79687

FINAL REPORT

ASSESSMENT OF THE POTENTIAL FOR GAS-FIRED POWER AND ITS CONTRIBUTION TO THE RESOURCE GROWTH CORRIDOR

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1 EXECUTIVE SUMMARY

Gustavson Associates was retained by the World Bank to assess the potential for gas fired power that might result from future hydrocarbon development in the Amu Darya and Afghan-Tajik basins located in Northern Afghanistan. Key findings of our work are listed below.

1) Northern Afghanistan includes parts of two large hydrocarbon basins: the Afghan-Tajik basin and the Amu Darya basin.
2) Previously discovered gas reserves near Sheberghan can probably provide sufficient gas for two 150 MW gas-fired power plants for about 20 years. Existing reserve estimates require confirmation by drilling, since the quantities are based on Soviet era data, which is generally reliable, but is dated.
3) Substantial work and investment is required to develop the discovered reserves. Several efforts are underway that hopefully will move things forward towards providing confirmation of supply to justify the construction of new facilities and power plants.
4) The oil-prone prospects of the Afghan-Tajik basin will probably be attractive to oil and gas companies. If discoveries are made, these oil prospects would produce associated gas. The gas rates would be relatively low, but sufficient for modular reciprocating gas engine plants (up to 20 MW each) that could be replicated as supply increases. Also the gas should be rich, and could be processed to strip out liquids such propane and butane to sell as bottled LPG. The Afghan-Tajik basin is strategically located in the high demand areas of Balkh and Kunduz provinces.
5) The deep gas targets of the Amu Darya basin have the potential for large discoveries of mostly dry gas. These deep targets have the potential to increase the power generation capacity substantially but the targets are exploratory at this time, and have a high degree of risk. Most international oil companies (IOCs) would not be interested in exploration of these targets because there is lack of infrastructure and no established gas pricing mechanisms. IOCs would have more interest in the possibility of oil discoveries in the Afghan-Tajik basin. The wildcard is the interest by the Chinese to further secure supplies of energy for imports into their country. Just to the north, Turkmenistan is exporting gas from the giant South Yolotan field to China. Chinese companies might initiate a vigorous exploration campaign in

Amu Darya portion of Afghanistan in the near future in an attempt to further increase this supply base.

6) The amount of gas-fired power generation that will be installed in Northern Afghanistan depends crucially on whether or not exploration of these two basins occurs, and if so, on the degree of exploration success. If there is very limited exploration success, then there could be enough gas supplies from previously discovered fields to meet limited gas needs and power demand in Northern Afghanistan alone. If there is exploration success only in the Afghan-Tajik basin then about 200 MW of power could be available for export from the region to other parts of Afghanistan or internationally in about ten years. If there also is substantial exploration success in the Amu Darya basin, then power exports from the region could be as high as 1,000 MW. However, there are likely to be challenges in coordinating hydrocarbon exploration and development activity with increases in demand for power and natural gas. Oil and gas firms may be reluctant to explore and develop when there is substantial uncertainty about demand for gas; while industrial developers (and power plant developers) may be reluctant to invest without assurance of energy availability.

2 INTRODUCTION

Gustavson Associates was authorized by the World Bank to identify and evaluate plausible scenarios for the development of gas fired power generation with gas supplied from the Amu Darya and Afghan-Tajik basins in Afghanistan. As part of this work, we prepared an Interim Report that documents the evaluation and analyses of Tasks 1 and 2 of the Terms of Reference for the contract.

This Final Report supersedes the Interim Report dated May 14, 2012. It includes scenarios for both discovered reserves and undiscovered prospective resources. For the discovered reserves, we have constrained production from the fields based on a twenty-five year demand forecast, including two new 150 MW power plants and local gas demand (industrial, commercial and residential) in Northern Afghanistan.

For the undiscovered prospective resources, we have not constrained production, and supply scenarios assume that any gas produced could be used domestically in Afghanistan and/or exported to unspecified markets. We prepared a probabilistic forecast of possible gas production from the undiscovered prospective resources. The gas production scenarios for the undiscovered prospective resources are based on two types of possible hydrocarbon discovery: associated gas production resulting from oil discoveries in the Afghan-Tajik basin, and deep gas discoveries in the Amu Darya basin.

The probability of success for the prospective resources is based on our own judgment for exploratory targets of this type. Other parties may have differing opinions about the probability of success.

3 TASK 1: IDENTIFY A PLAUSIBLE RANGE OF NATURAL GAS RESOURCES, RESERVES AND PRODUCTION IN THE AMU DARYA AND AFGHAN-TAJIK BASINS IN AFGHANISTAN

3.1 COLLATE AND EVALUATE EXISTING STUDIES ON POTENTIAL RESOURCES AND RESERVES IN THE BASINS

Gustavson has reviewed the data provided by the World Bank and also reviewed other information available in our company library and in the public domain. The scope of work requires that the reserves and resources be evaluated in the basins. For clarification, reserves of hydrocarbons are discovered through the drilling of wells where flow rate tests and estimated quantities of hydrocarbons are considered to be commercial.

By contrast, prospective resources are undiscovered, but are estimated based on the size of exploration targets and assumptions about the range of certain reservoir parameters should hydrocarbons be present. We do not consider contingent resources where hydrocarbons have been tested but the size and rate are considered to be uneconomic. For simplicity, we consider the quantities of hydrocarbons in the discovered fields to be reserves and the undrilled exploration targets to be prospective resources.

For information about discovered reserves, we note that the Gustavson report[1] prepared in 2005 provides the best source of information about the remaining reserves in the discovered oil and gas fields. The Gustavson report was a synthesis of previous studies and technical reports that were prepared during the Soviet era, mainly from the 1960s to the late 1980s. This is the most direct information about the fields, absent acquiring new data through drilling and testing.

For undiscovered resources, assessments prepared by the USGS in 2006 are the best and most complete information that we can find. As part of this study, we interviewed Craig Wandrey at

[1] Gustavson Associates, LLC, 2005, Promotion of Oil and Gas Producing Areas to the Private Sector, Grant Agreement No. H007-AF:, pp. i-VII-3.

the USGS in order to understand the supporting information for their assessment work. Mr. Wandrey confirmed that the resource estimates were based in part on existing Soviet era prospect maps that identified exploration targets based on a combination of gravity, magnetics and seismic. New 2D seismic lines have been taken over part of the area since 2006. They confirmed the presence of structures that were on Soviet era maps.

3.2 PROVIDE A COMPARISON BETWEEN THE GEOLOGICAL STRUCTURE OF THE BASIN, TO THE EXTENT IT IS KNOWN, AND SIMILAR PARTS OF THE BASIN IN NEIGHBORING COUNTRIES

The Amu Darya and Afghan Tajik basins are located within areas of northern Afghanistan and these two basins straddle the borders of neighboring countries. The general location of these two petroleum basins is shown on Figure 1. As indicated on the maps, just the southern portions of the Amu Darya and Afghan-Tajik basins occupy Northern Afghanistan. Figure 1 also shows approximate minimum and maximum distances of the southern margins from the territorial borders of neighboring countries.

On the southern margin of the Afghan-Tajik basin, there is another geologic province known as the North Afghan High that has some oil and gas potential. On the southern margin of the Amu Darya basin, there is a discrete structural zone known as the Kalaimor / Kaisar depression that is characterized in part by particular geological features that are present in this local area.

From a structural standpoint, the Amu Darya basin deepens to the northwest into Turkmenistan and is a large structural depression surrounded by mountain ranges to the south and basement highs to the north. Similarly for the Afghan-Tajik basin, the basin deepens to the north into neighboring Tajikistan and Turkmenistan and becomes a large structural depression surrounded by mountain ranges to the north and east, and by basement highs to the south.[2]

[2] USGS 2006 Resource Assessment

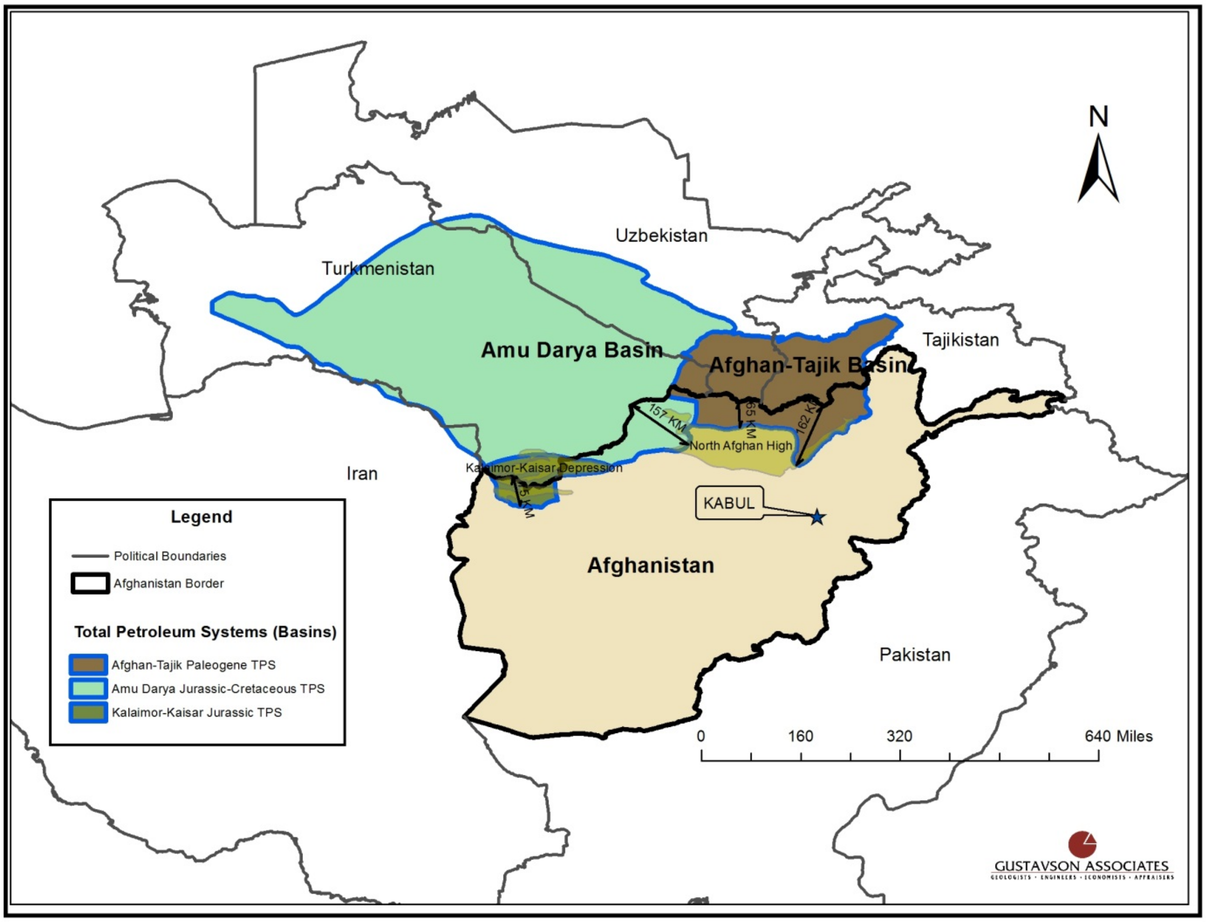

Figure 1 Map Showing General Location of Amu Darya and Afghan Tajik Basins

Figure 2 shows the location of fields and discoveries within the two basins on a regional basis. In the Amu Darya portion of neighboring Turkmenistan, there are large to super giant discoveries of natural gas. In the Afghan-Tajik basin, there are oil discoveries just across the border in neighboring Tajikistan. Figure 2 illustrates the fact that northern Afghanistan is part of a larger petroleum system where large volumes of hydrocarbons were generated from source rocks and then under the right conditions, hydrocarbons were trapped in structural, stratigraphic or other types of traps. A simplified illustration of a structural trap is shown on Figure 3.

Figure 3 also shows the main components of a petroleum system and these are as follows:

Source rocks – organic rich rocks that generate hydrocarbons as a result of the right temperature and pressure conditions in the subsurface

Reservoir rocks – porous and permeable rocks that are capable of containing significant quantities of hydrocarbons

Anticlinal Trap – A type of structural hydrocarbon trap whose closure is controlled by the presence of an anticline[3].

Seal - A relatively impermeable rock, commonly shale, anhydrite or salt, that forms a barrier or cap above and around reservoir rock such that fluids cannot migrate beyond the reservoir. A seal is a critical component of a complete petroleum system. The permeability of a seal capable of retaining fluids through geologic time is ~ 10^{-6} to 10^{-8} darcies[4].

Migration - The movement of hydrocarbons from their source into reservoir rocks[5].

[3] Schlumberger Oilfield Glossary / http://www.glossary.oilfield.slb.com
[4] Same as previous footnote
[5] Same as previous footnote

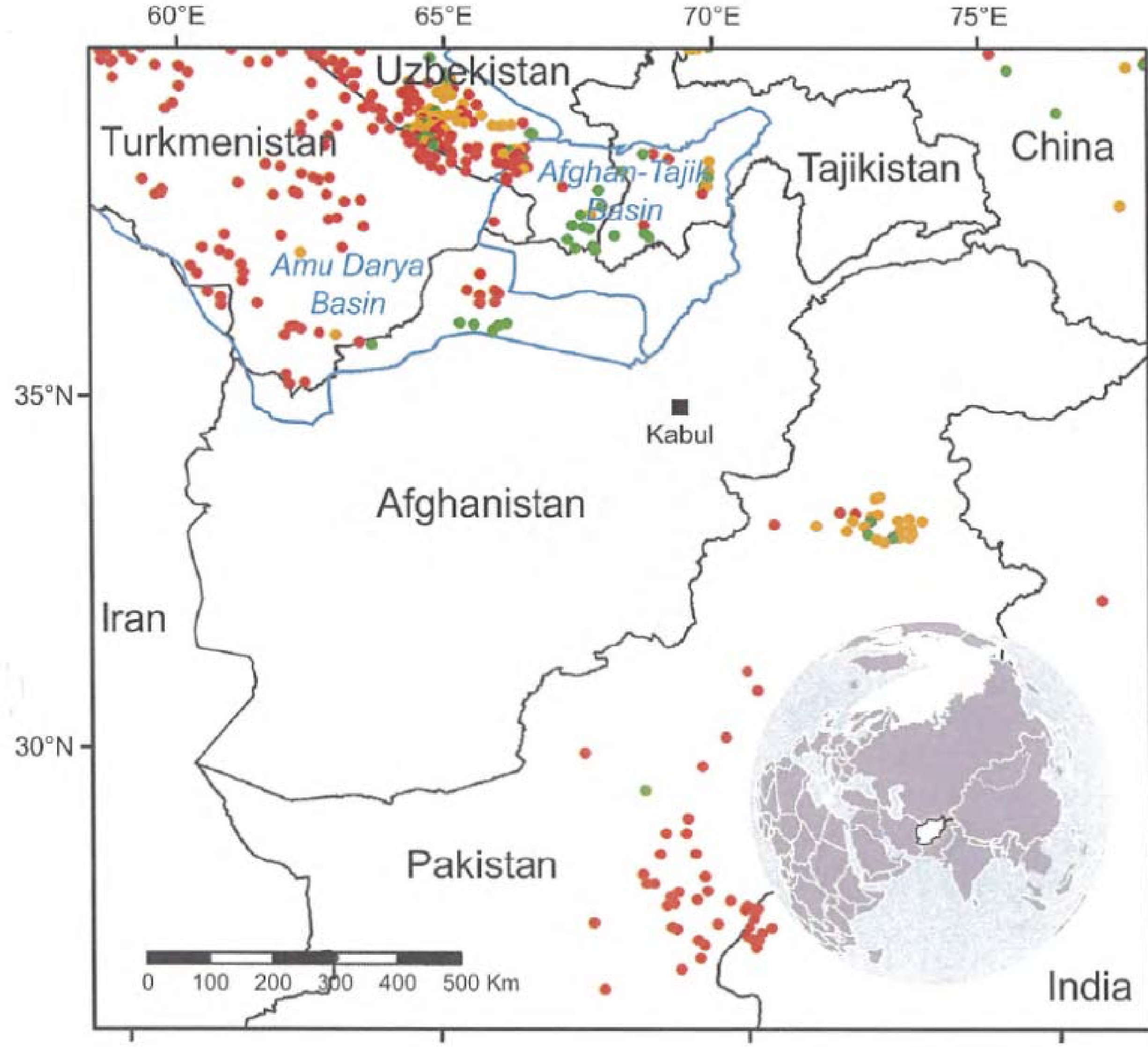

Figure 2 Regional Map Showing General Location of Oil & Gas Discoveries

(modified from U.S. Geological Survey OpenFile Report 2006-1253)

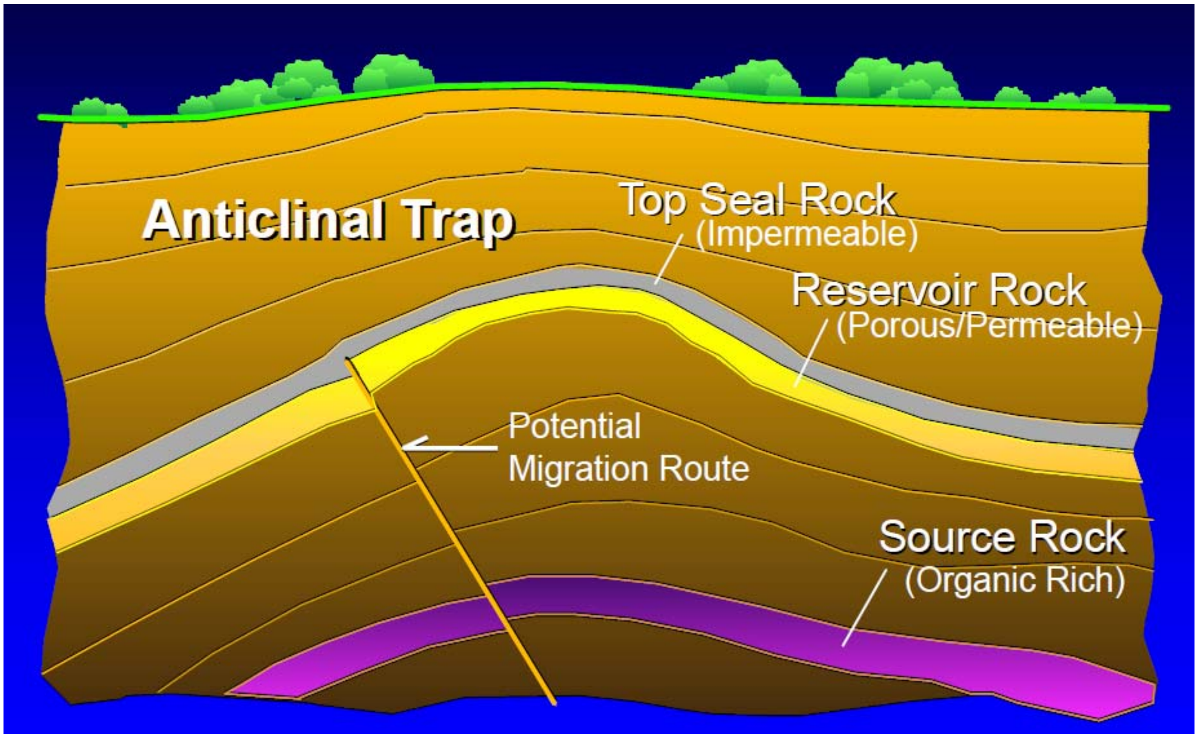

Figure 3 Schematic of Simple Anticline

Source: http://www.aapg.org/slide_bank/armentrout_john/index.shtml

Figure 4 and Figure 5 show the location of the discovered oil and gas fields in the Amu Darya basin including those in Turkmenistan in more detail. Figure 5 shows a map with the location of the main discovered fields on the Afghan side of the Amu Darya Basin. To the best of our knowledge, there are no discoveries on the Afghan side of the Afghan-Tajik basin. There are discovered fields in neighboring Tajikistan and Uzbekistan but coordinate information was not available to include them on Figure 4.

In addition and as discussed previously, there also are prospective resources that must be tested by drilling before reserves can be assigned. The prospective resources are exploration targets that have been defined by geophysical methods but have yet to be tested by exploratory drilling.

The potential to discover hydrocarbons in these targets has a high degree of uncertainty and exploration drilling may have a range of different possible outcomes such as:

- Well(s) drilled are dry and have no hydrocarbons condemning the target
- Well(s) encounter hydrocarbons but deposit is small and non-commercial
- Well(s) encounter hydrocarbons but may have a high amount impurities such as hydrogen sulfide that make it expensive to develop

The location of these exploration targets are shown on Figure 6 and likely would be targeted for future exploration by international oil companies. The exploration targets shown on Figure 6 are not the only possibilities for new discoveries. New exploration targets may be identified by geophysical surveys commissioned in the future. Future exploration drilling may result in new discoveries that can add to the overall reserve base of the country. Presently however, they have a high degree of risk and considered “upside potential”. The potential for new discoveries in Northern Afghanistan can be promoted to attract new foreign investment by international oil companies (IOCs).

The exploration models for these potential new discoveries are shown on Figure 7 based on the USGS assessment. For the most part, the targets are structural traps in the form of anticlines like the example shown on Figure 3. New seismic surveys will be required to accurately map these structures prior to drilling.

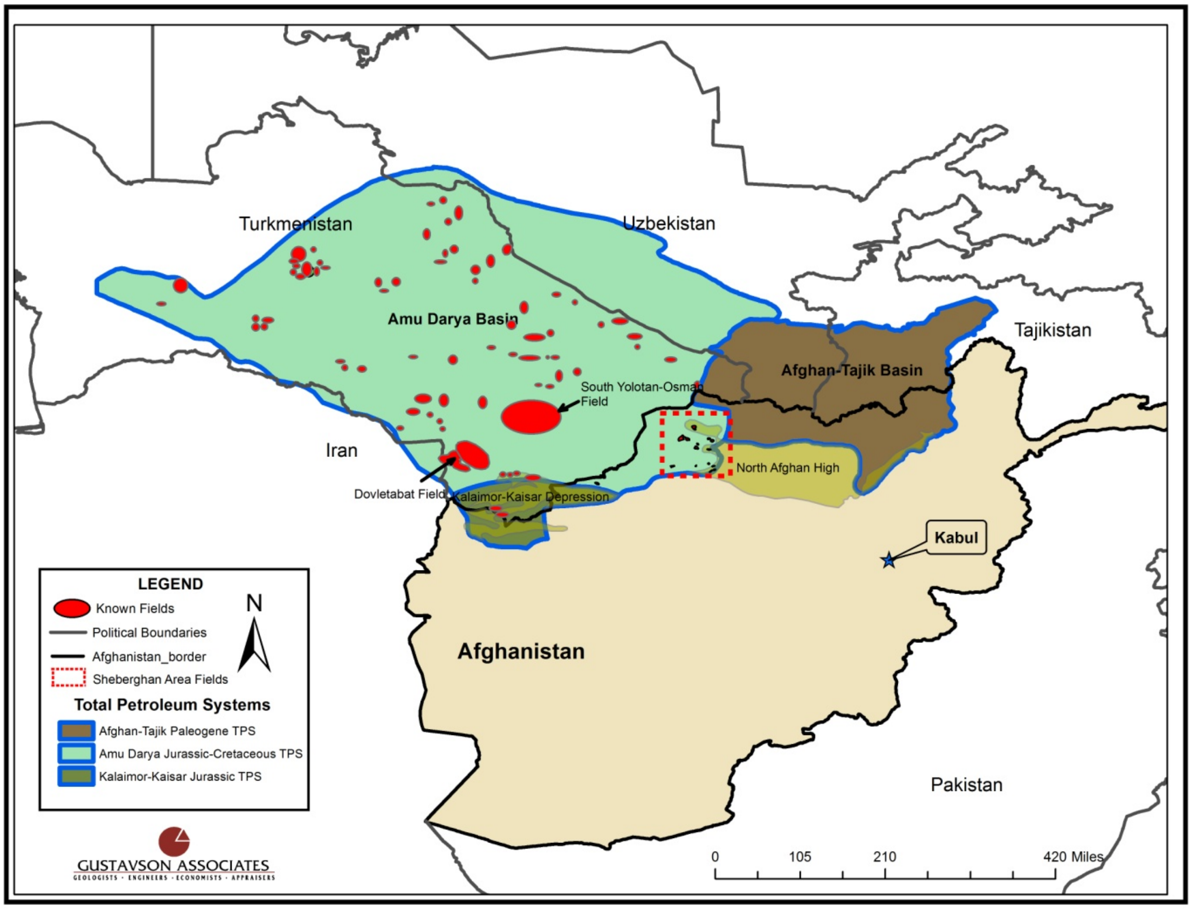

Figure 4 Basins with Oil & Gas Field Locations in Amu Darya Basin

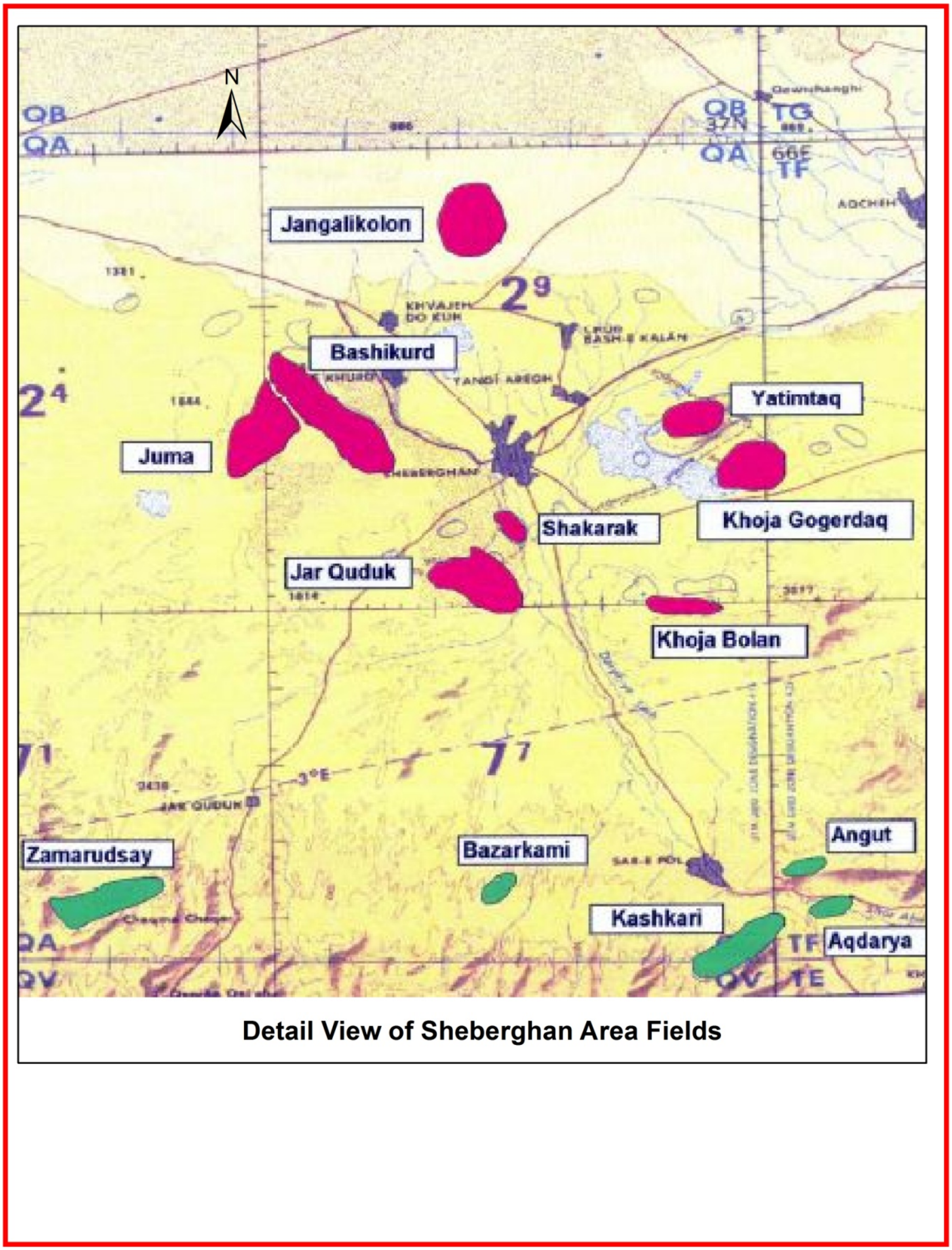

Figure 5 Map of Sheberghan Area Fields

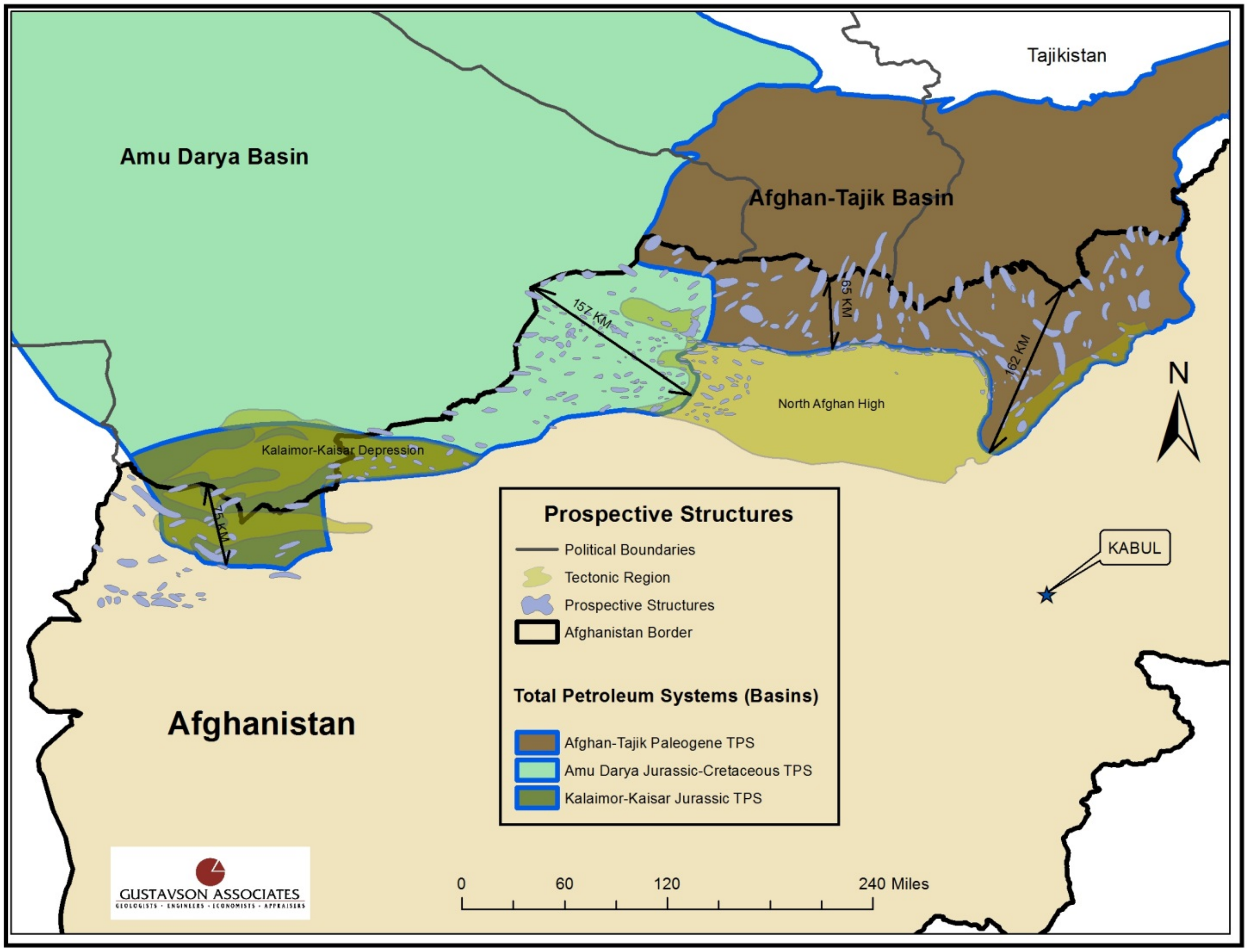

Figure 6 Location of Potential Exploration Targets in the Amu Darya and Afghan Tajik Basins

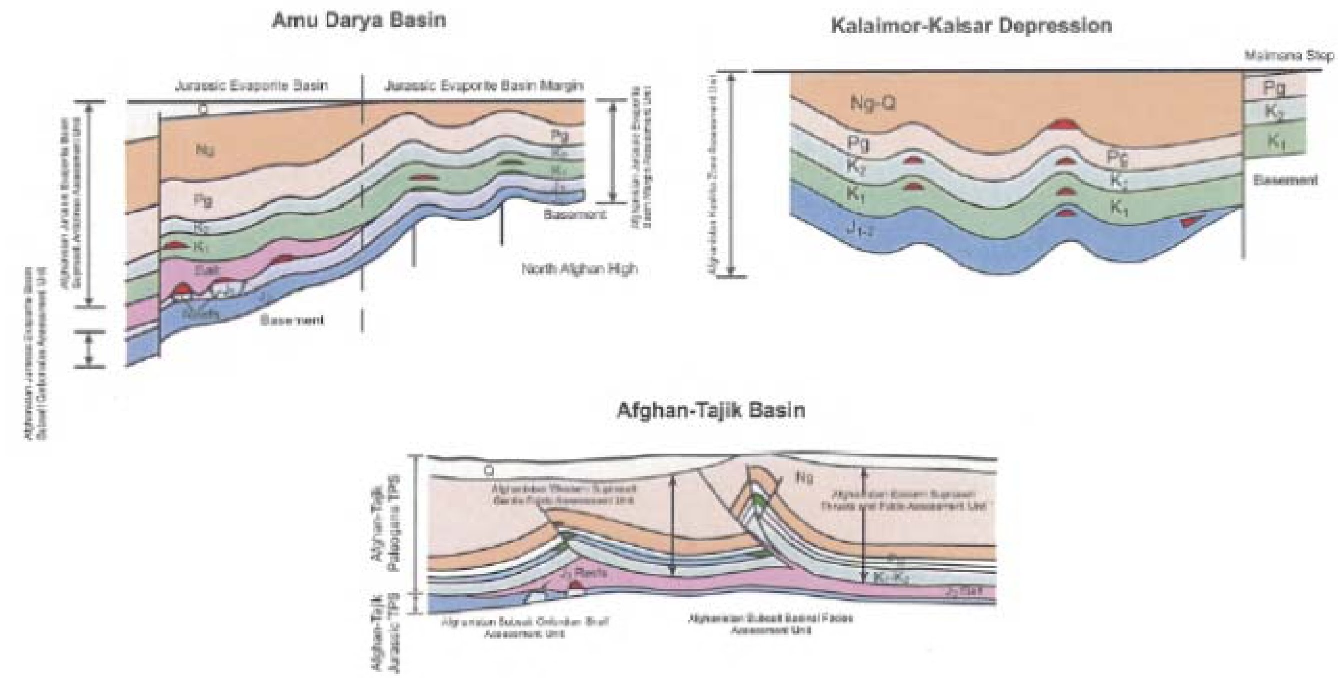

Figure 7 Geologic Models of Petroleum Occurrence

(modified from U.S. Geological Survey OpenFile Report 2006-1253)

3.3 COMBINING BOTH, IDENTIFY A PLAUSIBLE SET OF NATURAL GAS RESOURCES, RESERVES AND PRODUCTION SCENARIOS, RANKED FROM MOST TO LEAST PROBABLE

3.3.1 Gas Forecast, Discovered Fields

A new forecast has been prepared for additional development and workovers in the discovered gas fields in Afghanistan. This is considered to be a reasonable forecast for future gas production in Afghanistan for the next 25 years, if there were no additional exploration in the country. Initial gas demand was forecast at 500 thousand cubic meters per day (the approximate actual production in 2006), increasing at 5% per year. In addition to this, two steps in the demand forecast were assumed to represent two stages of gas-fired power plants, adding 1.1

million cubic meters per day in 2015 and again in 2018.[6] Based on our previous reserve estimates (Table 1) and well test information, a hypothetical gas supply forecast was created to meet this demand forecast. This supply forecast includes the following elements:

1. Continued production from currently producing wells.
2. Adding production from Jarquduq well # 21 in two years.
3. Adding production from one workover at Yatimtag.
4. Development of Juma-Bashikurd with 10 wells drilled between 2013 and 2033.
5. Adding production from four Kogitan wells at Khoja Gogerdaq between 2019 and 2032.
6. Development of Jangalikolon with two wells in 2031 and 2032.

Table 1 Gustavson Estimate of Remaining Reserves as of 1 Jan. 2003

Field	**Remaining Reserves billion m^3**
Khoja Gogerdak	16.77
Jarquduq	9.77
Yatimtaq	7.36
Juma	21.82
Jangalikolon	13.38
Bashikurd	6.37
Khoja Bulan	1.95
Total	77.4

Each modeled reservoir is assumed to act as a single volume. Declining reservoir pressures and well deliverability are calculated based on cumulative production and material balance. In general, wells are added when the total estimated production capacity falls near the demand rate. The demand and supply forecasts are shown on Figure 8 with the deliverability, or maximum gas capacity, shown by the green line. Figure 9 shows the supply forecast separated into the

[6] This demand forecast differs from that in "Gas/Power and Related Infrastructure Assessment", AEAI, April 5, 2011. The AEAI report considers a single power plant requiring about 1.5 million m^3 of raw (untreated) gas per day, without specifying a start date for the plant.

forecasts for the current producers and production added from each of the five fields. Figure 10 shows the added wells required to produce the supply forecast. Note that development of these five fields is expected to be able to meet this demand schedule for over 20 years, after which time adding more wells to attempt to meet demand from this group of fields shows diminishing return.

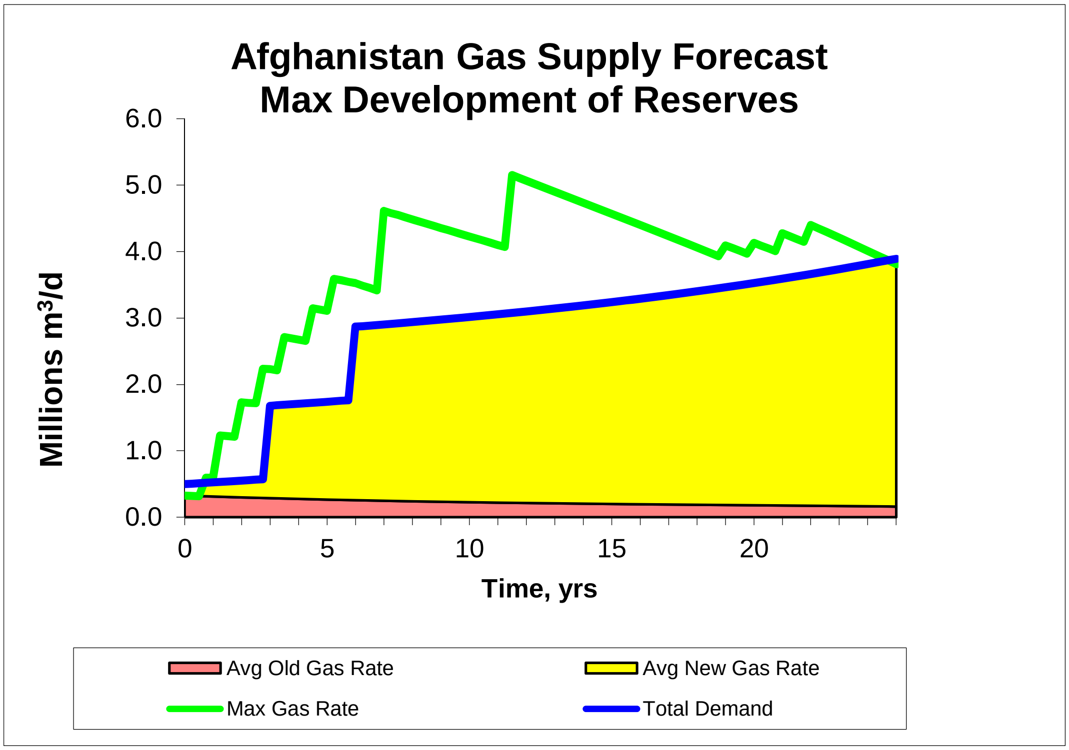

Figure 8 Supply and Demand Forecast

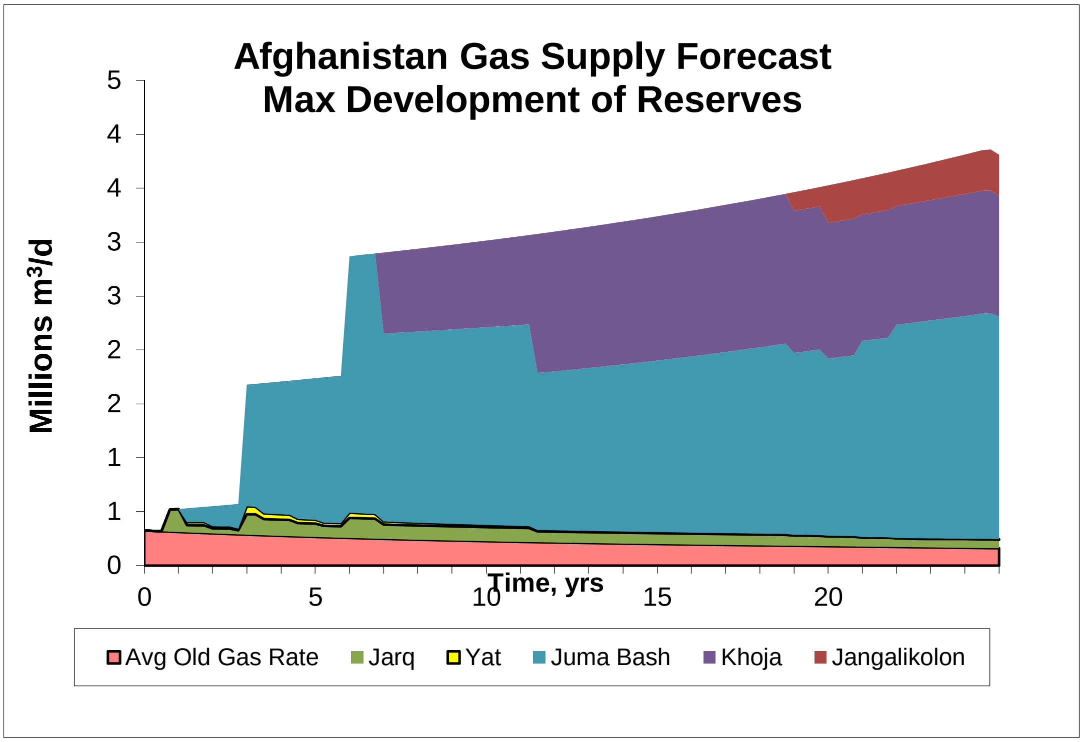

Figure 9 Supply Forecast Showing Source

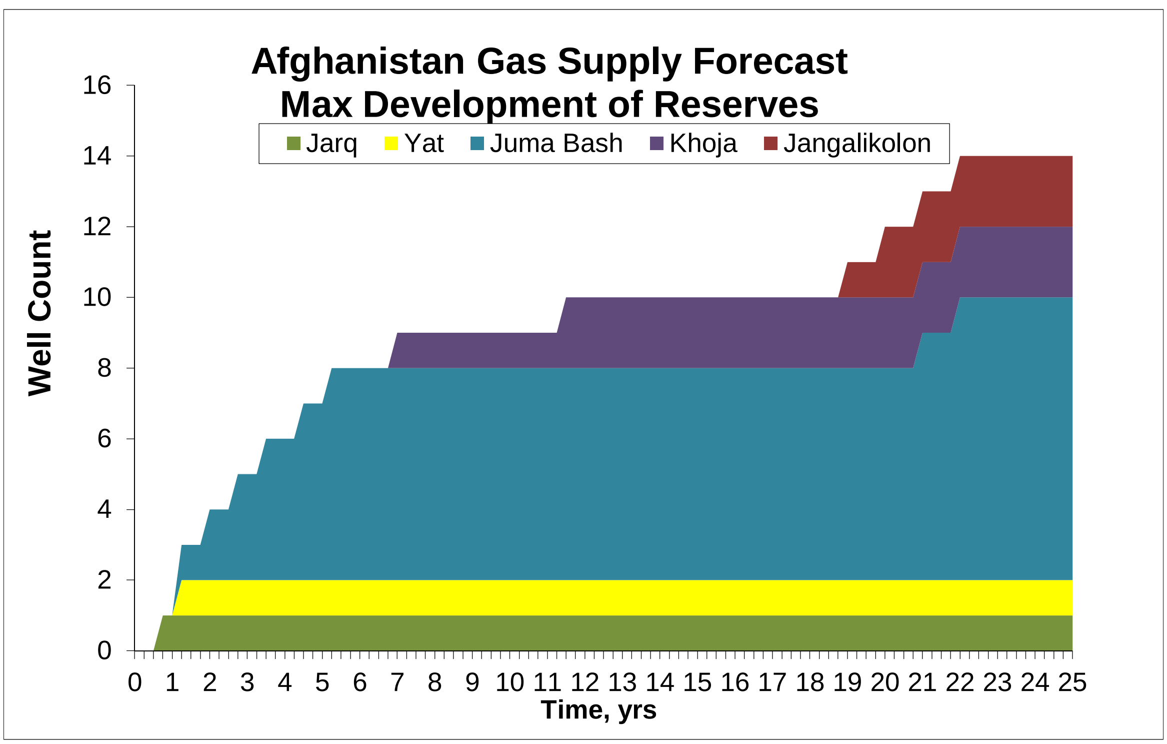

Figure 10 Added Well Count to Achieve Forecast Supply

Cumulative gas production from the existing and new wells over twenty five years is forecast to be about 25.3 billion m^3. This is about one third of the estimated reserves[7]. We estimate that substantial reserves of gas (about 50 billion m^3) would be available from the discovered fields for other purposes, even after supplying the assumed gas demand for two new power plants and local use including the Khud Berg fertilizer plant. Figure 8 shows that some gas supply could be available for alternative uses beyond the assumed demand forecast, since the capacity of the supply based on the assumed drilling schedule (max gas rate) exceeds assumed demand. However, if gas consumption were to exceed the demand forecast shown on the figure, then the reserves will be depleted more quickly, and the supply from the assumed wells will be unable to meet demand out to about year 25. Additional drilling could occur in the discovered fields to accommodate demand in excess of the assumed forecast. Additional drilling or workovers would definitely be required after about 25 years, even to accommodate the assumed demand. Such additional drilling or workovers could access reserves that are assumed not to be produced according to the assumed drilling schedule.

3.3.2 Gas Forecast, Resources

3.3.2.1 Associated Gas, Afghan-Tajik Basin

A probabilistic forecast has been prepared for gas production from prospective resources in Afghanistan. One set of exploration targets likely to be drilled in the short-term are the oil prospects in the Afghan-Tajik basin. Existing fields producing in the Tajik portion of this basin contain a significant amount of associated gas along with the oil. So, if oil discoveries are made, then there will likely be associated gas production. Development of these oil discoveries would require infrastructure for handling oil, gas, and produced water. Our projection has been based on the following assumptions:

1. 90 prospects as per the USGS

[7] Table 1 shows that reserves in the discovered fields as of Jan. 1, 2003 were estimated to be about 77.4 billion m^3. Reserves as of today would be about 75 billion m^3 assuming an historical average daily production rate of 700 thousand m^3 per day since Jan. 1, 2003.

2. A shifted lognormal distribution of prospective oil field size similar to that of the USGS[8] (Figure 11)
3. Solution gas/oil ratio ranges from 2,500 to 4,500 cubic feet per barrel
4. Probability of success for each prospect ranging from 6% to 18%
5. Exploratory drilling begins August 2013, with three months on average between the drilling of additional exploration wells
6. Time from the first successful discovery to first gas sales ranges is uncertain, but assumed to be between two to seven years, to allow for construction of an export pipeline or power plant
7. Time from subsequent discoveries to first gas sales from that discovery ranges from one to four years
8. The gas production is assumed to ramp up during drilling, maintain a plateau for a time period, and then decline Figure 12

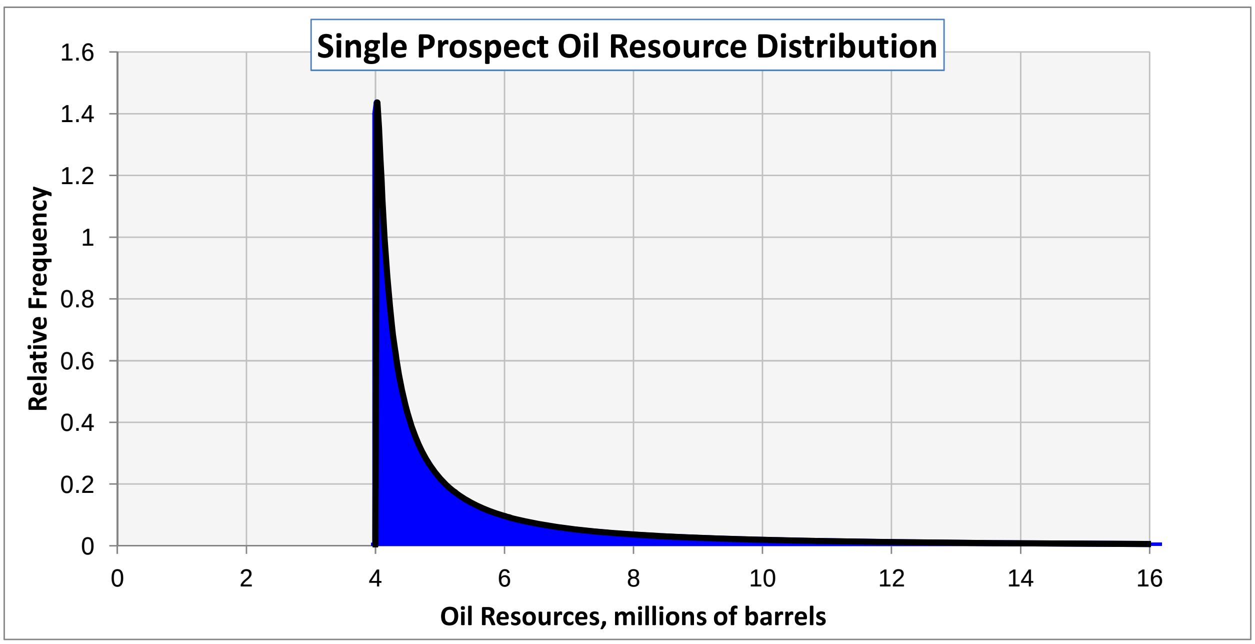

Figure 11 Example of Assumed Prospect Oil Resource Distribution

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[8] Mean 16.5 million barrels, standard deviation 43.1 million barrels, shifted right by 4 million barrels

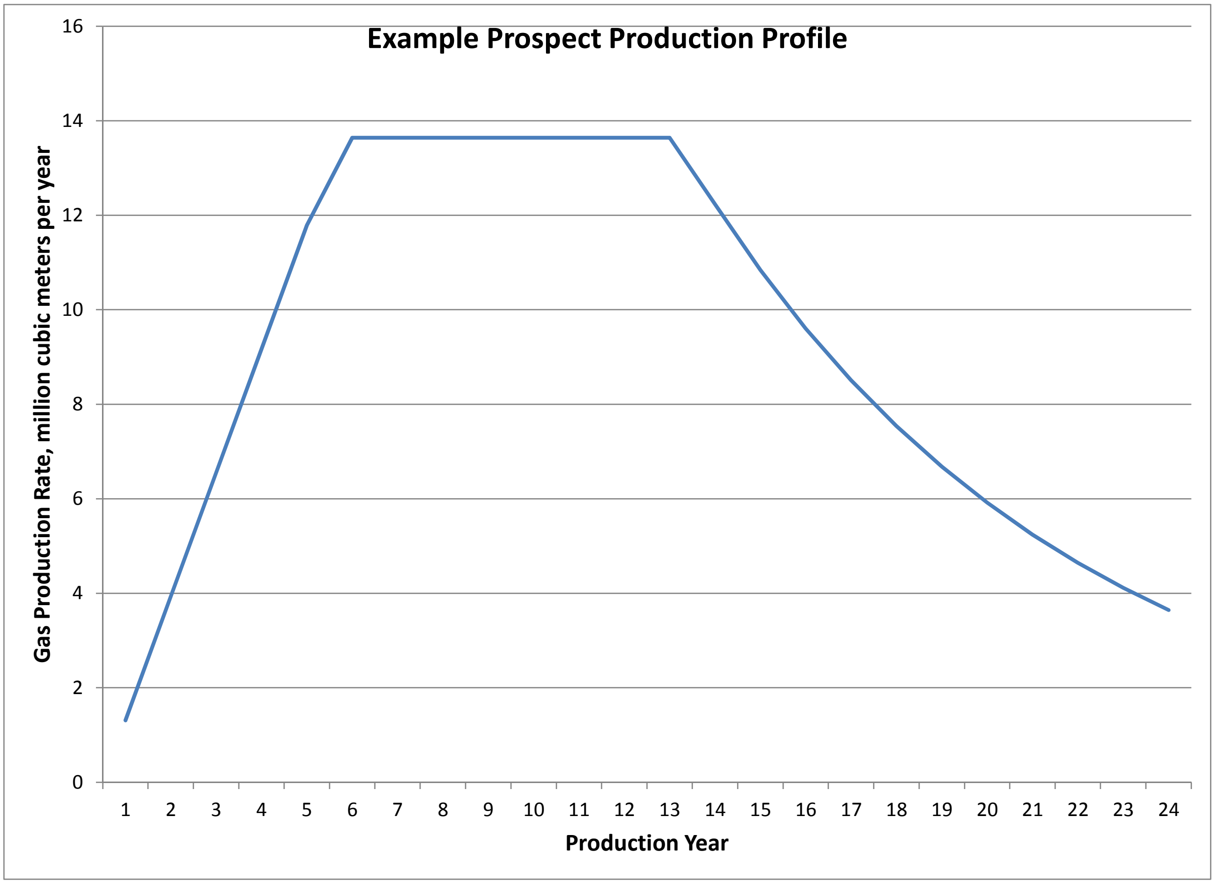

Figure 12 Example of Assumed Prospect Gas Production Profile

3.3.2.2 Deep Jurassic Gas, Amu Darya Basin

Another set of exploration targets which may be drilled in the short-term are the deep, Jurassic-age gas prospects in the Amu Darya basin. Our projection has been based on the following assumptions:

1. 50 prospects as per the USGS
2. A lognormal distribution of prospective field size similar to that of the USGS[9]
3. Probability of success for each prospect ranging from 10% to 20%
4. Exploratory drilling is carried on independently of the Afghan-Tajik basin, with the same parameters for its schedule, except that exploratory drilling begins three years later, August 2016
5. The same shape of field production profile was used as shown in Figure 12

[9] Mean 203 BCF, standard deviation 707 BCF, shifted right by 23 BCF

3.3.2.3 Results

Based on these assumptions, a probabilistic simulation was run to account for the uncertainty in all these parameters. The resulting distributions of gas resources, considering probability of success, are shown in Figure 13 and Figure 15, for the associated gas and deep gas, respectively. The distributions for the number of fields expected to be discovered are shown in Figure 14 and Figure 16. Based on the assumptions discussed above, there is a 95% chance that between one and seven fields will be discovered in the Afghan-Tajik basin. For the Amu Darya basin, there is a 92% chance that between two and eight fields will be discovered.

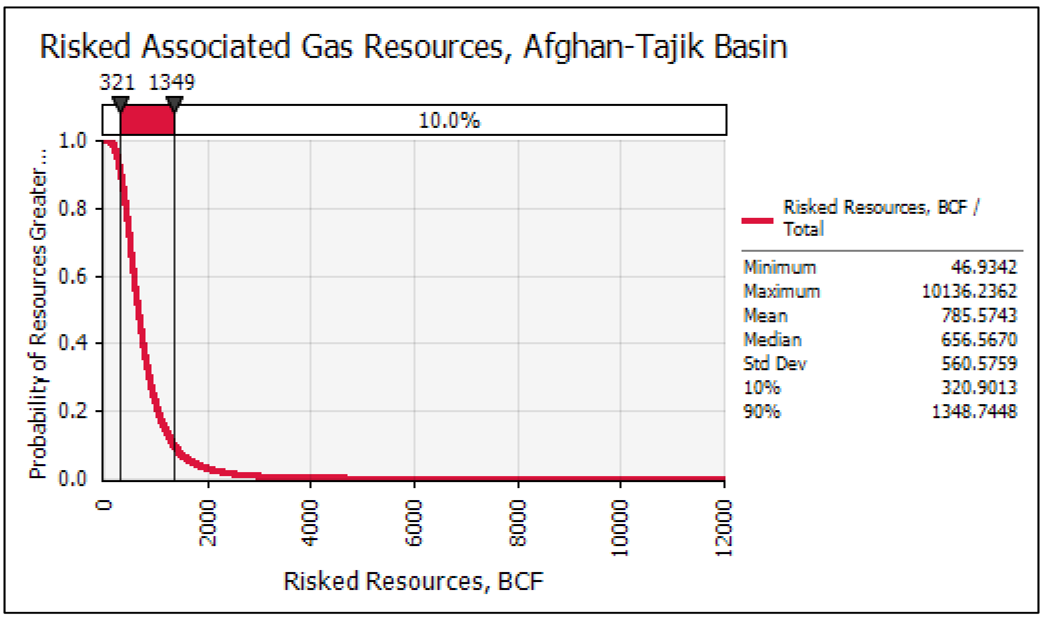

Figure 13 Cumulative Probability Distribution for Afghan-Tajik Gas Resources

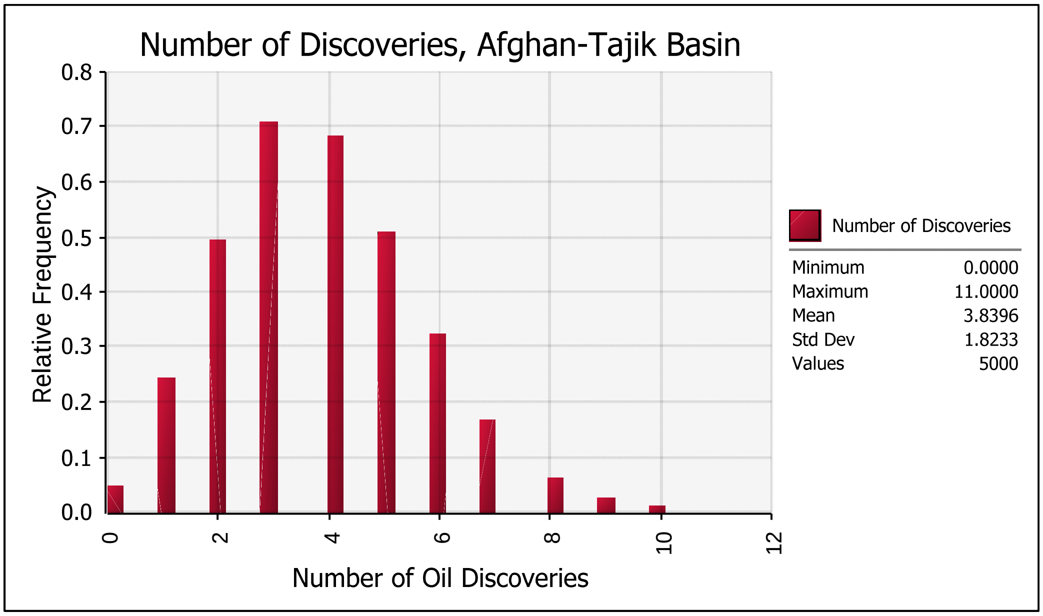

Figure 14 Probability Distribution for Number of Discovered Oil Fields

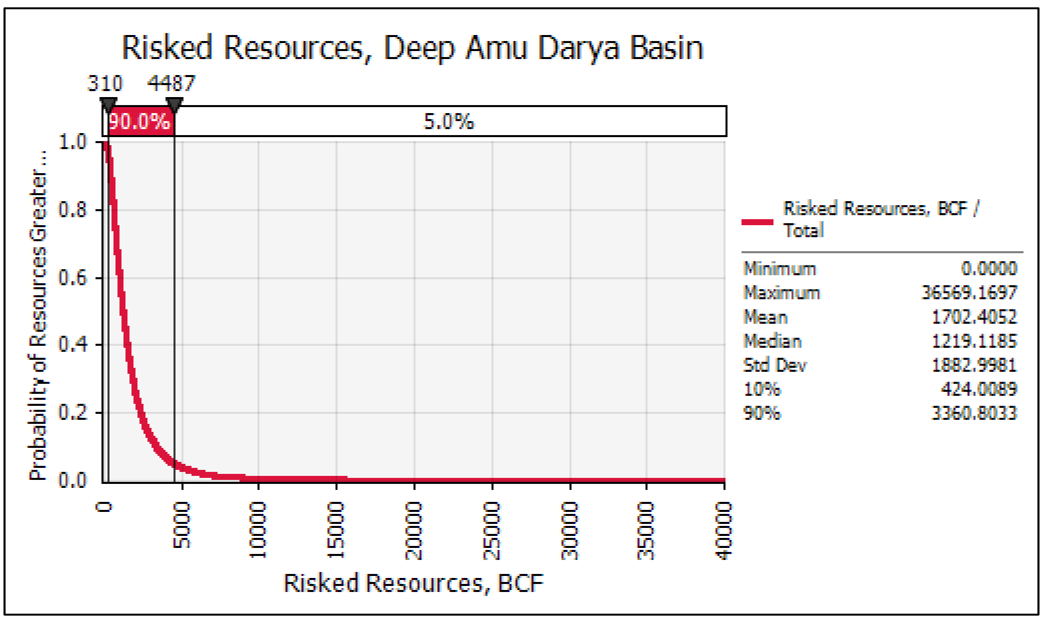

Figure 15 Cumulative Probability Distribution for Amu Darya Gas Resources

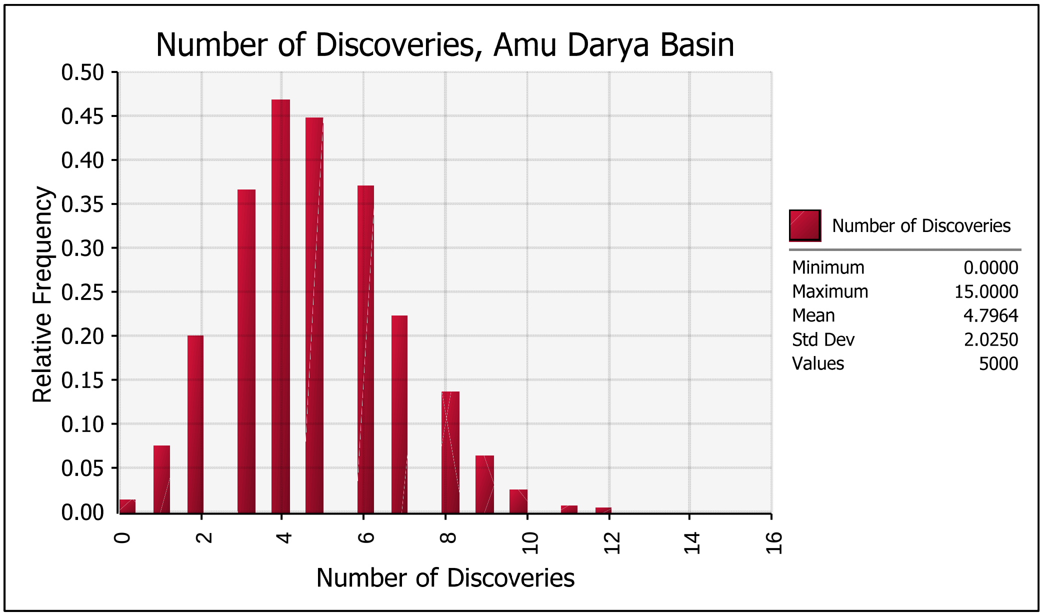

Figure 16 Probability Distribution for Number of Discovered Deep Gas Fields

The distributions for forecast gas production rates by year were sampled, and low, medium, and high forecasts were extracted based on the values expected to be met or exceeded 90, 50, and 10% of the time (P_{90}, P_{50}, and P_{10} values). The forecasts for associated gas and the oil discoveries are shown in Figure 17 and Figure 18. Table 2 shows a summary of the forecast for associated gas production.

Table 2 Summary of Associated Gas Forecast

Probability	Year of first associated gas production	Year in which associated gas production first exceeds 500,000 m^3/d
10%	2017	2019
50%	2019	2023
90%	2022	2030

The table shows that it is very unlikely that associated production from new oil field discoveries will occur before 2017, but that there is a 50% chance that such gas production will occur no later than 2019. However, the predicted gas rates are quite low. Production from the Sheberghan area fields was about 500,000 m^3 per day in 2006. There is only a 10% chance that at least this rate gas of gas production will occur from new discoveries in the Afghan Tajik basin by 2019. There is also a 10% chance that this rate will not be achieved by 2030! By way of

upside, there is a 10% chance that at least 3 million m^3 of associated gas will be produced per day by 2028.

The forecast for the deep gas discoveries is shown in Figure 19. A summary of the deep gas forecast is shown on Table 3. The summary shows that deep gas production is likely to occur later than production of associated gas, due to the probable lack of IOC interest in exploration for deep gas. However, if deep gas discoveries occur, then they could supply large quantities of gas.

Table 3 Summary of Deep Gas Forecast

		Year in which deep gas production first exceeds	
Probability	Year of first deep gas production	500,000 m^3/d	2 million m^3/d
10%	2019	2020	2022
50%	2021	2022	2026
90%	2025	2026	NA

The sums of the production forecast from development of discovered reserves and the three levels of gas resource forecasts, associated and deep gas combined, are shown in Figure 20. Of these forecasts, development of reserves is considered “most probable,” with each higher amount of forecast resources being successively less probable to achieve. This forecast is shown in Figure 21 and Figure 22 highlighting the relative contributions of reserves, associated gas, and deep gas, for the low case and high case.

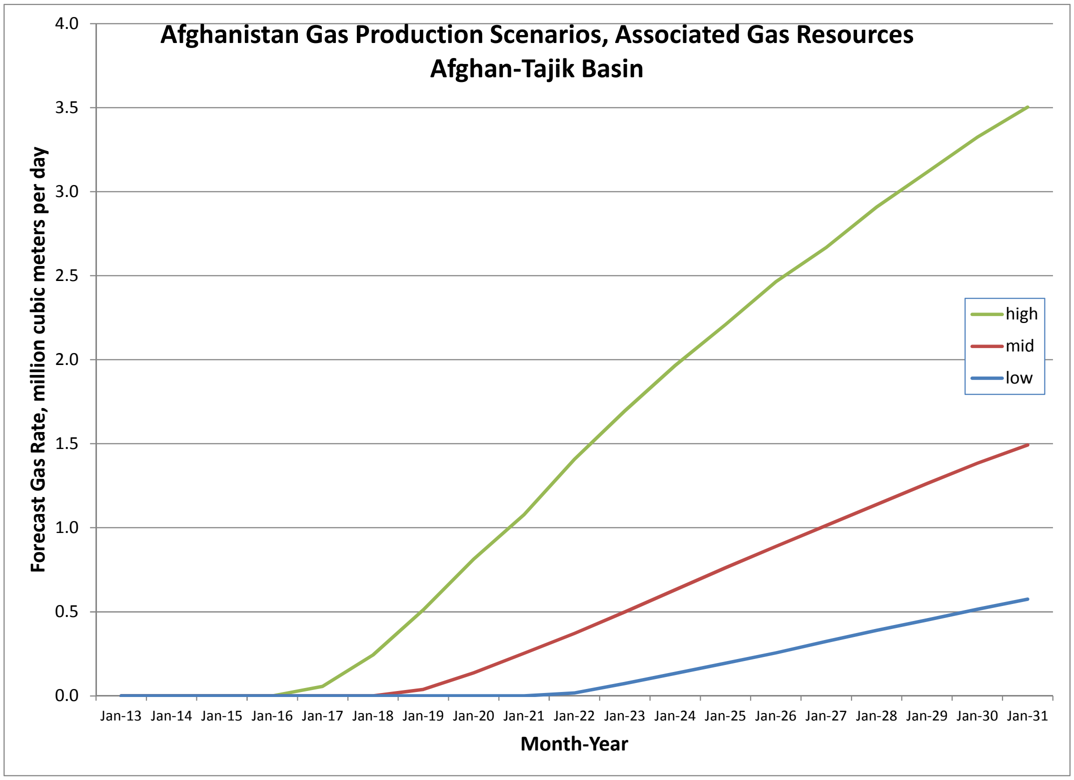

Figure 17 Associated Gas Production Profile, Risked Resources

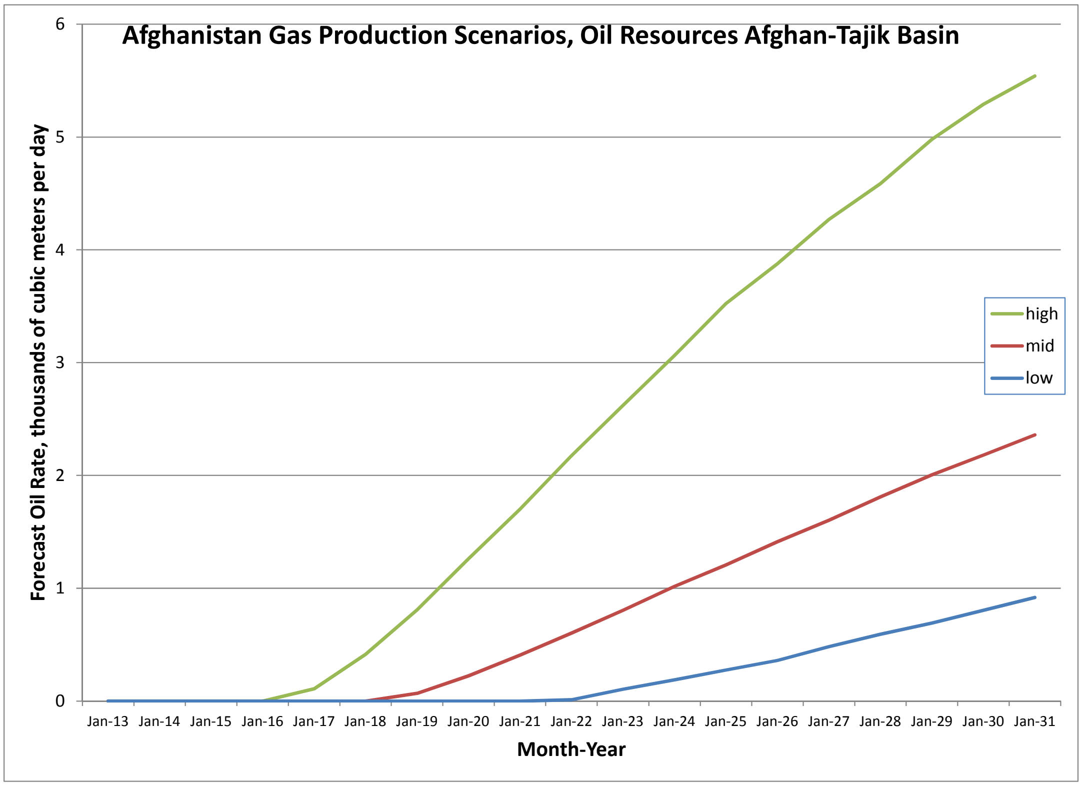

Figure 18 Oil Production Profile, Risked Resources

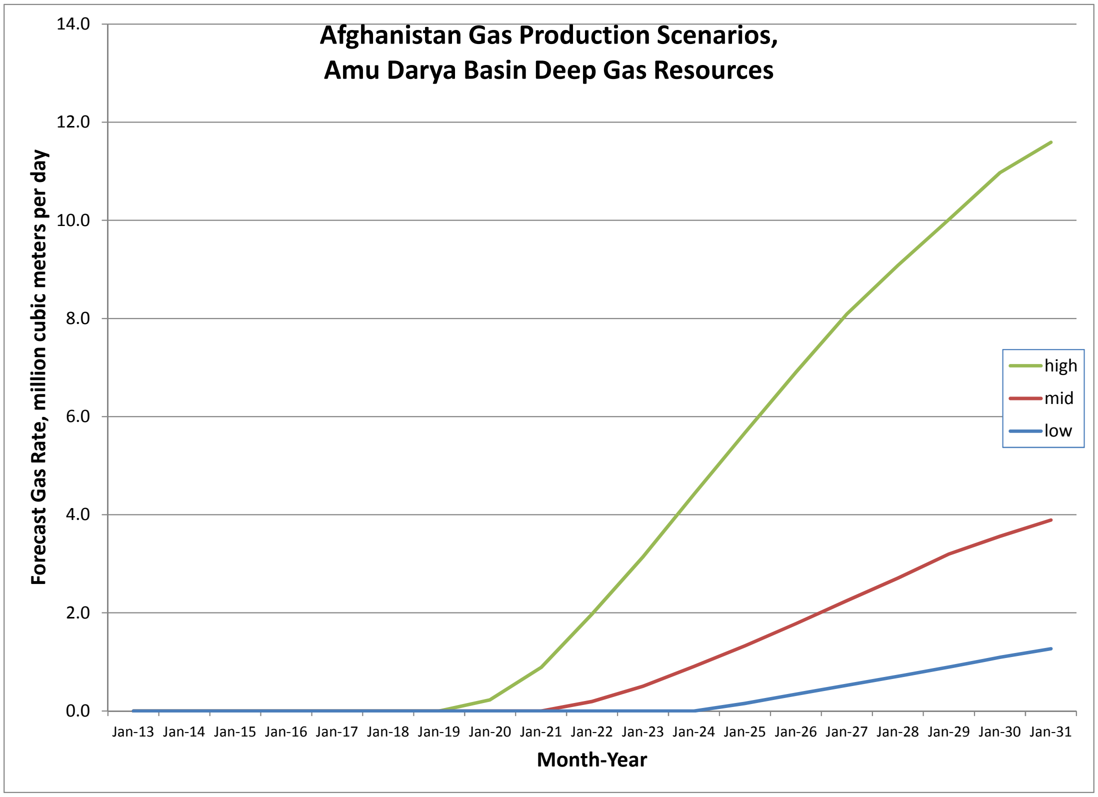

Figure 19 Deep Gas Production Profile, Risked Resources

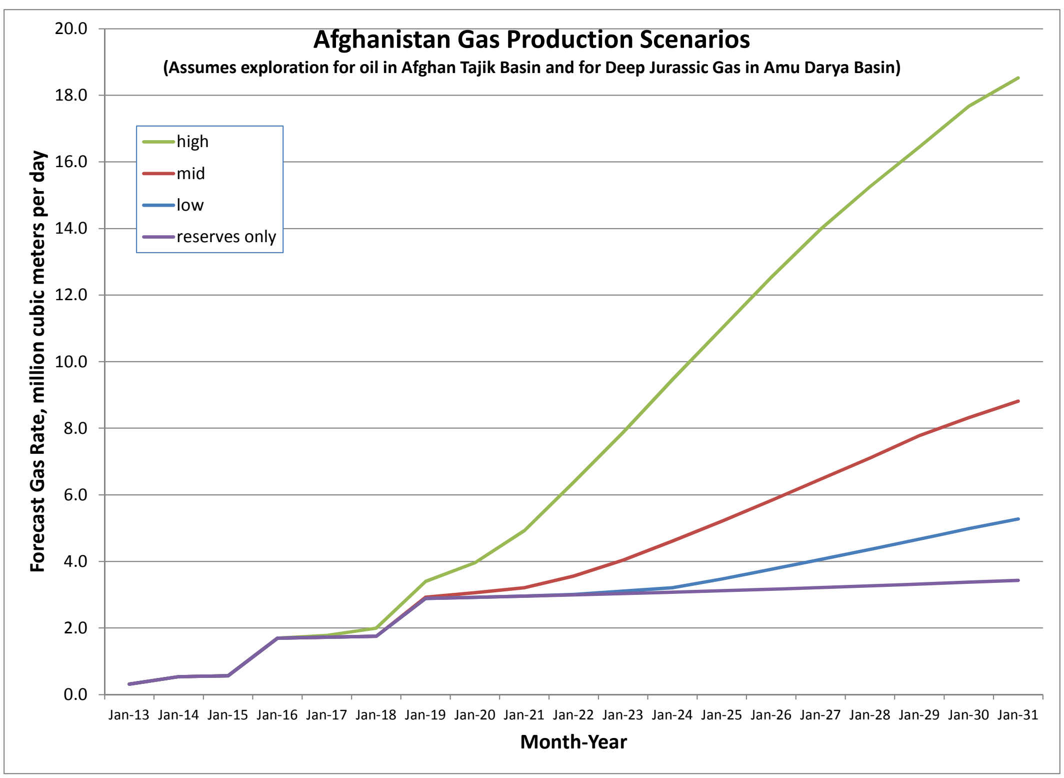

Figure 20 Total Gas Production Profile, Reserves and Risked Resources

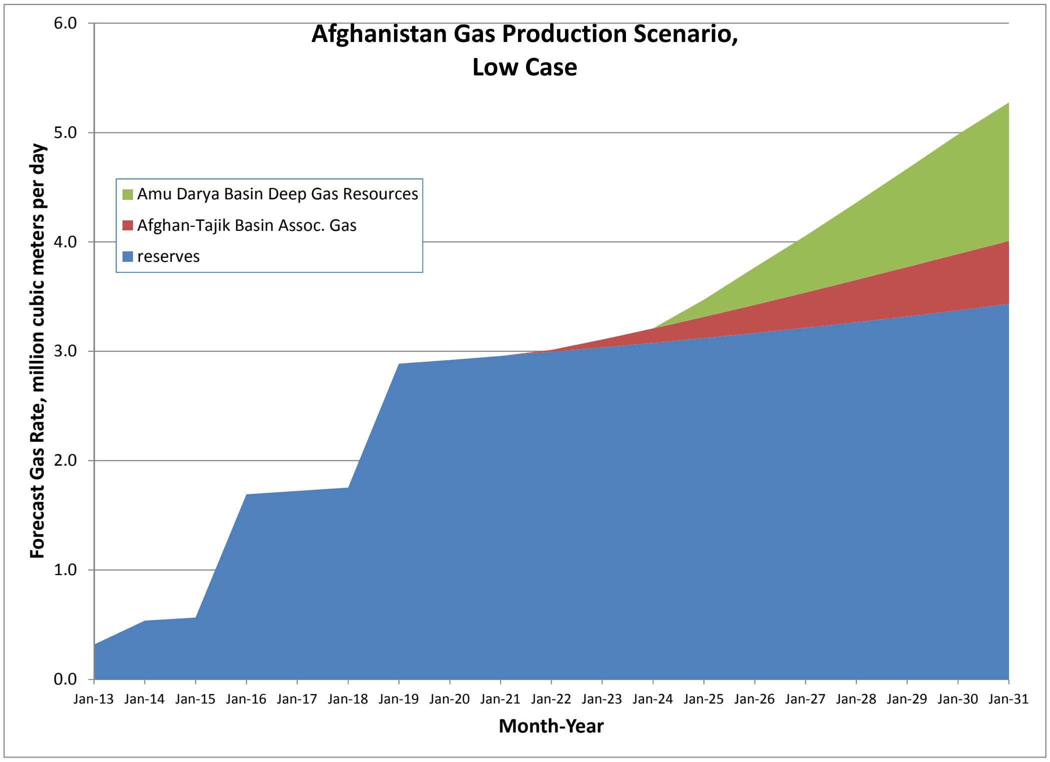

Figure 21 Total Gas Production Profile, Low Case

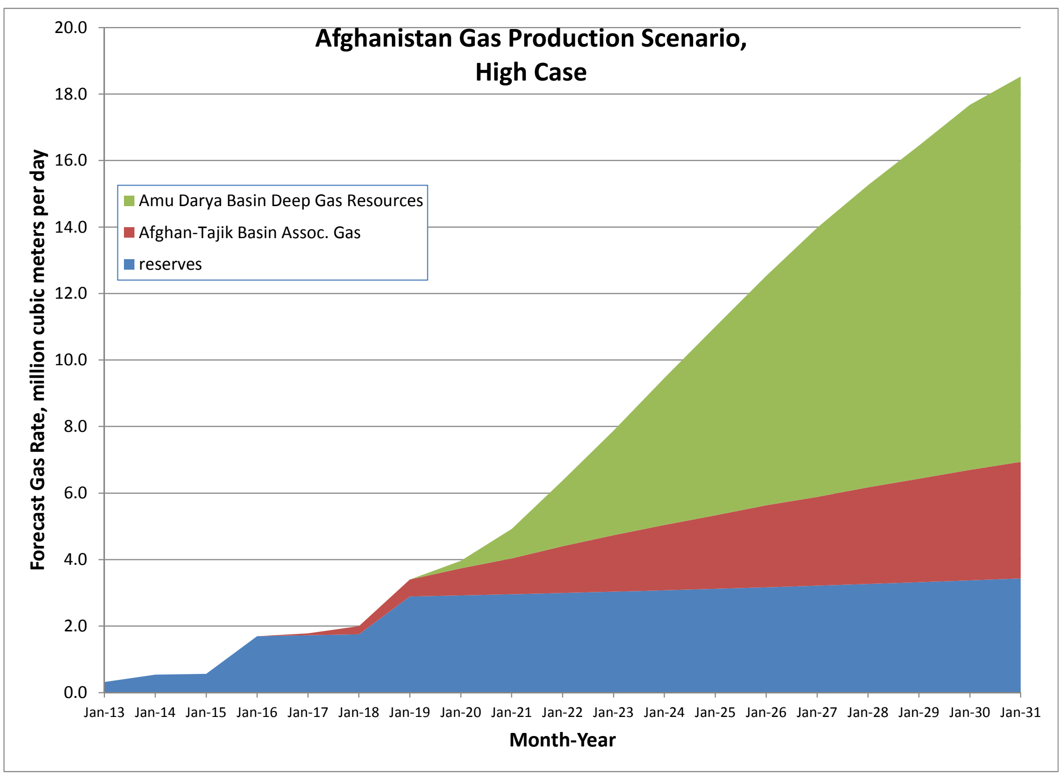

Figure 22 Total Gas Production Profile, High Case

3.4 TO THE EXTENT POSSIBLE, LINK THESE SCENARIOS TO SPECIFIC POTENTIAL FIELDS WITHIN THE BASINS, AND PROVIDE GEO-REFERENCES FOR THOSE

As mentioned in earlier sections, there are seven discovered gas fields located in the Sheberghan area. These fields are located in the Amu Darya basin and are the main gas discoveries that we are aware of. There may be a few other discoveries but likely their size is not substantial. The location of these fields are shown on Figure 4 and would be the main source of gas supply during the first few years of the production scenarios presented earlier.

It is not possible to provide geo references for the prospective resources. This is because it is unknown where the new discoveries will occur. However, we think it likely that new exploration will take place in the Afghan-Tajik basin because this area may be more oil prone.

4 TASK 2: ESTIMATE THE TIMESCALE OVER WHCH THE MOST LIKELY SCENARIOS WILL BE DEVELOPED

4.1 EVALUATE THE PRINCIPAL TASKS NEEDED AND RANGE OF TIME REQUIRED TO DEVELOP EACH BASIN, BASED ON, INTER ALIA, CURRENT LICENSE STATUS, THE DEGREE OF CURRENT KNOWLEDGE ABOUT THE BASIN AND ITS FIELD, AND THE TRACK RECORD OF CNPC OR OTHER LIKELY DEVELOPERS

For the discovered fields in the Amu Darya Basin, the critical operational steps include but are not limited to:

1. Workovers of existing wells and drilling new wells to acquire new data necessary to update production forecast, reservoir properties, gas composition and previous reserve estimates
2. Preparation of full field development plans that identify additional existing wells to be worked over and new wells to be drilled along with required production and gathering facilities and other infrastructure
3. Implement field development
4. Installation of critical infrastructure such as production facilities, pipelines and sweetening plant(s)

We first consider the range of time estimates from an operational and logistical standpoint. Three fields (Gerquduq, Yatimtag and Khoja Gogerdag) are currently producing gas and have shut-in wells available that can produce gas. These wells can be put into production quickly (three to six months) if standard oilfield equipment and services are available for workover, logging, perforating, testing and making any necessary repairs.

However, even if the work above is completed in the near future, the gas would have a limited market because of the lack of infrastructure. Historically, the main customer of the natural gas production was the fertilizer plant located at Khud Berg outside of Mazar e Sharif. The fertilizer plant uses the natural gas to make fertilizer and to generate electric power. The fertilizer plant

has strict specifications and requires gas with a very low amount of impurities, otherwise the catalysts and other sensitive equipment could be damaged. Although there are some remaining reserves of sweet gas at Khoja Gogerdag, these reserves are largely depleted. Most of the remaining gas reserves have varying levels of hydrogen sulfide and carbon dioxide that would have to be removed by a gas sweetening plant before the gas could be used for the fertilizer plant and also for new power plants. Therefore, at least one gas sweetening plant would have to be constructed to make the remaining gas reserves usable.

In addition, the existing pipeline networks are reportedly in a poor state. The main pipeline to Mazar e Sharif reportedly has leaks resulting in excessive line losses. The pipeline to the town of Sheberghan is laid on the surface and is also vulnerable to leaks. Further, the hydrogen sulfide is not currently removed from the gas stream and therefore, residents in the town are using gas that is potentially toxic.

Construction of new gas sweetening plants, gathering systems and pipelines will take time. There are several steps to be done including but not limited to:

1. Data acquisition of gas rates, pressures and composition,
2. Preliminary engineering and design,
3. Study of disposal options for the by-products such as carbon dioxide and hydrogen sulfide
4. Detailed design
5. Procurement of equipment
6. Construction
7. Plant Start-up

Even on a fast track, it will take a minimum of two to three years, more likely in the range of three to five years. There may be some interim solutions to accelerate, but this would have to be studied.

The above time frames do not consider other issues that could affect timing such as gas pricing and fiscal terms with the host country, other critical infrastructure such as regional power transmission systems, political instability...

For the undiscovered resources, the critical operational steps include but are not limited to:

1. Licensing out of exploration blocks (probably via open tender)
2. Acquisition of seismic and other data for the identification of new exploration targets
3. Exploration drilling to test prospects identified by seismic and other means
4. If a discovery is made, field appraisal to estimate the field size
5. Preparation of full field development plan
6. Well drilling, construction of field surface facilities (possibly including additional sweetening plants), development of oil and/or gas transportation infrastructure

The time to develop the undiscovered resources is longer and has a higher degree of uncertainty because of the inherent risks of exploration. For the purposes of our production scenarios, we have estimated that the time from the first successful discovery to first gas sales ranges from two to seven years, to allow for construction of an export pipeline or power plant. After the infrastructure has been constructed, we estimate that time from subsequent discoveries to first gas sales from that discovery ranges from one to four years.

The above time frames are considered reasonable both for the types of projects and the likely developers. However issues such as security and political instability could cause indeterminate delays. Also it is unclear how much demining will have to be done in advance of exploration activities.

4.2 IDENTIFY THE TASKS MOST LIKELY TO LIE ON THE CRITICAL PATH AND MOST LIKELY TO RESULT IN DELAYS (E.G., ANY GAPS IN THE REGULATORY FRAMEWORK), IN PARTICULAR DRAWING ON LESSONS LEARNED FROM THE REPEATED DELAYS IN ATTEMPTS TO DEVELOP THE SHEBERGHAN GAS FIELDS

4.2.1 Known Fields

One of the problems in developing the known gas fields in the Sheberghan area has been the desire on the part of power plant developers to get assurances about the accuracy of the gas reserves in the discovered fields. The concern is that the reserve estimates are based on old Soviet reports that were prepared in the early 1980s, and it is difficult to verify the technical information described and reported in these reports. Prior to moving forward with financing, there have been initiatives in the past and currently, to do new testing of existing wells or new drilling. The implementation of these initiatives to get the new data has been the subject of repeated delays, some of the reasons being known and some unknown. The requirement for new information to improve the confidence in the gas reserves continues to this day. Therefore, it is necessary to initiate the work to gather this new information in the gas fields. USAID has budgeted for the drilling of wells to confirm gas reserve estimates and to serve as a future gas supply source. Also, the Ministry of Mines is in the process of evaluating bids for workovers and testing of some existing wells in the Sheberghan area, with funding provided by the Asian Development Bank.

There are many open issues concerning pricing and marketing, including:

- The price of gas at the wellhead will need to be determined, as will other economic considerations concerning gas production, such as royalty rates and/or the form of the gas production contract
- If gas is used to fuel power generation, then power prices will need to be determined
- A power purchase agreement would be required before financing of power plants can be completed
- A appropriate compensation for gas sweetening will need to be determined

There are also many open issues concerning ownership of facilities that must be resolved, including:

1. Will gas production and power generation be achieved by a single entity, or will production and generation be undertaken by separate entities?
2. Who will invest in and operate the necessary gas sweetening plant(s)?
3. If the ownership of the power plant(s) is separate from gas production, will power generation be undertaken on a tolling basis where the generator receives a fee based on the amount of power generation, or will the generator purchase gas and sell power?

There will be numerous permitting issues including:

- Environmental and social permitting for oil and gas exploration activities
- Environmental and social permitting fro sweetening plant(s) and power plant(s)
- Access to water for operation of sweetening plant(s) and power plant(s)
- Permitting for acid gas disposal
- Construction and operation permits for oil and gas facilities and power plants

Previous oil and gas activity has experienced delays due to customs issues. Contractors were concerned that their equipment might be held up at the border upon entry to the country, and that it might not be permitted to leave the country upon completion of work.

4.2.2 Exploration Opportunities

More time will be required for exploitation of as-yet undiscovered resources. A necessary first step is the award of the rights to explore and develop acreage. In March of this year the Afghan Ministry of Mines requested expressions of interest for exploration, development and production in six exploration blocks in the region north of Mazar e Sharif, stating that the area would be open for exploration in early 2013.[10]

[10] http://mom.gov.af/en/news/7623

Once a company has been awarded the rights to a block, it will typically conduct a seismic survey and then analyze the large amount of data that is collected. The seismic data may indicate the presence of structural features in the subsurface that could contain hydrocarbons. There is existing Soviet era and more recent geological and geophysical data for the Amu Darya and Afghan-Tajik basins, so it is possible that a company may decide to forego new seismic work and proceed directly to the drilling of an exploration well.

The well may or may not discover hydrocarbons, and if so, the reservoir may contain either oil or gas. If the exploration well is successful, then it is standard practice to drill one or two appraisal wells to assess the size of the discovery. If the discovery size is large enough, the company will deem it to be commercial and will plan for additional drilling and construction of surface facilities to handle produced oil, gas, and/or water. A gas sweetening plant may be required in order to remove hydrogen sulfide and/or carbon dioxide from the produced gas. For a large discovery, commercial production typically begins before all of the planned wells are drilled, in order to generate revenue. Development drilling continues after first commercial production.

A sample timeline for exploration and development of a target on an awarded block is shown on Figure 23. The sample assumes that activity will begin in April 2013. The figure shows that it may take at least seven years from the start of exploration to the date of first commercial production. The actual time required will depend on circumstances, and may be longer or shorter.

ID	Task Name	Duration	Start	Finish
1	**Literature Review**	**15 days**	**4/1/13**	**4/19/13**
2	Leads and Prospects Analysis	15 days	4/1/13	4/19/13
3	**Seismic**	**484 days**	**4/1/13**	**2/5/15**
4	Seismic Survey Planning and Design	60 days	4/1/13	6/21/13
5	Seismic Bid Document Preparation and Receive Approval from GoA	20 days	6/24/13	7/19/13
6	Seismic Bid Receipt for Survey and Award Contract	90 days	7/22/13	11/22/13
7	Seismic Equipment Customs Clearance and Mobilization	60 days	11/25/13	2/14/14
8	Seismic Survey Data Collection	240 days	2/17/14	1/16/15
9	Seismic Data Processing (continuous as collected)	240 days	3/7/14	2/5/15
10	Seismic Mapping and Interpretation (continuous as collected)	240 days	3/7/14	2/5/15
11	**Exploration Well**	**500 days**	**2/6/15**	**1/5/17**
12	Well Planning	120 days	2/6/15	7/23/15
13	Well Bid Document Preparation and Receive Approval from GoA	20 days	7/24/15	8/20/15
14	Well Bid Receipt and Award Contract	90 days	8/21/15	12/24/15
15	Drill Rig and Other Equipment Customs Clearance and Mobilization	150 days	12/25/15	7/21/16
16	Well Drilling (+/- 3,000 meters)	90 days	7/22/16	11/24/16
17	Well Testing (assuming successful discovery)	30 days	11/25/16	1/5/17
18	**Appraisal and Development Wells**	**545 days**	**1/6/17**	**2/7/19**
19	Well Planning	120 days	1/6/17	6/22/17
20	Well Bid Document Preparation and Receive Approval from GoA	20 days	6/23/17	7/20/17
21	Well Bid Receipt and Award Contract	90 days	7/21/17	11/23/17
22	**Well Drilling - Well #1 (+/- 3,000 meters)**	**120 days**	**11/24/17**	**5/10/18**
23	Drilling	90 days	11/24/17	3/29/18
24	Testing (assuming successful discovery)	30 days	3/30/18	5/10/18
25	**Well Drilling - Well #2 (+/- 3,000 meters)**	**135 days**	**3/30/18**	**10/4/18**
26	Drilling	105 days	3/30/18	8/23/18
27	Testing (assuming successful discovery)	30 days	8/24/18	10/4/18
28	**Well Drilling - Well #3 (+/- 3,000 meters)**	**120 days**	**8/24/18**	**2/7/19**
29	Drilling	90 days	8/24/18	12/27/18
30	Testing (assuming successful discovery)	30 days	12/28/18	2/7/19
31	**Field Development**	**390 days**	**2/8/19**	**8/6/20**
32	Proceed with full field well development	30 days	2/8/19	3/21/19
33	Full Field Feasibility for Sizing of Facilities	**390 days**	**2/8/19**	**8/6/20**
34	**Gathering Center**	**120 days**	**2/8/19**	**7/25/19**
35	Design	30 days	2/8/19	3/21/19
36	Construction and Installation	90 days	3/22/19	7/25/19
37	**Sweetening Plant**	**390 days**	**2/8/19**	**8/6/20**
38	Design	120 days	2/8/19	7/25/19
39	Construction and Installation	270 days	7/26/19	8/6/20
40	**Processing Plant**	**390 days**	**2/8/19**	**8/6/20**
41	Design	120 days	2/8/19	7/25/19
42	Construction and Installation	270 days	7/26/19	8/6/20
43	**First commercial production**	0 days	8/6/20	8/6/20

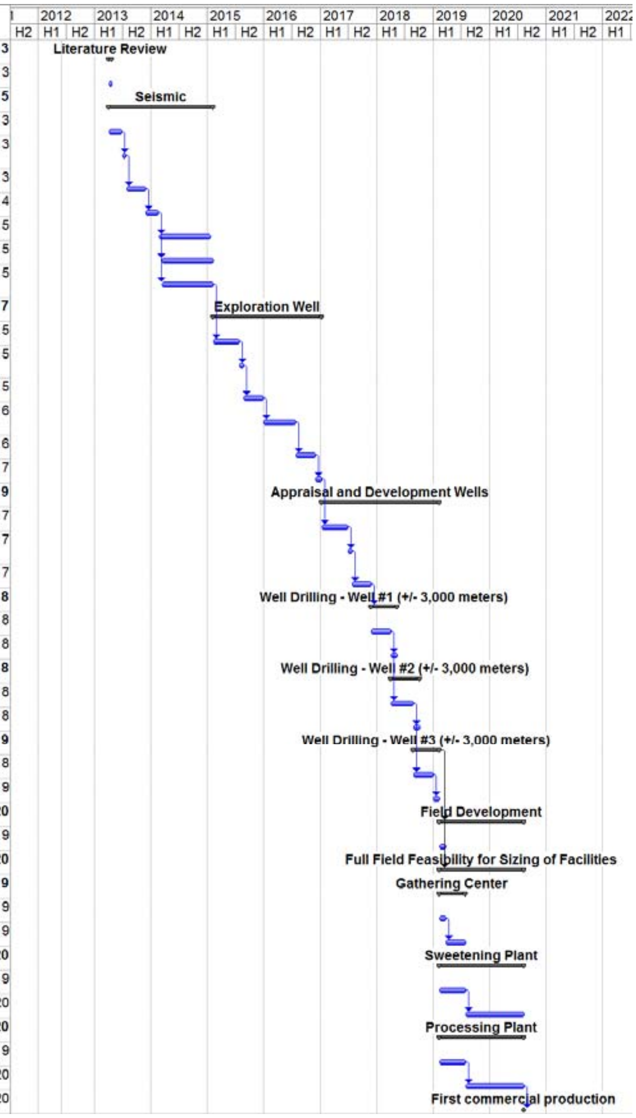

Figure 23 Sample Schedule for an Exploratory Opportunity

5 Task 3: IDENTIFY THE COMMERCIAL IMPLICATIONS OF EACH SCENARIO

5.1 USE INDUSTRY BENCHMARKS AND COMPARISONS TO EVALUATE THE MOST LIKELY COMMERCIALIZATION OPTION FOR EACH RESOURCES AND RESERVES SCENARIO

5.1.1 Introduction

As discussed in the previous sections of the report, the Amu Darya and Afghan-Tajik basins of northern Afghanistan contain a mix of discovered oil and gas reserves and undiscovered hydrocarbon potential. Although there are discovered oil reserves in four fields near Sari Pul, it is estimated that there is only a small amount of associated gas with these discoveries. Any associated gas resulting from the development of these oil fields would likely be flared, used as fuel gas and/or sold to the local villages for residential or light commercial use.

Aside from the oil reserves, the remaining hydrocarbon reserves are predominantly dry gas[11]. As discussed previously, these gas reserves contain H_2S and other impurities that would have to be removed through some type of gas treatment or sweetening plant. IOCs are not particularly attracted to develop dry gas reserves in emerging market countries.

When one looks at situations in different countries, IOCs prefer to find large or giant gas reserves which can be transported for export via pipeline or LNG to attractive high demand markets such as Europe, India, Southeast Asia, Japan or China. Sales of gas to the local market especially in an emerging market country is not particularly attractive because gas prices are frequently capped or subsidized due to policies instituted by the host government. While these local sales are not out of the question, IOCs are motivated to sell gas to the local market in pursuit of other objectives such as exploring for deeper oil targets and/or selling the associated gas in order to produce and sell oil from the same reservoir.

[11] Dry gas is mostly methane, possibly with impurities such as carbon dioxide and/or hydrogen sulfide. It does not contain significant amounts of heavier hydrocarbons such as propane or butanes.

IOCs would be attracted to exploration targets that are likely to contain oil. Although oil production can be subject to a domestic market obligation where prices are lower than world prices, IOCs have the anticipation that they can export the majority of the oil production in order to receive higher prices. Concession blocks offered in the Afghan-Tajik basin could be attractive to IOCs to explore for oil targets. These issues are discussed in further detail in subsequent sections.

It is not clear where produced oil would be refined. There is a small refinery in Hairatan on the Uzbek border in the vicinity of Mazar e Sharif, owned by the Kam group.[12] We do not know the capacity of this refinery. In June 2011, it was processing about 200 barrels per day.[13]

5.1.2 Amu Darya Basin

Discovered Fields

As part of our work on the project, we reviewed various reports supplied by the Client that have been prepared on energy and power. The recurring theme from these reports is that currently Afghanistan lacks the infrastructure and ability to generate sufficient supplies of electric power to meet domestic power demand. There is also demand for natural gas for commercial, industrial and residential uses. Currently, only a limited portion of the population has access to natural gas supplies.

Based on this review and our experience in the area, the commercialization options for the discovered fields are likely to be the following:

- Fertilizer plant in Mazar e Sharif
- Commercial / Light Industrial Customers in the Sheberghan area
- Residential Customers in and around Sheberghan and Mazar e Sharif
- New power plant(s) near the gas fields
- Compressed natural gas (CNG) for vehicles

[12] http://iwpr.net/report-news/oiling-wheels-afghanistan
[13] Ibid

Of these options, the new power plants are the most significant since they will consume the majority of the gas production. A power point presentation by Fichtner entitled "TA 7637 (AFG) – Power Sector Master Plan" presented power demand estimates for both Northern Afghanistan and the country as a whole.

In 2011, Afghanistan imported 2,250 GWh of electricity or about seventy three percent of its overall electricity demand. These imports came from Iran, Tajikistan, Turkmenistan and Uzbekistan and provide a cheaper alternative to domestically produced power from diesel. According to the Fichtner presentation, future demand for electricity is expected to increase substantially over the next twenty years (Table 4). The Fichtner presentation cited new gas fired power plants in Sheberghan as a supply option for increasing domestic electricity supply.

Table 4 Fichtner Summary Demand Forecast[14]

	Gross Demand GWh		**Peak Load MW**		
	Northern Part	Afghanistan Total	Northern Part	Afghanistan Total	North as % of Total
2017	1,300	5,750	240	1,100	23%
2022	1,800	7,800	325	1,450	23%
2032	3,100	13,000	560	2,350	24%

The Fichtner presentation also provided estimates of demand for individual Northern provinces as shown on Table 5.

[14] Data from PowerPoint Presentation, "TA-7637 (AFG) Power Sector Master Plan, Istanbul, 24 April 2012, presented by Fichtner, p. 17

Table 5 Demand in the Northern Part of Afghanistan Forecast by Provinces[15]

	Demand GWh					Peak Load MW			
Province	**2012**	**2017**	**2022**	**2032**	**CAGR**	**2012**	**2017**	**2022**	**2032**
Balkh	236	368	489	789	6.2%	44.6	67.9	88.6	143
Kunduz	112	225	295	497	7.7%	21.2	41.5	53.4	90.1
Faryab	107	177	224	377	6.5%	20.2	32.6	40.6	68.4
Baghlan	75	171	238	417	9.0%	14.3	31.7	43.1	75.6
Jowzyan	64	100	127	212	6.2%	12.1	18.5	23.1	38.5
Parwan	22	63	96	171	10.8%	4.3	11.6	17.3	31
Sar-e Pol	21	56	84	148	10.3%	3.9	10.3	15.2	26.8
Samangan	16	39	57	100	9.6%	3.1	7.1	10.3	18
Takhar	9	50	103	206	16.9%	1.8	9.3	18.7	37.4
Badakhshan	8	43	89	180	16.8%	1.6	8	16.1	32.6
Total	671	1,292	1,801	3,098	7.9%	127	239	326	561

The three provinces with highest projected future demand are Balkh, Kunduz and Baghlan. These high power demand provinces are highlighted on Figure 24 along with the locations of the two major mining projects; namely the Aynak copper deposit in Logar Province and the Hajigak iron ore project in Bamyan Province. Once constructed and in operation, the Aynak and Hajigak mining projects will require large amounts of power and may serve as anchor customers for the proposed new power plants.[16]

While the new plants would focus on serving customers in the north, it may be possible to ultimately serve a larger customer base by connecting to the transmission lines that are part of the North East Power System (NEPS). The location of NEPS is shown on Figure 24 and traverses along a north-south route in the eastern part of the country with terminus in Kabul

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[15] Data from PowerPoint Presentation, "TA-7637 (AFG) Power Sector Master Plan, Istanbul, 24 April 2012, presented by Fichtner, p. 18

[16] These mines may construct their own power plants. But new gas fired power plants could provide back-up power, if there is adequate power transmission capacity, and if such industrial demand had high priority compared to other power uses.

Province. Connection to NEPS provides the opportunity to supply the large customer base in Kabul province with an estimated population of 3.7 million people. This would depend in part on available transmission capacity and other supply options that are part of the power sector master plan. However new power plants using gas from the discovered fields can either reduce power imports or be used to accommodate growth in power demand.

Undiscovered Resources

The main exploration targets in the Amu Darya basin are deep Jurassic age reservoirs. Hydrocarbons that might be discovered in these targets are expected to be dry gas. The commercialization options for these resources would most likely be power generation. As new fields are discovered however, there will likely be increased demand for non-power uses of gas from commercial, industrial and residential consumers. These uses are elaborated in the next section. As evidenced by the prior field discoveries, the deep Jurassic targets have the potential for large reserves in individual discoveries. If future exploration campaigns are successful then the domestic market might saturate at some point in the distant future and export of the excess gas might be another commercialization option.

5.1.3 Afghan-Tajik Basin

The exploration targets in the Afghan-Tajik basin are anticipated to contain oil with associated gas. These targets would be attractive to IOCs and likely exploration blocks would be licensed out to companies in any upcoming bid rounds. The Afghan-Tajik basin is located near the population centers of the Balkh and Kunduz provinces (Figure 25). As associated gas is produced, the likely commercialization options are as follows:

- New power plants developed in small modules estimated +/- 20 MW increments using reciprocating gas engines
- Commercial and light industrial such as brick kilns, bakeries hotels, restaurants, hospitals, and stores
- Transportation – compressed natural gas (CNG) for use in cars, buses and delivery trucks

- Residential - cooking, space heating, water heating and clothes drying. LPG, also known as bottled gas, can be used for the same purposes, although its chemical composition is different. Bottled gas is a mixture of propane and butane, whereas natural gas is predominantly methane. Many residential appliances can use either fuel, although some minor adjustments may be required.
- Industrial - firms which use natural gas for heat, power, or chemical feedstock. This category includes firms engaged in mining or other mineral extraction, as well as businesses involved in brick manufacture, cement or food processing

We anticipate that new power plants would be added in a modular fashion because the associated gas reserves will be too small initially to support a larger plant in the range of 150 MW. IOCs will be inclined to start oil production as soon as possible to generate cash flow. A modular design would allow power generation using a smaller gas supply. In addition to power generation, the associated gas produced with the oil could supply the non-power uses listed above. Finding the right customers in the best location in the early stages of field development could allow delivery and sale of the gas in a cost effective and profitable manner and hopefully eliminate unnecessary gas flaring.

Given the proximity the major cities such as Mazar e Sharif, natural gas could be transported relatively short distances via pipeline and then distributed first to large commercial and industrial customers and then eventually to smaller households. Because the prospective targets in the Afghan Tajik basin are expected (if filled with hydrocarbons) to have oil with associated natural gas, the gas will likely be “rich gas” with high BTUs or heating values. Rich gas will have heavier hydrocarbon components such propane and butane in addition to methane. If this type of gas is found in significant quantities, then the cost and construction of a gas processing plant or plants could be justified in order to strip out the heavier hydrocarbons that could be sold as LPG in bottles to households or small commercial enterprises. This is a less capital intensive method for distribution of hydrocarbon fuel compared to building a natural gas distribution network.

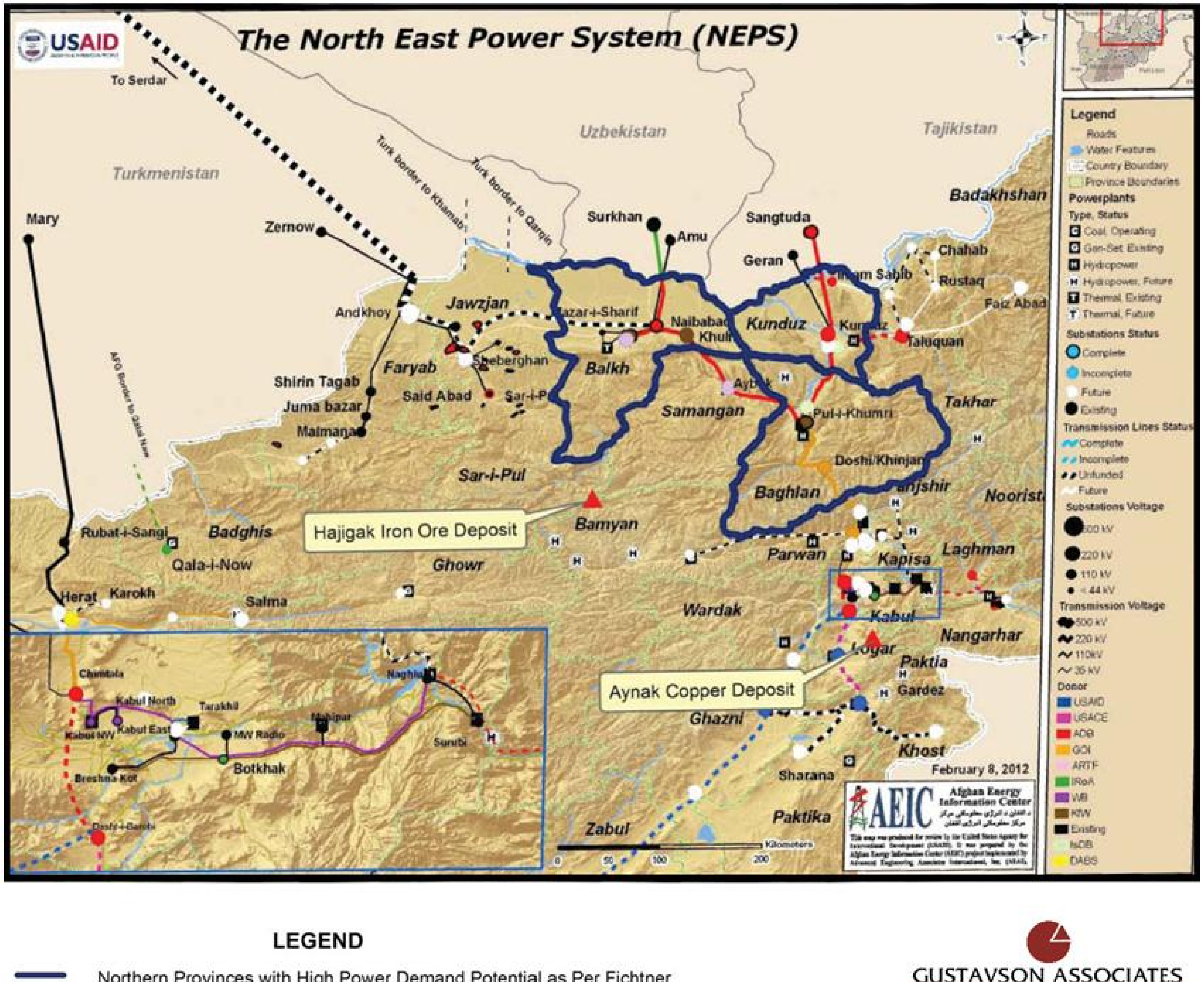

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Figure 24 - High Future Demand Areas in Northern Afghanistan

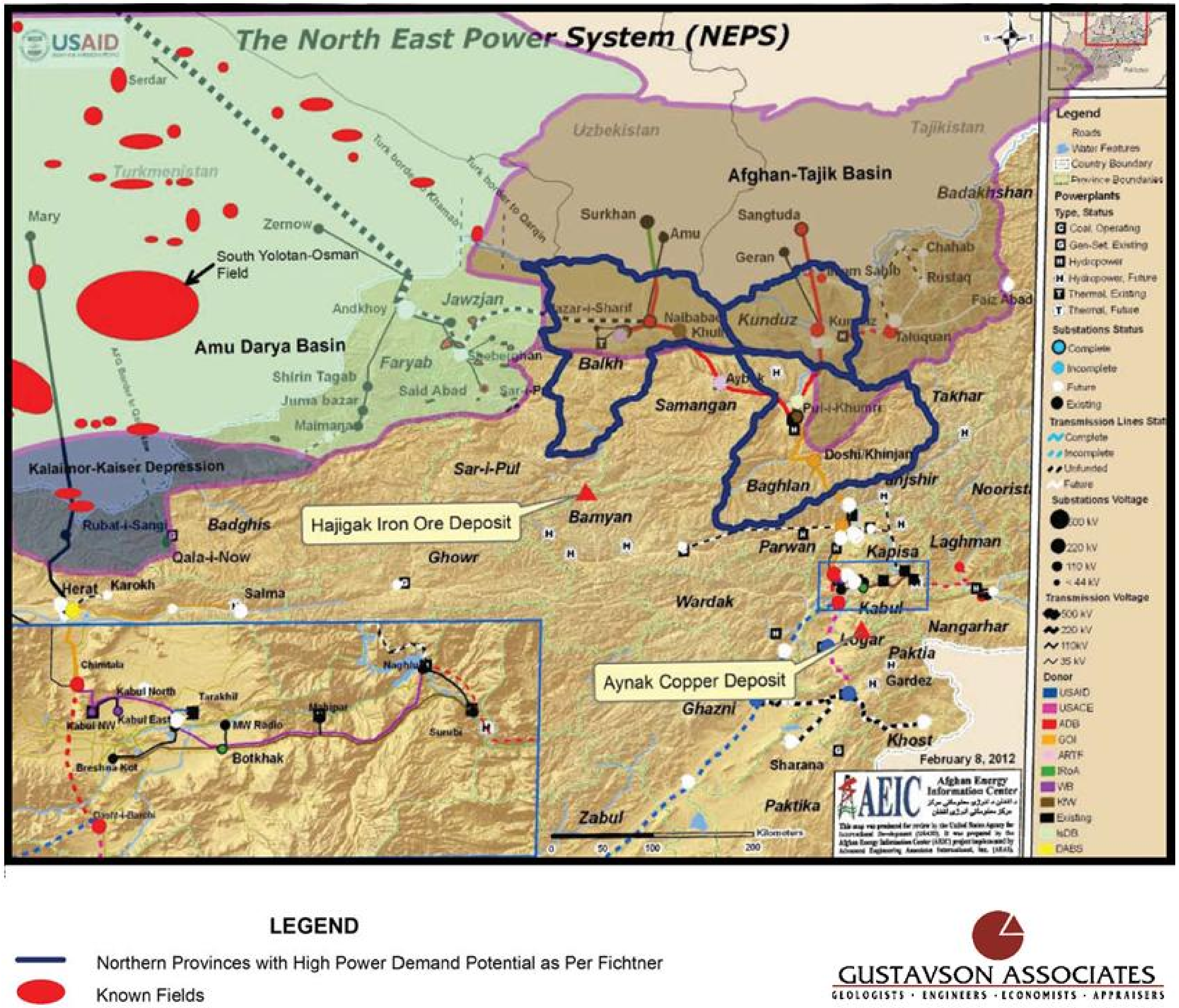

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Figure 25 - Outlines of Petroleum Basins in Relation to High Demand Areas

5.2 ESTIMATE THE APPROXIMATE POWER GENERATION CAPACITY THAT MIGHT BE FEASIBLE IN EACH SCENARIO (WHICH IN SOME SCENARIOS, MAY BE ZERO) OVER TIME

The hypothetical development scenarios developed in previous sections of the report were used as a basis for estimating future power generation capacity from the hydrocarbon reserves and resources of the Amu Darya and Afghan-Tajik basins. The power generation capacity is based on estimated fuel requirements for gas-fired power plants. In addition, we have constrained the power generation capacity in part based on the demand estimates shown in the Fichtner presentation. In our projections, new power capacity is limited to about 50 percent of the future capacity requirements estimated by Fichtner for the entire country of Afghanistan. This assumption is subjective and does not consider other factors such as transmission capacity constraints or other sources of power that might compete with the gas-fired plants.

Figure 26 is based on the low case. Gas production from reserves is shown by the solid red line and it is estimated that the production from all of the discovered gas fields is able to support two 150 MW power plants over the next twenty years. Fuel consumption of these plants is estimated to be 1.1 million cubic meters per day of natural gas. It is assumed that both plants could be designed, constructed and put in operation in the next six years. The reserve forecast is allocates part of the gas production to supplying historical non-power uses such as the fertilizer plant and local gas distribution. For the undeveloped resources (deep gas) in the Amu Darya basin, one additional large power plants could be supported later in the forecast period based on the hypothetical discoveries in the low case.

In the Afghan-Tajik basin, the potential for natural gas is as associated gas in oil reservoirs. The size of the gas resources is much smaller than the deep gas targets of the Amu Darya. IOCs will be anxious to start oil production quickly to generate cash flow and may resort to flaring if no gas market exists. One solution for power generation is to install small modular units with a capacity of around 20 MW. These could be justified with much smaller gas accumulations and then scaled upwards as more supply becomes available. This projection is shown on Figure 26 and involves scaling up each power plant to a maximum of 80 MW. In the low case example,

two small 20 MW power plants can be supplied based on hypothetical discoveries in the low case.

Figure 27 is based on the high case. There is no change in the production forecast for the reserves because these estimates have a higher degree of certainty. Therefore, the same number (two) of large power plants is supported by the reserves in the high case. In the case of associated gas, eight small 20 MW generators are possible, shown here grouped into two 80 MW power plants. For the deep gas, there is a substantial increase in gas supply based on successful new discoveries. These hypothetical discoveries could supply seven new large power plants.

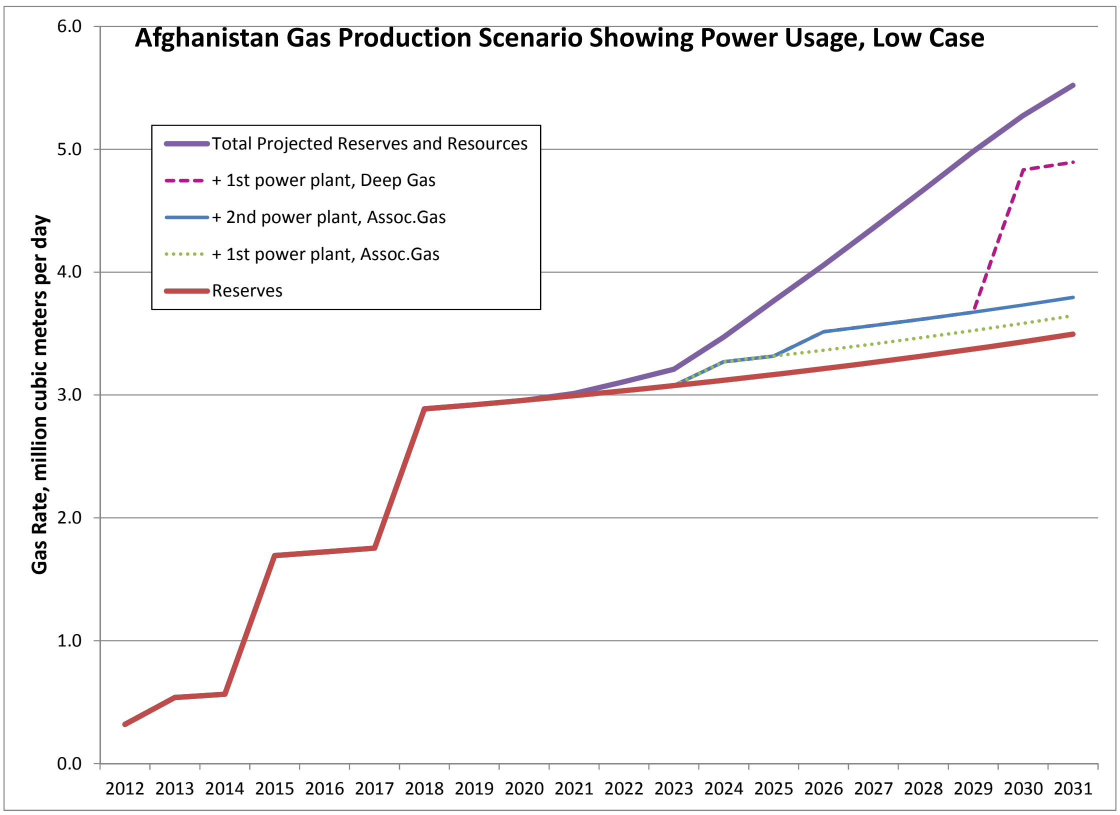

Figure 26 - Power Generation Capacity – Low Case

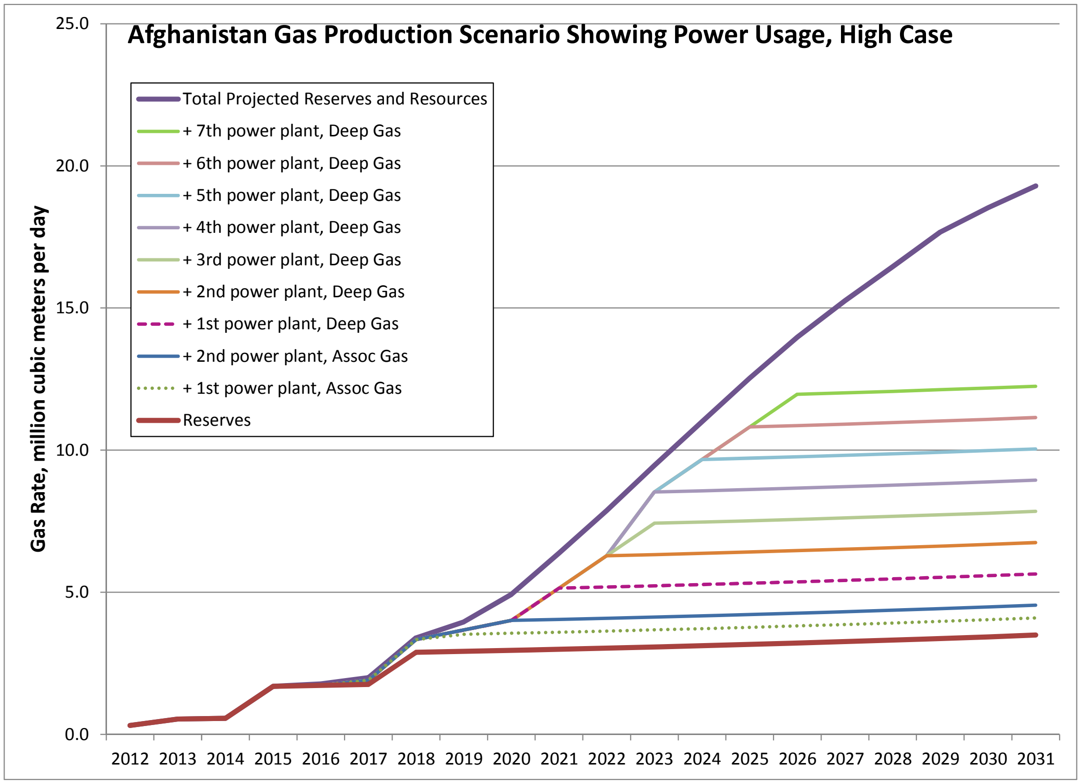

Figure 27 - Power Generation Capacity – High Case

One possible outcome is that no new discoveries are made in the deep gas in the Amu Darya Basin. Under this scenario, the reserves are still available to supply two large plants. However, the IOCs are assumed to concentrate on the oil targets of the Afghan-Tajik Basin and only small modular plants are possible. These results are shown on Figure 28 and Figure 29. In the low case, a third small generator is added late in the forecast. In the high case, more power is assumed to be generated from the Afghan-Tajik production in lieu of the additional Amu Darya production. This associated gas would be able to ultimately power 20 small 20 MW generators, grouped in Figure 29 into five 80 MW power plants.

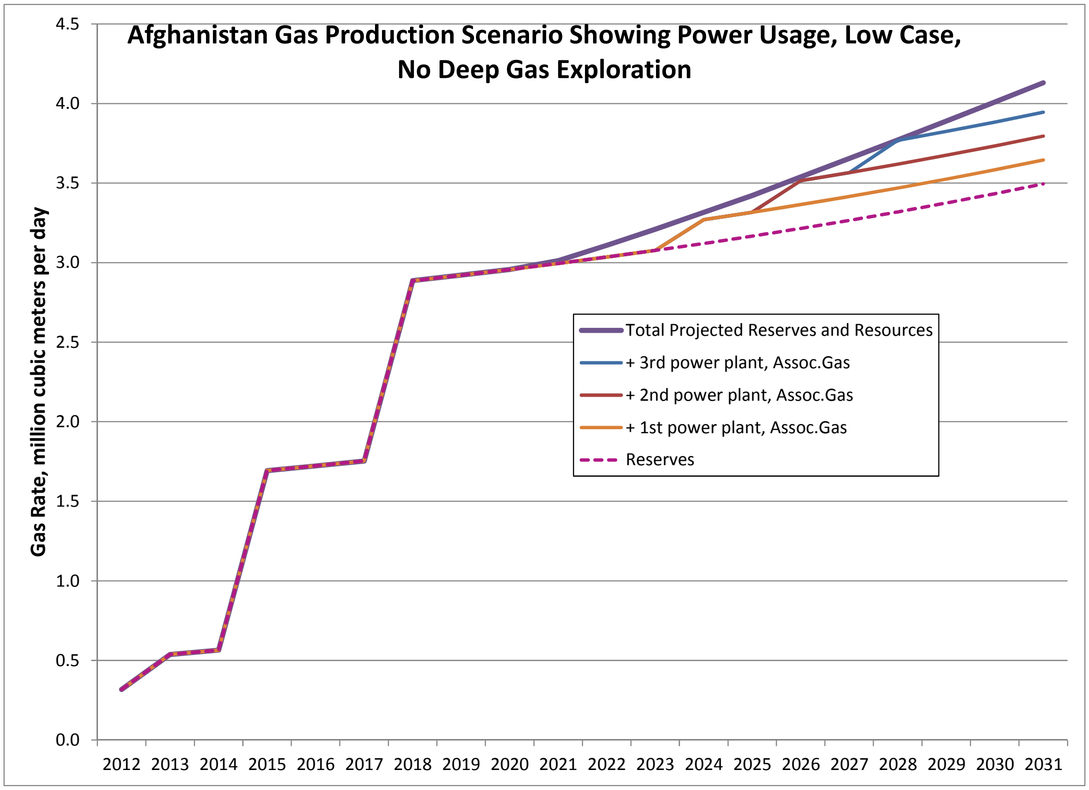

Figure 28 – Power Generation Capacity without Deep Gas, Low Case

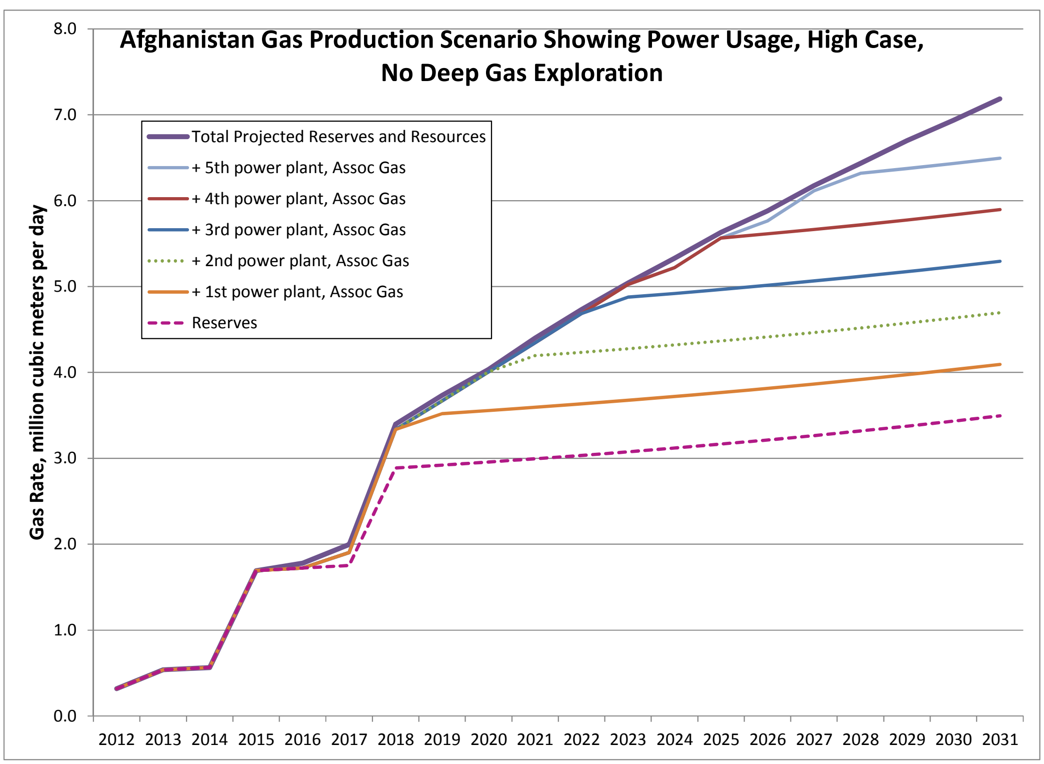

Figure 29 – Power Generation Capacity without Deep Gas, High Case

The gas-fired power generation capacity for each of the four scenarios described above is shown in Figure 30.

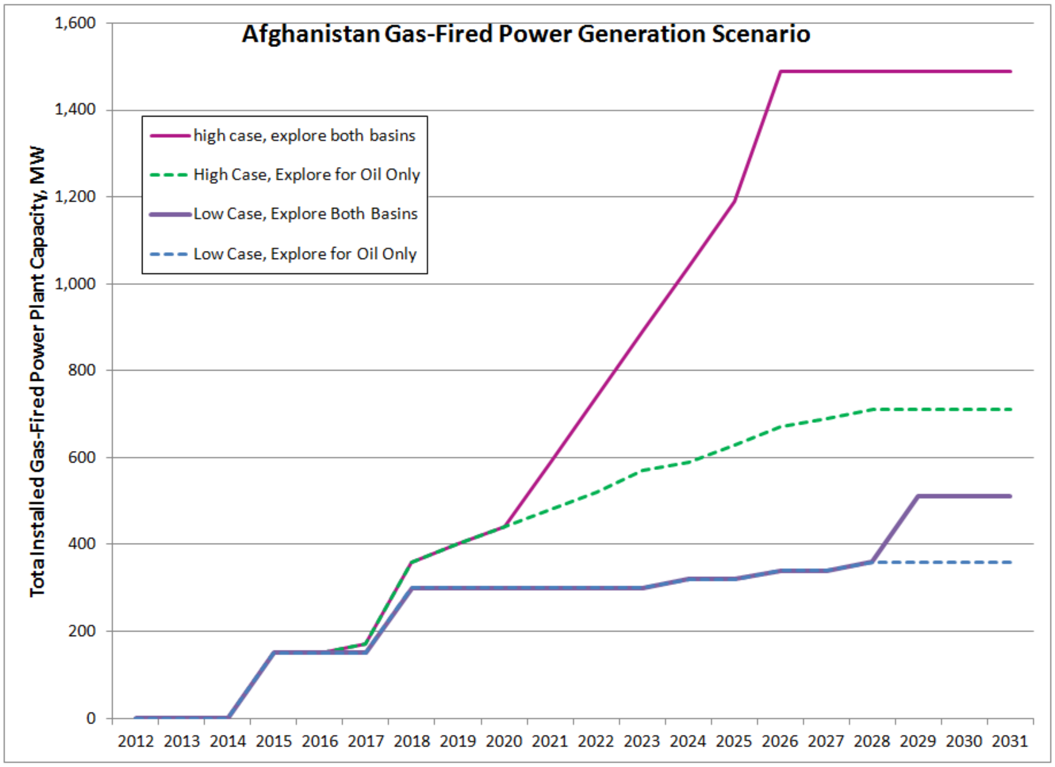

Figure 30 Installed Gas-Fired Power Generation Capacity

The dashed lines show the low and high cases if exploration only occurs in the oil-prone Afghan-Tajik basin. In the low case, there would be no additional gas-fired power generation beyond the two assumed large power plants for about 15 years. Even then there would only be a very small amount of additional generation. This scenario would occur if the exploration program was unsuccessful. In the high case, supplemental gas-fired power generation would occur in about 2018, with supplemental capacity exceeding 300 MW by about 2024. This scenario could occur if the Afghan-Tajik basin exploration program is very successful.

The solid lines show the low and high cases if exploration occurs in both basins. There is a much wider range of possible future gas-fired power generation in this case. On the low end, if there is very limited exploration success then there will not be supplemental generation capacity within the next 17 years or so. However, there is substantial upside potential for gas-fired power

generation if there are exploration successes in the Amu Darya deep gas. Total gas-fired power capacity fueled by gas from the two basins could reach about 1500 MW.

Note that these forecasts are based on what may be technically possible. They do not examine the economics of exploration, development, gas sweetening, or of power plant and power transmission construction.

5.3 FIT THESE COMPARISONS TO LOCAL CONDITIONS BY, E.G., IDENTIFYING LIKELY EXPORT ROUTES, EVALUATING SPARE CAPACITY IN EXISTING OR RENOVATED PIPELINES, AND/OR THE APPROXIMATE INVESTMENT NEEDED TO CREATE NEW CAPACITY

Figure 31 shows the same power generation scenarios as before, but superimposed with the peak power demand forecast for Northern Afghanistan from the Fichtner report.

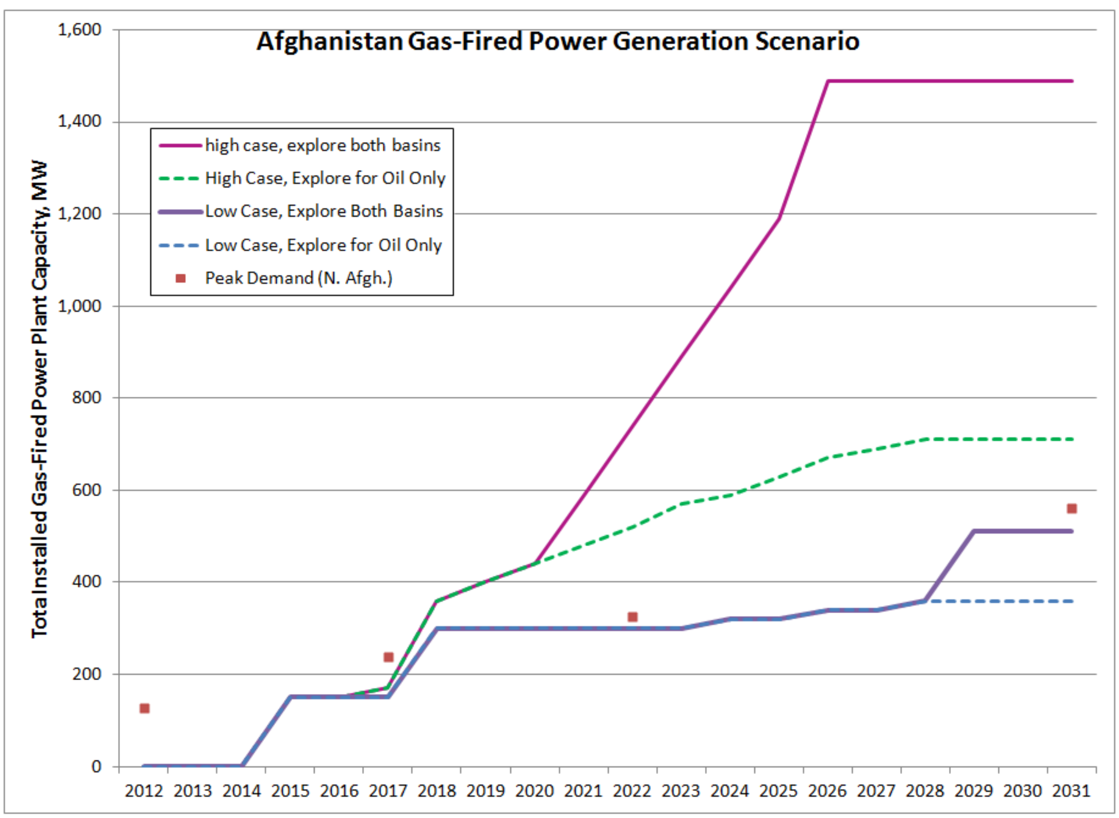

Figure 31 Power Generation Scenarios Relative to Power Demand

In the low scenarios, there would be insufficient gas-fired power generation fueled by the two basins to support peak power demand in Northern Afghanistan. This would occur if exploration was not successful. In the high scenarios, there could be sufficient gas-fired power generation both to supply peak demand in Northern Afghanistan to for power exports, providing that power transmission capacity were available. About 200 MW might become available in ten years for export from Northern Afghanistan for domestic use or export if there is a successful exploration program in the Afghan-Tajik basin alone. If there is a successful exploration program in both basins then exports could be as high as 1,000 MW.

In order to realize some of the development scenarios described in the previous section of the report, substantial investments are needed. The current state of the infrastructure and the existing fields is in fair to poor condition. No real investments have been made since the early 1990s and production could only be increased modestly from the existing wells. New drilling is required in most of the discovered fields in order to develop the reserves.

Regarding current pipeline infrastructure, there is a pipeline that transports gas from the Khoja Gogerdag field to the fertilizer plant in Mazar e Sharif (Figure 32). As discussed previously, this pipeline is in disrepair and is in need of major upgrades and replacement. In addition to the pipeline, the remaining gas reserves are sour and would require a sweetening plant plus the drilling of the undeveloped fields. Rough estimates of the initial investments required are listed below:

- Installation of new pipeline (91 km) from Sheberghan to Mazar e Sharif - $20 to $35 million
- Installation of compression and gas treating at Khoja Gogerdag - $10 million
- Workover of existing wells to test and increase production - $15 million
- Design and installation of gas sweetening plant for existing sour wells - $40 million
- Drilling, development and new facilities for Bashikurd – Juma field - >$100 million

The above estimates are for the existing reserves only. Additional investments would be required for the undeveloped resources and the cost estimates could vary considerably.

Historically, Afghanistan exported gas into neighboring Soviet block countries. To the best of our knowledge, natural gas exports from Afghanistan have not occurred since at least 1989. Given the energy demand for the country, it is unlikely that Afghanistan would export any gas in the near future because there is a shortage of gas.

If future exploration campaigns were highly successful and excess gas was discovered, then Afghanistan might export gas through historical export routes to north. Figure 32 shows an export pipeline going to the north to Turkmenistan. In meetings with Afghan Gas, this Consultant was told that this pipeline was constructed new in the late 1980s but was never put into service when the Soviet advisors pulled out in 1989.

In 2009, Turkmenistan began exporting gas to western China from the giant South Yolotan field in the southern portion of the country (Figure 33). If China continues its drive to secure further gas supplies from the Central Asian region, it is not out of the realm of possibilities that in the future, any excess gas from Afghanistan could be exported to China via the Turkmenistan link.

Another possible export option for Afghan gas discoveries could be the Turkmenistan-Afghanistan-Pakistan-India (TAPI) pipeline. This project has been under consideration since at least 1995. Although the project does not currently have financing, the Indian company GAIL signed a gas sale and purchase agreement with TurkmenGaz, the national oil company of Turkmenistan in May 2012.[17] One of the routes under consideration for this pipeline passes in the vicinity of Sheberghan.

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[17] http://en.wikipedia.org/wiki/Trans-Afghanistan_Pipeline

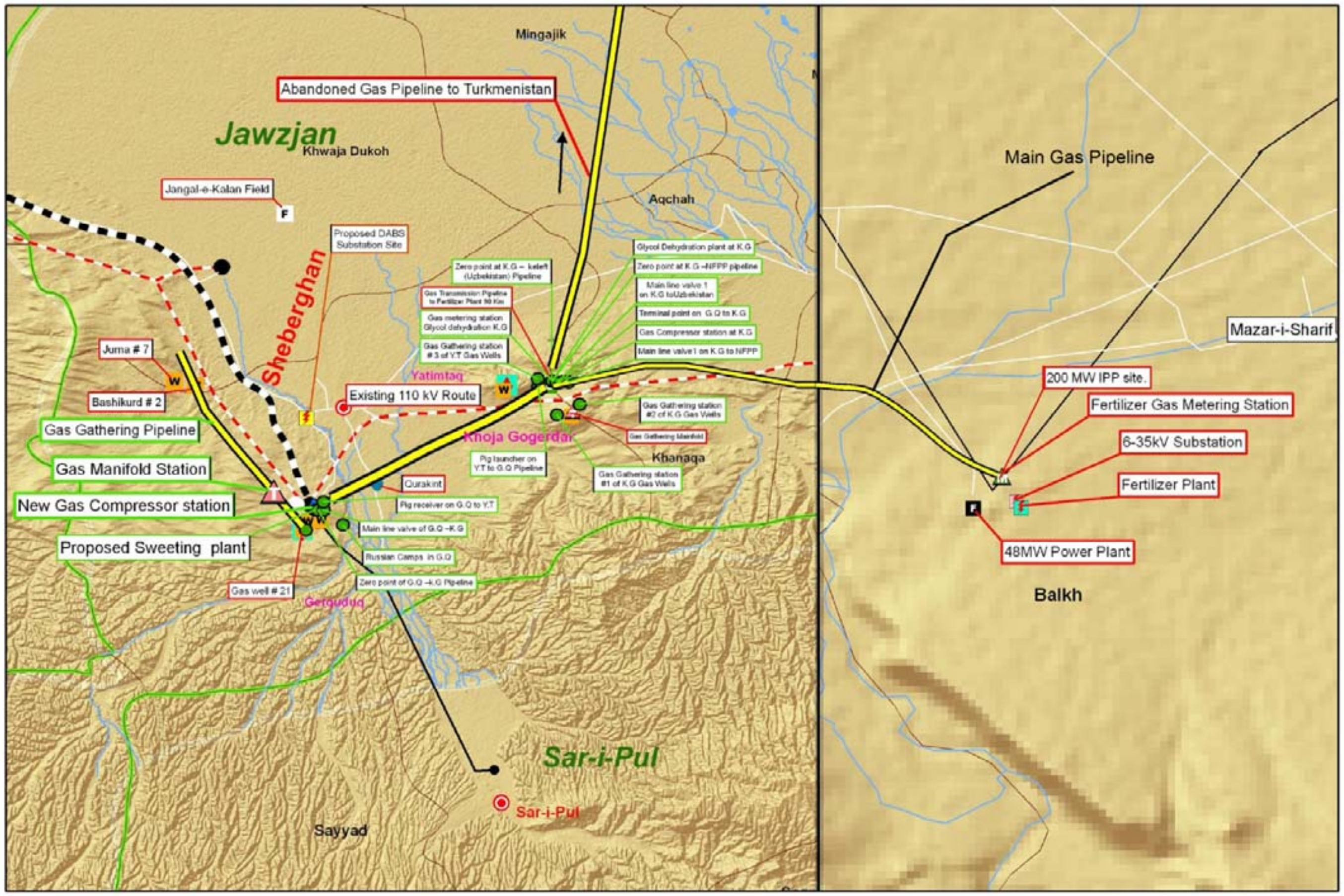

Figure 32 - Existing Gas Pipeline Network

Figure 33 - Regional Pipeline Network in Central Asia

6 TASK 4: IN CONCLUSION, IDENTIFY APPROXIMATE PROBABILITY, SCALE AND TIMING OF THE DEVELOPMENT OF GAS-FIRED POWER GENERATION IN THE AMU DARYA AND AFGHAN-TAJIK BASINS

There is a high probability that existing discovered reserves are sufficient to support two 150 MW[18] gas-fired power plants for over 20 years. OPIC has funding available for one of these. Interest has also been expressed by a private investor for development of a power plant. USAID is contemplating providing funding for the drilling of new wells at the Bashikurd-Juma field. Bashikurd-Juma contains discovered but undeveloped gas reserves in the Amu Darya basin. The majority of the remaining existing reserves contain H_2S and other impurities which would require sweetening before the gas could be used to supply a power plant. The source of funding for the gas sweetening plant is unknown. All of the above challenges will affect the potential timing of development. The soonest that the power plant could be expected to be operational is 2015 or 2016.

Two other sources of gas which may become available for additional power generation include (i) prospective associated gas resources in oil prospects in the Afghan-Tajik Basin, and (ii) deep non-associated gas resources in the Amu Darya Basin. The oil prospects are considered attractive targets for foreign IOCs. IOCs will be looking to dispose of the associated gas so they can produce the oil. Gas disposal options may include flaring or expensive re-injection but could also include supplying smaller size (up to 20 MW) power plants. Efforts are underway by the ministry soliciting expressions of interest from IOCs. Even with a tender round in the near future, the earliest like timeframe from beginning exploration to field production is about seven years. This represents relatively high-risk exploration, and production may be further delayed or never be discovered at all.

[18] A range of power plant sizes between 100 and 200 MW has been under discussion. To our knowledge, no final capacity determination has been made.

The deep gas prospects in the Amu Darya Basin provide a slightly better geologic chance of discovering large gas fields. However, it is currently unlikely to be an attractive investment opportunity to IOCs considering the lack of infrastructure and lack of pricing structures. However a single successful discovery could be sufficient to fuel an additional 150 MW power plant for several years.

APPENDIX A

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BIBLIOGRAPHY

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