

UNCONVENTIONAL RESOURCES IN TURKEY: MYTH OR REALITY?

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After the Shale Revolution in North America in early 2000's, a huge interest rose all over the world and Turkey, no doubt, is among those countries.

In this article, I will try to explain what unconventional resources are, which caused a revolution particularly in USA and turned this biggest hydrocarbon consuming and importing country into a hydrocarbon exporting one. I will also try to discuss, where in Turkey, might be these resources and how it can contribute to Turkey's energy independence.

UNCONVENTIONAL RESOURCES

In order to understand what unconventional resources are one must first understand the terminology and how hydrocarbons (a term used both for oil and gas) are formed.

Terminology

Especially in Turkish community, the term “unconventional” causes confusion. From a fluid type point of view Unconventional Resources are the same oil and gas that we produce conventionally. Actually, the term unconventional refers to the rock type where hydrocarbons are produced and the methodology that is used to extract them. Apart from the term Unconventional Resources, Shale Gas, Shale Oil, Tight Gas, Tight Oil and Self Sourced Resources are used widely in the industry.

In Turkish press or other publications, the term “Rock Gas” is used. Technically it is not correct to use such a term since all hydrocarbons are produced from rocks. So, rather than using “Rock”, we strongly recommend to use the term “shale” which is a type of rock which (if available) is capable to transform in situ organic matter into oil and gas.

Origin

What are these resources which is described with such different terms? As mentioned above unconventional resources is not something different from conventional oil and gas. The unconventional side of these resources are the rock from which hydrocarbons are produced and the methodology that is used to extract them.

Conventional oil and gas is produced from certain type of rocks where porosity and permeability is high. In other words, such rocks referred to as reservoirs are capable to transmit oil and gas without any stimulation. In such reservoirs, fluids exist from top to bottom as gas, oil and water.

Unconventional oil and gas, on the other hand, are those hydrocarbons which are produced from the same petroleum system with conventionals, but from a different rock type (Fig.1). These rocks, as stated above, are referred to as shales. If a shale is rich in organic matter it is referred to as Source Rock. Despite conventional reservoirs, it is very difficult to extract oil and gas due to very low transmissibility of fluids. To have economic flow rates, horizontal drilling and hydraulic fracturing is a must.

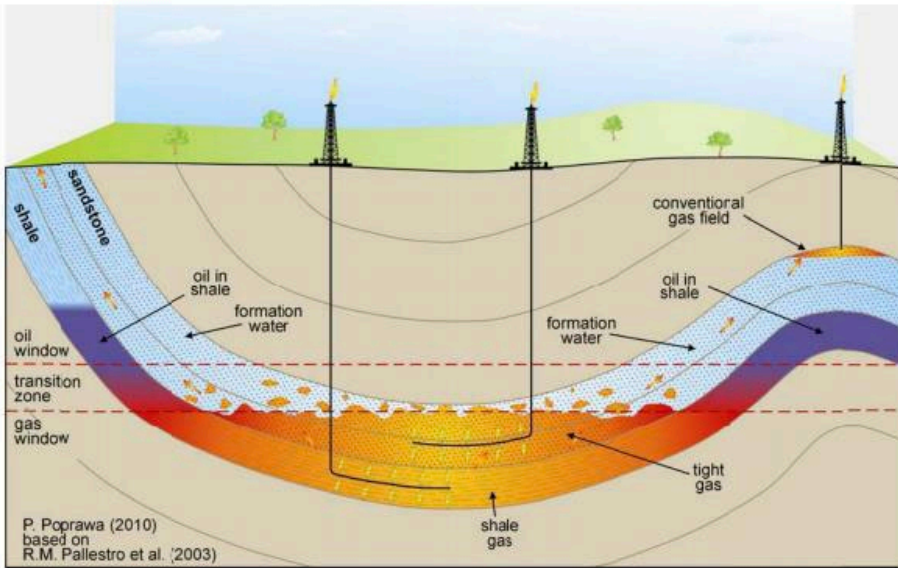


Figure 1: Conventional and Unconventional Resources in a Petroleum System. The distinction is made by the presence of free water. (Poprawa, 2010)

A less known unconventional resource is called “Basin Centered Gas Systems” or “Pervasive Tight Gas Systems”. The difference from shale gas is that these resources consist of various rock types. These various rocks, are very close to source rock and hence, have high gas saturation values. Despite conventional reservoirs, they exist below free water level and do not need any trap. The fluids exist from top to bottom as water, oil and gas which is just the opposite of a conventional system.

UNCONVENTIONAL RESOURCES IN THE WORLD

Exploration for unconventional resources go back to 1980’s. However, economic success and a well understanding of these systems are achieved in 2000’s. Due to this reason, I would like to discuss activities related to unconventional resources from 2000’s to nowadays. The basic question is, whether the success story achieved in North America can be replicated or not?

North America

There is no doubt that shale success story began in U.S.A. From 1980’s with the support of federal institutions and Ministry of Energy, different oil companies made investments for shale gas. Oil and gas pioneer George Mitchell’s economic extraction of shale

gas and afterwards are well documented in the literature. The point I want to emphasize here is rather the persistent exploration activities supported with technological innovations. Let's take a close look from two examples:

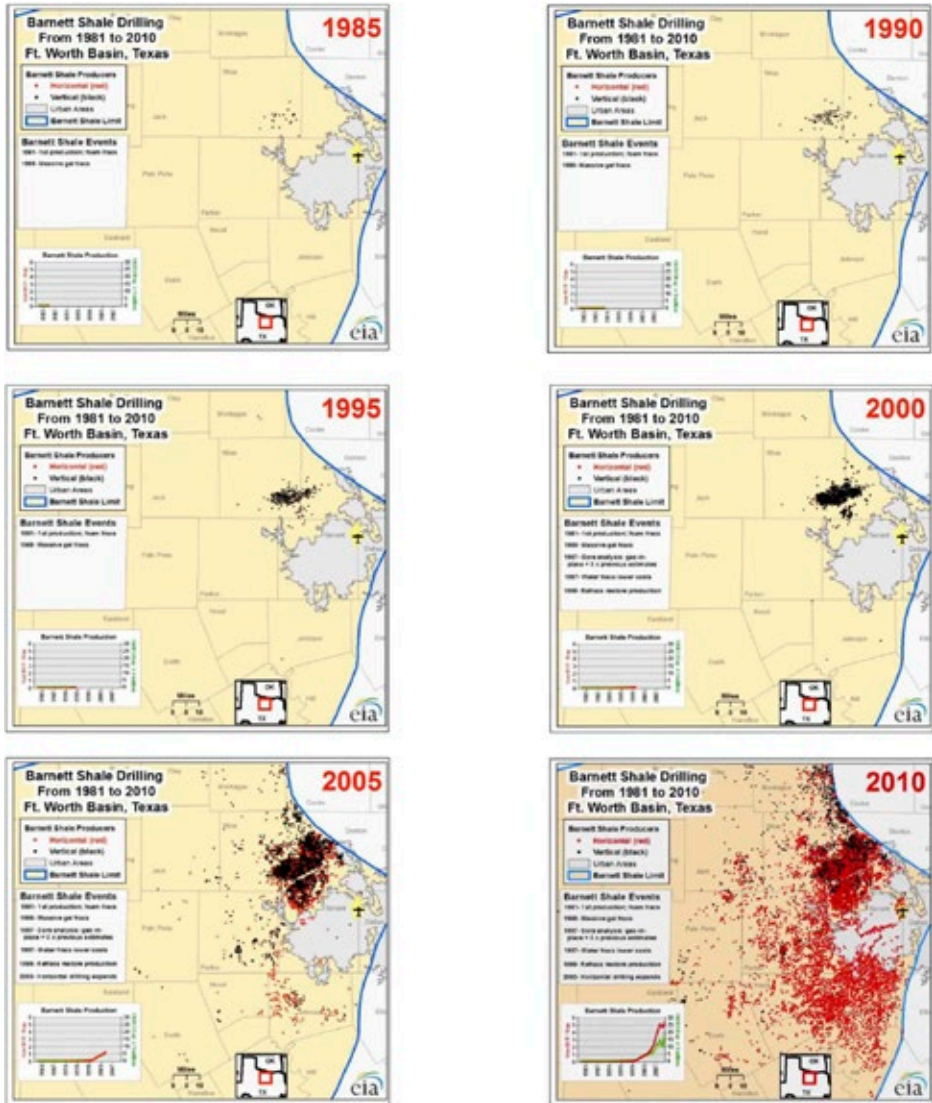


Figure 2: Wells drilled in Barnett formation between 1985 and 2010. Black dots represent vertical wells, red dots represents horizontal wells.

Mineralogy and number of wells drilled. First shale gas is extracted from a formation called Barnett, located in Texas, U.S.A. One of the major characteristic feature of this formation is its quartz rich content. The importance of high quartz content comes from the fact that it increases brittleness, which at the end, helps the formation to be hydraulically fractured much easier. The belief in high quartz content was so high that most geoscientist believed that other shales can not produce hydrocarbons. In this early era, oil companies searched for other “Barnett”’s. Unfortunately, not only in U.S. but in

the whole world shale mineralogy was different. It was so hard to find quartz rich shales like Barnett. This is the point where passionate explorationists and innovative engineering created a difference. Ongoing geological and engineering R&D activities showed that not only quartz rich, but also carbonate rich or even clay rich (which badly affects hydraulic fracturing) shales can produce hydrocarbons. Concerns related with fluid type was exactly the same. At the beginning very few people believed that oil can be produced from shales. However, today technology allows us to produce both oil and gas.

The second example is about the well types and numbers. In different platforms, we all hear that in U.S.A. tens of thousands of wells were drilled. So the question is, whether here in Turkey, we should drill the same number or not? The simple answer is No. Let's discuss this question by examining the development process of Barnett shale.

Figure-2, shows the wells drilled between 1985 and 2010 in Barnett formation, Fort Worth Basin, Texas. Red dots represent horizontal wells; black dots represent vertical wells. On the lower left hand corner production rate is shown.

First economic production rates were achieved in 1981. In 1985 massive gel fracs were implemented. In 1997 cores were extensively taken and gas in place estimations almost tripled. In the second half of 1990's oil companies began to use water in their hydraulic fracturing operations which lowered the overall costs. In 1999, fracked intervals were re-fracked and helped to restore production. Till 2005, the majority of the wells were vertical. However, after 2005 horizontal wells became almost a standard in the industry. The increase in red dots can be clearly seen in Figure-2.

Although first economic production was achieved in 1981, total production started to create a difference after 2000. The rule is simple: More wells you drill; more production you get. Just at this point, it is vital to understand that production performance of each well might be so different. Let's take a close look to Figure-3.

Figure-3 illustrates wells drilled in Eagle Ford shale, located in south Texas, between 2006 and 2010. Each circle represents a well, where the radius of the circle is proportional to its performance by means of barrels equivalent of hydrocarbons produced per day. Pink, orange and green zones represent gas, condensate and oil zones respectively.

Two points are important. First, production rates per well is not homogeneous, which means that wells with relatively high production rates and low production rates are close to each other. In other words, they are not concentrated in some certain areas. This shows us that unconventional reservoirs are much complex and relatively unpredictable than conventional reservoirs. Second, we can see that more wells were drilled in orange area. The main driving mechanism is economy. Orange area, as mentioned earlier represents areas rich in condensate which is easier to exploit than oil and gives a better profit rate than gas zone. This, for sure, does not mean that oil or gas zones are not worth to drill wells, but rather means that the economy in that area today, does not allow to drill. They will be drilled later in the future when oil price is high enough.

North America is a huge laboratory both for geoscientists and all professionals trying to understand the energy policies. There are lots of lessons learned in the industry and it is possible to discuss more topics here. However, not to bore the reader and to create space for different topics, now let's take a look to other parts of the world.

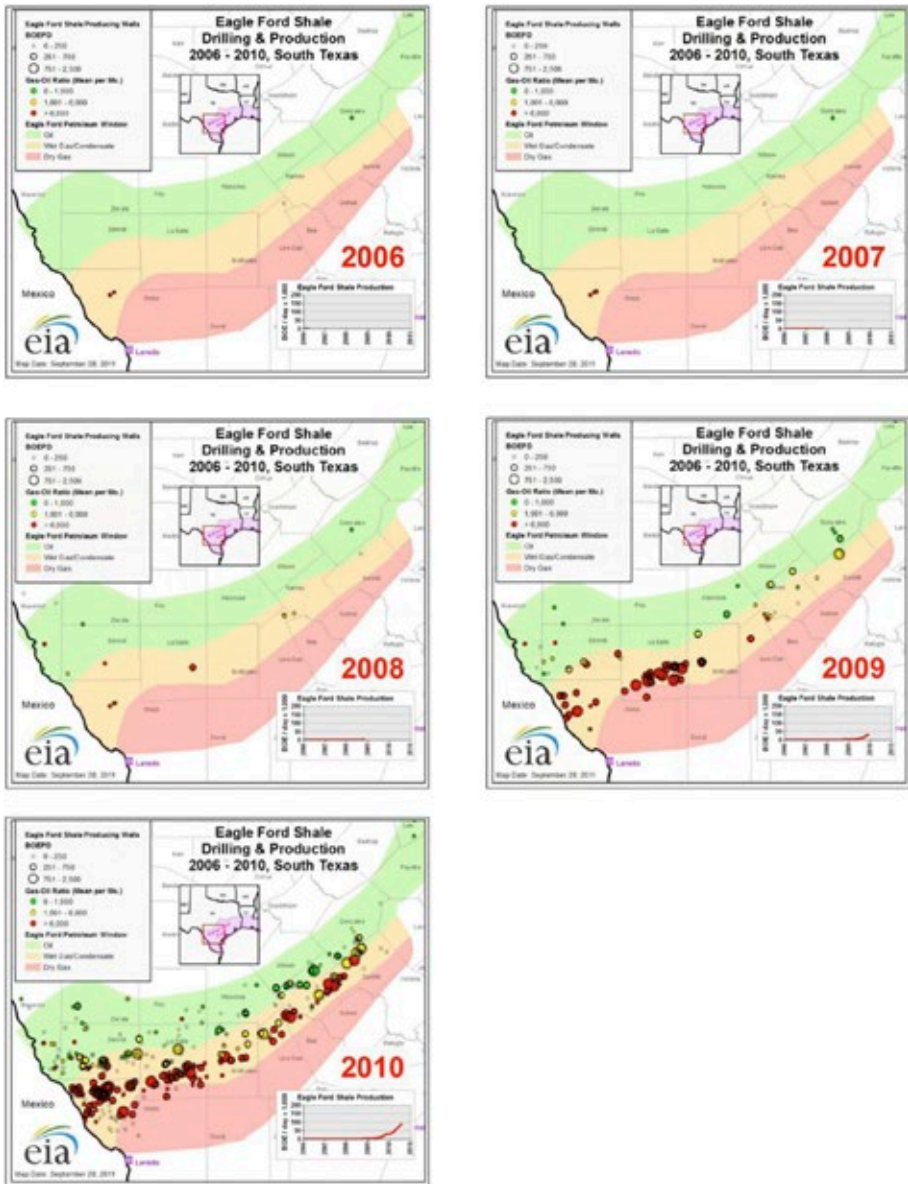


Figure 3: Wells drilled in Eagle Ford formation between 2006 and 2010.

Europe

European experience in unconventional is not as exciting as in North America. Several reasons exist. First of all, there are lots of countries in Europe, which means different bureaucracies, tax regimes etc. On top of that, European Union's environmental regulations creates extra difficulties for oil companies. At the moment, prevailing environmental sensitivities in Europe depends on political concerns rather than scientific facts. Almost always the arguments do not change: Polluting underground fresh water resources or creation of man-made earthquakes. It is not the purpose of this article to discuss such

issues, but let me state that all industrial activities include certain degree of environmental risk. Whether it is petroleum related or not, there is no zero risk industrial activity on the earth. Potential pollution of water resources is not limited to unconventional exploration or production. Bad engineering practices always did create environmental problems and will create in the future. At this point it is nonsense to discuss whether we need to extract these resources or not. The point is, how the industry can develop better standards to protect the environment while exploring and producing such resources.

SHALE BASINS OF POLAND

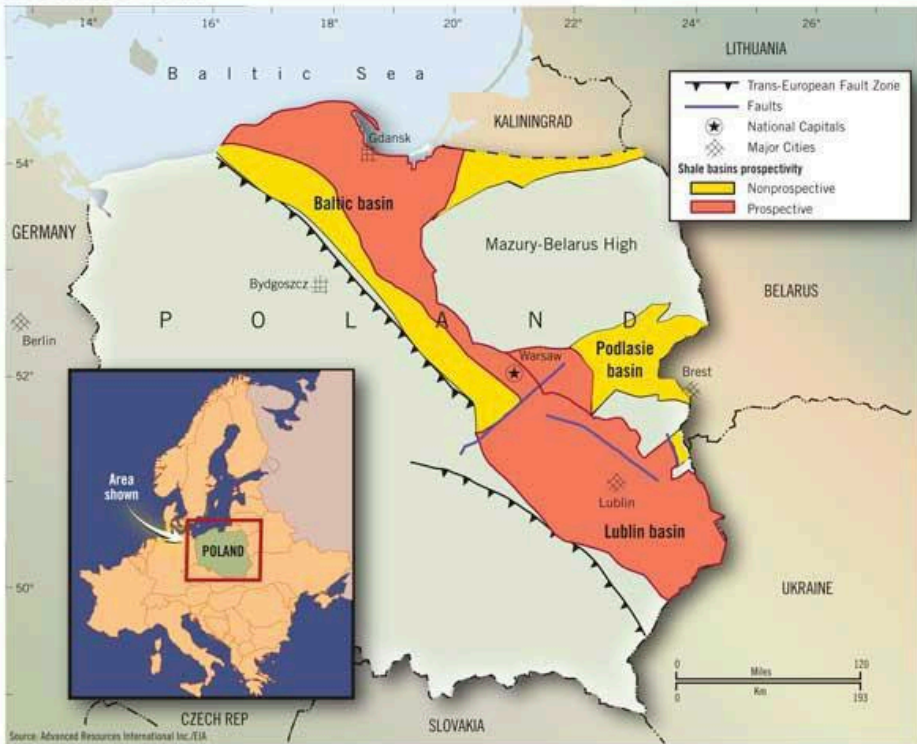


Figure 4 Baltic and Lublin Basins in Poland.

Putting aside environmental discussions, I think Poland is so far, the most important country in European experience. Favorable tax environment and less bureaucratic processes helped the country to turn into an attraction point. Together with the desire of both majors and small oil companies, Poland became the most active country in Europe regarding unconventional exploration. Exploration activities concentrated in two basins: Baltic and Lublin (Fig.-4).

First exploratory well was drilled in 2010. Almost by the end of 2014, 66 exploration wells were drilled within 50,000 km². 11 of them drilled horizontally and 24 of them were hydraulically fractured. The cost for a vertical well was around 12 million USD. It increases to 20 million USD if one wants to drill horizontal well and frac it. Despite 750 million USD spent, production rates were not encouraging. Together with Poland governments’ decision to increase tax rates almost up to 40%, many oil companies, in-

cluding majors like Exxon decided to exit the country. Poland today does not seem to be an attraction point but exploration activities still continue.

In other European countries, there is an ongoing unconventional exploration. However, all activities end up with hot debates about hydraulic fracturing. Such operations are banned in France and by June 2016, Germany announced that fracking operations are banned for shale gas exploration but limited activity might be allowed for sandstone reservoirs. This is just another example which shows that such decisions are made with political concerns, since there is no difference between fracking a shale and a sandstone. It seems that current public opinion and regulations in force will not allow short and mid-term progress in exploration activities.

United Kingdom seems to follow a different path. Although regulations are tight, no ban exist for hydraulic fracturing. Following Brexit, industry might feel more comfortable environment to explore unconventional resources.

Other

The quest for unconventional resources continue all over the world with different levels of exploration. China is believed to have one of the biggest resources in the world. Despite 150 wells drilled so far, no economic flow rates were achieved. The potential areas are in mountainous areas and lack of transportation infrastructure makes it very difficult to extract these resources. In 2012, Chinese government announced that it will open its shale gas blocks to foreign bidders. However, all blocks were rewarded to NOCs. Monopolistic nature of China's oil and gas industry does not seem to allow a production from shale gas in short and mid-term.

It seems that promising future will be in Argentina. So far, Argentina is the first country outside North America which succeeded to produce hydrocarbons from shales. Although Argentina government decided to nationalize assets from time to time, oil industry somehow survived and managed to invest in this country. Exxon, Shell, Repsol, Chevron, Wintershall are some of foreign oil companies. Together with YPF, Argentina's National Oil Company they focus on Vaca Muerta formation in Neuguen Basin (Figure-5). Just to clarify what is going on in Argentina, let's take a look to two Exxon wells. Bajo del Choique X-2 well was drilled to a total depth of 5750 m. Vertical well section is 4750 m deep and lateral length is 1000 m. Production rate is 770 bbl/d. The Invernada X-3 well is drilled to a total depth of 4600 m, in which 3600 m comprises the vertical and 1000 m the horizontal section of the well. It produces 448 bbl/d oil with 29,000 m³ of gas.

Another operator, Chevron, together with YPF, produces 35,000 bbl/d. If Argentina can sustain current investment environment and give more assurance not to nationalize shale blocks, the country will enjoy their own shale success story within a very short time period. Within 5 to 10 years cumulative shale oil production will follow the same trend as in North America.

UNCONVENTIONAL RESOURCES IN TURKEY

Figure-6 shows Turkey's sedimentary basins. In theory, these are the areas where potential unconventional resources are. However, the reality is a little bit different. Turkey,

despite wide range of people argue, is not an underexplored country. Petroleum geology of Turkey is well known and even in very high risk basins, wells were drilled.

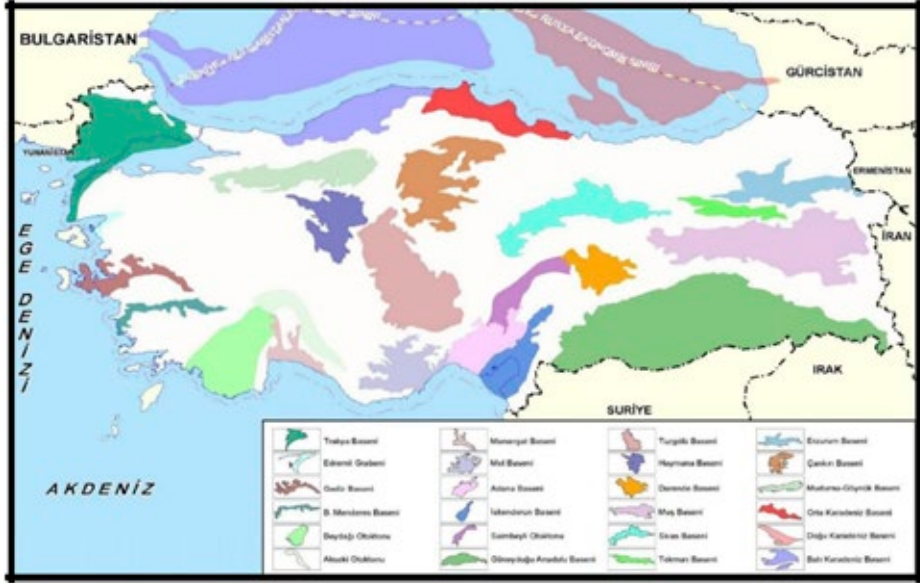


Figure 6: Sedimentary Basins in Turkey.

Thanks to those wells, in the majority of basins we know that source rocks are not mature enough to produce hydrocarbons. In other words, these basins are not capable of producing economic amounts of shale gas or shale oil. Two basins are exception. Thrace and South East Anatolia (SEA) Basins. These basins are also the ones where conventional oil and gas is produced. It is no surprise that the oil industry in Turkey, at the moment, focuses in these two basins. The exploratory wells drilled so far aims to prove the concept and show that economic flow rates are possible.

Shale Gas/Oil Activities in Turkey

Unfortunately, very few oil companies exist in Turkey. TransAtlantic Petroleum is probably the most important operating foreign company. Their successful operations contribute to the oil and gas industry in Turkey. Since I am working for National Oil Company, and public is more curious about her activities, in this section I will try to cover Turkish Petroleum’s (TP) efforts.

Since TP was not experienced enough to explore and exploit its potential unconventional resources, she sought to sign Joint Venture Agreements (JVA) either with small oil companies or majors. As a result of such philosophy, after various negotiations with different firms, in 2011, TP decided to sign an JVA with Shell oil company. The purpose was to understand whether Dadaş formation, located near Diyarbakır, can produce oil or gas. Two wells were drilled in the following years and one of them were hydraulically fractured. Recovering high gravity oil in this very first shale oil exploration well, was a major milestone and important success in the project. Although the concept was proven, relatively low flow rates showed geoscientists that there are still lots of homework to do.

After completing operations in these two wells, Shell decided to exit the project. It was not only due to the low flow rates, but a combination of internal policy changes, low oil prices with related downturn of the industry and Turkey's new petroleum law which caused trouble for areal integrity of licences. In 2016, Shell and TP signed termination agreement.

Today Turkish Petroleum continues its own exploration activities in Thrace and SEA basins. So far, one pilot well was drilled in 2015 and drilling of second pilot well is going on. In SEA, two wells will be drilled in 2017. After the geological evaluation of the wells, hydraulic fracturing is planned.

Up to now, I tried to explain what unconventional resources are and what is the situation right now including Turkey. I believe the critical question is whether the success in North America can be replicated? As some analysts claim, can unconventional resources supply Turkey's hydrocarbon demand for 40 years? Can it really be a huge resource to help Turkey declare her own energy independence. The simple answer is NO. Let me explain why by discussing items that is critical for a working shale play and comparing it with US analog. Items are listed in Table-1, explanations are as follows:

Number of Operators

Turkey, as we all know is not an oil country. In order to be successful in shale oil, existence of various operators is crucial. So, how can this dilemma be resolved? When we look at North America example, we see that it's the small oil companies that allowed shale plays to produce not the majors. Being able to adopt different geoscientific perspectives and having the ability to implement innovative technology allowed them to create this success story. Today, as a major, Exxon is an important player.

However, it was after she acquired XTO, a relatively small company specializing in the drilling and production of unconventional oil and gas, for 36 billion USD. So, the solution might be to create an attractive environment for these relatively small oil companies that specialize in unconventional exploration.

Data Available in Public Domain

Hydrocarbon exploration is an expensive and risky business. Sharing information is very crucial in minimizing the risk. It should be noted that when compared with U.S.A. there is a huge cultural difference regarding confidentiality. In U.S.A., many information including wireline logs, core analysis etc. is available in public domain. On the other hand, it is difficult for individuals or even oil companies to get geological data in Turkey. General Directorate of Petroleum Affairs (GDPA) is the main government organization responsible for storing oil business related information such as well related geological data, seismic data or production rates etc. For a certain degree this information can be purchased. Defining standards on which data should be considered as confidential and which other should not will help the industry to delineate the plays.

Property Rights

Apart from U.S.A., land owners do not have any right for underground resources. Operator companies negotiate with land owners to rent certain part of their land. This of

course is a minor issue compared with the situation in U.S.A. where oil companies negotiate how to share the resource. The major problem regarding property rights is related to population density where there is an upward trend in rental prices.

Service Companies in a Competitive Environment

Being an oil poor country there is very limited service companies in Turkey. Lack of a competitive environment results in relatively high service prices which in turn, increases total project cost.

Political Support

Political support is crucial for unconventional exploration activities. Poland, as discussed before, is a good example how exploration can boost when extensive political support exists. Such a strong political support is also available in Turkey. In order to maximize domestic energy input, Turkish government stated her support to the development of unconventional resources in the 10th

Development Plan (2014-2018). For details please refer to item 805. Consistently, deposits temporarily taken in exchange for investment plan (especially those for well commitments) are subject to Ministry of Energy’s approval. In other words, if a company states that it will make unconventional exploration and drill wells just for this purpose, with the permit taken from Ministry of Energy, it doesn’t pay any deposit.

Different Shallow Plays within Extensive Areas

Areal extent is the most important parameter contributing to the resource size. In this manner, it is very clear that Turkey does not have huge resources as U.S.A. The extent of Marcellus shale, for example, is almost equal to Turkey’s total area (Figure 7). This, creates the huge difference in resource size, market, number of wells drilled etc. It is also vital to state that shale formations in Turkey is deeper (3000-5000m) than US analogs, which is more difficult and expensive to develop.



(a)



(b)

Figure 7 Map showing areal extent of shale plays in US (a) and Comparison of Surface Area of Turkey and USA

High Oil/Gas Prices

Oil prices is the biggest motivation for oil companies. Hundreds of wells need to be drilled in unconventional plays and high oil prices definitely helps to achieve a sustainable activity. The question for Turkey is, whether it will be logical to invest in unconventional with nowadays low oil prices or not? The answer is Yes, with twofold, one; as an NOC, TP has the responsibility to unlock this potential and two: low oil prices mean low service prices, which is good not only for NOC's but also for private sector. Let's not forget that unconventional projects are in "Exploration Phase" in Turkey. No oil company, including TP, is drilling in factory mode. Few exploration wells were drilled at the moment and apart from the cost of hundreds of wells drilled in production phase, the impact of low oil prices is limited. Actually, low oil prices create a favorable environment for those companies who want to explore unconventional plays, not for those who produce.

Infrastructure

Unconventional activities, as mentioned earlier, is going on in two areas: Thrace and South East Anatolia. It can be clearly stated that having a plain terrain and, when compared to SEA, being a relatively small basin with 50 years of extensive conventional gas exploration, Thrace basin is a low cost basin when it comes to infrastructure. Extensive gas pipeline network is attractive for oil companies. On the other hand, in a potential development scenario for Dadas shale (SEA Basin), some investment must be made for pipelines. Several conventional oil fields and related pipeline network creates a base for infrastructure, but extensive pipeline network must be constructed during development or production phase.

Population Density

Population density in Turkey is relatively high. Compared to US, where population density is around 25 to 30 people per km², Turkey has a population density of 150-300 people per km². This is important not only from an operations point of view, where you have to take proper measures, but also from project economy where land costs and environmental measures increase expenses.

Learning Curve

Learning curve can be described as the increase of learning with experience or time. For example, to understand how well a formation can be fractured, an operator must perform the operation in several wells. Using some sort of fluid might not work for a certain formation. Proppant size, how it is distributed in the near wellbore, have an impact on overall production performance. Pre-frac models might change. Under such circumstances, operator writes down each lessons learned and increases its experience by time.

Let me give an example from drilling experience in US. An operator, Anadarko, drills 4200 to 4500 m long wells in Eagleford formation. In the beginning they were finishing drilling in 30 days. Last year, they set a US record and finished 4500 m long well within 5 days. Another operator, in Utica Shale Play, drilled 8243 m long well, which 2605 m is vertical and 5638 m is horizontal, only in 18 days. 124 stage frac is completed in 6 days.

No doubt companies in Turkey are building their own learning curves. However, overall experience seems to be far away from the North American experience.

Fiscal Regime / Regulations

As a project manager working for National Oil Company, it won't be fair to make such a comment, but I should say friends in the industry tell that Turkey, with her tax regime etc. has a relatively favourable environment to invest.

Water Resources

Water resources are crucial especially during hydraulic fracturing operations. In general, there is no problem reaching the water resources in Turkey. However, demand for water is increasing every day and water resources must be used carefully. Recycling the water used for hydraulic fracturing is an option but if one chooses to do so, it might create a problem in the project budget. During a development or production phase, another issue might pop up. That is the disposal process of contaminated water. Pumping them back into reservoirs deep (2000-5000 m) in earth seems to be limited for the moment. Either old wells must be used or new wells should be drilled (I would like to warn the reader that deep reservoirs mentioned here should not be confused with shallow fresh water reservoirs which exist from 20-300 m. in general).

Geology

All factors aside, Geology is the most important factor to have a good resource potential. What do we mean by geology? Simply having correct rock types, with good properties which exist in a relatively shallow depth. As geoscientists we always argue that Turkey is not an oil country. What does this mean from an unconventional point of view? In the majority of the basins we do have very limited thick source rocks (>25 m) with good organic matter content where we can easily interpret in 3D seismic and place a horizontal well. SEA and Thrace Basins, on the other hand, exhibit a good geology. By having a proven petroleum system, achieving economic flow rates in these two basins, may encourage oil companies to take some risk in other basins.

FACTORS NEEDED FOR A SUCCESSFUL RESOURCE PLAY	USA	TURKEY
Various operators in a play	P	O
Open Data	P	x
Property Rights	✓	?
Availability of Service companies in a competitive environment	P	O
Strong Political Will	✓	✓
Diverse shallow play types with large areal extent	✓	x
High gas/oil prices (Market)	P	P
Infrastructure	✓	P
2 Low population per km	P	x
Learning Curve	P	O
Fiscal and Regulatory Regimes	✓	P
Extensive Water Supply	✓	?
GEOLOGY	P	P

Table 1: Factors needed for unconventional plays and a comparison between Turkey and USA.

I hope all the arguments that I have written so far help us to find an answer to the question I mentioned several times. Can Unconventional Resources help Turkey to declare its energy independence? Unfortunately, No. By 2023, Turkey's hydrocarbon consumption is expected to exceed

1 million barrels/day. It is unlikely for unconventional resources to supply the demand on its own. However, the importance of unconventional resources comes from the fact that it certainly has the great potential to cause a serious decline in net hydrocarbon imports. Turkey produces 15-20 million barrels of oil per year and 600 million m³ gas per year (Figure-8). My personal opinion is that apart from offshore exploration, it is very hard to increase the domestic production except unconventional. As TP, although we do have an estimation about the Oil In Place and Gas In Place, we prefer not to declare these values due to two reasons. One; in the public opinion, any declared number is understood as if it is the recoverable reserve, second; reserve estimations must depend on data coming from pilot wells.

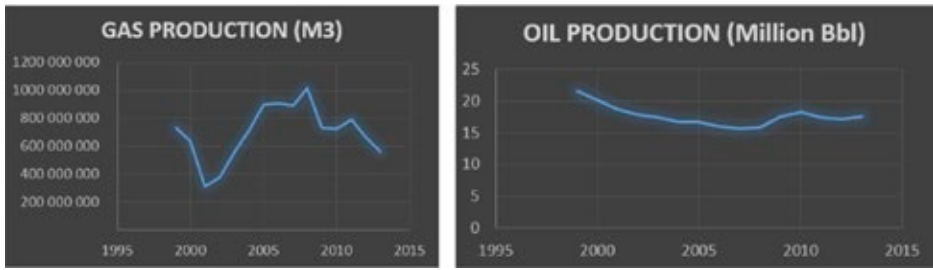


Figure 8: Oil and gas production of Turkey between 1999 and 2013 depending on GDP data.

All the values which exist in public domain, including EIA report, depends on certain assumptions. Nobody has enough solid data, which in this case are the core data and flow tests. As argued by some professionals in the industry, having a resource which can supply the demand in Turkey for 40 years is not realistic.

In conclusion, all unconventional resources including shale gas/oil, tight as/oil, Coal Bed Methane has the potential to dramatically increase the domestic production. Not only TP's, but all companies' efforts are worthwhile since 1 drop of domestic oil is much precious than exported counterpart.