ per year reduction of emissions beyond current policy levels with an investment of almost USD 6 trillion by 2030. In this category, spending will remain high or even accelerate during the next decade with the focus moving toward 'hard to abate' sectors; however, there will likely be diminishing returns after 2030 due to the increased cost of these projects.

**Select Partners Group investment in Conservation**

techem

A diversified platform across Europe that provides devices for the sub-metering and billing of energy and water, enabling better controls to reduce demand. Today, Techem's solutions account for 8.7 million tons of $CO_2$ emissions avoided per year, thereby contributing to global climate protection objectives.

### Carbon management

This category refers to the ability to capture, sequester, and use $CO_2$ from industry, power plants, or the air itself. Across each component of the carbon management value chain, new investable business models are emerging. These range from capturing, transporting and sequestering $CO_2$ underground, to using $CO_2$ in the creation of building materials, chemical processes and synthetic fuels. This value chain is commonly referred to as Carbon capture, utilization, and sequestration (CCUS). However, we prefer the term carbon management as it better reflects the nature of the carbon waste that must be managed to combat climate change.

In the near-term, carbon management opportunities are likely to be smaller as business models develop, with only around 0.6 Gt $CO_2$ per year removed by 2030, primarily from industrial emitters. However, we expect this category to become increasingly important over time; regulatory incentives will improve and contribute to **removing 10-20%[3] of the man-made $CO_2$ emissions which must be abated to reach net zero carbon**. We estimate that approximately USD 250 billion will be spent in carbon management this decade, expanding to over USD 1.6 trillion by 2040. Partners Group is in active discussions with several top industrial partners in the carbon management space.

### Investment needs are immense

Each of these decarbonization categories is necessary to reach the Paris Agreement goals.

Current policies are expected to reduce GHGs by an estimated 20-40% by the end of the century, resulting in an average global temperature of c. 2.7°C above pre-industrial levels[4]. Therefore, further action is needed. Throughout this paper, we will highlight the investment required to make emission reductions, particularly for $CO_2$, that align with the Paris Agreement goals. These reductions are beyond the scope of what is included in current policies but are urgently needed to reverse the impact of climate change.

As noted in the table below, a cumulative investment of **over USD 48 trillion will be required by 2040 to reduce $CO_2$ emissions by c. 21 Gt $CO_2$ per year** below current policy levels.

**Figure 4 – Summary of global $CO_2$ emission reduction & investment needed to reach Paris Agreement goals**

| Cumulative investment & $CO_2$ reduction | 2020 – 2030 | 2031 – 2040 |
|---|---|---|
| Replacement | USD 14.1tn; 5.5 Gt $CO_2$ pa | USD 18.8tn; 7.5 Gt $CO_2$ pa |
| Conservation | USD 5.7tn; 3.7 Gt $CO_2$ pa | USD 8.3tn; 2.0 Gt $CO_2$ pa |
| Carbon management | USD 0.2tn; 0.6 Gt $CO_2$ pa | USD 1.4tn; 1.9 Gt $CO_2$ pa |
| Total per decade | **USD 20.1tn; 9.8 Gt $CO_2$ pa** | **USD 28.3tn; 11.4 Gt $CO_2$ pa** |

Source: International Energy Agency (2020), BP Energy Outlook (2020), Bloomberg New Energy Finance (2021), Partners Group (2021).

3 Source: International Energy Agency (2020).
4 Source: Climate Action Tracker (2021).

## What we look for

Partners Group has developed a framework to analyze and assess decarbonization solutions across themes, geographies, and technologies. However, not all approaches are investable for infrastructure investors as they may not present attractive relative value or be scalable. At Partners Group, we focus on the following:

- **Clean power** (replacement) – renewable power development platforms and reliability and flexibility assets;
- **Low carbon fuels** (replacement) – natural gas and bioenergy in the near-term, and hydrogen and synthetic fuels in the longer-term;
- **Energy & resource efficiency** (conservation) – increasing efficiency gains and better waste management solutions;
- **Carbon management** – capture, transportation, and sequestration or use of carbon emissions.

Here are some factors that we focus on when evaluating infrastructure investments in decarbonization:

### Stable, long-term cash flows

Many companies in the decarbonization space have venture-like risk-return profiles; they are not expected to generate positive cash flow in the immediate future and customer contracts are short-term. Instead, we prefer assets that will generate stable free cash flow over the long-term. We also look for investments that mitigate that risk through structure and revenue 'stacking', while avoiding decarbonization assets with commodity price or volume risk.

### Strong market position with high barriers to entry

Decarbonization assets are becoming highly complex and require strong technical expertise and advanced logistical abilities. We look to be early movers by understanding emerging trends through our thematic sourcing, developing a broad network of industry experts, and finding the right partners. This allows us to assemble the best team to understand these complexities and gives us the time to fully analyze them.

### Platforms versus single assets

We have a strong preference for platform expansion investments with a combination of assets that are operating, under construction, and in the pipeline. Platform investments have several advantages over single asset investments, including the potential to deploy significant amounts of capital at scale. It is also possible to create value by de-risking projects from development to construction and completion, and to capitalize on cost efficiencies across projects. In addition, they offer the opportunity for efficient capital allocation between different projects in terms of size, geography and complexity, and risk diversification across projects in terms of geographies, markets, revenue streams, counterparties, sectors, and technologies.

### Low disruption risk

Regulatory tailwinds are driving decarbonization investment growth. These long-term plans, in many cases enshrined in law, provide us with comfort that these assets will face low disruption risk for many decades to come.

### Near-term transactability

Finally, we prioritize investments where we see a clear path to execution, such as investments in proven technologies with a track record of commercial adoption and in situations where we can establish a competitive advantage; for example, this could be through prior investment in the sector, existing operational expertise, or a wide, sector-specific relationship network. The synthetic fuels industry is a good example of this. These fuels are being developed by large strategics through in-house research and development, and commercial adoption is not yet proven; this makes it difficult to facilitate a transaction. In addition, we seek investments that have the potential to offer returns within our target range and that are achievable under a conservative base case, with additional optionality built on top via value creation initiatives.

**Figure 5 – Examples of characteristics we look for across solutions**

| | Cash flows | Market position | Platform scalability | Disruption risk mitigation | Near-term transactability |
|---|---|---|---|---|---|
| **REPLACEMENT** | | | | | |
| Renewables | | | | | |
| Reliability & flexibility assets | | | | | |
| Electrification | | | | | |
| Power storage | | | | | |
| Natural gas | | | | | |
| Bioenergy | | | | | |
| Synthetic fuels | | | | | |
| Hydrogen | | | | | |
| **CONSERVATION** | | | | | |
| Energy & resource efficiency | | | | | |
| Waste to value | | | | | |
| Agriculture & forestry management | | | | | |
| **CARBON MANAGEMENT** | | | | | |
| Underground sequestration | | | | | |
| Carbon transportation | | | | | |
| Direct air capture | | | | | |
| Carbon use | | | | | |

Source: Partners Group (2021). For illustrative purposes only.

CWP Renewables – Australia

## Partners Group's approach to carbon intensive investments

We are committed to avoiding greenhouse gas-intensive activities in our direct investment universe as we consider climate change regulations a material investment risk. Generally, this includes the following investments, which we avoid in principle due to their long-term risk and misalignment with market trends, unless we can develop a carbon reduction strategy to positively influence them towards a low-carbon transition:

- Businesses whose main product or service supports thermal coal extraction, transportation, or use for energy generation, and have no plans to address this;
- Businesses whose main product or service supports crude oil exploration, production, refining, transportation, or storage; or the transportation and storage of refined products (specialist derivatives production is not excluded);
- Service providers for the coal and oil upstream industry, such as drilling rig operators, fracking sand suppliers, and oilfield service providers;
- Treatment and logistics services for Canadian oil sands; and
- Deforestation or the burning of vast natural ecosystems for the purpose of land clearance.

In addition, for our direct infrastructure investments, which are those most exposed to carbon-intensive industries, we carefully assess their potential impact on climate change based on four critical factors:

1. Emissions intensity;
2. Alignment with a low-carbon economy transition pathway;
3. The materiality of carbon-intensity to operations; and
4. Partners Group's capacity to mitigate impacts through active ownership.

For primary and secondary infrastructure investments, we strive to invest with investment managers that align with our commitment to support a transition to a low-carbon economy. We also aim to reduce our exposure to carbon-intensive portfolios.

## The next generation of decarbonization infrastructure requires greater expertise

With traditional infrastructure investor profiles evolving and value-add investors continuing to innovate, private infrastructure is changing from portfolios of single assets to multi-dimensional businesses. This requires greater in-house expertise to navigate the growing complexity. At Partners Group, we aim to build sustainable businesses and infrastructure platforms across the decarbonization giga-theme.

### Thematic exposure

Partners Group was an early investor in **renewables**. Since 2001, we have built a global renewable portfolio containing >8.4 GWs of mostly contracted capacity. Our **natural gas** platforms offer a path to low-risk exposure towards emerging options like low-carbon gases and hydrogen. Within the **carbon management** industry, we focus on transportation and sequestration assets, which are underpinned by long-term 'take-or-pay' contracts, rather than the capture technology itself.

### ESG best practices

Building long-lasting businesses requires **best-in-class ESG initiatives**. Our dedicated ESG & Sustainability team is actively involved both pre and post-investment; they work closely with the investment teams and portfolio management to screen opportunities and develop ESG-focused value creation initiatives. For example, with our recent investment in **GREN**, a district heating and cooling platform in the Baltics that mainly uses biomass fuel, our ESG & Sustainability team has been highly involved in ensuring there is a pipeline of properly sourced 'sustainable' biomass. This is a critical step in ensuring the platform has a positive decarbonization impact and required specific knowledge that was held by our ESG & Sustainability team.

### Value creation

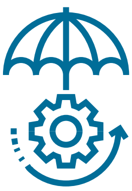
We employ three value creation strategies, with a demonstrated impact, across our infrastructure portfolio: **Building Core**, **Operational Value Creation**, and **Platform Expansion**.

In Building Core, we create value by de-risking the development and construction of core assets for those who are not willing to underwrite that risk. Operational Value Creation involves introducing entrepreneurial ownership and governance to operating businesses to increase their quality and performance, enable a transformation of the business, or to accelerate growth. While these are both valuable creation strategies, most of our infrastructure investments focus on Platform Expansion opportunities.

In-house value creation & research

Operating Directors and Entrepreneurial Governance (ODEG)

Portfolio & risk management capabilities



ESG

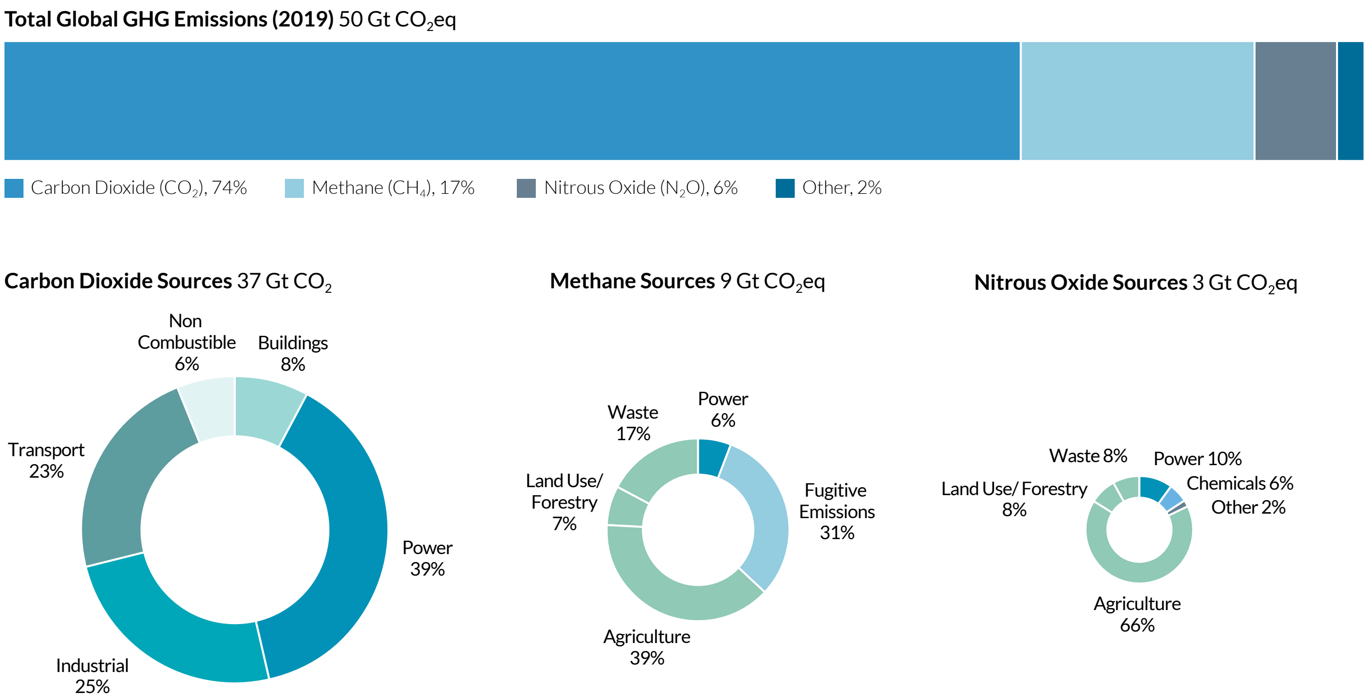
# 01
# The causes of climate change are broader than the power sector

The power sector's transition away from dirtier fuels – primarily through clean and renewable sources of energy and switching from coal to natural gas generation – has been the greatest focus of decarbonization efforts to date.

This transition is a logical, low-cost option for many countries. But, in reality, **the power sector only accounts for around 39% of the global $CO_2$ emissions responsible for climate change**; it is now apparent that tackling the electric power sector alone will not be enough to meet the Paris Agreement objectives.

It is vital, therefore, that we take a more holistic approach and recognize that a whole host of industries are contributing to GHG emissions, all of which represent a threat to the sustainability of our planet.

**Figure 6 – Sectors contributing to man-made GHG gases extend beyond power**




Source: World Resource Institute (2021), International Energy Agency (2021), BP Energy Outlook (2020), PG Analysis (2021).
Note: Gt $CO_2$eq = gigatons of carbon dioxide equivalent, a measure used to compare greenhouse gases to each other.

## Decarbonizing power generation remains key…

The continued decarbonization of power generation remains a top priority. Combustion fuels used for power generation drive emissions intensity and coal is the leading contributor. The introduction of low-cost renewable power and abundant natural gas discoveries over the past decade mean that legacy fuel replacement is the largest driver of global power emissions reductions. Renewable, **clean power** has been a major focus for Partners Group with investments in over 8.4 GWs of renewable, clean power. We also believe that power **reliability and flexibility** assets, which address renewable power intermittency, are critical to the energy transition and the continued growth of clean power.

Compared to a third today, renewables will need to be c. 60% of the power generation capacity mix by 2030, to reach Paris Agreement goals; this will require over USD 6 trillion of investment this decade. This growth in renewables and other emerging solutions, will lead to c. 5 Gt $CO_2$ per year of lower emissions from the power sector than current policy levels.

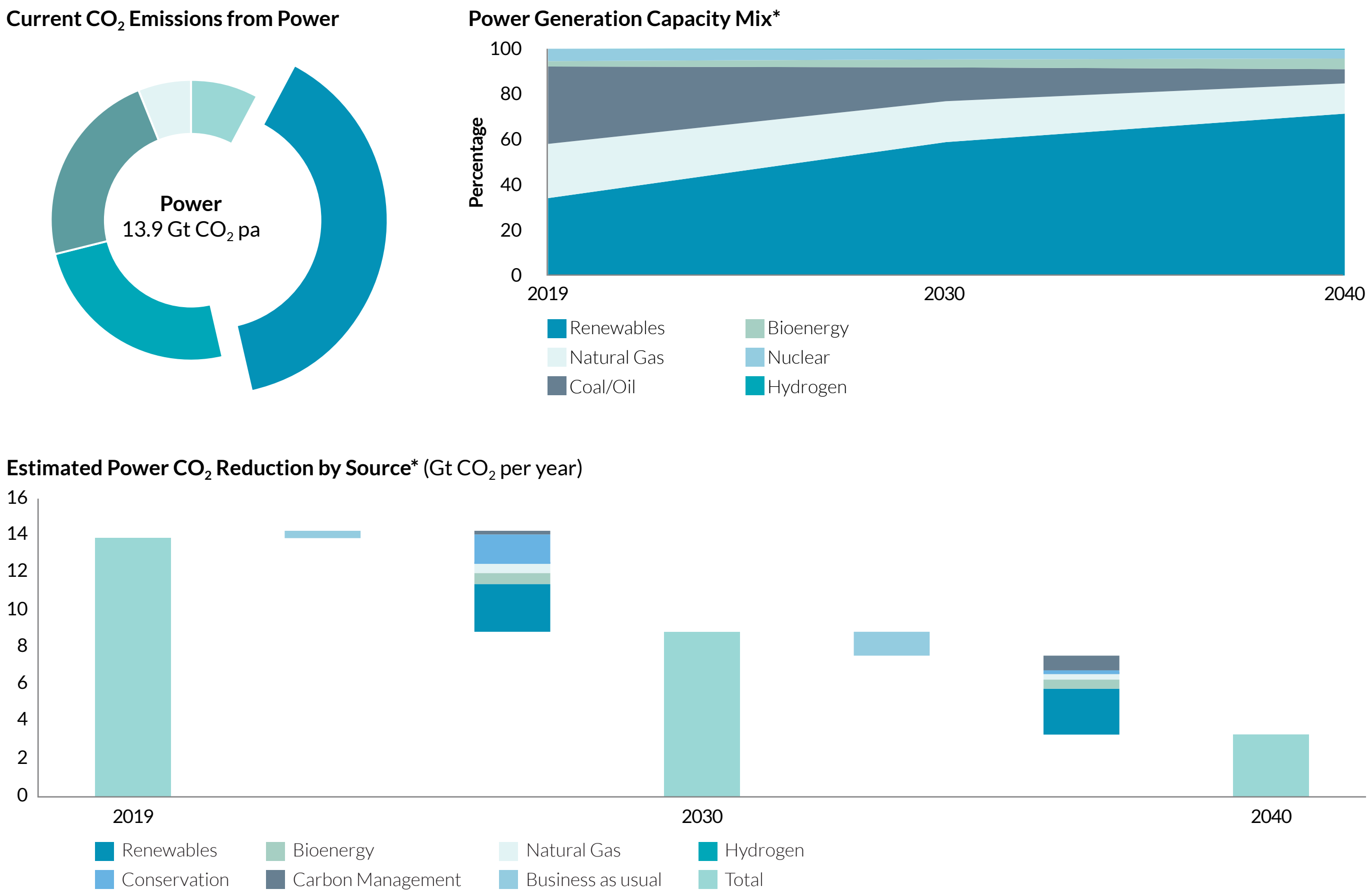
## …but industrial production is a significant carbon emissions contributor

While the power sector may be the highest-profile contributor to climate change, the manufacturing of construction materials (e.g., steel, iron, and cement) and the energy used in chemical processes are the largest industrial emissions producers. These have historically been considered 'hard to abate' emissions.

Fossil fuels will continue to be prevalent in industry with oil and coal comprising c. 40% of industrial energy sources in 2040; even in faster net zero scenarios they comprise c. 30%[5].

5 Source: International Energy Agency (2021).

**Figure 7 – Shifting power generation has the greatest impact on $CO_2$ reductions**




Source: World Resource Institute (2021), International Energy Agency (2021), BP Energy Outlook (2020), BNEF (2021), PG Analysis (2021).
Note: Renewables includes solar PV, wind, hydro, geothermal, CSP, marine. Renewable demand is lower than capacity.
* Estimates align with Paris Agreement targets.

However, evolving advances in **carbon management** and **energy and resource efficiency** are leading to large step changes in decarbonizing this sector. Conservation solutions will have the greatest impact on decarbonizing this sector through 2030 but carbon management and electrification efforts will substantially grow in the years following. We estimate that c. USD 800 billion will be required for industrial conservation and carbon management efforts by 2030.

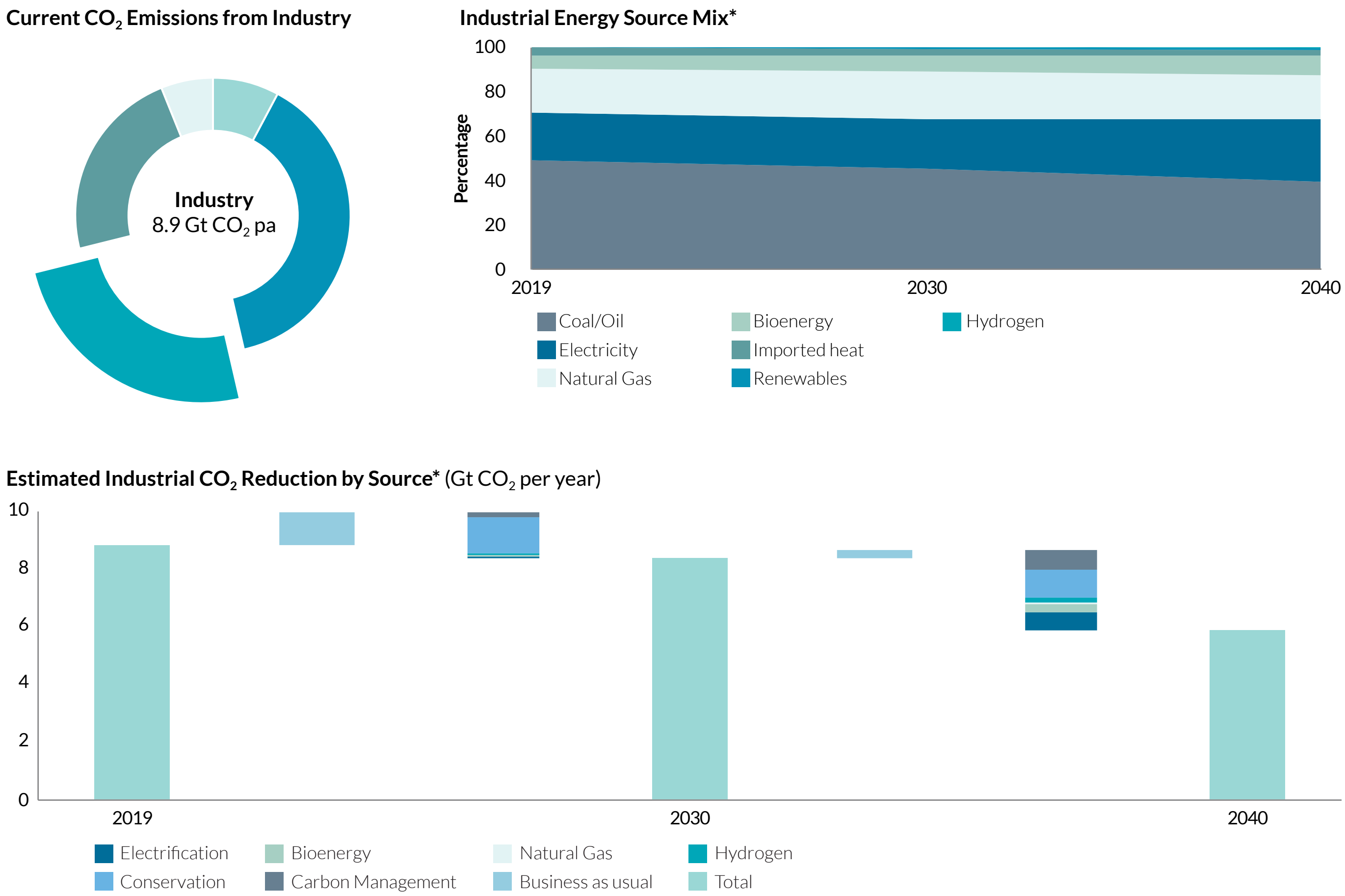
Within industry, conservation efforts are focused on efficiency gains through improving processes and recycling waste to reduce the need of new supply. In many cases though, further technological development is still required. This is particularly relevant in heavy industries, like steel and iron, cement, and chemicals, which contribute c. 70% of direct industrial $CO_2$ emissions[6]. It is difficult to use replacement fuels, particularly renewables, in these industries, given the high temperatures or feedstock types needed. However, some process improvements are already economical and viable. The largest (0.4 Gt $CO_2$ per year[7]) of these are within the chemical industry, but others require time to advance.

New carbon management solutions can capture, transport, and sequester carbon emissions or even use them. With recent financial incentives, such as 45Q tax credits in the US and the emergence of streamlined regulations from policymakers around the world, this type of infrastructure can reduce emitters' abatement costs and generate compelling returns in dense heavy industrial regions. In less dense industrial areas, energy and resource efficiency efforts (such as process gains), upgraded waste management programs, and electrification are the main contributors to emission reductions.

6 Source: International Energy Agency (2021).

7 Source: Goldman Sachs (2021).

## Figure 8 – Conservation is critical in the near-term as carbon management advances in coming years




Source: World Resource Institute (2021), International Energy Agency (2021), BP Energy Outlook (2020), McKinsey (2021), PG Analysis (2021).
* Estimates align with Paris Agreement targets.


## Investment example: Telepass

Telepass is a leading electronic toll collection (ETC) services provider with a 100% and 30% market share in Italy and Europe, respectively. This business has an asset base of c. 12 million active payment devices that are paid for through recurring monthly subscription fees. A number of strategic value creation initiatives are under way to accelerate the business' existing growth trajectory. These will establish it as a leading pan-European platform for customer-centric mobility services to optimize urban transport and reduce vehicle congestion and $CO_2$ emissions.

With economic and regulatory frameworks expanding for carbon management in developed nations, we estimate that over USD 1.6 trillion will be invested in the space by 2040. More importantly, these investments have an outsized impact compared to renewables. For example, a 15 million metric ton per annum carbon sequestration hub, together with the associated carbon capture facilities, has the equivalent decarbonizing impact of c. 7.5 GWs of wind power capacity at a much lower capital cost (see box below).

## Carbon management's economic return assessment

We have evaluated the decarbonization impact and associated cost of CCUS compared to building a wind farm. CCUS significantly outperforms in regions with dense clusters of industrial emissions and the right geology to store those emissions underground. From a pure capital cost perspective, 15 million metric tons of carbon capture and sequestration costs less than 25% of the capital cost associated with 7.5 GWs of wind power capacity (the equivalent of 15 million metric tons of $CO_2$ abatement). Further, even on a Levelized Cost of Abatement (LCOA) basis, where the value of the power being produced by the windfarm is accounted for, **the LCOA for CCUS is c. 23-43% lower than the equivalent wind generation** depending on the cost of capital and expected return on that capital.

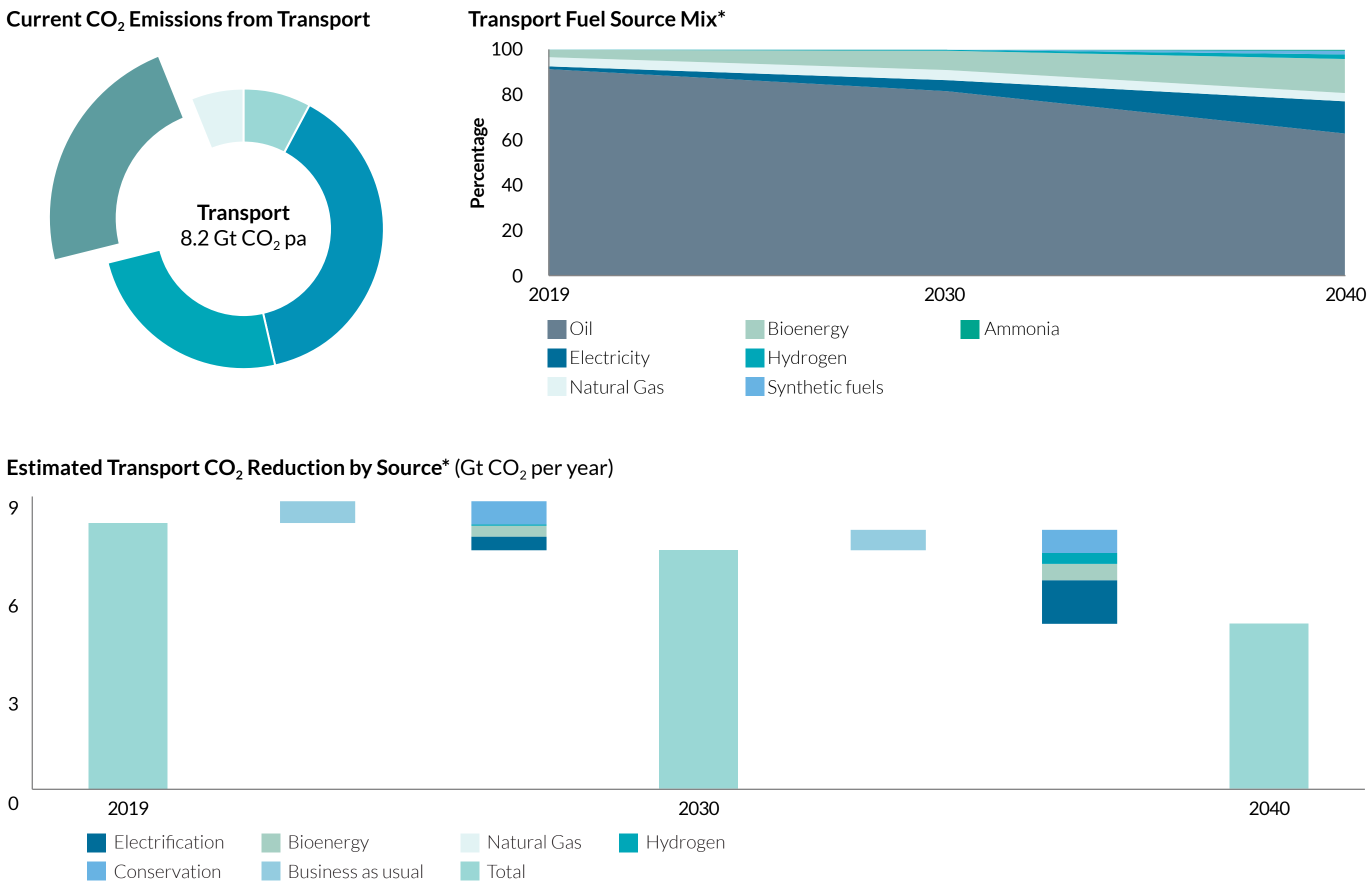
## Transport may be the most difficult emissions source to abate

Transport remains one of the most 'hard to abate' emission sources because transport modes are individually small and, critically, mobile. **Electrification** infrastructure will be the primary method of abatement in the sector and Partners Group is actively sourcing investments in this industry. However, in the near-term, we favor indirect plays on electrification that offer more favorable characteristics with positive free cash flow. An example is technology-enabled infrastructure services like **Telepass**. Partners Group recently invested in this pan-European leader in electronic toll collection providing mobility related services to customers.

**Biofuels** and **natural gas** will also play a role. In the longer-term, we believe that **synthetic fuels** and **hydrogen** represent a compelling opportunity for decarbonizing the transport sector. These alternative fuel sources are particularly useful for aviation and marine transportation, which are harder to electrify than light-duty cars and trucks.

Over the next decade, fuel efficiency efforts will simply offset increases in transportation demand. Meanwhile, increased electrification and biofuel penetration will lead to an emission reduction of 0.9 Gt $CO_2$ per year beyond current policy levels over this decade; this will cost USD 4.2 trillion. As shown below, the transition to electrification and the use of biofuel for transportation will accelerate in the second half of this decade and beyond, each becoming c. 15% of the transportation fuel supply by 2040. This will directly offset oil use and, combined with fuel efficiency efforts and other alternative fuels, will lead to a cumulative 3.1 Gt $CO_2$ per year reduction in emissions beyond current policy levels by 2040, despite increasing transportation demand.

## Figure 9 – Transportation decarbonization is slow this decade




Source: World Resource Institute (2021), International Energy Agency (2021), BP (2020), McKinsey (2020), BNEF (2021), Partners Group (2021).
* Estimates align with Paris Agreement targets.

## Building emissions are often underestimated

Buildings themselves account for almost 10% of direct global $CO_2$ emissions. This is primarily caused by poor insulation efficiency and manually set energy usage systems in residential and commercial buildings, as well as seasonal heating and cooling. However, when construction materials and the indirect energy used by occupants are considered, buildings suddenly account for over 25% of global emissions, which makes the sector one of the top contributors to climate change.

Increased electrification, efficiency gains and the introduction of smart buildings, mean that energy demand related to buildings in developed countries is set to fall by around a third over the next three decades. However, this will be more than offset by the rapid growth of energy use in buildings in developing regions, particularly in Asia and Africa, as living standards improve[8]. Carbon emissions will steadily decline in buildings over several decades as lower carbon intensive sources of electricity penetrate even in developing nations.

8 Source: BP Energy Outlook (2020).

## Local, regional, and international building codes are changing

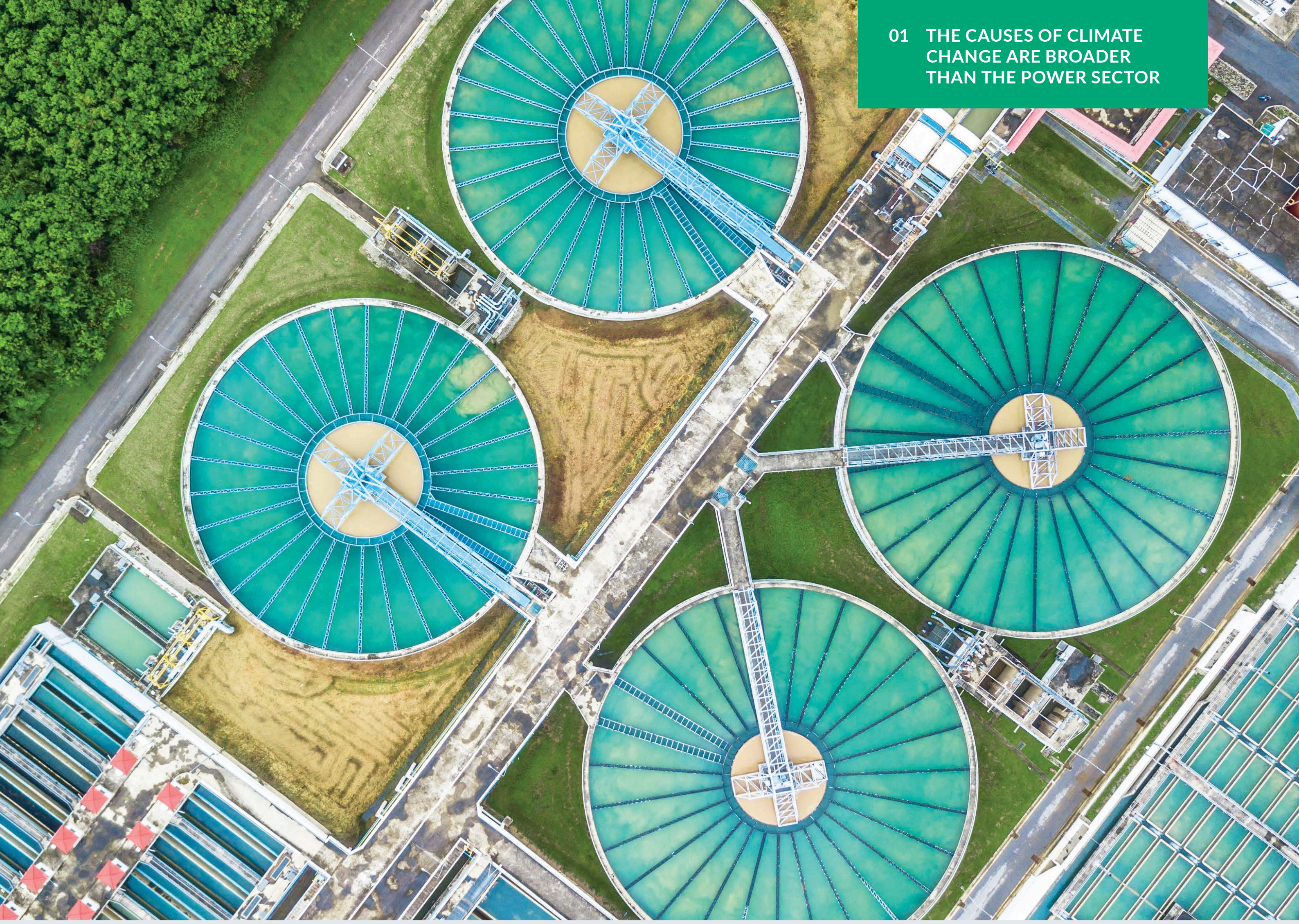
Regulatory bodies are rapidly incorporating environmental sustainability measurement into local and regional building codes. This is being done by either adopting a rating standard, such as LEED or WELL, as a threshold/condition of project approval or by the creation of more stringent codes on their own. While national standards for environmental building sustainability are yet to be seen, incorporation into the International Building Code (IBC) is already underway. The International Green Construction Code (IgCC) and the International Code Commission have issued plans for overplay codes aimed at driving building efficiency.

## Agriculture and forestry must not be forgotten

While agriculture and forestry waste do not have a significant impact on $CO_2$ emissions, they represent almost half of methane and three-quarters of nitrous oxide global emissions. These gases do not remain in the atmosphere for as long as $CO_2$ but are estimated to have c. 25x and c. 300x the impact[9], respectively, on climate change.

The solutions related to these emissions do not typically involve the need for new infrastructure; they pertain primarily to improving land and agricultural management practices. Nevertheless, converting agricultural and animal waste into bioenergy is a method of reducing methane emissions that exists in Partners Group's investment portfolio.

9 Source: US Environmental Protection Agency (2021).



## Turning dairy wastewater into low carbon fuels

**Resilient Infrastructure Group**, our water sustainability platform, is transforming agricultural wastewater on a large dairy farm in the Western US into **renewable natural gas** (RNG), also known as biogas or biomethane. This gas is sold to large commercial customers, through 'take-or-pay' contracts, who use it as compressed natural gas (CNG) in their vehicle fleets instead of the diesel fuel that would otherwise be consumed.

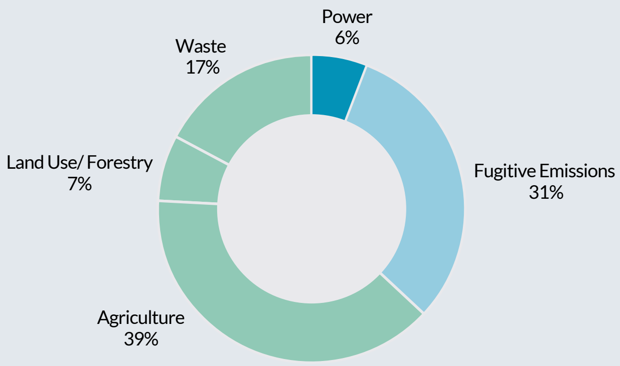
This asset is the largest stand-alone operational dairy manure-to-RNG project in North America and **avoids the release of c. 350 thousand tons $CO_2$eq per year of methane**. This has the equivalent annual decarbonizing impact of removing c. 76 thousand passenger cars from the road.

## Methane is discussed less but remains critical

While methane is the second most abundant climate change causing gas in the atmosphere, it is not discussed as often as $CO_2$. We believe this is due to the source of emissions (mainly agricultural and human waste and fugitive emissions from fossil fuel production) and the fact that remedies are related to proper management practices and regulations rather than large-scale infrastructure investment. However, methane's impact on climate change is substantial at 17% of total GHG emissions per year and must be addressed. In fact, according to the Intergovernmental Panel on Climate Change (IPCC), **methane has contributed to 30-50% of the already observed 1.2°C increase in global temperature.**

Some believe that the most significant action taken at COP26 was the **Global Methane Pledge** signed by over 100 nations. While this pledge calls for a 30% reduction in methane emissions by 2030, the countries in agreement only comprise about half of global methane emissions. Of note, China, Russia, and India are missing from the pledge; they constitute a third of global methane emissions between them.

**Methane Sources** 9 Gt $CO_2$eq




At Partners Group, we are evaluating methane emissions from two different perspectives: investing in the waste management, or waste-to-value industries, and reducing any methane emissions we produce within our own portfolio.

At **Resilient Infrastructure Group** in the US, we are already turning dairy wastewater into low carbon fuels, and at **GREN** in the Baltics, we are producing heat and electricity from industrial and municipal waste. Additionally, we are evaluating several other investment opportunities to convert many different waste streams into valuable fuels and materials. This includes electricity and bioenergy fuels production, as well as creating green plastics and base oils.

Fugitive emissions from fossil fuel operations are responsible for around a third of all methane released by human activity. This may be one of the easiest emission sources to abate through effective regulatory policies. According to the International Energy Agency, approximately 75% of methane emissions from fossil fuel operations would need to be eliminated by 2030 to achieve carbon neutrality by 2050. However, almost 45% of these emissions could be avoided today at no, or low, net cost. With policies like Leak Detection and Repair (LDAR) and bans on non-emergency flaring, the fossil fuel industry would be well on its way to reaching these goals.

We believe that natural gas is a low carbon fuel that is a necessary compliment to renewables in the transition to provide reliable and flexible baseload energy. We have a few investments that enable the movement of natural gas from regions of growing supply to those of demand. For these investments, we take special care to ensure minimal fugitive methane emissions escape from our infrastructure.

**Fermaca** is a natural gas pipeline system that carries low-cost natural gas from the US through a major industrial corridor in Mexico, with 5.3 billion cubic feet per day of combined capacity across the system. While this is a large pipeline system spanning 2,150 km, we limited fugitive methane emissions to 123,000 metric tons in 2021 and are further reducing these emissions with a 2% annual reduction target. For the past year, Fermaca reduced methane emissions by 3%, beating that target. This target continues to be evaluated by Partners Group's ESG & Sustainability team and the Board of Fermaca and is a component of the management team's annual compensation.

# 02
# Policy support advances investment opportunities but also adds complexity

## Public and private sectors both have a role to play in decarbonization

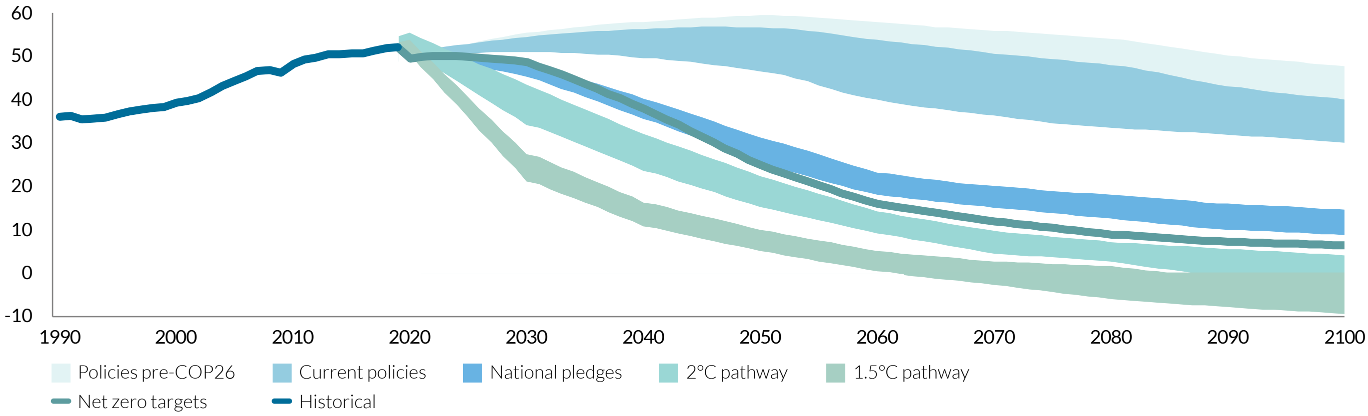
The world's largest economies are supporting efforts to reduce and reverse the impact of climate change through subsidies and regulations. However, **their actions, even after COP26, are still unlikely to have the impact required to meet the Paris Agreement goals**. New policies that have been enacted since the Paris Agreement have already reduced GHG emissions by up to 100 Gt $CO_2$eq per year from what they would have been by 2100. However, it is likely that another c. 50 Gt $CO_2$eq per year – equivalent to the current man-made global output – will be needed to achieve the Paris Agreement goals. Indeed, even current national pledges – recently updated for COP26 – that have not yet been implemented will be insufficient to achieve these targets.

In Chapter 1, the $CO_2$ reduction and fuel mix estimates are in line with reaching Paris Agreement goals, but achieving these levels of decarbonization will require over **USD 48 trillion of cumulative infrastructure investment by 2040**.

Since public spending will not reach this level on its own, it is likely that public subsidies will be used to de-risk new technologies and support investment returns from private capital until the risk profiles and unsubsidized economics converge with those of more traditional infrastructure investments. This is reminiscent of governments' roles in building the renewable power industry through feed-in-tariff regimes or tax credits on production or invested capital.

We expect a significant shift in global energy subsidy policies. The current focus on energy price stability will move towards a goal of reducing and repairing climate change's impact.

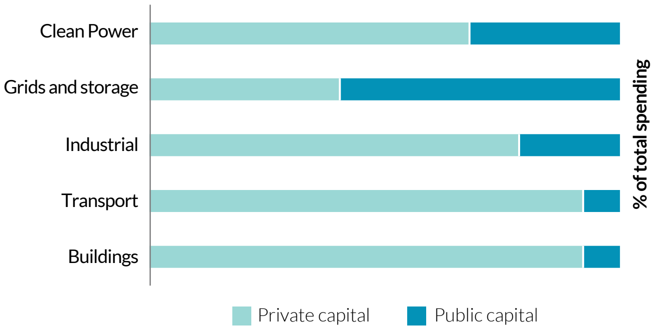
**Figure 10 – Global GHG emission scenarios (Gt $CO_2$eq per year)**




Source: Climate Action Tracker (2021).

Policymakers have already embarked on this journey and, by 2050, we expect that subsidies for carbon capture, sequestration, and use, as well as industrial energy efficiency and biofuels (among others) will all but replace policies that subsidize fossil fuel production today.

**Figure 11 – Over 70% of decarbonization capital will come from private investors (2025-2030)**



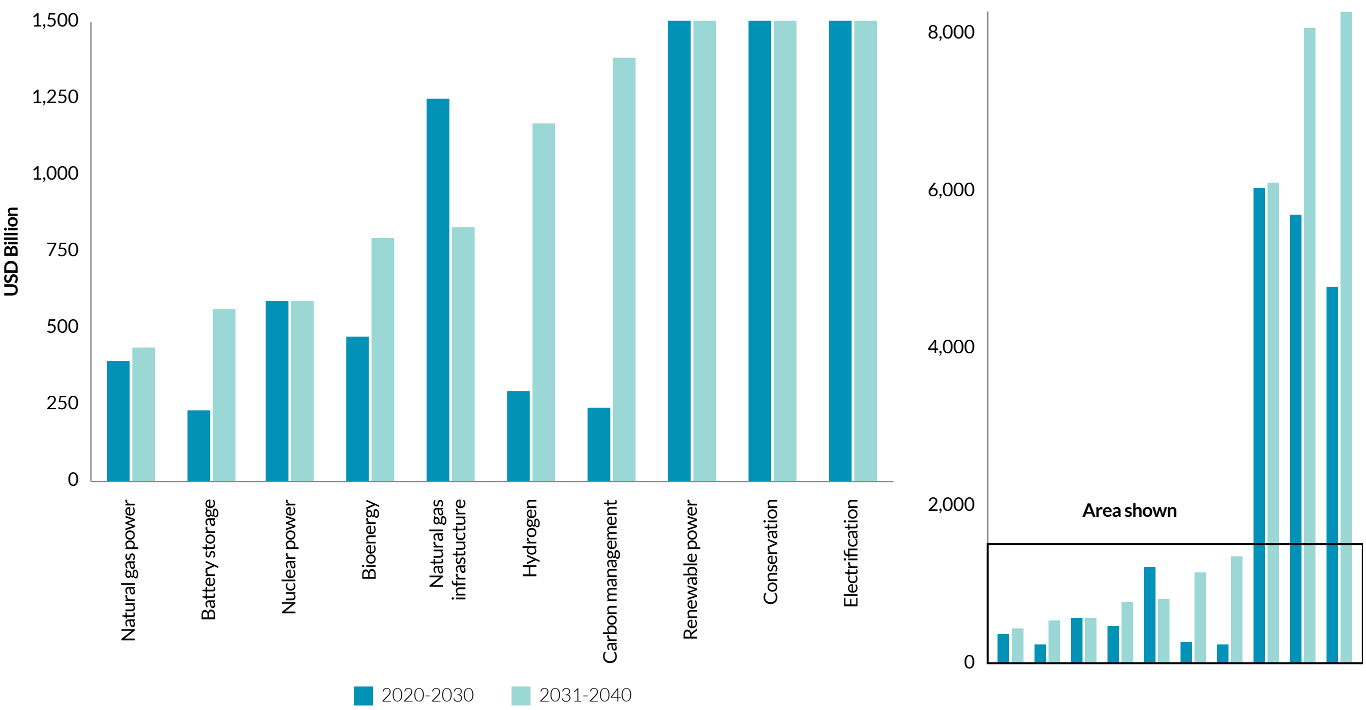

Source: International Energy Agency (2020).

## Decarbonization spending grows but more complex investments drive compelling returns

To achieve Paris Agreement goals, we estimate USD 20 trillion of global infrastructure investment will be required by 2030, and an additional USD 28 trillion in the following decade. As thematic investors, we are always looking ahead to where the structural shifts are moving. This allows us to be amongst the first to understand emerging areas of investment and new business models, giving us a critical head start.

Over the next ten years, developing clean renewable power remains the largest absolute investment opportunity, laying the groundwork to distribute clean electricity and reducing demand through conservation projects. While these continue to be areas of investment for us, we believe they are well understood by markets with significant capital already available for them – in some cases compressing investment returns.

**Figure 12 – Cumulative capital investment needed by solution (2020-2030 & 2031-2040)**




Source: International Energy Agency (2020), BP Energy Outlook (2020), Bloomberg New Energy Finance (2021), Partners Group (2021).
Note: Renewable power includes solar PV, wind, hydro, geothermal, CSP, marine.

The compression of investment returns is a trend that we have seen throughout market cycles when industries become more developed and well understood. As the infrastructure asset class has matured, new investors with a lower cost of capital have emerged. In our view, this makes certain types of investments less compelling from a risk-adjusted return. An example of this has been in the US utility-scale solar industry, which is a mature decarbonization market.

Prior to 2016, 65% of utility-scale solar assets in the US were commissioned by utilities, independent power producers (IPP), or other strategic players with the intention of long-term ownership and with levered return expectations ranging from c. 8-15%[10]. However, over time a 'developer model' with a lower cost of capital has emerged, with developers representing over a third of commissioned assets in 2022. This model has become increasingly impactful on return profiles in the US market.

**Anticipating this shift, we pivoted to new, more complex business models.** For example, in 2018 we sold our interest in **Silicon Ranch**, a utility-scale solar operator and developer with 880 MWs of capacity, and in 2021 we acquired **Dimension Renewable Energy**, a leading community solar and battery storage platform.

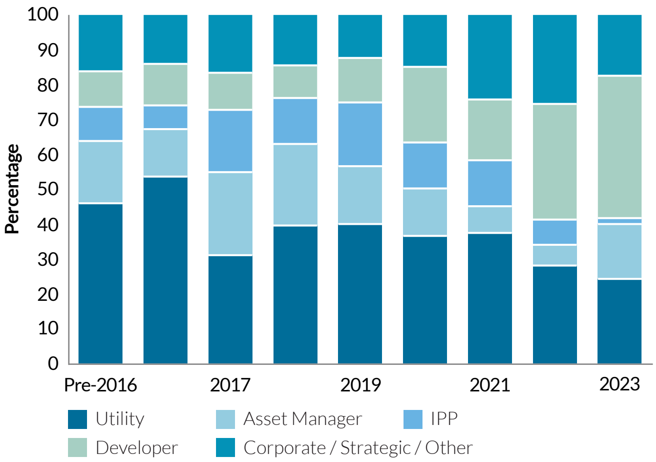
Through developing more complex niche platforms, we believe we can create value for our investors by constructing at scale with 'build multiple' costs.

While this shift towards the next generation of infrastructure investment can increase returns, it requires skillsets not previously needed by investors in the asset class.

Despite the increasing complexity of managing decarbonization investments, more investors have moved into this space over the past two years, reflecting the growing importance of ESG considerations embedded in financial investment decisions. Throughout the middle of 2021, USD 41 billion of private equity capital focused on decarbonization, and infrastructure investment was raised by private asset managers. Estimates suggest this could rise to c. USD 350 billion per year by 2030[11].

10 Source: Bloomberg New Energy Finance (2021).
11 Source: Preqin (2021), Goldman Sachs (2021).

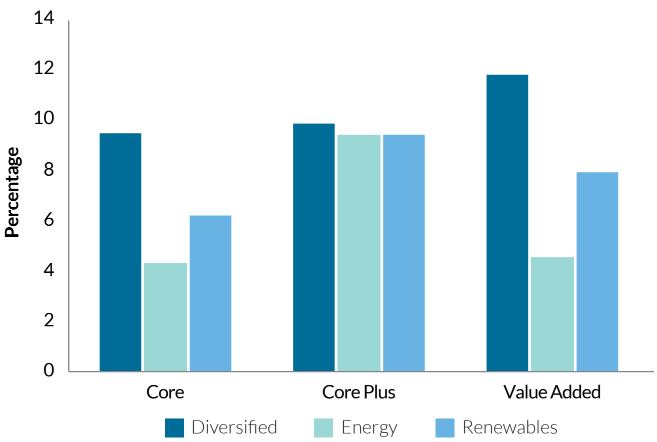
### Figure 13 – Owner types for US solar assets by year commissioned




Source: Bloomberg New Energy Finance (2021).

According to Preqin, while specialized funds are increasing in size, they have historically underperformed diversified infrastructure investors with a relative value approach. We believe that this is partially due to these funds being boxed into investing in certain industries throughout the fund's life, independent of the actual attractiveness of these industries. For example, specialized energy and renewables funds have globally underperformed diversified infrastructure investors in every type of investment strategy.

### Figure 14 – Direct global infrastructure weighted net returns by investment strategy since 1993




Source: Bloomberg New Energy Finance (2021).
Note: Excludes debt, fund of funds, and secondary strategies. Net average returns are weighted by fund capital. One outlier has been removed from the renewables value added strategy to represent more typical returns in that category.

# Navigating the complexity

## Q&A with experts

### Tom O'Flynn

Lead Operating Director (Chairman), **Dimension Renewable Energy**

Board Member, **TransAlta Corp**

Venture Partner, **Energy Impact Partners**

Former Chief Financial Officer, **AES Corp.**

Former Chief Financial Officer, **PSEG**

As the former finance chief for two of the largest power utilities in the US, **Tom O'Flynn** is helping guide Partners Group and Dimension Renewable Energy (our community solar platform where he serves as Chairman) through the **changing landscape in power generation**. Here, he explains why the power sector must be the first to decarbonize, whether the industry can meet its ambitious renewable goals, and what obstacles and opportunities abound on this path.

**Why has the power sector been the first to begin decarbonizing and why has industry been slower to react?**

It makes sense that the power sector was one of the first to begin decarbonizing since it has so many attributes that make this transition more straightforward than for other sectors – predominantly its regulated nature and size. By the time regulators began moving toward decarbonization, clean air (mostly the removal of sulphur oxides and nitrogen oxides) had already been regulated for years by the government, so this was just another evolution of that. Also, the power market is so large that incremental changes are easy to handle.

You can think of the power transmission system like a bathtub – it's so big that if you drop in new technologies, they can be unnoticeable with minimal price changes to the end customer. This is harder within industry because there usually isn't a regulatory forcing mechanism and the cost typically can't be spread out amongst a large pool.

The reasons for wanting to decarbonize are changing though, which is part of the reason why other sectors are becoming more active today. When the power sector began, it was a regulatory push, and now it's becoming a customer pull, which has a more forceful draw on industry.

**Industry and transportation are looking to electrify more energy to decarbonize. Do you believe the power sector can keep up with this demand and what are the challenges for those wanting to connect to the power grid?**

I believe that the higher levels of investment needed to meet increased demand, while further decarbonizing, are achievable. There is significant capital available for this, but the key to this growth will be managing supply chains better.

During the pandemic, we have seen incredible stress on the renewable supply chain, and I believe this type of stress will continue. Developers will need to plan ahead more and diversify the supply chain better across components and regions. This is becoming a critical part of enabling renewable growth at speed.

On the demand side, it is clear that industry and transportation are going to increasingly rely on clean electricity to decarbonize. The largest impediment to this is the intermittency of renewable power once the grid is saturated with it – which means that we will have to monitor and incentivize demand much better. For example, you don't want everyone coming home and charging their electric vehicle during peak demand hours and while solar generation is declining for the day. We will need systems that optimize power usage and send stronger pricing signals to incentivize consumer behavior without harming those most in need.

Also, increasing carbon-free generation during intermittent renewable periods will be a challenge. As we aspire to be net zero carbon, power storage and clean baseload generation technology must improve. Lithium-ion technology is good today but has limits. This will get better and, ultimately, we'll see hydrogen impact this space materially in the coming decade.

**What new emerging technologies, such as storage, in the power industry do you expect to be the next disruptors?**

There are a lot of new technologies emerging to deal with renewable intermittency issues and to decarbonize harder-to-abate industries. While many of them will play a role in the energy transition, it's tough to tell which technology will be the winner in each sub-sector. That's why it's critical to be competitive and efficient, but also agile and flexible.

Solutions that solve specific problems but are technology agnostic will have the right to win with the least chance of being disrupted. For example, I'm currently working with a company in the power storage industry. Today's storage solution of choice is lithium-ion battery technology, which can store several hours' worth of power, but unfortunately that won't be enough to move us toward 100% renewable power. The ultimate storage solutions will need to last days or weeks, not hours. But we can install these lithium-ion batteries today – they do help – and replace or add to them with new technologies, like hydrogen storage, as it becomes commercially ready.

The technology disruptors that I see on the horizon are hydrogen storage, as costs come down over the next decade, and carbon capture and removal, if carbon pricing becomes economical for power plants.

"There are a lot of new technologies emerging to deal with renewable intermittency issues and to decarbonize harder-to-abate industries. While many of them will play a role in the energy transition, it's tough to tell which technology will be the winner in each sub-sector. That's why it's critical to be competitive and efficient, but also agile and flexible. "

**Tom O'Flynn**

### Many of the opportunities for private investment have focused on utility-scale renewables. Are there new niches within renewables that are emerging with better risk-return profiles?

As we discussed earlier, demand-side management is the key to enabling new business models to emerge. Decentralized power generation is now a feasible and often better solution than historical power architectures as it can put less pressure on transmission systems and brings supply closer to where it's needed.

We are using this decentralized model at **Dimension Renewable Energy** to enable community solar developments and bring renewable power to a broader set of customers, including those where renewable power wasn't traditionally available. Through the community solar model, we can fill in renewable power with smaller scale developments near the customer and improve overall grid service. This is possible by understanding who our customers are and what they need.

I believe this decentralized model will continue to grow through technology (virtual power plants) and physical load aggregation.

### How does the new Bipartisan Infrastructure Act in the US impact your outlook for the power sector there?

The Infrastructure Act was positive for the power sector in the US but the true potential of it will be in the new technologies that grow from its funding. While the continuation of renewable tax credits is good, it wasn't a 'must have' as many renewables are now the low-cost option for power generation. The renewable train is already moving.

It is a significant push for emerging power industries in the country though – storage, offshore wind, hydrogen, and carbon capture. In these emerging areas, government support is needed to develop further until economics are on par with traditional energy investments, similar to the role government played with renewables in the past.

The tax credits and research funding in this law will bring forward the development and commercialization of these newer businesses sooner.

### What success factors will power companies need over the next two decades to remain relevant?

The power sector was controlled for years by large monopolistic utilities that were slow to change. Their primary concern was not introducing new technologies that could cannibalize their existing power generation fleets, but this is changing. The largest utilities are now selling off their traditional fossil fuel thermal assets and have become more responsive to customer demands.

This is also coming at a time when technology is being used to generate, allocate, and measure power in a way never possible before. These new businesses resemble a start-up more than a utility and the sector is changing faster than at any other time in history.

To be a relevant power company in the future, you need executives that are more flexible and agile than ever before because things will change. But you also need to be incredibly disciplined because many of these new technologies will not generate profits for years, if ever. This combination of skills is rare in an individual but is critical across the c-suite.

## Andreas Umbach

Lead Operating Director (Chairman), **Techem**

Lead Operating Director (Chairman), **Rovensa**

Chairman, **SIG Combibloc**

Chairman, **Landis+Gyr**

Former Chief Executive Officer, **Landis+Gyr**

With decades of experience leading smart grid and metering companies around the world, **Andreas Umbach** is a subject matter expert challenging the way Partners Group thinks about energy efficiency. He currently serves as Chairman of **Techem**, our sub-metering platform in Europe, which is helping customers **reduce energy consumption and GHG emissions through using tech-enabled devices and services**. Here, he discusses why conservation efforts to reduce energy demand across sectors is a critical step toward decarbonization this decade, and how the Internet of Things (IoT) is expanding the depth and breadth of how this can be accomplished.

**Global energy intensity per capita has declined by over a third in the past three decades. What has been the main driver of these energy savings, and is that changing?**

The single largest force behind energy efficiency has been government regulation. For decades, energy efficiency was about regulators reducing energy needs to ensure security of supply but, more recently, those efforts are expanding to reverse the impact of climate change.

Here, regulation is essential to define who bears these social costs and ultimately changes consumer behavior.

For example, the auto industry is an area where we've historically seen a big impact from energy efficiency; this has been driven by regulation. Thinking back to the 1980s, I don't remember too many people discussing how fuel efficient their car was but, over the following decades, regulators in Europe and the US focused on reducing vehicle energy consumption. Now we take increasing fuel efficiency for granted and it's even a feature in how some people describe their cars. But regulation was needed to push us in that direction.

While some industries have benefited from these regulations with large energy savings, future beneficiaries still exist; buildings, for example, have a similar carbon footprint to automobiles in Europe. Efficiency regulations for buildings have been slow to come but they're now emerging quickly.

**According to the IEA, over 60% of energy efficiency savings have been from the industrial and services sector since the beginning of the century. What has been the impediment to broader adoption in other sectors?**

The industrial and services sector has been the leader in energy efficiency projects because this is where regulation has focused; energy costs are also high.

In industries where the customer absorbs the energy cost, regulation has incentivized efficiency improvements. In large factories, energy is typically one of the biggest variable inputs and costs, so reducing energy consumption can have a huge impact on per unit profits. The economics, whether punitive or beneficial, drive most of these decisions.

In other sectors, like residential buildings, there is still little reason to make assets more efficient from an economic perspective. For example, the financial benefit to an individual apartment tenant isn't huge and, in many places, regulation does not require it. But, in markets with regulatory requirements, we are seeing a big impact on energy demand in buildings.

About 70% of people in Germany lease their homes. For many of them living in apartments, energy costs were traditionally split on a pro-rata basis across the whole building. This type of structure did not incentivize less energy use because individuals didn't reap the benefit or bear the burden. But, for several years now, Europe has required sub-metering by law to ensure that each tenant pays for their actual energy use.

Using **Techem** devices and services, we are enabling that sub-metering and helping tenants better understand their energy demands and the costs they can save. Regulations like the European Energy Efficiency Directive (EED) are spreading across the world as regulators now fight climate change. This will lead to broader adoption of energy efficiency savings in homes.

**Energy efficiency investments are expected to make one of the largest impacts in the reduction of global carbon dioxide emissions over this decade but their incremental impact is estimated to decline post 2030. Do you agree with this assessment?**

I do agree with this. The key is knowing which markets have the longest runways and when to enter them.

Think about how buildings are becoming more efficient. New buildings are built to impressive energy efficiency building standards and older buildings are being updated with more insulation. These types of investments make a large initial impact but with each additional feature added, the benefit of the impact lessens.

Back to the example of German sub-metering. This was a huge incremental change in the market and enabled significant energy savings in multi-family dwellings. While adding additional smart devices does impact energy efficiency, the impact becomes incrementally less with every new feature added and, certainly, incrementally less on every Euro spent. But, in the case of **Techem**, our tech-enabled devices are already installed in the home, with long-term contracts. We can then add other services, which may have less incremental impact but create significant savings value to tenants since the device is already installed. In this case, the key was being early in a regulatory shift and being able to expand value-add services past the initial purpose through the same device.

However, as more tech-enabled devices are installed, it becomes easier to repurpose or expand the use of these devices. This may have the impact of reducing, or flattening, the diminishing returns on energy efficiency we see today.

**In the past few years, there has been an explosion of tech-enabled devices and the Internet of Things (IoT) has enabled new services. As we can measure supply and demand better, what new disruptive business models do you see arising?**

There is a tremendous technology evolution happening right now that will allow us to save energy without sacrificing comfort. Today, optimizing energy consumption is time consuming. But tech-enabled devices, and the data they provide, will allow us to optimize this consumption automatically. Further, as the world transitions toward renewable power, which is intermittent, the same types of devices and services can balance the supply side.

Think about a company like Uber. Uber maximizes the use of resources by matching those who demand transportation with those providing it. The use of Uber vehicles is very high. This concept can also be applied to energy.

Through tech-enabled devices, we can balance power grids much more effectively in real-time, even with intermittent renewables, to match power production with demand. This could ultimately be used to provide real-time power pricing to customers, better reflecting the real cost of energy and driving more efficient consumer behavior.

In these instances, the essence of the traditional infrastructure business stays the same. But, through fine-tuning, we can improve the business model and operations. The disruption comes through the regulation and the business models will adapt to be better optimized.

**How will the increase in technology use enable more distributed or decentralized energy supply around the world?**

Today, our power systems are based on a model with high fixed and variable costs; you build a large power plant and that electricity is sent, sometimes far distances, to those who need it. While the system is usually balanced, it's difficult for producers to know how much electricity will be needed and, therefore, determine the need to oversize generation.

Though, with the increasing penetration of renewables, the variable cost of power has declined and can even be negative at times. This dynamic, with the ability to better understand and monitor power demand in real-time, has led to a shift where smaller decentralized generation sites, matched to balance with demand, can offer cost savings to consumers. As more tech-enabled devices are rolled out across the globe, this trend is expected to become more common.

> "The single largest force behind energy efficiency has been government regulation. For decades, energy efficiency was about regulators reducing energy needs to ensure security of supply but, more recently, those efforts are expanding to reverse the impact of climate change."
>
> **Andreas Umbach**

# 03
# The most compelling decarbonization infrastructure investments

Partners Group has developed a framework for analyzing and assessing decarbonization solutions across sectors, geographies, and technologies.

Utilizing this framework, we are focusing our investments on the following areas:

- **Clean power** (replacement) – renewable power development platforms and reliability and flexibility assets
- **Low carbon fuels** (replacement) – natural gas and bioenergy, in the near-term, and hydrogen and synthetic fuels in the longer-term
- **Energy & resource efficiency** (conservation) – increasing efficiency gains and better waste management solutions
- **Carbon management** – capture, transportation, and sequestration or use of carbon emissions

## Replacement of high emission fuels is currently the largest market opportunity

**Replacement** of high emission fuels remains the largest market opportunity for investors, and it is expected that c. USD 14 trillion will be invested this decade. Within this category, we believe that continued **renewable, clean power** growth and the use of **natural gas** power generation to provide reliability and flexibility to the grid will require more than 85% of this spending. **Bioenergy** investment will be smaller, at around USD 500 billion over the decade, but can offer strong returns in the geographies that exhibit regulatory support. **Hydrogen** will be a critical area of investment in the future but is unlikely to provide material investable opportunities within the next few years.

### Clean power remains the largest contributor to decarbonization in the near-term

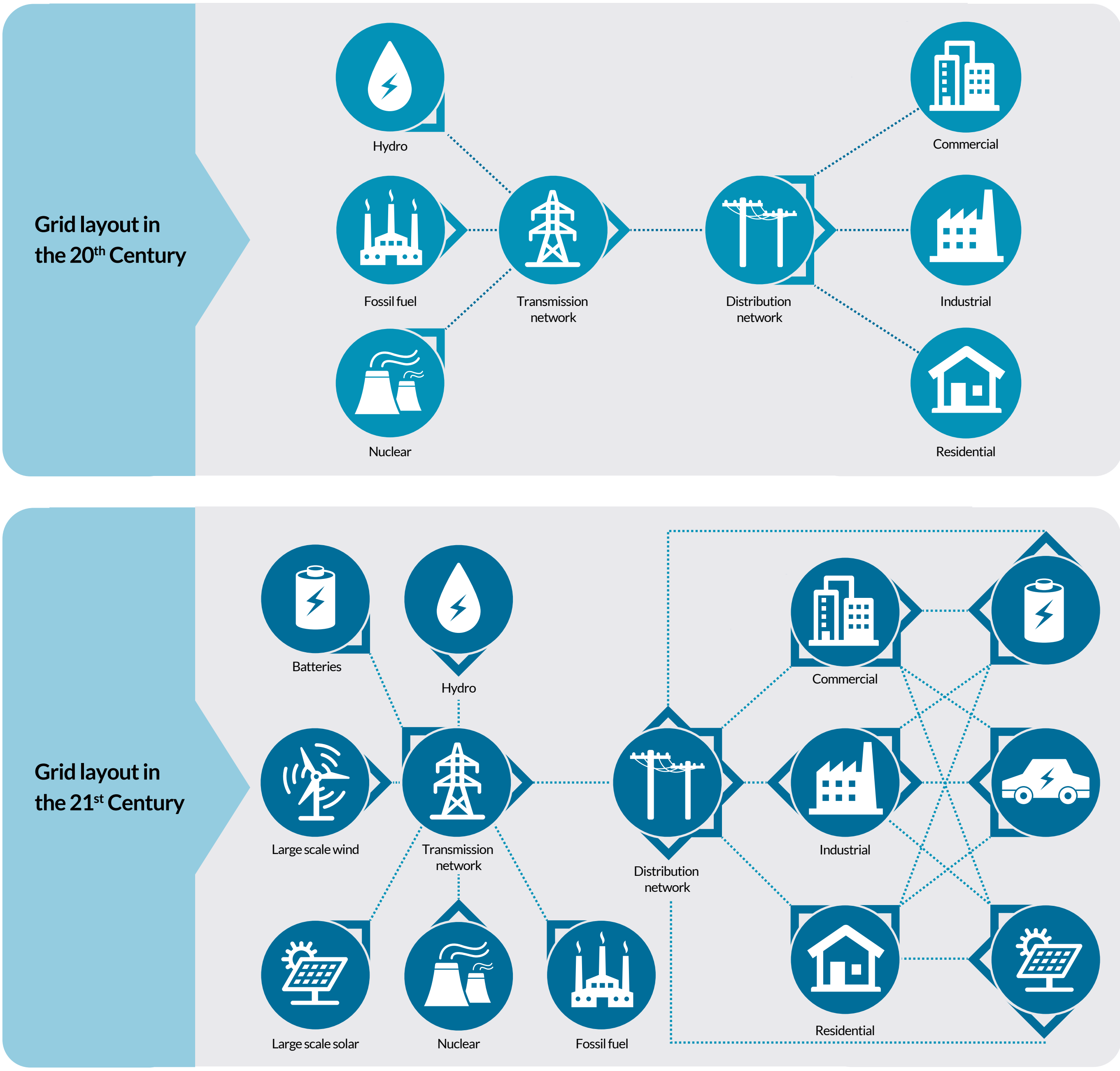
Renewable, clean power is expected to grow c. 8% annually through at least 2040, with c. USD 600 billion of investment needed annually – almost double the current levels – to hit Paris Agreement targets[12]. We expect this to remain an area of focus for infrastructure investors for many years to come, although the industry's structure and the way we invest within it has been shifting, as noted in Chapter 2.

12 Source: International Energy Agency (2021).

Until recently, operating or construction-ready utility-scale assets have provided more traditional infrastructure returns. But as the technology and cash flow profile of these assets has matured, lower-cost capital has entered the market and returns have been compressed. As a result, Partners Group has shifted toward newer models in the renewable power space. In particular, we believe that risk-return profiles favor **platform development** companies **and reliability and flexibility** solutions.

A reliable and flexible supply of power is vital to economic and social wellbeing. However, supply reliability is becoming more challenging to manage and is increasingly at risk as the power system is becoming more complex, as shown in figure 15. This is causing blackouts at an increasing rate, with severe economic and societal consequences.

**Figure 15 – Structural changes in global power systems**




Source: Partners Group (2021). For illustrative purposes only.

DIMENSION RENEWABLE ENERGY

## Investment example: Dimension Renewable Energy

Dimension Renewable Energy is a leading distributed energy platform focusing on community solar and battery storage in the US. It is focused on originating, developing, financing, and operating these assets with a deep pipeline of more than 180 projects totaling over 800 MWs of solar capacity and over 800 MWhs of battery storage across eight states. They will serve residential, commercial, and industrial subscribers from local communities where the projects are located.

Community solar benefits from several transformative decarbonization trends driving the low-carbon transition. These include the increasing environmental consciousness of consumers, a regulatory landscape facilitating the decentralization of the power sector to improve reliability, and broadening access to the benefits of renewable power for historically underserved consumers and households.

More traditional sources of baseload and dispatchable generation, such as coal, natural gas, and nuclear, are being displaced by wind and solar generation, which is both intermittent and unpredictable. Renewable generation is growing rapidly and, at the same time, economic and environmental pressures are accelerating the retirement of coal and nuclear capacity. Around 46 GWs per year of net capacity loss is expected over the same period, predominantly in Europe and North America. As a result, the share of intermittent wind and solar in the worldwide power mix is expected to grow significantly. We believe reliability and flexibility assets will become increasingly important to enable renewable growth until better storage technology evolves.

Renewable power generation addresses the supply side of the equation, while the electrification of transportation and buildings underpin dramatic demand growth. There are wide ranges in estimates of how much transportation will be electrified in 2040, from 4-20 times today's level[13]. However, in all scenarios, more electricity will be needed in the sector. Once vehicles are electrified, the source of electricity will determine the level of emissions produced through use. More renewable and low carbon electricity will therefore be needed to serve this demand growth.

Additionally, the further electrification of buildings, which already consume more than half of global electricity around the world, is estimated to grow by 34% over the next three decades[14]. This will add even more demand for clean power generation.

Partners Group has invested in over 20 clean power projects since 2001. Examples of renewable platform development companies in our portfolio include **Dimension Renewable Energy**, a leading distributed energy platform focusing on community solar and battery storage across the US, and **VSB Group**, a leading European developer, owner, and operator in the renewable energy sector. We have also invested in the reliability and flexibility solutions space, most recently acquiring a majority stake in **EnfraGen**, a leading developer, owner, and operator of specialized power generation assets in Latin America.

13 Source: International Energy Agency (2021).
14 Source: International Energy Agency (2020).


VSB

ENFRAGEN

## Investment example: EnfraGen

EnfraGen is a developer, owner, and operator of essential grid stability and renewable power generation businesses across Latin American investment-grade countries. EnfraGen's business model supports the process of the energy transition towards a more sustainable, lower carbon energy mix. It does this by enabling greater renewable penetration in the countries in which it operates while ensuring grid reliability during periods of renewable intermittency.

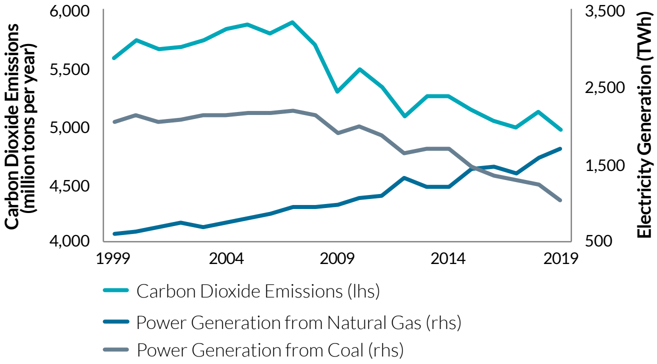
EnfraGen has two operating divisions which specialize in owning and operating energy transition assets. **Prime Energía** provides specialized grid stability power generation assets in Colombia and Chile. Through **Fontus Renewables**, the company provides hydro capacity in Panama and is developing efficient solar assets in Chile.

### Natural gas is a necessary complement for a reliable and flexible energy transition

The momentum behind the decarbonization of the power sector is undeniable. However, in most scenarios, the shift to fully clean power will take several decades. Indeed, at least half of primary energy globally is still likely to be generated from hydrocarbons in 2040, even in scenarios that align with the Paris Agreement[15]. Therefore, as we transition our energy sources toward renewable power, natural gas will provide an abundant and reliable complement. It will aid the transition due to its energy characteristics and lower environmental impact than liquid fuel or coal. Natural gas produces about half of the carbon emissions per unit of energy as coal[16]. As evidenced in the US, using natural gas for reliable power generation can significantly reduce emissions.

15 Source: International Energy Agency (2021).
16 Source: US Energy Information Agency (2021).

### Figure 16 – US carbon dioxide emissions decline as natural gas power generation displace coal




Source: US Energy Information Administration

Natural gas is a growing energy source as liquefied natural gas (LNG) markets increasingly connect the world's supply and demand centers. New, low-cost, abundant supply, particularly from the US and Qatar, can now be dispatched to meet global demand and mitigate geopolitical supply shocks. Meanwhile, sustainably sourced LNG has increasingly become a focus for policymakers in the US, Europe, and parts of Asia. Irrespective of the inclusion of natural gas sourced from shale within the sphere of 'sustainable', producers seek to further reduce carbon emissions and innovate through related industries such as carbon management.

At Partners Group, our focus in the natural gas value chain is connecting regions of abundant supply to those of growing demand and remaining far from the wellhead to diversify and reduce volumetric risk. Our investments in **CapeOmega**, an offshore natural gas infrastructure platform in Norway, and **Fermaca**, a leading operator of natural gas infrastructure in North America, are helping to transport this low carbon fuel to regions where it is needed for grid reliability and decarbonization.

CAPE OMEGA

## Investment example: CapeOmega

CapeOmega is a leading offshore infrastructure platform that transports natural gas from the Norwegian Continental Shelf to the European mainland. Located in one of Europe's only remaining gas regions, this essential and critical infrastructure is responsible for transporting over 25% of Europe's natural gas demand across its 8,000 km pipeline network.

CapeOmega provides this low carbon fuel to help Europe continue transitioning from dirtier fuel sources, like coal, and enable baseload power generation for grid reliability and flexibility while intermittent renewable power penetration grows. In addition, the company continues to innovate low carbon fuel solutions by now providing LNG marine transportation and is evaluating projects to produce clean hydrogen that can be mixed into natural gas flows.

## Investment example: Gren

GREN is one of the largest district heating platforms in the Baltics and generates a heat capacity of 881 MWs and a power capacity of 130 MWs across 387km of district heating networks. The platform's fuel is largely derived from renewable or recycled sources, mainly biomass.

Growing demand for district heating is being driven by several transformative trends in the region, including fast-growing economies and urbanizing populations, as well as rising support for sustainable energy initiatives. The company's sustainable heating services reduce reliance on conventional higher-carbon power sources, which will have broad positive stakeholder impact over the long-term.

### Bioenergy growth will focus on 'hard to abate' emissions

Bioenergy is a growing low carbon fuel source that is derived from organic feedstocks and used to replace high-emission fuels. It is produced by converting organic feedstock to fuel and, in many cases, the output is indistinguishable from the current fuels used. Bioenergy is considered a carbon-neutral fuel on a full life-cycle basis, as it only expels emissions that were captured during the life of the organic material and would otherwise be expelled once it dies. The main barriers to adoption are feedstock logistics and the cost of conversion. Costs are expected to decline by c. 25% over the next decade[17] and, as this happens, consumption will grow. However, total global growth will remain limited due to restrictions in the availability of viable feedstocks.

There are three main sources of bioenergy:

- **Biomass** generates energy, typically for electric power generation or heat, by incinerating organic waste materials. Sustainable biomass is expected to grow by 3-5% annually through 2050 as it replaces coal in developing nations and those with a 'dirtier' power fuel mix[17]. Partners Group recently acquired **GREN**, a district heating platform in the Baltics, where a primary fuel source is sustainable biomass. This sustainable heating platform will provide lower emission heating to thousands of homes and businesses in the region.
- **Biofuel** is an alternative, lower-carbon fuel source that is used in on-road vehicles, aviation, and marine vessels. Typically derived from food product or food waste, ethanol and bio or renewable diesel are the most commonly used biofuels, as well as emerging sustainable aviation fuels (SAF). The US, Brazil, and Europe account for 80% of global supply. Biofuel will play a critical role in decarbonizing transportation because it can be used in vehicles that are difficult to electrify, such as long-haul trucks, airplanes, and ships. Its role will be smaller in decarbonizing light vehicles that can be electrified.

  Government policies have driven biofuel growth while feedstock supply challenges have limited it; this situation is expected to continue. Over the past two decades, government requirements have led to a ten-fold increase in biofuel production[17], yet it still only accounts for 3.5% of transportation fuel. To meet Paris Agreement targets, biofuel consumption in transportation will need to triple by 2030 and more than quadruple by 2050. Governments will continue to drive that expansion. We expect that biofuels will be critical to the transportation sector's decarbonization and we are in discussions with several of the largest global players in this market.

17 Source: International Energy Agency (2020).

- **Biogas** is produced by decomposing organic waste, typically through a process called anaerobic digestion. Anaerobic digestors capture the GHGs that organic waste material emits, as part of a waste management process. The process ultimately produces an upgraded biogas called biomethane or renewable natural gas (RNG), which has the same chemical make-up as traditional natural gas.

  While RNG could technically meet c 20% of worldwide gas demand today, global production is currently at only 5% of that potential, or less than just 1% of global gas demand[18]. RNG is currently primarily used in Europe to generate electricity and heat where government subsidies are available, mainly in Germany. However, RNG demand has recently started to accelerate in other regions such as the Western US and Asia. In these regions, governments are using economic incentives to spur private investment. At **Resilient Infrastructure Group**, our US water sustainability platform, we are reducing methane emissions by transforming dairy wastewater into RNG; this is used as a substitute for diesel and can aid in decarbonizing a commercial vehicle fleet.

### The role of hydrogen as an energy vector

Hydrogen is a common gas and has the greatest energy content per unit of mass of any fuel. However, it has low energy per unit by volume, which means that transportation and storage costs are high. Furthermore, despite its abundance, pure hydrogen must be extracted from hydrocarbons via steam methane reformers or water in an energy-intensive electrolysis process. Hydrogen does not produce GHG emissions during the combustion process – only water is released. But its overall emissions profile varies greatly depending on how it is sourced.

There are three main types of hydrogen:

- **Grey hydrogen (>99% of worldwide hydrogen production)**. Grey hydrogen is derived from hydrocarbons; primarily, it is synthesized from natural gas. It is the most cost-efficient and dominant source of hydrogen today. However, the production of grey hydrogen emits large amounts of $CO_2$ – around 9kg/kg$H_2$ or around 830mt a year globally. This corresponds to 2% of global $CO_2$ emissions and represents more than the entire emissions of a large country.
- **Blue hydrogen (<1%).** Blue hydrogen relies on a similar production process to grey hydrogen, but carbon capture and storage are used to reduce emissions from the process by 60-90%. Carbon capture has environmental benefits but is an expensive process; it costs around USD 70 per ton, effectively doubling the production cost compared with grey hydrogen. Subsidies are emerging in Europe and the US, which could support growth in this area.
- **Green hydrogen (pilot stage).** Water can be split into hydrogen and oxygen via electrolysis. The process requires electricity and is completely carbon-free if coupled with a clean power supply like wind or solar. However, this process is not yet cost competitive with grey hydrogen.

Hydrogen will make a significant contribution to decarbonization in the future, but current investments are challenging. This is because most assets are yet to achieve the strong infrastructure characteristics we look for. For more thematic research on this topic, see our September 2021 research paper Low-Carbon Hydrogen: Key to Global Decarbonization.

18 Source: International Energy Agency (2020).

**Figure 17 – Hydrogen in numbers**

| | | | |
|---|---|---|---|
| **30%** of man-made GHGs targeted | **>30 nations** have released Hydrogen roadmaps | **USD 1.8/kg** to reach parity with natural gas | **40-75%** fail in production cost required |
| **2030s** Large-scale adoption | **15%** of the EU's primary energy by 2050 | **USD 80 Bn** of global projects in advanced stage | **USD 510 Bn** investment by 2030 to meet EU target |

Source: Shell (2020), Hydrogen Council & McKinsey (2021), Bloomberg New Energy Finance (2020), Partners Group (2021).


## Investment example: Techem

Founded in 1952 and headquartered in Eschborn, Germany, Techem caters to a global client base of real estate operators and private homeowners from its 100 locations in more than 19 countries. Its principal energy services business provides services and devices for the metering and billing of energy and water, plus device sales, hire and maintenance. In addition, its energy contracting business delivers heat, cooling, flow energy and light, as well as the planning, set-up, financing and operation of energy systems and energy monitoring and controlling services.

Techem is the market leader in Germany – the largest sub-metering market in the world – as well as in an additional 13 European markets. **Today, Techem solutions account for 8.7 million tons of $CO_2$ emissions avoided per year, thereby contributing to global climate protection objectives.**

## Conservation will be required to reduce emissions from existing sources

Conservation refers to reducing emissions by using improved processes or tools without replacing the high carbon emission source. We estimate that USD 5.7tn will be spent in this area globally over the next decade. Most of this investment will be deployed in **energy and resource efficiency** projects, such as process gains and for heat exchange in companies and buildings. These opportunities may be subscale for larger institutional infrastructure investors. However, certain niches, such as smart metering, have tech-enabled infrastructure service characteristics. Our investment in **Techem**, a leader in the energy management space in Europe, is an example of this.

### Waste management developments will help create a closed loop carbon economy

Waste management will be a growing area of interest for investors as policymakers incentivize the use of new and repurposed technologies to help create a closed loop carbon economy.

Currently, direct emissions from post-consumer waste are relatively small and contribute less than 5% of direct GHG emissions, but they are expected to triple by 2050 as populations increase and living standards improve. Of these emissions, which include both methane and $CO_2$, landfill is responsible for 50%, followed by composting and incineration, without energy extraction[19].

Several countries have adopted standards to convert waste-to-energy through incineration. The process incinerates non-recyclable waste to produce electricity or steam and emissions are scrubbed and filtered. This reduces mass waste, offsets fossil fuel use, and provides baseload levels of electricity in some areas. By itself, incinerating waste can be an expensive form of disposal but generating power or heat offsets the cost. Europe has been converting waste-to-energy since the 1980s and has 522 plants in operation, accounting for 28% of municipal waste treatment in the EU and 47% in Switzerland, for example. Meanwhile, in Asia, waste-to-energy has recently been growing in line with increased amounts of waste as economies expand. Partners Group is exploring several opportunities to invest in this growing theme in both regions.

19 Source: International Energy Agency (2020).

Recycling is at the top of the waste hierarchy and will be critical to a closed loop carbon economy. Mechanical recycling is an established process, which converts used materials into substances that can be re-used. But a newer technology, chemical recycling, is emerging. It has a limited history and higher costs, but it can recycle materials that are difficult to process mechanically and can remove impurities. As the aim of recycling is to reduce emissions that would otherwise have come from creating new products, it has the greatest impact in materials that are energy intensive to produce, such as metals, glass, plastic, and paper.

There are also new, specialized recycling areas that could offer compelling risk-adjusted returns. E-waste is an emerging market that is expected to grow by more than 165% by 2050. This has become a major focus because of expected shortages in the metals used to produce electronics, leading to significant price increases. It is estimated that discarded phones alone contain around USD 12 billion worth of metals.

Another related area is EV battery recycling, although, given that there is currently minimal global capacity, this is a longer-term opportunity. More generally, battery recycling is a small industry today – worth around USD 50 million per year – and focused on consumer electronic batteries. By the end of the decade, the total number of batteries available for recycling will grow more than six-fold. Therefore, capacity must increase and the capabilities for recycling larger batteries will need to be developed. Most of this capacity is expected to come online in China, but there will be expansion in Europe and the US as well.

## Carbon management is essential to reach Paris Agreement goals

Carbon management refers to the capture of man-made $CO_2$ emissions, either from point source emitters, such as industrial and power plants, or from the air itself. $CO_2$ is then transported to a site for sequestration or for use. This is commonly referred to as Carbon capture, utilization, and sequestration (CCUS).

Carbon management is essential for the world to meet the Paris Agreement goals. With today's technology, and without considering cost, only c. 90% of the emission reduction needed to reach the Paris Agreement goals is even possible without using carbon management solutions. Furthermore, if we incorporate the cost of abating emissions using current cost curves, only c. 60% of the needed emission reduction is possible without carbon management solutions at an implied carbon price of USD 100 per ton $CO_2$ – the higher end of most governmental carbon pricing schemes[20].

20 Source: Goldman Sachs (2021).

It is clear that carbon use and sequestration will be critical to the decarbonization equation. As the International Energy Agency points out: **"reaching net zero will be virtually impossible without CCUS"**.

Carbon management as a concept, and its related technologies, are not new; recently, however, ingenuity and policy advances are making this **the next generation in decarbonization for infrastructure investors**. New carbon management business models are emerging, which resemble traditional midstream models with similar returns and strong infrastructure characteristics. Expectations of how much global investment will be needed vary widely because the business models are new, but we estimate that around USD 1.6tn will be spent in this industry, around the world, by 2040.

In the near term, most captured carbon emissions will be sequestered underground. However, an emerging industry is evaluating new ways of using captured emissions to create building materials, synthetic fuels, and plastics. This will represent a significant leap forward in creating a closed loop carbon economy in the future.

### New business models have improved economics

Most sequestration sites are currently dedicated to a single or small group of facilities. However, sequestration hub models are under development; these will allow emitters to share infrastructure, which will reduce per unit costs by up to 70%[21]. Under this model, dedicated infrastructure will transport captured $CO_2$ emissions to the sequestration hub, where it is injected into the ground. The $CO_2$ can also be delivered for use as this area grows.

21 Source: The Zero Emissions Platform (2020).

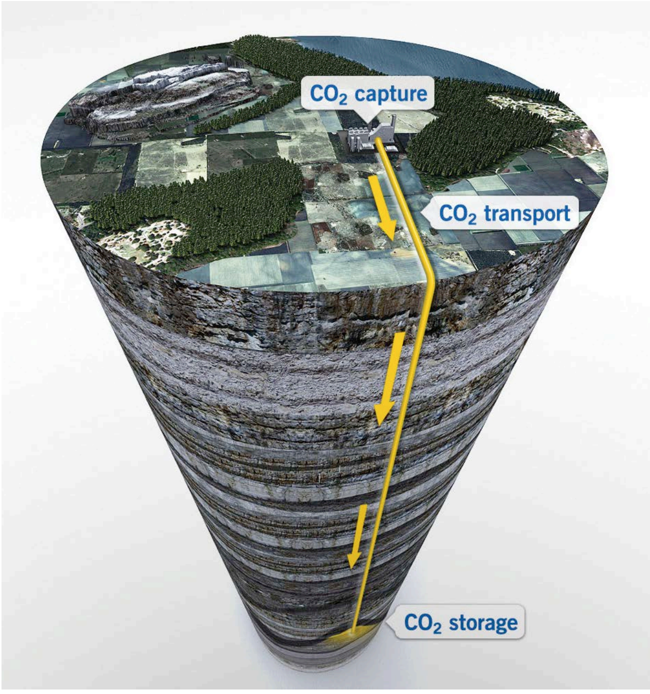
### How does CCUS work?

There are three distinct components of the CCUS value chain:

- **Source capture:** Equipment separates $CO_2$ before it is emitted into the atmosphere from point sources, or emerging technologies capture it from the air directly through direct air capture (DAC). The factors that have the greatest impact on the cost of capture include the type of technology used and the concentration of $CO_2$ emissions emitted from the source.
- **Transportation:** This occurs either by pipeline or ship. The pipeline segment is well defined and is similar to traditional hydrocarbon midstream structures and returns. Shipping is still in the early stage of development. Shipping $CO_2$ is, in theory, similar to LNG, but this has not yet been well demonstrated and there is still a need for innovation, particularly for offshore unloading. Regulatory frameworks, the development stage of pipelines, and a consideration of whether sequestration is onshore or offshore are the main factors in determining which method to use.
- **Underground sequestration (storage) or use:** In sequestration, $CO_2$ is injected underground into saline acquirers, depleted hydrocarbon fields, or oil reservoirs for enhanced oil recovery use. In these cases, the captured $CO_2$ is permanently sequestered. Typically, this business model entails a fixed fee per ton $CO_2$ sequestered, which is similar to hydrocarbon storage.

While the revenue models are slightly different for each part of the value chain, they are typically long-term, take-or-pay agreements with large industrial counterparties. This has advanced the most in the US, where the federal 45Q tax credit program and several state programs underpin these long-term economics. Similar frameworks are under discussion in other parts of the world, including Norway and the UK.

**Figure 18 – The CCUS value chain**




Source: Global CCS Institute (2021).

## Section 45Q tax credit enables CCUS development in the US

The **Energy Improvement and Extension Act of 2008** originally enacted the 45Q tax credit to incentivize the reduction of $CO_2$ emissions in the US. The Act provided a USD 20 per ton credit for carbon emissions that are captured and permanently stored, and USD 10 per ton credit for $CO_2$ used as an injectant (e.g., for secondary oil recovery). These levels of economic support did not spur significant investment.

The US Congress remedied this by modifying the tax credit in the **Bipartisan Budget Act of 2018** to USD 50 per ton for permanent sequestration and USD 35 per ton for use by 2026. It also applied the credit for smaller facilities, which were previously excluded. This modification makes it economic to sequester c. 5% of US point source emissions from almost none previously.

In the recently signed **Infrastructure and Jobs Act of 2021**, USD 11 billion of funding was established to finance CCUS development and enhance research and development, but no changes were made to the 45Q tax credit itself. In the still proposed **Build Back Better Act**, there is the potential to extend the timeframe to begin projects eligible for the credit; add a direct pay component, rather than needing tax equity; and increase the credit to USD 85 per ton for permanent sequestration, USD 60 per ton for use, and up to a USD 180 per ton credit for direct air capture. This increase in value would enable 10-15% of US point source emissions to become economic for capture and sequestration.

Currently, the owner of the capture equipment is the party eligible to claim the tax credit. This party must physically or contractually ensure the sequestration or utilization of the $CO_2$ and may elect to transfer the credit to another party that stores or puts the $CO_2$ to beneficial use. Credits are unit based and resemble the wind power Production Tax Credits. The credit can be claimed when an eligible project has:

- Securely stored the captured $CO_2$ in a geologic formation, or
- Beneficially used captured $CO_2$ (or its precursor carbon monoxide) as a feedstock to produce fuels, chemicals, and products in a way that results in emissions reductions as defined by federal requirements.

Several global policy programs are in place, or being designed, which are expected to support the monetization of $CO_2$ capture. Select examples of this include:

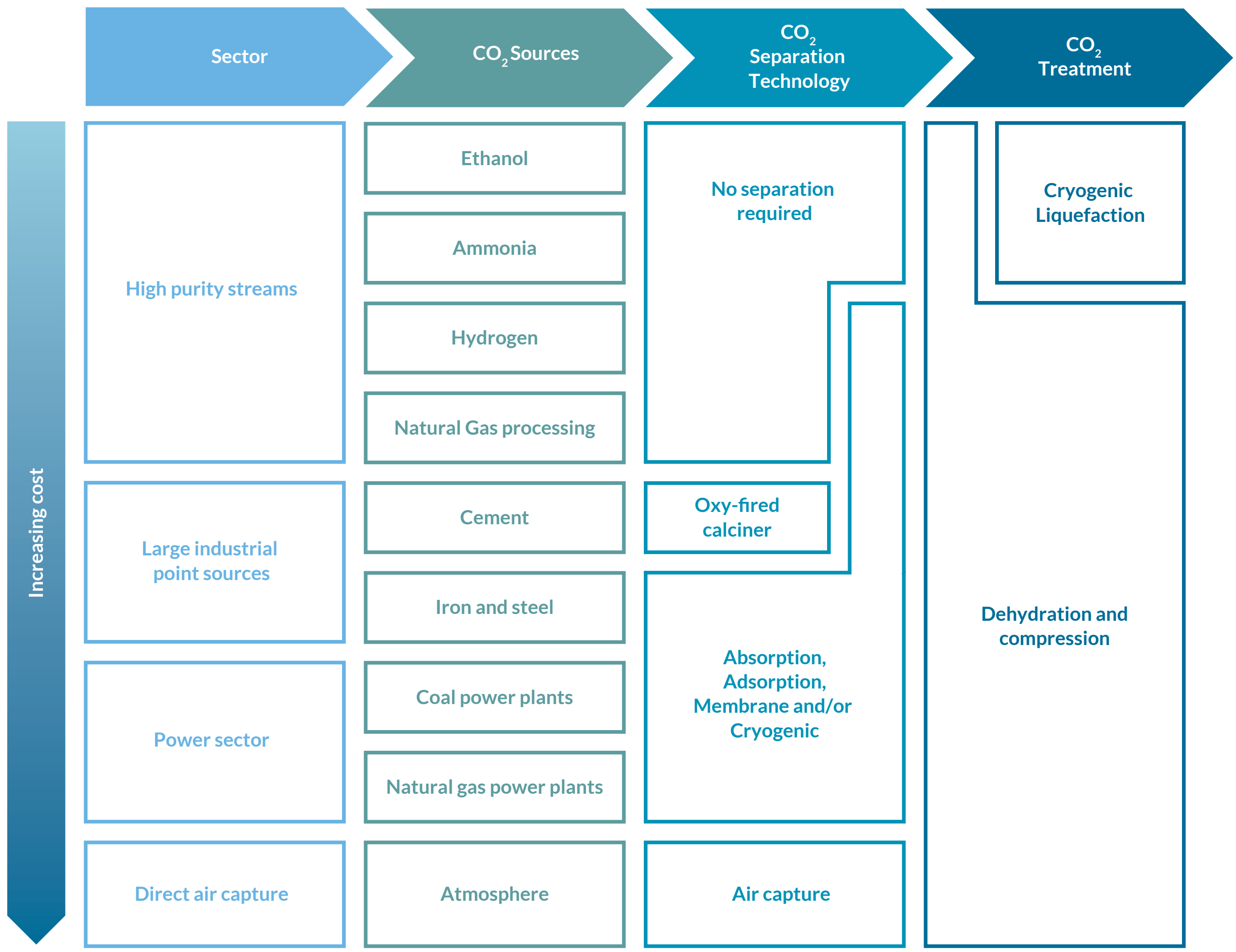
- **Paris Agreement Article 6** – This article, the final part of the Paris Agreement, creates a global/international compliance market for emissions reduction. The framework for implementation is still being finalized, but each country participating in the Paris Agreement will agree to a mandatory minimum amount of carbon offsets and use the newly established market to reach these goals. Captured and sequestered $CO_2$ could be sold into this new market to allow countries to meet their agreed upon reductions.
- **Carbon Offset and Reduction Scheme for International Aviation (CORSIA)** – CORSIA aims to keep international aviation's emissions at a 2019–2020 baseline level. It is considered one of the most likely and largest sources of future carbon credit demand. Airlines around the world will have to monitor and report emissions from their international routes to establish the baseline.
- **Low Carbon Fuel Standards (LCFS)** – British Columbia, the European Union, California, and Oregon have LCFS programs. In the US, several other state legislatures are at various stages of considering LCFS policies, including Colorado, Illinois, Iowa, Massachusetts, Nebraska, New York, South Dakota, and Washington. Additionally, regional LCFS proposals in the US include the Midwest Clean Fuel Policy Initiative and the Transportation and Climate Initiative (TCI), which cover 17 states across the Midwest and Northeast regions.

### Point source carbon capture technology is mature but still improving

As depicted in the carbon capture archetypes image below, there are a wide variety of carbon capture technologies available. Within each technology, there are numerous IP owners that are performing ongoing research and development to improve performance, efficiency, and capital costs. While there are some newer processes and advancements, which have not been sufficiently proven, the carbon capture process for high purity streams (the first facilities that will install capture equipment) is a relatively simple dehydration and compression – sometimes with cryogenic liquefaction – which requires no technology license. These processes have been in operation at scale for decades.

The $CO_2$ will typically go through two main processes: firstly, it is separated from other gases in the emitter flu, and secondly the $CO_2$ is treated in order to make it ready to transport (normally in a pipeline).

**Figure 19 – Carbon capture archetypes**




Source: Partners Group (2021). For illustrative purposes only.

The description of the separation technologies used is summarized below (ordered in highest technology maturity to the lowest):

- **Absorption:** Absorption is the uptake of $CO_2$ into the bulk phase of another material, e.g., dissolving $CO_2$ molecules into liquid solution (solvent). This process is typically used for the separation of $CO_2$ from other gases in post-combustion applications. Amine absorption has been the primary method of separating $CO_2$ from gas mixtures for more than 40 years and is the most commercially mature capture technology.
- **Membrane:** Membranes selectively separate $CO_2$ based on differences in solubility. The membrane materials used for $CO_2$ capture can be used in either pre or post-combustion applications. The advantage of membrane systems is that they are modular; however, they are ineffective at low pressures and low concentrations of $CO_2$ in conventional flue gas streams.
- **Adsorption:** Adsorption is the uptake of $CO_2$ onto the surface of another porous material (sorbent). $CO_2$ capture adsorbents may require less energy input compared to absorption capture with solvents, while offering greater flexibility in operating temperature ranges and fewer environmental impacts. This technology still requires further research and development.
- **Cryogenic:** Cryogenic processes cool the gas stream to separate the $CO_2$ depending on the different boiling points of various gases. Cryogenic capture is a fairly new technology and, as such, many system integration activities and full demonstrations have not been tested at a meaningful scale. Cryogenic capture avoids chemical separation and the need for the separation material, thus, there is no separation medium to replace or be poisoned by contact with the flue gas, potentially making the operation simpler.

### Direct air capture (DAC)

While direct air capture technology has not yet been proven commercially, it is currently being tested at scale. It is technically the best option for un-abatable emissions today, such as those found in transportation.

Direct air capture is a critical technology step in the path toward net zero carbon. In the absence of direct air capture, around 10% of emissions are un-abatable at any price today and c. 40% of emissions are not economic to abate at a carbon price above USD 100 per ton $CO_2$. Yet even at current higher estimated prices for direct air capture, it can abate what is currently unabatable. It is likely that, by the next decade, direct air capture will be economically comparable with the higher end of current government incentives or carbon prices and these facilities can be placed directly on top of existing sequestration hubs.

### Natural sinks

Natural sinks are naturally occurring carbon reservoirs such as soil, vegetation, and oceans, which can remove $CO_2$ from the air. According to the World Economic Forum, on a gross basis, oceans capture about a third of global $CO_2$, including naturally occurring $CO_2$. At the same time, forests capture more than half, primarily through living trees and organic matter in soil. However, deforestation is a growing problem that many policymakers are trying to address. Since 1990, deforestation has removed more than half of the world's sequestration potential from forests; this is equivalent to more than the whole of the European Union's GHG emissions per year. Progress was recently made on this front at COP26, when about 100 countries, representing 85% of the world's forests, agreed to end deforestation by 2030.

### Reforestation & Afforestation

Reforestation and afforestation both involve either planting trees or planning for natural tree regrowth. In reforestation, a forest once existed in the planned location, while in afforestation, the tree growth is new to the site. These are among the cheapest ways of sequestering carbon and sometimes cost nothing. But it takes a vast area to make a material impact and that impact is difficult to measure. Since trees both emit and capture carbon emissions, the net effect matters. On a net basis, all the trees in the world sequester only around 10 Gt $CO_2$ or 20% of global man-made GHG emissions.

# 04 Looking ahead: a closed loop carbon economy is the future

Today, captured $CO_2$ can either be permanently sequestered or used in several different ways. However, captured carbon today accounts for less than 1% of global emissions.

To reach net zero carbon goals over the next three decades, society will have to work to reduce overall emissions and develop a closed loop carbon economy that makes use of converted $CO_2$ for the remaining unabatable emissions.

In this closed loop carbon economy, unabated GHG emissions will be c. 5% of the level they are today[22]. Hydrocarbon fuels will reduce from 85% of primary energy to around 20% as renewables, bioenergy, synthetic fuels, and hydrogen replace them to make up 70% of primary energy, which is up from less than 10% today. Nuclear energy is c. 10% of primary energy supply. At this point, natural gas will account for about 60% of the reduced hydrocarbon use, up from less than 30% today, and carbon capture equipment will accompany almost all hydrocarbon combustion, except in transportation.

With developing nations increasing their use, primary energy consumption will be 10% higher than today. Yet the energy mix will be cleaner and most man-made GHG emissions will be captured. The captured emissions will either be used in building products, fuels, and chemicals, or will be sequestered into industrial hubs from point source emitters in the case of industrial and power segments, or via direct air capture in the case of transportation.

22 Source: International Energy Agency (2021). BP Energy Outlook (2020).

## Re-using captured $CO_2$ could be a significant contributor to closing the carbon loop

New uses, such as the production of building materials, fuels, and chemicals, are still under development and the ultimate costs are not yet known. This makes long-term estimates difficult at best, although new carbon usage could be as high as 7 Gt $CO_2$ per year by 2030 or 15% of current GHG emissions, under optimistic scenarios[23]. The largest beneficiary over the next decade will be **cement and other building materials, but synthetic fuels and other chemical processes** will develop over the longer-term. The largest development inflection for these technologies is expected to be in the 2020s as cost curves are predicted to flatten materially.

### Cement and building materials

Cement and other building materials currently account for 9% of global $CO_2$ emissions, with cement the highest emitter in this group.

Over 85% of cement carbon emissions come from a process called calcination, in which limestone is heated to remove its carbon and create calcium oxide, an important ingredient. Cement then acts as a binder between aggregates, or stones, to make concrete. Several practices and technologies are in development to reduce its carbon footprint, which range from energy efficiency initiatives and alternative fuel sources to using carbon sequestration technologies. However, few of these technologies are currently economic and there are few incentives for producers to make these changes.

Another innovation that could help is the introduction of **aggregates** made directly from captured carbon; several companies have started manufacturing and selling this new material. While it costs about twice as much as traditional building materials today, prices will fall with carbon capture costs, potentially to around USD 25/ton by 2030.

23 Source: McKinsey & Company (2020), International Energy Agency (2020).

### Synthetic fuels

Synthetic fuels, also called eFuels, combine $CO_2$ with hydrogen and would compete directly with hydrocarbon-based fuels and biofuels. They could be used in anything that uses traditional fuels with chemical modifications. Sourcing enough $CO_2$ and hydrogen to create these fuels at scale and economically are hurdles, but carbon capture technology can be used with a hydrogen plant to produce both feedstocks together. This technology exists today, but it is more expensive than both traditional fuels and biofuels.

Costs are expected to decline with further advances in carbon capture equipment and, at the lower end of the cost curve, synthetic fuels can already compete with some biofuel and traditional fuel in regions with a higher carbon tax. These types of fuel are expected to be introduced into 'hard to abate' transportation areas first, such as aviation and marine. Several large airlines have announced ambitions of achieving net zero carbon goals by 2050, but this will be difficult without alternatives like synthetic fuels. If airlines meet their pledges, 40% of all aviation fuel could be synthetic by 2070.

### Chemical processes

Converting $CO_2$ into **plastics** is vital in creating a closed loop carbon economy because plastics are responsible for more than half of global petrochemical emissions. This would see $CO_2$ used as a feedstock, rather than a waste product. Creating polymers, including plastic, from $CO_2$ would be the first step in this process, since this is already possible today and more effective conversion processes will emerge. As creating polymers is a highly energy-intensive process, the use of $CO_2$ to create methanol and, ultimately, the polymer, would offset potentially higher processing costs because $CO_2$ is much cheaper than the oil-based feedstock used to make new polymers today.

Ultimately, it is likely that chemical producers will be able to use a combination of renewable clean power and captured $CO_2$ to create chemical feedstocks for **olefins and styrene**, which are more complicated and widely used.

## Bringing it all together

At Partners Group, we envision a world that achieves the Paris Agreement goals with significantly reduced man-made GHG emissions and unabatable emissions as part of a closed loop carbon economy. But we realize that the overall decarbonization effort must be sizable and timely. This effort must begin today, and the USD 48 trillion of infrastructure spending, which we estimate is needed by 2040, is only the beginning. Renewables, and even broader replacement energy sources, cannot carry the full weight of this effort alone as we focus on 'hard to abate' emission sources. Replacement, conservation, and carbon management solutions will all play a critical role in decarbonization and have already begun to lead us toward the next generation of infrastructure investments.

Given the depth and breadth of the problem, private capital has a pivotal role to play in achieving Paris Agreement goals. Regulators will support these investments with stronger regulations and public funding to mitigate the risk-return profile of decarbonization investments until unsubsidized economics converge with those of more traditional infrastructure investments. This is similar to the role governments played in building the renewable power industry.

Partners Group aims to remain a leading player in this field. To do this, we plan to leverage our successful track record in the renewable space and thematic sourcing approach. We will invest in platforms that sit on the right side of the decarbonization value chain through a principal-protected underwriting approach and a proven value creation playbook.

# About Partners Group

Partners Group is a leading global private markets firm. Since 1996, the firm has invested over USD 170 billion in private equity, private real estate, private debt and private infrastructure on behalf of its clients globally.

Partners Group seeks to generate strong returns through capitalizing on thematic growth trends and transforming attractive businesses and assets into market leaders. The firm is a committed, responsible investor and aims to create sustainable returns with lasting, positive impact for all its stakeholders. With over USD 127 billion in assets under management as of 31 December 2021, Partners Group provides an innovative range of bespoke client solutions to institutional investors, sovereign wealth funds, family offices and private individuals globally. The firm employs more than 1,500 diverse professionals across 20 offices worldwide and has regional headquarters in Baar-Zug, Switzerland; Denver, USA; and Singapore. It has been listed on the SIX Swiss Exchange since 2006 (symbol: PGHN).

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