Prospect of Natural Gas Distribution Pipelines and Safety in Tanzania-a case Study

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Abstract. Energy security is the first priority in any society worldwide. Effective distribution of clean and safe energy is still a challenge for researchers in the energy industry. This study aims to design a natural gas distribution network for supplying clean and safe natural gas for transport, residential, industrial and commercial needs. A case study in Tanzania, for the Tanzania Petroleum Development Corporation (TPDC) natural gas distribution pipeline. Effective pipeline network will reduce the consumption of electricity, coal, and charcoal. For safety purpose, the gas pipeline leak detection system is necessary, which is discussed and proposed in this paper. The old traditional method used for distributing gas energy to the domestic users in Tanzania is through liquefied petroleum gas (LPG) cylinders. This method has numerous drawbacks as cases of accidents are frequently reported.

1. Introduction

Oil and gas in Tanzania have been discovered for more than a half century. In 1974 the first discovery of natural gas was sited at the Songo Songo Island followed by Mnazi Bay in 1982. In 2004 and 2006 the production of natural gas at Songo Songo Island and Mnazi Bay for commercial uses began. Since 2010, numerous discoveries and on-going geological investigation have led to substantial amounts of natural gas both onshore and offshore (see figure 2) [1], [2], [3], [4], [5], [6].

These discoveries have brought more challenges both to the government and the basic company of Tanzania Petroleum Development Corporation (TPDC) about how to manage the fast increasing of projects activities of oil and natural gas industry. The challenges consist of Policy, legal and institutional frameworks to manage oil and natural gas industry successfully [3].

In most parts of the cities, people use the liquefied petroleum gas (LPG) cylinders [7] as a source of gas energy. Although the LPG cylinders in cities can be sold from local shops, there are challenges for consumers about how to fight a fire explosion when it comes to their property and environment in general. This is due to lack of knowledge and protective equipment to consumers. These LPG cylinders have several disadvantages; the basic one is the incorrect method of keeping them at homes which can cause a fire.

The current project is investigating the possibility of constructing a natural gas distribution pipeline network from the city gate centre (Kinyerezi-Dar es salaam) to power plant generation, households, and commercial users.
The project is aiming at using the discharged natural gas from the transmission pipeline from two gas processing plants namely Madimba gas processing plant (Mtwara region) and Songo Songo gas processing plant (Lindi region). Dar es Salaam households, transportation and commercial users will be considered in the designing of the distribution gas network. This study aims to provide technical designing suggestions for natural gas distribution pipelines in Dar es Salaam city to deliver clean and safe energy for transport, residential, industrial and commercial needs. This proposed system will replace the old system of using LPG cylinders. Also will reduce the use of electricity, charcoal, wood and other fuels. In addition the risk of pollutions and danger to human life and the environment will be minimized.

2. Background of a Master Plan Project.

The national natural gas infrastructure project (NNGIP) was constructed in 2015 from Mtwara region to Dar es Salaam [8]. This natural gas pipeline infrastructure is owned 100% by the Tanzania government under Tanzania Petroleum Development Cooperation (TPDC). It consists 290km, 36” (onshore pipeline) from Mnazi Bay Madimba-Mtwara region to Somanga Fungu-Lindi region, 25km, 24” (offshore pipeline) from Songo Songo to Somanga Fungu-Lindi region, 197km, 36”(onshore pipeline) from Somanga Fungu-Lindi region to Kinyerezi-Dar es salaam region and 30km, 16” (onshore pipeline) from Kinyerezi to Tegeta-Dar es salaam, which make a total of 542km both onshore and offshore natural gas pipeline network up to now as shown in the figure 1. The feasibility study for the natural gas distribution pipelines in Dar es Salaam city was done in 2007, the project aim was to connect industries, institutions, transportation and households [9].

3. Tanzania energy consumption

Energy is essential in achieving economic prosperity and advances in social and overall human development. Energy has evolved to match with modern human development and requirement.

Biomass is the basic energy supply in Tanzania. This is because about 85-95% of the population of Tanzania does not have access to electricity hence many households use wood and charcoal as their source of energy for cooking and heating [10]. Hence biomass contributes up to 90% of overall primary energy consumption in Tanzania. Other energy sources are oil and gas 8%, electricity 1.5% and coal, wind and solar 0.5% [11] as shown in figure 3 below.

In Tanzania solid biomass in the form of wood and charcoal are the basic source of energy for cooking and heating. The wood used in rural areas is 26 million cubic meters (m³). Among this, 24...
million m$^3$ is used in cooking for households, 2.03 million m$^3$ is used in rural areas for small and medium-sized companies and 14.4 million m$^3$ is used in urban areas - especially as charcoal. According to the United Nations Convention on Climate Change, only 4% of the biomass used is sustainable, outside of the 90% of solid biomass energy is used by consumers. Most biomass requirements are for household used for cooking and heating, and the remainder (10%) is used by home-based companies, businesses, institutions and industries.

Charcoal is one of the main sources of energy for a household in urban areas, with 20% of the total energy consumption. Dar es Salaam city alone uses nearly half of Tanzania’s annual charcoal produced which is about 500,000 tons per year [12]. Therefore, this causes deforestation around 100,000 hectares of trees per year. Thus more efforts are required to decrease deforestation for the sustainability of the environments.

4. Proposed system-Detail design drawing

Switching from traditional energy sources to natural gas usage requires intensive safety care and comprehensive design of gas distribution pipelines. The gas operation can have negative effects on the environment, health and safety of people. Obedience to proper and good industry standards and practices will provide a significant in preventing such negative effects. It is essential to design and plan for remedial measures prior to any operation and management. Regulations of these operations and managements are essential to make sure that activities in the natural gas industry are performed by taking environment, health and safety matters into consideration [2]. Furthermore, the sophisticated gas leakage detection system for distribution pipeline network and equipment monitoring is the best way for preventing or reducing the negative effects to the environment, pipeline network and people for any happening of gas leakage.

The natural gas distribution pipeline schemes should be designed carefully with the required operation standards under the consideration for the economy, safety, and uniformity of pressure issues. The distribution lines must be properly-looped within the particular area and in all outlying areas.

The proposed system should fulfill the existing limitations of the natural gas distribution system in Dar es Salaam city. The proposed additional design and equipment are as explained below in figure 4. Furthermore, we propose real-time gas pipeline leak detection monitoring. Therefore, surface acoustic wave sensor network technology is the best safety measures technology for real-time distribution gas pipelines detection monitoring system.

![Figure 3. Primary energy supply in Tanzania](image)

![Figure 4. Proposed natural gas distribution and safety system](image)

5. Safety and Monitoring
Each distribution system, gas-meters and other connected devices must be provided with proper pressure regulating devices or acoustic sensors for safety monitoring against any accident that may happen.

When a leakage happens on the pipeline it causes changes to physical parameters on the surface on the pipeline. The surface acoustic wave (SAW) sensors will be used for sensing, identifying and measuring those physical parameters like temperature, pressure, torque, acceleration, tire-road friction, humidity acoustic wave, etc. The sensor will be linked with the remote terminal unit where signal processing will be taken place. The analysed signal from the remote terminal unit (RTU) will be broadcasted to assigned SCADA and mobile phone at a real-time. SCADA and mobile phone will be used as a real-time monitoring system, they will be received all the status of the pipeline distribution system. When a leak happens in the distribution pipeline system the SAW sensor will detect the leak and act as a remote terminal unit by broadcasting the information to SCADA and mobile phone via a global system for mobile communication (GSM) or ZigBee technology. The engineer/operator can receive at real-time that information at the control room and he/she can take quick measures either to shut-down the corresponding valve or the corresponding service line to avoid the serious damages to system, environment and to people. Also through the mobile phone the Engineer can receive the information at real-time anywhere he/she will be and can provide the way forward to operators in the control station.

6. Conclusion
Through the current study we can conclude as follows:

- The supplied natural gas from the distributed pipelines will be safer used by customers, also the environment will be highly protected from the risks of the pipelines leakages.
- Through using cheaper natural gas for cooking and heating people will be economically benefited rather than using LPG
- The use of the electricity will decrease for cooking and heating purposes and hence increase the income to the people.
- The transportation method of using tracks for liquefied petroleum gas (LPG) cylinders will be replaced with this distribution pipeline system; hence natural gas energy can easily be obtained for homes and commercial purposes.
- Also this system can be implemented to other regions and cities where natural gas transmission line passes.
- Through this system, the environment will highly be protected against the risk of deforestation and pollution. Furthermore, users will be also protected as well against any problems that may come after gas leakages.

Amongst the advantages that will be offered by the natural gas distribution system is the capability of supplying large amounts of energy to residential, transportation and commercial users which is more efficiency, reliable and cheaper compared to another source of energy like LPG, Charcoal, kerosene etc.

From this case study carried out at TPDC, we can say that the limited natural gas distribution network and the cost are the key barriers which must be taken into consideration so that to increase the service to the customers and to integrate the market. Finally, if a natural gas distribution scheme will be designed and operated properly, it will drive the development of Tanzania and her citizens abundantly. The clean energy gas for transport, residential, industrial and commercial uses will be easily obtained. This will reduce the demand for electricity, coal, charcoal, fuels, etc.; furthermore the risk from pipeline leakage will be reduced.

7. Recommendations
This chapter identifies some of the works that need to be done in order to provide a basis for the Government to facilitate the implementation of the Natural Gas Utilization Master Plan. This includes:

- Integration of the master plan project so that any customer can be able to access the natural gas services in their area taking into account that the population of Tanzania is increasing year after year. Also this project should move to another region so as to benefit all Tanzanians and increase the national economy.
- Establishing of the Monitoring system in this system is necessary. Through this, the system itself, the environment and human life will highly be protected against any accident that will be happening in any circumstances. The monitoring system should be monitored wirelessly to enhance real-time monitoring.
- The government, along with other natural gas stakeholders should provide education on the customers and the people in general for basic handling their natural gas appliances and how to protect themselves when gas leakage happens.

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