



CONFERENCE REPORT

GLOBAL FRACKING: KEY TO ENERGY SECURITY & TRANSITION?

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KENAN-FLAGLER BUSINESS SCHOOL
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INTRODUCTION

In 2016, we convened a conference to determine if the U.S. Fracking Revolution was about to go global. We concluded it was not any time soon. Now, in 2024, a second conference on 'Global Unconventional Production' was **convened to consider if such developments as** 1) the reemergence of supply embargoes; 2) the possible long-term decline/loss of Russian oil/gas; 3) sustained lower investment in new oil/gas production and 4) the threat of peak demand leading to stranded conventional oil/gas assets **will combine to create new momentum behind non-U.S. Unconventional production.**

A second conference goal was to test the following hypothesis: *That Global Unconventional development is the hydrocarbon production best suited to an era of Energy Transition.* This hypothesis is based on assuming that Unconventional development offers the following characteristics:

1. Because it doesn't require large upfront capital investments, it is easier to finance in an era where capital markets are ambivalent at best about hydrocarbon projects
2. Because it is not characterized by large, fixed asset 'steel in the ground,' it poses less risk of stranded assets for investors
3. Because of its 'short cycle' operating characteristics, it offers optionality well suited to the cyclical and global demand risks presented by an Energy Transition
4. Because of a lower carbon footprint than offshore, arctic and heavy oil production and its potential to achieve Net Zero on Scope I & II emissions, it is more suited to an era of de-carbonization.

To address these issues, the following questions were identified as the most important discussion topics for the conference:

Conference Questions We Don't Yet Know How to Answer:

1. Do we face *a long-term Energy Security Supply issue?* Do credible Outlooks foresee increasing dependence on OPEC, delivering increasing market control/pricing power to the Cartel?
2. *What has changed since 2016* regarding global Unconventionals potential? How have understanding of *resource potential* and *production techniques* evolved?
3. *What are today's economics for Global Unconventionals?* At what cost structures and price levels would non-U.S. unconventional oil/LNG production come 'into the money?'
4. What *other barriers* to Global Unconventionals development *remain?* How does this differ by location? How can *the barriers* to Global Unconventionals development *be addressed?*
5. *Are there Near-term potential Success Cases? What has to happen to unlock them?*
6. *Does Unconventional development have a lower carbon footprint* than other hydrocarbon production? *If so, can such a footprint be replicated in non-U.S. locations?*
7. *All Things Considered, are Global Unconventionals the best form of Hydrocarbon development for an Era of Transition?*

With these in mind, the conference program produced the findings described in the Executive Summary and the Key Findings full report that follows.

EXECUTIVE SUMMARY

- **Virtually all closely followed Global Energy outlooks foresee minimal Unconventional oil & gas production from now to 2050.** These same outlooks offer reference cases with global oil demand ranging from ~100 million barrels per day (mb/d) to 116 mb/d. To then balance supply & demand, **the outlooks increase their call on OPEC+ to ~50 mb/d or more. The call on OPEC alone is 40-45 mb/d** depending upon assumptions regarding future Russian production. The outlooks are mute regarding the energy security and price implications of these assumptions.
- In contrast to these outlooks, **Global Unconventional activity is picking up.** This activity is being **led by National Oil Companies (NOCs)** in China, Argentina and the Middle East. The major 3 oil field services companies are very engaged in these locations. Much of this Unconventional effort is gas focused.
- **The major International Oil Companies (IOCs) are more ambivalent** about Global Unconventional opportunities. Part of this involves the highly profitable Unconventional growth opportunities they enjoy in the U.S. Part also reflects their concerns that Unconventional projects elsewhere either show marginal economics and/or suffer from 'above ground risks' such as limited infrastructure, a lack of foreign exchange, and/or distrust in the laws and policies of the local government.
- **One factor affecting the economics of Global Unconventionals is the dramatic progress in U.S. technical and operating practices.** These have brought the best U.S. shale breakeven costs down towards \$30/b, leading to very attractive margins in today's environment. Many of these practices are being replicated internationally. For example, the conference was advised that **Argentina's Vaca Muerta now boasts breakeven costs** similar to the U.S. Permian. An estimate of **\$34/b** was offered by one service firm operating there.
- Consequently, **several IOCs see the long run potential of Unconventionals** in locations and are **creating investment options for later in this decade.** Algeria was described as offering attractive resources, a cooperative government and existing gas pipelines into Europe. Several IOCs are sustaining operations in Argentina's Vaca Muerta despite foreign exchange and political issues. There are hopes the Milei government can achieve a break from the political and economic instability of recent decades.
- **Canada is reemerging as an attractive location for Unconventional development.** Recent successes in completing crude and gas pipelines to the Pacific coast plus potential changes in provincial and federal government regimes could see Canada soon emerging as favored location for IOC and independent companies' Unconventional development outside of the U.S.
- **Australia, Azerbaijan and Georgia** are locations actively seeking Unconventional development. Despite offering interesting resource potential and supportive public policy, these locations **are in 'early days'** as regards producing their shale resources. **Other locations with attractive resources are likely to remain closed.** Fracking bans have shut down Europe, the U.K., Mexico and Colombia as opportunities. Even if these are removed, the potential for similar bans to return will retard IOC interest there.
- **Legacy fiscal regimes are a major barrier** to be worked. Many location fiscal regimes involve Production Sharing Contracts. These agreements were designed for projects with upfront capital and production per well very different from an Unconventional play. To incentivize IOC interest, these fiscal regimes must be tailored to the longer time periods and continuous drilling needed to secure an adequate Unconventional return. **Reducing the progressivity of fiscal terms towards neutrality and eliminating "cumulative parameters" (tied to target returns) were cited as the needed revisions.**

- In locations where foreign exchange is a concern, **host governments should consider the export potential of their Unconventional resources.** If this potential is considerable, as it is in Argentina, the **government should ‘invest’** in its realization by **providing an industry-specific foreign exchange regime** to underpin its development.
- A **strong conceptual case exists** that **Unconventionals are well suited** to be the preferred hydrocarbon production **for an Era of Transition.** This case consists of:
 - An abundant global resource base that addresses ‘Peak Oil’ supply concerns.
 - This resource base is not concentrated in a single region such as the Persian Gulf.
 - The source rocks are known to contain hydrocarbons, reducing exploration risk.
 - The resources are onshore and thus accessed without large scale capital assets.
 - Unconventional activities can thus be stopped without the large ‘stranded asset risk’ characteristic of offshore, tar sands and arctic production activities.
 - Unconventional production’s ability to be stopped and started provides operators with ‘optionality,’ a quality well suited to both the industry’s historic cyclical and the Transition risk of markets disappearing.
 - Finally, Unconventional production offers a smaller carbon footprint/per unit of production than other forms of development.

Unconventional production is typically natural gas, NGLs and/or light crude which are inherently lower carbon than much crude oil production

- **This case is well displayed in the U.S. and especially in the Permian.** There, regulatory support and access to low carbon electricity are enabling U.S. Permian operators to target being Net Zero by 2030. **However, such conditions are lacking in many global locations and will be difficult to create anytime soon.**
- At the policy-making level, **the present U.S. government is primarily focused on de-carbonization.** There is awareness of how **fracking has contributed to replacing Russian supplies into Europe post-Russia’s Ukraine invasion** but not much engagement with foreign governments to promote Unconventional development. **The risks of growing OPEC dependence long-term or the potential benefits of Global Unconventionals in mitigating such risks are out in the future and thus not a topic of focus.** There will be multiple opportunities for new **government post-2024’s election to demonstrate more interest** as it renegotiates the U.S.-Canada-Mexico free trade agreement, considers future options for replacing Russian gas supplies into Europe and the potential help Unconventional production can provide to friendly governments in locations like Argentina, Australia, Azerbaijan and Georgia.



KEY FINDINGS

QUESTION 1: Do we face *a long-term Energy Security Supply issue*? Do credible Outlooks foresee increasing dependence on OPEC, delivering increasing market control/pricing power to the Cartel?

- **Most widely followed Energy Outlooks** (*International Energy Agency or IEA, OPEC, ExxonMobil, BP*) show three characteristics: 1) *Reference cases with oil demand approximating 100 million barrels per day (MB/D) or higher in 2045-50; 2) Increasing dependence on OPEC+ for supplies, e.g., 40-50 MB/D required from OPEC alone in 2050; and 3) Minimal Unconventional oil production (<1 MB/D) outside the U.S.*
- While supply/demand outlooks for natural gas show less OPEC dependence, they also are characterized by minimal Unconventional production outside the U.S.
- Another outlook characteristic is **a large variance in the required amount of investment needed for new production**. For example, the IEA's 2023 Outlook to 2050 sees a need for 40 MB/D of new, non-OPEC production in its reference (STEPS) scenario and zero such production in its Net Zero scenario. (See IEA charts in Appendix)
- Taken at face value, **these outlooks suggest an increasing supply & price vulnerability from OPEC dependence**. This vulnerability would be accentuated by a decreased ability of the international oil industry to respond to price signals due to prolonged, regulatory hostility in markets like the U.S., Canada and the EU, constrained capital markets, and uncertainty about future demand.
- **This vulnerability is mitigated by the fact that energy outlooks have not been reliable predictors of new hydrocarbon supplies**. Typically, they project future supplies from known reserves. Consequently, they miss supplies from new locations and technology developments. For example, few pre-2010 outlooks foresaw Unconventional oil & gas production in the U.S. Neither did they foresee new oil-bearing provinces like Brazil and Guyana. OPEC's Persian Gulf suppliers, with their vast store of oil reserves, thus serve as the forecasters 'default option' for balancing future supply and demand. These producers align themselves with this default option by resting their policies on promoting the long-term value of their reserves and adjusting output to sustain prices which support their budgets without encouraging entry of large, new non-OPEC supply.
- That said, **the supply vulnerability buried inside IEA and other forecasts should not be ignored. Conditions which didn't exist in the past present formidable obstacles to new oil and gas development today**. Regulatory and capital market hostility may ease at times but are unlikely to disappear and may periodically intensify. Determined efforts to depress oil/gas demand in certain markets will also continue
- **These conditions are causing four reactions in the oil industry: 1) uncertainty towards long term demand and thus reluctance to invest in long-life projects; 2) diversification away from oil by historic industry players(need clarification here – "such as..."; 3) aversion to certain types of hydrocarbon production known to have visible environmental impacts, and 4) industry consolidation, i.e., fewer future players to respond to oil/gas market tightening.**
- **These reactions mean that the emerging non-OPEC industry will be less willing and able to respond to supply tightness and/or high prices. Reliance on the OPEC default option for supplies is therefore a risky assumption.** This also raises the question as to why virtually all forecasts seem comfortable making this assumption, even as they ignore the potential for Global Unconventional production to address its implied risks. It would seem they should be highlighting this growing reliance on OPEC supplies and the potential energy security risks that poses rather than burying the assumption within their reports.

QUESTION 2: *What has changed since 2016* regarding global Unconventionals' potential? How has industry understanding of *resource potential* and *production techniques* evolved?

- At the 2016 conference, Global Unconventional resource potential ex-U.S. was estimated to exceed 300 billion barrels of tight oil plus large volumes of NGLs and natural gas. These estimates were for reserves recoverable with existing technology, but made no assumptions regarding prices or production economics.
- ***Current expectations of technically recoverable Unconventional resources remain in ranges like those discussed in 2016.*** For example, IEA projects 316 billion barrels of Tight Oil to be technically recoverable outside the U.S. Comparable IEA figures for NGLs and natural gas are 545 billion barrels and 242 trillion cubic meters.
- ***What has changed is the industry's understanding of the resource quality in many locations.*** Argentina's Vaca Muerta is now acknowledged to have excellent shale quality resources – thick and prolific when produced. Alberta and Saudi gas plays are better understood and considered prospective. Algeria's Unconventional gas resources are considered very attractive, as is its location and pipeline connectivity to the European market. Colombia's rocks are highly regarded. A lifting of that country's fracking ban following next year's elections could attract investor interest. Mexico offers five potentially attractive shale basins which also are politically off-limits for the moment. The conference saw presentations of interesting potential in emerging locations: Australia's Beetaloo basin, the Republic of Georgia and onshore Azerbaijan.
- On the other hand, ***China continues to be seen as possessing difficult to access resources.*** Its rocks are deep, often highly fractured, and located in areas where water availability and nearby populations present operating challenges. In contrast to Saudi, the Unconventional resources in the United Arab Emirates (UAE) are not considered especially attractive. Little has changed in Europe. Early drilling disappointments in Eastern Europe continue to chill interest in Poland and neighboring countries. More prospective rocks in Germany, Netherlands and France remain politically off-limits. Little to no drilling activity in these countries means little understanding has been gained since 2016. The U.K.'s shale oil and gas potential remains politically deadlocked – its potential gas resources enjoying the dubious distinction of seeing fracking bans be removed and then reapplied.
- What also has ***changed are the technology and operating practices of Unconventional oil/gas production. The progress realized in U.S. shale basins, especially the West Texas Permian, is little short of astounding.*** Eight years ago, no one was drilling 3–4-mile lateral wells or quadrupling the number of completions per well. These wells are now 'drilled remotely' with minimal deployment of onsite personnel. Numerous other advances have been realized, including the ease and speed with which drill rigs are moved. Experience has taught some producers the volume and unit cost benefits of cube drilling as opposed to targeting basin 'sweet spots.'
- ***A notable development in U.S. Unconventionals is the emphasis on simplicity in the interests of cost efficiency.*** Exotic injections of chemical packages and more sophisticated proppants are now de-emphasized and much of the advanced technologies are now commoditized drawing lower revenues for the oil field service sector. This trend - reinforced by a smaller number of competing producers and by capital market demands for free cash flow – have dramatically lowered Permian metrics like breakeven costs and costs per well-foot drilled. As testimony to such developments, major oil field service firms like SLB have vacated the hydraulic fracturing operations business in the U.S. in favor of more lucrative non-U.S. markets.
- The question then considered at the conference was ***the extent to which these technical improvements can be replicated overseas.*** Responses from attendees amounted to a mixed bag of answers. Some technical improvements, such as the drilling of long lateral wells, are now common practice internationally. In certain locations, many of

the Permian workforce and operating practices have been replicated. ***Argentina was cited as a location where field operating practices and costs now resemble West Texas.*** This marks a dramatic change from 2016. Several factors contributed to these improvements. First, several of the Permian producers are also active in Vaca Muerta, e.g., COP, CVX and XOM. These firms are very focused economically and have sought to develop acceptable margins by driving down Vaca Muerta production costs. Second, a full complement of oil field services firms, including new Argentine companies, now competes for business. This has produced a third development, improved supply chain conditions. For example, local Argentine sand has replaced imported proppant. Finally, notable progress has been made on ‘take-away’ infrastructure, e.g. pipelines. Other obstacles remain in Argentina and are

discussed in detail below, but the progress made since 2016 is noteworthy.

- ***In other locations, adoption of U.S. operating practices has been partial*** at best. In certain locations, e.g., UAE, and China, state companies are leading the Unconventional development. Their deployment of U.S. operating practices has been uneven, and in China marred by a desire to ‘leap’ forward without thorough preparation. This can be seen as a glass ‘half full, half empty’ situation. On the one hand, operating costs in such locations remain above U.S. shale benchmark. On the other, these locations enjoy considerable potential for improvement.
- The combined effects of resource quality and operating practices define the relative economics of Unconventional resources outside the U.S. To this topic we now turn.

QUESTION 3: *What are today’s economics for Global Unconventionals? At what cost structures and price levels would non-U.S. unconventional oil/LNG production come ‘into the money?’*

- In one sense, the ***operating cost progress in several locations already demonstrates how competitive Global Unconventionals could be.*** As an example, Argentina’s Vaca Muerta is reporting impressive cost efficiency gains. At the 2016 conference, Argentina’s Unconventional average cost structure was judged to be in the \$50-80/b neighborhood. At the recent conference, one oil field service company reported Vaca Muerta average breakeven costs are down to \$34-42/b. No one at the conference disputed the assessment of Argentine operating costs having dramatically declined.
- However, ***the economics of Global Unconventionals*** involve more than just well productivity and field operating costs. They ***involve a full value chain*** that also includes: 1) logistics costs to market; 2) price and currency at delivery to customers; and 3) “government-take” by any/all means including taxes, royalties and profit sharing.
- Taking all factors into account, ***it is hard to see any international location which currently offers compelling economic margins ‘all-in’ at \$70-80/B crude prices.*** That said, Unconventional economics have improved enough since 2016 that National Oil

Companies (NOCs) are now very active in the space. Meanwhile, International Oil Companies (IOCs) see the economics in specific locations as sufficiently interesting to undertake limited operations and/or to position themselves for future development.

- ***NOC Unconventional economics are very different from those of IOCs.*** For starters, government-take for NOC’s accrues to their owner, the national government. On top of this, NOC Unconventional production often serves a national interest at the expense of the NOC’s ‘bottom line.’ For example, Saudi Aramco’s development of Jafurah basin gas resources is not just a function of what the firm realizes from selling the gas. Rather, the gas replaces oil products currently used in domestic power generation. This in turn frees up crude oil for export at international prices. Similar motives are driving ADNOC’s Unconventional drilling in the UAE. Despite cost and operating challenges, China’s PetroChina has dramatically expanded its Unconventional operations. PetroChina is forecast to employ 921 rigs drilling Unconventional wells next year. This figure would be second only to ExxonMobil’s activities in the U.S. In PetroChina’s case, its government owner has national security

concerns. These involve China's reliance on imported oil and gas (China is the world's largest oil importer) which could be blockaded during a confrontation with the U.S. and allies.

- ***The Unconventional economic picture looks very different to the IOCs*** and their independent oil company competitors. They are looking for adequate, risk-adjusted free cash flow taking all value chain elements into account. Almost all international Unconventional opportunities look marginal or worse to them on this basis. The situation is quite different for the major Oil Field Service companies. SLB, Halliburton and Baker Hughes are all profiting from Unconventional business internationally as they service the NOC activities in this space.
- Moreover, the ***international economics look very unfavorable when compared with current U.S. Unconventional production***. U.S. breakeven costs have dropped towards the low \$30/B level, U.S. production enjoys a flat 21% tax, and the infrastructure to deliver Unconventional production to market is largely built out. IOCs with U.S. Unconventional operations see additional runway to higher production over the next 3-5 years. This combination of marginal international economics, exceptional U.S. economics 'all-in' and continued U.S. growth plans explains much of the IOCs current ambivalent approach to Global Unconventionals.
- ***Unconventional economics are probably the best in Canada right now***. Field practices are similar to those in the U.S. and the regulatory/tax regime in Alberta is more favorable than in other locations. Take-away capacity to international markets is the limiting factor. Two pipelines to the Pacific coast, one for oil, one for gas/LNG, were recently completed, and full value chain economics for those volumes look attractive. ***The question for Alberta is whether additional take-away infrastructure can be built*** at an acceptable cost over a predictable schedule?
- As noted, ***Argentina's operating margins look more attractive. However, producer economics 'all-in' depend greatly on the destination of the production***. Much Vaca Muerta oil and gas is sold domestically for Argentine pesos. These revenues have been impacted by the unavailability of foreign exchange for conversion, and the 'blocked pesos' suffer from Argentina's high rate of currency devaluation. Swap transactions to secure \$US can result in discounts as high as 60%. To the extent Argentine production eventually shifts to exports paid in \$US, Vaca Muerta economics for the IOCs would improve dramatically. ***Conference participants pointed to a potential \$25 billion foreign exchange generation largely derived from exporting light Vaca Muerta crude production***. Two LNG export projects are also under development. While the IOCs debate 'stay or go' re: Argentina, state-owned YPF has increased its Unconventional activities. It now has 209 rigs operating in the Vaca Muerta and related shale basins.
- ***China looks like a high-cost operating environment***. IOC partnerships with China NOCs also bring complicating issues. On the other hand, government subsidies provide prices which support China Unconventional economics. A modicum of IOC activity exists in China alongside the intense efforts being exerted by PetroChina and other local firms. Given difficult resources plays, all the partnership issues and the dominance of Chinese NOCs, the outlook remains one of limited IOC activity in China's Unconventional basins.
- ***Algeria was identified as potentially offering IOCs perhaps their most attractive Unconventional opportunity***. Algeria's government and NOC (Sonatrach) were described as cooperative and desiring rapid progress. That said, it is early days for this opportunity. On paper Algeria has many of the fundamentals IOCs seek: good rocks, local infrastructure, and pipelines to a hard currency market. However, it has a legacy tax regime, water availability issues and some community resistance in the shale regions. Partnership issues with Sonatrach may need to be worked out. A steady negotiation and development process in Algeria can be anticipated from ExxonMobil and Chevron, who continue to enjoy growth opportunities in the U.S. and elsewhere.
- ***Presentations on Azerbaijan, Australia and Georgia suggested interesting potential for the future***. Australia was described as a case

where historic environmental opposition to fracking is being overcome by the gas shortage threatening major city power supplies. Azerbaijan and Georgia were described as overlooked gems – the former now offering its onshore potential, the latter unveiling a recent history of promising well results and favorable government postures. Both have pipeline connections to Europe; both also have unfavorable locations near to Russia and are subject to historic Russian influence/pressures. All three of these locations are in the ‘early days’ stage of developing their Unconventional potential.

- ***The major take-away here is that Global Unconventional activity is now underway, but it is being led by the NOCs.*** This will mean some Unconventional oil/gas volumes making its way into global supply/demand balances

over the next several years. ***As for the IOCs, they are creating ‘options’*** for later in this decade. As their U.S. plans mature and additional growth prospects dim, they likely will turn attention to Unconventional prospects outside the U.S. and compare them to such other development opportunities as they identify, e.g., other conventional and deepwater reserves.

- The economics of Global Unconventionals have improved enough in certain locations that one can expect IOC interest to strengthen going forward. For this to materialize into serious development plans, various barriers will need to be addressed, e.g., infrastructure bottlenecks, currency constraints, legacy tax regimes and political risks. To these we now turn.

QUESTION 4: What *other barriers* to Global Unconventionals development *remain*? Will this differ by location? How can *the barriers* to Global Unconventionals development *be addressed*?

- ***Numerous barriers impede development of Global Unconventionals.*** Foremost among these are: 1) ***Infrastructure to ‘take-away’*** production to markets; 2) ***Foreign exchange*** availability in the producing country; 3) ***Fiscal regimes***; and 4) Various forms of ***political risk***. Fiscal regime issues are widespread. The other barriers vary widely by location.
- Almost all international fiscal regimes are a variation of the ***Production Sharing Contracts (PSCs)*** developed in the 1980s. These agreements were designed with three considerations in mind: 1) that conventional and offshore production involve significant upfront capital investment after which producer expenditures are greatly reduced; 2) they also have long, sustained production plateaus and 3) that economic rents from cyclical price peaks should accrue primarily to the host country and not the producing company. As such, they ***could produce effective tax rates as high as 80%***. They do afford producing firms a quick return of their invested capital. However, ***many legacy regimes also posit a target return (‘cumulative parameters’)*** for the producing company, varying the production allowed the investor to vector towards the target. The overall effect

of these provisions is a ‘cap’ on the investor’s return and upside.

- These conditions are less relevant to Unconventional production where there is less upfront capital spent and more a requirement for constant drilling to grow and then sustain production. Unconventionals also trend towards being higher cost production, certainly when compared with prolific offshore fields like those now producing in Brazil and Guyana. ***Producing locations interested in attracting IOCs for Unconventional development will want to modify their legacy fiscal regimes*** – rendering them more suited to the characteristics of this type of production.
- This is especially the case since ***global locations are still competing with U.S. fracking operations*** for attention and investment. In the U.S., Unconventional players enjoy a ***flat 21% tax rate***, favorable treatment of amortizable expenses, and negotiable royalties. Booking reserves is not a ‘form-of-contract’ problem. They also can own 100% of the opportunity, eschewing any need to share with an NOC. ***These hard to replicate advantages point to one HARD CONCLUSION re: Global Unconventionals – they will not***

enjoy strong IOC/independent oil investment activity until those firms see their U.S. prospects to be plateauing and future-limited.

- Subject-area Experts at the conference stated that *legacy Production Sharing Contracts can be modified to incentivize Unconventional developments*. This perspective was shared in recognition of the fact that persuading Ministries long accustomed to PSC-based deals to revert to ‘Tax/Royalty’ arrangements would prove a ‘bridge to far’ in many locations. One conference speaker had attempted just this persuasion effort with his government, only to encounter an inflexible ‘PSCs have served us well’ response.
- *The two recommended PSC modifications were: 1) reduce the degree of ‘progressivity’ in the in the volume sharing arrangement to one of neutrality or slightly progressive; and 2) eliminate the cumulative parameters* which cap the investor’s total return. It was also recommended that future PSC-based regimes recognize the more complex upfront assessment required to determine an Unconventional play’s commerciality, and the longer time horizon required to build up production and generate adequate returns. Thus, Unconventional PSCs should allow adequate holding periods for undeveloped acreage and production terms once development has commenced.
- Other barriers are location specific. *Argentina and Canada were cited as cases where ‘take-away to market’ infrastructure has been an issue*. Canada’s problem has been especially acute; it has seen multiple cancellations of the Keystone XL pipeline and fierce resistance by environmental and indigenous groups to pipelines through British Columbia to the Pacific Coast. However, some progress has been reported in both Canada and Argentina. Potential now exists for further buildout of the logistics needed to take growing Unconventional production to market. Their circumstances and outlooks are discussed in more detail below. Australia is another case where take-away capacity is an issue. That country’s Unconventional potential, principally the Beetaloo basin, is located in the remote Northern Territory region. While some pipelines exist, more will be needed to deliver

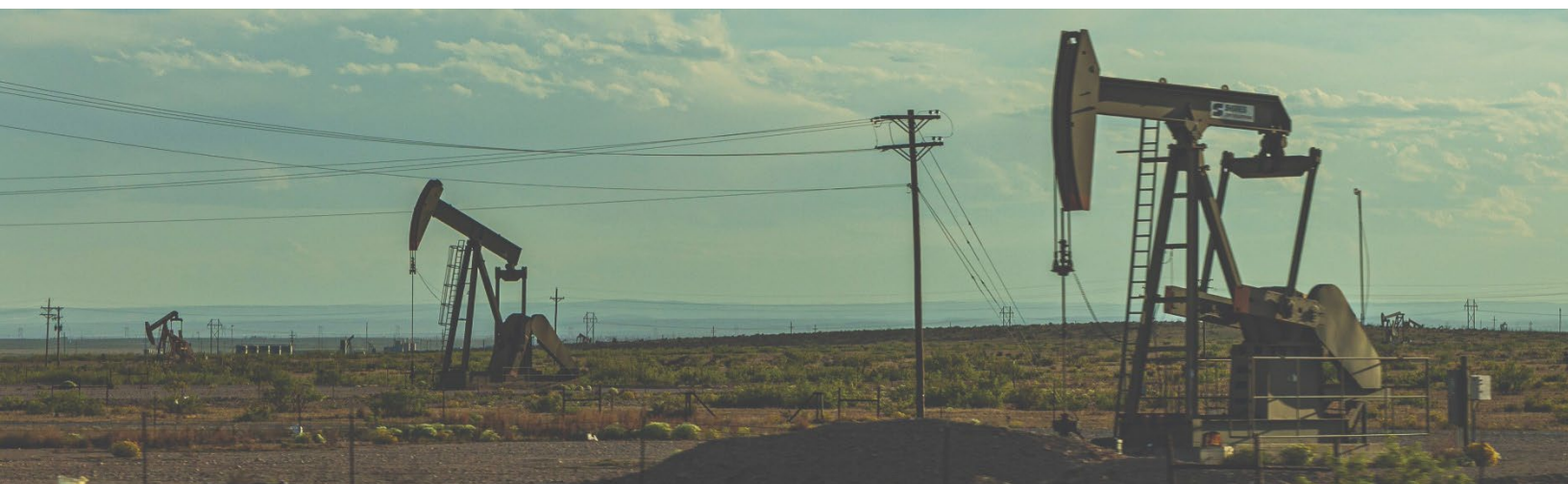
gas to the southeast Australia urban and industrial areas.

- Political risk covers a lot of barriers which impede Unconventional development. *Nowhere is political risk more of an issue than in Argentina*, where access to foreign exchange has become a key barrier. Almost all Vaca Muerta production is currently sold domestically. This means such sales generate revenue in Argentine pesos. IOCs operating there cannot convert these to hard currency without incurring long delays, during which time their pesos are exposed to major devaluations. Their alternative is to engage in swap or other ex-market transactions requiring discounts of up to 60%. Paying for needed imports, servicing external debts or remitting profits are all impacted, to a degree that brings into doubt the viability of the otherwise attractive Vaca Muerta economics. Oil field services firms operating there report similar experiences. They have found it difficult and expensive to import needed equipment, the cost of which is exacerbated by a ~20% ‘national tax’ on such imports.
- *Argentina’s history of debt defaults, expropriation of foreign investments and political instability poses heavy risks for Vaca Muerta development*. One foreign investor mused that “as soon as you make some money in Argentina, you can count on the government plotting to take it away.” IOCs are very aware of Argentina’s nine sovereign debt defaults, including on loans from the World Bank. They also point to the Kirschner government’s expropriation of Repsol’s stake in YPF. *Repsol bought 51% of YPF for \$15 billion in 1999 and in 2012, Argentina nationalized that stake. A long dispute ensued. Ultimately, Repsol received \$5 billion in government bonds as compensation*.
- *Reforms implemented by the current Milei government offer some hope that Argentina’s issues may be addressed*. Many of its policy changes, including fiscal reforms, seem well designed to improve the country’s chronic ills. That said, IOCs and others are waiting to see if Milei’s government can survive the fallout from imposing stark austerity measures on the provinces and Argentina’s welfare state.

- ***Vaca Muerta's development as an export revenue engine is a clear opportunity for Milei and his reform program. Conference speakers pointed to a potential \$25 billion foreign exchange generation by 2030*** from Argentine crude oil and gas exports. Today Argentina produces about 687 kbd. Speakers laid out a 'runway' to 1 mb/d by 2030 encompassing both intensified Vaca Muerta drilling and new pipeline takeaway capacity. They also noted that these crude pipelines are already privately funded.
- These facts suggest that if the Milei regime can stay its course and even facilitate Vaca Muerta's export potential, it could ease Argentina's chronic foreign exchange shortage and reinforce Milei's anti-inflation measures. ***Providing an industry-specific foreign exchange regime for the Vaca Muerta operators would be a major step in the direction of realizing this potential.***
- ***Mexico is the other country where political risk emerges as the principal barrier to Unconventional development.*** Despite proclaiming a goal of energy self-sufficiency, the Obrador presidency resulted in the neutering of Mexico's previous opening to international hydrocarbon investment. This has allowed Mexico's oil production to decline to 1.5 mb/d. Twenty years ago, Mexico produced 3.5 mb/d. Meanwhile, imports of natural gas have soared to 8 billion cubic feet/day. Fracking has been banned; a rule ignored by Pemex who masks such operations by describing them with euphemisms. A new president, Claudia Sheinbaum, takes office on

October 1. She belongs to Obrador's Morena party and is considered his protégé. ***So far little has emerged on the extent to which she may depart from Obrador's energy policies. Unless and until this happens, Mexico's considerable Unconventional potential will remain largely undeveloped.***

- Algeria received some notice in the political risk discussion. While its government was praised by some speakers as being very cooperative, the comment was also made that Algeria offers the 'worst of both French and Arab bureaucracy.' Georgia and Azerbaijan were also recognized as offering governments supportive of IOC investment. The continued need of those governments to 'walk a fine line' viz a viz Russia is the political risk issue for those locations.
- This 'Other Barriers' discussion resulted in ***a mixed bag of conclusions. Fiscal regimes remain largely unreformed and various political risks operate to cloud the attractiveness of many locations. There is however, a 'work in progress' flavor to all such barriers.*** The Fiscal regime discussions are now underway and progress in multiple locations appears likely. Political risks vary by location from 'a concern' (e.g., Canada) to 'acute' (Argentina and Mexico). In all cases save Mexico, recent trends suggest that political risks are lessening. Are these improvements enough to unlock Unconventional development? We now turn to the topic of potential near-term success cases.



QUESTION 5: *Are there Near-term Success Cases? What has to happen to unlock them?*

- ***NOCs are leading and will continue to lead Unconventional development globally.*** Their activities will produce the first ‘success cases’ in various countries, which successes will point the way for subsequent efforts by IOCs and others elsewhere.
- In terms of activity and production volumes, ***China and Saudi Arabia are two likely near-term success cases.*** PetroChina’s massive ‘Uncon’ rig count underscores China’s determination to access its shales and tight sands. Saudi Aramco’s Jafurah gas play is also likely to result in significant Unconventional gas production. ***These ‘successes’ are unlikely to convince IOCs that Global Unconventionals are ready for economic development;*** in both cases national objectives are the key drivers. Nonetheless, the extent of these activities and the volumes produced will raise the profile of Global Unconventionals. Oil field services companies will record material levels of operations and the volumes extracted from these plays will start showing up in energy supply/demand outlooks. The UAE may also record a material level of Unconventional gas production, albeit with economics not likely to attract IOC interest.
- Beyond these plays, ***Canada is the most likely location for a private sector Unconventional success case.*** The Duvernay and Montney basins offer large potential oil and gas plays. Alberta offers favorable regulatory and fiscal terms. Its government is eager for Unconventional production to grow, especially as it sees a limited future for growing tar sands production. Canada’s success in completing two pipelines to the Pacific illustrates its potential for growing both oil and LNG exports. These pipelines offer some existing spare capacity, but not enough to support multiple additional LNG plus crude exports. If Canada can demonstrate additional west coast pipelines can be built, it would put a solid foundation under the idea that conditions have changed from those which caused Kinder Morgan to sell off its Trans-Canada pipeline. Now-likely changes in government at both the federal and British Columbia levels would reinforce Canada’s potential for near-term Unconventional development.
- While Algeria’s potential was described in very favorable terms, the impression also emerged that the IOCs will take a measured approach there. The U.S. continues to offer ExxonMobil and Chevron highly attractive growth opportunities, and they have international growth projects in progress as well. It would not be surprising for the IOCs to take 3-4 years negotiating fiscal terms and other conditions such that they felt a serious commitment to Unconventional Algerian production was justified.
- ***YPF will continue to demonstrate Argentina’s Vaca Muerta potential*** as shown by the rig count it continues to operate. This again is driven by national, not private-sector type goals. IOCs will continue taking a ‘wait and see’ and ‘preserve the option’ approach while they assess the Milei government’s reform program and chances for survival. As noted, an industry-specific foreign exchange regime would go some distance towards encouraging the IOCs to develop the Vaca Muerta’s export potential. The next twelve months will demonstrate much about Argentina’s ability to develop, or not, the Vaca Muerta’s now visible pathway to 1 mb/d of crude production plus LNG export potential.
- Azerbaijan and Georgia seem attractive plays at an early stage of development. Smaller IOCs may enter there and shortly demonstrate their Unconventional potential. Australia has a serious need for domestic gas production, and smaller firms will demonstrate whether the Beetaloo’s economics can justify the pipelines needed to get its gas to market. IOCs will follow this activity with interest as Australia could offer them additional end-of-decade opportunities.
- For now, ***Mexico and Colombia’s*** attractive Unconventional resources ***appear off-limits*** due to fracking bans. The potential for political reversals exists in both locations, but

any material level of Unconventional activity will in any case be years into the future.

- In sum, ***the next several years will see NOCs realizing significant levels of Unconventional activity in the Middle East, China and Argentina. Much of this activity will be gas focused. The IOCs will be developing their options*** in various locations and targeting later in the decade for material FIDs. Canada is the one location where a change in political leadership and more infrastructure development could foster a faster pace of IOC activity. Algeria will be closely watched as a barometer of how seriously the IOCs will be developing their non-North American Unconventional opportunities. While many fundamentals look attractive there, time and effort will be dedicated to working on everything from the nature of the resource to reform of the fiscal regime.

- ***These ‘threshold’ levels of Global Unconventional activity are occurring without much active support from the U.S. government. At policy-making levels, the Biden administration’s focus remains de-carbonization and how to achieve it as rapidly as possible.*** That said, it has not actively opposed fracking in the U.S., and there is appreciation in the foreign policy agencies for the role U.S. supplies have played in replacing Russian oil & gas into Europe. Concerns about the longer-term risks of a growing ‘Call on OPEC’ are muted. Some of this reflects the fact such risks are not immediate, and some reflects administration hopes that de-carbonization will advance such that new supplies ex-OPEC are not needed. Meanwhile, the oil and gas industry has hardly advanced a case that Unconventional development is the best form of hydrocarbon development for an era of Energy Transition. Do the facts support such a case? To this issue we now turn.

QUESTION 6: *Does Unconventional development have a lower carbon footprint than other hydrocarbon production? If so, can such a footprint be replicated in non-U.S. locations?*

- ***Unconventional production produces light hydrocarbon molecules, natural gas, NGLs and very light crude oils. These take less energy to produce and ship, and if being refined, also take less energy to convert into end-products. As such, it is inherently ‘lower carbon’ than other developments which produce heavier crude and bitumen. It also involves less ‘steel in the ground’ than offshore or arctic production, thereby eliminating a material amount of Scope II emissions in its footprint. Offshore production increasingly requires the construction of large FPSO ships (Floating Production, Storage & Offtake vessels) which can cost \$1 billion each. Arctic production can require construction of man-made islands for producing wells and pipelines from very remote locations that are especially expensive to construct because of their need to be climate resilient and because of the inherent difficulties constructing such projects under arctic conditions also characterized by permafrost. A majority of Unconventional developments will require nothing like these types of assets and infrastructure.***
- Various ***producer commitments to achieve Net Zero on Scope I & II Permian production testify to Unconventionals’ potential to offer a very low carbon footprint.*** Much of this is achieved by electrifying the rigs, pumps and other equipment used in fracking operations and backing these up with renewables plus battery storage. ***The Permian*** is well suited for such electrification. It ***is situated where both solar and wind power can be accessed. Solar and wind can complement each other, solar obviously offering day-time generation while wind is often best at night. Battery storage then works well*** to move peak solar and wind generation to serve hours when the renewables may not be meeting all load demand. ***These conditions allow the Permian operators to commit to a Net Zero goal*** wherein their tasks are to use electric fracking equipment and bring transmission lines from renewable sources into their operations. Some backup power from a nearby utility like Vistra completes the process.
- ***Methane emissions and disposal of produced water are other issues that impact Unconventionals’ environmental footprint.*** After years of flaring much associated gas,

Permian producers are making intense efforts to cease flaring, capture methane leaks, and dispose of all gas production commercially. A multi-year buildout of gas logistics to the Gulf Coast is facilitating this development. LNG producers continue to face criticism regarding methane emissions and must continue to progress in that area. ***Abundant produced water and its disposal may now be the most challenging issue.*** The volumes involved are large and the seismicity issues associated with disposal into shallow wells has been concerning. With effort, Permian operators have been able to allay community concerns via more careful disposal well planning and drilling.

- ***Many of the conditions facilitating a low carbon footprint will only apply partially or not at all to the Global Unconventional operations.*** Renewable power + battery storage capacity hardly exists in almost all non-U.S. shale/tight sands basins and would have to be built from scratch. In many places the solar/wind combo will not be feasible and basic grid infrastructure is also lacking. Consequently, the potential to electrify global fracking operations will be constrained. The prospects for electrification are probably best in the

Middle East, where solar capacity could be built, and funding exists to support both solar and storage.

- To conclude, ***there are reasons why major oil firms chose the Permian to demonstrate their commitment to low carbon oil & gas production. These same conditions do not exist elsewhere today and can likely only be replicated in part.*** That said, ***Unconventional hydrocarbon production is inherently lower carbon*** on Scope I and II emissions than other forms of development and with effort can be made even lower carbon. However, Net Zero operating emissions is a target unlikely to be reachable outside of the Permian. IOCs considering international Unconventionals are likely to want to see a ‘runway’ to decarbonizing operations. Experience has taught them to anticipate environmental regulations wherever possible. The lack of such a runway may be a serious barrier for IOCs in specific locations.
- Whether this partial carbon footprint advantage is enough to support a case that Unconventionals deserve a ‘best in class’ reputation is our final topic.

QUESTION 7: All Things Considered, are Global Unconventionals the best form of Hydrocarbon development for an Era of Transition?

- ***A strong conceptual case exists that Global Unconventionals would be the best form of Transition hydrocarbon production.*** The following elements make up this case:
 1. A technically producible global resource base so abundant it puts any consideration of ‘Peak Oil’ supply decades into the future.
 2. This resource base is widely distributed rather than concentrated in a single region such as the Persian Gulf.
 3. These basins are known to possess source rock hydrocarbons, implying less exploration risk than with conventional or offshore exploration.
 4. These Unconventional resources are onshore and thus more easily accessed without the need for large scale capital assets to produce them.
 5. Consequently, Unconventional activities can be stopped at some future date without the large ‘stranded asset risk’ characteristic of offshore, tar sands and arctic production activities.
 6. Unconventional production’s ability to be stopped and started relatively quickly makes them ‘short-cycle’ in nature. This provides operators with more ‘optionality’ than other forms of production, a quality well suited to both the industry’s historic cyclicity and the Transition risk of market demand declining.
 7. Finally, Unconventional production offers a smaller carbon footprint/per unit of production than other forms of development, which footprint can be rendered even lower carbon through intentional electrification.

- This case is mitigated by two facts: 1) Unconventional production in many cases will be higher cost per Barrel of Oil Equivalent (BOE) than alternatives; and 2) Unconventionals involve their own environmental impacts, especially several involving water availability, usage and disposal. The different nature of Unconventional production also requires considerable adaptation of existing practices. Field operations must be reconfigured to undertake the continuous drilling needed to grow and sustain Unconventional production, and countries need to revised fiscal terms as previously outlined.
- The conference demonstrated that Unconventionals' cost issues are already being addressed in multiple locations and future economies are readily apparent. Take-away infrastructure is more impeded by political opposition than any technical or economic showstoppers. However, it also revealed that governments now in power in the U.S. and Europe hardly have Global Unconventionals on their radar screens. ***Little policy support exists for encouraging Global Unconventionals*** as a means of securing secure, reliable, and affordable oil and gas during an era of Energy Transition.
- ***These same governments also seem ready to accept growing reliance on OPEC, and more specifically OPEC's Persian Gulf producers.*** As noted, this dependence is embedded in the planning outlooks of agencies like the IEA. ***Why would these governments ignore a growing dependence*** that in the past has resulted in supply interruptions and price spikes?
- ***There are several answers to this question,*** none of which is so compelling that it should preclude governments from taking an altered approach:
 1. The growing dependence on OPEC is out in the future and governments are more focused on immediate issues
 2. The governments in power are primarily dedicated to sensitizing their publics to the climate crisis and the risks posed by hydrocarbon usage and are thus reluctant to endorse any form of oil/gas production as needed longer term
- 3. These governments either believe or want to believe the 'aspirational cases' offered by IEA and others (Accelerated Policy or Net Zero scenarios), under which the need for new hydrocarbon production is reduced.
- **A stubborn set of facts and recent events argues that resting policy on these beliefs will be risky and short sighted:**
 1. Energy demand growth continues to surprise on the high side. While characteristic of the developing world, recent surges in U.S. electricity demand demonstrate that developed economies may also see more than expected growth
 2. Oil & Gas demand continues to grow, despite all the efforts to wean developed economies off hydrocarbon usage. Currently at 104 mb/d of global oil demand, OPEC's 2050 116 mb/d outlook does not look unrealistic.
 3. War in the Ukraine reminded consumers how 'events' can alter long-standing energy supply relationships. It resulted in European gas shortages, soaring prices, and a scramble for alternative supplies. It also resulted in sanctions on Russian production, the long-term effects of which are still unknown
 4. The surge in U.S. AI/Tech/Manufacturing electricity demand has highlighted the limitations of renewables + storage as a single-source Transition solution. These consumers need ultra-reliable, high-quality power 24/7/365. They acknowledge it cannot come primarily from intermittent power supplies. Despite these companies having very public Net Zero aspirations, they are actively seeking supplies based on natural gas and nuclear generation.
- These reality checks are increasingly compelling policymakers to recognize that ***a single goal energy policy, de-carbonization, is risky and infeasible.*** Energy policy must instead be based on multiple goals - adequacy and security of supply, affordability, and de-carbonization - pursued together. ***For the reasons cited above, Global Unconventionals are well suited to support such a multi-goal energy policy.***
- ***There exist multiple fronts on which the next U.S. government could undertake a quiet turn***

towards support of Global Unconventionals.

Supporting alternatives to Russian gas supplies for Europe is an obvious example. Unconventional supplies from Algeria and Caucasus nations like Azerbaijan would be useful supplements to supplies coming from Qatar and U.S. LNG. The impending renegotiation of the U.S.-Canada-Mexico free trade agreement is another. This renegotiation will involve both the U.S. executive branch and the Congress. Consequently, any final agreement will need a broad base of U.S. political support. Mexico has arguably violated that treaty's energy provisions. Negotiating to allow U.S. firms back into Mexican hydrocarbon production would bring that country's shale basins into play while bolstering the entire Mexican economy. Supporting the Milei government's Vaca Muerta development could help sustain his overall reform program and perhaps break the long-standing cycle of foreign exchange crises feeding Argentina's hyperinflation.

- Finally, ***the U.S. government could reinforce producer efforts to de-carbonize their Unconventional production.*** This would involve closely monitoring their progress towards Net Zero in the Permian, validating its actual achievement, requiring the spread of suitable Permian practices to other basins, and encouraging their adoption globally.
- ***Such policy turns by the next U.S. government would implicitly endorse the case for Global Unconventionals as the best form of hydrocarbon production for an era of Transition.*** Then, as Unconventional supplies began to materially appear in current supply/demand balances, their feasibility and contribution would be more recognized. More options globally would materialize and efforts to overcome the barriers described in this report would intensify. The results would be a more secure and affordable energy outlook for the global economy, and one more responsive to however other aspects of the Energy Transition were working out.



APPENDIX

Slides & Charts Presented in Support of Key Findings

In this section we provide materials presented at the conference which illustrate and support the conclusions presented above.

Brief commentaries will be provided for each to emphasize the key data contained in each slide or chart.

I. Global Unconventional Resources recoverable with Current Technology

This data from IEA shows potential Unconventional oil & gas resources outside the U.S. at levels consistent with indications at the 2016 conference, e.g., 300+ billion barrels of tight oil ex-U.S.

Remaining technically recoverable fossil fuel resources, 2022							
Oil (billion barrels)	Proven reserves	Resources	Conventional crude oil	Tight oil	NGLs	EHOB	Kerogen oil
North America	220	2 392	235	215	146	797	1 000
Central and South America	303	854	247	57	49	497	3
Europe	14	111	56	19	28	3	6
Africa	125	451	312	54	83	2	-
Middle East	900	1 122	878	29	171	14	30
Eurasia	146	937	224	85	58	552	18
Asia Pacific	51	275	120	72	64	3	16
World	1 760	6 142	2 071	531	600	1 868	1 073
Natural gas (trillion cubic metres)	Proven reserves	Resources	Conventional gas	Tight gas	Shale gas	Coalbed methane	
North America	17	147	50	10	81	7	
Central and South America	9	84	28	15	41	-	
Europe	5	46	18	5	18	5	
Africa	19	101	51	10	40	0	
Middle East	83	121	101	9	11	-	
Eurasia	69	167	129	10	10	17	
Asia Pacific	21	138	44	21	53	20	
World	222	803	421	80	253	49	

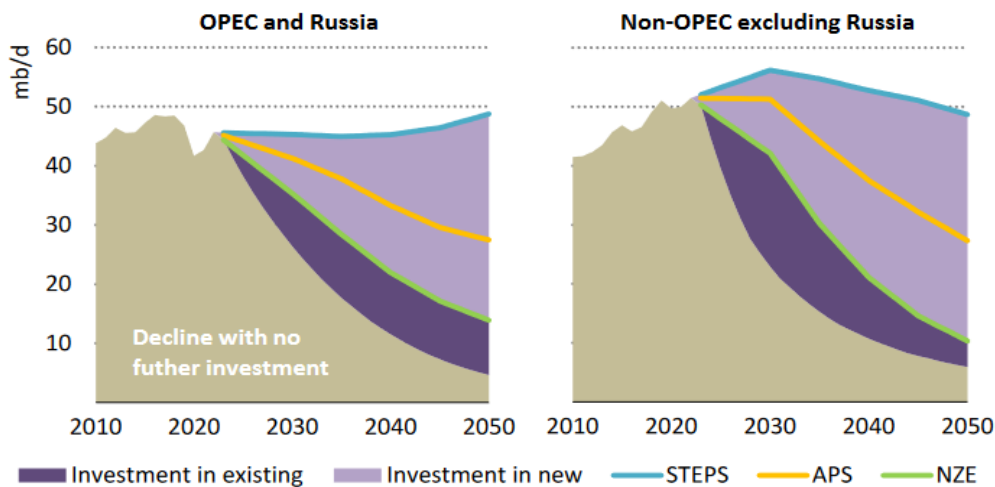
Source: IEA report ???, table 6.1

II. IEA's 2023 Forecast Oil Supply to 2050 'Call on OPEC+' and Needed Oil Discoveries

These two charts illustrate the minimal Unconventional production ex-U.S. in IEA's 2023 STEPS Scenario to 2050 and the 'Call on OPEC+' which results from the Persian Gulf states being the default producer reconciling oil demand and supply.

Global liquids demand and supply by scenario (mb/d)								
	2010	2022	STEPS		APS		NZE	
			2030	2050	2030	2050	2030	2050
Road transport	36.5	41.3	41.1	35.5	37.6	15.9	29.1	1.6
Aviation and shipping	9.9	10.6	13.5	17.2	12.5	9.0	10.5	2.1
Industry	17.2	20.6	23.3	25.5	21.4	17.8	20.3	14.3
Buildings and power	12.4	11.4	9.5	6.7	8.6	4.1	6.1	0.5
Other sectors	11.1	12.6	14.0	12.5	12.4	7.9	11.4	5.7
World oil demand	87.1	96.5	101.5	97.4	92.5	54.8	77.5	24.3
Liquid biofuels	1.2	2.2	3.0	4.5	4.8	7.0	5.6	5.4
Low-emissions hydrogen-based fuels	-	-	0.0	0.2	0.2	3.6	0.7	6.0
World liquids demand	88.4	98.7	104.5	102.1	97.5	65.4	83.7	35.7
Conventional crude oil	67.4	62.8	61.3	58.2	54.9	29.8	48.0	15.8
Tight oil	0.7	8.3	11.1	10.2	10.3	6.9	7.6	1.8
Natural gas liquids	12.7	19.0	21.2	19.4	20.1	13.6	16.2	4.4
Extra-heavy oil and bitumen	2.0	3.7	4.4	5.5	3.9	2.5	3.0	1.5
Other production	0.5	0.9	1.0	1.2	0.9	0.3	0.3	0.0
World oil production	83.1	94.8	99.1	94.5	90.2	53.1	75.1	23.5
<i>OPEC share</i>	40%	36%	35%	43%	35%	45%	37%	53%
World processing gains	2.2	2.3	2.4	2.9	2.4	1.6	2.3	0.7
World oil supply	85.3	97.1	101.5	97.4	92.5	54.8	77.5	24.3
IEA crude oil price (USD [2022]/barrel)	103	98	85	83	74	60	42	25

Oil production by OPEC & Russia and Other non-OPEC producers by scenario, 2010-2050



III. Factors Determining Unconventional Resource Attractiveness

This chart shows one firm's assessment of the factors bearing on the commerciality of Unconventional resources and how that firm rates the conditions in specific countries:

What is needed to unlock global shale and tight resource?

	U.S.	Canada	Argentina	Saudi Arabia	UAE	Russia	China	Australia	Mexico
Favorable Geology	✓	✓	✓	✓	✓	?	?	?	?
Land Rights & Lease Terms	✓	✓	?	✗	✗	?	?	✓	✗
Industry Capability & Supply Chains	✓	✓	?	?	?	?	✓	✓	✗
Infrastructure & Market Access	?	?	✗	?	?	?	✓	?	✗
Supportive Policies	✓	✓	✓	✓	✓	✓	✓	?	?

Visible
 Watchpoint
 Notable Gaps

Note that this assessment is from an IOC's perspective and would not reflect the assessment necessarily made by either a National Oil Company or an Oil Field Services firm.

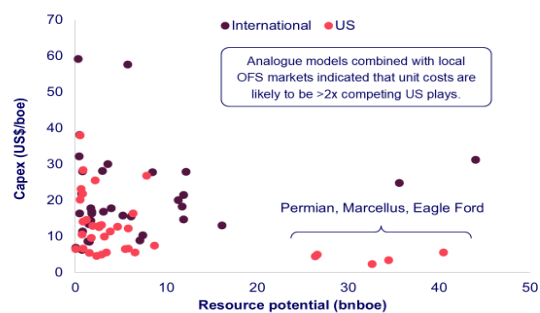
IV. Differing Views Presented on Attractiveness of Global Unconventional locations

The conference highlighted the role of National Oil Companies in leading Unconventional development as indicated by the following charts. This began with a comparison of international opportunities with cost and volume potential of the major U.S. basins.

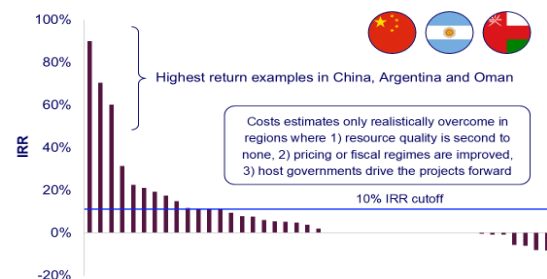
Casting a VERY wide net: global resource potential

Global unconventional boom (2009 to 2016) marked by extreme optimism to easily commercialize resources and rebalance regional gas markets

Global exploration benchmarks: US projects cheaper



Anticipated international unconventional well returns

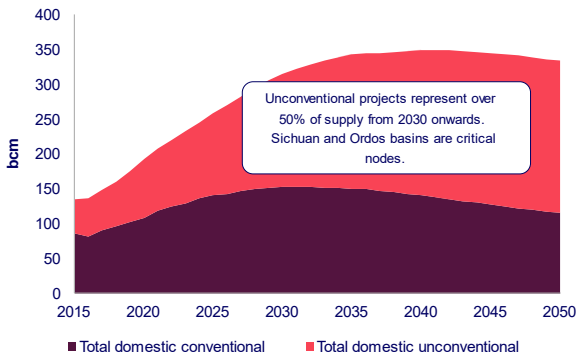


Additional data highlighted the leading role of NOCs in comparison with IOCs, who still enjoy a long, attractive runway in U.S. Unconventionals. Here you see the large activity of the Chinese state oil firms in developing gas for that economy, while U.S. IOCs scale up in the Permian.

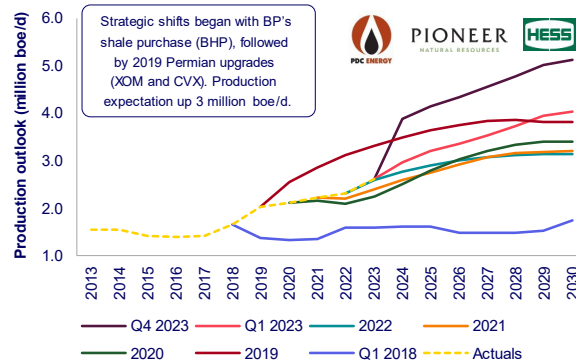
Commerciality often dictated by need as much as opportunity

NOCs play a more pivotal role going forward. Majors' short -cycle ambitions have been largely filled in Lower 48. What new tools and technologies can the Majors offer global shale?

China domestic gas production



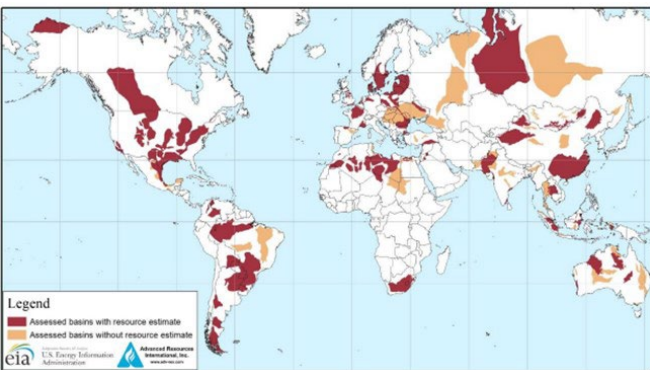
Evolution of Majors NA unconventional asset growth



These charts provide more detail, i.e., large Unconventional rig counts and new wells in China. Saudi Arabia and Argentina are other locations where NOCs, i.e., Saudi Aramco and YPF, are leading the way and their levels of activity are anticipated to grow over the next several years.

Estimated Size of Current International Markets

Map of basins with assessed shale oil and shale gas formations, as of May 2013



Source: United States basins from US Energy Information Administration and United States Geological Survey; other basins from ARI based on data from various published studies.

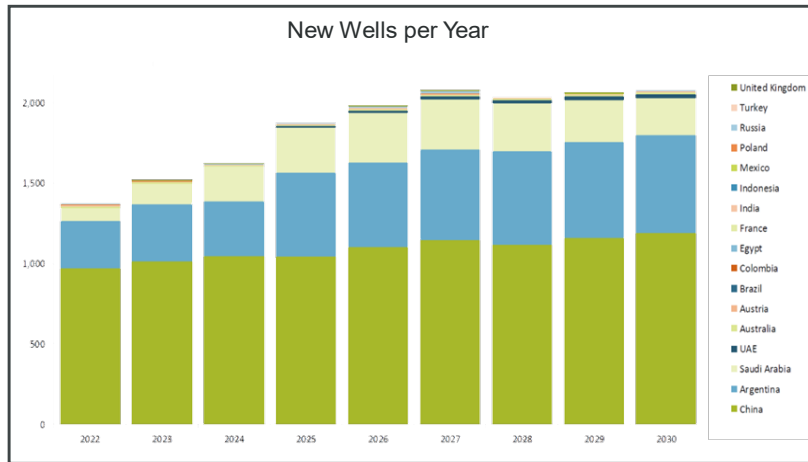
Estimated 2025 well counts & break-even price across the globe

O&G Company	Estimated 2025 Uncon Well Count	Estimated Break-even Price
ARC (CAN)	164	\$2.29
Tourmaline (CAN)	298	\$2.71
Diamonback (USA)	267	\$37.00
Chevron (USA)	482	\$42.00
Oxy (USA)	548	\$40.00
COP (USA)	569	\$43.00
Exxon (USA)	985	\$53.00
ADNOC (UAE)	10*	
YPF (ARG)	209	\$35-40
Aramco (Saudi)	279	
PetroChina (China)	921	

*Estimate only. Potential to be higher on recent agreements

Why is it Working in Argentina, Saudi & China?

- Time
- Service Ecosystem
- Infrastructure
- Logistics
- Materials Supply
- Accelerated Learning Curve
- Geologically Accessible



Source: Rystad Energy WellCube

V. International Progress on Unconventional Development Costs & Economics

The rig count chart above also notes estimated breakeven Unconventional costs and indicates the considerable progress made in Argentina's Vaca Muerta. Field operating costs there now resemble those of many U.S. Unconventional producers.

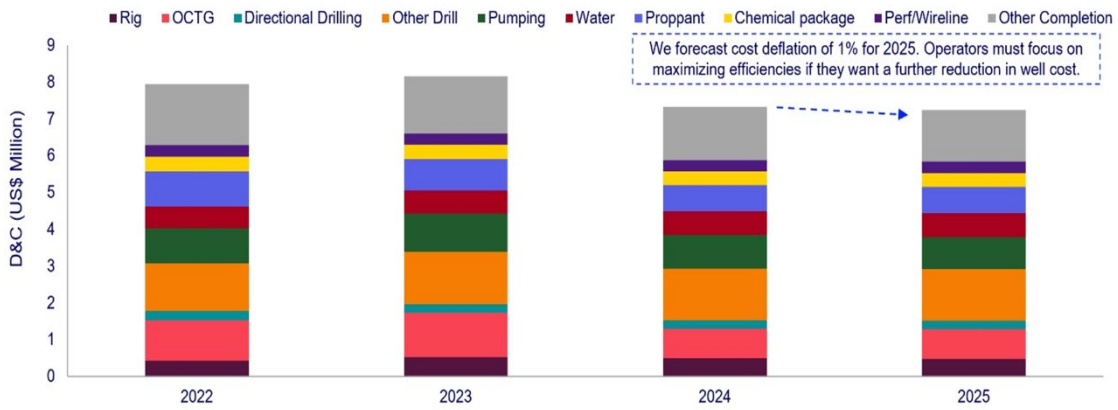
The U.S. continues to record progress in lowering Unconventional drilling costs. Formidable progress was achieved between 2016 and 2023. The chart below illustrates this progress in percentage terms for the various elements involved in Unconventional development.

Technical Evolution of US Shale Wells

<i>Frac Design and Production Evolution of US Shale Wells</i>		<i>Oil-Rich</i>			<i>Gas Rich</i>		
Parameter	Unit	2012 Average*	2023 Average*	Change	2012 Average*	2023 Average*	Change
Lateral Length	ft	6,349	9,814	55%	4,759	10,152	113%
Stage Count		20.5	45.6	122%	14.6	54.0	269%
Stage Intensity	ft/stage	309	215	-30%	325	188	-42%
Perf Clusters/Stage	/stage	4.8	9.7	102%	5.9	9.1	54%
Proppant Mass	lbs	4,300,000	19,800,000	360%	4,600,000	26,800,000	483%
Proppant Mass per Lateral Foot	lbs/ft	677	2,019	198%	970	2,641	172%
Fluid Volume	bbl	90,000	442,000	391%	127,000	577,000	354%
Fluid Volume per Lateral Foot	bbl/ft	14.1	45.0	219%	26.6	56.8	114%
Average Proppant Concentration	PPG	1.14	1.07	-7%	0.87	1.11	28%
Max Rate	bpm	43.3	98.5	128%	71.5	101.9	43%
Max Rate per Lateral Foot	bpm/ft/stage	0.14	0.46	227%	0.22	0.54	146%
365-Day Cumulative Oil Equivalent per Well	BOE/well	104,000	243,000	134%	193,000	665,000	245%
365-Day Cumulative Oil Equivalent per Lateral Foot	BOE/ft	16.4	24.8	51%	40.6	65.5	61%
Well Cost	Million\$	\$7.3	\$6.9	-6%	\$9.0	\$8.5	-6%
Cost per Barrel Oil Equivalent	\$/1-Year BOE	\$70	\$28	-60%	\$47	\$13	-73%

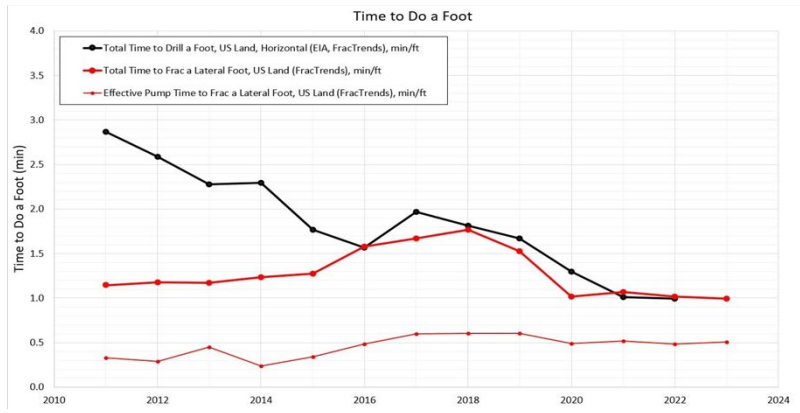
This progress increasingly emphasizes reduced time to drill wells, longer laterals, more completions per well, and simplifying operations in the name of efficiency.

Well Cost Estimates – Midland Wolfcamp



Drilling days:	15.6	15.2	14.7	14.4
Pumping days:	5.8	5.4	5.2	5.0

Lower 48 Upstream Cost CoE. Design: TVD - 8,500 ft, Lateral Length - 10,000 ft, Proppant - 2,400 lbs/ft, Water - 2,400 gal/ft, Stages - 50, Tier IV Diesel Zipper frac.



These gains have now been replicated in some international locations and not in others. As a result, operating margins have moved into positive territory in some locations while in others the NOCs move ahead, motivated by state and societal interests.

International U/C Cost Structure Headwinds

	Headwinds	In the money, or close?
Middle East	<ul style="list-style-type: none"> Delays Inconsistent planning NOC size – bureaucracy and role changes 	Yes. Perhaps not a priority yet.
China	<ul style="list-style-type: none"> IP protection Complicated organization Weak collaboration Export cash 	Yes. Technically inefficient. Few international partners.
Argentina	<ul style="list-style-type: none"> Fiscal security Low activity 	Yes. Structured approach to growth.
North Africa (Libya, Algeria, Chad)		No. Market proximity but not a priority and politically challenged.
Australia	<ul style="list-style-type: none"> Distance Scarce service availability 	Yes. Structured approach to growth.
Europe	<ul style="list-style-type: none"> Societal friction and anti-frac sentiment Stable regime and regulation 	No. Needs political support.

A point not reflected in the headwinds just cite is the structure of legacy fiscal regimes in almost all international locations. Based on Production Sharing Contracts designed for conventional and offshore production, their tax

progressivity and ceilings on IOC incentives are ill-suited to incentivize Unconventional production. These charts provide more detail on how fiscal regimes should be redesigned if Unconventional activity is to be encouraged.

- Hydrocarbon framework for unconventional same as for conventional
 - Global unconventional development at early stage, outside North America
 - Issues arise if conventional framework not flexible enough to adapt to unconventional projects

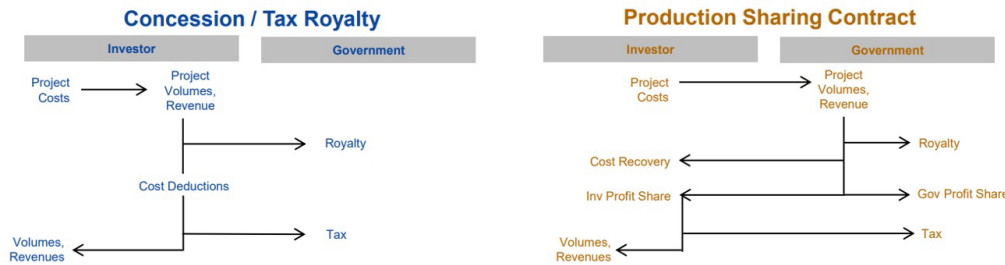
Unconventionals compared to conventionals

- Higher uncertainty in recovery / rate due to lower rock and/or fluid quality
- Generally higher cost structure vs onshore developments (more wells for same resource, complex drilling & completion)
- Longer timeframe to determine commerciality (exploration/appraisal not completed with a few wells, but continual learning/refinement)
- Slower build-up of production volumes; Continuous investment to maintain production
- May need specialized capabilities (horizontal wells, hydraulic frac, multilateral wellbores)
- Supply chain / infrastructure more challenging (e.g. sand and water sourcing/disposal, processing, transportation, sales)

Framework overview for unconventionals

- Sufficient exploration/appraisal timeframe to evaluate resource and optimize development plan (e.g. multi-year pilots)
- Production term that matches long-life of unconventional resources
- Ability to hold undeveloped acreage for long periods of time
- No systematic practice of dividing rights into different horizons
- Enabling use of land, roads, infrastructure, supply chain, with ability for simultaneous ops
- Fiscal terms reflecting returns commensurate with risk

The key reforms cited here work with the Production Sharing Contract but re-design it to fit the different production profile and work requirements of Unconventionals. The two key changes are to reduce the progressivity of the PSC effective tax rate towards neutrality and eliminate the ‘cumulative parameters’ which cap the investors total return.



- Equity in production/facilities differentiates two main systems – Concession Investor owns, PSC Gov owns
- Concession well-established in uncon N. America; but PSC can also be tailored to incent resource development
- Benefits of neutral or slightly progressive system
 - Government take constant or increases/decreases as project profits increase/decrease
 - Adapts to price and cost variations
- Encourage new developments and cost efficiencies
 - Avoid overly high royalties, extremely progressive fiscal terms, and those based on cumulative parameters
 - Avoid ring-fencing, enable consolidation
 - Market-based pricing, free to export profits, no currency restrictions, avoid double taxation
 - Able to book reserves
- Economic stability over project life

VI. Specific Locations with Unconventional Potential – Recent Progress, Remaining Barrier

Canada, specifically Alberta, emerged as one location where recent progress offers IOCs a basis for renewed interest. Two pipelines to the Pacific, one oil, one natural gas, are now in place and Canada's political environment is becoming more favorable to Unconventional development.

Economics/Tax Regime/Growth

- Geology - the rocks rock!
- Competitive royalties, fiscal regime
- AI data centres attracted to cheap gas
- ITCs and favorable geology for CCUS
- LNG Canada will export about 10% of domestic gas in the next six months, putting a new floor under prices
- New federal government likely in 2025, new provincial government in B.C. possible in October
- Carbon taxes have likely peaked
- Current Alberta Premier and administration most favorable to oil and since 2006

In Case You Forgot... Massive Resource Base

- Montney 567 TCF of gas - Alberta 224 TCF B.C. 271 TCF
- Liard Basin 167 TCF
- Horn River/Cordova 87 TCF
- Duvernay 2.4 billion barrels oil, 5.7 billion barrels condensate, 54 TCF of gas
- Oil sands – 173 billion barrels world's 3rd largest reserves
- Bitumen SAGD – 43 billion barrels (median case) remaining established reserves

The pipeline additions offer some current spare capacity. However, a demonstrated ability to deliver new pipelines as needed will be critical to unlocking Alberta's Unconventional growth. Memories of Kinder Morgan's Trans-Mountain pipeline travails and the overruns incurred by the Canadian government's project takeover remain strong.

Oil Pipelines

Pipelines	Export Capacity	Additions
All	3.94 MMB/D	
Enbridge	3.26 MMB/D	
Keystone	0.58 MMB/D	
Trans Mountain*	0.30 MMB/D	0.58 MMB/D
Express	0.31 MMB/D	
Others	0.21 MMB/D	
Rail	0.15 MMB/D	

***Capacity increase of 580,000 b/d May 2024**

Gas Pipelines

Gas Pipelines	Capacity	Current*	Additions
Enbridge BC	1.71 BCF/D	1.18 BCF/D	
Alliance	1.61 BCF/D	1.51 BCF/D	
Foothills	5.14 BCF/D	2.91 BCF/D	
TC Mainline	6.22 BCF/D	3.75 BCF/D	
Totals	14.68 BCF/D	9.36 BCF/D	
Coastal GasLink*	5.0 BCF/D	2.2 BCF/D	2.8 BCF/D

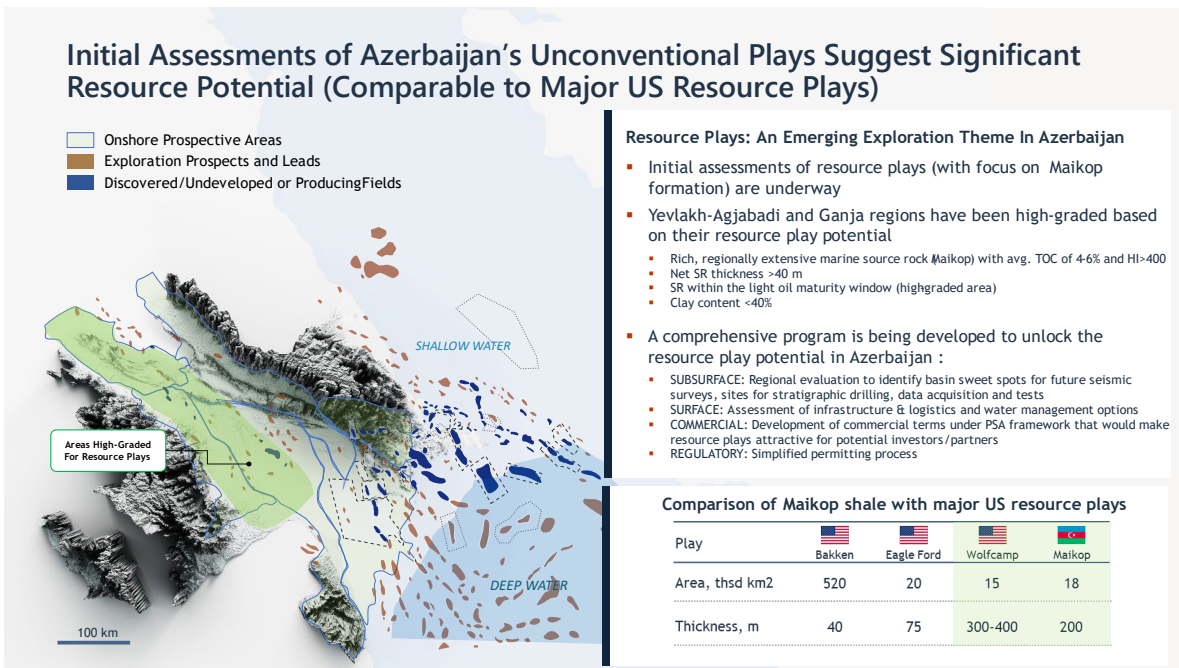
***Completed Q3 20204, LNG Canada to commence Q2/25**

Argentina's Vaca Muerta offers the most complex mix of attractions and risks. The resources are first rate, the potential economics attractive, but a variety of 'above ground' risks continue to discourage a full out IOC effort. The following chart summarizes Argentina's Unconventional pros/cons.

Lifting Barriers

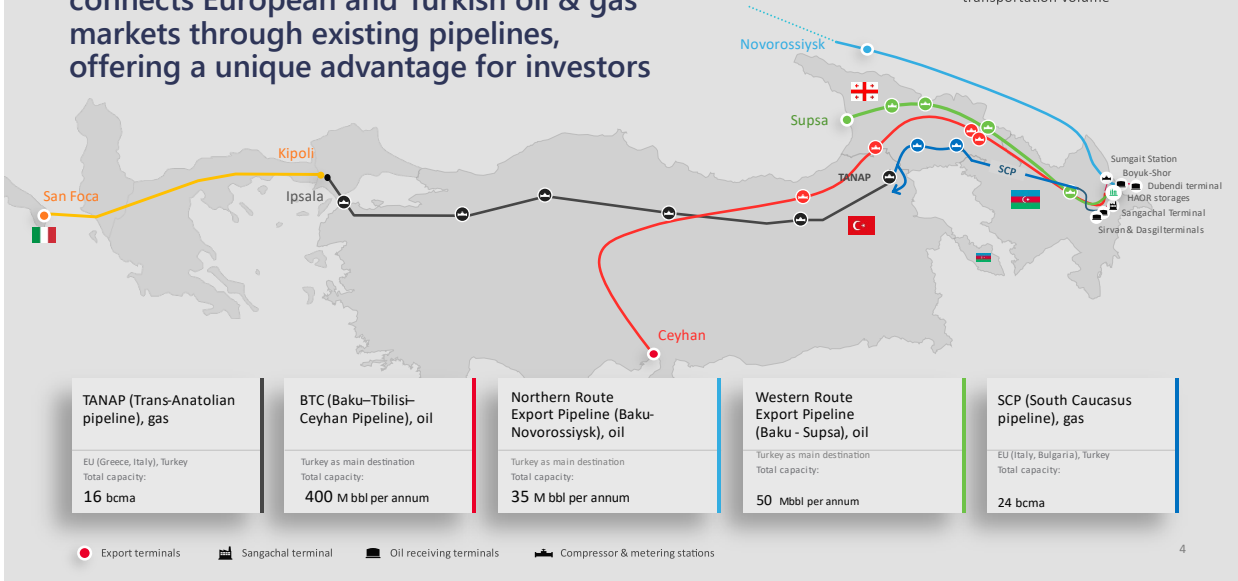


Other areas of potential interest include Algeria, Azerbaijan, Australia and Georgia. Algeria's attractive resources and existing gas pipeline connections to Europe have drawn interest from major IOCs. The other three locations are at a stage where they are campaigning to attract investors. Azerbaijan's historic relationship with IOCs, its need to reverse declining production and its established pipelines to market are factors in its favor.



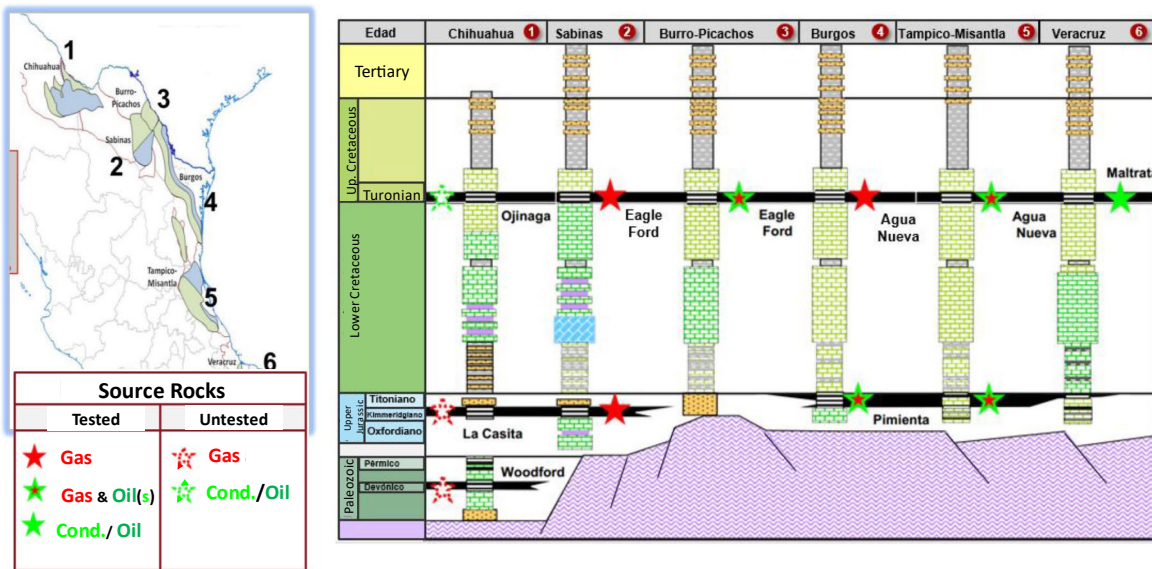
Azerbaijan's strategic location seamlessly connects European and Turkish oil & gas markets through existing pipelines, offering a unique advantage for investors

All pipelines currently have free capacity and potential to increase transportation volume



Mexico's multiple, near-to-the-U.S. shale basins appear off limits for now due to politically imposed fracking bans. It remains to be seen whether a new president from the same party that imposed the bans will take any different action in the face of Pemex' seriously declining oil & gas production.

Basins with Unconventional Resources N.E. - MEXICO



Paradigms: MEXICO Sep.2024

Declining Oil Production: 1.5 MM stbo/d

Declining Gas Production: 3.8 BCF/d

Increasing Gas Imports: 8.0 BCF/d

Pemex does not generate enough Production

Pemex is highly indebted > **US\$100 B**

Infrastructure is needed

New reservoirs continue to be discovered

CNH₂₀₁₉: ~19,600 Wells_{DATA} from ~30,600 drilled

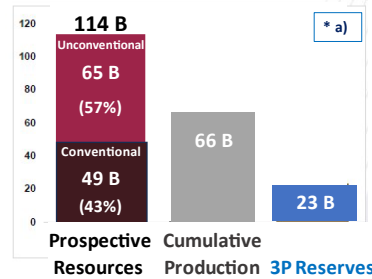
~8,500 Wells have been fracked.

[27 for unconventional]

→ No known Aquifer Contamination

Hydraulic Fracturing has been banned: Last 6 years

Government aims for Energy Independence



So,
why is Fracking Banned?

VII. Global Unconventionals Lower Carbon footprint

Unconventional production for shales/tight sands tends to produce natural gas, NGLs and very light crude oils. As such it is inherently lower carbon than other types of crude oil production, especially heavy oils and tar sands. The potential to electrify what amounts to 'industrial style' drilling/fracking of the resources offers considerable potential to lower this footprint further. In some places, electrification can be accomplished using renewable sources, i.e. wind, solar and storage. In many others the substitution of natural gas for diesel as turbine fuel can accomplish considerable de-carbonization. Here, not only is less CO₂ produced by the turbine's combustion, but the use of associated gas produced by the operation avoids releasing methane, CO₂ or both into the air.

Electric fracturing - 40,000 HHP frac spread

2 Gas turbines (NovalT™16) vs. 16 Tier 4 diesel engines

- 90%**
Lower NOx Emissions

Additional benefit on CO₂ expected from flaring avoidance when on Gas Turbines

14-hours full load operation, 2500HP diesel engines, 10kg CO₂/gallon* (-8% reduction CO₂ at base load ***)
- 20%**
Reduced Noise

85 dB(A) vs. 105 dB(A)**

(at 1m from equipment and 1.5m elevation)
- 86%**
Fuel Savings

2.6M\$ savings per month in fuel (3.0M\$ diesel vs 0.4M\$ natural gas)

14-hours full load operation (86% saving in intermittent operation profile***) (\$3.80 per gallon diesel, \$2.74 per Mcf natural gas*)
- 40%**
Smaller Footprint

Higher power density ...no power limits on e-drivers allow larger pumps (+5000HP) reducing pump fleet & trailer footprint

No need for liquid fuel storage ...reduce trailers traffic and logistics complexity

VIII. Global Fracking as the Best Form of Hydrocarbon Production for a Transition Era

This final slide summarizes the strong case for Global Fracking in an Era of Transition while also enumerating the various conditions and barriers which suggest 'Not Yet' and 'Not Until various Conditions evolve or are Addressed.'

Global Fracking – Best for a Transition Era?



The Conceptual Case

- **Enormous Resource Base** – addresses Peak Oil
- **Widely distributed** – for Energy Security
- **Short Cycle** – can be easily stopped if not needed
- **Fewer fixed assets** – less Stranded Asset risk
- **Optionality addresses business Cyclicity**
- **Lower carbon footprint** – Can be lower still

Concerns and Barriers

1. Many locations not 'in the money' yet, and not needed while U.S. still growing
2. Disruption & environmental concern lead to fierce opposition, Bans in locations
3. Home governments of major IOCs oppose supporting oil & gas development
4. Various local barriers from fiscal regimes to FX shortage, infrastructure, political risk

VERDICT: Well suited for Transition WHEN/IF oil/gas demand prove resilient & U.S. supply 'tops out'

