

CHAPTER-1 INTRODUCTION

1.1 SUBJECT OF RESEARCH

The subject of research is *“Asian Gas Grid (AGG): A Critical Analysis of its Feasibility”*. The study is on the feasibility of an Asian Gas Grid (AGG) pipeline that will connect various Asian countries for transporting gas. This gas grid proposes to connect various Asian countries and foster to the requirement of a “Green Asia Energy Corridor”. It would be able to fulfill the fuel needs and address environmental issues of several Asian countries. The proposed pipeline would deliver surplus gas sourced from countries like Russia, Turkmenistan, Iran, Bangladesh, and Myanmar, to growing consumption centers like India, China, ASEAN countries etc. The concept, however, will have to be developed considering techno-economic and geo-political feasibility of the project.

Asian economies including China, India and South Korea are currently growing at rates far greater than the US or Western Europe, and this trend is likely to continue in the future. As the economies grow, countries have started looking for more sources of energy. Natural gas has emerged as one of the potential energy sources. In order to fulfill the demand for natural gas, multi-dimensional strategies are being worked out including Trans-border transport of the fuel. The AGG is means by which the potential supply from gas rich countries can be routed to demand centers.

1.2 NEED FOR RESEARCH

Cross-border oil and gas trade has grown significantly in the past 50 years. Natural gas can be transported through pipelines or ships in the liquefied state (LNG). The case for transporting gas through pipeline is more compelling. Reserves close to the market or demand centers are depleting, hence the need to move the gas from further places. For this, pipeline transportation is the only alternative. Liquefied Natural Gas transported by pipelines is cost competitive only if the distance exceeds 3000 miles (4800 km).

Although Asia dominates the world LNG market, its tremendous potential is relatively under-utilized, as gas trade in the region via pipelines, is very limited. As economic growth continues, natural gas has a key role to play in Asia's future. Expanding the use of gas will help reduce oil dependency, as Asia has its own natural gas supplies. This would also alleviate the pollution currently produced by coal burning and CO₂ emissions.

Currently, the main obstacle to increasing the use of natural gas is the lack of sufficient terminals, long-distance pipelines, and local transport network systems. Development of transport and distribution infrastructure necessary for this will require support from the private sector, and especially governments. Natural gas is often referred to as the fuel of the future, and the Asian region stands to benefit greatly from expanding production and improving its trade and utilization.

Ernst & Young along with Tractebel carried out a study for Asian Gas Grid in the year 2005. But the proposal could not materialize due to lack of interest by the concerned countries. Now several Asian countries have begun showing interest in cross-border pipelines which can be extended to gain advantage of economies of scale.

1.3 OBJECTIVES OF THE RESEARCH

- 1) To analyze the Energy scenario, i.e. demand and supply analysis of Asian countries.
- 2) To define probable obstacles in implementation of the gas grid project on issues such as geo-political criteria, financing, project management etc, and suggest measures to overcome these obstacles.
- 3) To propose a plausible network for natural gas transportation through the Asian countries that meets techno-economic and geo-political viability criteria.
- 4) To suggest an optimum route and connectivity between various segments of the proposed gas grid, along with a suggested design of high pressure grid pipelines.
- 5) To develop a model for calculation of technical and financial viability of the Asian Gas Grid project.

1.4 RESEARCH METHODOLOGY

Research methodology is an operational framework within which the facts are placed so that their meaning may be seen more clearly. A structured research process can be carried out only by means of a systemic plan of action. An outline of the plan of action is provided in order to give structure to the process of research.

'Asian Gas Grid-A critical analysis of its feasibility' involved many dimensions as a research topic. The following dimensions were covered under the study:

1. Energy & Natural Gas Scenario (International & Asia)

2. Demand-supply scenario of Natural Gas in Asia
3. Experience of other cross border pipelines & gas grids
4. Geo- Political Scenario of Asia
5. Techno-Commercial feasibility
6. Financing the project
7. Project Management aspects

1. Energy & Natural Gas Scenario (International & Asia)

The study is descriptive in nature. In this chapter we have studied global natural gas reserves with emphasis on Asian countries that would be part of the Asian Gas Grid. The data is secondary in nature. It was collected from the sources like annual reports of international agencies, Government publications, magazines, books and websites (see in Bibliography). Information was also got from Energy Information Administration, International Energy Outlook, Energy Intelligence Research etc

2. Demand Supply Scenario of Natural Gas in Asia

The study is descriptive in nature. The key parameters of natural gas reserves in Asia, along with supply potential were studied. Keeping in mind the current economic growth and future projections, the possible supply and demand centers for natural gas were identified. Projections for demand and supply were made till 2025. The data is predominantly secondary in nature. The data was collected from international agencies, government annual reports, magazines; books etc (see Bibliography). Important sources of information are *BP Statistics Review, World Energy Outlook, World Gas Handbook, Energy Information Administration, International Energy Outlook* etc

In this research 20 years and 330 operating days has been taken as the life of gas reserve of a country to convert it into MMSCMD. The cumulative rate of consumption of a country is assumed to grow at 3 percent and its cumulative rate of production at 5 percent. It is also assumed that the rate of gas production can be raised to only 80% of the reserve. The difference between production and consumption is the net Export/Import of the country. Surplus/Deficit of gas of a country has been derived from the difference between the available reserve and consumption of that particular country.

3. Experience of Other Cross Border Pipelines & Gas Grids

The study is Descriptive in nature. Cross-border pipelines like the Iran-Pakistan-India Pipeline, Turkmenistan-Afghanistan-Pakistan-India Pipeline, Baku-Tiflis-Ceyhan Pipeline and Bolivia-Brazil gas Pipeline were studied to understand past experiences and probable issues and obstacles that undermine such projects.

Data is secondary in nature. Sources include; research articles, magazines, books, websites etc (see Bibliography).

4. Geo- Political Scenario of Asia

The study is descriptive in nature. Geographical location and climate of Asian countries were studied. Other key parameters of the study were internal and external political scenario and impact of major powers influencing the country's decision.

Data is secondary in nature. Sources: Government publications, magazines, books, websites and annual reports of international agencies etc. Important references include Ariel Cohen's *Proposed Iran-Pakistan-India Pipeline*, Croissant, Michael P & Bulent's *Oil and Geopolitics in Caspian Sea Region*, David G Victor's *Natural Gas & Geopolitics*, David Temple's *Intersection of Energy Politics*, Dr. Kirit S Parikh's *India's Energy Needs: Strategic Imperatives* etc.

5. Techno-Commercial Feasibility

The study is Diagnostic in nature. Study was carried out for route selection, system design and CAPEX and OPEX estimation of identified alternatives of various pipeline limbs covering the proposed AGG. The investment analysis of AGG limbs was based on IRR method (Internal Rate of Return). Assuming post tax equity IRR as 12 percent, the unit transportation charge of gas in USD/MMBTU was worked out for 3 identified alternatives of a limb. The alternative which gives least transportation cost was recommended. With this alternative as base case, sensitivity analysis was carried out on changing various parameters like project cost, debt-equity, interest rate, sales volume etc.

Data is both primary and secondary in nature. Sources include opinion of experts, data from execution experience of past pipelines in India, international standards for pipeline like API, ASTM etc.

6. Financing the Project

The study is Diagnostic in nature. Study was carried out to determine project financing methodology. This included Project Financing structure, formation of Special Purpose Vehicle (SPV), source of funds and risks involved.

Data is both primary and secondary in nature. Data is collected from sources like international agencies, government annual reports etc. Important sources of information are Prasanna Chandra's *Financial Management*, www.worldbank.org, www.wikipedia.com, www.adb.org etc

7. Project Management Aspects

The study is Diagnostic in nature. Based on past experience gathered from pipeline project execution experience in India, we have proposed the Project Management methodology for the proposed Asian Gas Grid. Our study includes: AGG Project Structure, Country-wise Organization for Limbs, Energy Charter, Project Schedule and Monitoring, AGG Stakeholders, Contract Management, Construction Management, Risk Management etc.

Data is both primary and secondary in nature. The data is collected from sources like opinion of experts, data from execution experience of past pipeline projects in India, Books on global project management etc.

1.5 STATISTICAL TOOLS

The study has used various statistical tools for presenting and analyzing the data. Internationally accepted mathematical formulae from various technical standards related to gas pipelines have been extensively used. These tools and formulae are elaborated in respective chapters.

Data in the form of tables, pie charts, bar charts, line charts etc are provided wherever necessary in the chapters on Demand/Supply analysis, Techno-Commercial analysis of AGG.

The following conversions used in gas industry were useful for this study:

- 1 BCM (billion cubic meters) = 2.8 MMSCMD (million standard cubic meters/day)
- 1 TCF (trillion cubic feet) = 4 MMSCMD
- 1 MTPA (million tons/ annum)= 4 MMSCMD

- 1 million BTU = 25.2 SCM (standard cubic meter)
- 1 TOE (ton oil equivalent) = 1120 cubic meter of gas

Following key formulas were used in the techno-commercial analysis of the AGG.

a) Calculation of Compressor Power (P):

$$P = \frac{m * H_p}{3600 * \eta_p} + \text{Mechanical Losses}$$

m = Mass flow rate (kg/hr)

η_p = Polytrophic efficiency

H_p = Head (J/Kg)

b) Pipeline wall thickness calculation was performed as below according to standard ASME B 31.8

$$P = (2 S t) \times F * E * T / D$$

where,

- D = Outside diameter of pipe (inches)
- E = Longitudinal joint factor (=1 for API 5L SAW Pipe)
- F = Design factor
- P = Design pressure (psi)
- S = Specified minimum yield strength (psi)
- T = Temperature derating factor
- t = Nominal wall thickness (inches)

c) Panhandle A equation for Pressure drop in the pipeline:

$$Q_{sc} = 1.198 * 10^7 * (T_b / P_b)^{1.0788} * [(P_1^2 - P_2^2) * d^{4.854}] / (\gamma^{0.8541} * L * T_m * Z_m)^{0.5394} * (E)$$

Where,

- Q_{sc} = Gas flow rate (MMSCMD)
- T_b = Base temperature ($^{\circ}$ K)
- P_b = Base pressure (Kpa)
- P_1 = Inlet pressure (Kpa)
- P_2 = Outlet pressure (Kpa)
- d = Inside diameter of pipe (m)

γ	= Gas specific gravity
L	= Pipe length (m)
T_m	= Mean absolute temperature of line ($^{\circ}\text{K}$)
Z_m	= Mean compressibility factor
E	= Pipeline efficiency

- d) The reputed project evaluation method of IRR (Internal Rate of Return) is used in the commercial feasibility study of AGG. IRR is the discount rate that generates zero net present value for a series of future cash flows.

1.6 SCHEME OF CHAPTERS

This research study has been presented in the form of chapters as per the following scheme:

The chapter on “**International Scenario of Natural Gas**” deals with the present as well as projected future scenario of energy/ natural gas all over the world. It deals with the trends of gas reserves, gas production and distribution, gas consumption, gas trade across the continents.

The chapter on “**Energy Scenario in Asia & Demand/ Supply Analysis**” deals with the present as well as projected future scenario of energy/ natural gas in the Asian Continent. The chapter deals with country-wise analysis of energy policy, gas reserves and production, sectoral analysis of energy mix, and estimated projection of gas surplus/ deficit on a perspective, up to the year 2025. A part of the surplus gas is proposed to be utilized for transportation through AGG for gas deficit countries.

The chapter on “**Present Experience in Gas pipelines and Gas Grid**” studies various aspects of transportation of natural gas through pipeline (offshore & onshore), LNG, current happenings in the gas rich north-western gas market like Iran, Turkmen, Qatar, and Dolphin gas is discussed. The experiences of cross-border pipelines which have been completed, or are under implementation like Iran-Pakistan-India P/L, Turkmenistan-Afghanistan-Pakistan-India P/L, Baku-Tiflis-Ceyhan P/L and Bolivia-Brazil P/L are studied.

The chapter on “**Issues & Obstacles Involved in AGG**” discusses various anticipated issues and obstacles like transit through third countries, negotiation complexity, regulatory framework, environment norms, harmonizing taxation, investment protection among other issues that could occur during various phases of the project.

The chapter on “**Geo-Political Analysis of Asian Countries**” analyses the features of AGG countries on various aspects such as geographical location &

climate, internal & external political scenario, relationship with neighboring countries and influence of major powers like US/ Russia.

The chapter on “**Techno-Commercial Analysis of AGG**” deals with establishing technical parameters of various AGG pipeline limbs like diameter of pipeline, number of compressors etc based on amount of gas flow from source of production to demand centers. In commercial analysis, the capital and operating expenditure of the pipeline are estimated and accordingly the transportation charge of gas through a particular limb is calculated assuming an IRR of 12 percent. Write-up on the software model for techno-commercial analysis is also presented.

The chapter on “**Project Financing of AGG**” discusses the importance of financing AGG project of such a huge magnitude. The various options available for sourcing the fund from debt and equity markets are presented along with the role of World Bank, ADB and other institutions. Financing challenges and associated risk mitigation to the lenders are discussed. The financing structure (debt & equity) for various AGG limbs are presented.

The chapter on “**Project Management of AGG**” discusses issues which are to be given attention while managing the AGG project. Some measures have been suggested based on experiences while executing cross-country gas pipeline projects. The issues discussed in the chapter are related to organization structure, planning, execution methodology, project monitoring, contract management, construction management, stakeholder management, quality assurance, risk management, project closure, success factors etc.

The chapter on “**Environmental Impact of Natural Gas**” discusses the benefits of using a clean fuel like natural gas, in comparison to other fossil fuels like oil, coal etc, and how AGG could meet the environmental norms of various participating countries.

Final chapters on “**Analysis and Findings**” and “**Conclusions and Recommendations**” highlight the results, recommendations and scope for further study.