SHEBERGHAN GAS GENERATION ACTIVITY (SGGA)

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Capacity Building Activities Related to Gas Gathering

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Prepared by:

Advanced Engineering Associates International, Inc. (AEAI)/SGGA Project Team
1707 L Street, NW, Suite 1030, Washington, DC (USA) 20036
Telephone: 1-202-263-0601

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Acronyms and Abbreviations

ADB	Asian Development Bank
AGE	Afghan Gas Enterprise
API	American Petroleum Institute
Bbls	Barrels
BCM^3	Billion Cubic Meters
CO_2	Carbon Dioxide
EPSC	Exploration and Production Sharing Contract
GOR	Gas/Oil Ratios
H_2S	Hydrogen Sulfide
MMCFD	Million Standard Cubic Feet Per Day
MoMP	Ministry of Mines and Petroleum
NDT	Nondestructive Testing
NFPP	Northern Fertilizer and Power Plant
NGLs	Natural Gas Liquids
OD	Outside Diameter
OSHA	US Occupational Safety and Health Administration
SOE	State-Owned Enterprise
TPAO	Turkish Petroleum
WPS	Welder Procedure Specification

1 Executive Summary

This report is the second in a series of three reports detailing "Natural Gas Processing and Gas Gathering Best Practices and Training." Specifically, this report covers the potential for capacity building opportunities for the Afghan Gas Enterprise (AGE) as an organization and also in terms of gas processing infrastruture. This is a unique approach as most analyses focus mainly on the training and personnel aspect of the problem. While this is certainly important, this report at the problem as a gap analysis using expected capability versus observed. In the infrastructure area, a similar analysis was conducted by defining existing system functionality and then prescribing a roadmap to enable increased gas processing volumes.

AGE has been limited in its capacity to expand its midstream gas gathering, transimission and local distribution activities by a lack of capital and management resources to properly operate and maintain the existing system. Since the the former Soviet Union left in 1989, there has been no capital for expansion and very limited money for maintenance of the existing infrastructure. Despite the fact that there are an estimated 63.9 billion cubic meters (BCM^3) of proven reserves remaining in the 8 gas fields in the Sheberghan areas, four of the eight fields have never been produced.

With the very limited resources that AGE has had to work with, it has done an excellent job of maintaining supply to serve its principal customer, the Northern Fertilizer and Power Plant (NFPP) near Mazar-e-Sharif, Balkh Province. Unfortunately, the supply of sweet gas available to transport to NFPP has been depleted almost to the point where the minimum requirements of the NFPP cannot be met. Sweet natural gas is both the raw material for the fertilizer produced and the fuel for power generation at NFPP.

The good news is that there are numerous potential markets for sweet natural gas in Afghanistan such as power generation, industrial development, and compressed natural gas for automobile fuel. The availability of fuel for these markets, particularly fuel that can be produced localy that does not need to be imported, is critical to the growth and development of Afghanistan.

This report provides suggestions for AGE management improvements, available gas supplies, pipelines, processing and facilities needed to produce and transport increasing volumes of natural gas. Included are suggestions for infrastructure and organizational growth for consideration as the industry continues to mature.

2 Natural Gas Delivery Capacity Building Activities

The former Soviet Union invested significant resources to allow the production of natural gas in Afghanistan. There are two significant issues that provide challenges to utilizing and expanding those facilities.

A. The primary purpose of the development and production facilities installed by the Soviet Union was to mine, treat and transport natural gas to the Soviet Union. Only limited facilities were installed for use by local distribution or industry in Afghanistan.
B. Since the Soviet Union left Afghanistan in 1989, there have been no investments made to further develop the natural gas production resources and little, if any, investments to maintain the existing natural gas resources.

There are significant proven gas reserves and some pipeline distribution and transmission facilities in Afghanistan, however, little has been developed and the existing infrastructure is largely in poor condition.

The following sections describe the current condition of the AGE natural gas infrastructure and structures and presents steps which may be taken for improvement.

3 AGE: Current Operating Structure

AGE as of the date of this report remains an enterprise owned by the Government of Afghanistan. As a State-Owned Enterprise (SOE), it is subject to funding and managerial oversight that is outside the scope of this document. The relevant portion of the SOE structure, however, is that while it is technically "owned" by the Ministry of Finance, AGE is operated and administrated by the Ministry of Mines and Petroleum (MoMP). The AGE budget is administered through MoMP and covers the complete portfolio of AGE operations and maintenance.

3.1 Limitations

While an SOE structure by definition does not necessarily limit an entity if it is managed correctly, AGE is fundamentally limited in its ability to grow as a gas company for several reasons. One of the first decision points that must be made when addressing the current operating structure is the specific area of the gas value chain that will be serviced. The current structure of AGE most closely resembles a midstream company with limited transmission and distribution capacity. If the assumption were made that AGE would eventually function best as a midstream company with defined responsibility for transmission and limited distribution, then a capabilities assessment of desired capabilities versus existing can be performed. Once the capability gaps are identified, targeted mitigation strategies ranging from capacity building to outsourcing key functions can be developed.

Gas companies or divisions of gas companies, regardless of their function in the value chain, must address and excel in some core areas. While specifics will be detailed later in this paper, the following areas detail clear shortfalls in the current operating structure of AGE:

3.1.1 Personnel

AGE is currently task-organized based on functional areas that are typical of a large gas company and include upstream, processing, compression, pipeline, vehicle maintenance, administrative, purchasing, safety, engineering, etc. Unfortunately, years of neglect, little to no training and 100% employee retention has resulted in the development of a corporate culture that is ill-suited to service a competitive off-taker of natural gas. The following is an itemization of some of the critical shortfalls in AGE personnel management:

- Nonexistent corporate vision, goals, plan for growth
- Employees are compensated regardless of work performance (i.e. paid whether they show up for work or not)
- Nonexistent, modern human relations policies
    - Performance incentives
    - Hiring/firing actions
    - Evaluations
    - Equal opportunity
    - Leave/holiday
    - Benefits
- Lack of formalized training, apprenticeships, internships, development programs
- Failure of management to implement basic safety and occupational health programs
- Inconsistent and undocumented operating and maintenance procedures

3.1.2 Plant Property and Equipment

Even the most cursory inspection of AGE facilities reveals infrastructure that has been poorly maintained, neglected and lacking basic tools and spare parts. While it is apparent that AGE has attempted to keep its equipment operating as long as possible as evidenced by fresh paint and somewhat manicured grounds at the gas plants, the fact is that the equipment that was abandoned when the Soviets left Afghanistan in 1989 has deteriorated to the point where repair and/or refurbishment is no longer economically feasible.

Figure 3-1: Soviet Dehydration Plant at Khoja Gogerdaq

While there is some material that may be salvageable such as fittings and valves, tools, etc., the only operable midstream equipment includes the recently constructed compressor station, amine plant and associated equipment. Some of the plant, property and equipment related activities necessary to modernize AGE include:

- 100 percent inventory of all tools, valves, fittings, etc.
- Develop and implement inventory and warehousing procedures
- Purge gas from, dismantle, condemn and monitor existing facilities
- Identify, map and mark existing pipelines in gas plants
- Develop and implement hazardous waste and chemical disposal policies
- Divest from non-core natural gas business areas such as the housing, health clinics and social services currently performed
- Modernize construction equipment
- Procure safety and personal protective equipment for 100% of the workforce that either works or transits through hazardous and/or industrial areas

3.1.3 Capital Improvement

Gas companies typically operate and maintain equipment in order to optimize the natural gas value chain but also to ensure that the equipment can be safely operated to the end of its useful life. Spare parts, consumables, diagnostic equipment, etc. required for daily operations and maintenance should be standardized and carried as expenses for budgetary and financial disclosure statements. In the case of AGE, however, long-term planning should clearly differentiate expenses from a mid- to long-term capital improvement strategy. The difference is that the former is required for delivery of quality natural gas while the latter is necessary for longevity and expansion.

A gas company can fund capital improvement projects in various ways including the utilization of profits from gas sales, debt, bonds, etc. Two primary areas of capital improvement should be addressed:

- Budgeting for equipment replacement at end of life
- Procurement and construction of new facilities to meet increasing demand

End-of-life replacement budgeting is a fairly simple concept. The decision to fund expansion, however, is more difficult and certainly more risky. Ideally, AGE would be postured such that gas supply is matched to downstream demand with a potential to increase as demand increases. The most likely scenario is that processing capability will lag demand increase resulting in the requirement to decide who gets gas first. A related problem is competition for the same gas. These issues must be addressed through planning for capital improvement using profits from gas sales or possibly some type of debt. In the development of this plan, AGE should be advised to develop certain sales milestones or gates that would cue investment in improvement consistent with downstream natural gas consumer development.

3.1.4 Standards and Procedures

As mentioned previously, AGE operates without approved and standardized procedures and policies establishment of and adherence to a set of procedures and policies designed to not only optimize and modernize AGE operations, but to ensure that gas can be produced safely and reliably is one of the most critical, near-term needs. While development of the procedures is not difficult, AGE must ensure that these procedures are tailored to the conditions in Afghanistan and are consistent with the long-range plan for AGE. The ideal scenario is that AGE would contract with subject matter experts who could co-develop and tailor requisite procedures and standards. Once complete, training, inspection, auditing, corporate culture changes, etc. would be necessary to ensure that there was widespread implementation. In other words, development of tailored standards and procedures is a subset of the problem where the full solution requires assurance that these documents will become part of AGE's culture.

3.1.5 Business Planning, Budgeting and Procurement

The business of selling natural gas is a concept that has never matured in AGE. The activities of the last decades were unfortunately characterized by zero cost awareness and generally operating at a financial loss while the focus on simply delivering gas to the NFPP was paramount. Near-term development and focus on the following areas is necessary to ensure the maturation and profitability of AGE:

- Gas pricing based on production costs
- Gas allocation
- Business planning
- Supply chain development
- Acquisition process development
- 1-, 3- and 5-year budgets
- Standardized invoicing, collecting and gas metering
- Analysis, tracking and control of production and operating costs

4 Status of Training and Way Forward

The preceding section, while not designed to be all encompassing, demonstrates the expected outcome when an entity is neglected for decades. Afghan ingenuity has enabled continued gas supply to Sheberghan and some villages in Jowzjan, but without immediate and substantial changes, the future is bleak. Coincident with the construction of midstream gas processing facilities and pipeline repairs, AGE was provided with training designed to provide exposure to modern best practices employed by gas companies worldwide. This section will detail the training that was delivered to AGE in 2013-2014 as well as provide a roadmap for future training.

4.1 Welding

A quality, audited and fully compliant welding program is a core competency of a natural gas company. Currently, AGE possesses a fledgling, organic pipeline welding capacity that could be matured through the implementation of the following concepts:

- Develop and adhere to welding standards for pipeline and gas plants
- Develop auditing and inspecting procedures and processes
- Establish apprenticeship and journeyman programs
- Develop an in-house welder training program or contract with an outside supplier of welding training services
- Liaise with local donor organizations or seek investment in vocational technical programs designed to train natural gas pipeline and gas plant welders
- Continue to source and maintain modern welding and associated safety and test equipment
- Develop nondestructive test requirements and develop an organic capability possibly through “train the trainer” data collection programs coupled with independent analysis

A brief internet search reveals a large amount of companies dedicated to welding and associated natural gas industry training. While funding is always a constraint, due diligence must be performed when selecting a training entity as welding on natural gas pipeline and in natural gas plants is very specialized. The following figure details the type of training that would be expected when contracting with a training entity or hiring a consultant that would be tasked with maturing the AGE welding program.

1.0 SCOPE OF SERVICES

1.1 Provision of Customized Welder Skill Training meeting the client requirement with the following details:

1.1.1 The focus of the training will be on 5G (fixed) downhill progression

1.1.2 Electrodes to be used will be cellulosic type E6010 plus E7010

1.1.3 The welder will perform Certification Test as per American Petroleum Institute (API) 1104

1.1.4 The cost of this proposal will cover institutional certification. If American Welder Society certification is required, a revision of the price will be provided accordingly.

1.1.5 Duration of the program is 7 weeks.

1.2 Program Schedule

1.2.1 Safety Induction and Orientation – 1 day

1.2.2 Start of Welding Practices – 5 days

1.2.2.1 Review of Welding Procedure Specification (WPS)

1.2.2.2 Familiarization on Machine Control

1.2.2.3 Procedure for Fit-up as per WPS

1.2.2.4 Perform Welding Practice on Surfacing Weld

1.2.2.5 Perform Welding practice on Plate

1.2.3 Start of Welding Practices – Pipe (5 weeks)

1.2.3.1 Perform Welding practice on Pipe 5G (Downhill)

1.2.4 Refreshing Training prior to Welder certification Test Pipe (1 week)

1.2.4.1 Perform Refresher Training on 5G (Fixed) Downhill

1.2.4.2 Perform Welder Certification Test as per approved WPS

1.2.4.3 Note: This is an advanced course. The welders who will attend this program have to be experienced welders (documents requested).

Figure 4-1: Sample Welder Training Statement of Work Scope

While the welding skillset is heavily reliant upon hand-eye coordination and concentration, it typically takes years for a welder to master the ability to consistently produce specification-compliant high pressure pipeline quality welds. Furthermore, when planning for welder training, attrition should be contemplated as not everyone that commences training will satisfactorily complete the program. The following, additional excerpt from a typical welder training statement of work serves as an example of some of the logistics concerns and training methods.

3.0 TRAINING HOURS

3.1 The training hours will be Saturday to Thursday – 9:00 am to 5:00 pm (2 coffee breaks and 1 Hour lunch) = 7 clock hours

4.0 LANGUAGE OF INSTRUCTION

4.1 English language will be used in the teaching of this course. The translator will be provided by the client if deemed necessary.

5.0 LECTURE/TRAINING METHODOLOGY

5.1 Courses will be conducted by educators and trainers who have many years of experience in the field of welder training and related industries to ensure the effective implementation of the quality training. A combination of classroom lecture and practical training will be employed to facilitate the acquisition of knowledge and skills. Written and practical examinations will be conducted to evaluate understanding of the various subject areas in welding.

Figure 4-2: Sample Welder Statement of Work Training Method

A typical course of instruction will culminate with the welder candidate taking and successfully passing a pipeline welding test. This test can either be provided by the trainer or provided by the pipeline company to ensure that all welders are qualified to the same standard.

4.2 Compressor Operator Training

Training for compressor operators should encompass the full scope of activities/tasks required to keep the compressors operating at peak performance for as long as possible. AGE labor and engineering must focus on the fact that every minute that the compressors are not operating is equivalent to a volume of gas that will not be consumed or sold. The training received by AGE personnel at Khoja Gogerdaq was designed to develop a team of operators that were able to perform the following tasks:

- Basic maintenance functions
- Safe start up and shut down
- Check fluid levels
- Read and record error codes

- Monitor inlet and outlet pressures
- Monitor temperatures
- Monitor and record Caterpillar engine parameters
- Monitor and record parameters on the Adem III display
- Document maintenance tasks both preventative and unscheduled
- Document tool box inventories
- Complete a daily operations logbook
- Perform a risk analysis
- Manage the supply chain
- Order consumables

The table below is a sample list of training items that was provided to AGE operators. This table can be utilized to demonstrate the depth of training that will be required in future efforts:

Table 4-1: Sample Compressor Operator Training Tasks

Type of Training	Area of Training	Description	Hours
Practice	Mechanical	Compressor soft foot	1
Practice	Mechanical	System	1.5
Practice	Mechanical	Use of tools	0.5
Practice	Mechanical	Oil level for compressors and engine	1
Practice	Mechanical	Compressor valve installation	1
Practice	Supply chain	Consumable inventory	1
Theoretical	Mechanical	Engine start-up procedures	1
Theoretical	Mechanical	Engine parts	1
Practice	Operation	Compressor valves and function	1
Practice	Operation	Compressor log	1
Practice	Operation	Adem III display and parameter selection	1
Theoretical	Operation	Compressor parts and theory of operation	1.5
Theoretical	Operation	Oil system components and theory	1.5
Practice	Operation	Start-up procedures	1.5
Practice	Operation	Valve operations during start-up	1
Practice	Operation	Shutdown procedures	1.5
Practice	Operation	Diagnosis of shutdown codes	1.5

Ideally, AGE would require 12-18 months of hands-on operator and maintenance training utilizing a combination of theory and practice in a classroom as well as out on the equipment. The installed compressors are significantly automated and knowledge of the control systems as well as adherence to standard maintenance and operating procedures can be learned easily. Oversight and multiple “what if” scenarios along with exposure to troubleshooting and assistance in routine maintenance would be the perfect step towards grooming a solid operational team at Khoja Gogerdaq.

4.3 Dehydration Plant Operator Training

While the compressors are fairly automated with safeguards to prevent damage to the prime mover (engine) as well as the compressor, the dehydration plant and midstream processing equipment in general, requires a steeper learning curve. A sample of the types of training that AGE has received is detailed in the following table:

Table 4-2: Sample Dehydration Plant Operator Training Tasks

Type of Training	Area of Training	Description	Hours
Practice	Mechanical	TEG replenishment	1
Practice	Mechanical	Dew point measurement	1.5
Practice	Mechanical	Use of stripping gas	0.5
Practice	Mechanical	Boiler light off	1
Practice	Mechanical	Electrical connection	1
Practice	Supply chain	TEG inventory and waste disposal	1
Theoretical	Mechanical	Boiler temperature regulation	1
Theoretical	Mechanical	Tracing flow of gas through the system	1
Practice	Operation	System start up	1
Practice	Operation	Increasing TEG flow	1
Practice	Operation	Shutdown	1
Theoretical	Operation	Effect of temperature on dew point	1.5
Theoretical	Operation	Liquid knock out	1.5
Practice	Operation	Operational logs and records	1.5
Practice	Operation	Filter maintenance	1
Practice	Operation	Pressure differential indication	1.5
Practice	Operation	Emergency procedures	1.5

In the case of dehydration operations, there is no substitute for the training that can be provided by an experienced operator. While the sample training provided above focuses heavily on theory and practical application, it is the day to day adjustments in process controls and reacting to changes in gas flow that will be the difference between just learning theory and truly becoming a commercial operator.

4.4 Suggested Areas for Training

Training can be accomplished in a variety of methods customized to available funding and necessary timeline. The following methods are applicable and ranked in order of most effective to less effective:

- Services contract designed to provide turnkey operations and maintenance with a requirement to provide hands-on rigorous training
- Construction services with associated training
- Embedded training conducted onsite in Sheberghan, Afghanistan
- Outsourced training either in Afghanistan or outside the country designed to “train the trainer”

Areas that should be addressed immediately and in advance of execution of any gas purchase agreement with a commercial off-taker include:

- Safety
- Occupational health
- Operations procedures and processes
- Scheduled maintenance
- Unscheduled maintenance
- Procurement
- Spares and consumables
- Quality Assurance/Quality Control
- Metering

5 Organizational Capacity Building Analysis and Suggestions in Support of Infrastructure Expansion

As discussed previously, AGE is best-positioned to assume a role in the natural gas midstream and transmission component of the value chain. Clearly, there are many hurdles that need to be overcome prior to entering into a commercial offtake agreement and certainly in advance of any future infrastructure expansion. The simple solution in developing countries is the rather generic approach aimed at capacity building. While this is applicable to AGE, quicker effects could be generated if the specific capacity building tasks were directly traced to requirements for a gas company. This requirements-based approach to capacity building is designed to focus on those core competencies that are essential to safe, effective and efficient natural gas operations. Before delving into an AGE capability analysis and associated derivation of capacity shortfalls, it is helpful to provide some thoughts on potential high-level developmental goals to perhaps establish a time reference for development.

5.1 Near-Term

In the Near-term, AGE would benefit by focusing on those activities that result in a self-sustaining entity that is capable of meeting demand for natural gas consumption in Sheberghan and Mazar-e-Sharif. Support of domestic production is not only helpful to the Afghan people but it promotes energy security as well as provides revenue to the Government of Afghanistan. Included in these Near-term activities should be a solution to funding and contracting for engineering services in support of the new Khoja Gogerdaq to Mazar Pipeline

5.2 Mid-Term

Midterm goals include completion of the new pipeline and investigation into either a joint venture or an international oil company to develop the western Afghan-Tajik blocks. Consideration should also be given to public-private ventures either in the near-term or mid-term to act as a more immediate source of funding.

5.3 Long-Term

In its mature state, AGE will operate as a midstream company capable of constructing domestic pipelines, including laterals to future/planned international pipelines (i.e. TAPI). All operations and maintenance procedures and processes will be aligned with international best practices and AGE will be regarded as a safe, profitable and reliable natural gas operating company.

5.4 Core Capabilities Assessment

In an attempt to quantify the specific types of capacity building that would be required, and assuming that AGE's primary responsibility will be management and operations of midstream, transmission and limited distribution, an analysis of required capabilities can be performed. Rather than simply hiring experts in the field, this type of analysis is useful in identifying critical areas where development must occur in order to allow AGE to perform on a commercial gas purchase agreement. In support of this analysis and using international best practices as a guideline, the following high-level core capabilities must ultimately be demonstrated by AGE in gas processing:

- Safety
    - Dehydration Unit operations
    - Amine Plant operations
    - Compressor operations
    - Scheduled and unscheduled maintenance
    - Pipeline and facility blowdown, purge and repressuring procedures

In order to meet the requirements for pipeline and plant construction, the following high-level capabilities must be demonstrated:

- Pipeline and Plant Construction
    - Transmission/gathering
    - Distribution
    - Cathodic protection
    - Metering

And perhaps just as important as the technical core capabilities, AGE must be run as a business with a pervasive understanding of the role of safety, efficiency, quality, compliance, etc. as core functions. The following list represents the non-technical/business functions that must be developed:

- Corporate Operations Plan
- Management Selection
- Business modeling
- Marketing
- Procurement Procedures
- Financial management
- Personnel/Human Relations

Again, the preceding list is designed to be high-level, but this type of analysis is designed to provide a greater level of specificity over the more generic conclusion of the past years which simply highlighted the requirement to completely rebuild AGE. In performing the analysis of required capability versus the observed, it is important to understand that the goal is to establish a corporate culture. It is fairly easy to bring in a consultant to provide safety training, for example. It is much more difficult, however, to develop a culture at AGE where the unsupervised are able to audit and correct conditions that do not comply with the AGE safety program autonomously.

5.5 Assessment Rating of Core Capabilities

The core capabilities of AGE were qualitatively assessed based on a comparison of existing capability versus capability expected of a company that conforms to international best practices in areas of midstream operations, pipeline and plant construction and business operations. The analysis was based on observation of AGE practices as well as interviews with personnel responsible for the specific areas. The following qualitative assessment categories were assigned to each core area:

Assessment Rating	Definition
	Demonstrates consistent ability to perform
	Either incomplete ability or not possible to ensure enduring compliance
	No observed capability

Figure 5-1: Assessment Rating Scale

5.6 Midstream Functions

The following table details the expected core capability of a midstream company and AGE's specific performance in each area. Given the required capacity building effort, the defined success metrics will ensure that AGE can safely and consistently produce natural gas that meets requisite specification for delivery.

Table 5-1: Midstream Processing Assessment

Capability	Assessment (Current)	Required Capacity Building	Success Metric
Safety	AGE does not currently adhere to specified safety standards	Management commitment to a culture of Safety: Formal safety training as applied to processing Implement safety programs at AGE Gas Plants (Khoja Gogerdaq and Yatimtaq) Implement a reporting program to monitor safety compliance and incidents	Safety Division of AGE focused on Gas Plants Adherence to safety policies Demonstrated reduction in accidents
Maintenance	Soviet compressors, dehydration plant and amine plant are no longer serviceable or maintained New compressors, dehydration and amine plant onsite	Maintenance training from operating company Scheduled maintenance program Troubleshooting training	AGE follows scheduled maintenance program Monitoring of facility up-time and preventable repair occasions
Gas Processing Standards for Transmission and Distribution	AGE will need to develop standards in order to deliver consistent quality of gas	Assist AGE to develop standards to deliver consistent quality Formal training in gas quality measuring and analysis (chromatography, Drager Tube) Laboratory practice schedule and procedures monitored	Approved and published procedures for gas quality monitoring with ability to affect production.

Capability	Assessment (Current)	Required Capacity Building	Success Metric
Compressor Operations	Soviet-installed compressors failed Limited ability to operate new compressors	Continued formal operator training Unscheduled and scheduled maintenance training	Ability to ensure consistent "up time" through scheduled and unscheduled maintenance Adherence to operational schedule
Dehydration Unit and Amine Plant Operations	Soviet-installed equipment failed Limited ability to operate newly installed equipment	Formal operator training Implement operations schedule	

5.7 Pipeline and Gas Plant Construction

As AGE looks towards expansion (consistent with increasing offtake), it expects to be able to expand its natural gas infrastructure. Should AGE ultimately decide that infrastructure expansion is out of its planned work scope, the assessment and corresponding capacity building requirements detailed in the following table are necessary for safe and sustained natural gas production.

Table 5-2: AGE Construction Assessment

Capability	Assessment (Current)	Required Capacity Building	Success Metric
Welding	AGE has 4 welders capable of welding to rated maximum allowable operating pressure of installed equipment	Ad-hoc journeyman program started Formal and On-the-job training Training sustainment plan	4-6 qualified welders with ability to pass API-1104 (or AGE-specific) test. Established journeyman program
Weld Inspection	AGE does not have access to nondestructive testing (NDT) and will require training to use equipment	Provide formal NDT training Develop AGE weld inspection standards Train/procure ultrasonic weld inspection equipment	Adequate technical capability to assess weld inspection services Potential for in-house

Capability	Assessment (Current)	Required Capacity Building	Success Metric
	Requires training on general understanding of process		UT capability
Construction Standards	No standardized construction process	Assist AGE to develop construction standards, inspection process for pipeline & gas plant. Standards to include pipelines, compressor stations, treating facilities, dehydration , metering, instrumentation, electrical, civil, corrosion control and all facets of construction and operation of a Midstream Operating Company	Approved and published standards for pipeline and plant construction Adherence to Construction and Maintenance standards.
Inspection (Quality Assurance/Quality Control)	No inspection capabilities inherent to AGE	Implement inspection program designed to ensure construction by AGE labor or external company conforms to AGE standards. Program to include instruction, safety, operators, environmental, etc.	3-4 construction inspectors General adherence to AGE construction standards
Safety	AGE does not currently adhere to specified safety standards TFBSO has provided ten guidelines for pipeline rehabilitation	US Occupational and Health Agency (OSHA) or Department of Transportation type training AGE to develop safety standards and safety monitoring program Subject areas include hydrogen sulfide (H_2S) awareness, confined space entry, gas detecting, explosive levels, etc.	Health Safety and Environment department with a minimum of 4 employees In house safety training and adherence to own process Monitoring and

Capability	Assessment (Current)	Required Capacity Building	Success Metric
			compliance program with safety incentives

5.8 Corporate Operations

AGE is currently not set up to operate as a profitable business and does not possess any of the business attributes typical of a functioning gas company. A similar analysis of the expected capabilities was performed in this area, however; success metrics were not identified as these will have to be determined by the Government of Afghanistan once a final decision is made as to AGE's structure. The assessment is included in the following table:

Table 5-3: Corporate Operations Assessment

Capability	Assessment (Current)	Required Capacity Building
Management	Managed as a SOE with no motivation for profit or understanding of financial loss	Advise AGE on developing optimal management and manpower structure Assist in the preparation of job descriptions and management training
Business Plan	No observed capability	Assist AGE in the development of a business plan
Procurement	Limited procurement capability No discretionary budget	Coordinate with Government of Afghanistan Implement AGE procurement process Assist AGE in developing procurement relationships with regional vendors for supplies and equipment

Capability	Assessment (Current)	Required Capacity Building
Personnel	Revised labor chart required for a corporatized AGE	Assist AGE with the development of an HR process Develop a hiring plan and job descriptions Advise on the development of compensation and incentive packages
Financial Management	No observed capability	Assist AGE in the development of a transparent financial system that at a minimum implements financial controls, asset management, payroll, taxation, cash flow, operations, etc.
Marketing	No off-take from Sheberghan-Mazar pipeline except to NFPP	Assist AGE in expanding its gas sales in developing commercial and private markets

5.9 Assessment Process and Continuous Process Improvement

The preceding core capabilities assessment should be utilized to inform the specific areas that are to be highlighted for capacity development. Once the required core capabilities are identified and assessed, the process of identifying areas for improvement is academic. In many cases, however, the assessment and capacity building process stops after this step. To best suit AGE, international best practices in gas processing, pipeline and plant construction and business operations, should be utilized to inform not only the specific capacity building tasks required from a consultant or outside training source, but they should also inform success metrics. This is the last step in the process designed to ensure that the corporate culture of a gas company has truly matured. This iterative process is detailed in the following figure:

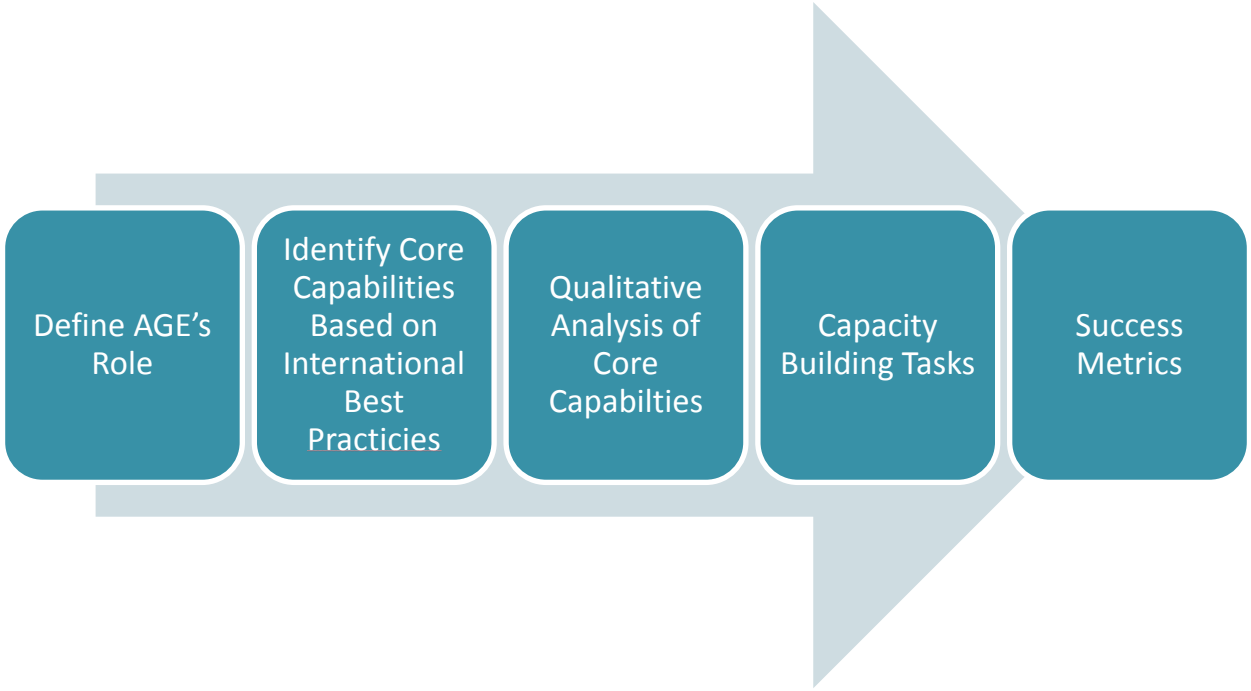

Figure 5-2: AGE Assessment Process

In its mature form, as detailed in the figure above the assessment process becomes part of a continuous process of improvement where the auditing function of quality assurance can be used to iteratively inform new capacity building tasks. This is the prescribed end state for AGE and as such must be reflected in any capacity building or development program. Continuous process improvement is a key characteristic of the best-in-class gas companies.

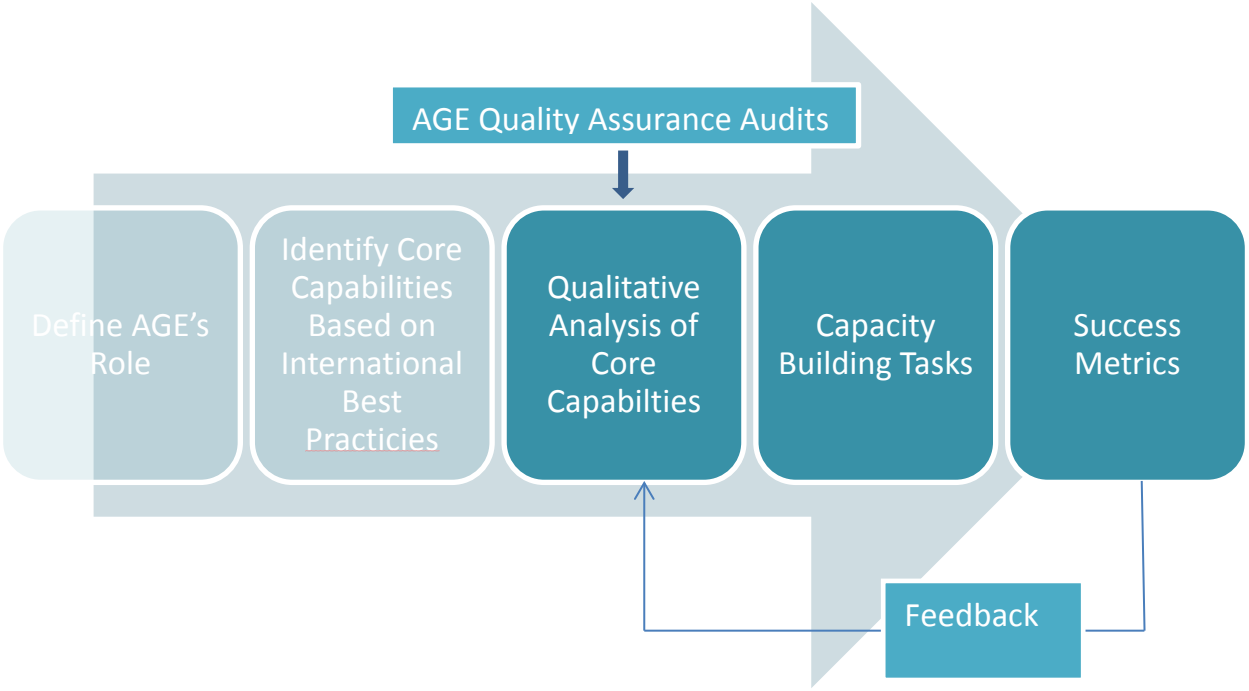

Figure 5-3: AGE Continuous Process Improvement

6 Current AGE Operating Capacity

6.1 Reserves

There are currently eight known gas fields in northern Afghanistan which are producing natural gas or have the capacity to be developed.

Currently producing fields are as follows:

- Gerquduq
- Shakarak
- Yatimtaq
- Khoja Gogerdaq

Fields that have been explored but not developed for production include:

- Jangali Kalan
- Juma
- Bashikurd
- Khuja Bulan

The figure below depicts the location and the relative shape of each field.

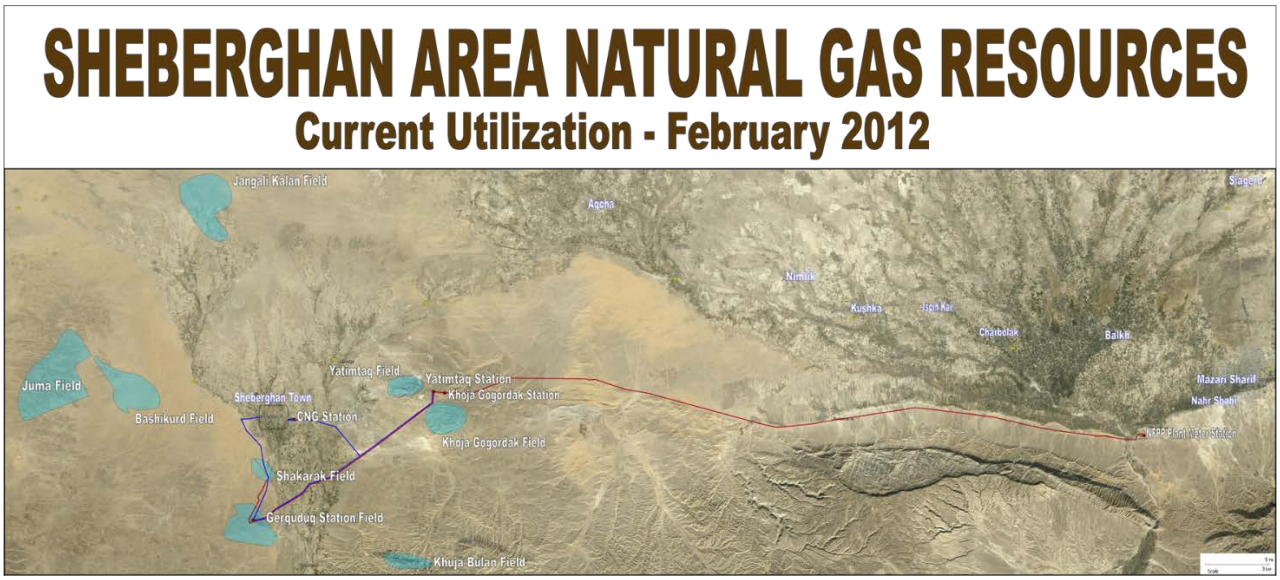

Figure 6-1: Sheberghan Area Natural Gas Resources

The most definitive information on the current reserves in the Sheberghan area comes from a report prepared by Gustavson Associates in April of 2004. This report for the most part confirms estimates that were originally made by the Soviet Union. There have also been estimates made in a report by Hill International, Inc. in August of 2004.

Table 6-1: Estimated Recoverable Reserves

FIELD	RUSSIAN (BCM^3)	GUSTAVSON (BCM^3)	HILL REMAINING RESERVES (BCM^3)
GERQUDUQ	26.79	9.77	17.04
KHOJA GOGORDAK	58.57	16.77	11.69
YATIMTAQ	6.22	7.36	6.18
JANGALI KALAN	15.25	13.38	15.25
JUMA	6.77*	21.82	6.77
BASHIKURD	10.41	6.37	4.41
KHUJA BULAN	2.54	Unknown	2.54
SHAKARAK	Unknown	Unknown	Unknown
TOTALS	126.55	75.47	63.88

*Note: The Russian estimate for Juma appears to be a typographic error in the Gustavson report.

6.2 Facilities/Infrastructure

The existing AGE facilities were built starting with geological studies in 1957 under a technical assistance program with the Soviet Union. With the Soviet occupation starting in 1979, gas production was emphasized. By the mid 1980's, 90% of the gas being produced in Afghanistan was being transported to the Soviet Union. The gathering treating and transmission system was built primarily for the purpose of exporting natural gas to the Soviet Union. A 32" (820 mm) outside diameter (OD) and a 28" (720 mm) OD pipeline were built between the Khoja Gogerdaq Compressor Station and Keleft in the Soviet Union for export purposes. In 1965, the 12.75" (325 mm) OD pipeline was built between Khoja Gogerdaq Station and Koda Barq near Mazar-e-Sharif to provide natural gas to the NFPP, which was designed to use 780,000 M^3 of natural gas per day (M^3/d). This equates to 27.545 (MMCFD). The process at NFPP requires sweet gas that is natural gas with only trace amounts of H_2S. High or even relatively small concentrations of H_2S in the gas stream can cause a multitude of problems. Note that in Table 9-2, the physical effects according to OSHA are delineated.

Today, AGE currently is producing gas from four reservoirs

- Gerquduq Field
- Shakarak Field
- Yatimtaq Field
- Khoja Gogerdaq Field

All of the facilities described in this section are operated by AGE.

6.2.1 Gerquduq Field

Gerquduq Field is located just to the west of the town of Sheberghan in northern Afghanistan. Wells that are currently producing include three high pressure (10 – 12 bar) sweet gas wells, Well Numbers 2, 59, 69, and 70; three medium pressure (1-2 bar) sour gas wells: Well Numbers 61, 68 and 73; and two low pressure (0.5 – 1 bar) sour gas wells: Well Numbers 31 and 80. The Shakarak No. 2 well is a high pressure sweet gas well that is also produced through the Gerquduq Station piping.

Note that the sour gas that is currently being produced from Gerquduq Field, according to AGE personnel, averages 140 ppm (parts per million) H_2S, which can cause health issues with prolonged exposure, but is not typically a sufficient concentration to cause serious injury or death.

6.2.2 Gerquduq Station

The Gerquduq Station serves as the gathering station for the wells in the Gerquduq Field as well as the Shakarak Field. The station consists of gathering piping and metering, including sweet gas and sour gas headers. The station also has compression capabilities which have not operated in over 25 years. They are reported by AGE not to be operable. Gerquduq Station also has two parallel amine sweeting plants, each reportedly was capable of treating three million $M^3$of gas per day, but were not designed to be run simultaneously. These units have been inspected by several groups, and have been found to be in such

poor condition that rehabilitation would be cost prohibitive. Also, these units require a significant quantity of water and electric power to operate, which are currently not available. Maintenance and operating personnel for the Gerquduq Field are also headquartered at Gerquduq Station.

6.2.3 Pipelines Serving Gerquduq Field

Three pipelines carry gas from Gerquduq Field. All three are welded carbon steel construction.

- A low pressure (0.5 to 1 bar) pipeline 6.25" (159 mm) OD carries low pressure sour gas in a northerly direction a distance of approximately 16.4 kilometers (10.2 miles) from the Gerquduq station to the west side of the City of Sheberghan, where it connects to the Sheberghan City Distribution System on its west side.
- A 16" (400 mm) OD sour gas pipeline carries gas from the medium pressure header at Gerquduq Station for a distance of approximately 29 kilometers (18 miles), north and east to Yatimtaq Station. This pipeline is currently shut off at a block valve approximately 16 kilometers (9.9 miles) northeast of Gerquduq Station. From that block valve, a 6.25"OD (159 mm) pipeline carries the sour gas approximately 10.5 kilometers (6.5 miles) northwest to its connection with the Sheberghan City Distribution System on its east side. This is the main supply line for the Sheberghan City Distribution System.
    - This pipeline also serves the Afghan CNG filling station, which is located on the east side of Sheberghan. The CNG station is designed to use 18,000 M^3/d (0.6 MMCFD. The CNG station includes a small scale plant to remove H_2S from the gas stream to make the gas suitable for automobile fuel.
- A third pipeline carries sweet natural gas from the sweet gas header at Gerquduq Station to Yatimtaq Station. This pipeline is 28"OD (720 mm) and is approximately 28 kilometers (17.4 miles) in length. It currently operates between 6.5 and 10 bar (94 and 145 psig). The condition of this pipeline is not known, but has continuously remained in service for well over 25 years. This pipeline was formerly the main delivery pipeline from the Gerquduq field to the compressor station at Khoja Gogerdaq. Current flow is approximately 155,000 M^3/d (5.47 MMCFD). Although this pipeline should be capable of significantly higher operating pressure and flow, it is assumed that years without cathodic protection or dehydration of the gas will have resulted in significant corrosion and decreased pressure capacity.

6.2.4 Shakarak Field

Shakarak Field has one producing well, Shakarak No. 2. Its 2012 production was 90,000 M^3/d (3.18 MMCFD). The gas produced is sweet gas. This well is connected to production facilities at Gerquduq Station by way of a 6.25"OD (159 mm) pipeline approximately 6 kilometers (3.7 miles) in length.

6.3 Sheberghan City Distribution System

A local distribution system serves the City of Sheberghan. It operates at a pressure between 0.5 and 1 bar (7-15 psig), however, pressures near atmospheric have been observed with customers using small vacuum pumps to pull gas from the system. The system layout is not known and was not a part of previous investigations. AGE reports that the system utilizes approximately 57,000 M^3/day (2.01 MMCFD) which is not metered at the delivery points to the end users. AGE also reports that only about 20% of the gas that is used is paid for by the users.

As previously noted, the gas being distributed for household use in Sheberghan averages 140 ppm of H_2S. Table 9-2 below illustrates the harmful effects of H_2S as concentrations increase. Although the effects are most likely reduced by burning the H_2S, continued utilization of 140 ppm H_2S gas in residential use is an issue that should be addressed and mitigated.

Table 6-2: Effects of H_2S Exposure

Concentration (ppm)	Symptoms/Effect
0.00011-0.00033	Typical background concentrations
0.01-1.5	Odor threshold (when rotten egg smell is first noticeable to some). Odor becomes more offensive at 3-5 ppm. Above 30 ppm, odor described as sweet or sickeningly sweet.
2-5	Prolonged exposure may cause nausea, tearing of the eyes, headaches or loss of sleep. Airway problems (bronchial constriction) in some asthma patients.
20	Possible fatigue, loss of appetite, headache, irritability, poor memory, dizziness.
50 – 100	Slight conjunctivitis ("gas eye") and respiratory tract irritation after 1 hour. May cause digestive upset and loss of appetite.
100	Coughing, eye irritation, loss of smell after 2-15 minutes (olfactory fatigue). Altered breathing, drowsiness after 15-30 minutes. Throat irritation after 1 hour. Gradual increase in severity of symptoms over several hours. Death may occur after 48 hours.
100-150	Loss of smell (olfactory fatigue or paralysis).
200-300	Marked conjunctivitis and respiratory tract irritation after 1 hour. Pulmonary edema may occur from prolonged exposure.
500-700	Staggering, collapse in 5 minutes. Serious damage to the eyes in 30 minutes. Death after 30-60 Mins.
700-1000	Rapid unconsciousness, "knockdown" or immediate collapse within 1 to 2 breaths, breathing stops.

6.4 Yatimtaq Field

The Yatimtaq gas field was originally developed in the early 1960's with technical assistance from the Soviet Union. While numerous wells were drilled, most were never completed. The three wells in the Cretaceous reservoir, wells numbers 14, 20 & 21, continue to produce sweet gas at a reported rate of 60,000 M^3/d (2.12 MMCFD).

The majority of the remaining wells were drilled into the Jurassic reservoirs, which contain relative high concentrations of H_2S and carbon dioxide (CO_2), requiring removal prior to the gas being utilized. In 1962, one well blew out and burned for three years before being brought under control by the Soviets. Current reserve estimates take into account the substantial loss due to that blowout.

6.4.1 Gathering Pipelines in Yatimtaq Field

Seventeen, 6.25" OD, (159 mm) gathering pipelines were built between a central gathering station and the wells. To date, only two of these pipelines have been used with an additional three of the original gathering pipelines being dedicated by AGE for production of the wells that have been recently recompleted by Turkish Petroleum (TPAO) under funding from the Asian Development Bank (ADB).

6.4.2 Yatimtaq Station

Yatimtaq station is the termination of the 17 gathering pipelines referred to above. Each of the gathering lines terminates in a meter run and flows into a common header. Yatimtaq station is also the termination of the 28" pipeline that transports sweet gas from Gerquduq field. (Paragraph 9.2.3.2 refers). Yatimtaq station also includes separation equipment for liquid knock out, but does not include any dehydration equipment.

6.4.3 Yatimtaq Amine Treating Plant

A 100 gallon per minute amine treating plant has been recently installed adjacent to Yatimtaq station. (Amine treating units are rated in size by the gallons per minute of amine circulated through the system) The Amine unit is modular and capable of removal of H_2S and CO_2 from the gas stream for up to 962,000 M^3/d (34 MMCFD). It is capable of being operated at pressures between 500 psig (34.5 bar) and 1200 psig (82.7 bar).

Acid gas (CO_2 and H_2S) removed from the gas stream is to be incinerated in a flare which was originally installed to flare blowdown gas at Yatimtaq Station, but reportedly was never used. Provisions have been made to replace and rebuild all of the pilots and fuel gas equipment on the flare.

Final commissioning of the Amine treating plant has been delayed until proper personnel can be brought into the site for detailed training of AGE personnel in the safe operation of this plant. Upon commencing operations, outside personnel with appropriate industry expertise will be needed to supervise operations and conduct on-the-job training continuously for multiple years to ensure that the AGE operators are properly trained in the operation, periodic testing and safety requirements of this plant.

The amine plant also includes three slug catchers designed to keep slugs of liquids from reaching the amine contactor tower. Also included in the plant are liquid storage tanks, a reverse osmosis water treating system, fuel gas, and instrument gas systems. Due to the nature of the gas being processed, all blowdown gas is sent to the flare system for incineration.

The Yatimtaq Amine Plant is connected to the Khoja Gogerdaq to NFPP pipeline at Khoja Gogerdaq by a new 1.8 kilometer (1.1 mile) 12.75" OD (325 mm) high pressure pipeline that has been installed between Yatimtaq Station and Khoja Gogerdaq Station. The pipeline includes a pig launcher at Yatimtaq and a pig receiver at Khoja Gogerdaq, both capable of running smart pigs to gauge the integrity of the pipeline. It also includes methanol injection capabilities to avoid hydrates in the winter, since there are no dehydration facilities at Yatimtaq. Although all welds on this pipeline have been ultrasonic inspected, the pipeline still requires hydrostatic testing before it is put into service.

6.5 Khoja Gogerdaq Field

6.5.1 Khoja Gogerdaq Gathering

The Khoja Gogerdaq Gathering field has 22 producing wells that are all sweet gas. The field produces approximately 200,000 M^3/day (7 MMCF/day). Gathering lines transport the produced gas to Khoja Gogerdaq Station where it is comingled with gas from Gerquduq and Yatimtaq fields.

6.5.2 Khoja Gogerdaq Station

Khoja Gogerdaq Station was originally designed as the origination point of the 32" (820 mm) and the 28" (720 mm) export pipelines. Three large compressors still are in place at Khoja Gogerdaq, but have not been operated since 1989. Many of the ancillary systems such as the starting air, cooling and electrical systems have been removed and pieces salvaged for other uses. The compressors were designed to operate at a significantly higher inlet pressure from the production fields than is available today and were not deemed to be salvageable for use for AGE domestic transmission purposes.

Khoja Gogerdaq also has dehydration facilities that are unlikely to be salvageable for the quantities and pressure available to the station from current production sources. Metering facilities are still in place and are marginally functional.

Recently, three field type compressors were installed and commissioned at Khoja Gogerdaq to boost the gas pressure to the 12.75" OD (325 mm) pipeline that serves the NFPP. In addition to compressors, metering, and dehydration facilities were installed at the Khoja Gogerdaq station to serve the NFPP pipeline. Connecting piping and pressure reduction valves were installed to allow the flow from the Yatimtaq Amine Plant to supplement the gas that is run through the compressors at Khoja Gogerdaq.

6.5.3 Khoja Gogerdaq to NFPP Pipeline

A 12.75" (325 mm) OD pipeline was built in 1965 linking Khoja Gogerdaq Station with the NFPP. The pipeline is approximately 89.1 kilometers (55.4 miles) in length. Since the 1989 departure of the Soviet

Union, there has been little if any funds available for maintenance of this pipeline. It has been repeatedly repaired to keep it in operation by AGE engineers and technicians.

Recently, AGE has replaced approximately 12 kilometers (7.5 miles) of this pipeline in seven sections. At last report, one of the sections was yet to be tied in due to security concerns. It is planned to use an uprating procedure to bring the pipeline back up to a maximum allowable operating pressure (MAOP) of 21 bar (305 psig), which should be sufficient to supply the NFPP natural gas requirements for the foreseeable future.

Until the last section is tested and tied in, the maximum allowable operating pressure (MAOP) for the pipeline is restricted to 10.3 bar (150 psig). When this tie in is made, compressor technicians will be required to reinstall compressor valves that were removed to provide this restriction. Until additional sweet gas supplies are made available, further increasing the pressure on this pipeline will have minimal effects on the volume of natural gas delivered to NFPP.

The figure below shows a schematic of the gathering fields and connecting piping for the Sheberghan area as of February 2012.

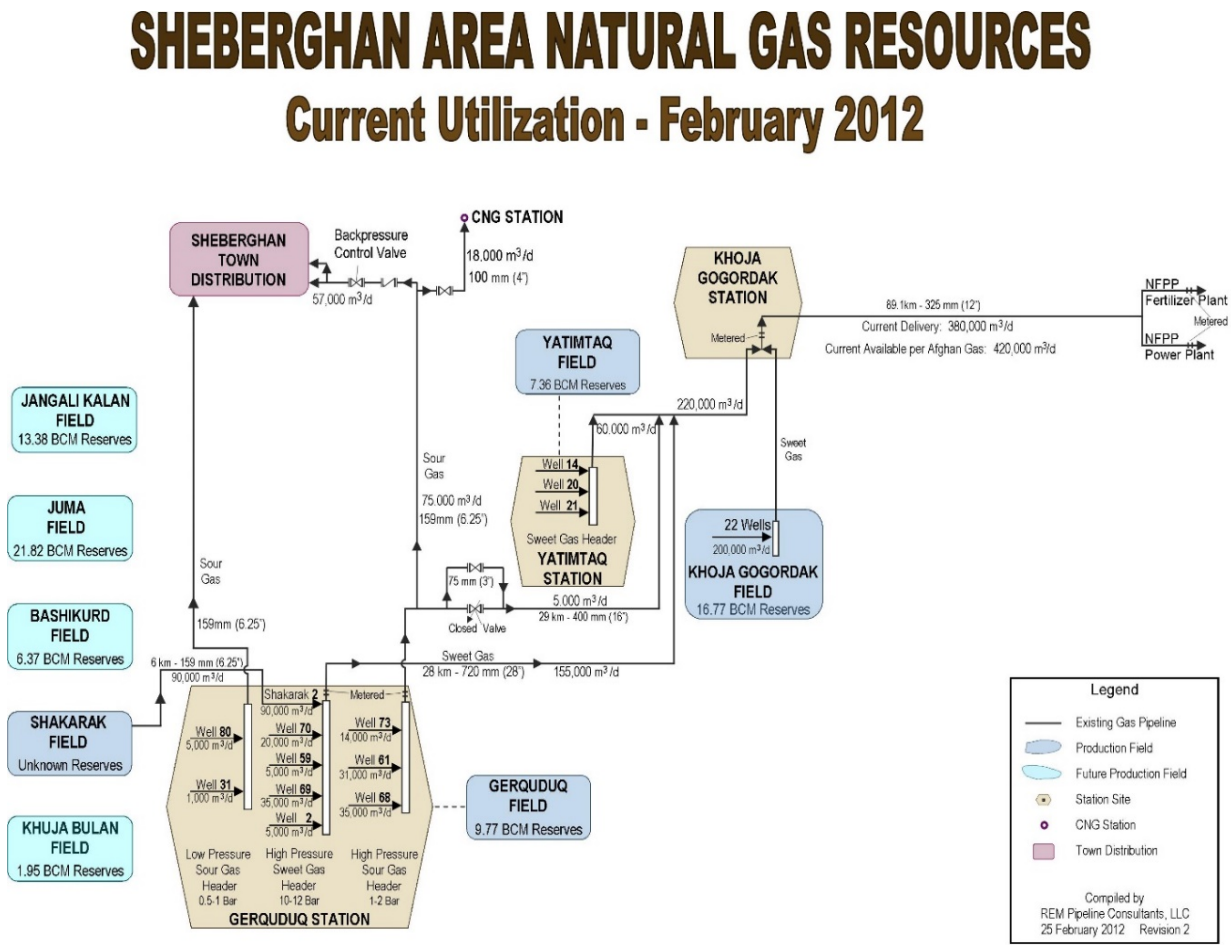

Figure 6-2: Sheberghan Area Natural Gas Infrastructure Schematic

7 Physical Capacity Building for Infrastructure Expansion

Expansion of the existing AGE system is vital to the long-term viability of AGE and to the expansion of natural gas availability for power generation, industrial development and domestic use by the people of Afghanistan.

Expansion can be grouped into three categories, which must be kept within balance to allow for economic expansion of AGE operations.

- Production of Natural Gas – Wells drilled and completed to supply natural gas for transmission to the end user. This should also include a detailed reservoir management program.

- Pipelines – Gathering, transmission and distribution pipelines that gather and carry gas from the wellhead to processing facilities and ultimately to end users for power generation, industrial and domestic uses
- Facilities - Natural gas processing, treating and compression facilities to bring wellhead produced natural gas up to required standards for efficient transportation and utilization by the customer.

7.1.1 Pipeline Replacement and Repairs

The pipeline system in the Sheberghan area is, for the most part, in poor condition for a number of reasons, all with the root cause of inadequate funding. The system suffers from the following:

- External corrosion due to the lack of adequate coating and the absence of any effective cathodic protection
- Internal corrosion due to non-utilization of existing separation equipment to remove water and other well produced liquids from the pipes.
- Internal corrosion due to not having any effective dehydration equipment.
- Lack of training of AGE personnel in repair and maintenance procedures
- Internal corrosion due to high levels of H_2S and CO_2 combined in the gas stream, resulting in a very corrosive environment
- Old and non-working equipment for construction and repair of the pipelines
- Lack of proper materials to repair broken or worn out equipment and fittings
- Lack of proper security to allow AGE personnel to work in certain areas
- Lack of engineering planning capacity to design and purchase up to date equipment and services

7.1.1.1 Khoja Gogerdaq to NFPP Pipeline Repair and Uprating

The 89.1 km (55.4 miles) 12.750" OD (325 mm) pipeline between Khoja Gogerdaq station and the NFPP plant was originally installed in 1965. Only limited maintenance has been performed between 1989 and 2012, by AGE including replacement of some short sections of pipe, installation of drains at low points where leaks have occurred and installation of leak clamps where leaks have been found.

The original pipeline was made up of 325 mm OD x 8 mm wall thickness (12.75" OD x 0.314" w.t.) Russian steel 20 pipe, which was welded and coated with a coal tar enamel corrosion protection coating. Russian steel 20 pipe has a yield strength of 31,329 pounds per square inch. Using the standard design formula for steel pipeline design minimum yield strength:

$$P = (2\ St/D)$$

Where: P = Design pressure in pounds per square inch-gauge

S = Yield strength in pounds per square inch

t = Nominal wall thickness in inches

D = Nominal OD of the pipe in inches

Therefore:

$$P = (2 \times 31329 \times .314)/12.75 = 1543 \text{ psig } (106.3 \text{ bar})$$

Most pipelines that are operating in similar lightly populated areas are allowed a maximum allowable operating pressure design factor of 0.72. This would mean that were this pipeline in good condition, the allowable operation pressure would be as much as 1111 psig (76.6 bar), depending on other factors such as valve and fitting pressure ratings. The current maximum operating pressure of 150 psig (10.3 bar) requires less than 10 percent of the original strength of the pipe to maintain its integrity.

Typically pipelines are installed with a 20 to 30 year service life expectancy. This pipeline has been in service for 50 years, the last 26 years being without any active cathodic protective rectifiers. The pipeline is not capable of being internally inspected (known as "smart pig") due to the lack of pig launchers or receivers and the lack of information on areas where a smart pig could hang up within the pipeline causing a long-term outage for NFPP.

As a way to extend the life of this pipeline until a replacement pipeline could be completed, AGE personnel, with the assistance of subject matter expert instructors has replaced six of seven planned replacement sections of the pipeline totaling 12 kilometers (7.5 miles). The remaining segment has been welded and is awaiting proper security conditions to hydrostatic test and tie in this section. Once this is completed, AGE will institute an uprating plan which was developed using US Department of Transportation Part 192 Guidelines. This uprating will bring the pipeline maximum operating pressure up to 305 psig (21 bar).

At 100% capacity, the NFPP used 780,000 M^3/day (27.55 MMCFD) of natural gas. Completion of this uprating should allow up to a maximum of 860,000 M^3/day (30.37 MMCFD) flow to the NFPP plant, provided that there was enough sweet gas available at Khoja Gogerdaq to supply the pipeline.

7.1.1.2 Khoja Gogerdaq to NFPP Pipeline Replacement

In order to maximize potential deliveries of natural gas to the Mazar-e-Sharif area and to ensure long-term operation of the NFPP, plans were made to install a new pipeline adjacent to the existing Khoja Gogerdaq to NFPP pipeline.

Approximately 93.5 kilometers (59.0 miles) of 12.75" OD (325 mm) x 0.250" (6.35 mm) w.t. API 5L ERW, X 42 Line Pipe coated with 12-14 mils of fusion bonded epoxy was purchased and has been delivered to AGE. Approximately two thirds of this pipe is stockpiled near the Khoja Gogerdaq Station and one third of the pipe is stockpiled on NFPP plant property. An additional 1000 meters (.62 miles) of 12.75" OD (325 mm) x 0.500 (12.7 mm) w.t. API 5L ERW, X 46 Line Pipe was ordered and delivered bare (without external coating) to replace the Balkh River crossing near the NFPP.

Although a full survey could not be performed due to security issues along the route, the design is planned to lay the new pipeline approximately 10-20 meters to the south of and generally parallel with the existing pipeline. Engineering designs have been made and materials have been procured and delivered for block

valve installations along the route as well as smart pig launchers and receivers to allow for cleaning and internal inspection of the new pipeline, which are not possible with the old pipeline.

Block gates are designed to be below ground to maximize security along the route. Cathodic protection stations are specially designed to be at the ground surface so as to not draw attention to the pipeline's location. The old pipeline will remain well marked.

The plan is for AGE to provide construction labor and equipment. Equipment will need to be either purchased or rented and must be in near new condition. Existing AGE equipment will not be sufficient to install this pipeline as many delays were experienced during the construction of the replacement sections on the existing pipeline due to repeated equipment breakdown.

AGE will also need to obtain outside engineering assistance to design and construct the Balkh River crossing. If an alternate crossing location is used that would allow for open cutting of the river bed, an additional one to three kilometers of pipe will be required, due to the likely additional distance required to reroute the pipeline. Outside assistance will also be required to run potential soil tests and to specify and install rectifier systems to protect the new pipeline from corrosion.

Construction specifications for the project were completed several years ago and should be reviewed, but are essentially complete for the pipeline installation project. AGE will also need to bring in experienced pipeline construction and inspection subject matter experts to ensure that welding and testing operations are carried out in accordance with international codes. It is likely that some additional welders will also be required.

While ultrasonic weld inspection equipment was procured and used on the compressor and amine plant and connecting piping to ensure that welds met the required quality, there are no technicians in Afghanistan that are currently trained to use this ultrasonic inspection equipment. Technicians must be brought in from outside of Afghanistan to do this quality control work.

Completion of this pipeline is critical to assuring potential investors of the long-term supply of natural gas that will be absolutely necessary to their investments in power, industry or even local distribution.

The new pipeline would be capable of delivering up to 2,365,000 M^3/d (83.5 MMCFD) at a delivery pressure of 210 psig (14.5 bar). This is approximately five times the current delivery to NFPP and more than three times the maximum stated requirement for NFPP.

7.1.2 Natural Gas Dehydration

Dehydration of natural gas is necessary for the following reasons:

- As the temperature drops water in the gas stream will form hydrates, which, like ice, will plug up a pipeline, but at higher temperatures than water will normally freeze
- Water in the pipeline will pool in low places and inhibit flow

- Water pooled in low areas of the pipeline can cause internal corrosion of the pipe and requires significant costs and efforts to repair internal corrosive damage
- Free water in the pipeline when combined with CO_2 or H_2S is extremely corrosive and may cause internal corrosion and stress corrosion cracks in the pipe

While a detailed inspection of existing dehydration facilities at Khoja Gogerdaq and Gerquduq has not been made, from a cursory inspection, it appears that they are sized too large for effective utilization and that extensive repairs would be required.

A dehydration unit was recently installed and is operable at Khoja Gogerdaq. It is designed to operate either with the low pressure operation with the compressors at Khoja Gogerdaq 125 to 350 psig (8.5 to 24 bar) or with the high pressure gas that will come from the Yatimtaq Amine plant, which will be between 500 psig and 1200 psig (34.5 to 83 bar)

The dehydration unit is sized to dehydrate a maximum of 34 MMCFD (962,772 M^3/day). In its current configuration this would be dehydrating a mixture of the gas from the existing sweet gas compressors at Khoja Gogerdaq, which will be discussed in section 10.1.3 and from the Amine Treating plant at Yatimtaq which will be discussed in Section 10.1.4. Pressure reduction valves are in place to reduce the higher pressure from the amine unit.

7.1.3 Compressors at Khoja Gogerdaq

Three identical compressors were installed at Khoja Gogerdaq Station to boost the pressure to allow additional throughput in the Khoja Gogerdaq to NFPP pipeline. These were necessary since the free flowing pressure from the wells has continued to decrease. Each compressor is a skid-mounted, modular two stage reciprocating compressor with a 1380 horsepower Caterpillar natural gas driven engine. Compressors are tied to common suction and discharge headers. Compressors may be run individually or two compressors may be run together if sufficient gas volume is available. The third compressor is designated as a spare. The standby spare compressor is rotated between the three, allowing for maintenance to the compressors without a reduction on operating volume.

Compressors are rated for a minimum suction pressure of 55 psig (3.8 bar) and a minimum discharge pressure of 250 psig (17.2 bar). All three of the compressors have been manually limited to a maximum discharge pressure of 150 psig (10.3 bar) by removal of one of the compressor valves on each unit. Full utilization of the compressors' capacity will require an experienced technician to replace the removed valves and completion of the pipeline testing and uprating procedure.

Each compressor unit is individually rated to compress from a minimum of 16 MMCFD (453,069 M^3/day) and a maximum of 24 MMCFD (679,604 M^3/d). Unless there is additional low pressure sweet gas discovered, it is unlikely that the compression capacity at Khoja Gogerdaq will need to be expanded. If after the new pipeline is built it is decided to abandon the rehabilitated line, it may be possible to use one of the compressors to pump the gas pressure from 350 psig (24 bar) to the 750 psig to 1000 psig (52bar to 69

bar) pressure required to flow gas from the low pressure wells into the new high pressure pipeline. Changes to the compressor cylinders would be required to allow for the higher output and some parts of the compressor skid package may need replacement to allow for this higher pressure. It is believed that these changes could be performed on location in Khoja Gogerdaq by a team of experienced technicians.

A better utilization of the low pressure sweet gas once sufficient gas is already in the line to the NFPP plant and future uses near Mazar-e-Sharif may be to replace some of the 140 ppm gas in the Sheberghan distribution system with sweet gas.

7.1.4 Natural Gas Sweetening Plant

A natural gas sweetening plant has been installed adjacent to Yatimtaq station. The amine based sweetening plant removes H_2S and CO_2 from the natural gas stream.

H_2S is deadly in relatively small concentrations and can cause serious corrosion problems with steel pipe. CO_2 is an inert gas that does not burn, but also when mixed with water causes severe corrosion problems with steel pipelines. Combined, the two cause very severe corrosion. CO_2, although not poisonous, acts as an asphyxiant by replacing the oxygen in the air. It is colorless and odorless and therefore can be quite dangerous in confined spaces.

The sweetening plant will treat gas from three wells that were recently recompleted in the Yatimtaq field by TPAO under an ADB project. The wells were all completed in the Jurassic zone and can be expected to contain significant concentrations of both CO_2 and H_2S.

A 100 gallon per minute (amine circulation rate) amine sweetening plant has been installed at Yatimtaq and is near ready for commissioning. The plant is modular. The main plant is located on five skids which are interconnected with fuel gas, amine, electrical and control piping. The installation also includes a fuel gas system, separators and liquid knock outs, acid gas scrubbers, liquid storage tanks, and a reverse osmosis water treatment system. The amine plant requires electrical power as do many of the systems. A 300 Kw natural gas powered electrical power generator is included in the system.

The Amine gas sweetening plant is designed to operate at a minimum pressure of 450 psig (31 bar) and 1200 psig (82.7 bar). It is rated to remove a 2.8% acid gas content with a maximum treated volume of 34 MMCFD (962,772 M^3/d) The volume of gas actually treated will be dependent on the actual concentrations of H_2S and CO_2 in the gas stream from the new wells as well as the available pressure. In general, a higher acid gas concentration will reduce the capacity and lower pressure will also reduce the capacity of the amine plant. Conversely, pressures at the higher end of the operating range and lower percentages of acid gas concentration will increase the capacity of the unit. All volume treating calculations are based on the outlet gas having less than 10 ppm H_2S and less than 1% CO_2.

Acid gas removed from the gas stream will be incinerated in an existing flare at Yatimtaq that it approximately 165 feet (50 meters) in height. Three new pilots and automatic relighting equipment and

instrumentation have been purchased and are on site. Installation these pilots will be required before the amine gas sweetening plant can be commissioned.

7.2 System Expansion

Expansion of the AGE transmission system will require incremental additions and replacements to the system. As currently constructed or as outlined in the ongoing plans above, the system will handle all of the gas that is currently available to the pipeline system. Incremental capacities as each of these projects is completed and commissioned are shown in Table 10-1 below:

Table 7-1: Capacity and Infrastructure

INSTALLATION	CAPACITY AFTER INSTALLATION	UTILIZATION AFTER INSTALLATION/COMMISSIONING
Existing Pipeline Repair & Uprating	860,000 M^3/d @ 21 bar	380,000 M^3/d @ 9 bar
Compressors with valves removed limiting outlet pressure. Dehydration unit installed at KG,	456,000 M^3/d @ 10.3 bar	456,000 M^3/d @ 10.3 bar
Compressors after valve reinstallation	906,138 M^3/d @ 24 bar	504,000 M^3/d – Limited by sweet gas availability
Uprated Pipeline with Sweetened gas from Yatimtaq	860,000 M^3/d @ 21 bar	456,000 M^3/d from compressors / 404,000 M^3/d from Yatimtaq
Khoja Gogerdaq to NFPP Pipeline Replaced with New Pipeline	2,365,000 M^3/d @51.7 bar inlet 14.5 bar outlet	962,772 M^3/d – limited by capacity of amine plant and capacity of dehydration unit

As noted in Table 10-1 above, the current delivery capacity is limited by the availability of sweet gas from, Gerquduq, Shakarak, Khoja Gogerdaq and Yatimtaq fields. It is possible that one or more of the wells that are currently producing sweet gas in these fields can be reworked to improve deliverability. Utilization of the compressors has resulted in an approximate 20% increase from the existing wells due to the lower required suction pressure. The current discharge pressure restrictions on the compressors are having some effects on throughput, but these are relatively minor.

Bringing the Yatimtaq gas sweetening plant online will have a significant effect on the total gas deliverables, increasing the total volume by almost 50%.

The Yatimtaq gas sweetening plant and the Dehydration unit are both limited to 962,772 M^3/d (34MMCFD). The Yatimtaq gas sweetening plant may be further limited by the availability or the concentration of H_2S and CO_2 in the gas available from the newly recompleted wells at Yatimtaq. Preliminary well test reports are conflicting, so that actual gas compensation and volumes may not be available until the wells are tied in and operating.

7.3 Next Steps

7.3.1 Gerquduq Field TPAO wells

TPAO, as a part of the same project sponsored by the ADB also reported to have recompleted four wells in the Gerquduq Field, although ADB never verified that the work was completed. These wells were also in the Jurassic Zone and have the same H_2S and CO_2 issues as the ones completed at Yatimtaq.

7.3.2 Replacement of 28 Kilometer, 28" Pipeline

As previously noted, the Gerquduq field is connected to the Yatimtaq and Khoja Gogerdaq Stations by a 28" (720 mm) OD pipeline, 28 kilometers (17.4 miles) in length that was installed approximately 50 years ago and has not been regularly maintained since 1989. Since the condition of this pipeline is not known and the current operating pressure is 6.5 to 10 bar (94 – 145 psig), it must be assumed that this pipeline will need to be reconditioned or replaced before high pressure gas can be moved from the new wells drilled at Gerquduq field.

Although this pipeline does not have a pig launcher or receiver, it could be taken out of service to run a smart pig, once the Yatimtaq sweetening plant is fully online. If the results of the smart pig were good, the pipeline could then be uprated by hydrostatic testing. The more likely scenario for this line, due to the fact that it has been used continuously with wet gas, no cathodic protection and little or no maintenance, would be to replace the pipeline with a smaller diameter pipeline. Calculations indicate that a 10.75" (275 mm) or a 12.75" (325 mm) pipeline would be sufficient to transport the approximately 1,400,000 M^3/d (49.52 MMCFD) balance of the gas required to fill the new pipeline between Khoja Gogerdaq and NFPP to capacity.

7.3.3 Gerquduq Gas Sweetening Plant

In order to utilize the gas from the four new wells recompleted by TPAO/ ADB at Gerquduq field, the gas must first be treated to remove the harmful H_2S and CO_2 from the gas stream.

A second amine gas sweetening plant will need to be built to do this. It is dangerous to transport gas that has high levels of H_2S and CO_2, since any leak caused by accidentally cutting or damaging a pipeline carrying this gas could result in illness and likely many deaths to persons in the area of the damage. Additionally, due to the corrosive nature of the H_2S and CO_2 together, particularly with moisture present, the likelihood of the pipeline developing a leak is higher than on a normal pipeline. This would also result in serious casualties.

It is best to transport this type of gas from gathering fields in low carbon mild steel pipes and to remove as much of the free water as possible from the system at each wellhead. A wellhead scrubber is suggested for each wellhead. It is also preferred to place the Amine sweetening plant as nearly as possible to the wells. (Note: there are a number of other methods available for removing H_2S and/or CO_2 from gas streams, but in the quantities which are likely to be encountered in at these locations, Amine is the most often utilized option.)

The size of the amine plant should be dependent on the volumes and pressure of the gas to be treated as well as its acid gas level. The plant that was installed at Yatimtaq is modular and therefore is scalable so that additional units may be added as the need grows. Significantly larger units, such as the two originally installed at Gerquduq may be economical with scale, but require gas from other fields to be transported significantly longer distances along with the inherent dangers of doing so.

As the size of each amine sweetening plant increases, the amount of H_2S residual also increases. Incinerating this residual gas in a flare causes sulfur dioxide emissions which are restricted in quantities, depending on locations. For this reason, some or all of the residual gas may require disposal of either through a program of reinjection into a depleted gas field, or through a sulfur recovery process, resulting in stable elemental sulfur, such as the Claus method. Elemental sulfur is used to make matches and as raw materials in other processes which could become local industries. The Claus process requires significant additional equipment and may be reason for building a single larger amine sweetening plant, rather than multiple smaller ones.

Another method of dealing with the residual gas is to use another process to make sulfuric acid, which has many commercial uses.

7.3.4 Gerquduq Dehydration Unit

Since the gas exiting an amine plant is saturated with water, it will be necessary to install a dehydration unit at the outlet of the Gerquduq Amine Sweetening Plant. It is anticipated that this unit will be larger than the one currently installed at Khoja Gogerdaq and may be advisable to install two smaller units to allow for some redundancy during maintenance or breakdown.

Installation of the Gerquduq Dehydration Unit is essential to the future maintenance and operation of the upgraded and now maintained pipeline facilities.

7.3.5 Future Development

Development of the fields where there has been no production will require extensive engineering study and calculations to determine the most efficient and economical designs and the facilities required. Potential long-term improvements would be possible based on the additional availability of gas. These may include a 100-200 Megawatt independent power plant located between the Gerquduq Gas Field and Sheberghan, one or more CNG automobile filling stations located at Mazar-e-Sharif, additional industries located at Sheberghan, Koda Barq and Mazar-e-Sharif. In addition, the stable gas supply will allow construction of an Independent power plant at Koda Barq near Mazar-e-Sharif.

7.3.6 Undeveloped Additional Natural Gas Production Fields

There are currently four (4) proven natural gas fields in the Sheberghan area that have not been developed. The fields along with estimated proven reserves in BCM^3 follow:

- Jangali Kalan Field 13.38 BCM Reserves
- Juma Field 21.82 BCM Reserves
- Bashikurd Field 6.37 BCM Reserves
- Khuja Bulan Field 1.95 BCM Reserves

The center of the Jangali Kalan Field lies approximately 40 km (24.9 miles) north of the Gerquduq Station and is approximately 25 km (15.5 miles) northwest of Sheberghan City. The field is in the Kogitan formation and all reserves are considered to be sour gas (containing significant quantities of H_2S).

The center of the Juma Field is located approximately 31 km (19.3 miles) northwest of Gerquduq Station and is approximately 28 km (17.4 miles) west-northwest of the center of Sheberghan City. It is also in the Kogitan formation and reserves are considered to be sour gas.

Bashikurd Field is located adjacent to the Juma field. It is approximately 22.5 km (14 miles) northwest of Gerquduq station and approximately 18 km (11.4 miles) west-northwest of the center of Sheberghan City. Also in the Kogitan formation the gas is considered to be sour gas, but slightly less sour than Juma Field.

Khuja Bulan Field is located approximately 20 km (14.4 miles) southeast of Gerquduq Station and approximately 24 km (15 miles) southeast of the center of Sheberghan City. The Khuja Bulan Field is estimated to have approximately 300 ppm H_2S. It is technically sour, but much less so than the Jangali Kalan, Juma and Bashikurd fields. As the Khuja Bulan field has only 1.95 BCF reserves and is fairly remote to the rest of the system, its development may not be as economical as the other fields included in this report.

7.3.7 Development of Jangali Kalan, Juma and Bashikurd Fields

It is reasonable to assume that the Jangali Kalan, Juma and Bashikurd fields will be developed together with the Juma and Bashikurd fields developed first, followed by the Jangali Kalan field when the demand for additional natural gas supply causes the investment in infrastructure to make economic sense.

Although detailed engineering study is required to route and size the required pipelines, the left side of Figure 7-1 depicts a conceptual layout of how the fields may be developed.

Initially a trunk gathering pipeline assumed to be 12.75” or 16” (325 mm or 400 mm) OD will be laid from the to-be-constructed Gerquduq Gas Sweeting Plant to a point between the Juma and Bashikurd fields. It is estimated that this trunk line will be approximately 33 km (20.5 miles) in length. Lateral pipelines will be laid from the trunk line into each field and gathering lines designed for each well in each field.

When the Jangali Kalan Field is developed, the trunk gathering pipeline will be extended approximately 27 km (16.8 miles) into the Jangali field.

Since the gathering trunk line will be carrying very sour gas, particular attention will need to be given to the design of the metallurgy of the pipe. In addition, wellhead separators will be required to remove water from the gas stream to minimize corrosive effects. Extra thickness of pipe is also recommended.

As previously discussed, an Amine Gas Sweetening plant is recommended to be constructed at Gerquduq station. Depending on engineering issues, this plant could also be located between the Juma and Bashikurd fields to minimize the distance that the sour gas will need to be transported. The sweetened natural gas leaving the Gerquduq Amine Sweetening plant will be odorized for the safety of personnel and residents in the area.

A 100- to 200- megawatt power plant is presumed to be a primary customer for the gas from the Jangali Kalan, Juma and Bashikurd fields. The balance of the sweetened natural gas could be transported to the Khoja Gogerdaq to NFPP pipeline for delivery to customers in Mazar-e-Sharif, or utilized for additional power production in Sheberghan in the future.

7.3.8 Development of Khuja Bulan Gas Field

Development of the Khuja Bulan Field may be less attractive on an economic basis than the Jangali Kalan, Juma and Bashikurd fields due to its remote location and more modest reserves (1.95 BCM). However, it could be developed in two ways that may serve to supplement the useful life of some facilities.

1. A gathering pipeline approximately 20 km (12.4 miles) in length could be laid between the center of Khuja Bulan field and the proposed Gerquduq gas sweetening plant. The gas from Khuja Bulan field would be comingled with gas from Jangali Kalan, Juma and Bashikurd fields and treated at the Gerquduq gas sweetening plant.
2. A gathering pipeline approximately 21.7 km (13.5 miles) in length could be laid to the Yatimtaq gas sweetening plant. This would supplement the gas from wells in the Yatimtaq field as they become depleted and would maximize the life of the Yatimtaq gas sweetening plant.
3. As a third alternative, a small sweetening plant could be installed at Khuja Bulan field and the gas could be delivered to the sweet gas pipeline between Gerquduq and the Sheberghan local distribution requiring a pipeline approximately 14 km (8.7 miles).

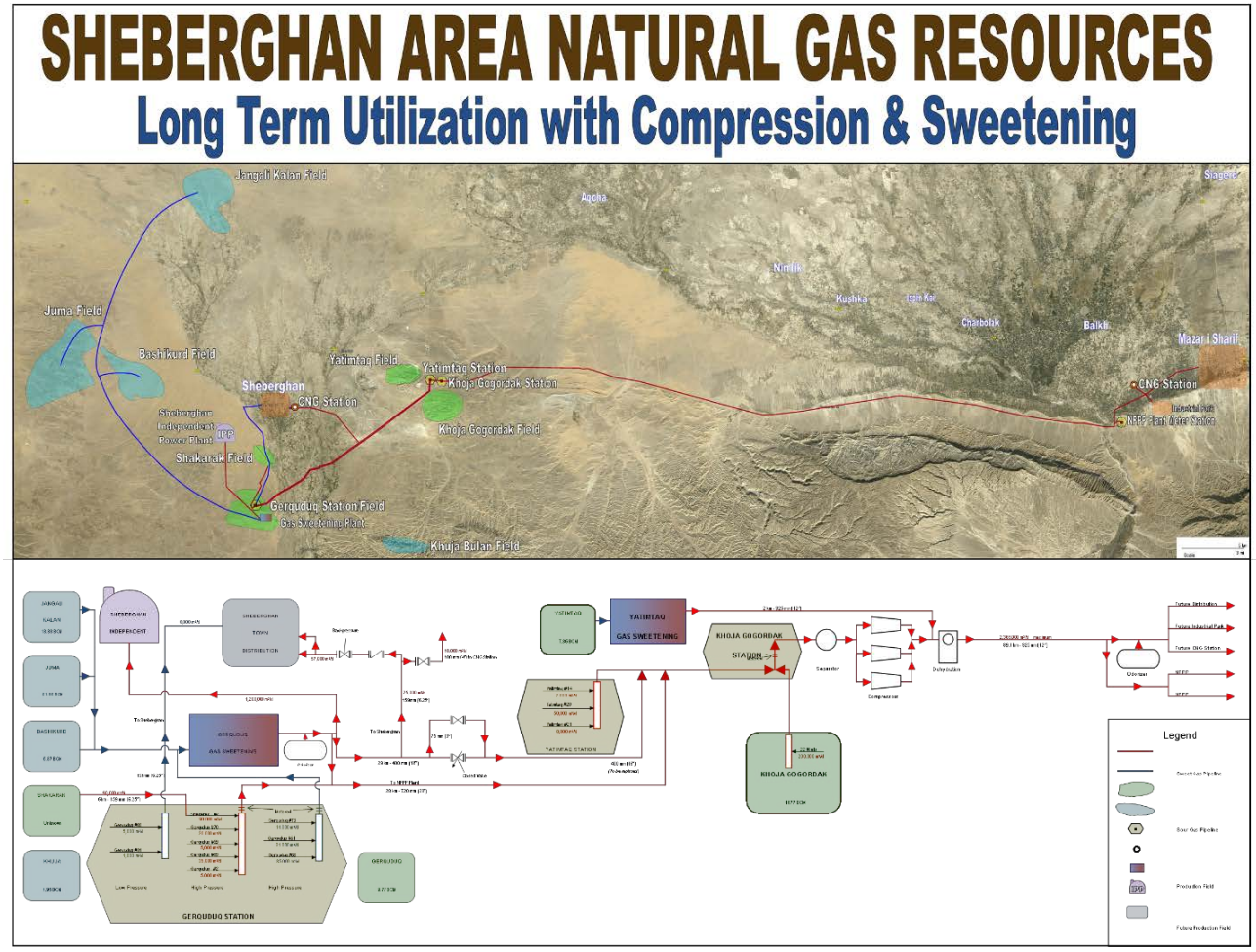

Figure 7-1: Long-Term Utilization of Natural Gas and Related Infrastructure

7.3.9 Additional Development at Koda Barq and Mazar-e-Sharif

Completion of the new pipeline between Khoja Gogerdaq and NFPP, along with the development of additional sweet gas supplies from Jangali Kalan, Juma, Bashikurd and Khuja Bulan fields will result in a volume of gas that is three to four times the requirements of NFPP. This gas can be sold for use by various customers. Potential projects include:

- Additional power generation at Mazar-e-Sharif
- CNG automobile filling station at Mazar-e-Sharif
- Industries in Mazar-e-Sharif or Koda Barq

Although it is not likely that the NFPP can utilize all of the 780,000 M^3/d gas that it was originally designed to use, allowing for that volume would still leave a potential surplus capacity of approximately 1,585,000 M^3/d flowing to NFPP.

For comparison, a 36-Megawatt turbine power plant (General Electric LM 6000 Turbine Generator) requires approximately 280,000 M^3/d. The available surplus at full capacity would result in enough gas being available at NFPP to operate five 36 megawatt power plants. The actual usage of the surplus capacity will be dependent on the best economic and needs for the long-term utilization for the gas.

The gas currently being transported to NFPP is not odorized, due to process restrictions at the NFPP. Gas being used for power generation, local distribution or other industries should be odorized before delivery to the customer.

8 Gas Compositions per Reservoir Type

The table below details the difference in gas composition of the different reservoir types. A dry gas reservoir gas composition is significantly different than gases from an oil and gas condensate reservoir. Oil and gas condensate reservoir gas is rich in Natural Gas Liquids (NGLs). Gas composition from the reservoirs is important as it dictates the required field surface facilities for gas treatment and natural gas processing. The Yatimtaq gas contains H_2S and therefore Yatimtaq is sour. Extra gas treatment with liquid amines is required to remove the H_2S and make it safe for industrial and commercial use.

Table 8-1: Typical Gas Compositions by Reservoir Type

Component	Symbol	Yatimtaq Dry Gas Composition (Mole %)	Associated Gas from Oil Formation (Mole %)	Separator Gas from Gas Condensate Reservoir (Mole%)
Nitrogen	N2	0.26	3.91	0.13
Carbon Dioxide	CO2	3.13	0.00	0.01
Methane	C1	96.02	85.62	83.01
Ethane	C2	0.51	6.18	9.23
Propane	C3	0.0785	2.56	4.50
Iso-Butane	I-C4	0.00	0.36	0.74
N-Butane	N-C4	0.00	0.73	1.20
Iso-Pentane	I-C5	0.00	0.19	0.31
N-Pentane	N-C5	0.00	0.17	0.25
Hexanes Plus	C6+	0.00	0.28	0.62
Hydrogen Sulfide	H_2S	0.0015	0.00	0.00

8.1.1 Speculative Gas Reserves

In 2005, the U.S. Geological Survey (USGS) cooperated with the Afghanistan MoMP and Industry Joint Oil and Gas Resource Assessment Team to assess the undiscovered petroleum resources of Afghanistan. Much of the petroleum resource potential of Afghanistan and all of the known crude oil and natural gas reserves were found to be in northern Afghanistan, located in parts of two petroliferous geologic basins—the Amu Darya Basin to the west around Sheberghan and the Afghan-Tajik Basin to the east around

Mazar-I-Sharif. The assessment was based on the geologic elements of a total petroleum system, which included (1) source-rock presence, maturation, petroleum generation, and migration; (2) distribution and quality of reservoir rocks; and (3) character of traps and time of formation with respect to petroleum migration. Data from detailed studies of geochemistry, petroleum geology, geophysics, and tectonics combined with basin historical exploration and production analyses were used to aid in the estimation of the number and sizes of undiscovered petroleum accumulations.

Table 8-2: Potential Undiscovered Hydrocarbons in Afghanistan

Undiscovered Recoverable Hydrocarbons	Crude Oil M Metric Tons (MM Barrels)	Natural Gas Billion Cubic Meters (Billion Cubic Feet)	NGLs (MM Barrels)
Amu-Darya Basin	10 M MT (73 MM Bbls)	214 BCM (7,553 BCF)	(195 MM Bbls)
Afghan-Tajik Basin	209 M MT (1,523 MM Bbls)	230 BCM (8, 134 BCF)	(367 MM Bbls)
Total	219 M MT (1,596 MM Bbls)	444 BCM (15,687 BCF)	(562 MM Bbls)

From the above chart, the volume of natural gas for gas gathering by Afghanistan Gas Enterprise could be almost equal in both the Amu Darya and Afghan-Tajik Basins but is totally dependent on exploration and gas/oil field development.

The oil prone Afghan-Tajik Basin will have associated gas from the oil reservoirs and a great potential for NGLs requiring a processing plant. A centrally located processing plant could produce NGLs in volumes as much as 25% or more of the oil volume in the basin and generate considerable revenue for AGE. The remaining residue gas, the gas left after NGL extraction and similar to Dry Gas, could be used to generate electricity in gas turbine generators. Dry Gas from gas reservoirs near Sheberghan could be processed and pipelined to supplement the electrical generation effort.

Figure 8-1: Basins and Exploration Blocks in Northern Afghanistan

To date, exploration and production sharing contracts (EPSCs) for two exploration blocks have been signed, for Sanduqli and Mazar-e-Sharif blocks. The Sanduqli block borders Turkmenistan and Uzbekistan in the north and spans 2,583km². The Mazar-e-Sharif block borders Uzbekistan in the north and has an area of 2,715km². The participating interests of Dragon Oil, TPAO, and the Ghazanfar Group in the two blocks are 40%, 40% and 20%, respectively. Dragon Oil is the operator of the Sanduqli block while the Mazar-e-Sharif block is operated by TPAO. AGE would need to negotiate and contract with Dragon Oil and TPAO for natural gas processing of gas from their blocks with a central processing plant. An AGE-owned central processing plant could then process gas from the remaining Afghan-Tajik Basin blocks - Ahmadabad, Balkh, Mohammed Jan Dagar, and Shamar when those blocks are developed.

8.1.2 Gas Production from Gas Oil Ratio in Oil Reservoirs

The Society of Petroleum Engineers International has published data that associated gas from an oil field can have Gas/Oil Ratios, of from 200 to 900 standard cubic feet per barrel of oil. Therefore for every 10,000 bpd produced, associated gas could be from 2.0 MMCFD (million standard cubic feet per day) to 9.0 MMCFD. In the Amu Darya Basin, China National Petroleum Corporation has been awarded EPSCs for three oil prone blocks; – Zamarudsay, Bazarkhami, and Kashkari. Current estimates of oil production by 2016 could be 40,000 bpd. Gas from this oil production would then be from 8.0 to 36.0 MMCFD of NGL rich gas.

Oil reserves in the Afghan-Tajik Basin blocks have been estimated as 20 times those of the Amu Darya Basin. Conservatively, oil production from the Afghan-Tajik Basin blocks could be 200,000 bbl/day or 5 times the Amu Darya Basin. Based on this oil production, associated gas to be processed in a NGPP could be from 40 to 180 MMCFD.

9 Concluding Comments

Based on the reserves available to AGE, there is significant potential to grow into a vibrant and successful midstream operating company. There is very significant demand and multiple opportunities to monetize the natural gas resources in the Sheberghan area. These include:

- Power Generation at Sheberghan
- Full gas supply to the NFPP assuming pricing is at least equal to cost to produce
- Power Generation at Mazar-e-Sharif
- Industry at Sheberghan
- Industry at Mazar-e-Sharif
- CNG automobile filing stations at Mazar-e-Sharif

In order to take advantage of these opportunities, the Government of Afghanistan and MoMP must support real management change at AGE so that the skills to procure, construct and maintain the AGE facilities in an environment that is safe and conducive to positive progress will become ingrained into the culture of AGE. They must also fund the expansion, either through borrowing, international donor support or cash flow. Once this happens, the positive energy and cash flow from completed operations should support future expansion and the training and craftsmanship learned by the AGE workers will allow AGE to do most of the work with minimum external assistance.

10 References

Information contained in this report is based on the references as follow in this section. All documents referenced have been obtained from the public domain and are generally available for downloading from the internet.

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