U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

HEARING CHARTER

Tapping America's Unconventional Oil Resources for Job Creation and Affordable Domestic Energy: Technology and Policy Pathways

Tuesday, April 17, 2012
10:00 a.m. -12:00 p.m.
2318 Rayburn House Office Building

PURPOSE

On Tuesday, April 17, 2012, the Committee on Science, Space, and Technology will hold a hearing entitled, "*Tapping America's Unconventional Oil Resources for Job Creation and Affordable Domestic Energy: Technology and Policy Pathways."* The purpose of this hearing is to examine unconventional oil resources and identify technology and policy pathways to develop domestic energy resources.

WITNESS LIST

- **Mr. Andrew Slaughter,** Chair – Resource & Supply Task Group, National Petroleum Council Report "*Prudent Development;"*
- **Ms. Karen Harbert,** President and Chief Executive Officer, Institute for 21st Century Energy, U.S. Chamber of Commerce;
- **Dr. Michelle Michot Foss,** Chief Energy Economist, Center for Energy Economics, Bureau of Economic Geology, University of Texas-Austin;
- **Mr. James Brown,** President and Chief Operating Officer, Whiting Petroleum Corporation;
- **Mr. Daniel Weiss,** Senior Fellow and Director of Climate Strategy, Center for American Progress Action Fund.

BACKGROUND

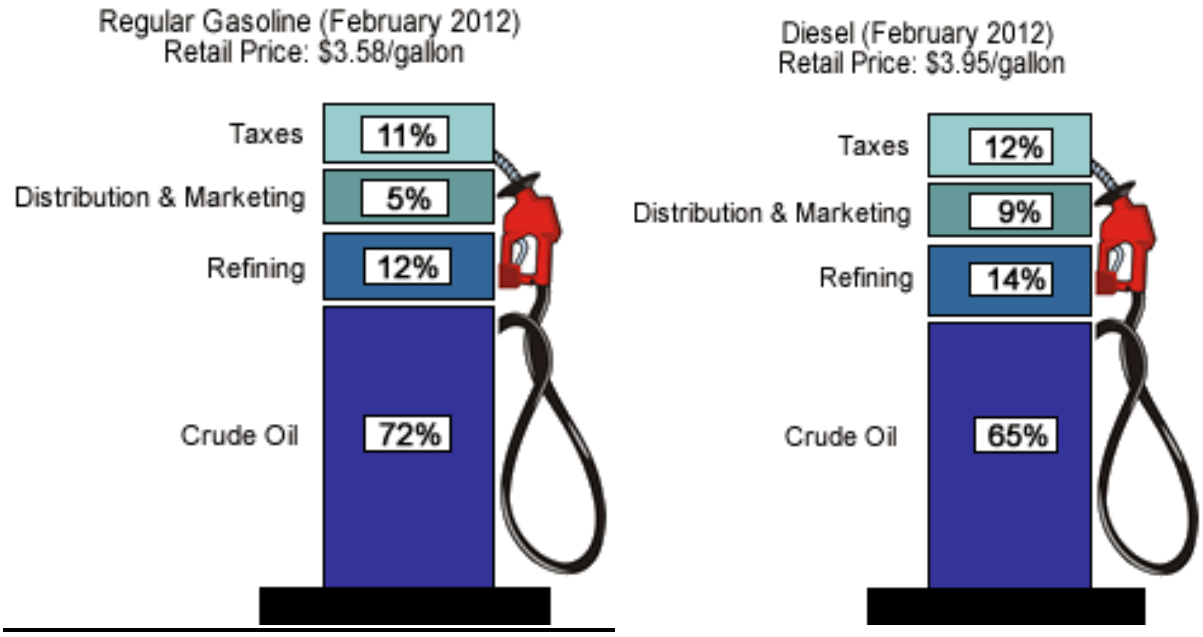
Gasoline Prices

The national average price of a gallon of regular gasoline is currently $3.91,[1] an increase of about 60 cents per gallon since the beginning of the year. The Department of Energy's Energy Information Administration (EIA) estimates prices will remain close to four dollars per gallon throughout the summer of 2012 (Figure 1). The primary factor driving gasoline prices is the price of crude oil, representing 72 percent of the total cost of a gallon of gas (Figure 2). However, taxes, refining costs, and distribution and marketing also contribute to the price of a gallon of gasoline.

Figure 1. U.S. Gasoline and Crude Oil Prices.

[1] As of Thursday April 12, 2012. http://fuelgaugereport.aaa.com/

Figure 2. What we pay for in a gallon of gas.[2]



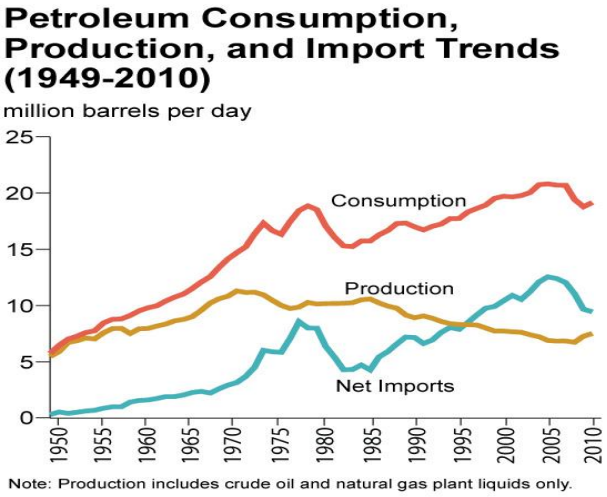
Crude Oil Market Conditions

Demand

Crude oil is a commodity traded in a global market, thus the price of a barrel of oil is set by a number of factors; namely global supply and demand conditions, geopolitical factors, and additional costs imposed by supply chain and infrastructure factors.

The United States currently consumes approximately 19 million barrels of petroleum per day (MMbd) (Figure 3), with global daily oil consumption at 89.1 MMbd. Global oil consumption is expected to increase about one percent, or 800,000 bpd, in 2012.[3] The United States demand for crude oil has been decreasing over the previous decade and over the next two decades domestic demand for

Figure 3. Petroleum Consumption, Production, and Import Trends.

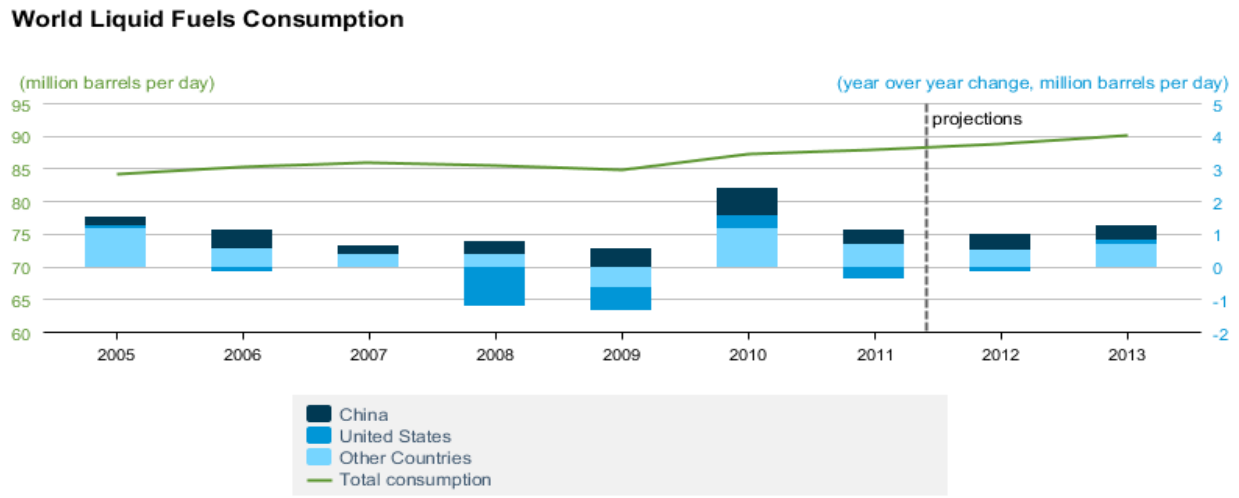


[2] U.S. Energy Information Administration, "Gasoline and Diesel Fuel Update," April 9, 2012. Accessible at: http://www.eia.gov/petroleum/gasdiesel/

[3] International Energy Agency, "*Oil Market Report,*" March 14, 2012. Accessible at: http://omrpublic.iea.org/currentissues/full.pdf

crude oil is expected to decline by 1 percent per year;[4] however, global demand is projected to increase, primarily driven by economic growth from non-OECD countries (Figure 4).

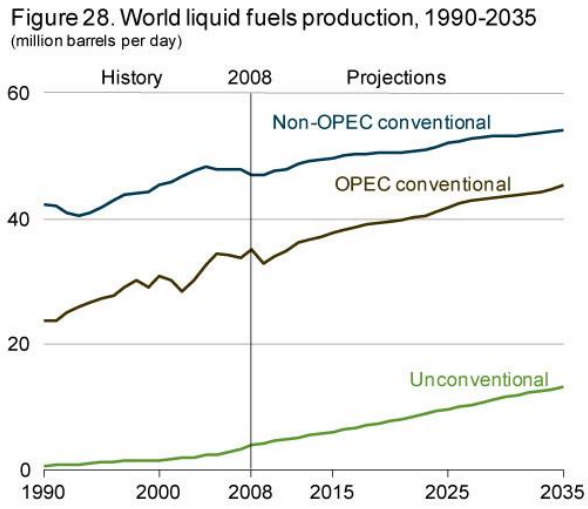
Figure 4: World Liquid Fuels Consumption[5]



Supply and Production

The United States currently produces 9.7 MMbd of refined petroleum per day (Figure 6). Global supply currently is 90 MMbd[6] (Figure 5) and is projected to grow to 112 MMbd by 2035.[7] The majority of current proven oil reserves are held by national oil companies, (Figure 7) though shifting resource outlooks are fundamentally altering resource ownership.

Figure 5: World liquid fuels production (EIA)



[4] National Petroleum Council, Working Document of the NPC North American Resource Development Study, "*Paper #1-6: Unconventional Oil,*" September 15, 2011, p. 14. Accessible at: http://www.npc.org/Prudent_Development-Topic_Papers/1-6_Unconventional_Oil_Paper.pdf

[5] Energy Information Administration, "Short-Term Energy and Summer Fuels Outlook," April 10, 2012. Accessible at: http://www.eia.gov/forecasts/steo/report/global_oil.cfm

[6] U.S. Energy Information Administration, "The Availability and Price of Petroleum and Petroleum Products Produced in Countries Other Than Iran," February 29, 2012. Accessible at: http://www.eia.gov/analysis/requests/ndaa/pdf/ndaa.pdf

[7] U.S. Energy Information Administration, "International Energy Outlook 2011," September 2011. Accessible at: http://www.eia.gov/forecasts/ieo/pdf/0484%282011%29.pdf

Figure 6: U.S. Crude Oil and Liquid Fuels Production[8]

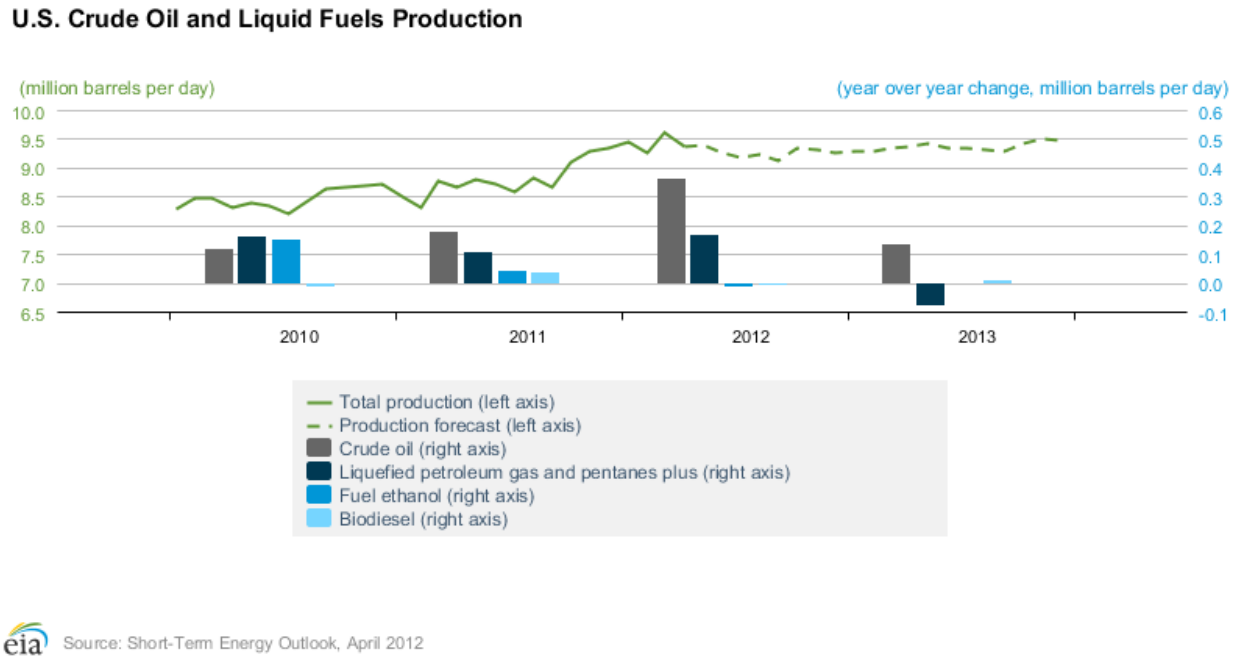
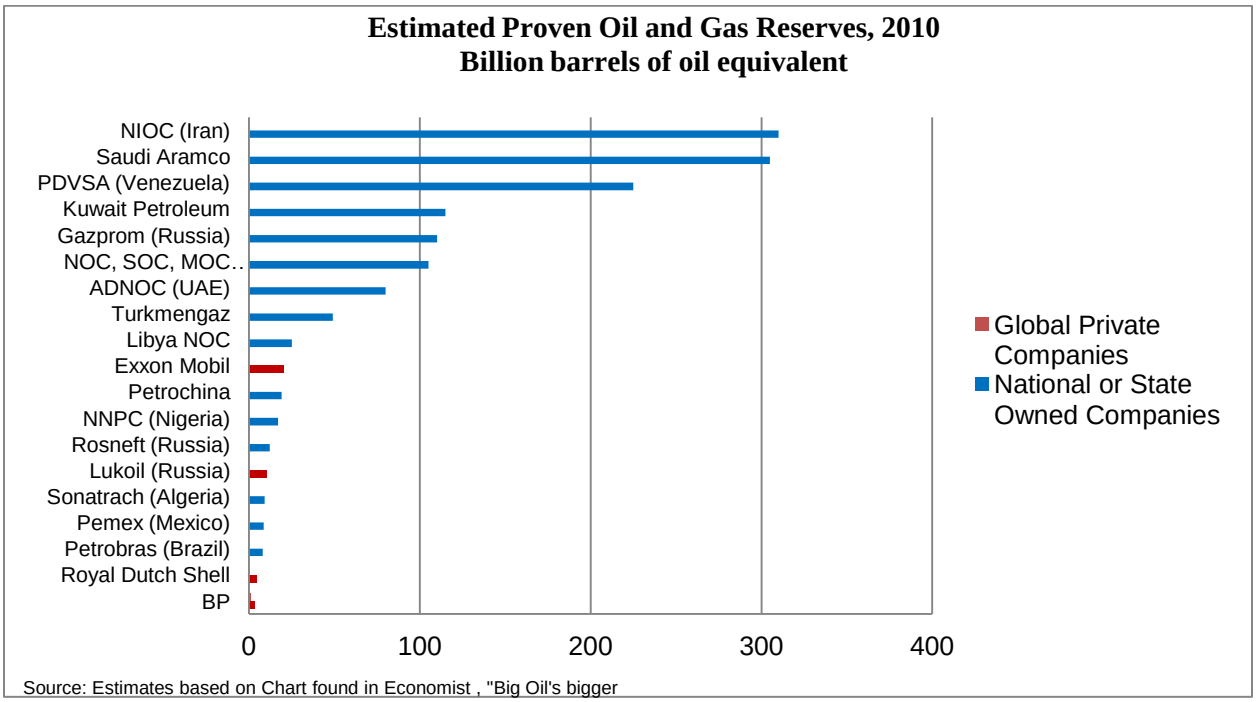


Figure 7: Proven Oil Reserves by Company[9]

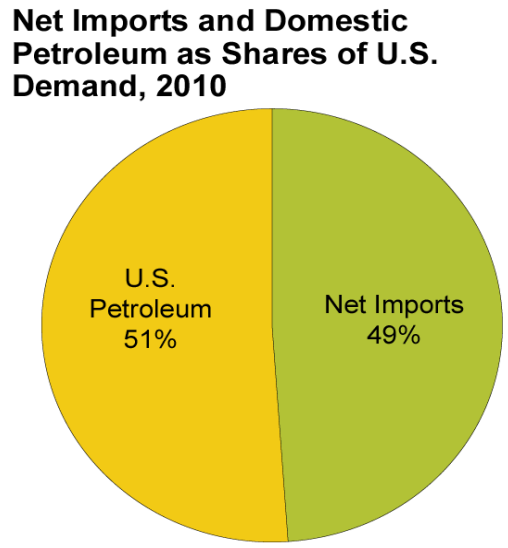


[8]U.S. EIA "Short-Term Energy and Summer Fuels Outlook."
[9] Adapted from data provide in *The Economist*, "Big Oil's bigger brothers," October 29, 2011. Accessible at: http://www.economist.com/node/21534794

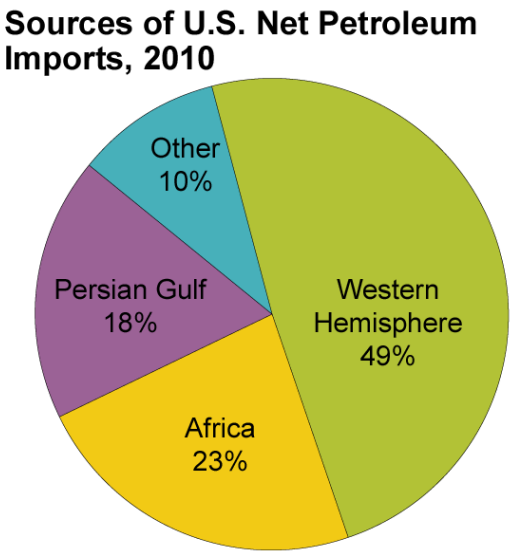
Petroleum Imports

In 2010, the U.S. was a net petroleum importer of 9.4 MMbd, representing just under half of total U.S. demand (Figure 8). Approximately half of U.S. crude oil and petroleum imports are from the Western Hemisphere, with Canada as the top trading partner, providing 25 percent of U.S. imports. Due largely to the increased production associated with oil sands, Canada's oil production has increased 75 percent since 2000, and the U.S. import of Canadian petroleum increased 50 percent over that time period (Figure 9).

Figure 8: Net Imports and Domestic Petroleum Production[10]

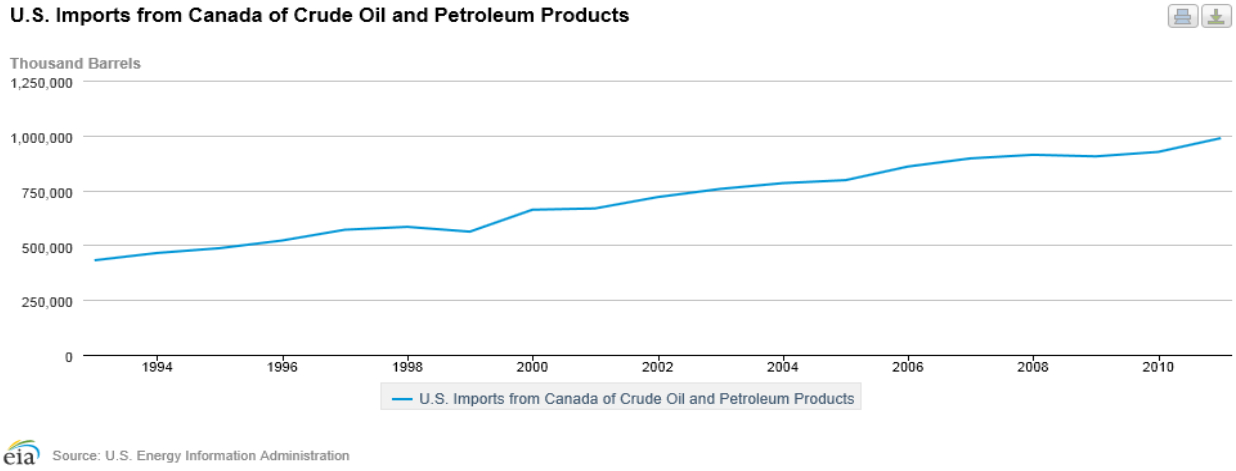


Source: U.S. Energy Information Administration, *Monthly Energy Review,* Table 3.3a (April 2011), preliminary data.



Source: U.S. Energy Information Administration, *Petroleum Supply Monthly* (February 2011), preliminary data.

Figure 9: U.S. Imports from Canada of Crude Oil and Petroleum Products[11]



[10] U.S. Energy Information Administration, "Energy in Brief," June 24. 2011. Accessible at: http://www.eia.gov/energy_in_brief/foreign_oil_dependence.cfm

[11] U.S. Energy Information Administration, "Petroleum & Other Liquids," March 19, 2012. Accessible at: http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=MTTIMUSCA1&f=A

Global Oil Production Environment

Key Conclusions of National Petroleum Council's "*Prudent Development"* Report

The National Petroleum Council (NPC) is a federally chartered advisory committee the purpose of which is to advise the Secretary of Energy on matters relating to oil and natural gas. As an advisory committee, the NPC provides advice at the request of the Secretary of Energy. In response to a request from Secretary of Energy Steven Chu, the NPC issued a report in September 2011 titled *"Prudent Development: Realizing the Potential of North America's Abundant Natural Gas and Oil Resources.*"[12] The report is a "comprehensive study to reassess the character and potential of North American natural gas and oil resources…"[13] The study reached four primary conclusions:

1.) "The potential supply of North American natural gas is far bigger than previously thought;
2.) North America's oil resources are also much larger than previously thought;
3.) Natural gas and oil resources will be needed even as energy efficiency reduces demand and lower-carbon alternatives become more economically available on a large scale; and,
4.) Realizing the benefits of natural gas and oil depends on environmentally responsible development."[14]

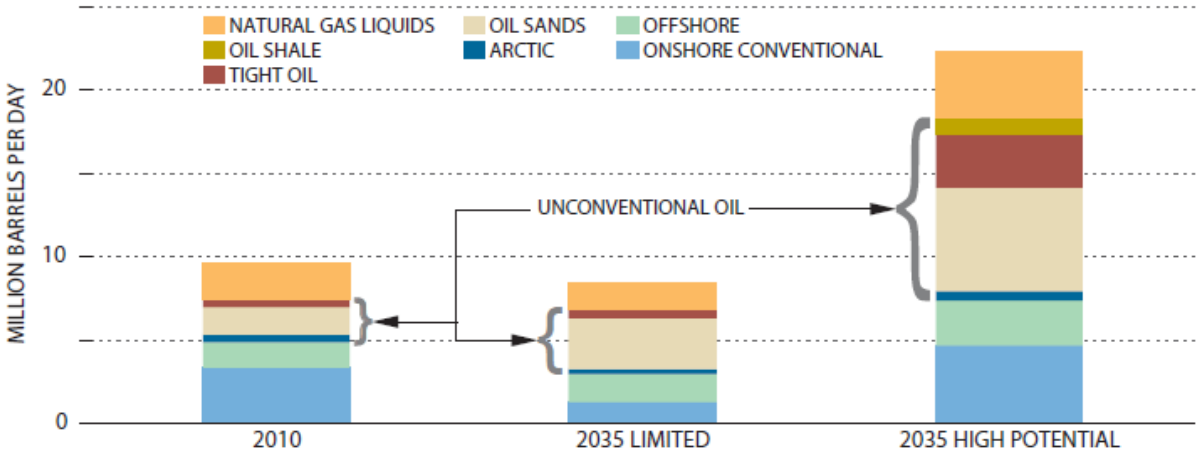
The first chapter of the report identifies crude oil and natural gas resources and supplies and considers the prospects for North American oil development with various challenges associated with different resource bases, including offshore, Arctic, onshore oil, unconventional oil, and pipeline infrastructure issues. (Figure 10) Within the various resource basis, the NPC estimates:[15]

- Currently technically recoverable in the Continental U.S. at nearly 60 billion barrels of oil;
- Arctic contains an estimated 100 billion barrels of recoverable oil;
- Alberta oil sands with a recoverable oil potential of more than 300 billion barrels;
- Onshore conventional oil estimated at 80 billion barrels,
- "Tight oil"[16] could produce an additional 34 billion barrels;
- Oil shale could yield resources estimated at 800 billion barrels.

[12] National Petroleum Council, *"Prudent Development: Realizing the Potential of North America's Abundant Natural Gas and Oil Resources,*" September 15, 2011. Executive Summary accessible at: http://www.npc.org/reports/NARD-ExecSummVol.pdf
[13] NPC Executive Summary, p. 1
[14] Ibid.
[15] NPC "Prudent Development, p. 46.
[16] "Tight oil" is oil contained in traditional deposits, but could not flow through the tight formation rock, thus was traditionally inaccessible.

Figure 10: National Petroleum Council Resource Estimated Potential Production.

Figure ES-6. More Resource Access and Technology Innovation Could Substantially Increase North American Oil Production



Notes: The oil supply bars for 2035 represent the range of potential supply from each of the individual supply sources and types considered in this study. The specific factors that may constrain or enable development and production can be different for each supply type, but include such factors as whether access is enabled, infrastructure is developed, appropriate technology research and development is sustained, an appropriate regulatory framework is in place, and environmental performance is maintained.

Note that in 2010, oil demand for the U.S. and Canada combined was 22.45 million barrels per day. Thus, even in the high potential scenario, 2035 supply is lower than 2010 demand, implying a continued need for oil imports and participation in global trade.

Source: Historical data from Energy Information Administration and National Energy Board of Canada.

Resource Characterization and Potential Supply

Conventional resources are generally defined as those resources which are recovered from a reservoir in which oil, natural gas, and water accumulate in a layered arrangement. Conventional deposits have historically provided the majority of oil and natural gas production.[17]

Unconventional resources are then defined as what is not considered "conventional" - resources that cannot be produced, transported, or refined using traditional techniques. An unconventional deposit is one in which the distribution of oil and gas is throughout a geologic formation over a wide area, rather than within a discrete deposit. The NPC considers heavy oil, tight oil, oil shale, and oil sands as unconventional resources.

The NPC provides three categories of potential oil supply:

- "Oil in place" is an estimate of both the discovered and undiscovered oil, thus it is simply an approximation of how much oil is in the ground.

[17] Whitney, Gene; Behrens, Carl E.; Glover, Carol. Congressional Research Service, "Us Fossil Fuel Resources: Terminology, Reporting, and Summary." December 28, 2011. Accessible at: http://www.crs.gov/Products/R/PDF/R40872.pdf

- "Resources" refer to the oil volumes that are economically recoverable, as well as volumes that could be recovered in the future, but are not considered commercial at the time of estimation. Those unconventional resources that are not in commercial production at the time of estimation are not counted as "resources" because no oil can be economically produced with existing deployed technology.
- "Reserves," a sub-set of "resources," is the oil that can be produced economically with current technology at the time of estimation. This is also referred to as "proven reserves" or "economically recoverable reserves." Conversely, "ultimate potential" is an estimation of the amount of oil that could become recoverable with significant improvements in economic conditions and advancements in recovery technology.

Types of Unconventional Resources

Heavy Oil

Heavy oil, also known as bitumen, and has a higher viscosity and specific gravity than light crude oil. In North America, this resource is most prevalent in Canada, from a region termed the "heavy oil belt," and is similar to the production of Canadian oil sands. Oil in place in this region is estimated at over 35 billion barrels, and produced 382,000 barrels per day in 2009.[18] Current production techniques have facilitated development of the most easily accessible heavy oil resources, however further technology advancements can facilitate the ultimate potential of the resource.

Tight Oil

Tight oil is produced using a combination of horizontal wells and fracturing to unlock hydrocarbons locked in low permeability and porosity siltstones, sandstones, and carbonates, or shale plays. Notable tight oil plays include the Bakken in North Dakota, Montana, and Saskatchewan; the Eagle Ford in southern Texas; the Cardium in Alberta; and the Miocene in California (Figure 11). Recent technological advancements have turned tight oil resources into one of the "most actively explored and produced targets in North America."[19]

Estimations of tight oil potential are significant (Figure 12). The Bakken Formation in North Dakota alone contains estimated recoverable resources ranging from 3.65 billion barrels to 4.3 billion barrels; the USGS identified the Bakken as the largest continuous oil accumulation ever assessed by the agency.[20] Additionally, continued advancement of extraction technology and resource characterization may greatly expand this estimate.

[18] NPC Unconventional Oil White Paper, p. 11.
[19] NPC Unconventional Oil White Paper, p. 84.
[20] The group based these estimates on published literature, reports from state and gederal government agencies, and industry information. References also include USGS reports, and a NETL/DOE report.

Figure 11: Producing and Prospective Tight Oil Plays in the US and Canada[21]

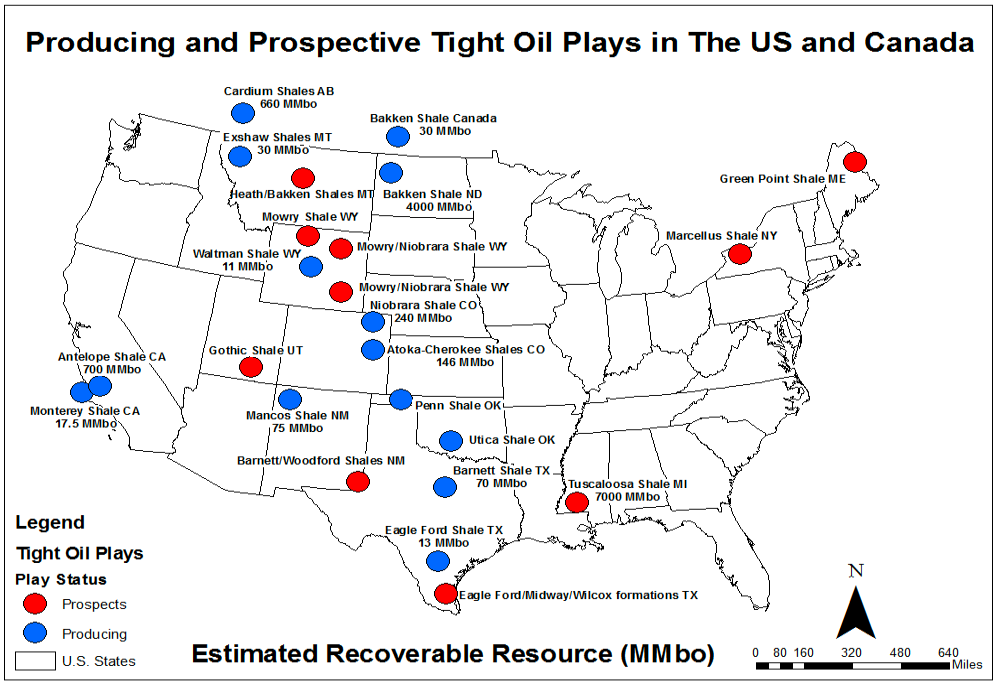


Figure 12: Estimates of Recoverable Resources for Producing Tight Oil Plays (BB = billion barrels) [22]

Table TO1 – Estimates of Recoverable Resources for Producing Tight Oil Plays

Formation	States/Provinces	Resources (BB)
Bakken	ND, MT, SK	3.650 to 4.300
Cardium	AB	0.660 to 1.890
Monterey (Antelope play)	CA	0.718 to 3.500
Niobrara	CO, WY	0.240
Atoka-Cherokee	CO	0.146
Mancos	NM	0.075
Barnett	TX	0.056
Exshaw	AB, MT	0.030
Eagle Ford	TX	0.013
Total		**5.588 to 10.25 (could be as high as 34 BB from NPC private industry data survey)**

[21] NPC, "Prudent Development," p. 121.
[22] NPC, Unconventional Oil White Paper, p. 87.

Oil Shale

Oil shale refers to deposits in which the petroleum component, kerogen, has not fully transformed into oil or gas; thus, the kerogen must be heated to transform it into an upgraded hydrocarbon. This physical state presents challenges to recover the resource which does not permit it being pumped directly from the ground. Oil shale must either be processed above ground (ex situ) or in place (in situ). Potential oil shale production in the US is estimated to be 6 trillion barrels of oil in place, mostly concentrated in the Green River Formation in Colorado, Utah, and Wyoming. However, due to the complexity of recovering the resource, only a fraction of the oil in place will be suitable for recovery.[23] Oil shale has a limited production history in the US, and currently there is no commercially-viable oil shale production in the US.

Oil Sands

Oil sands are a mixture of sand and other rock materials containing crude bitumen, thick viscous crude that can be in a near solid state at reservoir temperature. Production technologies vary as to the location and characteristics of various deposits, including mining and extraction technologies. Additionally in situ processes, such as steam assisted gravity drainage, cyclic steam stimulation, and solvent injection, are used for extraction and production.

In North America, significant oil sands deposits have been identified in both Canada and the United States. In Canada, oil-in-place estimates for oil sands have been estimated at 1.8 trillion barrels, vaulting Canada into second place behind Saudi Arabia for total oil reserves. (Figure 13)[24] Of this total, 7% or 131 billion barrels are estimated to be contained in shallow deposits, recoverable by surface mining or bitumen extraction. The remaining 93% are contained in deeper deposits which will require in situ recovery techniques. Estimates of US oil sands in place are

- Figure 13: Oil Sands Resources

State	Discovered (BB)	Undiscovered Bitumen-in-Place (BB)	OBIP (BB)
California	1.9	3.0	4.9
Utah	11.9	8.2	20.1
Texas	3.9	0.9	4.8
Oklahoma	ND	0.8	0.8
Alabama	1.8	4.7	6.5
Kentucky	1.7	1.7	3.4
Alaska	ND	19.0	19.0
New Mexico	0.1	0.2	0.3
Tri-State	0.2	2.7	2.9
Wyoming	0.1	0.1	0.2
Total	21.6	41.3	62.9

[23] The RAND Corporation has estimated that between 500-1100 billion barrels may be recoverable. Accessible at: http://www.rand.org/pubs/monographs/2005/RAND_MG414.pdf

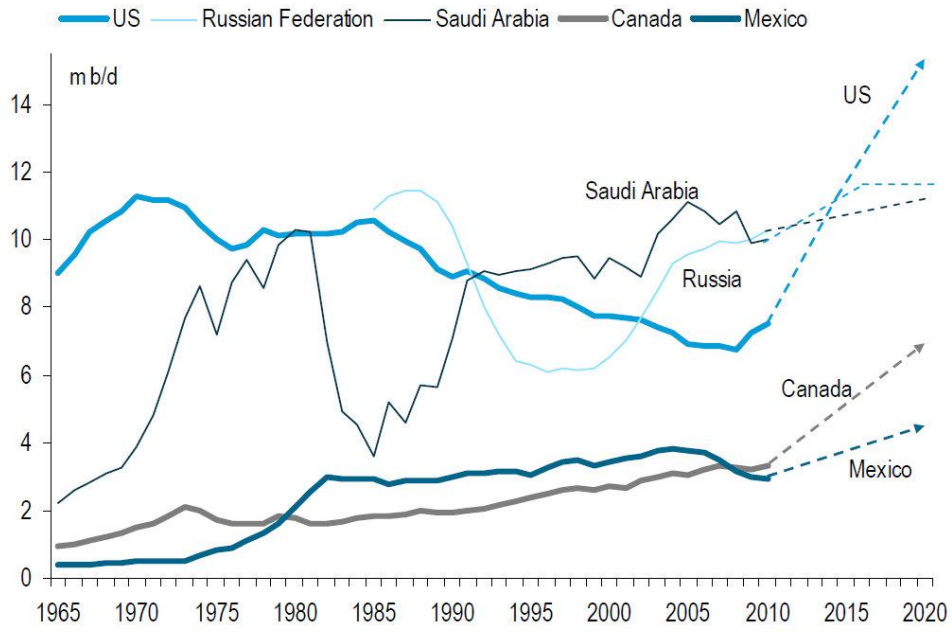
[24] NPC, Unconventional Oil White Paper, p. 72.

approximately 54 to 62.9 billion barrels spread across ten states.[25]

According to an analysis by Citi, the growth of unconventional oil resources, including the Canadian oil sands, tight oil and oil from shale, North American oil and gas liquids production could double by 2020 and overtake both Russia and Saudi Arabia in oil production (Figure 14).[26]

Figure 14: U.S. Unconventional Oil and Gas Production

Figure 8. US production could overtake Saudi Arabia and Russia's this decade



Source: BP, Citi Investment Research and Analysis

Key Technology Advances

A number of advances in key technologies have facilitated increased energy production in unconventional oil plays. For example, the use of "enhanced oil recovery," or injecting steam or a gas (typically carbon dioxide) into the ground to extract additional liquids from a previously drilled well, accounts for 19% of total onshore oil production in the lower 48 states.[27] Additionally, Canada's investment in in-situ technology facilitated the expansion of oil sands production.

[25] NPC Unconventional Oil Resources White Paper
[26] Citigroup, "Energy 2020: North America, the New Middle East?" March, 20, 2012. Accessible at: https://ir.citi.com/XrlJppnooam%2FCDzHLsIFFJI%2B2XIik7UrYk1deekRQLtTrCHYY%2Fkq2g%3D%3D
[27] NPC Prudent Development p. 106.

Oil Shale

The potential for the development of key production technologies may enable the production of oil shale, one of the world's largest unconventional hydrocarbon deposits. The NPC estimates oil shale sits at 8 trillion barrels of oil in place, approximately 6 trillion barrels of which is located in the United States and 80% of which lies under U.S. federal lands.[28] Historical efforts have been made to develop oil shale but tapered off as crude oil dropped in price throughout the 1990's.

However, interest in the huge potential of oil shale returned in the last decade, and pursuant to the Energy Policy Act of 2005, the Bureau of Land Management began development of a leasing program on federal lands that contain oil shale. The first round of research, development, and demonstration leases were awarded in 2006, and another round of leases were offered in 2009 but are yet to be awarded. On February 3, 2012, the Bureau of Land Management's proposed new regulations that would reportedly "reduce available lands for oil shale development in Colorado, Wyoming and Utah by more than 75 percent. In addition, it would only allow research on the leases until industry demonstrates that commercial development is technically viable and environmentally safe."[29]

Tight Oil: The Bakken Play

The development of the Bakken formation provides an illustrative example of how technology can greatly expand energy production. The advent of horizontal drilling, coupled with hydraulic fracturing stimulation, made the development of the Bakken fields, located in North Dakota economical.

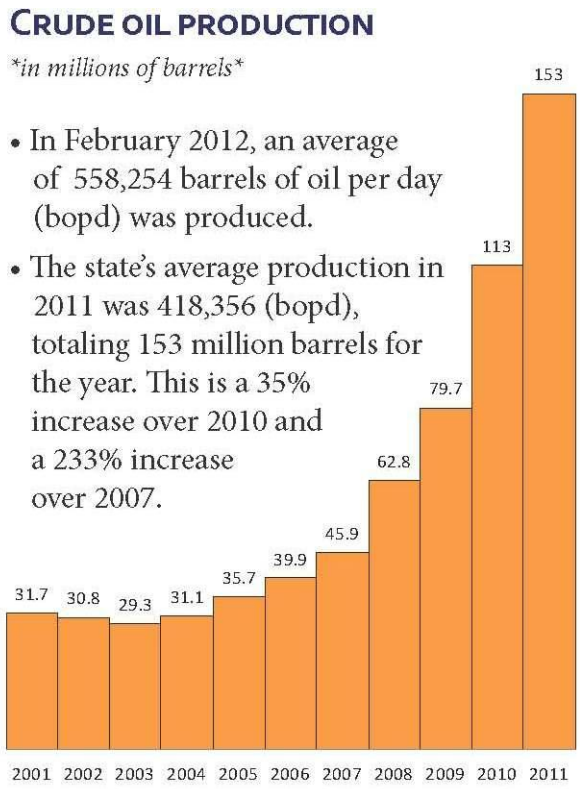
The Bakken formation occupies about 200,000 square miles of the subsurface of the Williston Basin, underlying parts of Montana, North Dakota, and Saskatchewan. First discovered in 1951, the rock formation consists of lower shale, middle dolomite, and upper shale. An April 2008 USGS report estimated the amount of technically recoverable oil, using readily available technology, within the Bakken Formation at 3.0 to 4.3 billion barrels, 25 times more than a 1995 estimate. The Bakken Formation estimate is larger than all other current USGS oil assessments of the lower 48 states and is the largest "continuous" oil accumulation ever assessed by the USGS.[30] The presence of vertical to sub-vertical natural fractures in the shale formation makes the Bakken an excellent candidate for horizontal drilling.

Energy production in the Bakken Formation has reshaped North Dakota's economy. North Dakota is now the third largest oil producing state, producing 558,254 MMbd.[31] (Figure 15) The unemployment rate is the lowest in the country at 3.1 percent[32] and the average wage in the oil

[28] NPC Prudent Development, p. 122.
[29] Taylor, Phil, *E&E Greenwire*, "Obama proposes rollback of shale plans for Rocky Mountain West," February 3, 2012. http://www.eenews.net/public/Greenwire/2012/02/03/1
[30]"Continuous" oil accumulation means that the oil resource is dispersed throughout a geologic formation rather than existing as discrete, localized occurrences http://www.usgs.gov/newsroom/article.asp?ID=1911
[31] North Dakota Oil & Gas Industry "Facts and Figures," Updated April 12, 2012Accessible at: http://www.ndoil.org/image/cache/Facts_and_Figures_2012_4.12.pdf
[32] U.S. Department of Labor, Bureau of Labor Statistics, "Unemployment Rates for States," March 30, 2012. Accessible at: http://www.bls.gov/web/laus/laumstrk.htm

and gas extraction industry was $89,020 in 2011.[33] In 2010, the oil and gas production industry contributed $749.5 million in taxes.[34]

Figure 15: North Dakota Crude Oil Production



[33] ND Oil & Gas "Facts and Figures."
[34] Ibid.