International Journal of Energy Engineering 2015, 5(2): 17-24
DOI: 10.5923/j.ijee.20150502.01

Gas Pipeline Network Design for Koya City: Case Study

Jafar A. Ali*, Hayder H. Abbas, Loghman Khodakarami

Faculty of Engineering, Koya University, Koya, Iraq

Abstract The first worldwide concern is energy security. Supplying a clean energy in efficient way is still an important topic for many researchers. This paper investigates designing of gas distribution network as a safer, cleaner and convenient energy option for the city of Koya in Kurdistan Region, taking Gashtiari neighborhood as case study. The old traditional ways to supply gas for domestics' consumers in Koya city is by cylinders and road trucks have many disadvantages; this is due to road traffics and accidents and explodes of gas cylinders as well. The network linked 162 houses via 3500m pipes with different diameters. The source of the gas will be one of the local oil fields locates 18 Km outside the city. The designed results show that every single house in the region is consuming 300m^3/month as average in cold weather (November – March), this will reduce to 100m^3/month in hot weather (April – October). Also the conservation in energy equal to (442-663) MWh/day in case if using the designed network. Detailed drawing of the network and route map is provided using Arc GIS. The aim of the study is to deliver clean energy for transport, residential, industrial and commercial needs. This will reduce the demand for electricity; in addition the risk of pollutions will be decreased.

Keywords Pipeline, Gas network, Energy, GIS, Koya city

1. Introduction

In Kurdistan Region and Iraq the housekeepers are using only the Liquefied Petroleum Gas LPG cylinders. No gas pipeline system exists in the country except in some buildings and complexes. LPG is a mixture of hydrocarbons, which are in gaseous state at ambient temperature and pressure but these are liquefied under pressure for easy storage, handling and transportation in pressurized vessels. It is obtained through crude oil refining or from natural gas through fractionation. Butane and Propane are the main constituent hydrocarbons in LPG. Others present in traces or small fractions are Iso-butane, butylenes, n-butane, propylene etc. [1]. Although the gas cylinders in Kurdistan can be obtained from local shops, but it's difficult to deal with. The current project is investigating the possibility of building gas network for the country housekeepers and commerce. The project is focusing on using the discharged gases from the local oil fields and burned. As case study the city of Koya 80km from the capital city of Erbil will be considered. This city includes one of the biggest oil fields in Kurdistan Region. Among the city Gashtiari neighbourhood will be considered to design the gas network for it.

The old style of the gas cylinders which is used nowadays in Koya and Kurdistan householder's kitchens should be replaced. These cylinders have too many disadvantages; the main one is the wrong way of keeping them at homes which might cause fire. In addition its difficult to be obtained and moved to the houses due to the heavy weight of these cylinders [2]. The use of natural gas as fuel for city energy purposes is increasing worldwide due to its many impressive advantages over traditional choices of fuels like petrol, diesel etc. Besides being more dependable, energy efficient and economical the natural gas is the cleanest of all the fossil fuels having considerably low emission levels, making it best energy choice for a wholesome environment. In view to address mounting pollution level and to improve upon the deteriorating air quality in urban areas, there is an urgent need to switch over from traditional liquid fuels to natural gas for transportation and other energy requirement [3]. Natural gas consists mainly of methane. If a natural gas contains a relatively large quantity of other lighter hydrocarbons it's called a wet gas. A natural gas called a dry gas if the quantity of the other lighter hydrocarbons is relatively small [4].

Liquefied petroleum gas and liquefied natural gas can share the facility of being stored and transported as a liquid and then vaporized and used as a gas. To achieve this, liquefied petroleum gas must be maintained at moderate pressure but at ambient temperature. The liquefied natural gas can be at ambient pressure but must be maintained at a temperature of roughly -1 to 60°C [5]. Hydrocarbon gases are generated with the oil, and although they consist largely of methane, they usually also include heavier hydrocarbons. Thermogenic conversion of organic matter to hydrocarbons continues at accelerating rates with increasing depth and temperature until all organic matter, including theoil itself,

* Corresponding author:
jafar.dalo@koyauniversity.org (Jafar A. Ali)
Published online at http://journal.sapub.org/ijee

has been converts largely to methane and carbon-rich residue [6].

At the City of Koya there are two oil fields both are locating few kilometres away from the city centre. The oil fields are disposed the natural gas by burning them, meanwhile the city can get benefit from them. The current study investigates the process of building pipelines network to distribute gas for Koya city residents. The gas source will be one of the local oil field and transmit to the city via pipeline. The need for an optimum route is more important as this can reduce a huge operational cost.

Gas storage system is needed for peaks shaving in gas distribution systems to increase its efficiency. In gas pipeline network, gas storage systems are used to store city gas during low consumption time and discharged the stored gas in the peak time. This will increase the efficiency of gas distribution systems [7]. Gas transmission pipelines are a safe form of energy transportation compared to rail, road trucks, and sea. Table 1 compares the safety of pipelines with the other modes of transportation. It's shown that the road trucks cause 87.3 times more deaths than pipelines, and are 34.7 times more likely to cause a fire or explosion [8]. However, special precautions should be taken to minimize the risk of mechanical damage during future excavations and reinstatement of other services, agricultural machinery, etc. [9].

Table 1. [8, 13]: Comparison of modes of energy transportation

Transport	Death	Fire / Explosion	Injury
Road Truck	87.3	34.7	2.3
Rail	2.7	8.6	0.1
Barge	0.2	4.0	0.1
Tanker Ship	4.0	1.2	3.1
Pipeline	1.0	1.0	1.0

2. Koya City Energy Consumption

Energy does not only play an important role in our everyday living, but also has an essential role in the development of industry, agriculture, medicine and all fields of human activities [10]. There is increasing demand for energy in Kurdistan Region KR, due to the rapid increase in population Figure 1.

The recent years is showing dramatic increased for energy demands as the population of the city increased to 150000 in 2014. The big number of population in a small town like Koya is caused busy traffics. This has increased the risk of energy transportation via vehicles.

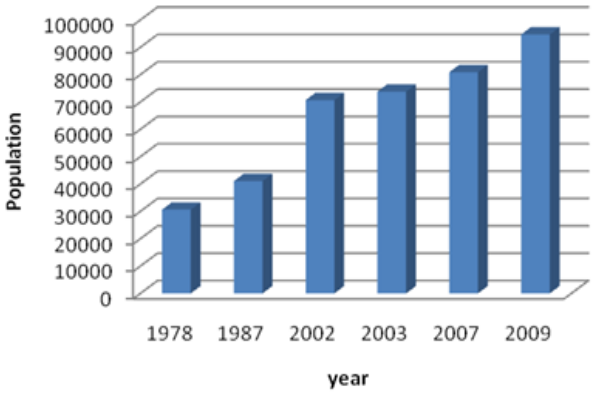


Figure 1. Population in Koya city [12]

It is raising standards of living, and the immigration from conflicts parts of Iraq to the KR is another issue. Koya city shared the problems with the Region and the world increasing demand for energy and environmental degradation.

Koya geographically is located to the mid of Kurdistan Region at 630m above sea-level Figure 2. The total area is about 2025km². It is considered as a bridge connects the main cities of Erbil, Slemani and Kirkuk. This strategic location has enabled the city to prosper and become one of the centers of commerce, education and culture in Kurdistan.

The consumption of energy in Koya city is divided into four sectors, residential, commercial, industrial, and governmental. Table 2 shows the distribution of power consumption in Koya city during the years 2007 – 2009 [11]. 88% of the city energy is consumed by the domestics, 10% commercial and 02% by industries.

It shows the percent of consumers and category in Koya city started from 2007 to 2009, its clear that the market for energy is dominated by the domestic customers. A survey was carried out among high school students; a total number of 160 samples of questionnaires were collected. The results indicated that 95% from domestic consumers are using kerosene and electrical power to heat their houses. 82% from domestic consumers use electricity to heat water whilst 16% are using kerosene [12].

The majority of the electric heaters use in Kurdistan is consuming about (2000 – 3000) Watt. From the survey results show 82% using EWHS, and 95% using EH and kerosene, the total number of householders in Koya is 12489. Based on 10 hours working, the range of energy consumption in the city is (442 – 663) MW.h/day. Therefore, using the gas pipeline in the city is something can't be over locked.

Table 2. Category and percent of consumers in Koya [11]

Year	Domestic	Commercial	Industry	Agriculture	Government
2007	87%	10%	1%	0%	2%
2008	88%	10%	1%	0%	1%
2009	88%	9%	1%	0%	2%

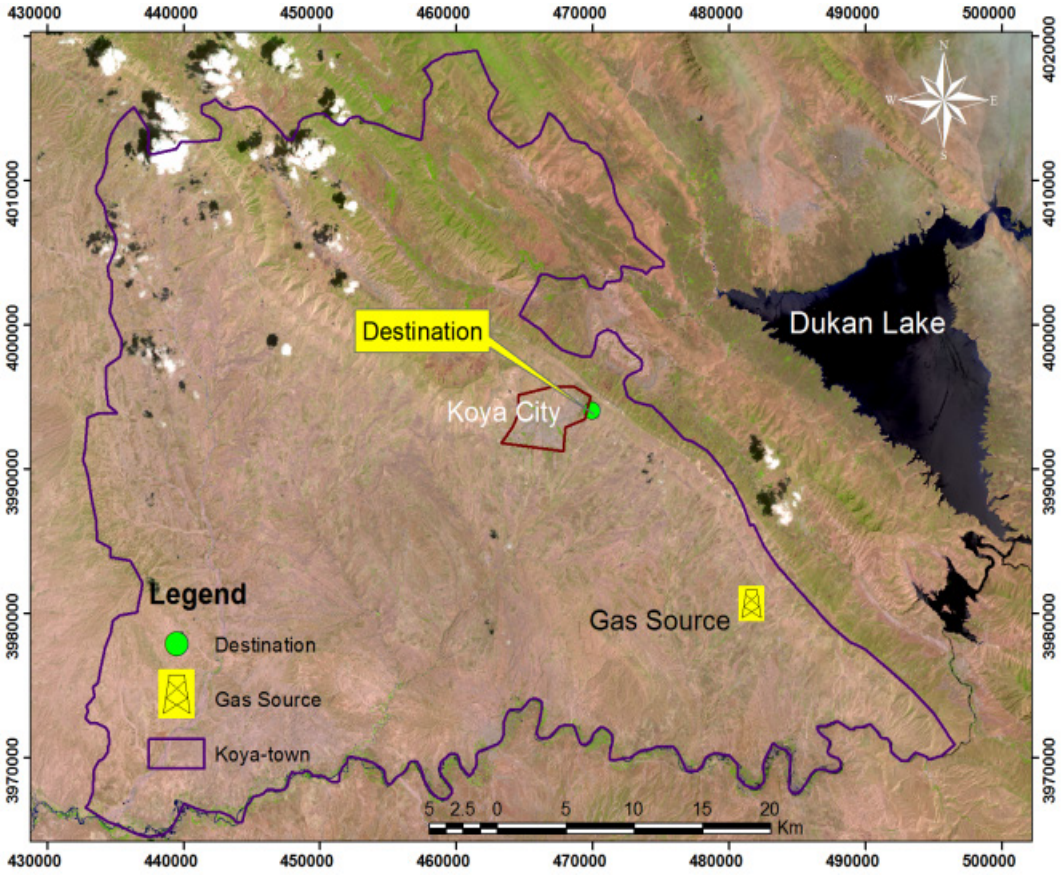


Figure 2. Koya city location

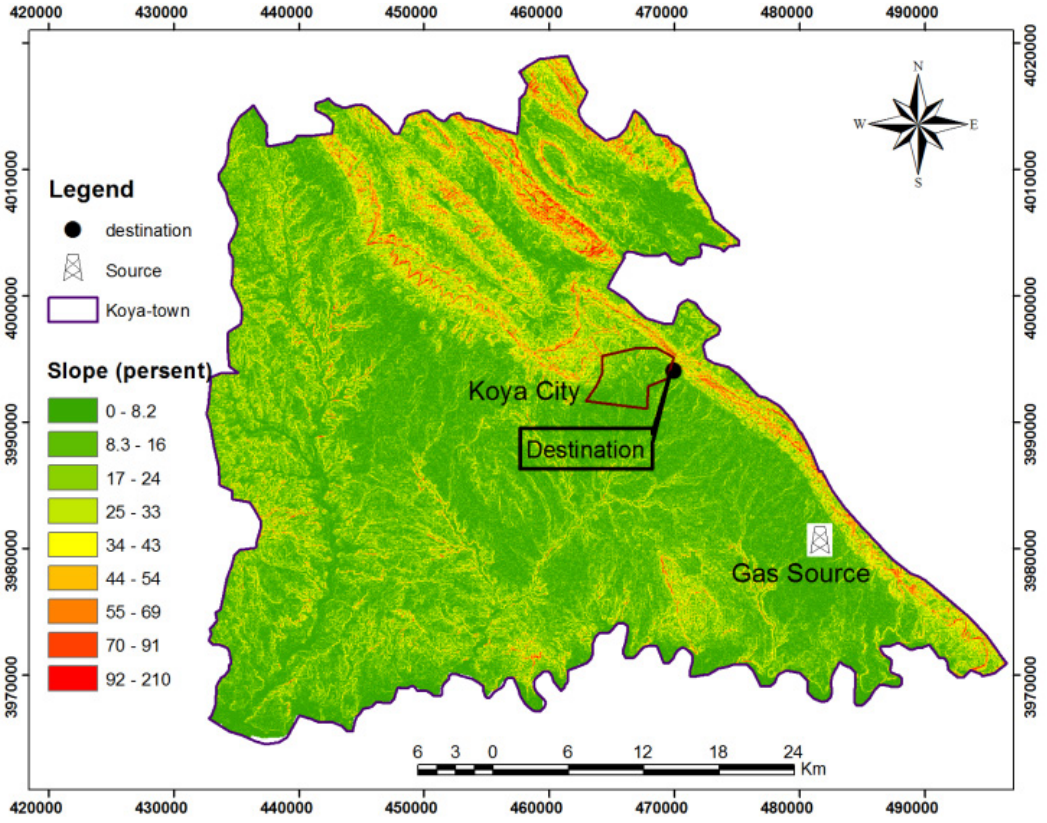


Figure 3. Slope factor map

3. Main Gas Pipeline

Koya is surrounded by two oil fields TaqTaqrunning by Genel Energy and Shiwashan run by Gasplusboth having natural gases burned, whilst the city is in need of energy. Total of six flares are existing in the city. All are burning the natural gases discharged from the oil fields. Despite the waste of money they are polluting the city environment. Shiwashan is located 18km from the city, therefore it will be considered as a source of gas supplier in the current study. A pipeline will be extended from the oil field to an area near the city. An optimal route for the pipeline has been found using Geographic Information System. GIS is a powerful toll to integrate thematic layers in an automated environment to compute possible shortest route with associated costs. The selected path must comply with the requirements of the user, it reduces the cost and time of the project execution and hence the operating expenses. The slop factor was considered during the rout selection, i.e. the areas with sharp slops are considered as an expensive and the pipe has avoided it. The slop factor of the area is shown on map in Figure 3.

The green colour indicates to smallest slope range (0 – 8%) whilst the red colour indicates to the biggest slope ranged above 92%. It appears from the figure that the city is located in an area with higher slop than the gas source (oil field). Therefor the gas need to be pushed from the source to reach the city, and the pipeline must goes through less slop zones.

The smallest slops were counted from the source to the destination. Then a path was created, this is the shortest optimal rout of the gas pipeline connects the oil field with the city of Koya, see Figure 4. The black solid line indicates to the pipeline route, whilst the gas source is the oil field. The world standards for the gas pipeline can be applied for the implementation of the project and the pipe construction.

Figure 5 shows the profile of the gas pipeline from the source to the city, it goes along the mountain avoided the sharp slopes. The gas source is at the starting point 0km whilst the city is located at the end point 18.2km. The length of the pipe is about 18km with the maximum elevation of 690m after 12km in the interval between the source and the destination. Whilst the minimum elevation detected is about 585m just after the source. Therefore the difference in the elevation is about 110m for 18km pipe length. Therefor several compressors are needed to be installed along the pipe within the first 12km from the source. These compressors are behaving as raisers to increase the pressure inside the pipe to push the gas forward. This pipeline will be able to move the discharged gases from the oil filed to the city and uses as a source of energy for the consumers.

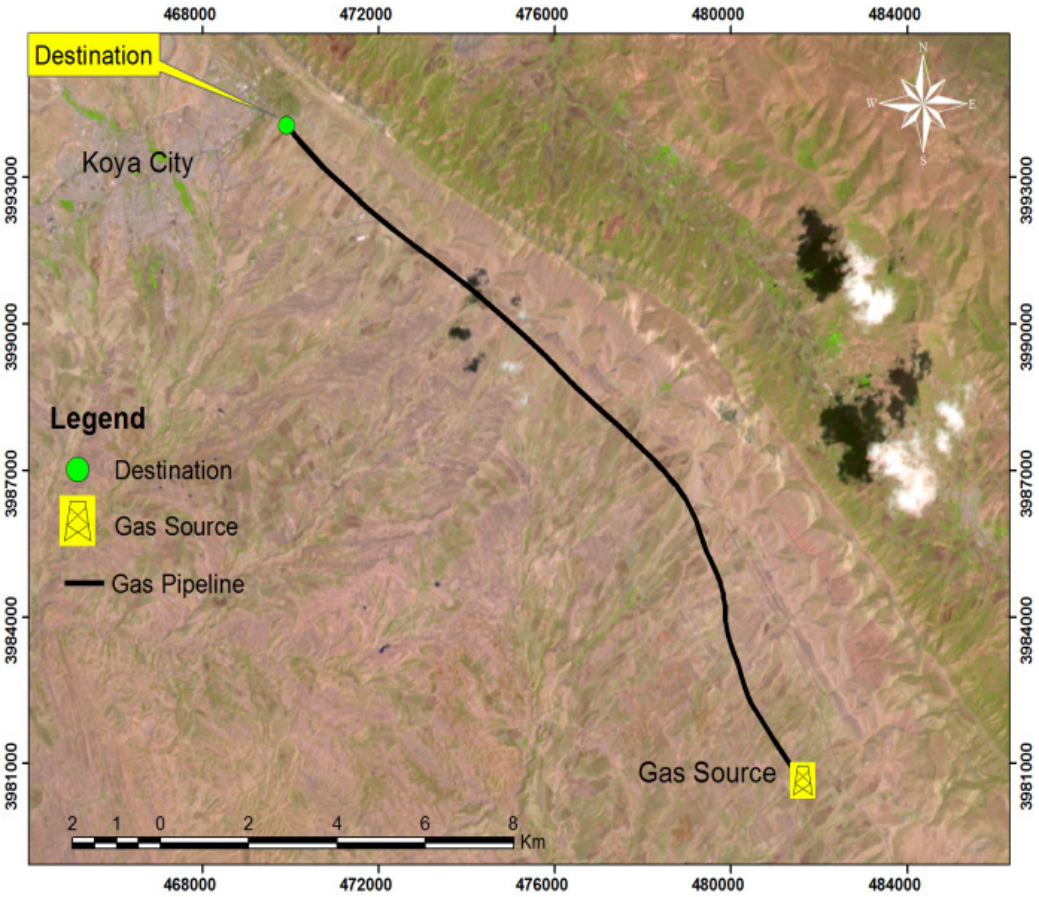


Figure 4. Optimal gas pipeline route

Figure 5. Gas pipeline profile with elevations

Table 3. Typical cost for 1m pipe plus installation

Maine pipeline cost for 1m pipe				
Diameter (in)	**wall thckness (in)**	**Pipe price $**	**Installation price $**	**Total Price $**
4	0.188	0.35	7.26	7.61
4	0.219	0.35	7.66	8.00
Network cost for 1m pipe				
Diameter (in)	**wall thckness (in)**	**Pipe price $**	**Installation price $**	**Total Price $**
3	0.133	0.26	7.41	7.67
3	0.141	0.26	7.41	7.67
2	0.133	0.14	6.48	6.62
2	0.141	0.14	6.48	6.62

Gas storage will install outside the city at the destination to connect the main pipeline inlet with the outlet pipes to the city. The inlet pipe is the main pipeline that is transmits the gas from the source whilst the outlet is the pipe that is supply the gas to the city network. The size of the storage could be small, as the gas flow rate is controlled from the source via valves. Only the amount of the gas consumed by the city will be transmitted.

Survey has been carried out to find out the amount of gas consumption for mid-level houses in the region. It's found that the average gas usage for a single house in cold seasons is 300m^3/month, this value will reduce to 100m^3/month in hot weather (April – October). This figures also approved by collecting the gas bills from mid level house keepers in the neighbouring countries which has similar environment. Gashtiari neighbourhood in Koya city include 162 houses, therefore the average gas consumption for this area is 32400m^3/month.

4. Detailed Design Drawing

The basic approach for gas pipeline route network analysis in Koya city was to get the Geo-eye satellite image, geo-referencing of the satellite image, route network analysis and then a completed digitization for the area. Various features were drawn with the help of drawing tool such as residential areas and road network. Several layers were defined. Attributes were assigned to each feature in the map which was collected by the field inspections and manually. These data include the information about all the features drawn on the map such as buildings and information about its physical status. The geo-database table can be edited furthermore and new information can be added or removed.

All the layers were merged into one, so the criteria regarding the gas pipeline can be considered. In this case study two different layers of the pipeline were developed, first one is the main pipeline which has the highest width and second which is the sub part of the main line, has somewhat low width.

Route selection shall take into account the design, construction, operation and maintenance of the pipeline taking the following into consideration; safety of public and personnel working on or near the pipeline, environmental protection, others properties and facilities such as electrical interferences, future explorations and developmental plans. The image shown in Figure 6 is the final design which shows the route networking for laying the pipeline in Koya city. The red line is the main pipeline through which the gas is supplying. Its connected to the green spot which is the gas storage located outside the city. The storage is also connected to the main pipeline. Furthermore branches were connected to the bigger diameter pipeline. Lines with blue colourare the secondary pipeline through which all the

tertiary lines are linked so that supply can be possible to all the houses.

5. Cost and Revenue

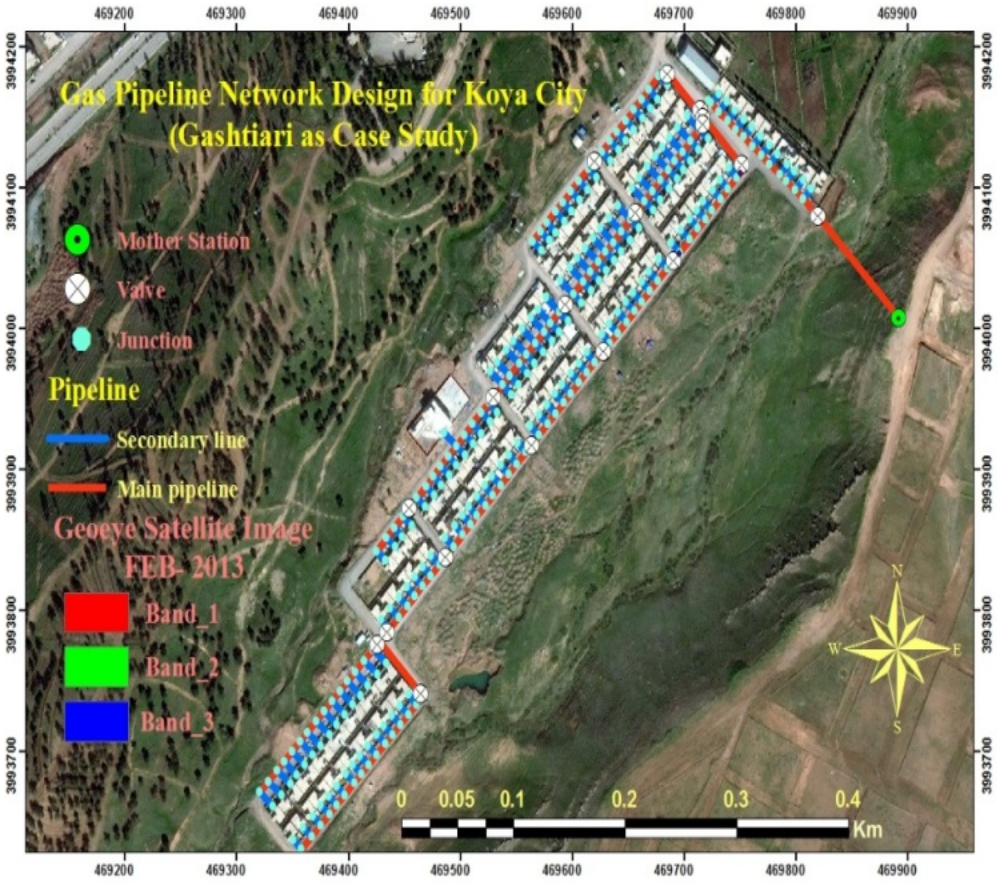
In Iraq and Kurdistan Region the government subsides the electricity cost which is paid by costumers, they pay approximately 10% of the real cost. The cost to generate electricity in Kurdistan region for 1MW.h is equal $15.5 and $30.6 for hydropower and gas turbine respectively. Therefore, the conservation achieved by the gas network project in consumed energy is equal to (442 – 663) MW.h/day, as a result the government revenue will be approximately ($6851-$10267.5) for hydropower and ($13525.2- $20287.8) for gas turbine [12].

As for the current project a survey was carried out in the local markets, the cost for 1m pipe plus installation and for different pipe diameters was found as presented in Table 3. The cost for the main pipeline is about $145620, whilst the cost for the network depends on the customer demands. Only for Gashtiari neighbourhood it cost about $24362 for 3500m pipe.

6. Result and Discussion

The source of the gas is an oil field located near the city of Koya. Oil fields in Iraq and Kurdistan are usually burning the discharged gases to get rid of them. In the current study the discharged gases from the oil field is intended to be invested and transmit to the city via pipelines. This is reducing the environmental impacts of the oil fields on the surrounding areas. The solid black line in Figure 4 represents the optimal route of the pipeline to link the oil field with the city. The route was selected based on the minimum slope; it has passed along a hilly area 2025 km^2 where all the slope factors were given using GIS, Figure 3. It is avoided the sharp slopes with a shortest distance to reach the destination.

The length of the pipe is about 18km. The elevation of the source is 600m above the sea level, whilst the destination elevation is about 670m. The maximum elevation that the pipe route will cross is about 690m in an area about 12km from the oil field (source). The amount of gas is needed to the city can be provided directly by the main pipeline, this pipe will be ended at a location outside the city. Then it is distributed to the houses, smaller pipe diameter should be used for this purpose. The gas network for Gashtiari neighbourhood in the city is presented in Figure 6; the network included 166 houses supplied with the gas. Raisers are needed in some areas where the pressure is low inside the network. Valves and meters are also included in the network with extra attention should be given to the safety issues. The network map was created using GIS.



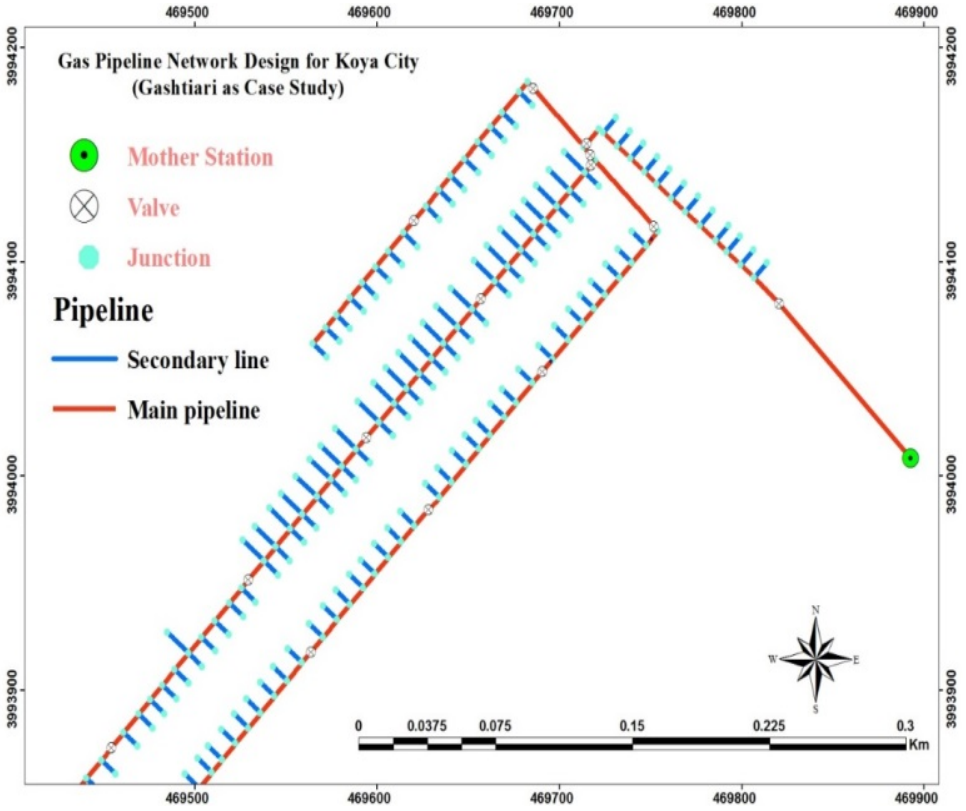


Figure 6. Gas Pipeline Network Design in Koya City (Gashtiari as Case Study)

7. Conclusions

From the current study the following will be concluded:

- The discharge disposed gases will be used and the environment will be protected from the risk of the pollution.
- Economic benefits for the country as this gas will be cheaper than LPG and Kerosene that is used for the heating purposes in the region.
- The demand for the electricity will be reduced as the later uses for the heating purposes and cause extra load on the suppliers.
- The track mode of gas transportation will be ended; and the gas easily can be obtained from homes.
- Similar projects can be carried out for the other cities which have local oil fields across the country.
- Environmentally friendly clean gas will be supplied to the house holders and the risk of pollution and road accidents will be reduced.

REFERENCES

[1] Annon. “Air Duct Cleaning, LPG Gas Cylinder Tips” Internet: http://www.indiahometips.com/lpg-cylinder-tips.html, June, 2013 [Oct. 07, 2013].

[2] J. A. Ali, “Koya City Gas Distribution Network” *FirstInternational Symposium on Urban Development*, Koya, Kurdistan Region, 2013, pp. 355 - 359.

[3] Indian Petroleum and Gas Report, Internet: http://www.indiaenvironmentportal.org.in/files/file/Indtroduction%20report.pdf, Dec. 21, 2011 [Jan. 05, 2015].

[4] P. L. Sandler. The Petroleum Programme. York, UK: Specialist Language Services S.L.S.

[5] J. G. Speight. *Environmental Analysis and Technology for the Refining Industry*. New Jersey, USA: John Wiley and Sons, 2005, pp. 239.

[6] U. Mahadevan. *Fundamentals of Petroleum and Petrochemical Engineering*. New Delhi, India: SBS Publishers and Distributers, 2012, pp. 13.

[7] M. Komori, K. Wakasa, T. Takeuchi, Y. Shimoda, T. Mori, T. Sakurai, K. Numata, M. Kohara, T. Kawamura, K. Shoda, T. Ishimori, A. Koyanagi and G. Fujii, “High Efficiency Gas Distribution System” High-Efficiency Distribution Project Sec. R&D Dept. The Japan Gas Association 1-15-12, Toranomon, Minato-ku, Tokyo, 105-0001 Japan.

[8] P. Hopkins. “High design factor pipelines: integrity issues” *The Journal of Pipeline Integrity,* PP. 69 – 97, 2005.

[9] CPM Group “CPM Concrete Drainage System- Pipeline Design” Internet: http://www.cpm-group.com/downloads/Concrete-Pipe-Installation-Guide.pdf, [Oct. 08, 2013]

[10] O.C. Ozerdem and H. H. Abbas, “Simulation of a novel approach of accurate solar Photovoltaic array”, *Eighth Electrical and Electronics Engineering (ELECO) International Conference,* 2013,pp.558 – 561.

[11] H. H. Abbas, “The feasibility of using a solar power generator system in Kurdistan: Koya city as a case study”. *First International Symposium on Urban Development: Koya as a*

Case Study, 2013, pp. 151 - 157.

[12] H. H. Abbas, "Spatial Planning of Solar Energy Resource by Using GIS". Diploma Thesis, Faculty of Engineering Duhok University, Kurdistan Region –Iraq, 2011.

[13] Allegro Group: Association of Oil Pipe Lines "Oil pipeline safety: a research update" Internet: www.aopl.org , April 2000 [Oct. 08, 2013].