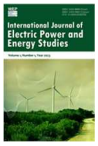
WEP Warwick Evans Publishing

International Journal of Electric Power and Energy Studies

ISSN: 3006-2004 (Print), ISSN: 3006-0826 (Online) | Volume 3, Number 2, Year 2024
DOI: https://doi.org/10.62051/ijepes.v3n2.01
Journal homepage: https://wepub.org/index.php/IJEPES/index



Brief Analysis of Approaches to Peak Regulation for Natural Gas Storage

Ben Shang, Yunfeng Chen, and Dong Zhang

Shaanxi Gas Group New Energy Development Co., Ltd, Shaanxi 710000, China

ABSTRACT

With the increasing proportion of natural gas in energy supply, considering the changes in urban natural gas consumption time and peak pipeline pressure, how to balance gas supply and consumption will become the key to ensuring winter supply. This article aims to study and solve the problem of natural gas storage peak shaving, analyze the current situation and the advantages and disadvantages of different situations, and propose specific solutions. By studying underground gas storage facilities, liquefied natural gas (LNG) storage, compressed natural gas (CNG) storage, distributed gas storage systems, intelligent scheduling, and policy market mechanisms, new ideas are provided for building a low-carbon, efficient, and flexible gas storage peak shaving system.

KEYWORDS

Natural Gas; Gas Storage Peak Shaving; Virtual Power Plant.

1. INTRODUCTION

Natural gas, as a clean and efficient energy source, has been widely used worldwide. However, due to the mismatched industry attributes of natural gas production and consumption in terms of time and space, the contradiction between supply and demand sides has become increasingly prominent. Therefore, establishing a reliable gas storage peak shaving system is of great significance for balancing supply and demand and ensuring energy security. This article draws on the business model of virtual power plants to study the establishment of a natural gas virtual storage peak shaving management system through upstream and downstream collaboration, in order to solve the problem of seasonal and regional gas supply and demand imbalance.

2. ANALYSIS OF THE CURRENT SITUATION OF GAS STORAGE PEAK SHAVING

2.1. Utilizing Underground Gas Storage for Peak Shaving

Underground gas storage is currently the most mature natural gas storage method, mainly including depleted oil and gas fields, aquifers, and salt caverns. They can store excess natural gas during periods of low demand and release it during peak periods to meet demand. Advantages: Large capacity, high security, relatively low cost. Disadvantages: Long construction period and certain requirements for geological conditions.

2.2. Peak Shaving Using Liquefied Natural Gas (LNG)

LNG is stored by cooling natural gas to about -162℃ and liquefying it, with a volume of only 1/600 of its gaseous state, making it easy to transport and store. Advantages: Strong flexibility, can serve as an effective supplement to underground gas storage. Disadvantages: The process of liquefaction and re-gasification consumes high energy and requires special storage and transportation facilities.

2.3. Peak Shaving Using Compressed Natural Gas (CNG)

CNG compresses natural gas to a high-pressure state for storage, suitable for small and medium-sized storage needs. Advantages: Relatively low investment cost, suitable for peak shaving of urban gas supply systems. Disadvantages: Small storage capacity per unit volume and large footprint.

2.4. Utilizing Distributed Gas Storage Systems for Peak Shaving

Deploying multiple small-scale gas storage facilities within urban or industrial parks to form a distributed gas storage network. Advantages: good flexibility, fast response, able to meet peak demand in local areas. Disadvantages: limited overall gas storage capacity, complex management and maintenance.

2.5. Intelligent Scheduling and Monitoring

Utilizing big data, cloud computing, and artificial intelligence technologies to achieve real-time monitoring and intelligent scheduling of the natural gas supply chain. Advantages: Improve resource utilization efficiency, reduce waste, and lower operating costs. Disadvantages: Rapid technological updates require continuous investment in research and development.

3. IDEAS FOR PEAK SHAVING OF GAS STORAGE

Drawing on virtual power plants and the overall requirements of the National Energy Administration for gradually opening up the socialization of natural gas pipelines and "managing the middle and opening up both ends", relying on the diversified resources of natural gas upstream, convenient provincial transmission pipelines and downstream city and county pipelines, stable downstream industrial user loads, and open socialized gas storage facilities, a virtual gas storage peak shaving resource integration system is established. Through energy management, promote the interconnection and intercommunication of natural gas resources (including LNG, CNG), pipeline networks, gas storage facilities, and users, unify and integrate intelligent scheduling and management services, and achieve value management of resources, users, and enterprise energy. Simply put, it is to build a network of "resources+pipeline network+users", creating an integrated natural gas source network load and storage, creating value for users, and creating benefits for society.

4. APPLICATION SCENARIOS AND BUSINESS MODELS

4.1. Application Scenario Assumption

4.1.1. Load Side Application Scenarios

a. Adjusting seasonal fluctuations: During the winter heating period, natural gas demand surges, while in summer demand is relatively flat. The upstream gas supply also follows this uneven pattern, which puts enormous pressure on customers' own supply stability.

b. Stabilizing demand fluctuations: With the impact of economic activity, weather changes, temporary maintenance, and policy adjustments, accurately predicting natural gas demand by natural gas users

has become increasingly complex, which may lead to supply shortages or surpluses, triggering clauses for natural gas deviation settlement.

c. Balancing user structure: From residential gas consumption to industrial gas consumption, there are significant differences in demand among different user groups, and their sensitivity to prices varies. Balancing various aspects of gas demand is a major challenge.

4.1.2. Resource Side Application Scenarios

a. Balancing regional resources: Natural gas resources are unevenly distributed globally, and regions that rely on imported resources may face risks such as international geopolitical security and price fluctuations.

b. Adjusting production capacity: Natural gas supply and production are limited by geological conditions, long facility investment cycles, equipment maintenance and updates, policy guarantees, gas field safety, and other factors, making it difficult to quickly respond to changes in market demand.

c. Accelerating energy transition: With the global push for energy transition, natural gas plays a role as a transitional energy source, requiring its production and transportation processes to be more green and low-carbon. Technological transformation and cost control have become difficult points.

4.1.3. Application Scenarios on the Pipeline Side

In terms of gas supply and demand, the pipeline network focuses on balancing supply and demand, peak shaving and valley filling, and ensuring the safety of pipeline capacity. Combining the flexibility of virtual gas storage peak shaving scheduling, peak shaving and valley filling can be carried out during peak and valley periods. Due to the strong planning of the pipeline network, the peak shaving capacity is limited, especially during peak hours. The natural gas virtual gas storage peak shaving management system can integrate various storage scheduling facilities to ensure supply-demand balance on a larger scale.

4.2. Business Model Analysis

4.2.1. Resource Load Side Combination Mode

a. Diversifying resources to reduce costs. Establishing long-term contractual relationships between upstream resource providers and downstream users, forming a stable supply chain, and optimizing download paths by combining diversified upstream resources to deliver gas supply projects nearby. This allows for unified procurement, consumption, resource exchange, and pipeline network transportation of project resources with upstream and downstream enterprises in the region, minimizing pipeline transportation costs and achieving a healthy flow of the supply chain, ultimately achieving the goal of gas storage and peak shaving.

b. Peak shaving for large industrial users. Collaborating with multiple parties to promote the integration of source, network, load, and storage, especially for large industrial users with periodic production plans, is beneficial for adjusting the gas source for production regulation behaviors such as project shutdown and load reduction. With the advantage of controlling gas volume regulation, it can be supplied to users according to market-oriented resource regulation, achieving the goal of gas storage peak shaving.

c. Large industrial user purchasing agent. During the peak winter gas consumption period in northern China, the daily gas consumption reaches about 3-7 times that of the off-season, resulting in serious "gas shortage" and other phenomena. After determining the demand of users, it is possible to lock in the quantity and price with upstream and downstream in advance, purchase from the resource library in advance, and sell to end users in winter, which can provide users with dual protection. If a user locks in a certain proportion of winter resources in advance, they can achieve safe and stable gas

consumption in winter, avoiding significant price fluctuations in market-oriented resources during winter.

4.2.2. Load Side Combination Mode of Pipeline Network

The national, provincial, and county-level regions are gradually promoting the interconnection and intercommunication of the "one network" pipeline network. If some pipeline companies have storage and resource allocation capabilities, the measurement can adopt the financial cross time period "accounting" method. Natural gas can be purchased during the gas valley period and extracted during the gas peak period to realize the time value of resources, but a certain storage fee must be charged. Explore the utilization of underground gas storage facilities and LNG receiving stations' storage capacity on both the pipeline network and load sides, and achieve 'virtual storage' through signing gas supply contracts.

4.2.3. Combination Mode of Gas Storage Load Side

Introduce underground gas storage facilities or above ground reserve facilities connected to the pipeline network for gas supply. The gas storage facilities have the ability to store gas for peak shaving. In principle, the gas is supplied from April to October each year and sold to the public at market prices from November to March. For example, a certain gas storage facility can achieve a single month of gas injection or extraction during the off-season, which has a large storage capacity. During the peak winter season, the gas is released, and combined with market-oriented resources, gas storage peak shaving can be achieved.

4.2.4. Source Network Load Storage Combination Mode

Natural gas resources (including LNG and CNG), pipeline networks, gas storage facilities, and user inter-connectivity to achieve value management of resources, users, and enterprise energy. Promote the interconnection and intercommunication of natural gas pipelines, ensure flexible allocation between different gas sources, long-distance pipelines, and urban pipelines, and introduce intelligent control platform software systems. Through strategic alliances and other means, integrate key links in the upstream and downstream of the natural gas industry chain, and improve the overall operational efficiency of the natural gas industry chain.

5. SIGNIFICANCE

5.1. Reduce User and Upstream/Downstream Procurement Costs

From the perspective of industrial chain economy, in order to cope with seasonal cyclical changes and regional resource imbalances, upstream resource providers have introduced punitive economic clauses in contracts and formulated equivalent constraint rules for resource deviation settlement. The national pipeline network has also added punitive equivalent clauses for downstream demand deviation. Virtual natural gas storage peak shaving can reduce deviations, which not only protects the rights and interests of resource suppliers, pipeline transportation providers, users, and gas storage providers, but also practices the entrepreneurial spirit and commercial reputation. It is also combined with the reasonable allocation of resources in the natural gas upstream and downstream industry chain by the market, thus achieving the goal of cost reduction and efficiency improvement.

5.2. Promote Market-oriented Reform of Natural Gas Prices

From the perspective of deepening institutional reform, virtual gas storage peak shaving has broken the traditional integrated operation mode of upstream, midstream, and downstream. It solves the problem of supply and demand imbalance such as unstable resource supply, unstable demand, and difficulty in reserving pipeline capacity through coordinated scheduling, and promotes more market entities on the resource side, pipeline side, load side, and gas storage side to actively participate in

the oil and gas public trading platform, achieve market-oriented open bidding, create an open, fair, and just natural gas trading price system, and promote market-oriented gas price reform.

6. GUARANTEE MEASURES

6.1. Accelerating the Research and Application of Business Models

Accelerating the research and application of business models is an important guarantee for virtual gas storage peak shaving projects. Research and application should be carried out in combination with actual regions, focusing on the four major elements of source network load storage and market entities for deduction and practice, connecting "resources", establishing "one network", regulating "load", and simulating "storage". Integrate upstream and downstream resources, long-distance pipeline companies, urban gas companies, industrial users, and gas traders to form a complete channel purchase and sales network for upstream, midstream, and downstream.

6.2. Building an Information Platform for the Gas Industry

Utilizing modern network information technology to coordinate resources, schedule resources, and balance resources, building a digital platform for the upstream and downstream of the gas industry, vigorously developing end users in channel applications, diversifying resource procurement, researching upstream and downstream industrial policies, establishing a gas storage peak shaving management system, cooperating with large enterprises, replicating experience, technology, and platforms, while focusing on local business incubation and cultivation, and establishing a comprehensive management system.

6.3. Upstream and Downstream Collaborative Promotion of Policy Support

Virtual gas storage peak shaving cannot be achieved without the support of government industrial policies. It requires upstream and downstream cooperation and mutual support to jointly promote the healthy development of the natural gas industry's production, supply, storage, and sales system, and achieve effective allocation of resources. The government can encourage enterprises to participate in the construction and operation of gas storage and peak shaving facilities by formulating preferential policies and establishing market trading mechanisms. Accelerate the coordinated optimization and allocation of upstream and downstream industrial chain elements, promote the interconnection of pipeline networks and resources, increase multi-faceted cooperation in the integrated industrial chain of source, network, load, and storage, learn from mature models at home and abroad, promote energy conservation and consumption reduction, ensure national energy security, and serve national economic construction.

7. CONCLUSION

In summary, the virtual gas storage peak shaving business is still in the exploratory stage. Although there are unfavorable conditions such as low user enthusiasm, unstable downstream users, poor channel consumption, large upstream price fluctuations, imbalanced market supply and demand, and insufficient institutional mechanism innovation, an efficient and flexible natural gas storage peak shaving system can be built overall. If market analysis, policy guidance, institutional improvement, and optimization of resource allocation can be strengthened, gas storage peak shaving will definitely enter a new stage.

REFERENCES

[1] Shen Xin, Chen Jindian, Wei Chuanbo, Hao Yingpeng. Development Experience and Enlightenment of Natural Gas Peak-shaving Reserve System in Europe and America [J]. International Petroleum Economics, 2017(03).

[2] Zhou Mingliang. On the Necessity and Urgency of Establishing Strategic Natural Gas Reserves [J]. Enterprise Reform and Management, 2020(10).

[3] Liu Jianxun; Liu Yan. Development Status and Prospects of China's Underground Gas Storage Construction [J]. Applied Chemical Industry, 2022(04).

[4] Wang Yongliang, Cao Mansheng, Gao Yajie. China's Natural Gas Peak-shaving Measures and Suggestions under the Background of "Dual Carbon" [J]. International Petroleum Economics, 2022(05).

[5] Wang Liang, Jiao Zhongliang, Gao Peng, Zhao Yongliang. Discussion on the Integration of "Pipeline Capacity Trading + Dispatch Operation" Model for China's Natural Gas Pipeline Network --Part One of Research on China's Natural Gas Pipeline Network Operation Mechanism [J]. International Petroleum Economics, 2019(08).