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Future of Unconventionals in a Low-Carbon World

Energy Research Paper

The Al-Attiyah Foundation

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Over the past 20 years, unconventional resources have become a significant part of the global energy mix, accounting for one-third of the world's total oil & gas supplies. However, to achieve net-zero goals by 2050-2070 and the Paris Agreement's target of keeping global temperature increases below 1.5°C, a significant transition is required in the next 30 years. This transition will entail a global shift in energy supplies from all forms of fossil fuels to cleaner and low-carbon alternatives.

What are the challenges of phasing-out unconventionals? Which unconventional resource might be the first to become uneconomic in a declining demand scenario? What is the climate equity of unconventionals, and is there a clear argument for their accelerated phase-out?

ENERGY RESEARCH PAPER

This research paper is part of a 12-month series published by the Al-Attiyah Foundation every year. Each in-depth research paper focuses on a current energy topic that is of interest to the Foundation's members and partners. The 12 technical papers are distributed to members, partners, and universities, as well as made available on the Foundation's website.

- The pathway to a 2050 (or 2070) net-zero scenario will have important implications for all unconventional oil & gas producers and poses the challenge of how and where to cut down their supplies. Resources with the highest costs are likely to be the first to be phased-out by market forces. However, policymakers and producers must consider other factors, such as environmental risk, emissions intensity, and energy security implications, to ensure an efficient, sustainable, and safer transition to a net-zero energy mix.
- In a declining demand scenario, ultra-deepwater and shale may still be economically viable in the long-term, as they have low break-even costs. However, extra-heavy oil and oil sands are expensive and high- carbon and are likely to be phased-out first. The costs of Arctic oil & gas production vary depending on the location. Norwegian oil and Russian Arctic gas supplies are relatively inexpensive and may remain viable for a longer period compared to US and Russian Arctic oil supplies that could be phased out earlier.
- The emissions intensity of extra-heavy oil and oil sands is much higher than the average conventional and unconventional oil resource, even with all the mitigation measures in place. These projects emit 3x - 4x more than the least emitting oil field and ~30% more than the average oil & gas field[i]. Although Arctic oil & gas, ultra-deepwater, and shale do not have the same emissions intensities as extra-heavy oil and oil sands, they still carry a significant environmental risk compared to conventional projects.
- Some types of unconventional oil & gas developments carry a higher environmental risk than conventional developments. Others may be comparable to conventional, development particularly when compared to mature, energy-intensive conventional fields.
- A 2050-2070 net-zero goal can be reached without relying on existing extra-heavy oil, oil sands, and Arctic oil resources. Supplies can be gradually phased-out without materially impacting the global oil supply-demand balance.
- Phasing-out ultra-deepwater gas supplies will have a minimal impact on the global gas supply-demand balance. However, shale and Arctic gas supplies from developed or under-development reserves will still be needed for the global energy transition unless they are replaced by new conventional gas supplies.

The pathway to a 2050 net-zero target requires a universal and profound shift away from fossil fuels and accelerated investment in renewables and low-carbon energy sources. Although a range of pathways exists, almost all transition scenarios project a steep decline in fossil fuels demand by 2030 (and / or 2050), with a substantial degree of consensus on their phase-down.

The pathway to a 2050 (or 2070) net-zero scenario will have important implications for all unconventional oil & gas producers and poses the challenge of how and where to cut down their supplies. Resources with the highest costs are likely to be the first to be phased-out by market forces. However, policymakers and producers must consider other factors, such as environmental risk, emissions intensity, and energy security implications, to ensure an efficient, sustainable, and safer transition to a net-zero energy mix.

Unconventional Resources

- Shale gas: hydrocarbons trapped within shale rock formations. Shale is a fine-grained sedimentary rock that is rich in organic matter, and when heated and pressurised over time, the organic matter can transform into gas. In order to extract the gas from shale rocks, hydraulic fracturing (or fracking) is used, which involves injecting a mixture of water, sand, and chemicals into the shale rock at high pressure, causing it to fracture and release the trapped gas.
- Similar to shale gas, tight oil (including shale oil) is found in impermeable shales or carbonate rocks and is extracted similarly to shale gas through hydraulic fracturing.
- Oil sands (also known as tar sands or natural bitumen) are a combination of 80% sand, 10% bitumen, 5% water, and 5% clay. Bitumen is a semisolid, tar-like mixture of hydrocarbons. It can be extracted by mining (for shallow deposits) or by steam or solvent extraction (for deeper deposits).
- Extra-heavy oil has an API gravity below 15°C, and may require steam injection or other thermal methods to flow from the reservoir.
- Ultra-deepwater refers to oil & gas reserves located in water depths greater than 1,500 metres.
- Arctic oil & gas reserves are found in Arctic-like conditions, characterised by ice, permafrost, and extreme temperatures. A vast majority (~84%) of Arctic oil & gas reserves are located offshore.
- Both ultra-deepwater and Arctic oil & gas can be categorised as unconventionals because of the complications associated with operating in the extreme weather and offshore conditions.

Figure 1: Demand for Oil (Energy Transition Scenarios)

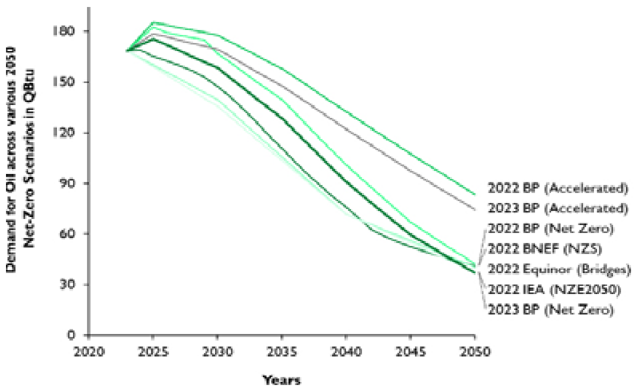
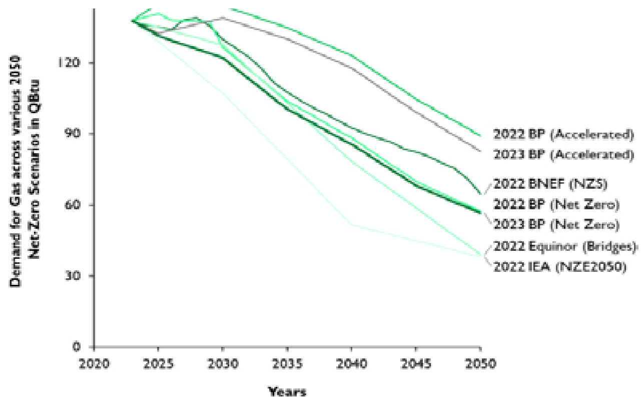


Figure 2: Demand for Gas (Energy Transition Scenarios)



Over the past two decades, technological advancements and cost reductions allowed unconventionals to become essential to the global fossil fuels supply mix. Despite their perceived environmental risks, unconventionals form a significant portion of the global oil & gas supply most notably from North America. Unconventional resources have helped diversify supplies, improved regional energy security, shortened capital recovery cycles for projects, and provided greater production flexibility.

The perceived environmental risk associated with unconventionals stems from their reputation as lower-quality supplies than conventional sources and the technical challenges involved in their development.

Unconventional resources are often located in hard-to-reach areas or have technical constraints, making their extraction difficult.

Extracting unconventionals such as shale, oil sands, and extra-heavy oil require enhanced extraction techniques such as strip mining, steam injection or hydraulic fracturing to allow the hydrocarbons to move or to create sufficient rock permeability, compared to ultra-deepwater and Arctic resources that can be extracted through conventional extraction processes, albeit coupled with advanced drilling technologies and complex surface facilities and logistics, given their challenging operating environments.

Although unconventionals carry a higher environmental risk compared to conventional developments, they do not necessarily generate the same carbon footprint. The average lifecycle emissions from many kinds of unconventional oil production are much greater than conventional oil, although some studies suggest they can be comparable. For instance, oil sands have 17% higher emissions than refined US crude on average, while shale oil has 21% - 47% higher emissions than conventional oil[ii].

However, lifecycle emissions from unconventional gas ranges between 6% lower to 43% higher than conventional gas production[iii]. Enhanced oil recovery (EOR) using carbon dioxide could have a lower net carbon footprint than conventional oil. Similarly, highly mature conventional fields with many wells and high energy use for water injection and treatment of produced water would also have higher than average carbon footprints.

Within the unconventionals resource class, heavy and extra-heavy oil, as well as oil sands, are the most carbon-intensive and carry a greater environmental risk when compared to conventional resources. Ultra-deepwater and shale, on the other hand, generally have lower carbon footprints than conventional resources but still pose significant environmental hazards. Whereas Arctic unconventional resources have a lower carbon intensity than conventional resources, they pose a substantially greater environmental risk with intrusion on the sensitive local ecosystems, and the risk of oil spills which are slow to degrade and hard to clean up in the cold and often dark conditions.

The conflict in Ukraine has reminded policymakers of the vital lesson of avoiding dependence on a solitary source of imported energy and re-emphasised the importance of prioritising domestic resources. While certain unconventional oil resources can be phased-out with negligible effects on global or regional security of supply, the same cannot be said for some unconventional gas reserves, which are necessary to advance the energy transition unless new conventional gas supplies could replace them.

Regardless of how unconventional resources are phased-out towards a 2050 net-zero scenario, there remains a substantial opportunity for upstream players to decrease emissions by investing in abatement technologies related to methane venting, flaring, and leakage across all unconventional sources.

In a declining demand scenario, ultra-deepwater and shale may still be economically viable in the long-term, as they have low break-even costs. However, extra-heavy oil and oil sands are expensive, high-carbon and are likely to be phased-out first. The costs of Arctic oil & gas production vary depending on the location. Norwegian oil and Russian gas Arctic supplies are relatively inexpensive and may remain viable for longer periods compared to US and Russian Arctic oil supplies that could be phased out earlier.

Figure 3: Break-even Prices for Existing Unconventional Oil Projects

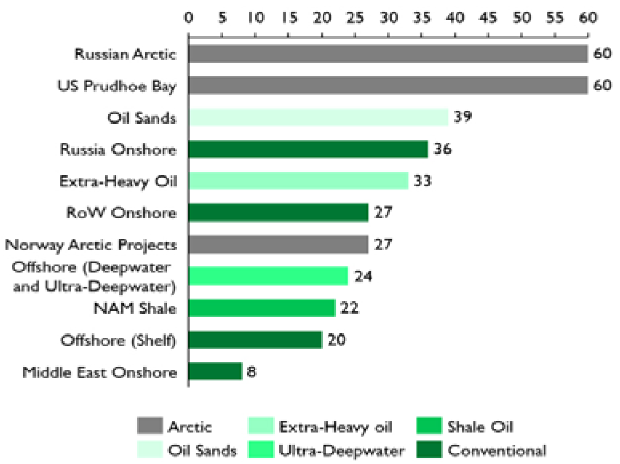
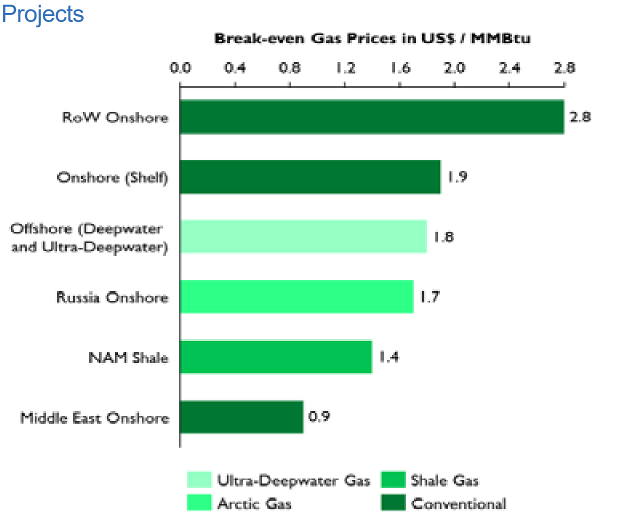


Figure 4: Break-even Prices for Existing Unconventional Gas Projects



Existing shale and deepwater oil projects are currently the most cost-competitive compared to conventional projects, with demonstrated consistent cost reductions over the last decade. The average break-even price for these projects ranges between US$ 22 / bbl – US$ 24 / bbl (see figure 3). It is also likely that a significant proportion of these resources will remain economically viable by 2030 and 2050, with the projected 2050 net-zero scenario price of US$ 35 / bbl in 2030 and US$ 24 / bbl in 2050[iv]. Therefore, based purely on these prices, shale and deepwater oil projects could continue to play a vital role throughout the energy transition.

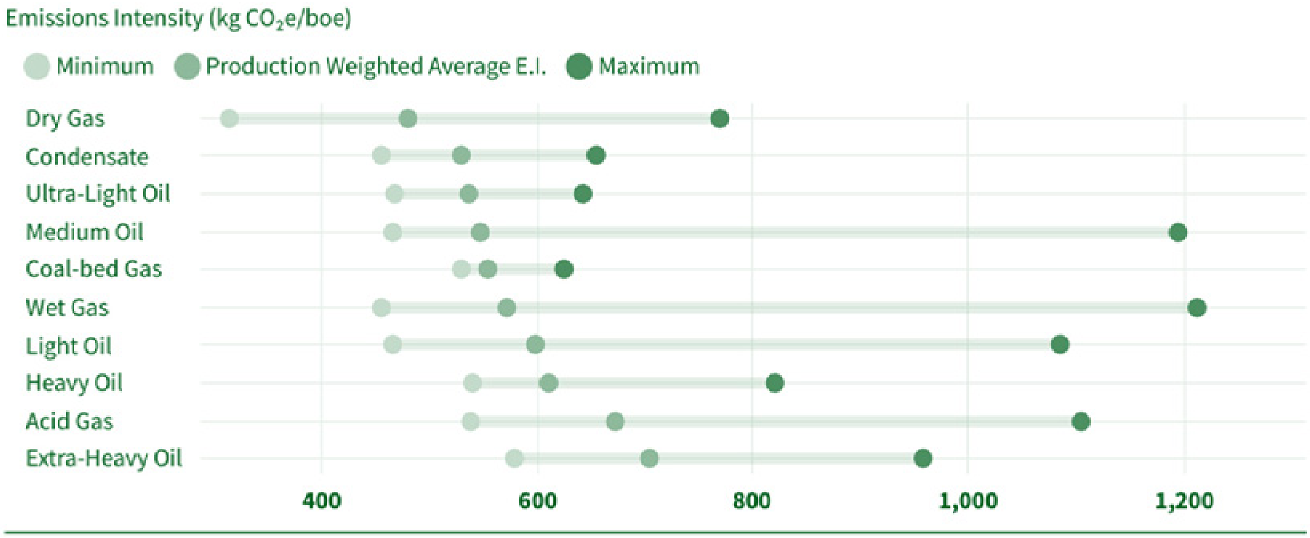
The average break-even prices for shale and deepwater gas projects currently range between US$ 1.4 – US$ 1.8 / MMBtu (see figure 4), which is also in line with or below the projected 2050 net-zero scenario price of US$ 1.8/ MMBtu for US supplies and US$ 3.8 / MMBtu for European supplies in 2050[v]. Remote gas supplies, however, would need liquefaction and shipping, which would probably result in delivered costs above the European estimated figure.

In contrast to shale and deepwater oil, existing oil sands and extra-heavy oil projects are typically more costly, with an average break-even range of US$ 33 – US$ 39 / bbl (see figure 3). However, they remain comparably cost-competitive with many conventional Russian projects, with an average break-even of US$ 36 / bbl[vi]. But, given their higher average break-even, it is probable that both oil sands and extra-heavy oil will be the first to be phased-out in the energy transition.

The challenging operational conditions in the Arctic have traditionally made production more expensive than other unconventional projects. Globally, most of the Arctic oil production is in Russia, accounting for ~20% of its overall oil production[vii], albeit with the highest global break-even between US$ 50 / bbl – US$ 70 / bbl[viii]. Arctic oil projects in North America, such as Prudhoe Bay in Alaska, have an average break-even of US$ 60 / bbl[ix]. Equinor has asserted that following sizeable efficiency investments and tax incentives, the break-even of their Arctic projects ranges between US$ 27 – US$ 35 / bbl[x].

While Arctic oil might be relatively expensive to extract, Arctic gas is much more competitive. Like Arctic oil, Russia also dominates in Arctic gas production, making up ~80% of its total gas production[xi], with an average break-even of US$ 1.7 / MMBtu[xii].

Figure 5: Range of Lifecycle Emission Intensities for Unconventionals



The emissions intensity of extra-heavy oil and oil sands is much higher than the average conventional and unconventional oil resource, even with all the mitigation measures in place. These projects emit 3x - 4x more than the least emitting oil field and ~30% more than the average oil & gas field[xiii]. Although Arctic oil & gas, ultra-deepwater, and shale do not have the same emissions intensities as extra-heavy oil and oil sands, they still carry a significant environmental risk compared to conventional projects.

No other conventional resource has a higher climate impact than heavy, extra-heavy, and oil sands. According to an analysis conducted by IHS Markit in 2022, Canadian oil sands' average greenhouse gas (GHG) intensity declined to 69 $kgCO_2$-eq / bbl in 2020[xiv]. Since 2009, the GHG intensity of oil sands production has declined by 20% (or 17 $kgCO_2$-eq / bbl) with an average decline of ~1.5 $kgCO_2$-eq / bbl / year[xv].

However, Canadian oil sands projects have experienced significant variations in their GHG intensity ranging between 41 $kgCO_2$-eq / bbl to 175 $kgCO_2$-eq / bbl, mainly due to some operations ramping down, leading to temporary spikes in GHG intensity for some production[xvi]. Nevertheless, the impact on the overall average was muted due to its relatively limited occurrence.

Canada's planned carbon price for 2030 is expected to increase to CAD $170 / tCO_2-eq, from current levels of CAD $50 / tCO_2-eq[xvii]. The impact of the increase in carbon price on Canadian oil sands and extra heavy oil production will be significant. At current exchange rates, the range of emissions would translate into costs of $1.52-6.48/bbl at today's carbon price and $5.16-22.02/bbl at the 2030 price. Oil sands operating costs in 2023 are from US$9.25-10.36/bbl for Cenovus[xviii], and US$23.29/bbl for CNRL[xix], to take examples from two major operators, indicating that the carbon price might result in a 50-100% increase in operating costs by 2030.

Nevertheless, overall operating costs would still be well below anticipated crude prices, so operations would continue, although investment in new production would be discouraged. The increase in carbon price may also incentivise the industry to adopt cleaner technologies, such as carbon capture, cogeneration, solvent extraction and electrical heating, and reduce emissions, reducing carbon costs and allowing operations to continue.

In addition, other emissions mitigation solutions such as solar steam installation, CCUS, and using green hydrogen in refining can also aid in reducing emissions intensity. The Miraah project in Oman uses a solar thermal array with capacity of 1021 MW (thermal) to generate steam for heavy oil recovery at the Amal Field[xx]. Solar steam installation helps reduce the use of fossil fuels, while CCUS provides a sustainable way of capturing and utilising CO_2 emissions. Unconventional producers can also prevent petcoke combustion during the refining process through the use of advanced technologies such as gasification or fluidised-bed combustion, which can help mitigate emissions.

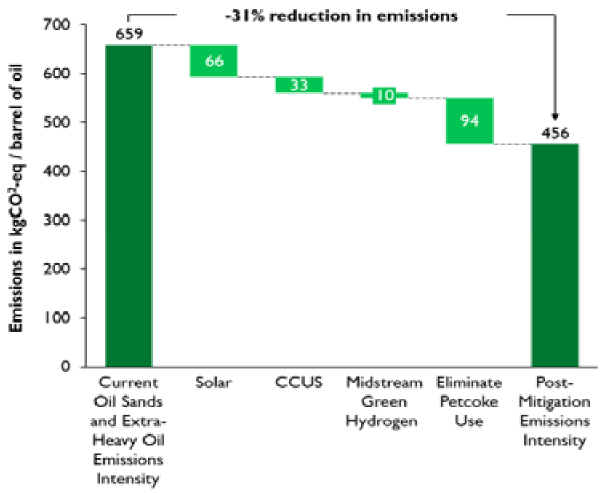
The Canadian government has also introduced a number of policies, such as the Technology Innovation and Emissions Reduction (TIER) Programme, to support the domestic oil industry's transition to cleaner technologies and reduce emissions.

Various emissions mitigation solutions are available for heavy, extra-heavy, and oil sands, but implementing them is challenging. These resources require more heat, steam, and hydrogen for extraction, transportation, and conversion to refined products. Their refining process also results in more petcoke. Still, solutions such as solar steam installation and carbon capture, utilisation, and storage (CCUS), using green hydrogen in refining, and preventing petcoke combustion could be explored to reduce their emissions intensity.

However, implementing these solutions could be difficult and costly, especially as they rely on emerging technologies. For example, solar steam installations can incur high capital expenditure costs, but savings from reduced gas usage can provide long-term payback. CCUS technologies have been used successfully across some oil & gas fields but increase production costs.

Nonetheless, among all unconventional resource types globally, heavy, and extra-heavy oil, and oil sands are most likely to become uncompetitive through a carbon pricing mechanism.

Figure 6: GHG Emissions Mitigation Strategies for Heavy and Extra-Heavy Oil and Oil Sands



Canadian oil specialist companies have also been buying oil sand projects in Canada from ICOs in recent years. This is attributed to a number of factors, including the relatively low oil prices at times, IOCs' targets for emissions reductions, and the ongoing efforts to reduce carbon emissions and diversify the Canadian economy.

One example of such a company is Suncor Energy, which has been a major player in the Canadian oil sands industry for many years.

Suncor has a number of oil sands projects in Alberta, including the Fort Hills and Syncrude facilities. Earlier this year, TotalEnergies accepted an offer from Suncor Energy to buy the entirety of the former's oil sands assets in Canada[xxi].

Other Canadian oil specialist companies, such as Canadian Natural Resources Limited (CNRL) and Cenovus Energy, have also been active in acquiring oil sands projects. CNRL, for instance, acquired the Joslyn Oil Sands Project from TotalEnergies in 2018[xxii], and most of the Athabasca Oil Sands Project from Shell in 2017[xxiii].

Moreover, conventional and unconventional developments come with environmental risks from routine and unplanned interruptions, which augments their phase-down. However, unconventional oil & gas developments are known to carry a higher environmental risk than conventional developments.

Heavy and extra-heavy oil and oil sands carry the most significant environmental risk among unconventional energy sources. These resources have dense and viscous compositions, making it challenging to flow from production wells under typical reservoir conditions. Consequently, energy-intensive extraction methods like strip mining and water, steam, or chemical solvents are used to extract them. End-products of heavy and extra-heavy oil and oil sands also contain higher impurities such as sulphur and heavy metals, and require deep conversion refineries to break down their fuel oil and bitumen yield into preferable light products, further worsening their environmental profile.

Upstream activities in the Arctic face technical difficulties due to low temperatures, strong winds, varying ice formations, and seasonal darkness, which increase the risk of planned events. The Arctic ecosystem is fragile, with even routine disruption leading to severe consequences such as waste and water discharge and disturbances to biodiversity.

The Arctic's remote location, lack of infrastructure, and in-hospitable conditions pose significant challenges for responding to accidents and complicate oil spill cleaning operations.

Deepwater operations primarily pose environmental threats through unpredictable events such as oil spills. Offshore operations have the potential to result in accidental releases of oil into the ocean, with the likelihood and severity of a spill increasing with the depth of the operation[xxiv]. For instance, between 1971 and 2010, there were 23 large offshore spills, totalling more than 1,000 barrels of oil equivalent on average every 21 months across the US Continental Shelf[xxv]. Deepwater oil spills have more long-lasting environmental consequences than those onshore or in shallow water as the cycles of cold deepwater ecosystems move slower.

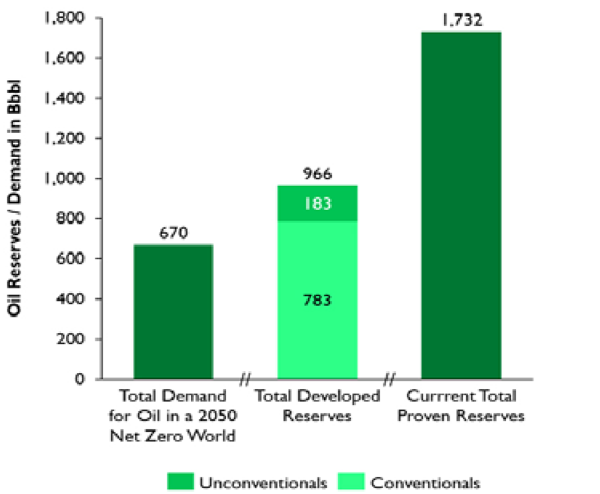
Shale oil & gas is found in low permeability rock formations, extracted through hydraulic fracturing, injecting large volumes of water, solvents, and sand into the tight rock formations to create small cracks releasing the trapped oil & gas. Hence, shale production results in a large environmental footprint compared to conventional developments, with marked implications for habitat degradation, such as soil erosion and biodiversity loss.

Since shale deposits are difficult to access (because they are more sparsely distributed over a large area and individual wells are less productive), these developments require more wells than conventional oil fields and, subsequently, greater land area. The decline rates in production are also typically higher for shale developments, necessitating additional wells to sustain output.

A 2050 net-zero target can be reached without relying on existing extra-heavy oil, oil sands, and Arctic oil resources. Supplies can be gradually phased-out without materially impacting the global oil supply-demand balance.

Currently, developed global oil reserves are 39% more than the projected demand of 670 Bbbl between 2023-2050 in a 2050 net-zero scenario[xxvi]. Unconventional oil reserves constitute 19% of the total proven oil reserves, which could be phased-out, still leaving a surplus of 113 Bbbl[xxvii]. Current total proved reserves, including undeveloped, are nearly three times the 2023-2050 "budget".

Figure 7: Oil Reserves vs Demand for Oil in a 2050 Net Zero World



A large part of these are unconventional, particularly Canadian oil sands and Venezuelan extra-heavy oil.

The extent to which current conventional oil reserves can meet total global oil demand in a 2050 net-zero scenario hinges on their extraction rate. In 2022, unconventional oil production accounted for 27% of global oil supplies.

An accelerated phase-out of unconventional oil supplies over the coming years could create a global supply-demand gap before new conventional oil supplies can sufficiently replace them. To avoid such a scenario, additional investments will be required in current conventional fields that might be exposed to stranded asset risks in the long-term.

However, an accelerated phase-out of unconventional oil supplies may still be feasible without causing a significant shortfall in the global supply-demand balance. In a 2050 net-zero scenario, oil demand is projected to decline by 20 Mbbl / d by 2030, and supply from existing fields is estimated to decrease by 18 Mbbl / d. The 2 Mbbl / d supply-demand gap could be filled by the ramping-up of underdeveloped conventional projects and some expansion of existing shale and tight oil, providing an estimated 6 Mbbl / d of supply. This would result in a surplus of 9 Mbbl / d by 2030.

Figure 8: Annual Production by Oil Type, 2022

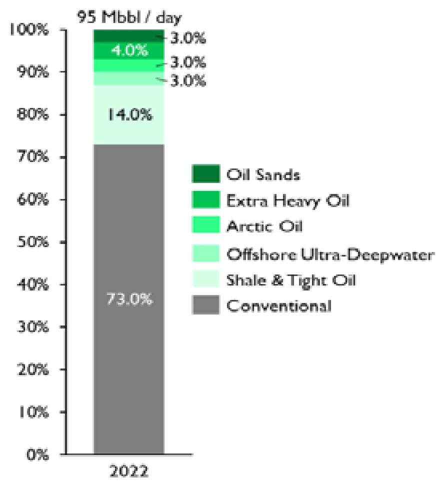
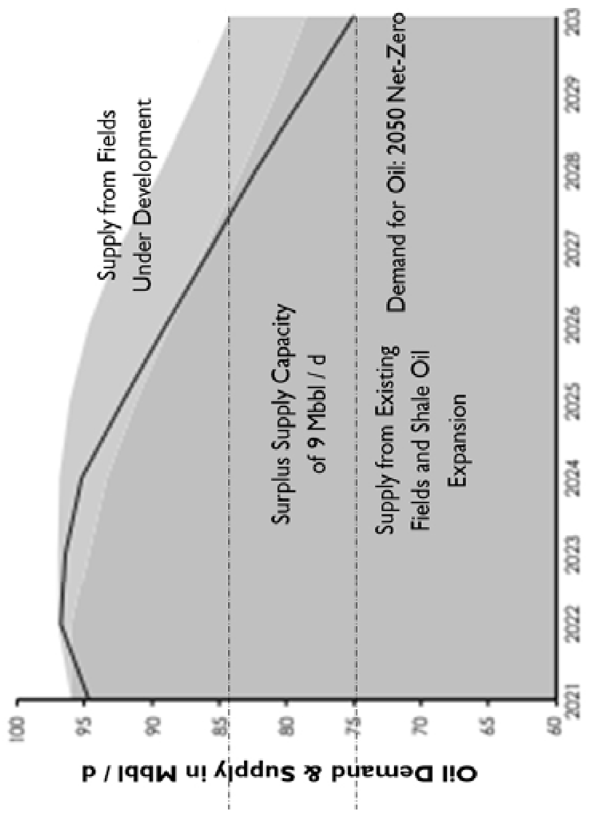


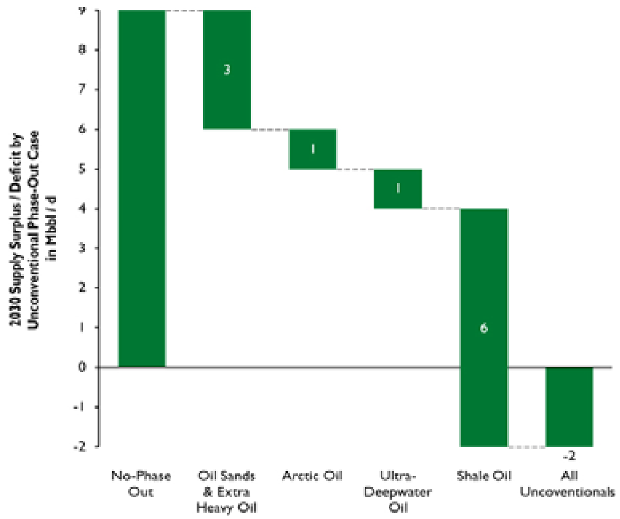
Figure 9: Project Oil Demand vs Supply by 2030



In such a scenario, some shale oil can be phased-out without the need for any compensating action. However, a complete phase-out of shale oil would result in a net 2 Mbbl / d supply-demand gap, which would have to be offset through increased conventional supplies. Given the co-location of shale oil & gas resources, phasing-out shale oil supplies (whilst still keeping shale gas supplies) could still provide ~4 Mbbl / d of shale oil as a by-product, which would be enough to maintain the global oil supply-demand balance in 2030.

Phasing out unconventional oil supplies would result in a significant shift in the global oil supply mix. The reduction of unconventional oil from non-OPEC+ members would increase the importance of conventional oil supplies from Middle Eastern OPEC+ members and Russia.

Figure 10: Supply Surplus / Deficit by Unconventional Phase Out Case



As a result, these countries would gain considerable market and political power, which could affect global energy security and stability. And this change in the global oil supplies mix will also be contrary to the global energy transition, which ensures that there is diversity in oil supply sources from non-OPEC+ members, in order to have a stable and sustainable future of oil production.

Phasing-out ultra-deepwater gas supplies will have a minimal impact on the global gas supply-demand balance. However, shale and Arctic gas supplies from developed or under-development reserves will still be needed for the global energy transition unless they are substituted by new conventional gas supplies.

The global gas gap of 102 BCM is much smaller than oil, with a less steep demand reduction curve, which makes an accelerated phase-out of unconventional gas much more difficult. Currently, total gas reserves from developed and undeveloped reserves stand at 188 TCM, against an anticipated demand of 79 TCM in a 2050 net-zero scenario.

Figure 11: Gas Reserves vs Demand for Oil in a 2050 Net Zero World

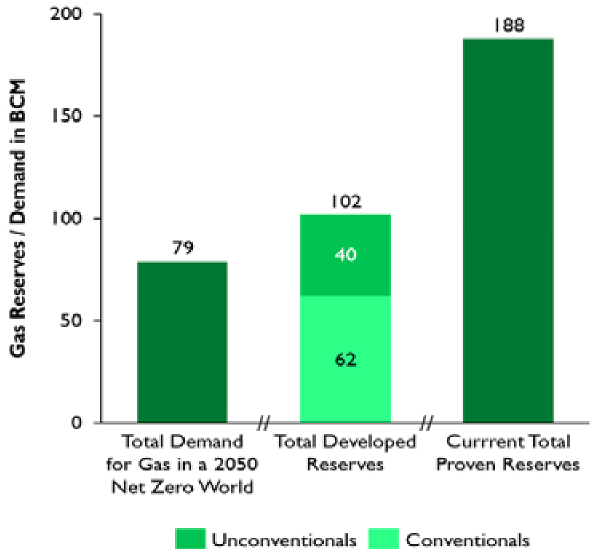
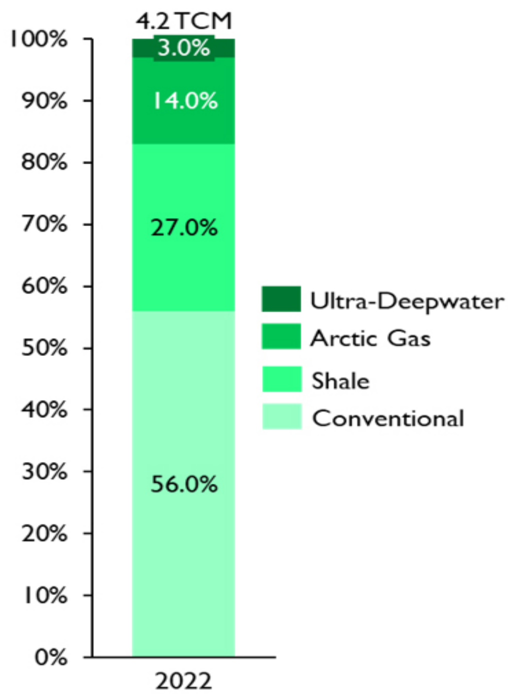


Figure 12: Annual Production by Gas Type, 2022



Ultra-deepwater gas reserves account for 3% (or 6 TCM) of the total gas reserves, allowing it to be phased out feasibly without materially affecting any country's global supply or supply security dynamic. Ultra-deepwater gas is predominantly produced in countries such as Brazil, the US Gulf of Mexico, Mozambique, Israel, Egypt, India, and China, and likely in future Tanzania, Mauritania, and Senegal. However, some countries, such as Israel, view ultra-deepwater gas developments (particularly the Tamar and Leviathan offshore gas fields) as critical for domestic energy security. Europe has also shown a strategic interest in these fields following the disconnection of energy ties with Russia.

Around 260 BCM of gas goes to waste every year through flaring, venting, and leakage. ~210 BCM of this could be economically brought to the market to rebalance any potential supply-demand disequilibrium from an accelerated phase-out of ultra-deepwater gas supplies. However, a significant part of this flared gas is in Russia, Iran and Venezuela, where political barriers make it hard to capture and use.

Arctic gas reserves account for 26% (or 50 TCM) of the total reserves, and shale reserves account for 16% (or 30 TCM) of the total reserves. Given their substantial contribution to global supplies, the phase-out of these resources is not possible without considerable development of alternative supplies of conventional gas to replace them.

However, new conventional gas developments will involve significant capital investment, high decline rate, prolonged lead times, with an average delay of up to 20 years, starting from the point of exploration license issuance to the beginning of production.

Therefore, replacing unconventional gas supplies with new conventional sources may result in disruptions in the short-to-medium term gas supply-demand balance, redirect investment focus from key transition technologies, and increase stranded asset risk.

North America dominates shale gas production, with the US accounting for 90% of the global supply. Shale is the US's primary source of gas production, accounting for 85% of the country's gas output. Most of the shale gas output is consumed domestically within the US, making the country self-reliant. Hence, an accelerated phase-out of shale gas could significantly impact the US's security of gas supply and European Union (EU) countries that rely on seaborne LNG supplies from the US following reduced pipeline gas flows from Russia. For this reason, it is more likely that some conventional gas production in Russia will be phased out or remain undeveloped, while unconventional production from the US, Canada and some deepwater basins replaces it.

CONCLUSION

In theory, a 2050 net-zero scenario could be achieved without unconventional oil and some unconventional gas supplies. However, the current reality is that we are not on track to achieve net-zero by 2050. While reducing unconventional production may appear like a reasonable solution to reach this target, it would be very risky given the likely continuing medium-term demand for fossil fuels, especially gas and LNG.

It's also important to consider the consequences of stopping unconventional production entirely, which could potentially be dangerous on various levels. Firstly, it may concentrate conventional production across a few countries, threatening the security and stability of fossil fuels supply.

Secondly, it may encourage these countries to over-produce, reducing overall efficiency, and increasing the environmental impact of fossil fuels production.

A more balanced approach would be for unconventional producers to reduce their emissions towards 2050 net-zero by mitigating Scope 1 & 2 emissions, while still remaining reasonably cost-competitive. For instance, oil sand heavy oil producers can use more renewable-derived heat and steam, and hydrogen for extraction, transportation, and conversion to refined products. Tight oil and gas producers need to eliminate routine flaring, minimise methane leaks, and improve life-cycle water management.

Such emissions reduction techniques can partly offset the effect of higher carbon prices and other charges. Although investment in new long lead-time unconventional projects will be deterred, existing operations can continue for long periods. Conversely the short production horizon of tight oil and gas makes it more competitive in a world of uncertain future demand. Unconventional oil and gas is of different types, even the same resource types may have different characteristics, and operators can make different choices about field development to balance reducing emissions and costs. Even though unconventional hydrocarbons may seem to be less competitive in a carbon-constrained world, strategic logic will likely give it a continuing important role. For the leading conventional oil and gas producers in the Middle East and Russia, their decisions on output levels will be a key determinant of how much room there is for unconventionals.

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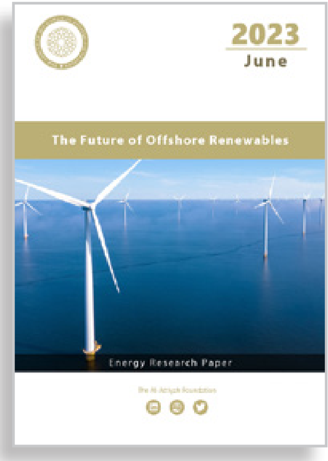

June - 2023

The Future of Offshore Renewables

Offshore renewable resources can be captured through various technologies such as offshore fixed or floating wind turbines, floating solar photovoltaic panels, wave and tidal conversion systems, and other ocean energy technologies such as ocean thermal energy conversion and salinity gradient.

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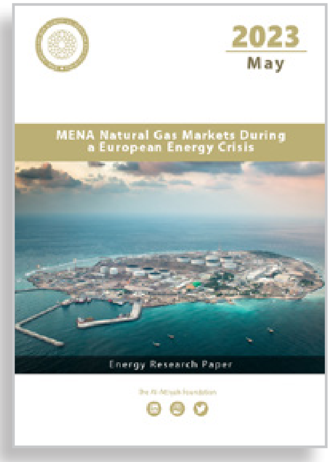

May - 2023

MENA Natural Gas Markets During a European Energy Crisis

The Middle East and North Africa (MENA) region has always been a strategic cornerstone of the European energy mix, but now it has gained newfound value for the continent as it adapts rapidly to a "Russia-less" energy world. In the shortterm, these MENA countries are set to be instrumental to European energy security.

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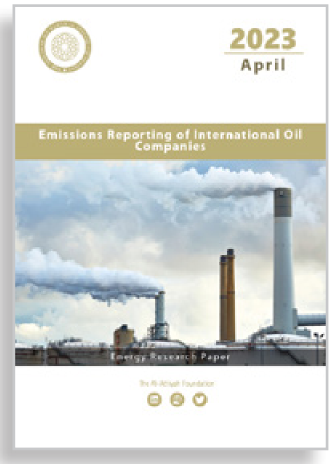

April - 2023

Energy-Report-2023-04- Emissions Reporting of International Oil Companies

The oil and gas industry, a major contributor to global greenhouse gas (GHG) emissions, faces increasing pressure from environmental, social, and governance (ESG) factors influencing investment decisions. Despite the uncertainty of its future in the energy transition context, demand for oil and gas is not expected to diminish in the nearterm.

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Our partners collaborate with The Al-Attiyah Foundation on various projects and research within the themes of energy and sustainable development.

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