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Economic Impact of Gas Transmission Bottlenecks in Long-Distance Natural Gas Pipelines on Pipeline Network Operation

Chenhui Yin

PipeChina Sichuan-East Gas Pipeline Co., Ltd., Wuhan, Hubei 430000

Abstract: ***Amid the ongoing transformation of the global energy structure and heightened environmental protection awareness, natural gas, as a clean and efficient energy source, has continued to increase its share in global energy consumption. Long-distance natural gas pipelines, as critical infrastructure connecting natural gas production areas and consumption regions, play a crucial role in ensuring energy supply and promoting regional economic development. On this basis, this study examines the economic impact of gas transmission bottlenecks in long-distance natural gas pipelines on pipeline network operation, with the aim of providing a useful reference for relevant research and decision-making.***

Keywords: Long-Distance Natural Gas Pipelines, Gas Transmission Bottlenecks, Pipeline Network Operation, Economic Impact, Energy Supply, Regional Economic Development, Global Energy Structure Transformation, Environmental Protection Awareness.

1. INTRODUCTION

With the global energy structure transformation and the improvement of environmental protection awareness, natural gas, as a clean and efficient energy source, has increasingly prominent status in energy supply. Long-distance natural gas pipelines, as an important link connecting gas sources and consumer markets, their operational efficiency is directly related to the stability and economy of energy supply. In actual operation, gas transmission bottlenecks often occur, which not only affect the efficiency of natural gas transmission but may also have a profound impact on the economic benefits of pipeline network operation.

2. OVERVIEW OF GAS TRANSMISSION BOTTLENECKS IN LONG-DISTANCE NATURAL GAS PIPELINES

The gas transmission bottleneck of long-distance natural gas pipelines refers to a phenomenon where the pipeline transmission capacity cannot meet the demand due to certain limiting factors during natural gas transmission, resulting in low transmission efficiency. Insufficient pipeline design capacity, or pipeline aging and corrosion leading to a decrease in actual transmission capacity. Compressor station failures, delayed maintenance, or technical limitations result in insufficient pressure to drive natural gas flow. Improper scheduling, poor information flow, or delayed emergency response lead to ineffective utilization of existing pipeline resources. Market demand fluctuations, inflexible price mechanisms, or contract constraints cause mismatches between pipeline transmission plans and actual demand. Regulatory restrictions, environmental protection requirements, or government intervention affect pipeline construction and operation. The emergence of gas transmission bottlenecks can lead to unstable natural gas supply, increased operating costs, reduced economic efficiency, and may even affect the normal production and life of downstream users. Identifying and resolving gas transmission bottleneck issues is of great significance for ensuring energy security and improving pipeline network operation efficiency.

3. ECONOMIC IMPACT OF GAS TRANSMISSION BOTTLENECKS IN LONG-DISTANCE NATURAL GAS PIPELINES ON PIPELINE NETWORK OPERATION

3.1 Decrease in Gas Transmission Efficiency

A decrease in gas transmission efficiency means that the pipeline cannot transport sufficient natural gas as scheduled, which leads to unstable supply and affects the normal production and operation of downstream users.

Due to unstable supply, users may experience natural gas shortages or supply interruptions, which reduces user satisfaction with suppliers and may lead to user loss. Frequent supply interruptions or shortages affect the supplier's market reputation and may cause potential customers to switch to other more reliable suppliers. If the decrease in gas transmission efficiency results in failure to fulfill supply contracts with customers, suppliers may face the risk of breach of contract and need to pay liquidated damages or compensate for losses. In situations of tight supply, natural gas market prices may fluctuate, especially during peak demand periods, prices may rise sharply, affecting market stability. To cope with the decrease in gas transmission efficiency, temporary measures may be required, such as adding compressor stations, expanding pipeline capacity, or upgrading and transforming, all of which increase operating costs. A decrease in gas transmission efficiency may increase the risk of natural gas leakage, which not only causes resource waste but may also pollute the environment. A decrease in gas transmission efficiency may be related to issues such as pipeline aging and equipment failure; if these issues are not resolved in a timely manner, the risk of safety accidents may increase.

3.2 Increase in Operating Costs

Increased operating costs directly erode a company's profit margins; especially when revenue does not grow correspondingly, the company's net profit will decline significantly. If the increase in operating costs causes the return on investment to fall below expectations or the industry average, it may affect investors' confidence, thereby impacting the company's financing capacity and stock price performance. In a highly competitive market environment, increased operating costs may cause companies to lose their competitive advantage in price, service, or product quality, affecting market share. Increased operating costs may lead to cash flow constraints, especially when the cost increase cannot be offset in the short term by raising prices or increasing sales volume. To cope with the increase in operating costs, companies may need to increase borrowing or extend debt maturities, which will increase financial expenses and debt burdens.

3.3 Revenue Loss

Revenue is the main source of a company's cash flow; revenue loss will lead to a reduction in cash flow, affecting the company's daily operations and payment capabilities. Revenue loss directly results in reduced profits, and especially when fixed costs cannot be adjusted immediately, the company's net profit will be severely affected. Revenue loss may affect a company's ability to repay debts and increase the risk of default, especially when the debt burden is heavy. Revenue loss will affect a company's return on investment, which may lead to a decline in investors' confidence in the company, affecting the company's financing capacity and stock price performance. In the case of revenue loss, companies may be unable to maintain or improve the quality of their products or services, thereby losing competitiveness in the market. If revenue loss prevents a company from competing effectively, it may lose existing customers or fail to attract new ones, leading to a decline in market share. Revenue loss may lead to layoffs or cuts in employee benefits, affecting employees' work motivation and loyalty to the company. Revenue loss may force companies to reduce investment in research and development and innovation, affecting their long-term competitiveness and market adaptability. Sustained revenue loss may make it impossible for companies to maintain their brand image, affecting consumers' perception and trust in the brand.

4. STRATEGIES FOR IMPROVING THE ECONOMIC IMPACT OF NATURAL GAS LONG-DISTANCE PIPELINE TRANSPORTATION BOTTLENECKS ON PIPELINE NETWORK OPERATIONS

4.1 Optimizing Pipeline Design and Planning

Before designing a pipeline, conduct in-depth market research to understand current and future natural gas demand. Use historical data and trend analysis to forecast demand, ensuring the pipeline design can meet market needs for a future period. Evaluate different pipeline technologies and materials to select the most suitable technical solution. Considerations include the pipeline's pressure resistance, corrosion resistance, thermal expansion coefficient, construction difficulty, and cost. Design should account for possible future technological advancements and changes in market demand, reserving a certain expansion capacity. A slightly larger pipeline diameter can be chosen during design to enable future increases in gas transmission capacity by enhancing compressor power or adding more pipelines.

4.2 Implement Pipeline Expansion and Upgrades

Conduct a comprehensive assessment of the gas transmission capacity, equipment condition, and operational efficiency of existing pipelines to identify bottlenecks and areas requiring improvement. Based on the assessment results and market demand, develop a detailed expansion plan. The plan should include expansion goals, required technologies and equipment, expected costs and benefits, and a construction schedule. Select appropriate expansion technologies based on the specific conditions of the pipeline. Possible technologies include increasing pipeline diameter, enhancing compressor power, adding more compression stations, and using high-efficiency pipeline materials. Conduct detailed design of the expansion project and obtain relevant government approvals and permits. The design should consider the impact of construction on existing pipeline operations, as well as environmental and social impacts. During construction, ensure project quality and safety, and minimize interference with existing pipeline operations. Adopt advanced construction technologies and management methods to improve construction efficiency.

4.3 Establish a Flexible Scheduling Mechanism

Deploy advanced monitoring technologies, such as SCADA (Supervisory Control and Data Acquisition systems), to collect real-time pipeline operation data, including key parameters like pressure, flow rate, and temperature, as well as equipment status information. Utilize big data analytics and machine learning technologies to analyze the collected data and predict the pipeline's gas transmission capacity and potential bottlenecks. Predict future natural gas demand based on historical data and market trends. Develop a dynamic scheduling model to automatically adjust the pipeline's gas transmission plan based on real-time data and prediction results. The model should consider multiple factors, such as market demand, pipeline status, equipment availability, and weather conditions. Formulate detailed emergency response plans to address unexpected events, such as equipment failures and natural disasters. The plans should include measures like quickly adjusting gas transmission routes, activating backup equipment, and communicating with users.

4.4 Policy and Planning Support

The government can play an important role in policy and planning support regarding the improvement of gas transmission bottlenecks in long-distance natural gas pipelines and the economic impact of pipeline network operations. In terms of policy support, sufficient financial subsidies should be given to long-distance natural gas pipeline projects, especially for upgrading and renovation projects and the application of new technologies. For projects aimed at enhancing pipeline gas transmission capacity, adopting innovative technologies such as new internal coating technology to reduce frictional resistance, or updating high-efficiency compressor equipment, the government providing a certain proportion of financial subsidies will help reduce the financial pressure on enterprises, encourage them to actively invest in improving gas transmission bottlenecks, and thereby improve the economics of pipeline network operations. Formulating preferential tax policies is also crucial; reductions or preferential treatments should be granted to long-distance natural gas pipeline operating enterprises in terms of value-added tax, income tax, etc. For example, during the investment and construction period of pipeline expansion projects, relevant taxes can be appropriately reduced to lower the operating costs of enterprises. At the planning level, the government should scientifically plan the layout of long-distance natural gas pipelines from a macro perspective, comprehensively considering factors such as gas source locations, consumer markets, and geographical environments to ensure a reasonable pipeline layout and reduce gas transmission bottlenecks caused by unreasonable planning. In the process of regional development planning, it is of great significance to actively coordinate the relationship between natural gas pipeline construction and other infrastructure construction. It is necessary to comprehensively plan the layout and schedule of transportation, electricity, and other infrastructure and natural gas pipeline construction to create favorable conditions for pipeline construction, ensure its smooth progress, further improve the operational efficiency and economic benefits of the pipeline network, and promote the healthy development of the natural gas industry.

5. CONCLUSION

The existence of gas transmission bottlenecks in long-distance natural gas pipelines not only restricts the effective transmission of natural gas but may also trigger a series of economic problems, such as increased operating costs, reduced market competitiveness, and affected investment returns. To address the issue of gas transmission bottlenecks, comprehensive management from multiple aspects such as technology, management, and policy is required to improve the overall operational efficiency and economic benefits of the pipeline network.

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