Unconventional Oils: The 21st Century Rescuer?

By Jean Balouga*

Introduction

Fossil fuels (coal, oil, and natural gas) account for roughly 85 percent of global energy consumption. Renewables and nuclear energy make up the rest. And while the growth in solar and wind has been enormous, the base is small, and intermittency and infrastructure challenges remain a significant hurdle to widespread adoption. In the wake of the Macondo oil spill in 2010, the Fukushima nuclear incident in 2011, and the shale gas "revolution," the energy landscape is changing. Higher prices and technology applications at scale are driving the unconventional resource revolution as there are enormous unconventional oil and gas resources the world over. This phenomenon has the potential for creating a new energy reality, one in which the U.S. once again becomes a global leader in oil and gas production. This, coupled with efficiency improvements and alternative supplements, can substantially reduce U.S. oil imports, achieving a significant reduction in her balance of payments. It can also simultaneously create an engine for economic growth, a platform for technology and innovation, job creation, new tax and royalty revenues, and the revitalization of domestic industries.

The realignment of world oil prices upward, settling above $100 per barrel over the past year, is spurring a transformation of oil technology and markets. The oil industry is posting substantial profits, reinvesting significant capital, and gaining new capacities to identify, probe, recover, and process oils that were once unknown, inaccessible, unmanageable, or uneconomical. As such, oil corporations and national oil companies are developing a wide array of new oils worldwide.

Blurred Definition

Though they have been recognized as new sources of petroleum, according to the U.S. Energy Department, unconventional oils have yet to be strictly defined. In reality, new oils are emerging along a continuum from conventional crudes to transitional oils to unconventional oils, with their classification varying according to the ease of extraction and processing. While no two crudes and oil processes are identical, petroleum products—at least for the time being—are expected to remain relatively unchanged in appearance and use despite burgeoning changes in oil quality. That gasoline, diesel, and jet fuel will likely remain unchanged at the pump will obscure the fact that oils are transforming upstream, with unintended societal consequences—from increased climate forcing and groundwater contamination to forest destruction and impacts on indigenous cultures.

Many new breeds of petroleum fuels are nothing like conventional oil. Unconventional oils tend to be heavy, complex, carbon-laden, and locked up deep in the earth, tightly trapped between or bound to sand, tar, and rock. Unconventional oils are nature's own carbon-capture and storage device, so when they are tapped, we risk breaking open this natural carbon-fixing system. Generally speaking, the heavier the oil, the larger the expected carbon footprint. From extraction through final use, these new oils will require a greater amount of energy to produce than conventional oil. And as output ramps up to meet increasing global demand for high-value petroleum products, unconventional oils will likely deliver a higher volume of heavier hydrocarbons, require more intensive processing and additives, and yield more byproducts that contain large amounts of carbon. This is a key moment to determine the future energy balance between oil and low-carbon alternative fuels. This paradigm shift in petroleum sources, if left to the marketplace alone, will likely have profound local and global impacts. Understanding the trade-offs associated with unconventional oils will be instrumental to managing them prudently. Only with sound policy guidance can we arrive at a de-carbonized fuel system to drive our transportation sector and fuel the global economy.

This heterogeneous bundle of resources not only represents a departure from conventional oil, new oils differ widely from one another as well. The spectrum of new oils runs the gamut: some of tomorrow's liquid hydrocarbons are akin to today's oil, others will evolve but remain more oil-like, and still others will be synthesized from coal or natural gas. Transitional oils, for example, tend to have conventional make-ups but are difficult to extract. These include tight oils, which is oil trapped in shale that can be accessed by hydraulic fracturing or "fracking", a procedure by which rock formations are fractured by injecting fluids to force them open, allowing oil (and gas) to flow out. Ultra-deep oils, that are buried as remotely as 10 miles below the water's surface, are also considered transitional. More coal-like oils include semisolid extra-heavy oils such as bitumen in tar and oil sands, kerogen in oil

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shale, and liquid oils derived from coal itself.

Tight and Transitional Oils

Conventional oils are also being found in difficult-to-reach places. Ultra-deep oil in the Gulf of Mexico, for example, can be trapped many miles below the ocean floor. Oils have been discovered under 4 miles of water, salt, sand, and rock as well. Deep pre-salt fields—generally high-quality oil located in deep-sea areas under thick layers of salt and requiring large-scale investment to extract—are offshore of Brazil and West Africa. They are the first of their kind being drilled around the globe. In North America, tight shale oils are being fracked in the northern Bakken (spanning North Dakota, Montana, Saskatchewan, and Manitoba); in Eagle Ford, Barnett, and the Permian basin in Texas and New Mexico; in the Cardium play in Alberta; in the Miocene Monterey and Antelope deposits in California; in Mowry-Niobrara in Wyoming and Colorado; in Oklahoma's Penn Shale; in Montana's Exshaw Shale; and in Utica Shale in Colorado, Wyoming, and New Mexico. Additional transitional tight shales are being probed for oil (and gas) in New York, Maine, Mississippi, Utah, and Alaska's North Slope and Cook Inlet.

There is an even-greater potential for new tight oils on a global scale in China, Australia, the Middle East (especially Israel), Central Asia (Amu Darya Basin and the Afghan-Tajik Basin), Russia, Eastern Europe, Argentina, and Uruguay.

Transitional oils are oils with conventional compositions that are extracted by unconventional means. As conventional oils become less accessible, new, more technical, energy-intensive methods are being developed for their recovery, from ultra-deep wells drilled miles below the sea to fracturing shale rock in order to tap oil trapped in low-permeability siltstones, sandstones, and carbonates deep in the earth. But no two source rocks are alike. Therefore, no two shale oils are exactly alike. The lighter and sweeter the oil, the less involved the processing and the higher the yield of high-value petroleum products, including gasoline, diesel, and jet fuel. But the more extensive the recovery method, the more energy is required for extraction, which means that these oils tend to result in higher carbon emissions and other societal impacts.

New oil conditions in the Arctic are unlike any other and will require drilling in some of the coldest waters, far from civilization, amid areas of high environmental sensitivity and unpredictable weather. Still, the Arctic Circle nations, including Russia, the United States, Canada, Norway, and Denmark—with one-sixth of the world's landmass and spanning 24 time zones—may constitute the geographically largest unexplored prospective area for petroleum remaining on earth. The United States Geological Survey has assessed the area north of the Arctic Circle and concluded that about 13 percent of the world's undiscovered oil and 30 percent of the world's undiscovered gas may be found there.

In the latter part of the twentieth century, as conventional oils became more heterogeneous, their geography became increasingly more diversified. **Heavy oils** in California, Venezuela, China, Indonesia, the Middle East, and along the Alberta-Saskatchewan border initiated the oil transition.

Unconventional Oils

Lacking a clear definition, unconventional oils are typically identified by their characteristics. The heavier the oil is—for example, oil sand (bitumen) and oil shale (kerogen)—the more carbon laden, higher in sulfur, and filled with toxic impurities. Unconventional oils are typically much heavier and sourer than even the lowest-quality conventional oil. An array of unconventional solid, liquid, and gaseous hydrocarbons can be processed into petroleum products. But these extra-heavy, impure oils require very large energy inputs to upgrade and preprocess into synthetic crude oil that is then processed by a refinery. Some new oils are effectively solid and must be removed through mining or heated in place *(in situ*) until they flow. These new oils tend to be less valuable than conventional crude, which is readily transformed into the most marketable petroleum products by today's standards.

Oil Sands (bitumen)

They are a combination of quartz sand, clay, water, trace minerals, and a small (10–18 percent) share of bitumen, and their sulfur content can be in excess of 7 percent. Bitumen is made up of organic components ranging from methane—the simplest organic molecule—to large polymeric molecules having molecular weights in excess of 15,000. This extremely complex hydrocarbon mixture can be synthetically processed into oil. However, it cannot be transported to market by pipeline without adding diluting agents—such as gas-processing condensates including the diluent pentanes plus—to meet pipeline density and viscosity limitations. A large portion of Alberta's bitumen production is currently upgraded to synthetic crude oil and other products before shipment to refineries.

Extra-Heavy Oils

The bitumen contained in oil sands is the most prevalent extra-heavy oil. The estimated world's total quantity of extra-heavy oil in place is 5,756 billion barrels (WEC, 2007:121). The province of Alberta, Canada—including the Athabasca Wabiskaw-McMurray, Cold Lake Clearwater, and Peace River Bluesky-Gething regions—has the globe's largest deposits of bitumen. Outside of Canada, 21 other countries have bitumen resources, including Kazakhstan, Russia, Venezuela, and Africa, including the Republic of Congo, Madagascar, and Nigeria. In the United States, oil sands are deposited in at least a dozen states, including (in relative order) Alaska, Utah, Alabama, California, Texas, Wyoming, Colorado, and Oklahoma. However, the U.S. and other nations' oil sand reserves are currently considered to be far smaller in volume than Canada's reserves and may also be less easily recovered due to different physical and chemical compositions. Extra-heavy oil (non-bitumen) is recorded in 166 deposits worldwide, the largest in eastern Venezuela's Orinoco Oil Belt. The deposits are found in 22 countries, with thirteen of the deposits located offshore.

Oil Shale (kerogen)

This is "immature oil" that has not been in the ground long enough to form oil. It is mostly composed of clay, silt, and salts, with a small (12 percent) share of insoluble organic matter (kerogen) and even smaller (3 percent) share of soluble bitumen. The organic kerogen, once extracted and separated from the oil shale, can be processed into oil and gas. Like oil sands, oil shale has a similarly high sulfur content—up to 7 percent. Kerogen has the potential to be one of the largest unconventional hydrocarbon resources in the world. Conservatively, it is estimated at 2.8 trillion barrels (WEC, 2007:94). In North America, the richest and thickest oil shale deposits are in the Green River Formation, which covers portions of Colorado, Utah, and Wyoming. Prudhoe Bay, Alaska, and additional basins in Colorado (Piceance), Utah and Colorado (Uinta), and Wyoming (Washakie) are also known locations of oil shale. A block of U.S. states bordered by Michigan, Missouri, Alabama, West Virginia, and Pennsylvania contains a grouping of large oil shale plays, that is, promising areas targeted for exploration. Internationally, Brazil, Israel, Jordan, Sumatra, Australia, China, Estonia, France, South Africa, Spain, Sweden, and Scotland all have notable oil shale deposits. (There is an estimated 1.7 billion barrels of oil shale in Nigeria (WEC, 2007:114)).

Production Method	**Product**	**Operating Cost**	**Supply Cost**
Cold (Wabasca, Seal)	Bitumen	6-9	14-18
Cold heavy oil with sand (Cold Lake)	Bitumen	8-10	16-19
Cyclic steam (Cold Lake)	Bitumen	10-14	20-24
SAGD	Bitumen	10-14	18-22
Mining/extraction	Bitumen	9-12	18-20
Integrated/mining extraction, upgrading	Syncrude	18-22	36-40

Costs in Canadian dollars (assumed at 2005 US $0.85), at plant gate.

TABLE: Estimates of Operating and Supply Costs by Production Method

Source: WEC, 2007, p.124

At the core, geologic and chemical factors determine the geography of new oils. Global oil - that beyond confirmed assets currently owned by companies or contained in countries (proven reserves) - is being remapped. Looking ahead, it is increasingly likely that international oil companies will be involved in developing the "frontier" oils -shale, tight, deep offshore, Arctic - due to their expertise and experience. Innovative, asset-rich, profit-driven, and technologically capable international oil companies may be a significant factor in identifying North America's large unconventional oil reserves. This will not diminish the longer-term dominant role of state-run national oil companies, which own some 75 percent of the world's proven conventional oil reserves and still reap the benefits of their comparatively low production costs. Still, these national companies have historically lagged on commercial reserve replacement given tensions to use national capital budgets to fulfill important social and economic goals. International oil companies will have to take on more risk, developing new oils in new geographies and under new conditions. But the prospects for profit are driving these difficult plays.

Further Challenges

In addition to the uncertainty of not yet having an economical and environmentally viable commercial scale technology, the following challenges should be considered:

Impacts on water, air, and wildlife: Developing oil shale and providing power for oil shale operations and other activities will require large amounts of water and could have significant impacts on the quality and quantity of surface and groundwater resources. In addition, construction and mining activities during development can temporarily degrade air quality in local areas. There can also be long-term regional increases in air pollutants from oil shale processing and the generation of additional electricity to power oil shale development operations. Oil shale operations will also require the clearing of large surface areas of topsoil and vegetation which can affect wildlife habitat, and the withdrawal of large quantities of surface water which could also negatively impact aquatic life.

Socioeconomic impacts: Oil shale development can bring an influx of workers, who along with their families can put additional stress on local infrastructure such as roads, housing, municipal water systems, and schools. Development from expansion of extractive industries, such as oil shale or oil and gas, has typically followed a "boom and bust" cycle, making planning for growth difficult for local governments. Moreover, traditional rural uses would be displaced by industrial uses and areas that rely on tourism and natural resources would be negatively impacted.

That said, as with all energy sources, there continue to be operational risks and consequences. The practice of fracking is not without controversy. Environmental concerns about water contamination, water use at scale, recycling and proper disposal, land use, property values, noise, haze, methane, and greenhouse gas emissions, seismicity, concerns around wastewater disposal, congestion and other local issues will have to be responsibly addressed. But technology, well integrity, operational "best practices," and community engagement, coupled with proper regulation and enforcement, should make realization of the benefits of this resource achievable.

Not surprisingly, many of the concerns related to shale gas development are also associated with accessing unconventional oil. As is the case with unconventional gas, industry has committed to step up its game with respect to responsible management of both "above" and "below ground" issues, greater transparency, education and community engagement. Smarter, safer, cleaner is now an operational necessity.

As development continues at scale, new issues will undoubtedly arise—including the build-out of new supporting infrastructure, the role of exports, the timing and sequencing of development initiatives, the right mix of federal and state regulation, etc. However, the prospect of sizable new production opportunities in the United States and North America necessitates a reassessment of America's decades old tool kit and a serious policy rethink when it comes to mapping out the coming decades as she progresses toward a more sustainable energy future. This serious policy rethink applies to oil-exporting African countries as well.

Conclusion

Most analysts agree that for a variety of reasons (growing global demand, concentration of resources, limited access and governance challenges, infrastructure needs, balance of payments outflows, changing geopolitical alliances, and security considerations) America's current energy system - like most energy systems- is simply unsustainable. A transformation is already underway. But it will take decades to complete. While there are potential opportunities for commercial development of large unconventional oil and gas resources, such as oil shale, in the United States, these opportunities must be balanced with other potential technological, environmental and socioeconomic challenges.

Recommendations

There is the need for the formation of a powerful Advisory Committee that would provide an independent forum to research and clarify aspects of unconventional oil supply that are a source of confusion and debate. There is also the need to create an environment that fosters innovation and results in production growth, and access to acreage with sufficient oil resources combined with long-term stable fiscal regimes and fiscal measures that provide industry the certainty and time needed to develop unconventional resources in an economically viable, socially acceptable, and environmentally responsible manner.

The current governance structure established for conventional crude oil, its processing specifications, and its byproducts will need to be revisited with the new oils in mind. Therefore, new rules will likely be required to deal with new fuels. This includes managing their (direct and indirect) impacts and determining the mix of unconventional oils in the future mix of petroleum products; and then there must be synergy among countries exploiting unconventional oils on energy technology and policy, programs, and approaches to advance a secure and environmentally responsible world energy system.

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IAEE/Affiliate Master Calendar of Events

(Note: All conferences are presented in English unless otherwise noted)

Date	Event, Event Title and Language	Location	Supporting Organizations(s)	Contact
2012				
November 4-7	31st USAEE/IAEE North American Conference *Transition to a Sustainable Energy Era: Opportunities and Challenges*	Austin, Texas	USAEE/CTAEE/IAEE	USAEE Headquarters *usaee@usaee.org*
2013				
January 17-18	8th Conference of the Spanish Association *For Energy Economics*	Valencia, Spain	AEEE	Gonzalo Saenz de Miera *aeee@aeee.es*
April 8-9	6th NAEE/IAEE International Conference *Energy Resource Management in a Federal System: Challenges, Constraints & Strategies*	Lagos, Nigeria	NAEE/IAEE	Adeola Adenikinju *adeolaadenikinju@yahoo.com*
April 22-23	4th ELAEE Conference *Energy Policy in Latin America: Regional Integration and the Promotion of Renewables*	Montevideo, Uruguay	LAAEE/IAEE	Marisa Leon *melon@adme.com.uy*
June 16-20	36th IAEE International Conference *Energy Transition and Policy Challenges*	Daegu, Korea	KRAE/IAEE	Hoesung Lee *hoesung@unitel.co.kr*
July 28-31	32nd USAEE/IAEE North American Conference *Industry Meets Government: Impact on Energy Use & Development*	Anchorage, Alaska	USAEE/IAEE	USAEE Headquarters *usaee@usaee.org*
August 18-21	13th IAEE European Conference *Energy Economics of Phasing Out Carbon and Uranium*	Dusseldorf, Germany	GEE/IAEE	Georg Erdmann *georg.erdmann@tu-berlin.de*
2014				
June 15-18	37th IAEE International Conference *Energy to Survive 2020*	Prague, Czech Republic	CZAEE/IAEE	Jan Myslivec *janmyslivec@yahoo.com*
September 19-21	4th IAEE Asian Conference *Economic Growth and Energy Security: Competition and Cooperation*	Beijing, China	CAS/IAEE	Ying Fan *yfan@casipm.ac.cn*
2015				
May 24-27	38th IAEE International Conference *Energy Security, Technology and Sustainability Challenges Across the Globe*	Antalya, Turkey	TRAEE/IAEE	Gurkan Kumbaroglu *gurkank@boun.edu.tr*