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BUILDING A JUST WORLD
AND A SUSTAINABLE PLANET

Clean Energy Investment in Emerging Markets and Developing Economies

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Executive summary

Under Brazil's G20 Presidency in 2024, the Energy Transitions Working Group (ETWG) has initiated a series of meetings focused on different priorities, including "Accelerating Financing for the Energy Transitions".

One of the key deliverables under this priority is the development of a "Roadmap to Increase Investment in Clean Energy in Emerging Markets and Developing Economies (EMDEs)". In support of Brazil's G20 presidency, this study seeks to contribute to the development of a comprehensive energy roadmap by offering OPEC's insights into the future energy mix through 2050.

OPEC's projections underscore a significant and sustained increase in global energy demand. Solar and wind energy are poised to be the fastest-growing energy sources, with anticipated annual growth rates nearing 7%. This growth trajectory is expected to result in a cumulative increase of nearly 43 million barrels of oil equivalent per day (mboe/d) from 2023 to 2050. This substantial rise is indicative of a broader shift towards renewable energy, supported by a concurrent decline in coal demand, which is projected to decrease by approximately 29 mboe/d over the same period. This decline is expected to be particularly pronounced in the OECD and China, driven by enhanced emission reduction measures.

In alignment with global climate goals, OPEC places significant emphasis on technological innovations critical for achieving a low-carbon future. Carbon abatement technologies, including advanced carbon capture and storage (CCS) systems, hydrogen production technologies and direct air capture. These technologies are pivotal for mitigating greenhouse gas emissions and sustainably meeting increasing global energy demand. OPEC's support for these technologies reflects a commitment to both reducing carbon footprints and ensuring energy security. Moreover, OPEC believes that the CCE approach could drive a transformational leap towards a sustainable society, enabling everyone to reduce GHG emissions while utilizing all energy sources efficiently.

The OPEC Fund exemplifies the dedication of OPEC Member Countries to fostering sustainable development. Since its founding in 1976, the OPEC Fund has committed over $27 billion to more than 4,000 projects across 125 countries, supporting various initiatives including clean energy and infrastructure development. In 2023 alone the OPEC Fund invested $1.7 billion in 55 projects, reinforcing its role in bridging the financing gap for EMDEs. The Organization's initiatives include the Food Security Action Plan and the Climate Action Plan, which aim to bolster resilience and address urgent needs in vulnerable regions.

The experiences of OPEC Member Countries offer valuable insights into successful approaches for financing clean energies. Saudi Arabia's Green Financing Framework is a prime example of how comprehensive financing approaches can attract significant investments in clean technologies. The Kingdom's commitment to investing $1.5 trillion in clean technologies by 2030, coupled with its robust public-private partnerships, underscores the effectiveness of structured frameworks and international standards in mobilizing resources.

1. Introduction

Under Brazil's G20 Presidency in 2024, the Energy Transitions Working Group (ETWG) has initiated a series of meetings focused on different priorities, including the first priority, "*Accelerating Financing for the Energy Transitions*".

One of the key deliverables under this priority is the development of a "*Roadmap to Increase Investment in Clean Energy in Emerging Markets and Developing Economies (EMDEs)*". In support of Brazil's G20 presidency, this study seeks to contribute to the development of a comprehensive energy roadmap by offering OPEC's insights into the future energy mix through 2050. It examines a range of scenarios beyond the Reference Case, with a particular focus on advancing clean technologies and concepts such as Carbon Capture, Utilization, and Storage (CCUS), direct air capture (DAC), hydrogen, and the Circular Carbon Economy (CCE).

Energy demand is anticipated to shift significantly in the coming decades, largely due to the large increase in the global population, which is expected to rise from just over 8 billion today to 9.7 billion by 2050. This population surge will be predominantly concentrated in Emerging Markets and Developing Economies (EMDEs). Additionally, urbanization is expected to continue to increase, with nearly two-thirds of the global population—over 6.6 billion people—projected to reside in urban areas by 2050.

Given these trends, the global workforce consisting of individuals aged between 15 to 64 years is projected to exceed six billion by 2050, integrating nearly 860 million new entrants into the labour market. This demographic shift aligns with the anticipated robust growth in global GDP, with an average annual increase of 2.9% between 2023 and 2050. Non-OECD countries are set to lead this growth, expanding at an annual rate of 3.7%, while OECD countries will experience more modest growth at 1.6% annually. As a result, the global economy is set to more than double in size, from $165 trillion in 2023 to $358 trillion in 2050. Given the pivotal role of the non-OECD in global economic growth and the corresponding rise in energy demand, the development of a roadmap to increase investment in clean energy within these regions has emerged as a top priority.

Drawing on the experiences of OPEC Member Countries in financing clean energy projects, this report offers valuable insights into overcoming the challenges and seizing the opportunities in non-OECD countries. It provides a comprehensive analysis of how global energy demand is likely to evolve over the medium and long term, highlighting the necessity of an inclusive approach that leverages all energy sources. The ultimate goal is to align these efforts with the Paris Agreement's objectives by reducing emissions while supporting sustainable economic growth, particularly in the rapidly developing regions of the world.

2. OPEC's perspective on global energy demand

Until a few years ago, the main focus of policymakers was on emissions reduction, with the dominant mainstream narrative almost exclusively focused on a comprehensive transition towards using renewable energy. Since then, voices have increasingly been calling out the shortcomings of this approach given the realities of following this path. This includes shortcomings related to renewables' integration costs, the sourcing of critical minerals, electricity grid requirements, battery manufacturing capacity, rising prices for consumers.

Starting in 2022, geopolitical events and a surge in energy prices served as a wake-up call, revealing the interconnected challenges of energy security, affordability, and accessibility alongside emissions reduction. Countries reacted differently to energy shortages on the international market during the recent energy crisis, mirroring their respective capabilities. Wealthy and developed countries were able to help their citizens. At the same time, in developing countries, which account for around 80% of the global population, governments had significantly less room for maneuver. Thus, these energy crises forced policymakers to reassess their targets and approach, emphasizing the need for a more comprehensive and balanced strategy.

Moreover, there were also important market signals in 2023 that served to underpin the growing realization that any large-scale restructuring of the global energy system would take time. Global oil demand increased by 2.6 million barrels a day (mb/d) in 2023, rising to its highest level ever, while coal demand, despite all the policies and efforts targeting a reduction in its use, also reached unprecedented levels.

At the same time, it should be noted that with regard to renewables, the world saw the greatest annual increase in capacity over the course of 2023, and EVs saw their strongest ever annual sales. Strikingly, however, a large part of this growth was concentrated in China, while growth in other countries and regions was not as expected. Additionally, it should be mentioned that renewables and EV expansion is coming from a low base.

It is becoming increasingly evident that one key lesson policymakers are taking into consideration is that initial, overly optimistic assumptions that renewable energy deployment costs would inevitably and irreversibly decline on the back of technology advancements and growing economies of scale, was misguided. It is important to be reminded that this theoretical concept only works assuming that all other factors remain constant. However, this is clearly not the case given the real-world impacts of geopolitics, macroeconomic and trade developments, as well as often unforeseen knock-on consequences of attempting to scale up at a such a rapid pace. These can all create obstacles and offset the impact of technological progress, for instance.

On the policy level too, recent softening proposals for Euro-7 emissions norms, the US debate to temper vehicle emissions standards starting with model year 2027, or even the UK decision to entirely push back a 2030 sales ban on internal combustion engines are indicative in this regard.

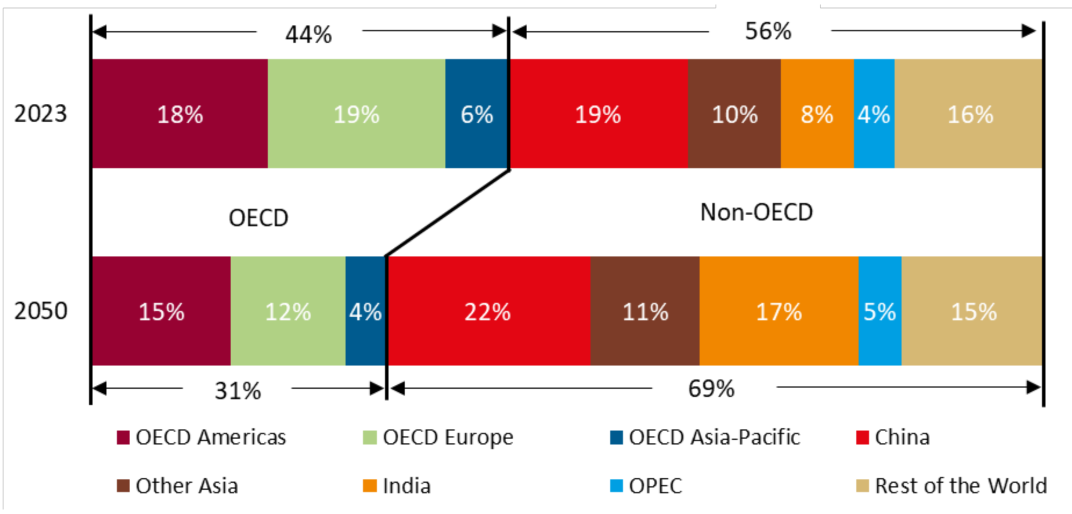
To be clear, these examples are not an indication that EV and renewable energy deployment costs will not decline, or that EV sales and renewable energy capacity will not increase in the years to come. The point is that the overly ambitious expectations about how fast these solutions could penetrate energy markets and substitute oil-based products can be considered overblown.

2.1. Key assumptions

The Reference Case in OPEC's World Oil Outlook (WOO) 2024 is built on a number of assumptions related to population and economic growth, evolution of energy policies and technology development. In detail, the Reference Case anticipates the total global population increasing from 8.1 billion in 2023 to an estimated 9.7 billion by 2050. Non-OECD regions are set to provide almost all of the world's population growth, with the Middle East and Africa (excluding OPEC nations) projected to account for over half of the global population additions. By 2050, the global workforce will grow by 859 million people, although its share will decline slightly due to an increasing and ageing population. Moreover, increasing urbanization will impact future energy demand, with 68% of the global population set to reside in urban environments in 2050, up from 57% in 2023.

The global economy is set to more than double in size in absolute terms from $165 trillion in 2023 to $358 trillion in 2050, while global average income is projected to rise from roughly $20,600 (2021 PPP) in 2023 to $36,000 (2021 PPP) by 2050. Global GDP growth between 2023 and 2050 is expected to remain robust and increase at an average rate of 2.9% p.a. Non-OECD countries dominate the growth outlook with an expected average rate of 3.7% p.a., while OECD countries are expected to grow at a rate of 1.6% p.a. (Figure 2.1).

Figure 2.1 Distribution of the global economy, 2023 and 2050



Source: OPEC

In terms of energy policies, energy security concerns are likely to remain paramount for decision makers, with an anticipated greater pushback and scrutiny on new energy policies on several fronts. It also assumes a gradual evolution of technology, with no sudden technological breakthroughs. Internal combustion engine (ICE) vehicles will remain predominant in road transport, while electric vehicles (EVs) continue to encounter challenges related to driving range, supply chains and reliable charging infrastructure. Aviation is likely to remain one of the most difficult sectors to decarbonize, whereas major technological advancements have resulted in the adoption of alternative fuels in the maritime shipping sector. The oil industry's infrastructure, technological expertise and capacity for investment uniquely position it to lead in hydrogen production, distribution and storage.

2.2. Energy demand outlook by fuel

The current energy landscape can be described by competing narratives on future pathways, with no clear consensus on what the future should look like. Some scenarios, many of which are backcasted, have overly ambitious targets for the medium and long term. These targets are challenging for developed countries and even more so for developing ones. Nevertheless, they have been at least partly adopted as a basis for political action, energy policies and related investment decisions. Meanwhile, issues related to financing, technical viability and availability of resources are often neglected and ignored. This could lead to unintended consequences, including a lack of energy security, affordability and social cohesion.

Table 2.1 outlines the outlook for global energy demand by primary fuel in the Reference Case. Total primary energy demand is expected to rise from approximately 301 mboe/d in 2023 to 374.1 mboe/d by 2050. This represents an increase of over 73 mboe/d, or just above 24%, over the outlook period. The average growth rate for the entire period is projected at 0.8% p.a., with growth expected to decelerate towards the end of the outlook horizon. This slowdown aligns with trends in slower population and economic growth, as well as improvements in energy efficiency in end-use and energy transformation.

Table 2.1 World primary energy demand by fuel type, 2023–2050

	Levels (mboe/d)						Growth (mboe/d)	Growth (% p.a.)	Fuel share (%)	
	2023	**2030**	**2035**	**2040**	**2045**	**2050**	**2023-2050**	**2023-2050**	**2023**	**2050**
Oil	92.9	103.1	106.0	107.4	108.5	109.6	16.7	0.6	30.9	29.3
Coal	78.0	71.6	66.1	60.0	54.4	49.1	-28.9	-1.7	25.9	13.1
Gas	69.1	75.9	80.6	84.8	87.9	89.6	20.5	1.0	23.0	24.0
Nuclear	14.8	17.0	18.9	20.9	22.7	24.3	9.6	1.9	4.9	6.5
Hydro	7.6	8.6	9.2	9.9	10.7	11.6	4.0	1.6	2.5	3.1
Biomass	29.1	32.1	34.0	35.5	36.5	37.4	8.2	0.9	9.7	10.0
Other renewables	9.6	19.0	27.1	35.1	43.6	52.4	42.9	6.5	3.2	14.0
Total	**301.1**	**327.3**	**342.0**	**353.7**	**364.4**	**374.1**	**72.9**	**0.8**	**100.0**	**100.0**

Source: OPEC

However, the expected slowdown in primary energy demand growth is less pronounced when considering final energy demand (post-energy transformation). This is largely due to the anticipated rise in the share of renewables, such as wind and solar, which incur minimal transformation and transmission losses. As these renewables partially replace fossil fuels, like coal, which have higher transformation losses, the impact on final energy demand is mitigated.

The Reference Case shows big shifts in the energy mix throughout the outlook period. However, it also indicates that all fuels will be needed to satisfy global energy demand growth. Oil and gas will remain crucial for energy supply in the period to 2050, with their combined energy mix share expected to stay above 50%.

As shown in Figure 2.2, the strongest incremental demand over the outlook period is expected for other renewables (mostly wind and solar), which increases by almost 43 mboe/d, owing to strong policy support and favourable economics in many regions. The share of other renewables in the energy mix rises from around 3.2% in 2023 to 14% in 2050.

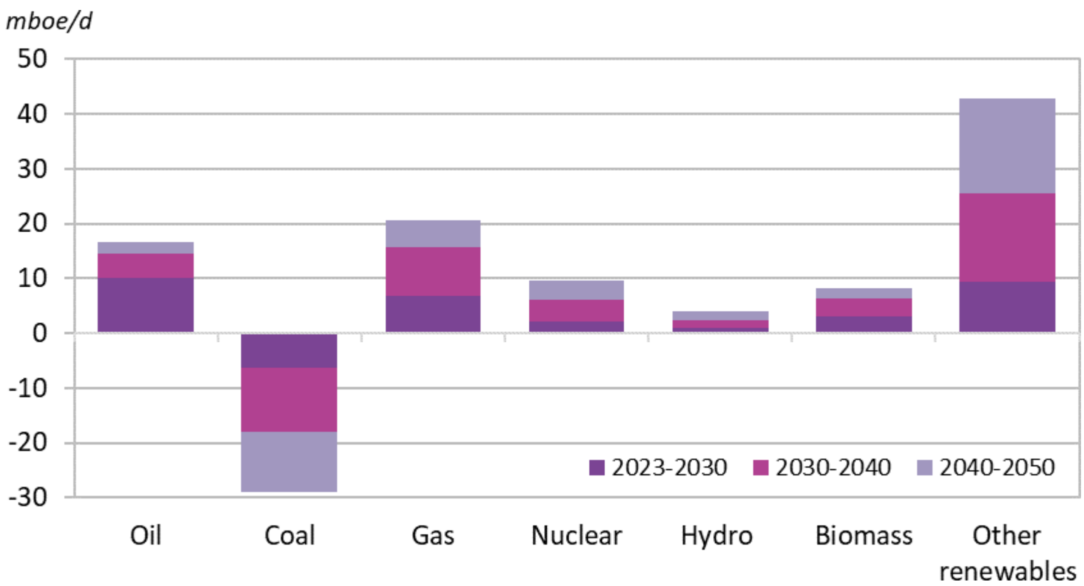
Natural gas demand is expected to increase by 20.5 mboe/d and reach 89.6 mboe/d in 2050. Natural gas will play an important role in CO_2 emissions reductions by replacing coal in the power generation mix.

Oil demand is projected to increase by almost 16.7 mboe/d in the period to 2050 and reach 109.6 mboe/d. This corresponds to 120.1 mb/d of liquids demand in 2050, indicating an increase of almost 18 mb/d from 2023 levels. Oil's share in the energy mix declines from almost 31% in 2023 to 29.3% in 2050, but it remains the fuel with the largest share in the energy mix by 2050.

The combined share of oil and gas in the energy mix, although declining modestly, remains above 50% throughout the outlook period.

Coal is the only primary fuel expected to see a demand decline, dropping by about 29 mboe/d due to energy policy and climate commitments, as well as ageing power plants. Demand falls from almost 78 mboe/d in 2023 to just above 49 mboe/d in 2050, predominantly due to developments in China and OECD countries.

Figure 2.2 Growth in primary energy demand by fuel type, 2023-2050



Source: OPEC

2.3. Energy demand by major regions

The global long-term energy demand forecast also combines different regional trajectories. Table 2.2 and Figure 2.2 show the energy demand outlook by major region. It becomes evident that demand growth to 2050 will come entirely from non-OECD regions, while energy demand in OECD countries is expected to stay flat and/or decline.

Within non-OECD, there are several countries/regions that are crucial to energy demand growth. They include India, OPEC and the large group of Other Developing Countries.

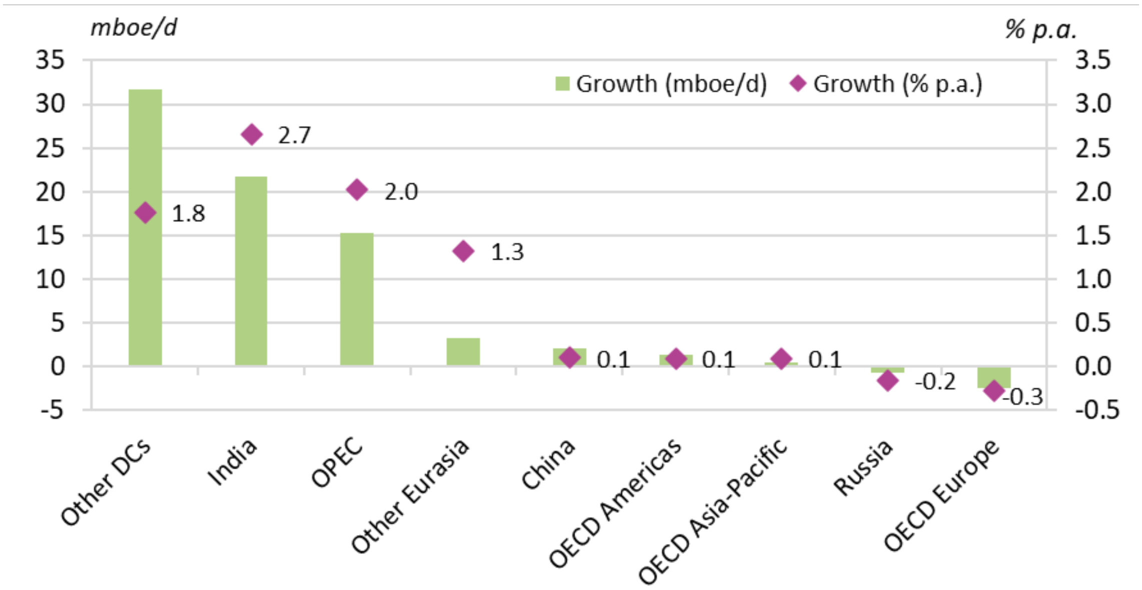
Table 2.2 Total primary energy demand by region, 2023–2050

	Levels (mboe/d)						Growth (mboe/d)	Growth (% p.a.)	Share (%)	
	2023	2030	2035	2040	2045	2050	2023-2050	2023-2050	2023	2050
OECD Americas	54.9	56.1	56.5	56.2	56.1	56.4	1.4	0.1	18.2	15.1
OECD Europe	34.5	34.0	33.5	32.9	32.3	32.0	-2.5	-0.3	11.4	8.6
OECD Asia-Pacific	17.7	17.9	18.0	18.1	18.1	18.2	0.5	0.1	5.9	4.9
OECD	**107.1**	**108.1**	**108.1**	**107.2**	**106.6**	**106.6**	**-0.6**	**0.0**	**35.6**	**28.5**
China	74.8	78.9	79.4	78.3	77.5	76.9	2.1	0.1	24.8	20.6
India	21.1	26.6	30.6	34.6	38.8	42.9	21.8	2.7	7.0	11.5
OPEC	21.3	26.8	30.0	32.8	35.0	36.5	15.3	2.0	7.1	9.8
Other DCs	52.6	62.1	68.7	75.3	80.4	84.4	31.8	1.8	17.5	22.6
Russia	16.5	16.4	16.1	15.9	15.8	15.8	-0.7	-0.2	5.5	4.2
Other Eurasia	7.7	8.4	9.0	9.6	10.3	11.0	3.3	1.3	2.6	2.9
Non-OECD	**194.0**	**219.3**	**234.0**	**246.5**	**257.8**	**267.5**	**73.5**	**1.2**	**64.4**	**71.5**
World	**301.1**	**327.3**	**342.0**	**353.7**	**364.4**	**374.1**	**72.9**	**0.8**	**100.0**	**100.0**

Source: OPEC

Energy demand in India is expected to more than double over the outlook period, reaching levels close to 43 mboe/d in 2050. The estimated average growth rate is 2.7% p.a., which makes it the region with the fastest energy demand growth. The major reason is a growing population and an expanding middle class, in combination with fast economic development. As a result, India's share in global energy demand is projected to increase from 7% in 2023 to 11.5% in 2050.

Figure 2.3 Growth in primary energy demand by region, 2023–2050



Source: OPEC

Energy demand in Other Developing Countries (consisting largely of developing countries in Asia, Africa and Latin America) is set to increase by 31.8 mboe/d over the outlook period and is expected reach 84.4 mboe/d in 2050. Energy demand in OPEC Member Countries is anticipated to increase from 21.3 mboe/d in 2023 to 36.5 mboe/d in 2050, driven by population and economic growth and ample available energy resources.

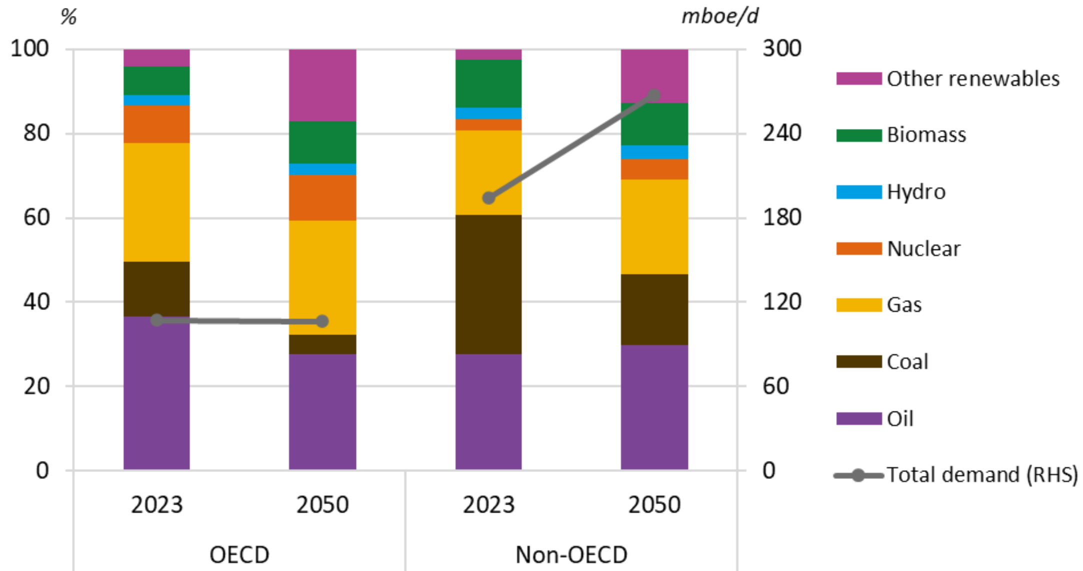
At the same time, energy demand in China is expected to increase only modestly, from 74.8 mboe/d in 2023 to 79.4 mboe/d in 2035, before witnessing a gradual decrease thereafter to just below 77 mboe/d in 2050. This is mostly due to declining coal demand and the rising share of renewables, nuclear and natural gas in the mix. Consequently, China's share in global energy demand is set to drop from 24.8% in 2023 to 20.6% in 2050.

Primary energy demand in the OECD region is projected to increase only slightly in the period to 2030, followed by a marginal decline between 2035 and 2050. Over the outlook period, OECD energy demand is set to drop by around 0.6 mboe/d. This is due to low population and economic growth, market saturation and increasing energy efficiency (including the penetration of renewables). Looking within OECD sub-regions, OECD Americas and OECD Asia-Pacific are both expected to see modest growth of 1.4 mboe/d and 0.5 mboe/d, respectively. This will be more than offset by a decline from OECD Europe, where primary energy demand is set to fall by 2.5 mboe/d over the outlook period.

Figure 2.4 shows the changing primary energy mix in the OECD and non-OECD regions between 2023 and 2050. In both regions, the share of fossil fuels in the energy mix is expected to decline over the outlook period. However, the figure illustrates very different regional patterns.

The overall share of fossil fuels in the OECD is expected to decline from almost 78% in 2023 to 59.4% in 2050. This is mostly due to the decline of oil's share in the mix, which drops from 36.5% in 2023 to 27.7% in 2050. Coal also declines, losing more than 8.6 percentage points (pp) to reach 4.5% in 2050. The share of natural gas in the OECD energy mix is set to decline only slightly and settle at just below 27.2% in 2050. The gap will be filled by rising shares for other renewables (+13 pp), biomass (+3.1 pp), nuclear (+1.8 pp) and hydro (+0.5 pp).

Figure 2.4 Energy mix in OECD and non-OECD and primary energy demand, 2023–2050



Source: OPEC

In the non-OECD, the pattern in energy demand development is different. Based on strong population and economic growth, oil and gas increase their respective shares modestly by 2.2 and 2.6 pp, respectively, to 2050, and the share of coal in the mix drops by a hefty 16.4%. Consequently, the overall share of fossil fuels is expected to decline by 11.6 pp between 2023 and 2050. The increase will come predominantly from other renewables (+10.1 pp) and nuclear (+2.2 pp).

It is important to note that the overall level of energy demand is a key denominator for the final energy mix. In the OECD, primary energy demand is set to decline in the long term, which helps to hasten the increase in the share of renewables. In the non-OECD, energy demand increases throughout the outlook period, which is why the share of renewables in 2050 in the non-OECD is lower compared with the OECD.

Oil demand is expected to decline in the OECD, due to the overall stagnation of the energy market and the active substitution with renewables. At the same time, oil is expected to witness the second-largest demand increase in the non-OECD, rising from 53.8 mboe/d in 2023 to 80 mboe/d in 2050. This increase of 26.3 mboe/d over the outlook period is supported by strong population growth, an increasing middle class and rising energy access. The transportation sector, as well as industry (i.e. petrochemicals), are set to account for the largest share of this increase. Consequently, the share of oil in the non-OECD energy mix is expected to rise to almost 30% in 2050, up from 27.7% in 2023. Oil will become the fuel with the highest share in the non-OECD energy mix, overtaking coal by 2030.

Natural gas demand in the non-OECD is projected to increase from 39 mboe/d in 2023 to 60.7 mboe/d in 2050, shifting up by around 21.7 mboe/d over the outlook period. Strong demand growth for natural gas mirrors rising energy access in many developing countries, as well as resource availability in many regions, including the Middle East & Africa. Furthermore, many countries see an increasing role for natural gas in their strategies to reduce CO_2 emissions, mostly through replacing old and inefficient coal-fired power plants with combined cycle power turbines plants (CCGTs).

Biomass demand in the non-OECD is projected to increase from almost 22 mboe/d in 2023 to nearly 27 mboe/d in 2050, driven by the increasing use of advanced biomass. This will more than offset an expected decline in the traditional use of biomass, as access to modern energy services in developing countries increases. At the same time, hydropower demand is expected to expand from 5.2 mboe/d in 2023 to 8.6 mboe/d in 2050, driven by new capacity additions, mostly in Asia and Africa.

Finally, coal demand in the non-OECD is set to decline by nearly 20 mboe/d in the outlook period, due to efforts to reduce CO_2 emissions, the replacement of coal-fired electricity generation by other fuels and swapping old and inefficient coal-fired plants with supercritical units. The reduction in coal use is expected to come almost exclusively from China, where coal demand is anticipated to decline by 22.5 mboe/d, which is partly offset by increases elsewhere, including India.

3. Alternative scenarios

In OPEC's view, there is an urgent need to widen the debate on the global energy future to be more inclusive, open-minded, technology-agnostic, and realistic. Two alternative scenarios to the Reference Case were developed. Each scenario is based on a distinct set of assumptions with respect to adopted energy policies, economic growth trajectories, the use of available technology options and investment priorities.

The first scenario shows an alternative possible pathway to achieve emission reductions consistent with the main long-term goals of the Paris Agreement, with the view of offering a different narrative, and in OPEC's view, a more realistic means of achieving these long-term goals. In the Technology-Driven Scenario, a greater deployment of technological solutions to abate CO_2 emissions enables a greater share of oil and gas to be maintained in the long term. This reduces economic harm to the economies of energy-exporting developing countries and also sees an increased share for renewable energy.

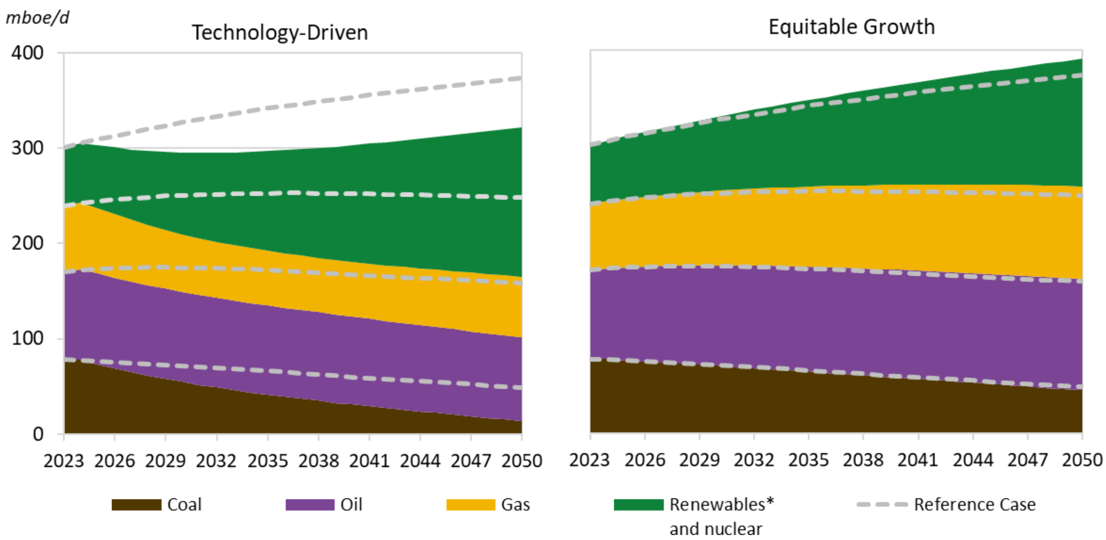
The Equitable Growth Scenario sees stronger economic growth in developing countries and is combined with a policy framework that fosters development needs, including enhanced energy access and energy poverty eradication. In turn, this accelerated and more equitable economic growth in the 'Global South' results in a stronger rise in overall energy demand and, in part, requires higher demand for oil and gas.

As a consequence, these countries experience higher levels of industrialization and urbanization, which then leads to a larger middle class and improved living conditions for billions of people. This helps to improve energy access in the least developed regions and aids in the further eradication of energy poverty. It also results in a quicker transition to modern sources of energy in these countries, including renewable energy, oil, gas, and nuclear power, especially in the latter half of the outlook period.

3.1. Summary of energy demand scenarios

Major trends in future primary energy demand for alternative scenarios are presented in Figure 3.1. Clearly, driven by varying narratives, future energy demand in these scenarios differs significantly in terms of both overall levels and the composition of the energy mix.

Figure 3.1 Global primary energy demand in the Reference Case and alternative scenarios, 2023–2050



Note: Renewables include hydro, biomass, wind, solar and geothermal energy.
Source: OPEC

In the Technology-Driven Scenario, a measurable difference in energy demand can already be observed during the current decade. Energy demand in this scenario is projected to decline in the period to 2030 due to assumed efficiency improvements introduced with a relatively short lead time, meaning the effect starts to be visible within a few years. The faster deployment of more efficient technologies limits the growth of final energy consumption, which increases more slowly compared to the Reference Case during the first half of the outlook period. Moreover, new technologies will also intensify the electrification of industry, transportation, and the residential sector.

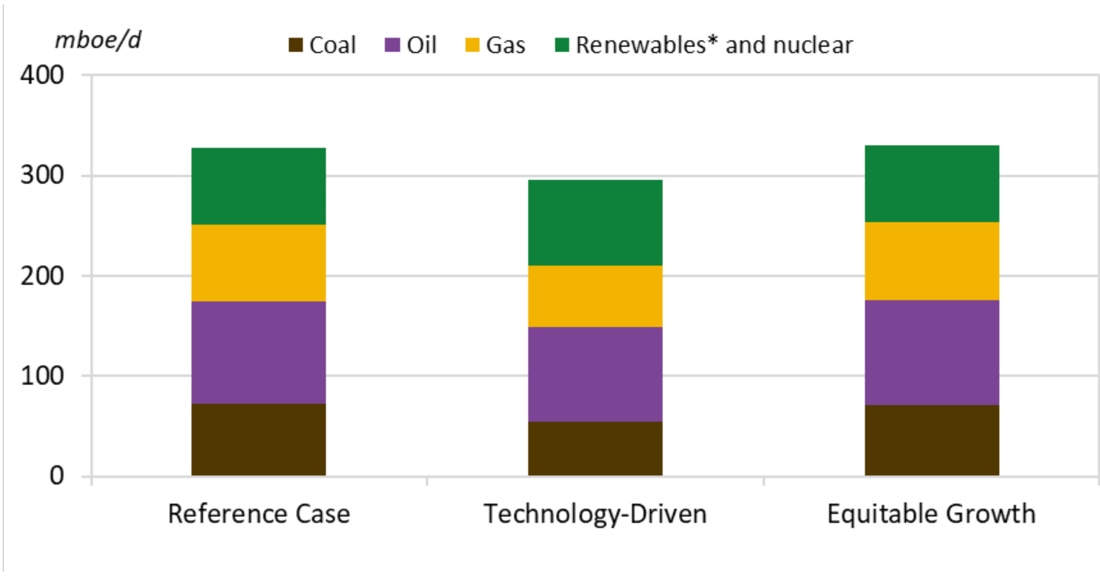
The second effect is linked to how expanding electricity demand is met. Coal will be particularly impacted because reducing its use offers the fastest and most cost-effective way to curb emissions. This is in addition to the industrial use of coal being affected by more efficient processes. The decline in electricity produced from coal will be more than offset by the projected rapid growth in renewables and, to some extent, by nuclear energy. The latter is anticipated to come mainly from small modular reactors that substantially shorten the long lead times of large nuclear power plants. Increased electricity production from these sources will also partly substitute natural gas, on top of lower gas demand due to more efficient gas turbines.

The combined effect of these factors on primary energy demand in the Technology-Driven Scenario by 2030 is presented in Figure 3.2. The overall decline in energy demand in this scenario between 2023 and 2030 is not large, estimated at less than 6 mboe/d. However, due to growing energy demand in the

Reference Case during the same period, the gap between the two is projected to increase to around 32 mboe/d by 2030. Lower coal demand is projected to account for more than half of this. Significantly lower demand is also projected for natural gas and oil. Part of this decline will be offset by higher primary demand for renewables and nuclear. Combined demand for these two energy sources in the Technology-Driven Scenario is projected at 85.4 mboe/d, which is almost 9 mboe/d higher than the corresponding Reference Case demand by 2030.

Figure 3.2 also shows that neither global energy demand nor the energy mix in the Equitable Growth Scenario is significantly different from the Reference Case in the period to 2030. The main reason for this pattern is that this period is relatively short for any significant departure of regional GDP levels compared to the Reference Case. Therefore, total energy demand in the Equitable Growth Scenario is only 3.1 mboe/d higher by 2030, mainly due to faster oil and gas demand growth in developing countries, each being around 1.8 mboe/d higher compared to the Reference Case. Somewhat faster growth is also projected for renewables, while coal demand is slightly lower compared to the Reference Case.

Figure 3.2 Global primary energy demand in the Reference Case and alternative scenarios, 2030

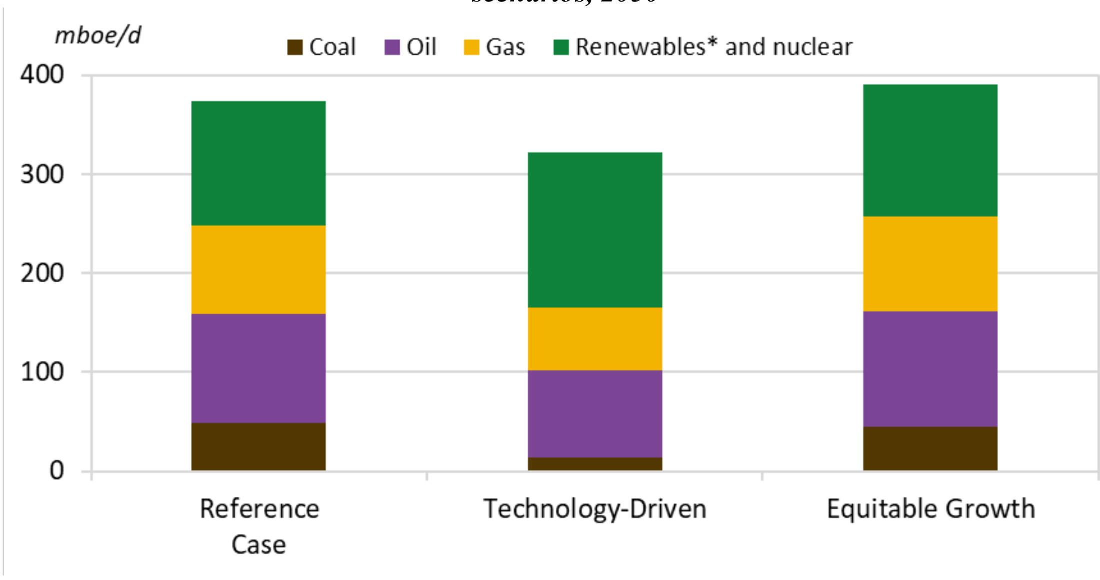


Note: Renewables include hydro, biomass, wind, solar and geothermal energy.
Source: OPEC

Nevertheless, these changes indicate the momentum building towards a larger change when moving to the second part of the outlook period, as presented in Figure 3.3. It shows that the demand gap between the Technology-Driven Scenario and the Reference Case widens to 52 mboe/d by 2050, despite the fact that demand in the former is back on a growth trajectory as incremental demand in developing countries outweighs the potential for further efficiency improvements. These were mostly explored in the first part of the outlook period.

A larger gap of almost 17 mboe/d by 2050 is clearly visible in the case of the Equitable Growth Scenario, when compared to the Reference Case. Global energy demand in this scenario continues expanding at higher rates driven by faster economic development, especially in developing countries, and improved living standards and energy access for billions of people. It is worth noting that assumed global GDP growth rates in this scenario are not significantly higher compared to the Reference Case. Nevertheless, the cumulative effect of long-term annual growth rates that are on average higher by around 0.3% is sufficient to push global GDP levels in this scenario almost $20 trillion higher compared to the Reference Case by 2050, with a large part of it taking place in developing countries.

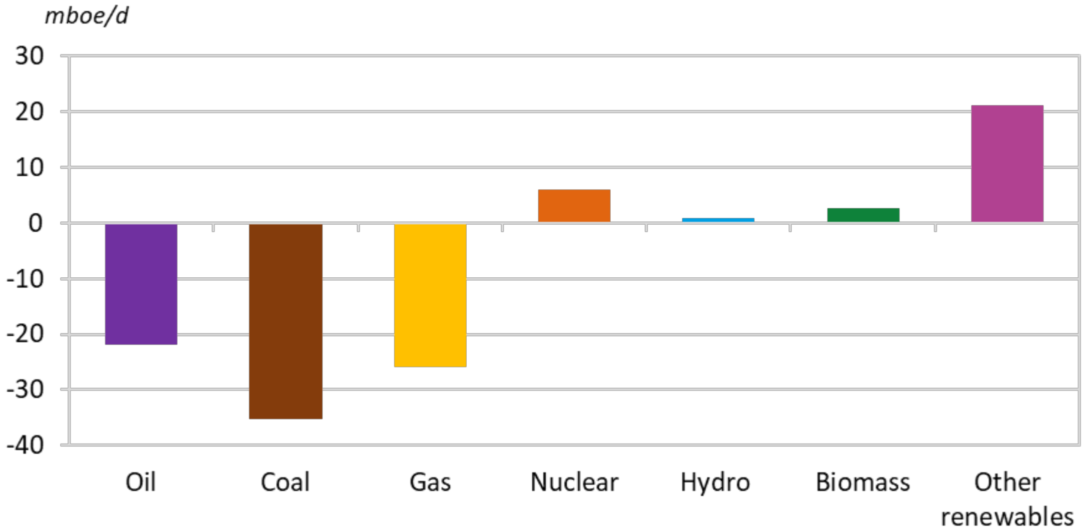
Figure 3.3 Global primary energy demand in the Reference Case and in alternative scenarios, 2050



Note: Renewables include hydro, biomass, wind, solar and geothermal energy.
Source: OPEC

In the case of the Technology-Driven Scenario, details on the changing energy mix are presented in Figure 3.4. Given the ambition to reduce emissions to levels consistent with the Paris Agreement, coal demand in this scenario continues to decline, falling to a level below 14 mboe/d in 2050. This is 35 mboe/d lower compared to the corresponding demand level in the Reference Case and around 64 mboe/d lower than observed demand in 2023. In fact, this means the almost complete elimination of coal, especially in OECD countries, from the future global energy mix.

Figure 3.4 Change in primary energy demand between the Technology-Driven Scenario and Reference Case, 2050



Source: OPEC

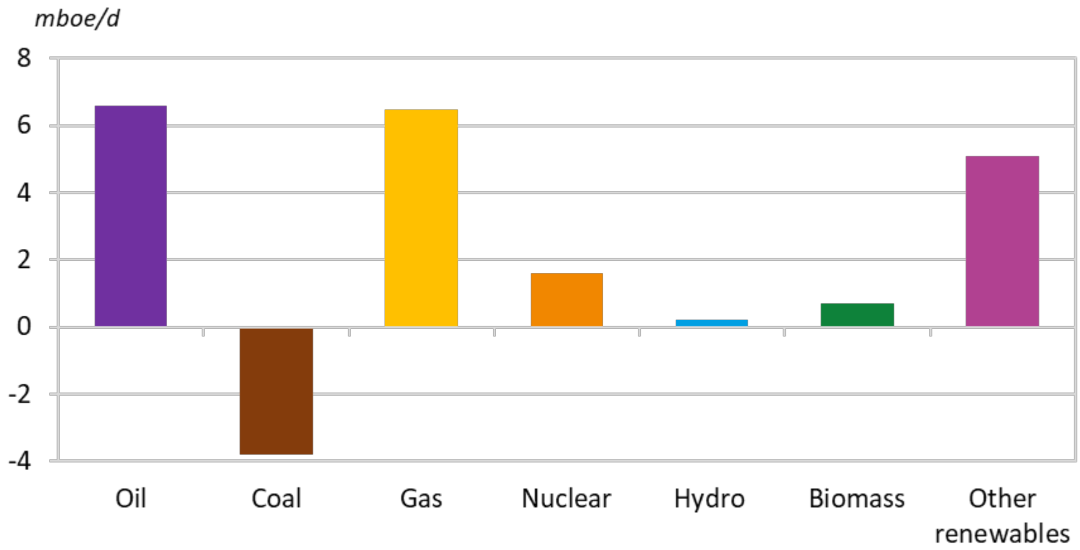
Demand for natural gas will also be significantly affected in the Technology-Driven Scenario. Demand for this energy source is projected to decline by around 8 mboe/d in the period to 2030. It will then stabilize at this lower level and even marginally increase over the last ten years of the outlook period supported by available CCUS capacity. Its initial decline will be mostly affected by the substitution with renewable sources, the electrification of the residential and industry sectors and energy efficiency improvements in major developed and developing countries, mainly the US and China. The overall impact is that, by 2050, gas demand is projected to revert to a level comparable to the beginning of the outlook period. This is, however, around 26 mboe/d lower compared to the Reference Case in 2050.

Oil demand in this scenario will be less affected. Emission reductions primarily achieved by coal substitution in the power and industry sectors, lower demand for coal and gas due to efficiency improvement measures, as well as the extended use of carbon removal technologies at a later stage, will lessen the need for oil substitution in hard-to-abate sectors, especially the transportation and petrochemical sectors.

The demand outlook for renewable energy sources and nuclear energy shows a different picture. Combined demand for these sources is projected to increase by around 96 mboe/d over the outlook period, growing from 61 mboe/d in 2023 to almost 157 mboe/d in 2050. In the Technology-Driven Scenario demand for solar and wind is projected to be 21 mboe/d higher compared to the Reference Case in 2050, while nuclear energy provides an additional 6 mboe/d.

In the long term, the prospects for the energy mix in the Equitable Growth Scenario, compared to the Reference Case, is provided in Figure 3.5. As already mentioned, global primary energy demand in this scenario is expected to be 16.9 mboe/d higher than in the Reference Case by 2050. The largest part of this additional energy demand will be met by oil and gas, each growing by an additional 6.6 mboe/d and 6.5 mboe/d, respectively. This means that gas demand in the Equitable Growth Scenario is projected to increase by 27 mboe/d between 2023 and 2050. The corresponding oil demand increase is 23.3 mboe/d.

Figure 3.5 Change in the primary energy demand between the Equitable Growth Scenario and Reference Case, 2050



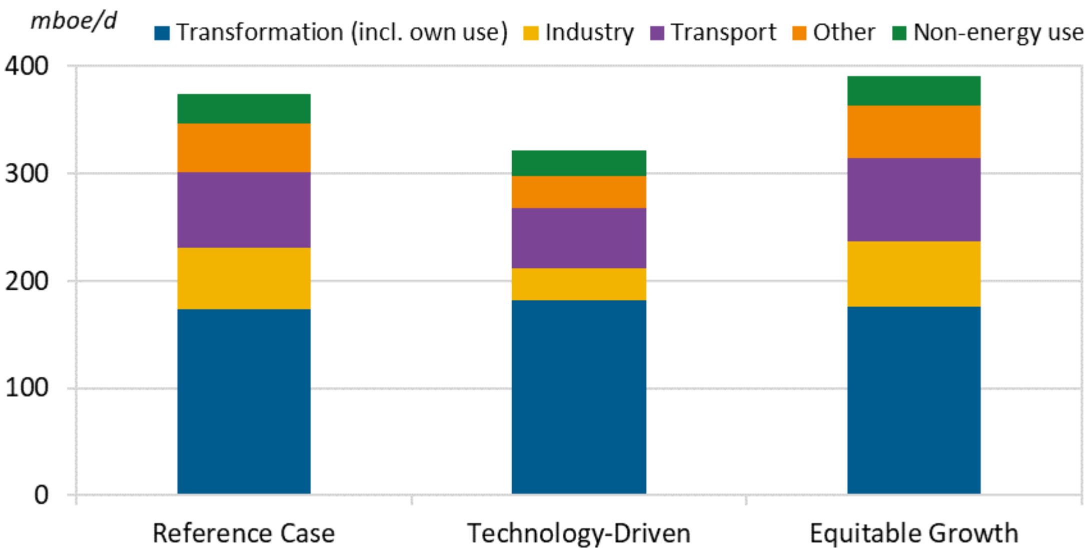
Source: OPEC

Moreover, continued demand growth is also projected for solar and wind. In fact, solar and wind combined will be the fastest growing energy source in the Equitable Growth Scenario, increasing by almost 7% p.a. on average over the entire outlook period, or cumulatively by almost 48 mboe/d between 2023 and 2050. This is around 5 mboe/d higher than Reference Case projections. Adding in incremental demand for nuclear, hydro and bioenergy pushes the overall demand growth for these forms of energy up by around 72 mboe/d in the period to 2050.

Coal demand is projected to decline in all scenarios considered in this Outlook, the Equitable Growth Scenario being no exception. Moreover, the drop in coal demand in this scenario is even steeper than the Reference Case. It is projected in the range of 33 mboe/d between 2023 and 2050, which is 3.8 mboe/d more than the corresponding number in the Reference Case. This additional decline is projected mainly in the OECD and China, where a part of the higher GDP is used to implement additional measures to reduce emissions.

Figure 3.6 complements the previous discussion on the changing energy mix in alternative scenarios by providing an overview of global energy demand in 2050 from a sectoral perspective. In the Technology-Driven Scenario, global energy demand is projected to be lower in all sectors of final energy consumption compared to the Reference Case. As mentioned in the narrative for this scenario, the main reasons for this lower demand are a higher rate of electrification, the use of more efficient technologies and progressing fuel substitution across all sectors.

Figure 3.6 Global energy demand by sector in the Reference Case and alternative scenarios, 2050



Source: OPEC

For the Equitable Growth Scenario, demand changes at the sectoral level, compared to the Reference Case, are much less complicated because demand in all major sectors is projected to be higher. The largest incremental demand is seen in the transportation sector, estimated to be 7 mboe/d higher than 2050 demand in the Reference Case. This is not surprising, as mobility tends to increase with a higher level of economic activity. A significant increase in energy demand is also projected in the residential, agriculture, industry and transformation sectors. However, the level of incremental demand in these sectors is much lower, in the range of 3 to 4 mboe/d.

4. Enabling technologies

Reducing greenhouse gas (GHG) emissions while providing sufficient energy to meet growing needs requires all types of available technologies, including carbon abatement technologies and hydrogen. In addition to their crucial role in mitigating the impact of climate change, they can also contribute to improving energy security, provide solutions in hard-to-abate areas, such as transport and industry, and offer opportunities for hydrocarbon-producing nations to develop cost-effective new business opportunities that complement existing assets.

4.1. Carbon abatement technologies

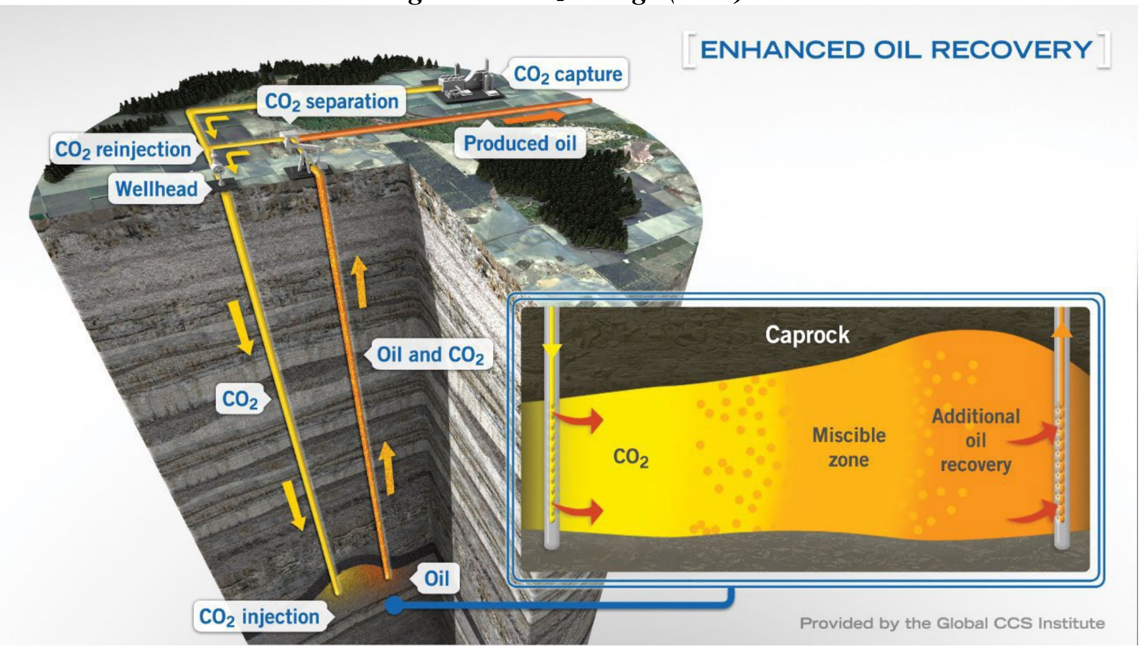
Carbon abatement technologies are assumed to significantly contribute to CO_2 emissions reduction in all scenarios considered in the outlook. A rapid expansion of CCUS capacity is assumed in the Reference Case, while even faster capacity expansion would be required if the global energy system moves in line with the trajectory suggested in the Technology-Driven Scenario.

Moreover, carbon abatement technology constitutes an integral part of emissions reduction efforts in a large majority of other available outlooks, some of them assuming much higher installed capacity by mid-century. Therefore, it is important to create an environment that is conducive to accelerating investments in these technologies, including stationary applications of CCUS, supplemented by other forms of carbon capture, such as DAC, and mobile CCUS applications in the maritime sector and for heavy trucks.

4.1.1. Carbon capture, utilisation and storage (CCUS)

CCUS encompasses a range of processes and technologies aimed at capturing CO_2 emissions from industrial sources or removing it from the atmosphere, then using the captured CO_2 in various applications or storing it underground. One of the effective options to utilize captured CO_2 is to improve enhanced oil recovery (EOR), see Figure 4.1.

Figure 4.1 CO_2 storage (EOR)



Source: Global CCS institute

Moreover, CCUS has the added benefit of being able to simultaneously remove other harmful pollutants. Up to a 50% reduction in NO_x emissions with this method has been observed. This dual benefit strengthens the argument for broader deployment of CCUS.

In addition to reducing emissions, CCUS offers the promise of improving the environmental footprint of the building blocks of modern life – plastics, concrete and steel. On top of these environmental benefits, if the CCUS industry expands globally, it could help preserve existing jobs and create new ones, while improving the ability of companies to sell or export low-carbon products.

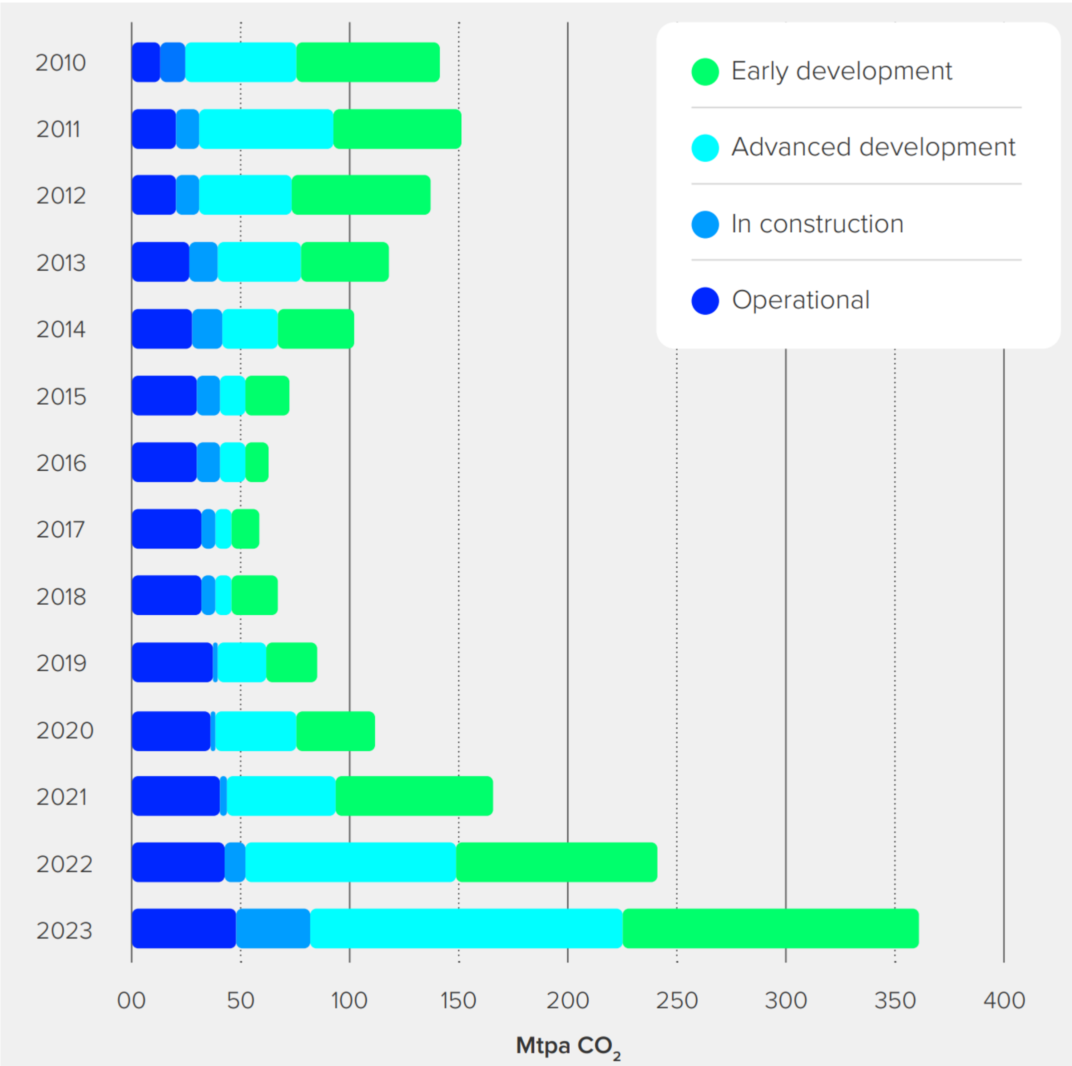
CCUS also positively affects the social cost of carbon. By capturing CO_2 where it is produced, CCUS reduces potential environmental and public health degradation, thereby minimizing the costs associated with climate change. This demonstrates that CCUS is not just a tool for combating emissions, but also has broader societal benefits.

For these reasons it is important to accelerate efforts to remove barriers and create supporting incentives for CCUS deployment. It is important to broaden areas where this technology is applied. Currently, it is deployed primarily in the oil and gas sector; however, large opportunities also exist in power generation, as well as in cement and chemical production, where the technology has the potential to be a critical mitigation option.

According to Global CCS institute, the capture capacity of CCS projects has seen a remarkable increase in 2023, growing by 48% since the publishing of the Global Status Report of CCS (GSR) in 2022. This represents the largest annual rise since the upward trend in CCS development began in 2018.

As of July 2023, the number of CCS facilities in the development pipeline has reached an all-time high, increasing the total number of projects currently in progress to 392 and marking a 102% y-o-y increase. Over the past year, 11 new facilities have commenced operations, and 15 new projects have begun construction. Figure 4.2 demonstrates that overall, 198 new facilities have been added to the pipeline since 2010, bringing the total to 41 projects in operation, 26 under construction, and 325 in advanced and early development stages. This surge in projects highlights the growing momentum in CCS development.

Figure 4.2 Capacity of commercial CCS facility pipeline since 2010



Source: Global CCS Institute

In recent years there has been a significant increase in equity financing and interest in project finance for CCS initiatives. Many businesses seeking to profit from the provision of CCS services, especially in the transport and/or storage of CO2, are now emerging on the back of decades of government-sponsored research, development, and deployment, industry net zero commitments, and expectations of more stringent climate policy.

Scaling Up of CCS through 2030

According to Global CCS institute, the level of policy support for CCS has reached an unprecedented level in 2023. This increased backing has significantly strengthened the business case for CCS, resulting in the most rapid growth of the CCS project pipeline observed to date. The enhanced policy environment has provided a robust framework for CCS projects, reinforcing the viability and attractiveness of these technologies (Institute).

In the Americas, there have been substantial policy enhancements and announcements of multiple new CCS projects and networks. Notably, the US has seen an increase of 73 new facilities since the 2022. Canada’s Alberta province has selected 19 projects to develop carbon storage hubs, in addition to six sequestration hub agreements announced in spring 2022. In Brazil, Petrobras has injected 10.6 $MtCO_2$ into pre-salt reservoirs in the Santos Basin in 2022, surpassing its 40 $MtCO_2$ target and aiming to reinject 80 $MtCO_2$ by 2025.

In the Asia Pacific, the report notes that both government and industry have shown significant activity, with several new project announcements and supportive policies. The APAC facility count increased by 34 since the GSR 2022 report. Japan's long-term CCS roadmap sets a target for the first commercial CCS projects to commence by 2030 and aims to store up to 240 Mtpa of CO_2 by 2050. Japan’s Organization for Metals and Energy Security (JOGMEC) has selected seven candidate projects for feasibility studies, while Australia has reformed its safeguard mechanism, establishing a framework for future emission reduction regulations, including an annual 4.9% reduction of baseline emissions to 2030.

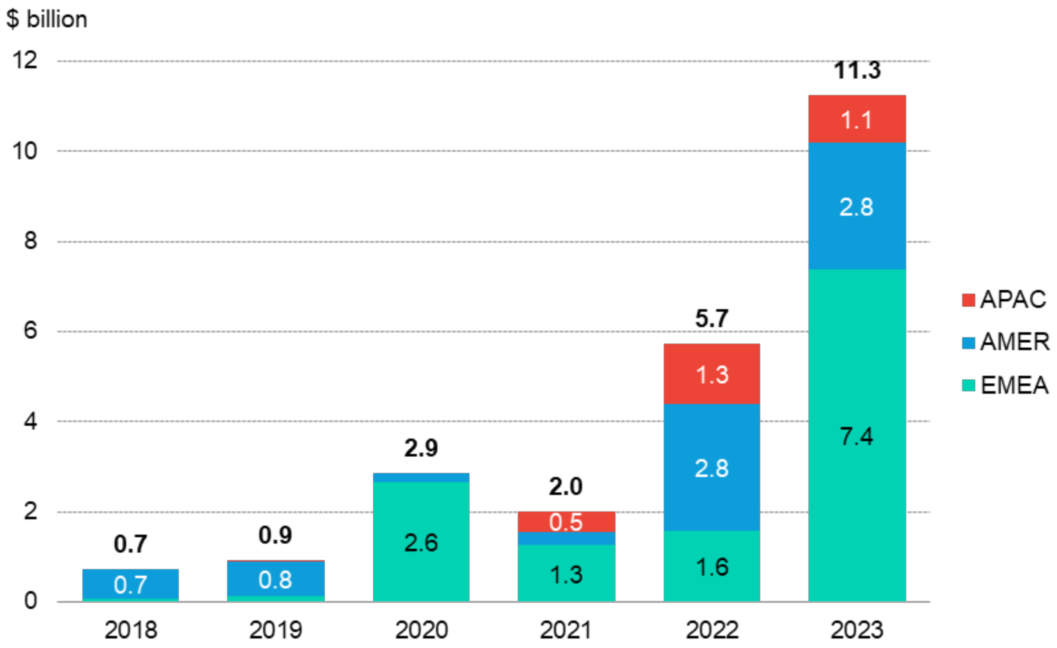
The GSR report also details activity in Europe, where the European Commission has rolled out several new legislative proposals and advanced funding for CCS projects through the Innovation Fund and Connecting Europe Facility. There has been a 63% rise in projects at various stages of development and operation since the publication of the GSR. The Norwegian Northern Lights project, the world’s first open-source CO_2 transport and storage infrastructure, is expected to be online in 2024 and is built ready for expansion. North Sea sites continue to dominate as preferred locations for CO2 storage, though other opportunities are emerging.

In the Middle East and North Africa, the CCS market accounts for approximately 8% of global capture capacity and is poised for considerable growth. The UAE and Saudi Arabia have made significant commitments, with the UAE hosting COP28 and both nations announcing net zero targets, driving accelerated adoption of CCS technologies in the region. The combined capture capacity of CCS projects in development, construction, and operation in Qatar, Saudi Arabia, the UAE, and Oman totals 19.5 Mtpa.

Overall, the rapid escalation in CCS project development and the unprecedented level of policy support underscore a transformative period for CCS technology, setting the stage for further advancements and broader deployment.

According to Bloomberg NEF, global investment in CCS nearly doubled for the second year in a row (Figure 4.3), reaching a record $11.3 billion in 2023. Rising political support and subsidies have pushed projects to take final investment decisions in markets such as Europe, the Middle East and the US.

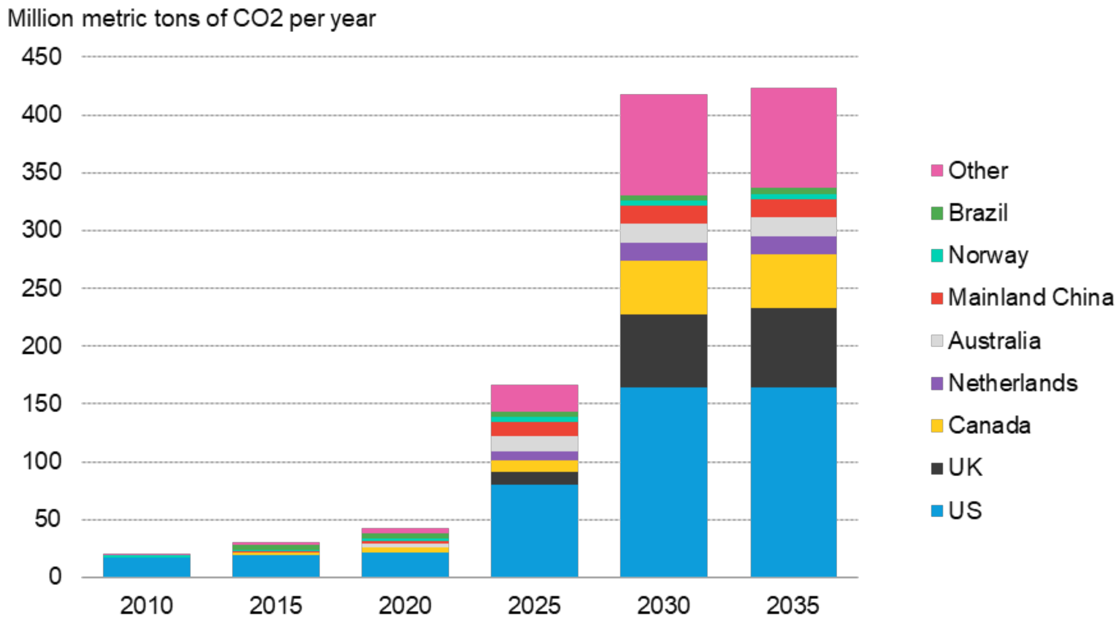
Figure 4.3 Global investment in carbon capture, utilization, transport and storage by region



Source: BloombergNEF

CCS is expected to reach around 425 million metric tons of CO_2 annually by 2035 (Figure 4.4). This projected scale of CCS deployment highlights the growing recognition of its potential to contribute significantly to global decarbonization efforts. CCS plays a crucial role in capturing CO_2 emissions from industries that are difficult to decarbonize, such as heavy manufacturing, steel, and cement production, as well as power generation from fossil fuels (BloombergNEF, CCUS Market Outlook).

Figure 4.4 Proposed carbon capture capacity by market

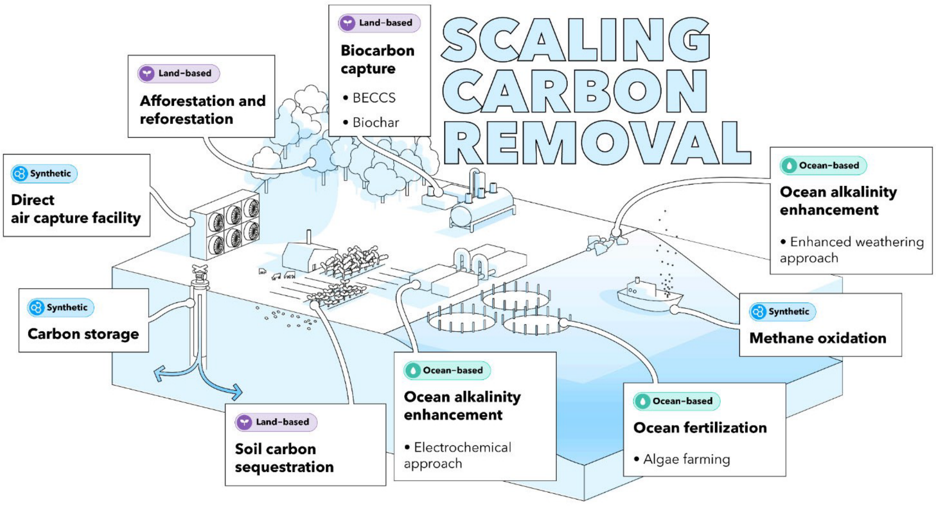


Source: Bloomberg NEF

4.1.2. Direct Air Capture (DAC)

It is increasingly evident that carbon removal is essential to keeping global temperatures below the critical threshold of 1.5°C. While a variety of technologies are available to meet this challenge (see Figure 4.5), each has its own advantages and drawbacks. There are several key technologies, including DAC, carbon storage, methane oxidation, afforestation and reforestation, biocarbon sequestration, regenerative farming, ocean fertilization, enhanced weathering, and electrochemical ocean capture.

Figure 4.5 Carbon dioxide removal technologies



Source: Bloomberg NEF

DAC works by bringing air into contact with a sorbent, a material that filters CO_2 from the air. Sorbents are 'regenerated' rather than disposed of once they are saturated with CO_2. Regeneration involves exposing the sorbent to what is known as a 'swing cycle', where the temperature, pressure, moisture and/or electrical voltage on the sorbent is shifted, causing the CO_2 to be stripped from it. DAC technologies can be classified by type of sorbent and associated swing cycle. Investments in more energy efficient, cheaper sorbents would drive down system costs. Entirely novel swing cycles could also disrupt the industry.

Two primary approaches to DAC have been deployed and currently dominate both funding and research: liquid solvent absorption (L-DAC) and solid adsorption (S-DAC).

In L-DAC, alkaline solvents like sodium hydroxide, potassium hydroxide, or calcium hydroxide are used to absorb CO_2. This method is considered mature, but it has high-temperature requirements for regenerating the solvent, which typically necessitates burning natural gas during the capture process. Recently, new solvents have been developed that aim to address high-temperature regeneration, potentially lowering costs and improving efficiency.

In contrast, S-DAC uses solid sorbents, commonly amines, to capture CO_2, which adsorbs onto the surface of the solid material rather than being absorbed into a solution. S-DAC systems have a lower temperature requirement (80-100°C), making them easier to electrify. However, these systems tend to be more energy-intensive than L-DAC. Beyond these two methods, newer technologies using electrochemistry and passive contactors are also being explored to improve the efficiency of DAC.

BloombergNEF notes that despite that despite its potential, DAC is currently expensive, with carbon removal costs exceeding $600 per ton of CO_2. This makes DAC one of the most costly carbon removal methods available, limiting its broader adoption.

To reduce costs, one potential solution is to increase the surface area per unit mass of sorbent. By expanding the surface area of materials, the amount of sorbent needed is reduced, which also improves the energy efficiency of regeneration since less non-surface area sorbent acts as a heat sink. Another avenue for cost reduction is the development of new sorbents with less energy-intensive regeneration processes. One example is metal-organic frameworks, which have been proposed as a promising material for solid sorbents due to their large surface area and the potential for lower regeneration costs.

According to BloombergNEF, over $2.8 billion has already been invested in DAC, and major players, such as Occidental Petroleum Corporation, are entering the market to commercialize emerging technologies. For example, Oxy acquired Carbon Engineering for $1.1 billion in August 2023, illustrating the increasing interest in DAC.

Norway is positioning itself as a DAC commercialization hub, with new direct subsidies proposed. Companies like Removr and Carbon Engineering are already advancing commercial-scale projects in Europe.

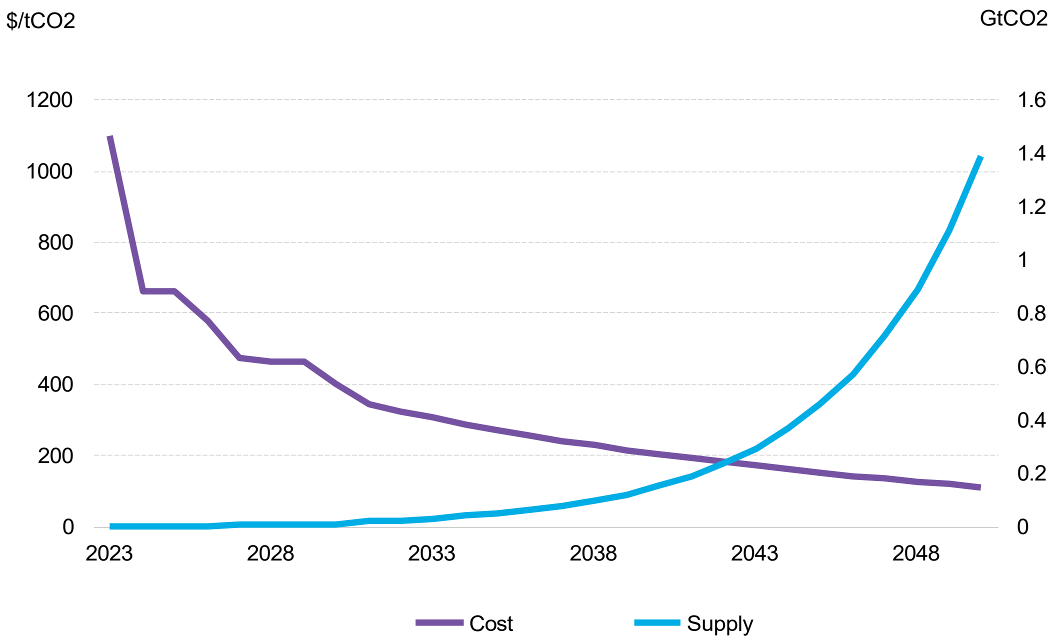
If DAC costs fall to $110 per ton by 2050, the technology could capture a significant share of the carbon offset market, especially as more governments and corporations push for climate pledges.

As the demand for carbon offsets increases due to climate pledges, more opportunities will emerge for companies to take substantial market shares in the carbon removal space.

The US is a prime location for DAC projects due to generous subsidies, federal grants, and favorable geology. Many suppliers are capitalizing on the ample storage options in the US, especially in areas with strong solar and wind power potential to support renewable energy-powered DAC plants.

In terms of policy, the US Inflation Reduction Act offers a significant incentive with a $180 per ton CO_2 tax credit, making it the most DAC supportive policy to date. This act has influenced some policy developments in the EU, UK, and Norway, but most countries still lack the regulatory framework needed to encourage DAC deployment. BloombergNEF forecasts that DAC abatement costs will fall to $400 per ton by 2030 and $110 per ton by 2050, provided that technological advancements and supply scaling occur as expected (Figure 4.6).

Figure 4.6 DAC cost projections until 2050



Source: Bloomberg NEF

4.1.3. Hydrogen

Hydrogen is a versatile energy carrier and feedstock and has the potential to be used in a wide range of applications. These include industrial processes where it could partly substitute the use of coal and gas, district heating in the residential sector, and road transportation. There are also opportunities to integrate hydrogen into existing natural gas networks. Moreover, hydrogen could also play an important role in supporting the growth of renewable energy due to its potential use as a form of energy storage.

However, the wider adoption of hydrogen depends on its position in the value chain. The deployment of blue hydrogen relies on the widespread adoption of CCUS and storage capacity availability. Significant expansion of CCUS capacity would provide a great opportunity for the refining industry to enter the hydrogen market given its extensive history of expertise, technological advantages and infrastructure required to quickly increase hydrogen production at competitive prices, assuming that demand for the product exists.

At the same time, blue hydrogen will need to compete with green hydrogen produced via electrolysis. The economics of green hydrogen are influenced by electricity prices and plant utilization rates. The cost of electrolysers and renewable power sources needed for green hydrogen production remains a significant barrier. Intermittency of solar and wind power generation is another challenge. Reducing production costs is crucial to make this type of hydrogen economically competitive. In addition, green hydrogen depends heavily on water availability. It is estimated that to produce 1 kg of green hydrogen around 8.94 kg of water is required. However, water scarcity remains a major challenge in some regions around the world.

According to Bloomberg NEF (BloombergNEF), clean hydrogen production is set for significant growth, with electrolyser shipments forecasted to double or triple in 2024, and clean hydrogen supplies projected to increase thirtyfold by 2030. Despite these impressive projections, the actual pace of development still falls short of the ambitious targets set by many governments. One of the primary challenges is the lack of identified buyers for much of the hydrogen being produced, which makes securing final investment decisions difficult. To address this, there needs to be greater development of midstream hydrogen infrastructure to support its transportation and storage.

Governments are currently off track in meeting their policy targets for hydrogen adoption. To achieve these goals, there need to be stronger demand incentives, higher carbon prices, and more robust support for midstream hydrogen development.

Demand for clean hydrogen remains relatively low. Only 12% of the clean hydrogen production capacity planned for commissioning by 2030 has secured offtakers, a slight increase from 11% in October 2023. Furthermore, only a fraction of the contracted volume is binding. Large salt caverns for clean hydrogen storage are being constructed in the US and Europe, with countries in the later working on hydrogen pipelines, but these efforts are currently insufficient to meet the anticipated demand (BloombergNEF).

Investment in hydrogen projects is increasing, but it remains relatively low. As of now, only 5% of the hydrogen capacity expected to come online by 2030 has reached a final investment decision (FID). This represents an improvement from 3% in 2023 and 1% in 2022, but it still highlights a significant gap in investment required to meet future hydrogen production goals (BloombergNEF).

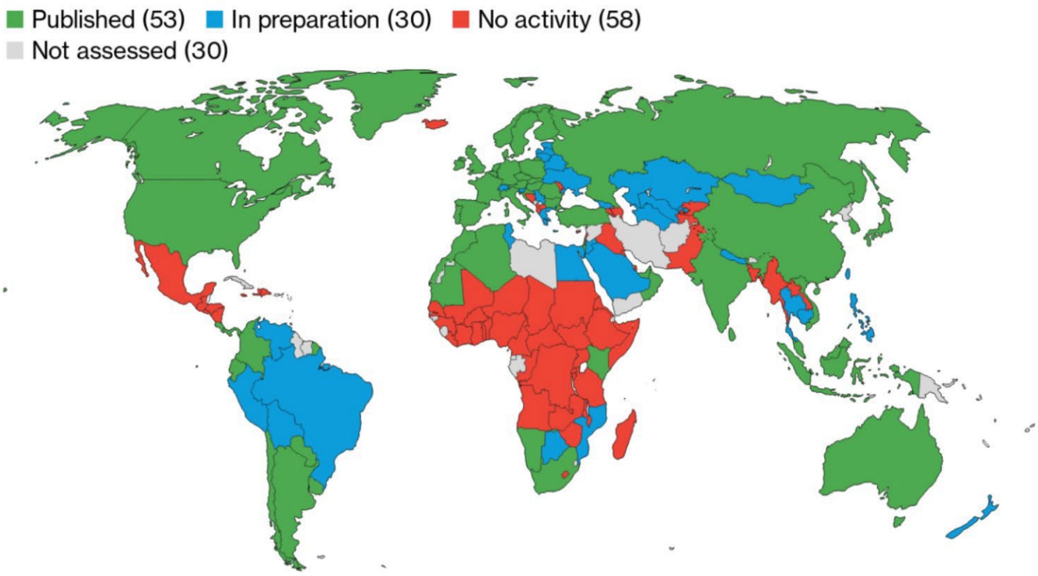
As of 2023, a total of 53 countries have developed a hydrogen strategy, with an additional 30 countries in the process of preparing one. Notable updates to hydrogen strategies have been made by Japan, Germany, and the US, while others, including Australia and the Czech Republic, are currently in the process of refining their strategies (Figure 4.7).

Looking ahead to 2030, 16 countries have set ambitious targets to produce approximately 24.6 million tons of hydrogen per year. Concurrently, 10 countries aim to utilize the same amount—24.6 million tons—of hydrogen annually. This highlights a significant alignment between production and consumption goals in various regions.

The majority of hydrogen strategies are concentrated in Europe, the Middle East, and Africa, accounting for about 62% of published strategies. The Americas follow with 21%, and the Asia Pacific region contributes 17%.

In a recent development, Vietnam finalized its hydrogen strategy, setting a target to produce between 100,000 and 500,000 metric tons of hydrogen per year by 2030. By 2050, Vietnam aims to significantly scale up annual production to up to 20 million tons, underscoring its commitment to expanding its hydrogen industry over the long term.

Figure 4.7 Hydrogen strategies by country



Source: Bloomberg NEF

Regardless of the direction that the energy industry takes in the years to come, it is clear that continuous advancements in hydrogen technologies, investments in its deployment and related infrastructure, as well as stable policy frameworks, are essential to unlock the full potential of hydrogen in the future energy mix.

4.2. Actions undertaken by OPEC Members Countries

It is evident that OPEC Member Countries have made significant strides in contributing to collective GHG emissions reduction with the objective to achieve the Paris Agreement goals, to which all OPEC Member Countries are signatories.

In recognizing the issue, OPEC Member Countries are contributing to global efforts to reduce emissions and achieve the Paris Agreement goals, while considering their national circumstances and capabilities. Historically, OPEC Member Countries have accounted for only around 4% of cumulative global CO_2 emissions since 1850.

To achieve climate targets, OPEC Member Countries are implementing comprehensive strategies, and as a result, have been increasingly investing in decarbonizing technologies, renewables, nuclear energy, and hydrogen in recent years.

There is a recognition among OPEC Members Countries of the crucial role that renewable energy can play in diversifying their economies, mitigating emissions, and enhancing energy security. Saudi Arabia, for instance, under its Vision 2030, aims to generate 50% of its power from renewable energy sources by 2030, up from less than 0.2% in 2021. NEOM, a project on the Kingdom’s Red Sea coast, is to be a futuristic region powered 100% by renewable energy. In 2023 alone, Saudi Arabia invested nearly $10 billion on clean energy projects. Similarly, the UAE has set a target to generate 50% of its energy from clean sources by 2050, reflecting substantial commitments to solar and nuclear energy. Nigeria has set an ambitious goal of renewable sources accounting for 30% of its energy mix by 2030. Kuwait has announced its plan to produce 15% of its total energy from renewables by 2030 and Algeria has announced a goal of 27% renewable power generation by 2030.

OPEC Member Countries have significant potential for developing solar and wind power, however, capitalising on this potential requires substantial investments, supportive policy frameworks, and advances in renewable energy technologies. Currently, several commercial-scale wind and solar plants are operational with several more announced or already under development. For instance, Saudi Arabia’s renewable capacity reached 4.1 GW in the first half of 2024, with 2.1 GW of this capacity coming online in 2023 alone.

Furthermore, new developments in nuclear power have been increasing the share of low-carbon energy connected to electricity grids. For example, the Barakah power station will provide a huge 5.6 GW of capacity to the UAE’s electricity grid.

Another use of abundant renewable energy sources is for the production of hydrogen through electrolysis. Additionally, blue hydrogen that is produced from hydrocarbons but is coupled with CCUS offers a lower-cost alternative to hydrogen production. Algeria’s National Hydrogen Roadmap sets the goal of producing and exporting 30 to 40 TWh of hydrogen and hydrogen derivatives by 2040.

Furthermore, the first shipment of low-carbon ammonia from Saudi Arabia, produced with the use of CCUS, was shipped to Japan for power generation in 2023. 2024 saw the UAE deliver a shipment of low-carbon ammonia to Japan as well.

Like many other countries on the continent, African OPEC Member Countries have shown interest in using hydrogen as an energy carrier. Consequently, the African Hydrogen Partnership was established to facilitate cooperation in this area. Several African countries have partnered with the German Government and set up so-called 'Hydrogen Offices' in Nigeria to facilitate dialogue.

There is a strong emphasis on investing in technologies such as CCS and CCUS to mitigate carbon emissions. Currently, several CCS facilities exist in OPEC Member Countries, and more projects are already under development or have been announced. Furthermore, other Member Countries have announced plans to explore the development of CCS.

4.2.1. Strategies of OPEC National Oil Companies

OPEC Member Country National Oil Companies (NOCs) and International Oil Companies (IOCs) operating within OPEC nations are critical players in the global energy transition. These entities are implementing comprehensive strategies that extend beyond national plans, focusing on reducing GHG emissions throughout the entire hydrocarbon supply chain. By adopting advanced technologies such as CCUS and hydrogen production, these companies are contributing significantly to a sustainable energy future.

A primary focus for these NOCs and IOCs is the reduction of GHG emissions. Aramco is at the forefront, targeting zero gas flaring by 2030 and addressing emissions through efficiency gains, renewables, and CCUS. One of its flagship projects, the Jubail CCUS hub, is set to capture up to 9 million metric tons of CO_2 per year starting in 2027. Additionally, Aramco has developed on-board carbon capture units for ships, which function similarly to SO_x scrubbers, supporting the continued use of oil products in the shipping industry while reducing emissions.

In the UAE, ADNOC has significantly reduced gas flaring, and invested heavily in hydrogen and CCS technologies, with ADNOC's efforts part of a broader commitment to sustainability. Other NOCs, including GEPetrol (Equatorial Guinea), NOCs and IOCs in Iraq, KPC (Kuwait), LNOC (Libya), NIOC (IR Iran), NNPC (Nigeria), PDVSA (Venezuela), SNPC (Congo), SNPG (Gabon), and Sonatrach (Algeria), are also investing in CCUS, renewables and low-carbon fuels, collectively demonstrating OPEC Member Countries' support for emission reduction and energy transitions.

Diversification into renewable energy and alternative fuels is another critical strategy for these companies. Aramco has allocated around 10% of its capital investments to new energy ventures, including hydrogen production and renewable energy. Similarly, the increase in the share of ADNOC's renewable energy investments from 19% to 29% between 2010 and 2022 underscores the importance of these issues. KPC, aiming to achieve zero flaring by 2040 and reduce methane emissions by 30% by 2030, exemplifies the broader trend among NOCs to integrate sustainable practices into their operations. Recently, Sonatrach announced its new climate strategy aimed at reducing GHG emissions and increasing the use of energy from renewables.

Across NOCs and IOCs in OPEC Member Countries, several common themes are evident, including the expansion of CCUS capabilities, development of hydrogen as an energy source, and significant reductions in gas flaring. Sonatrach, for example, has committed to zero flaring by 2030, a goal it has pursued since the 1980s. Aramco's ongoing investment in the Jubail CCUS hub and ADNOC's achievements in reducing flaring by 90% since its founding further illustrate the shared commitment to decarbonization across these companies. These strategies are essential for maintaining competitiveness in an increasingly carbon-intensive world.

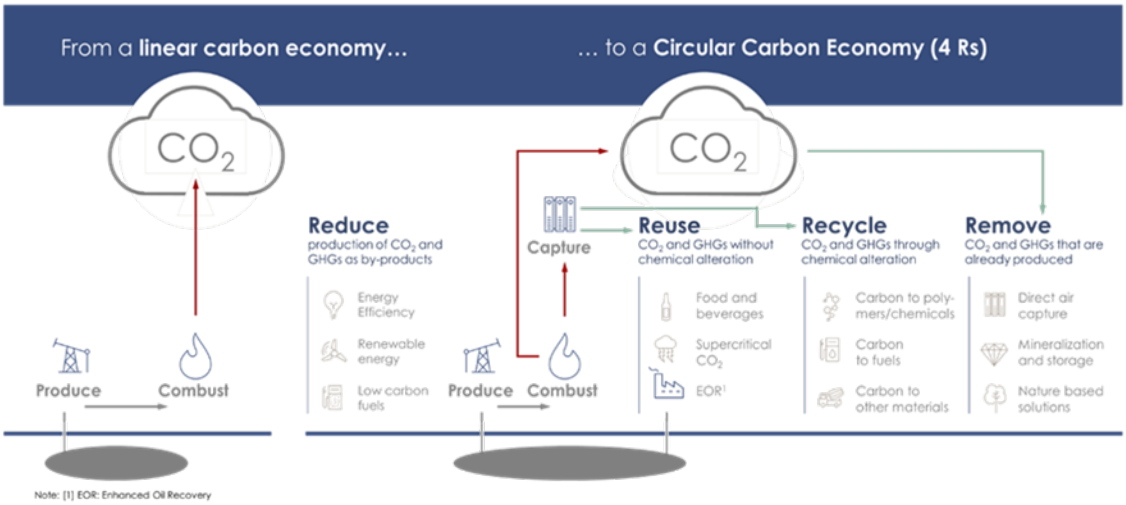
Despite these forward-looking strategies, these NOCs and IOCs face significant challenges – ageing infrastructure, the need for substantial investment, and political and economic uncertainties are major hurdles. Addressing these issues will require robust financing solutions, supportive policy frameworks, and international collaboration. However, these challenges also present opportunities for innovation and the development of new technologies, particularly in areas like CCUS and hydrogen.

4.3. Implementing the Circular Carbon Economy

Acknowledging the need to reduce GHG emissions, the G20 Energy Ministers endorsed the CCE Platform with its 4Rs framework (reduce, reuse, recycle and remove), proposed by the Kingdom of Saudi Arabia in 2020 (Figure 4.8).

The CCE is a voluntary, holistic, integrated, inclusive, pragmatic and complementary approach towards more comprehensive, resilient, sustainable and climate-friendly energy systems that support and enable sustainable development, ensuring energy access and enhancing climate action. The CCE framework encourages countries to use all technologies, forms of energy and mitigation opportunities, considering resource availability, capacities and national circumstances.

Figure 4.8 The Circular Carbon Economy



Source: OPEC

The CCE's 4Rs help develop strategies for managing carbon. The amount of carbon that needs to be managed is reduced using energy resources that do not emit carbon (e.g. nuclear power) as well as energy efficiency measures. Biomass resources, such as trees and plants recycle carbon by drawing it from the atmosphere. These resources also derive bioenergy, whereas carbon capture and DAC technologies can remove carbon from the atmosphere. Moreover, carbon can be reused and converted to feedstock for chemicals, concrete and other building aggregates, or even fuels.

Overall, CCE offers an approach to address climate challenges, while contributing to sustainable development and economic diversification. It utilizes all available levers to address emissions while generating value. Focusing on energy and emissions, it takes a holistic view on emissions reduction technologies, recognizing the economic value of carbon and emphasizing the diversity of national circumstances.

The CCE represents a transformative approach to managing carbon emissions by focusing on four key principles – reducing, reusing, recycling, and removing carbon. This model emphasizes viewing carbon not as waste but as a valuable resource that can be cycled through the economy, minimizing environmental impact and supporting sustainable development.

The first principle is reducing carbon emissions at the source. This involves improving efficiency, adopting cleaner technologies, and minimizing waste to significantly lower the amount of carbon that enters the atmosphere. For instance, in the oil and gas industry, efforts to minimize gas flaring are crucial. While gas flaring can be necessary for safety, it releases substantial amounts of

CO_2. By implementing advanced systems and programmes to reduce flaring, companies can substantially cut their carbon emissions.

Reusing carbon involves capturing emissions and repurposing them in industrial processes. This approach not only prevents CO_2 from being released into the atmosphere but also turns it into a valuable resource. An example of this is EOR, where captured CO_2 is injected into oil reservoirs to help extract more oil while simultaneously sequestering the carbon underground. This method not only improves oil recovery but also ensures that a portion of the CO_2 is permanently stored, thereby reducing overall emissions.

The recycling aspect of the CCE framework focuses on transforming captured carbon into new, valuable products. CO_2 can be converted into materials such as synthetic fuels, building materials, or consumer goods. For example, captured CO_2 can be used to produce more durable and faster-drying cement, which is beneficial for the construction industry. Additionally, CO_2 can be utilized in the production of carbon fiber and synthetic fuels, providing sustainable alternatives to traditional materials and reducing reliance on new raw materials.

Finally, the principle of removing carbon from the atmosphere involves both natural and technological methods. Natural methods, such as reforestation, help offset emissions, while technological solutions like CCS offer ways to extract CO_2 directly from the air. An example of natural removal is planting trees, particularly mangroves, which are effective at sequestering carbon, restoring ecosystems, and protecting coastlines. Technological innovations, such as mobile carbon capture technologies, could also mitigate emissions from vehicles and ships, preventing them from entering the atmosphere.

The CCE concept offers a viable pathway for managing carbon emissions in a sustainable and economically advantageous manner. By focusing on reducing, reusing, recycling, and removing carbon, industries can transform their operations, turning carbon from a liability into an asset. As more organizations adopt this framework, the goal of achieving global climate targets becomes more attainable, promoting both environmental sustainability and economic growth.

4.3.1. Saudi Arabia and the Middle East Green Initiatives

The Saudi Green Initiative and the Middle East Green Initiative were announced early in 2021 to chart a path for Saudi Arabia and the region to protect the planet by defining an ambitious roadmap that rallies the region and significantly contributes to achieving global climate change targets. These initiatives will entail a number of ambitious actions, including the planting of billions of trees, increasing the share of energy from renewables, and enhancing the efficiency of hydrocarbon technologies.

Recognizing that Saudi Arabia and the region face significant climate challenges, such as desertification and air pollution that can shorten life expectancy, the Saudi Green Initiative aims to raise vegetation cover, reduce CO_2 emissions, combat pollution and land degradation, and preserve marine life. Ambitious actions will include: planting ten billion trees within the country in the upcoming decades; increasing the percentage of protected areas to more than 30% of the country's land area, exceeding the global target of 17% per country; and reducing CO_2 emissions by more than 4% of global contributions through a renewable energy programme that will generate 50% of the country's energy from renewables by 2030, as well as various clean hydrocarbon technology projects expected to eliminate more than 130 million tons of CO_2 emissions.

Similarly, the planting of an additional 40 billion trees in the region is expected to be the world's largest afforestation project. This initiative, along with a number of other bold projects, are designed to reduce the region's CO_2 emissions by 60% and look to reinforce partnerships and collaboration, introduce integrated approaches to achieve regional sustainable development and to enhance quality of life. They are also expected to reflect the interest that Saudi Arabia and other Gulf Cooperation Council Member States, in particular, and Middle Eastern countries, in general, attach to environmental preservation and international climate action, achieving a collective emissions reduction of more than 10% of global contributions.

Saudi Arabia is also looking to work with neighbouring countries to transfer knowledge and share experiences, considering that these initiatives stem from the leading role of Saudi Arabia in helping meet global challenges. They are a continuation of the Kingdom's efforts to tackle climate change during its G20 Presidency in 2020, which resulted in a declaration on the environment and the adoption of the concept of a CCE.

Saudi Arabia's CCE strategy represents a significant commitment to reducing GHG emissions and transitioning toward sustainable energy solutions. Central to this strategy are advancements in CCS and hydrogen technologies. CCS is pivotal in capturing up to 90% of CO_2 emissions from major industrial sources, such as refineries and power plants. Saudi Arabia, with its extensive geological formations, has the potential to store billions of tons of CO_2, making CCS a cornerstone of its GHG reduction efforts. The implementation of these technologies supports the country's goal of achieving net zero emissions by 2060.

The success of Saudi Arabia's CCE strategy is evident through several key achievements. The country has operationalized multiple CCS facilities, capturing and sequestering significant quantities of CO_2. For instance, the Arabian Industrial Gas Company, in collaboration with global partners, is advancing major CCS projects that contribute to effective CO_2 management. Additionally, Saudi Arabia's investment in hydrogen technology has surpassed $50 billion, reflecting its substantial commitment to these projects.

In parallel, Saudi Arabia is advancing its hydrogen economy, focusing on both green and blue hydrogen. Notably, the NEOM Hydrogen Project is set to be the world's largest green hydrogen initiative, with an investment of $5 billion.

5. Financial mechanisms and investment gaps in action

As stipulated in the Paris Agreement, developed countries were called to take the lead in reducing global emissions, recognizing that significant mitigation and adaptation actions are needed in order to achieve its long-term goals, based on the best available science and the principle of equity, while taking into account common but differentiated responsibilities and respective capabilities. In addition, the provision of support in terms of climate finance, technology development and transfer, and capacity building have been recognized as key enablers for increased action and implementation.

The IPCC's Synthesis Report for the Sixth Assessment Report (IPCC AR6) draws attention to the fact that the largest climate finance gaps are in developing countries, while financial support for these countries is a critical enabler to enhance mitigation action and address inequities in finance. Mitigation investments need to increase by at least sixfold in Southeast Asia and in the Pacific, fivefold in Africa and fourteenfold in the Middle East by 2030 to hold warming below 2 degrees C. Finance for adaptation, as well as loss and damage, will also need to rise dramatically. Developing countries will need $127 billion per year by 2030 and $295 billion per year by 2050.

One of the most anticipated outcomes of the incoming COP29 is a potential agreement on the new collective quantified goal (NCQG) that will supersede the $100 billion pledge established at COP21. The agreement on the NCQG is a critical step for progress on the climate agenda and the Paris Agreement, as most developing countries' climate plans are contingent on a significant boost in climate finance provisions.

5.1. Core climate finance instruments

The Green Climate Fund (GCF), launched in 2010, is the world's largest climate fund. By December 2023, the GCF had amassed a portfolio value of $13.5 billion, or $51.9 billion with co-financing taken into account. The fund's substantial resources are directed towards initiatives that aim to mitigate and adapt to the impacts of climate change, ensuring that developing nations can pursue sustainable development pathways.

The Adaptation Fund (AF) was established in 2001 with a dedicated focus on supporting adaptation projects in developing countries. Initially created under the Kyoto Protocol, its mandate was extended in 2018 to serve the Paris Agreement, further solidifying its role in the global climate framework. By COP28, the AF had garnered cumulative contributions totaling $1.3 billion from 26 countries. These resources are crucial for financing projects that help vulnerable communities adapt to the adverse effects of climate change.

The Special Climate Change Fund (SCCF), created in 2001, is a mechanism that finances projects across a broad range of sectors, including adaptation, technology transfer, and energy management. The fund has been instrumental in helping developing countries implement climate-related initiatives through the $383 million received from 16 countries. The SCCF's broad mandate allows it to address various climate challenges, supporting countries in building resilience and reducing greenhouse gas emissions.

The Least Developed Countries Fund (LDCF) is specifically designed to assist Least Developed Countries (LDCs) in preparing and implementing national adaptation programmes. This fund, which had accumulated $2 billion in contributions from 29 countries ahead of COP28, provides essential financial support to the world's most vulnerable nations. The LDCF focuses on addressing the unique challenges faced by LDCs, enabling them to enhance their capacity to adapt to the impacts of climate change and secure a sustainable future.

The Fund for Responding to Loss and Damage was agreed upon at COP27 and represents a significant step forward in addressing the impacts of climate change on vulnerable developing countries. This new fund is specifically aimed at helping these countries respond to loss and damage resulting from climate-related events. By COP28, pledges for this fund had reached $679.7 million, highlighting the international community's recognition of the need to support those most affected by climate change.

However, despite these significant initiatives, they fall short of the green energy investment needed in EMDEs, which require far greater financial resources to effectively transition to sustainable energy systems and meet their growing energy demands in alignment with global climate goals.

5.2. Bridging finance gaps and scaling investments

The global stocktake decision adopted at COP28 dedicates an important chapter to climate finance, highlighting the significant gap between the resources mobilized and the needs of developing countries to implement their commitments under the Convention and the Paris Agreement. Developing countries need an estimated $5.8–5.9 trillion for the pre-2030 period to implement their climate commitments. Investments in clean energy need to be around $4.3 trillion per year until 2030, increasing to $5 trillion per year until 2050 to achieve net zero emissions by 2050. In terms of adaptation, annual finance needs for developing countries are estimated at $215–387 billion up to 2030.

The decision emphasizes the importance of increasing grant-based, highly concessional finance and non-debt instruments to support developing countries in their just transition towards low emissions and climate-resilient development. It underscores the responsibility of developed countries to provide financial resources to help developing countries with both mitigation and adaptation efforts, continuing their existing obligations. Although the decision acknowledges that climate finance from developed countries increased to $89.6 billion in 2021, with a likelihood of meeting the goal of $100 billion per year in 2022, the goal was not met in 2021 due to challenges in securing finance from private sources.

Concerns arise from the widening adaptation finance gap, inadequate climate finance levels, and insufficient technology development and capacity-building for adaptation in developing countries, especially those vulnerable to climate change. Contributors are urged to fulfill their pledges promptly, ensuring resource sustainability. Additionally, there are strong calls for multilateral development banks and other financial institutions to increase investments in climate action, including grants and concessional finance.

The decision highlights the varied definitions of climate finance used by different stakeholders. It urges developed countries to meet the $100 billion per year climate finance goal through 2025, emphasizing the importance of public funds and better coordination. Additionally, it stresses the need to significantly increase adaptation finance beyond previous commitments (doubling) to help developing countries build resilience and implement their national adaptation plans by 2030.

5.3. Setting New Collective Quantified Goal (NCQG)

The New Collective Quantified Goal (NCQG) on climate finance aims to build on the lessons learned from the previous $100 billion goal, addressing the shortcomings and challenges that emerged. One of the key lessons highlighted by developing countries is that the previous goal did not adequately reflect their needs and priorities, as outlined in the Standing Committee on Finance's Needs Determination Report. The report underscores that climate finance and investments have not flowed sufficiently to developing countries, and the failure to meet the 2020 target has emphasized the critical need for reliable and sustained public support. These insights are crucial as the NCQG seeks to establish a more effective and responsive framework for climate finance.

In terms of principles and implementation, the NCQG must align with the principles of common but differentiated responsibilities (CBDR) and respective capabilities (CBDR-RC). This alignment is essential to ensure that the new goal reflects the varying responsibilities and capacities of developed and developing countries. The NCQG should address the full scope of Article 9 of the Paris Agreement, which emphasizes the obligations of developed countries to provide financial resources to support climate action in developing nations. Furthermore, the new goal should be designed to provide easy access to resources for developing countries without increasing their debt burdens. The Enhanced Transparency Framework should be utilized for monitoring and accountability, ensuring that the commitments made under the NCQG are met with transparency and effectiveness.

5.4. Financing sustainable development: lessons from OPEC Member Countries

5.4.1. The OPEC Fund for International Development

The OPEC Fund was established in 1976 as a separate organization dedicated to supporting sustainable development in low- and middle-income countries, focusing on the realization of the UN Sustainable Development Goals (SDGs). Since its founding, the OPEC Fund has committed over $27 billion to more than 4,000 projects in over 125 countries, contributing to an estimated total project cost exceeding $200 billion. In 2023 alone, the Fund committed $1.7 billion across 55 projects aimed at increasing economic resilience, supporting growth, and fostering development.

The OPEC Fund's operations have ensured the provision of more than 11 million households with access to water and sanitation, the development of approximately 4 GW of electricity generation capacity, and supported over 350,000 micro, small, and medium-sized enterprises. Additionally, the Fund has financed the construction and rehabilitation of more than 11,000 kilometers of roads and railways, significantly improving infrastructure and connectivity.

In response to global challenges, the OPEC Fund has launched several initiatives. For instance, the $1 billion Food Security Action Plan was introduced in 2022 to address supply chain disruptions. Simultaneously, the Climate Action Plan aims to raise the share of climate financing to 40% of all new financing by 2030, with climate finance already accounting for 33% of total approvals in 2022.

The OPEC Fund's commitment to sustainable development is further reflected in its ESG policy framework, which aligns with best practices in order to maximize impact. The Fund's strong financial position is underscored by its AA+/Outlook Stable ratings from Fitch and S&P. In 2023, the OPEC Fund issued its inaugural SDG Bond, raising $1.5 billion for development finance.

Honoring the achievements of organizations and individuals dedicated to poverty reduction and sustainable development, the OPEC Fund also bestows its Annual

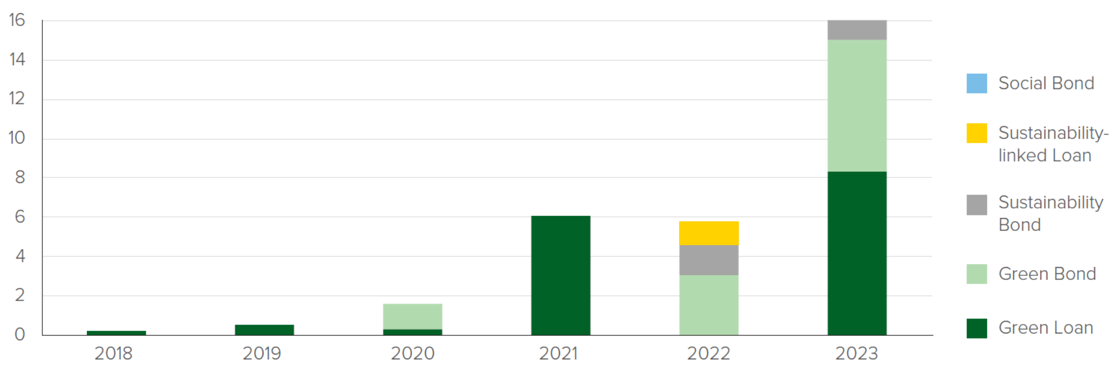
Award for Development, introduced in 2006, which is accompanied by a $100,000 prize.

Through its wide-ranging initiatives, the OPEC Fund continues to be a vital force in promoting sustainable development, addressing global challenges, and empowering communities worldwide. The Fund exemplifies how sustainable development can be effectively supported while also encouraging investment. It is essential to focus on strengthening and supporting existing organizations that have already made strides in these areas, rather than establishing new ones, which could increase the debt burden on developing countries, particularly those still facing energy poverty.

5.4.2. Saudi Arabia's strategy to accelerating climate finance

Saudi Arabia’s strategic approach to financing its sustainability initiatives provides valuable lessons for other countries striving to achieve their climate and economic goals. Since 2018, the Kingdom’s engagement in sustainable finance markets has gained significant momentum. The year 2023 marked a notable turning point, with Saudi Arabia’s sustainable debt issuance surging nearly threefold compared to the previous year and reaching $16 billion in 2023 from a modest $519 million in 2019. This dramatic increase is largely attributed to major Vision 2030 projects, such as NEOM, the Red Sea Global development, and large-scale solar power plants. These initiatives are led by consortiums including prominent developers like the Public Investment Fund (PIF), ACWA Power, SABIC, Red Sea Global, and Aramco. Sustainable loans initially spearheaded the expansion of green investments in the Kingdom starting in 2021, but green bond issuance has since gained significant traction. By 2023, Saudi Arabia achieved a well-balanced mix of both sustainable loan and bond issuance (Figure 5.1).

Figure 5.1 Saudi Arabia’s sustainable finance flows, $Bn.



Source: KAPSARC’s construction from Bloomberg NEF.

To sustain this momentum, the Kingdom aims to further develop its domestic sustainable finance infrastructure in line with global standards. The new “Green Financing Framework” issued by the Ministry of Finance is a significant advancement, offering greater clarity on how green debt proceeds are managed, allocated, and monitored. It includes oversight by a ministerial committee and transparent auditing by external parties. Green Finance Frameworks, adopted by various countries such as the UK and private entities such as Amazon, ensure adherence to principles for utilizing proceeds from sustainable sources. Continuous internal and external monitoring helps address concerns such as greenwashing, which is a major issue for ESG investors. The GFF’s launch is crucial for ensuring accountability and transparency, thereby building investor confidence, which is essential for catalyzing the growth of the Kingdom’s capital markets and attracting sustainable investors.

Vision 2030 outlines Saudi Arabia’s ambition to enhance its role in finance and international relations by attracting foreign investment, forming financial partnerships, and participating in global financial collaborations. This strategy is embodied in the Financial Sector Development Program, aiming to position Saudi Arabia as a leading global financial hub and attract a wider range of private investors. The GFF plays a crucial role in this initiative by modernizing the financial landscape and aligning it with the highest international standards. This framework will facilitate the development of a more extensive capital market offering, enabling the Kingdom to actively engage in emerging financial markets, including those related to sustainable finance, while ensuring a strong, dynamic, and stable sector.

To finance a diverse range of climate initiatives, Saudi Arabia recognizes the need for substantial resources beyond public revenues and seeks increased private sector participation. The Kingdom aims to boost Foreign Direct Investments by 30%, green investments by 40%, and private sector contributions by 40–60% by 2030. The GFF outlines key focus areas for public investments in climate mitigation and adaptation, clarifying which projects will receive government support or remain in the public domain. By providing greater clarity for sustainability-focused private investors and reducing their exposure to project risks, the GFF enables Saudi Arabia to have its sustainability strategy accredited externally (e.g., by Moody’s Investors Service), enhancing the Kingdom’s sovereign debt profile in the ESG investing space.

In summary, the GFF is a fundamental component of Saudi Arabia’s sustainability, economic diversification, and financing strategy within the Vision 2030 framework. It aligns public stakeholders and initiatives while offering high-level guidance for private investors. By elevating the Kingdom’s sovereign profile and providing opportunities for capital market diversification, the GFF sets the stage for upcoming ESG disclosure guidelines and green taxonomy, complementing Saudi Arabia’s sustainable finance toolkit.

6. Conclusion

The global energy landscape is undergoing a profound transformation driven by growing energy demand and an urgent need to address climate change. OPEC's outlook provides critical insights into these transitions, highlighting the dual challenge of meeting rising energy needs while advancing towards a low-carbon future.

OPEC's projections reveal a clear trajectory towards increased energy demand, with renewable sources such as solar and wind set to lead the growth. The anticipated rise of nearly 43 mboe/d by 2050 underscores the critical role that these technologies will play in the global energy mix. The decline in coal demand, projected at approximately 29 mboe/d over the same period, reflects a significant shift towards cleaner energy sources, while oil and gas will continoue to contribute by more than 50% of energy demand by 2050 This transition is particularly pronounced in developed economies and major energy consumers like China, driven by stringent emission reduction measures.

OPEC's commitment to advancing key technologies – such as CCS and hydrogen—demonstrates a forward-looking approach to mitigating climate impacts while addressing rising energy demand. These technologies are essential for reducing greenhouse gas emissions and achieving global climate targets. By supporting these innovations, OPEC aims to ensure that energy transitions are both sustainable and resilient, providing a balanced approach to energy security and environmental stewardship.

The OPEC Fund stands as a testament to the dedication of OPEC Member Countries to fostering sustainable development. With over $27 billion committed to more than 4,000 projects, the OPEC Fund plays a pivotal role in addressing financing gaps in EMDEs. The fund's initiatives, including the Food Security Action Plan and the Climate Action Plan, illustrate a robust commitment to enhancing resilience and addressing critical needs in vulnerable regions.

The experiences of OPEC Member Countries offer valuable lessons in successfully managing energy transitions. Saudi Arabia's GFF exemplifies how comprehensive and structured financing strategies can drive substantial investments in clean technologies. The Kingdom's commitment to investing $1.5 trillion in clean technologies by 2030, along with its emphasis on public-private partnerships, highlights the effectiveness of aligning national strategies with international standards to attract and mobilize resources.

The path to a sustainable energy future demands a coordinated global effort to scale up financial resources, embrace technological innovations, and implement effective policies. OPEC's outlook and the initiatives of its Member Countries provide a robust framework for navigating these challenges. Continued international collaboration, coupled with the adoption of advanced technologies and innovative financing mechanisms, will be crucial in achieving a resilient and sustainable global energy system.

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List of abbreviations

AF	Adaptation Fund
CBDR	Common but Differentiated Responsibilities
CBDR-RC	Common but Differentiated Responsibilities and Respective Capabilities
CCS	Carbon Capture and Storage
CO_2	Carbon Dioxide
COP	Conference of the Parties
COP27	27th Conference of the Parties
COP28	28th Conference of the Parties
EMDEs	Emerging Markets and Developing Economies
ESG	Environmental, Social, and Governance
GCF	Green Climate Fund
GFF	Green Financing Framework
GHG	Greenhouse Gas
GW	Gigawatt
KAPSARC	King Abdullah Petroleum Studies and Research Center
LDCF	Least Developed Countries Fund
mboe/d	Million Barrels of Oil Equivalent per Day
NCQG	New Collective Quantified Goal
NGOs	Non-Governmental Organizations
PDA	Public Development Assistance
PIF	Public Investment Fund
SCCF	Special Climate Change Fund
SDGs	Sustainable Development Goals
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change

Organization of the Petroleum Exporting Countries

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