China's Oil and Gas Industry in Energy Transitions: National and International Perspectives

Overview

The oil and gas industry has been proficient at delivering the fuels that form the bedrock of today's energy system and society. But increasing social and environmental pressures on the industry raises a number of questions about the position of oil and gas companies in the societies in which they operate. The challenges these companies face vary given the diversity of oil and gas companies around the world and different actors will play different roles based on their varying mandates and strengths and the contributions that they make. With ever increasing ambitions to reduce GHG emissions, but against a backdrop of rising global emissions, today's oil and gas companies face a fundamental question: are they part of the problem, or can they be part of the solution?

China's commitment to peak CO_2 emissions by 2030 and achieve carbon neutrality by 2060 will have profound consequences for its National Oil Companies (NOCs). The targets are spurring the companies to consider what roles they want to play in the future and how they are going to balance their energy security responsibilities with their energy transition strategies.

This paper looks at the largest NOCs in China: the China National Petroleum Corporation (CNPC), Sinopec, China National Offshore Oil Corporation (CNOOC) and Shaanxi Yanchang Petroleum. We explore their current strategies, the opportunity space for these companies, and how they can contribute to carbon neutrality targets while enhancing national energy security. These strategies are compared and contrasted with the strategies being pursued by other international and national oil and gas companies.

Mapping the oil and gas industry

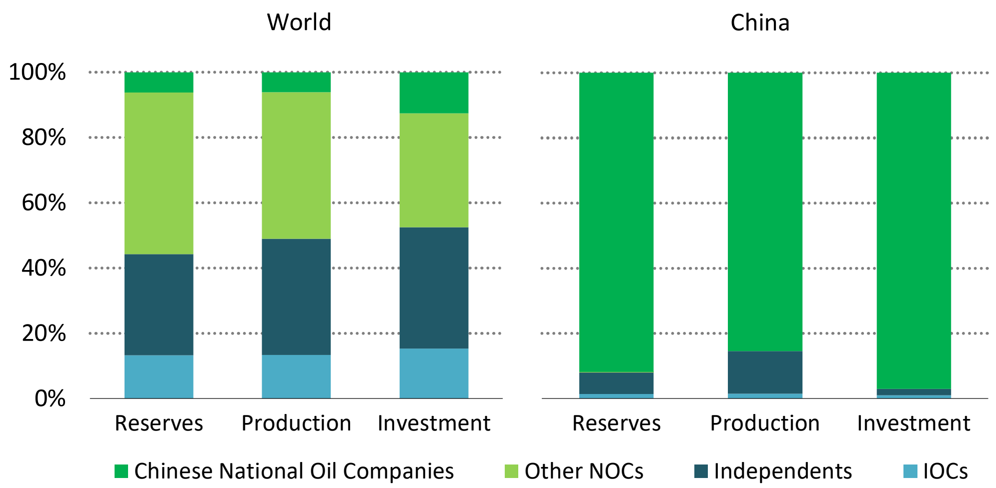
The oil and gas industry includes a very diverse mix of corporate structures and governance models, from small enterprises to some of the world's largest corporations. In this paper we examine and compare the responses and possible roles of the large International Oil Companies (IOCs), Chinese NOCs, and other NOCs.

IOCs are integrated companies listed on US and European stock markets, and most are involved with all aspects of the oil and gas supply chains: from upstream operations, processing and refining, transport and marketing.[1] NOCs have a mandate from their home government to develop national resources, typically including a legally defined role in upstream development; some also make large upstream investments outside the home country (these are sometimes known as international NOCs).

NOCs include the largest companies both in terms of production and in terms of reserve size. More than half of the current proven-plus-probable oil and natural gas reserves globally are held by NOCs while the IOCs hold just under 15% (the remainder is held by independent companies, including those in Russia, a large number of North American shale companies, and diversified conglomerates). NOCs on average have a lower-cost asset base than IOCs, meaning that they account for a slightly smaller share of overall investment levels.

The four Chinese NOCs are responsible for more than 85% of total oil and natural gas production in China (including both direct operations and non-operated assets) and they were responsible for almost all of upstream investment in China in 2021. Three of the Chinese NOCs also have an international presence including operatorship: in total, around 30% of their aggregate oil and gas reserves are located outside of China, and these areas saw around 15% of their capital spending in 2021. They are also active overseas in the downstream sector. For example, CNPC has invested in European refineries and has established a refining and trading joint venture that owns the Grangemouth refinery in Scotland and the Lavéra refinery in France.

Figure 1 ⊳ Reserves, production and investment by company type, 2021



Source: IEA analysis based on Rystad (2022)

Note: Independents comprise all privately-held companies apart from the IOCs.

[1] In this report's classification, the IOCs include: BP, Shell, TotalEnergies, and Eni (the "European IOCs"), and Chevron, ExxonMobil, and ConocoPhillips (the "US IOCs").

The energy transition to a net zero world

To frame the risks, challenges and opportunities for the oil and gas industry in the future, we draw on the following three scenarios for the energy sector.

The **Stated Policies Scenario (STEPS)**, which reflects current policy settings based on a sector-by-sector assessment of the policies in place and announced by governments around the world. This scenario explores where the energy system might go without major additional steers from policy makers.

The **Announced Pledges Scenario (APS**), which includes all of the climate commitments made by governments up to the beginning of October 2021. This includes the Nationally Determined Contributions, made as part of the Paris Agreement, and longer term net zero targets, including China's 2060 carbon neutrality target. This scenario assumes that all announced pledges are met in full and on time.

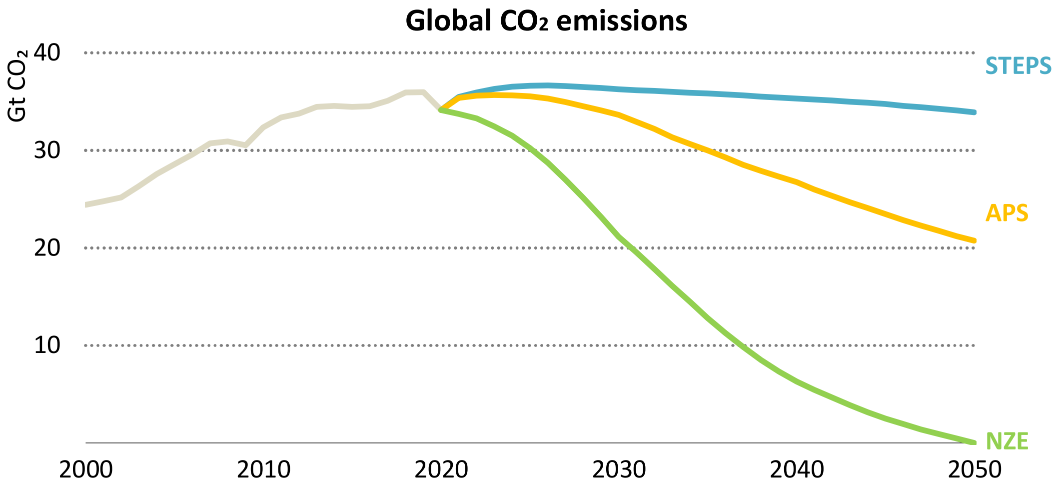
The **Net Zero Emissions by 2050 Scenario (NZE),** which sets out a pathway for the global energy sector to achieve net zero CO_2 emissions by 2050. Advanced economies reach net zero emissions in advance of others. This scenario also meets key energy-related United Nations Sustainable Development Goals (SDGs), in particular by achieving universal energy access by 2030 and major improvements in air quality.

Emissions

In the STEPS, the energy system of the future looks similar to that of the past. Following a strong rebound in emissions in 2021, global CO_2 emissions rise to the late 2020s before peaking and declining very slightly. By 2050 emissions are just below today's level: if emissions continue their trend after 2050, the rise in temperature in 2100 would be around 2.6 °C (with a 50% probability). In the APS, there is a faster decline in emissions, especially after 2030, and a large emissions gap opens up with the STEPS. In the NZE, global CO_2 emissions fall by around 35% between 2020 and 2030 and drop to zero in 2050. This pathway is consistent with limiting the global temperature rise to 1.5 °C as set out in the Paris Agreement.[2]

[2] In the Paris Agreement, countries agreed to an objective of "holding the increase in the global average temperature to well below 2 °C and pursuing efforts to limit the temperature increase to 1.5 °C"; this goal was affirmed in the Glasgow Pact signed at COP26 in November 2021.

Figure 2 ▷ Global CO_2 emissions to 2050 in the STEPS, APS and NZE

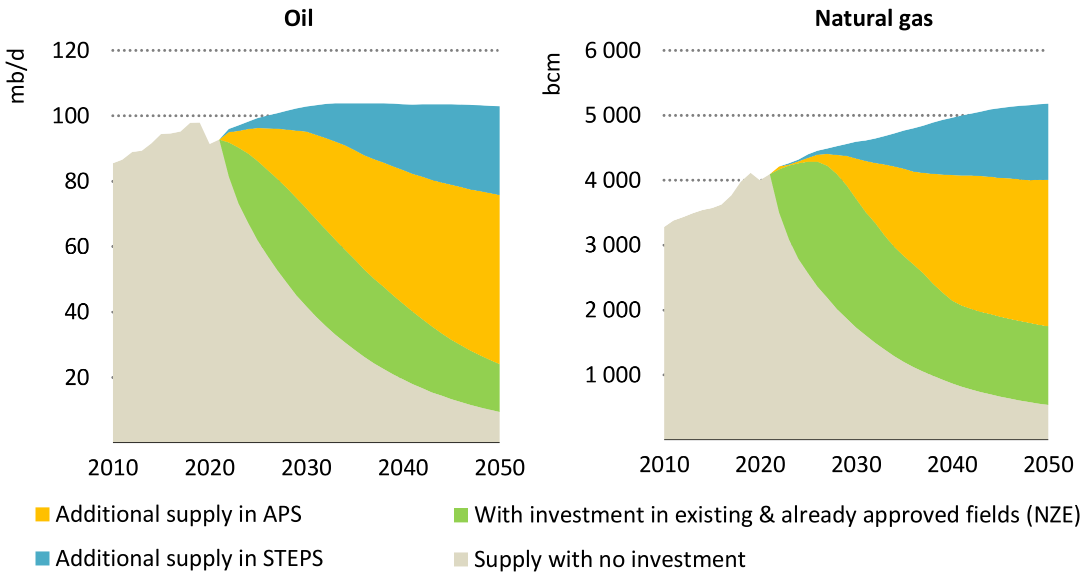


Oil and gas supply and demand

Oil demand shows an eventual peak and decline in all three scenarios, but with very different timing and sharpness. In the STEPS, demand flattens at 104 mb/d in the mid-2030s and then declines very slightly to 2050. In the APS, global oil demand peaks soon after 2025 and declines to 77 mb/d in 2050. Most of this change stems from a phase down in the use of internal combustion engine vehicles in favour of electric vehicles (in 2050, 70% of the cars on the road globally are electric compared with 30% in the STEPS). In the NZE, oil demand falls to 72 mb/d by 2030 and further to 24 mb/d by 2050. There are no new internal combustion engine cars sold from 2035 in this scenario and there are major shifts away from the use of oil in aviation and shipping. In 2050, 70% of oil use is in applications where it is not combusted, such as chemical feedstocks, lubricants, paraffin waxes and asphalt.

Natural gas demand increases in all scenarios over the next five years but with sharp divergences afterwards. In the STEPS, natural gas demand grows by 15% between 2020 and 2030 (reaching more than 5 100 bcm in 2050). In the APS, natural gas demand reaches its maximum level soon after 2025 and falls below 2020 levels by 2040. The largest differences between the trajectories for gas demand in APS and STEPS are seen in the power sector, given an extra push for solar PV and wind, and gas use in buildings given a much stronger push to electrify space and water heating in advanced economies and in China. In the NZE, natural gas demand drops sharply from 2025 onwards and falls to 1 750 bcm in 2050. By 2050, more than 50% of natural gas consumed is used to produce low-carbon hydrogen, and 70% of gas use is in facilities equipped with carbon capture, use and storage (CCUS).

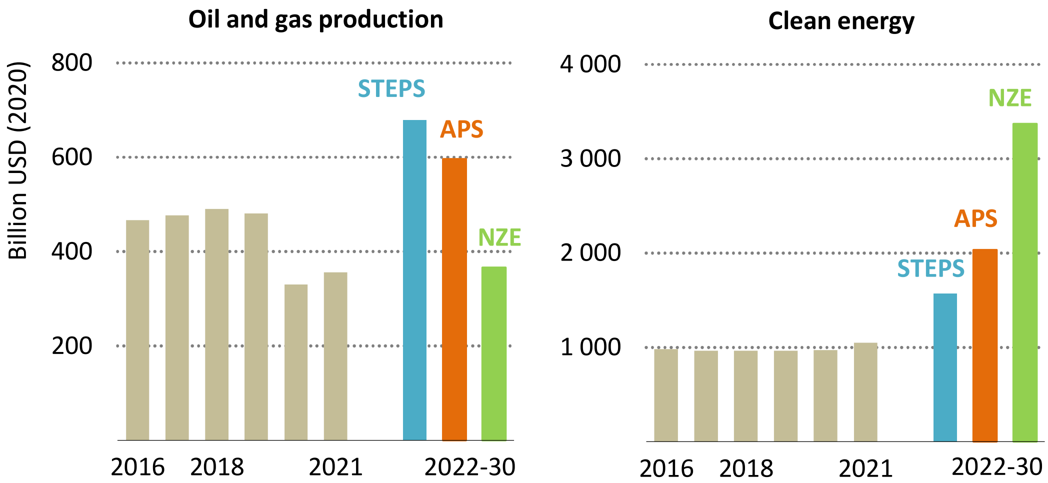
Figure 3 ▻ Global oil and natural gas supply by scenario



The differences in the trajectories for oil and gas demand mean that upstream oil and gas investment levels are also very different. In the STEPS, around USD 680 billion is spent on average each year to 2030, double the levels seen in 2020 and 2021. In the APS, even though oil and gas demand peaks in the mid-2020s, the rate of decline in demand is much slower than the annual loss of supply from existing fields.[3] Around USD 600 billion is spent each year on average to 2030 in both existing and new oil and gas fields to ensure a smooth match between supply and demand. In the NZE, the trajectory for oil and gas demand means that no new oil and natural gas fields are required beyond those that were approved for development by the end of 2021. Continued spending to maintain production from existing assets and to reduce associated emissions is still needed.

[3] If all capital investment in producing oil fields were to cease immediately, this would lead to a loss of over 8% of supply each year. If investment were to continue in producing fields but no new fields were developed, then the average annual loss of supply would be around 4.5%.

Figure 4 ▹ Investment in oil, natural gas and clean energy by scenario



Recent levels of upstream oil and gas investment, which fell sharply in 2020 and 2021, are broadly aligned with the amounts needed on average each year to 2030 in the NZE. This is not the case for investment in clean energy technologies, which are more than triple current levels in the NZE. If the supply side moves away from oil or gas before the world's consumers do, then the world could face periods of market tightness and volatility. Alternatively, if companies misread the speed of change and over-invest, then these assets risk under-performing or becoming stranded.

Trajectories for oil and gas demand in China

China is the world's largest energy consumer today: it consumes around 15% of global oil demand and 8% of global natural gas demand, and also emits around one third of global CO_2 emissions.

In the STEPS, oil demand in China grows by about 20% between 2020 and 2025, it then remains broadly flat to 2030 before falling back to around today's level in 2050. In 2050, around 60% of the cars on the road in China are electric.

In the APS, the scenario consistent with achieving China's 2060 carbon neutrality target, trends to 2030 are similar to the STEPS, but there is a sharp decline in oil demand after 2030 given extensive efforts to be on course for carbon neutrality in 2060. Oil is displaced most extensively in the transport sector as a result of a rapid shift to electric vehicles (nearly 80% of cars in 2050 are electric). By 2050, more than 40% of oil demand in China is for use as a feedstock in petrochemical production.

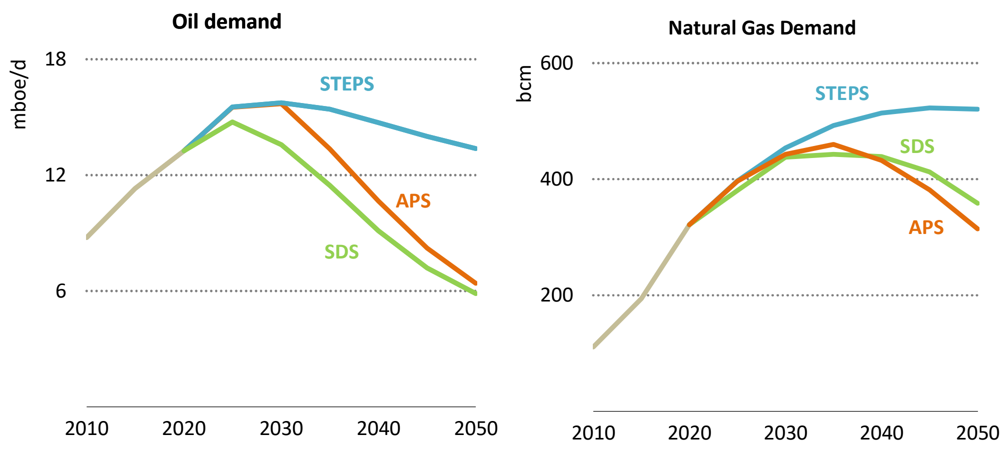
The IEA's recent report on *An energy sector roadmap to carbon neutrality in China* set out an alternative pathway for China with enhanced policy efforts to 2030 (IEA, 2021a). This scenario, which is similar the **Sustainable Development Scenario** (SDS) included in the WEO-2021, included an accelerated decline in coal use in power, larger investment in clean energy technologies, and an increase in efficiency measures across end-use sectors. The long-term trends in the SDS are similar to the APS, but there is faster action to 2030, allowing for a smoother year-on-year pace of change thereafter.

In the SDS, oil demand grows by just over 10% to 2025; demand then peaks and falls back to 2020 levels by 2030. This is caused mainly by a much greater acceleration in sales of electric cars (sales in 2030 are 45% compared with 35% in the APS and STEPS), alongside reduction in petrochemical demand due to an increase in material recycling.

For natural gas, there is much more consistency between the three scenarios to 2030, and demand increases by around 40% between 2020 and 2030. In the STEPS and APS, the increase in gas use is largest in industry and buildings; in the SDS, the increase is largest in the power sector as there is a greater level of coal-to-gas switching.

Trends diverge after 2030. In the STEPS, demand increases by a further 15% to the mid-2040s, reaching a maximum level of around 525 bcm. In the APS and SDS, natural gas demand peaks in the mid-2030s. Gas demand is marginally higher in the SDS than in the APS in the 2030s given a more rapid shift away from coal in the power sector; this is mostly replaced by renewables and nuclear, but natural gas can also help offset some of the reduction in coal. By 2050, in both scenarios, natural gas is used primarily to provide electricity system flexibility, in cement production, and as an input to hydrogen production (mostly with CCUS).

Figure 5 ▻ Scenarios of oil and natural gas demand in China to 2050



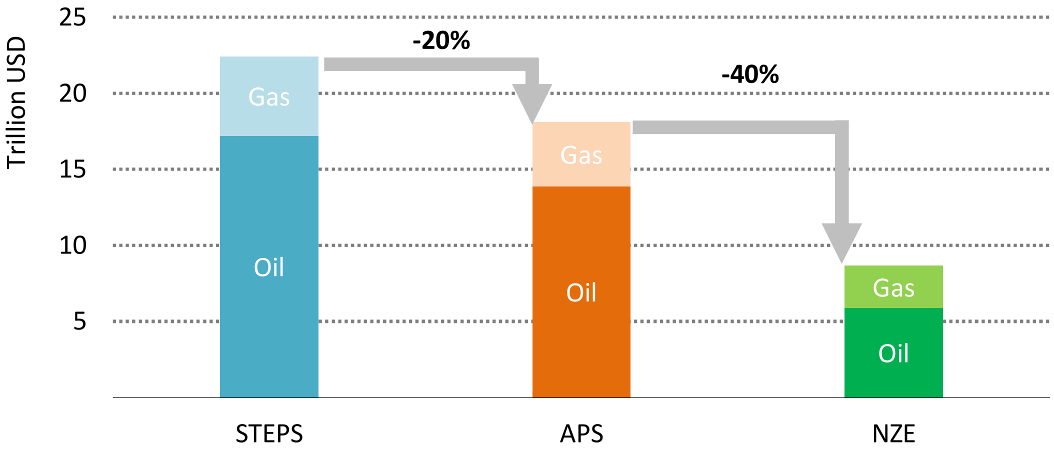
Risks for the oil and gas industry in energy transitions

The oil and gas industry is used to facing risks and operating with a high degree of uncertainty. Companies have developed strategic resilience and continuously anticipate and adjust their business models to new trends that can affect the profitability of their business, as seen with the sharp drops in oil prices in 2008, 2014, and 2020. Yet energy transitions present some new and pervasive risks that are different and could imply a more fundamental reshaping of the industry.

One major uncertainty is over the pace of the change**.** Whether the energy sector will follow a trajectory closer to the STEPS or the NZE will depend on actions from policy makers. While there is global consensus on the need and urgency to act to limit the temperature rise to well-below 2°C and pursue efforts towards 1.5 °C, the reality – as seen in the STEPS – does not currently match the rhetoric. Countries are also progressing at different paces. This has important implications over the level the industry should be investing into new and existing sources of supply.

In the case of over investment, there is a risk is of underutilised, unprofitable or stranded assets, putting greater financial pressure on producing countries and companies alike. Our analysis shows that in the NZE, the present value of future oil and gas production is 60% lower than in the STEPS.

Figure 6 ▻ Present value of future oil and gas production to 2050 by scenario



In the case of underinvestment, oil and gas markets would tighten, leading to higher and potentially more volatile prices. When a price rise is caused by a supply-side shock, this penalises consumers of the fuel in question and hits the economies in countries that are net importers. High prices also accelerate the policy momentum and economic attractiveness of alternatives to oil, especially in countries that are particularly sensitive to price swings (including China and other emerging demand giants in Asia). Finally, producers of oil would benefit from higher revenues and the key strategic and environmental question would be whether those revenues are reinvested in new oil and gas production, returned to investors or home governments, or used to boost spending on cleaner fuels and technologies.

For NOCs and their home governments that rely on oil and gas sales to finance social programmes, the implications of the NZE are even more stark: per-capita oil and gas income in the NZE in 2030 is 75% lower than in 2020. Without much more diversified economies and sources of tax revenue, revenue from hydrocarbons in the NZE would not be sufficient to finance essential areas such as education, health care, public sector employment and so on. These pressures could mean much more limited funding is available for continued investment in the upstream.

The ability of the oil and gas industry to access external sources of finance also changed. Financing can be important to the industry if revenues suddenly drop: in 2020, for example, the IOCs borrowed around USD 80 billion to face the downturn induced by Covid-19 (Bloomberg, 2022). As financial markets push for greater transparency on the long-term risks and returns of companies and investments, oil and gas companies may struggle to access market capital at favourable rates.

A further risk for NOCs in energy transitions is that they will struggle to fulfil their core mandates to produce domestic oil and natural gas resources and enhance national security while simultaneously meeting other domestic targets for emissions reductions.

IOCs and NOCs have a high level of agency and ability to shape positively the pace and direction of energy transitions. Some low-carbon technologies, such as biofuels or offshore wind, could benefit from existing knowledge and competences of companies; companies are experts in managing complex projects, which could be of great benefit to building large-scale renewable or other low-carbon technologies; and the large size of IOCs and NOCs means significant revenue could be redirected to fund capital-intensive clean energy technologies. The IOCs and internationally-focused NOCs – including some of the Chinese NOCs – also know how to manage operations across different countries with differing governance conditions: utilising this global reach could help expand clean energy technologies into countries that would otherwise struggle to finance these projects.

Strategic responses of the industry to date

Targets to reduce emissions from oil and gas activities

The emission reduction targets made by companies typically include a number of common elements such as reducing scope 1 and 2 emissions, often with specific methane and flaring targets, and addressing scope 3 emissions.[4] Direct comparisons are not simple, however, as they also differ in a number of important aspects. For example: some reductions are for scope 1, 2 and 3 emissions in aggregate, whereas others include only scope 1 and 2 emissions; there are no industry-wide agreed methodologies to calculate scope 3 emissions; reductions can be expressed as emissions intensities or as absolute reductions; companies may have different targets regionally and globally; they can include all equity shares or exclusively cover operated assets; reductions can be specified as a "target" or "ambition" with unclear definitions of the differences between these; and baselines differ, or are not mentioned at all.

All IOCs have now set scope 1 and 2 emission reduction targets to 2030 albeit varying in timing and aspiration. European IOCs have made short, medium and long-term emission reduction targets with several aiming to achieve net-zero carbon neutrality by mid-century. The US IOCs have made emission reduction targets only to 2030, although Chevron and ExxonMobil have noted an ambition to achieve net-zero operations by 2050, and ConocoPhillips announced a long-term carbon-neutral Scope 3 ambition.

Some of the NOCs, including Saudi Aramco, ADNOC and Qatar Energy have announced a mixture of short and long-term emission target goals, but most other NOCs have not. The Chinese NOCs have recently been building their capability to measure emissions and until recently had not announced any specific emissions reduction targets. Following China's announcement to peak carbon emissions by 2030 and achieve carbon neutrality by 2060, all of the Chinese NOCs have now also announced an intention to peak their emissions before 2030 although these lack the specificity of the IOCs. CNPC, as a member of OGCI, has committed to OGCI's commitment to reduce group methane emissions intensity to less than 0.2% by 2025 and OGCI's ambition to strive for "near zero" methane emissions by 2030. CNPC has individually pledged a target to reduce its own methane emissions by 50% by 2025.

[4] Scope 1 = direct emissions from energy and other sources owned or controlled. Scope 2 = indirect emissions from the production of electricity and heat, and fuels purchased and used. Scope 3 = indirect emissions from sources not owned or directly controlled but related to their activities (such as employee travel, transport and production of purchased fuels, and end use of fuels, products and services).

Table 7 ▻ Greenhouse gas emission reduction targets of select companies

	Company	Scope 1 & 2 baseline	2025	2030s		2050	Methane		Routine flaring
			Target	Year	Target	Target	Year	Target	
IOCs	BP [1, 2]	2019	5%	2030	50% [A]	50% [3,A,i]			M
IOCs	Eni [1, 2]	2018	40%	2035	100%	100% [3,A,i]	2025	80% [4]	E
IOCs	Shell [1]	2016		2030	20%	100% [3,i]			E
IOCs	TotalEnergies [1]	2015	15%	2030	20%	100% [A]	2030	80% [4]	M
IOCs	Chevron [1]	2016		2028	35%				M
IOCs	ExxonMobil [1]	2016		2030	20-30%		2030	70-80%	DNM
IOCs	ConocoPhillips	2016		2030	40-50%	100% [A]	2025	10%	M
NOCs	Saudi Aramco [1]	-				100%			-
NOCs	ADNOC	2013		2030	25%		2025	<0.2%	M
NOCs	Qatar Energy	2013		2030	25%				M
CNOCs	CNPC [1]		PB			100%	2025	50%	-
CNOCs	Sinopec		PB			100%			-
CNOCs	CNOOC		16%	2030	PB				-
CNOCs	Shaanxi Yanchang			2030	PB				-
	IEA NZE	2020		2030	60%		2030	80%	E

Notes: [1] OGCI member company. OGCI members have a reduction in the average emissions intensity of production from 23 kgCO2eq/boe in 2017 to less than 17 kgCO2eq/boe by 2025, a methane intensity target of less than 0.2% by 2025 and a near zero methane ambition to 2030 on both operated and equity assets. [i] indicates carbon intensity target of all products sold. A indicates aim/ambition/aspiration (versus a target). [3] includes scope 3 emissions. [4] target achieved, Eni using a baseline of 2014. Routine Flaring metrics are assessed against the World Bank Group's Zero Routine Flaring (ZRF) by 2030 goal: E = exceeds, company targets an earlier year to achieve ZRF; M = meets, endorses ZRF by 2030; DNM = does not meet, target in place but does not fully achieve ZRF; - indicates lack of target.

Sources: IEA analysis based on company reports and interviews with Chinese NOCs.

Targets to diversify investment and portfolios

The investment profile of the oil and gas industry is rooted in traditional oil and gas activities: investment in clean energy projects comprised around 4% of total oil and gas industry spending in 2021 (IEA, 2021b).

European IOCs have taken a broad view of potential value chains outside of oil and gas investments, with interest in solar, wind and geothermal electricity generation, electricity services and marketing, bioenergy, carbon capture utilisation and storage (CCUS), low-carbon hydrogen, and CO_2 removal technologies such as "Nature Based

Solutions". For example, BP acquired Lightsource (a solar PV producer), Shell acquired Savion (a solar and energy storage developer) along with others in Europe and the US, Eni acquired Solar Konzept Greece and Dhamma Energy Group, and TotalEnergies acquired 20% of Adani Energy and has other solar and wind assets in Total Quadran. Offshore wind projects have seen the most recent increase in investment growing from an average yearly spend of less than USD 1 billion in recent years to nearly USD 3 billion in 2021 led by Equinor, BP and Eni (IEA, 2021b)

The American IOCs have generally invested lower percentages into alternative technologies than their European peers but have new strategies to expand investment in areas most closely aligned with existing company strengths including bioenergy, carbon capture and storage, and low-carbon hydrogen.

Amongst the NOCs, Saudi Aramco, ADNOC and Qatar Energy, have indicated focus on CCUS and low-carbon hydrogen and hydrogen-based fuels. Saudi Aramco's USD 110 billion Jafurah development includes a facility to produce low-carbon hydrogen from natural gas facilities equipped with CCUS, and it signed an agreement to build a hydrogen and ammonia plant from hydrogen from electrolysis (Aramco, 2021) (S&PGlobal, 2021). ADNOC has awarded a contract to construct a project producing hydrogen from natural gas with CCUS (ADNOC, 2021). Qatar Energy announced a mandate to increase its carbon capture capacity from 1 million tonnes CO_2 captured per year ($mtCO_2/y$) today to 9 $mtCO_2/y$ as part of its plans to market lower-emissions liquefied natural gas (LNG) (Reuters, 2022).

The Chinese NOCs tend to view natural gas as a low-carbon energy source[5] and they have goals for natural gas production or investment within their alternative energy or diversification plans. In terms of clean energy technologies, they have announced plans to develop solar and wind projects (including projects to reduce emissions from traditional operations), geothermal heat, CCUS and low-carbon hydrogen and hydrogen-based fuels.

CNPC plans to invest 3-6% of its total capital budget and 20% of its research and development (R&D) investment in clean energy technologies and it initiated CNPC Kunlun Capital in 2021 with the intent to invest about USD 1.5 billion in clean energy technologies (ETRI, 2022) (Petrochina, 2021). CNPC announced that "new energy" (including natural gas and clean energy technologies) will account for 7% of company revenue by 2025, one third by 2035, and 50% by 2050.

Sinopec has not set out a specific energy transition strategy but it has made some investment into clean energy technologies (EDRI, 2022). Sinopec is one of the largest geothermal heat providers in the world and it recently completed a 1 million tonnes per year (Mtpa) CCUS project, now China's largest (SWFI, 2020; Xinhua, 2022). It has

[5] Natural gas is a fossil fuel and so most countries and companies do not view it as a low-carbon energy source.

indicated that it will use cash flow from oil and gas operations to test clean energy technologies including CCUS, hydrogen produced using electrolysis and wind power.

CNOOC has set a goal to reach 5 GW of installed solar and wind renewable electricity capacity by 2030 alongside a wider move to increase the development of clean energy technologies and natural gas (CNOOC, 2022).

Shaanxi Yanchang has initiated a number of CCUS pilot projects, one demonstration project with CCUS, and aims to develop more than 1 Mtpa CO_2 capture capacity annually by 2025 (Yanchang, 2022). It also has a number of solar PV projects (with total capacity of 160 MW), and has a 20 MW wind project under construction.

Table 8 ▷ Current diversification options by selected IOCs and NOCs

	Oil and gas growth rates to 2030			Activity and investment in alternative businesses						
Company	**Oil**	**Natural gas**	**LNG**	**Solar PV and wind**	**Geothermal**	**Electricity Services**	**Bioenergy**	**CCUS**	**Low-carbon Hydrogen**	**Nature-based solutions**
BP	-	-	+	●	◐	●	●	◐	○	◐
Eni	-	+	+	●		●	●	◐	○	◐
Shell	-	+	+	●	○	●	●	●	○	◐
TotalEnergies	-	+	+	●		●	●	●	○	◐
Chevron	+	+			◐		●	●	○	
ExxonMobil	+	+					●	●	○	
ConocoPhillips	+							○		
Saudi Aramco	+			●				●	○	
ADNOC	+			●				●	○	
Qatar Energy		+	+					●		
CNPC	+	+		○	◐		○	◐	○	○
Sinopec	+	+		○	●			◐	○	
CNOOC	+	+		○				○	○	
Shaanxi Yanchang	+	+		○	○			◐	○	

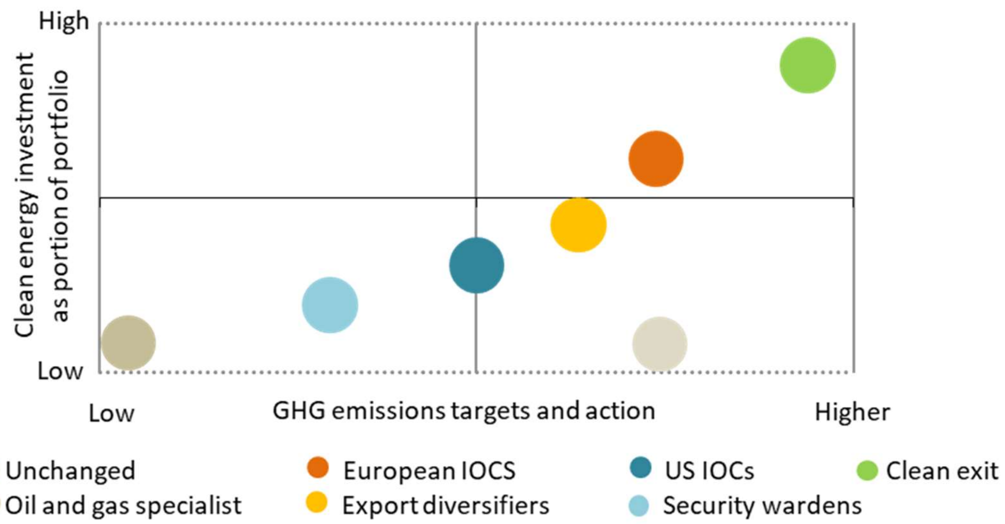
Notes: ● = growth supported by strategic investments (M&A), project final investment decisions (FID) and/or spending on commercial-scale activities; ◐ = announced strategy with minor investments, venture capital and/or R&D spending; ○ = announced strategy but with limited evidence of investment activity or no announced strategy but minimal investments. Electricity services include battery storage and EV charging. Bioenergy includes advanced biofuels and biomethane. + = strategic target to increase production, - = strategic target to decrease production. Eni and TotalEnergies strategies grow oil and gas to 2025 and then plan to decrease oil rates to 2030.

Sources: IEA analysis based on company reporting, publicly disclosed investments and interviews with Chinese NOCs.

Mapping company approaches

The energy transition strategy of oil and gas companies to date has focussed on two primary areas: transforming traditional operations by setting and implementing emission reduction targets and looking to transition away from oil and gas activities into clean energy technologies. There are potential trade-offs between these two axes, and each company will need to make its own decisions depending on their portfolios, investor pressures, strategic views and current capabilities. Companies have made variable levels of commitment and we have mapped the responses to date in the following way:

Figure 9 ▻ Mapping the responses of oil and gas companies to energy transitions to date



Unchanged: a number of export-reliant NOCs and private equity companies have yet to make any decisive changes in their operations. In the context of energy transitions, these companies will face ever increasing pressure from a reduction in oil and gas revenues and from increased costs associated with their emissions.

Oil and gas specialists: A number of NOCs and private equity companies remain committed to producing oil and natural gas but are looking to reduce scope 1 and 2 emissions, e.g. OneDyas (NL) and Neptune Energy (UK). As long as oil and gas are in demand and returns on investment are sufficient, their strategic focus will be to supply them as cleanly and efficiently as possible. Their "social licence" to operate may erode over time given the pace and nature of energy transitions.

European IOCs: The European IOCs have a relatively free remit to explore opportunities across the energy transition landscape and have been looking both to reduce emissions from their core operations and diversify their portfolios with a range of clean energy technologies. This group of companies has opted to diversify into low-carbon liquids and gases as well as solar and wind.

US IOCs: The US IOCs announced climate targets and energy transition strategies later than their European peers. Most of these companies remain committed to grow both oil and natural gas production, but strategies focus on emission reductions and they are to expand investment and activities in areas with synergies with existing company strengths. These companies have opted to stay closely aligned to their strengths in liquids and gases both in the short and medium-term strategies rather than opting to diversify into other energy sources.

Energy security wardens: Chinese NOCs and many other NOCs are choosing to focus on increasing oil and gas resources given their mandate to provide domestic oil and natural gas production while also securing energy imports. Domestic emission reduction targets mean these companies need to adapt operations to reduce emissions. Given the size and nature of many NOCs, some could look to lead the development of specific clean energy technologies with strong synergies with existing operations or that require large upfront capital financing.

Energy export diversifiers: Export-focused NOCs will be impacted by climate targets from importing countries that will reduce oil and gas revenues and impact state budgets. A number of these NOCs, such as Saudi Aramco and ADNOC, are undertaking efforts to reduce emissions from existing operations and to make greater volumes available for export. They are also looking to promote low-emission fuels that can provide a more resilient, long-term way to generate revenue from domestic resources in energy transitions.

Clean exit: Some companies are looking to divest fully from oil and natural gas. One example is Ørsted (formerly the Danish National Oil Company [DONG]) that transitioned to offshore wind built on its core strengths following strategic pressure from local policy changes. This eliminates emissions from the company itself but may not lead to wider emissions reductions if its assets continue to operate under the ownership of different company (indeed overall emissions could increase if the acquiring company is less focussed on limiting scope 1 and 2 emissions).

Assessing the strategic options

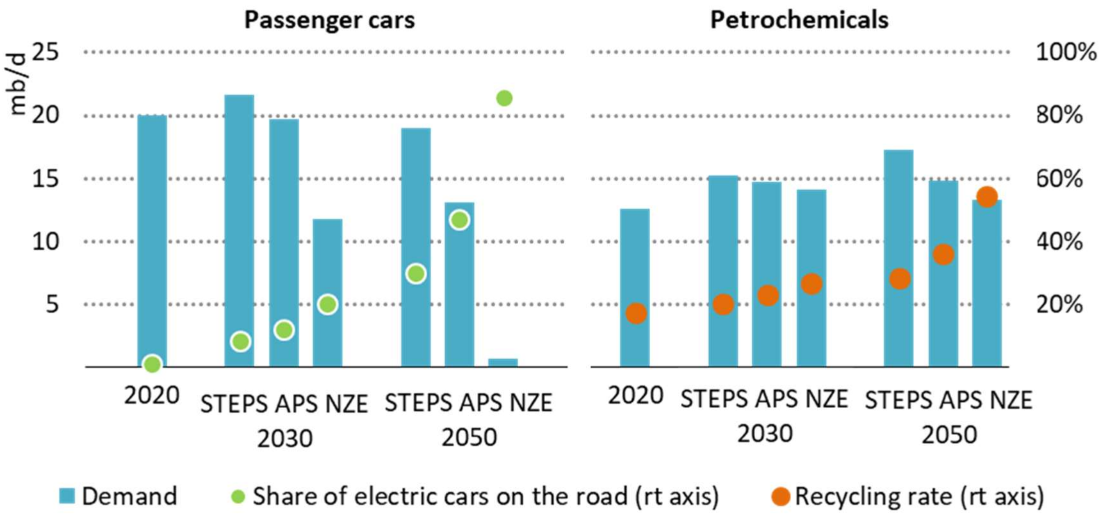
There is no single response or long-term business model that will be suitable for the wide range of companies active in the oil and gas sectors. Owners of the companies will decide which strategies to follow, based on their portfolio, capabilities, responsibilities and competencies against their vision of the future and to seek out areas of competitive advantage. In each case, the merits and risks attached to company strategies will be the subject of close scrutiny, as will the returns on proposed investments and the value proposition for shareholders and society. In choosing their approach, some of the key issues to be addressed include:

Views on future oil and gas production levels: the large differences between the outlook for oil and gas in the STEPS and NZE is mirrored by differences in the outlook of companies for oil and gas supply growth. For example, BP and Shell, have indicated aggregate oil and gas production will decline to 2030 while many of the other IOCs seek to grow production of oil and gas in the future. Chinese NOCs, for their part, must supply energy to fuel China's growth and limit increases in oil and gas imports as oil demand plateaus around 16 mb/d in the early 2030s and gas demand grows by more than 60% in the STEPS before plateauing in the mid-2040s. Most IOCs and NOCs view that natural gas will comprise a growing share of their traditional oil and gas project portfolios given an expectation that natural gas demand will be more resilient to future climate ambition.

Balancing energy security with domestic climate targets: the activities of NOCs are typically set by their host states, and there is no guarantee that these companies will be charged with the development of other clean energy sources. In China, the 13th and 14th Five-Year Plans look to support national energy security by strengthening domestic oil and gas exploration and development alongside an update to integrate corporate social responsibility. The 14th Five-Year Plan aims to diversify oil and gas import sources and also to develop CCUS and recycling projects. A number of state-owned entities and private companies already have a foothold in many renewable energy sources. These companies could be best placed to allocate capital to these new activities, with the Chinese NOCs focussing on traditional oil and gas activities to contribute to energy security efforts rather than risking money on unfamiliar business areas. However, it is also the case that some of these clean energy projects are a close match to the existing skills and resources of the Chinese NOCs and, without their input, investment and project development may not proceed at the required pace.

Oil product supply and demand: the rapid rise in electric vehicles in the NZE means that gasoline and diesel demand falls even faster than the drop in aggregate oil demand. In contrast, demand for ethane, LPG and naphtha (mainly used as petrochemical feedstocks) are much more resilient. Energy transitions therefore pose major questions for refiners who would need to increase the yield of lighter products and reduce the output of traditional refined products. In addition, plastic recycling rates are set grow to grow rapidly (in the NZE they increase to more than 50% globally). Globally, about 15% of plastic is recycled today. China has been increasing its focus on recycling and has a growing refinery capacity and so it is well placed to develop the recycling technologies needed globally while working to limit its own level of oil import (IEA, 2021c).

Figure 10 ▷ Changes in key oil demand sectors in the STEPS and APS to 2050.



Whether to be an innovation leader? The oil and gas industry has historically been a major innovator; for example by developing ways to extract oil and gas from deepwater reservoirs and from tight and shale rocks. The IOCs have been undertaking less in-house innovation in recent years and aggregate levels of R&D spending have fallen over the last decade. Nonetheless, both IOCs and NOCs could be involved in a wide range of clean energy technology innovation that is needed to achieve net zero emissions, and they could enjoy a major commercial advantage in a number of areas.

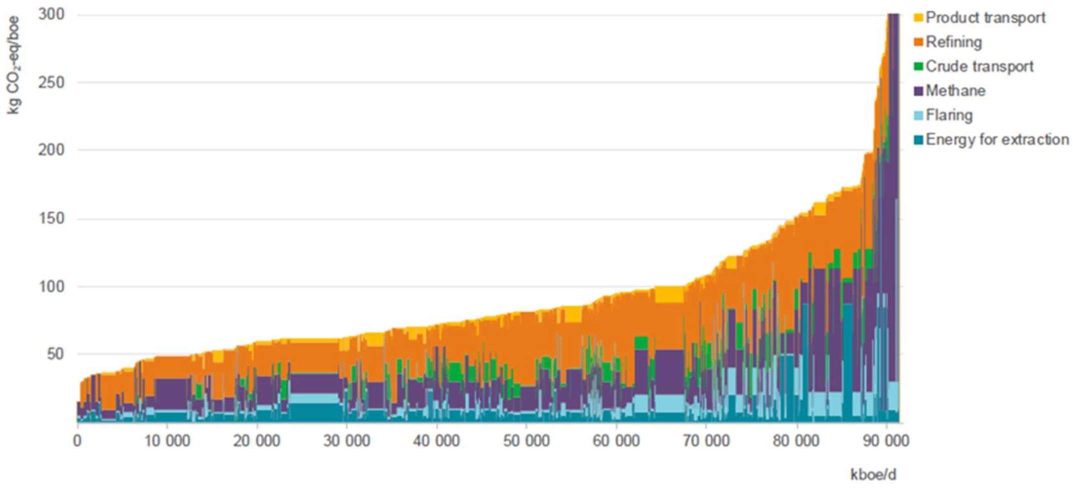
Current and future employment needs: the oil and gas industry is a major employer: CNPC alone directly employs more than 1.2 million people. Energy transitions will be accompanied by marked shifts in energy sector employment and there will be a need to retain, upskill, reskill and evolve a very large number of people. A number of companies are also facing challenges with hiring and retaining employees given perceptions of an industry in decline (as evidenced by falls in petroleum engineering programs) and competition for workers with data and clean technology companies. Company cultures may also need to adjust to make it more receptive to new business models, technologies and approaches.

Alongside these questions, there are more technical issues on the options to lower emissions from existing operations and the alternative clean energy technology options that could be best suited to the existing skills and capabilities of oil and gas companies. These are examined in more detail below.

A closer look at reducing emissions from existing operations

Oil and gas operations are responsible for around 15% of global energy sector GHG emissions today (IEA, 2020).

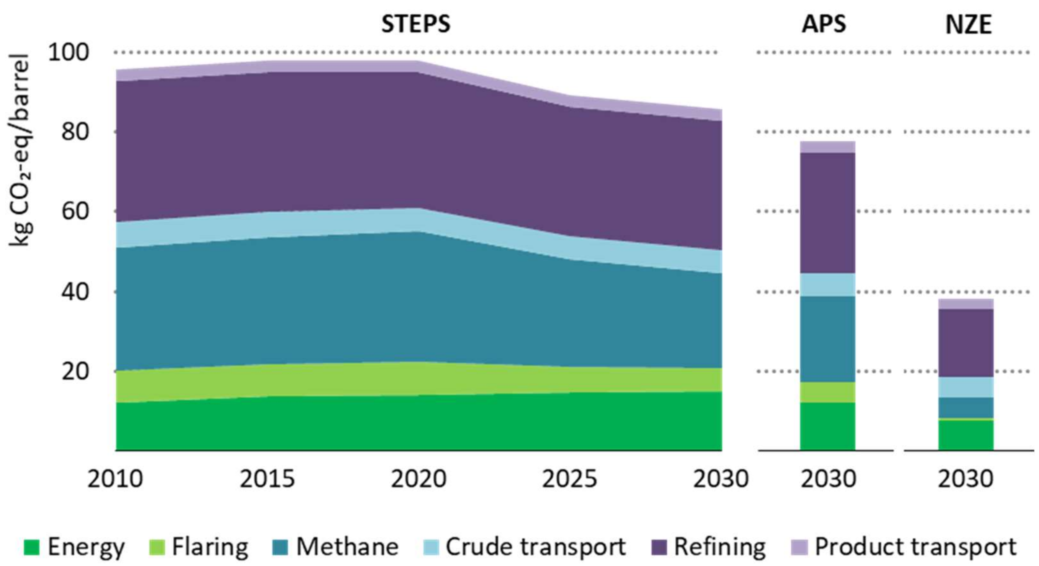
Figure 11 ▷ **Scope 1 and 2 emissions intensity of global crude oil, condensate and NGLs production, 2021**



There is a very broad range in the indirect emissions intensity of different sources of oil and gas: supplying the most-emitting sources of oil and gas results in more than four-times the indirect emissions than the least-emitting sources. The global average emissions intensity of oil production falls by just over 65% between 2020 and 2030 in the NZE to less than 40 kg CO_2-eq/barrel in 2030. Forward leaning operators cut emissions to much lower than this global average level.

The key levers to reduce emissions from oil and gas operations are similar across similar sectors, regardless of location. They include: concentrated efforts to reduce and prevent methane leaks, eliminating all non-emergency flaring, integrating renewables into operations, and improving the energy efficiency of operations.

Figure 12 ▷ **Global average emissions intensity of oil production**



Reducing and preventing methane leaks is the single largest focus area for the oil and gas industry to reduce emissions. The IEA estimates that 75% of methane emissions are technically feasible to eliminate this with about 45% achievable at break-even costs using average natural gas prices from 2017-2021. In 2021, venting accounted for more than two-thirds of methane leaks from China's oil and gas sector. Pan-industry knowledge sharing to support best practices for eliminating methane leaks can act to help the industry move more quickly to reduce emissions. In 2021, a number of Chinese oil companies formed the China Oil and Gas Methane Alliance with the goal of sharing best practices (CNPC, 2021). In China, where natural gas is viewed as a 'low carbon fuel', it is important to note that poor greenhouse gas emissions operations can result in lifetime cycle emissions higher for natural gas than some coal sources (IEA, 2019).

In the NZE, all non-emergency flaring is eliminated globally by 2030, resulting in a 90% reduction in flared volumes by 2030 (IEA, 2021d). China flared nearly 3 bcm of natural gas in 2020 ranking it as the 9th largest flaring country. Given China's growing reliance on natural gas, this is a major waste of a precious resource.

By switching to low-carbon energy sources to run operations either through direct efforts or by purchasing clean power from third parties, operators can eliminate the use of fuels and their emissions to power operations. CNPC, for example, recently committed to develop a solar-powered oil field in Yumen along with its purchase of 1.85 GW of solar PV panels. CNOOC has utilised its experience in offshore installations to transition an offshore platform into an offshore wind turbine in its efforts to examine how to decarbonise nearby oil and gas platform operations (Reuters, 2020).

Energy efficiency improvements can play a leading roles in reducing emissions from both upstream and downstream operations, while digitalisation offers potential to identify new areas of opportunity to reduce energy usage. All Chinese NOCs are exploring and deploying energy efficiency improvements. For example, CNOOC and Sinopec are looking to increase efficiency by utilising waste heat, electrifying operations, eliminating obsolete, low efficiency plants, and improving recycling at refineries.

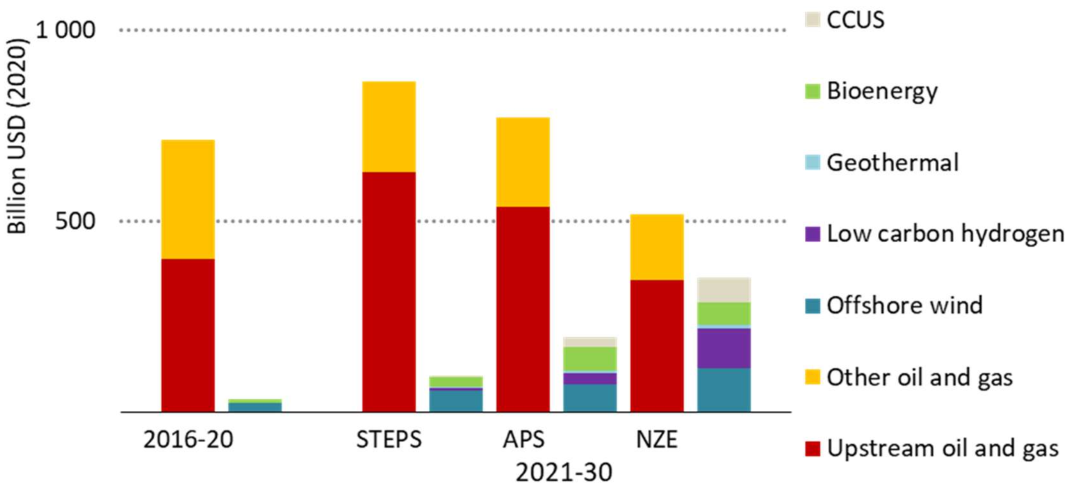
A closer look at investment in clean energy technologies

Some oil and gas companies intend to reposition themselves as "integrated energy companies" by diversifying their operations towards clean energy technologies.[6] For example, some IOCs and NOCs are developing roles as an electricity generator and a provider of electricity into homes and industry.

[6] This includes both integrating the new technologies into their portfolios or developing clean energy expertise and spinning them off as separate companies.

It is not axiomatic that all companies will, or even should, look to do this. Yet there are a number of technologies and fuels that could be a particularly good match with their existing skill sets of companies, including their experience with managing multibillion-dollar projects and in handling liquids and gases. Options include offshore wind, low-carbon hydrogen and hydrogen-based fuels, bioenergy, CCUS, geothermal. Investment in these technologies are nearly USD 190 billion on average each year to 2030 in the APS and more than USD 310 billion in the NZE. There are other areas that could make use of the industry's existing transport retail market customers, such as battery and electric vehicle charging; these technologies also grow rapidly in the NZE.

Figure 13 ▹ Capital investment in clean energy technologies that are a good match to the existing skills of oil and gas companies



Note: CCUS includes carbon capture use and storage for power generation, industry and hydrogen production.

Offshore wind includes both fixed and floating turbines and the environmental assessments, construction, installation, maintenance and related logistics of their development can be well-suited to the offshore oil and gas industry. Annual offshore wind sector investment was just under USD 25 billion between 2016 and 2020 with the oil and gas industry responsible for about 5% of total (WEI 2021). Annual investment grows to more than USD 115 billion on average in the 2020s in the NZE. CNOOC has developed a number offshore wind projects to reduce emissions from operations and provide electricity to the grid in China.

Carbon capture, use and storage (CCUS) can reduce emissions from power, heavy industry, hydrogen production, as well as remove CO_2 from the atmosphere (via direct air capture with CO_2 storage or bioenergy with carbon capture and storage [BECCS]). CCUS investment stagnated in the 2010s, but annual investment grows to nearly USD 65 billion in the APS in 2030. This is a promising area for oil and gas companies that can leverage the subsurface data and knowledge as well as the workforce to drill and operate injection wells for long-term use and repurpose existing infrastructure. IOCs aim to finance a number of CCUS projects to reduce emissions from industrial hubs (e.g. HyNet in the UK and Northern Lights in the North Sea). All Chinese NOCs have projects either in operation (Sinopec, CNPC, Shaangxi Yanchang) or recently announced (CNOOC Ltd). Sinopec has the most operational experience having operated a 0.6 Mtpa injection site for enhanced oil recovery since 2018 and started its Qilu 1 Mtpa capture project.

Low-carbon hydrogen can be produced from natural gas with CCUS or produced via electrolysis powered by low-emissions electricity; it can be used in industrial processes (e.g. in a refinery), directly as a fuel (e.g. in fuel cell vehicles), converted to low-carbon hydrogen based-fuels (e.g. ammonia), or used as an energy carrier. The oil and gas industry is expressing interest in low-carbon hydrogen given the potential to use natural gas, and the need to process and transport liquids and gases sometimes over long distances. Annual investment in low-carbon hydrogen and hydrogen-based fuels grows from relatively low levels in recent years to more than USD 100 billion in the NZE on average in the 2020s. There are a number of projects underway that involved oil and gas companies, including a USD 470 million demonstration project that is being developed by Sinopec (Reuters, 2021).

Bioenergy can provide solid, liquid and gaseous fuels that could be of particular importance to reduce emissions from long-distance transport and heavy industry. Annual investment in all forms of bioenergy grows across from USD 9 billion in recent years to over USD 60 billion in the NZE on average in the 2020s. Eni performed the first bio-refinery conversion in 2014 and it aims to increase production to about 35 kboe/d by 2024; TotalEnergies spent USD 230 million on a bio-refinery conversion between 2015 and 2019; and Shell has announced a decision to convert part of a refinery into a 13 kboe/d biofuels plant.

Geothermal energy encompasses a range of technologies that either produce power from hot subsurface fluids or utilise the subsurface to generate or store heat. This requires extensive subsurface knowledge and drilling expertise that is similar to skills used in upstream oil and gas operations. Annual investment in geothermal grows from just over USD 2 billion in recent years to over USD 10 billion in the NZE on average in the 2020s. Sinopec is a major provider of geothermal heat, and Chevron and BP led a USD 40 million funding round in a technology company trialling geothermal power generation from geologically common reservoirs.

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