THE STATUS AND PROSPECTS OF UNDERGROUND GAS STORAGE IN NIIGATA

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SUMMARY

JAPEX has been utilizing three depleted gas fields, in Niigata Prefecture for underground gas storage (UGS) since 1980 in order to execute a long-term well test and deal with seasonal fluctuations of gas demand, in other words, peak-shaving. Though the size of the reservoirs that UGS has been applied is relatively small, valuable experience and lesson have been obtained through the operation of UGS. JAPEX realizes that utilization of gas storage has been becoming the essential requisite tools for coping with seasonal gas demand fluctuation. Background of UGS and knowledge learned from the operation are presented in this report. As reservoir characteristics have been understood through well data at the time of development and production, the operation of UGS gave good consistency with an estimation that had been obtained by a theoretical calculation.

There are several gas reservoirs in Niigata, which we have been producing, whose total ultimate gas storage capacity would be more than 20 billion cubic meters. These reservoirs will be able to play an important role of keeping gas supply and demand in balance during operation of gas transportation. Storage also will allow load balancing of daily throughput levels on pipelines and emergency backup in the event of a production failure or the non-delivery of gas. Though order of priority will be given to establishment of the transportation infrastructure, installation and expansion of the gas pipeline network system will create a chance to utilize UGS as an economical solution and huge benefits in greater reliability of supply and gas delivery cost reduction in the gas markets.

L' ÉTAT ET ESPÉRANCES POUR LA PROVISION SOUTERRAINE DU GAZ DANS LE DÉPARTEMENT DE NIIGATA

RESUME

JAPEX utilizait depuis 1980 trois réservoirs du gaz épuisés dans le département de Niigata pour la provision souterraine du gaz (PSG). C'est pour exécuter un examen de puits à long terme et prendre mesures pour les fluctuations saisonnières de la demande de gaz. La dimention des réservoirs qui étaient appliqués à la PSG est relativement petite, mais des expériences précieuses étaient acquises par l'opération de PSG. L'utilisation de la provision de gaz devenait un outil nécessaire contre les fluctuations saisonnières de la demande de gaz. Le "background" et la connaissance acquis par l'opération de PSG sont présentés dans ce rapport. Comme les charactéristiques des réservoirs étaient obtenues par les données de puits au moment du dévelopment et la production, l'opération de PSG présente une cohérence avec l'estimation qui a été obtenue par le calcul en théorie.

Dans le département de Niigata, il y a plusieurs réservoirs de gaz que nous exploitions, où la capacité totale de la provision de gaz serait plus que 20 milliards mètres cube. Ces réservoirs pourront jouer un rôle important de maintenir l'équilibre entre l'approvisionnement et la demende pendant le transport du gaz. La provision permettra aussi l'égalisation de la quantité quotidienne du gaz dans les tuyaux et le "back-up" en cas d'accident comme l'arrêt de production ou du transport de gaz. L'établissement de l'infrastructure du transport aura la priorité, mais l'installation et l'expansion des réseaux des tuyaux de gaz vont créer une chance pour utilizer la PSG comme une solution économique et des bénéfices immences vers une plus grande confiance en l'approvisionnement et pour la réduction des frais de transport du gaz.

1. INTRODUCTION

UGS plays vital role in JAPEX gas pipeline operation in Niigata Prefecture in Japan. JAPEX has been utilizing three depleted gas fields, namely Katagai field, Kumoide field and Shiunji field in Niigata Prefecture for UGS since 1980' in order to execute a long-term well test and deal with seasonal fluctuations of gas demand, in other words, peak-shaving. Among the three, only Shiunji gas field is actively in service as UGS. Though the size of the reservoirs that UGS has been applied is relatively small, valuable experience and lesson has been obtained through the operation of UGS. Utilization of gas storage has been becoming the essential requisite tools for coping with seasonal gas demand fluctuation.

The ability to store gas ensures supply reliability during periods of heavy demand by supplementing pipeline capacity. Storage also allows load balancing of daily throughput levels on pipelines, which is necessary to ensure smooth operation of the pipeline system. Moreover, it enables greater system efficiency instead of satisfying winter demand by adding new production facilities, the industry can place gas in storage during the summer and maintain production at much more constant level throughout the year.

Underground storage of gas is unique in comparison with other commodities in terms of its integration with distribution system to maintain overall system integrity. Storage reservoirs are used as a convenient place to store gas when more gas is moving alone pipeline system than currently needed, and a convenient place to obtain gas when gas flow on the pipeline system is insufficient to maintain the pressure needed to sustain the system's deliverability.

2. UGS EXPERIENCE IN NIIGATA

2.1 Background of UGS

Niigata Prefecture is located Japan Sea side and 330km away from Tokyo. Shiunji gas field is located northern area of Niigata. Two wells, Well No.-7 and 8, were converted to UGS in 1988 after 25 years of gas production. Because of limited local market gas demand and cost saving, existing wells and facilities have been fully utilized for UGS operation except a compressor for gas injection. Shiunji gas reservoirs are composed of relatively high permeabe sand stone and contain liquid-free methane rich gas. At that time, LNG, from Arun gas field in Indonesia, has been started flowing into our grid, the local gas fields were obliged to play additional role as swing producer for big consumers including power generation plants. The location of Shiunji is closed to the market, the application of UGS was selected for gas transportation management in stead of reinforcement of pipeline capacity.

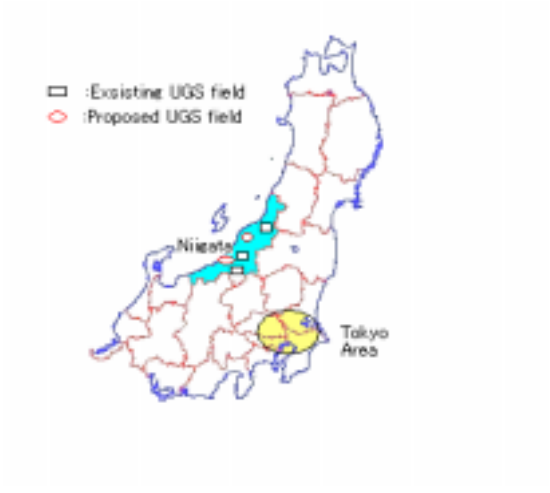

Fig 1 UGS Fields in Niigata

2.2 Operation and Inventory management

Specifications and particular data of the Shiunji wells are as follows;

Well No.	Well No.-7	Well No.-8
Reservoir Well Depth	Shiunji-I , Sand-stone 1,097m-1,261m	Shiunji-II, Sand-stone 894m-915m
Well Completion	2-3/8" TBG- 2string+2packer Perforation	2-3/8" TBG- 1string+1packer Anchor completion
OGIP	314 MMm3	381 MMm3
Cumulative Gas Production up to 1988	182 MMm3	237 MMm3
Start of Gas Storage	Jan 1989	Jan 1989
Storage Capacity	146 MMm3	157 MMm3
Injection Rate	150,000 m3/D (Rated Capacity of Compressor)	
Withdrawal Rate	350,000 m3/D (Rated capacity of Dehydrator)	

Table 1: Data of Shuinji Wells

Conceptual flow of the Shuiunji UGS is shown in Fig2. Shiunji field is connected to industrial gas users and city gas through Nakajyou -Matsuhama gas pipeline. The UGS was planed because the aged Shiunji and neighbor fields did not have enough swing capability to cope with peak-demand.

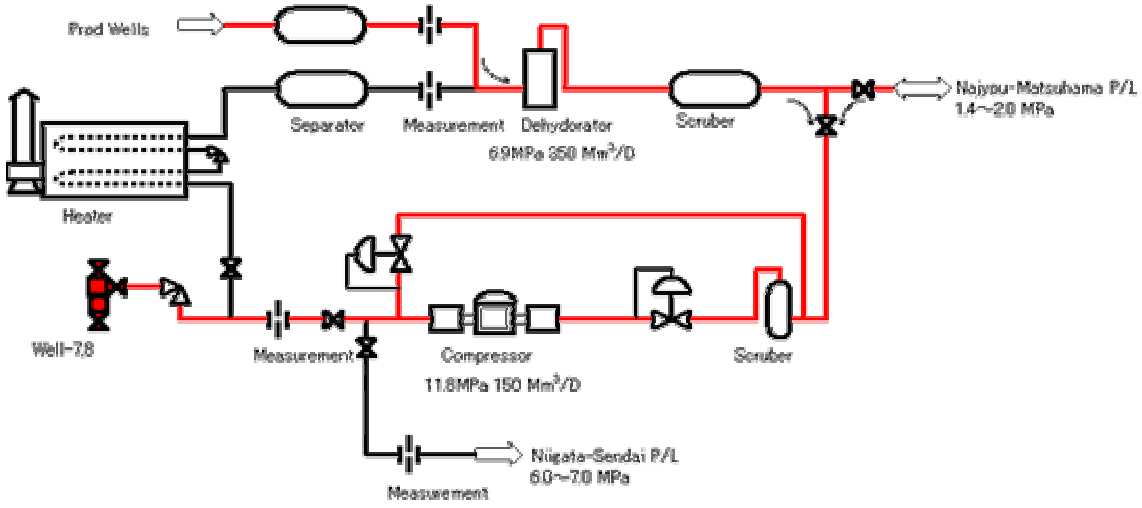

Fig 2: Conceptual Flow of Shuinji UGS

Periodical bottom-hole pressure measurement has been conducted for inventory management. As shown in Fig 3, the pressure hysteresis of Shiunji well Sk-7 indicates a water encroachment to gas reservoir. During the primary production period, water encroach into gas reservoir, and while gas injection period, water is pushed back into aquifer. Reservoir modeling has been executed to predict reservoir performance and the results of reservoir simulation gave good agreement with the actual performance.

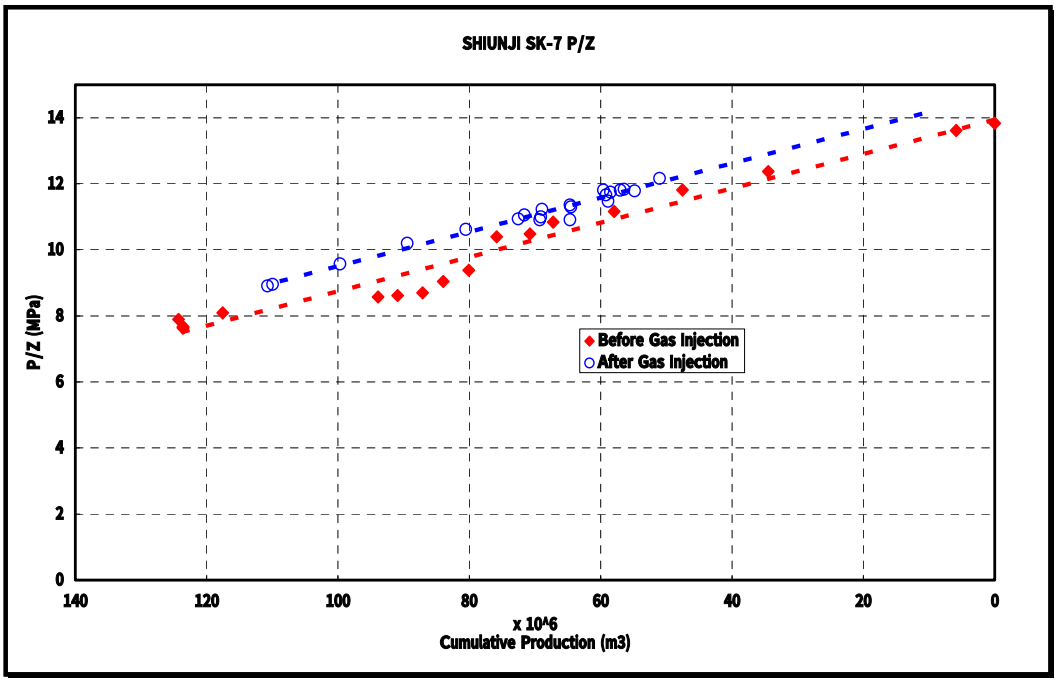

Fig 3: Pressure-content hysteresis curve of Shiunji SK-7

Summary of performance of total Shiunji UGS operation, consisted of well No.7 and 8, is shown in Fig 4. Storage and withdrawal operations of gas at the UGS has been begun since Jan 1989 and the performance shows that the utilization of UGS capacity has been limited, by contrast with reservoir storage capacity, to small seasonal fluctuation of gas demand. Surplus capacity of working gas has not been utilized because of non-existence of effective infrastructure of grid and small size of local market.

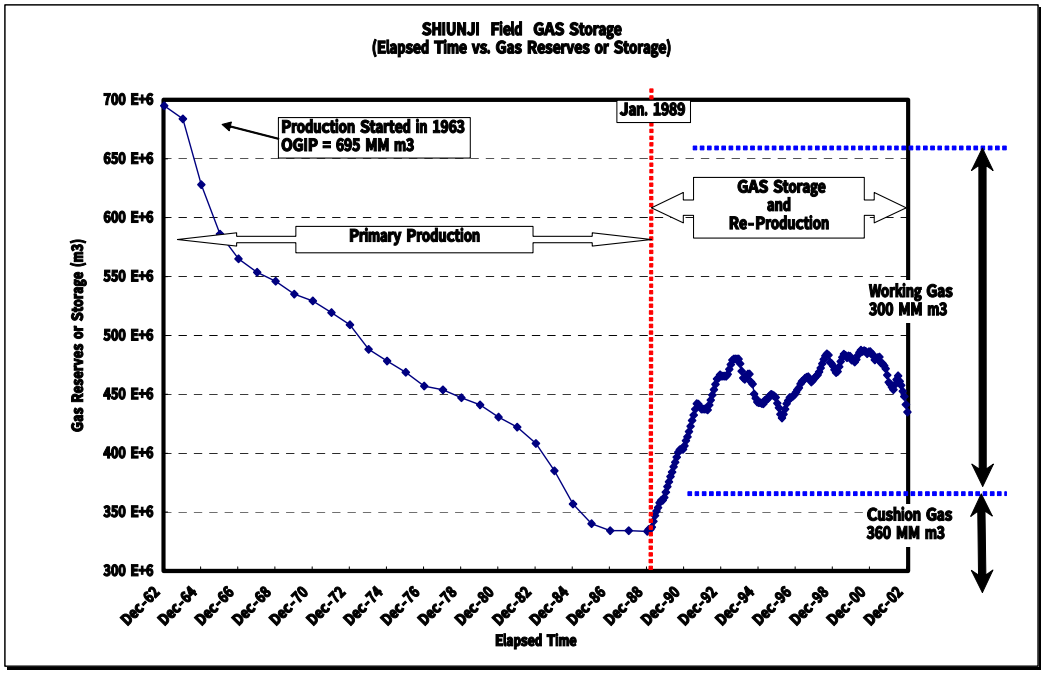

Fig 4: Elapsed Time vs Gas Reserves

Fig 5 illustrates simplified classification of the Shiunji UGS and it shows that maximum working gas is 300 million (MM)m3 when the re-production pressure is 6.9MPa. To optimize gas

withdrawal and injection rate, additional wells and facilities has to be taken into consideration. For example, a well completed with 5-1/2"TBG for Shiunji reservoirs can produce more than 1,100,000Sm3/D.

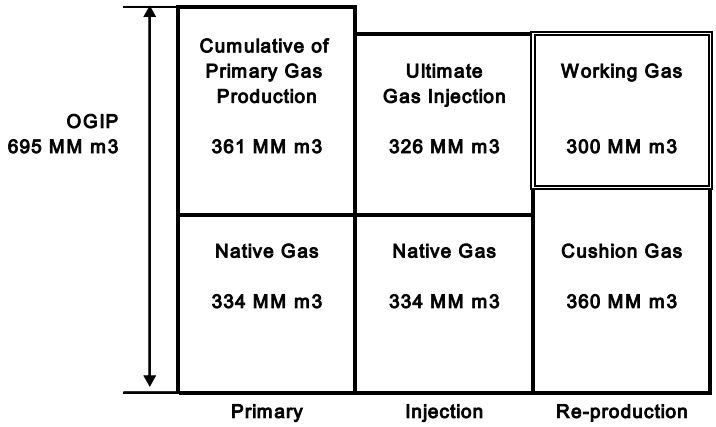

Fig 5 :Simplified Classification of Shiunji UGS gas

3. PROSPECTS FOR UTILIZATION OF UGS

3.1 Candidate UGS and Infrastructure in Japan

In Niigata, JAPEX has been operating various size of gas fields since 1960'. Although the scale of fields size are relatively small, there are a couple of significant UGS candidates and one of them is shown in table 2.

Yoshii fields	Storage Capacity BCM	Current Storable Gas Volume BCM	Cumulative . Gas Production BCM
Yoshii field	16.4	13.6	16.9
Other gas fields	5.3	2.9	4.2
Total	21.7	16.5	21.1

Table 2 : Storage Capacity of Proposed UGS

JAPEX also owns and operates gas pipeline network over 800 km in Niigata. Through the network, JAPEX supplies both domestic gas and imported LNG. However, the total length of gas trunklines in all over Japan is still only about 3,000 km as shown in Fig 6.

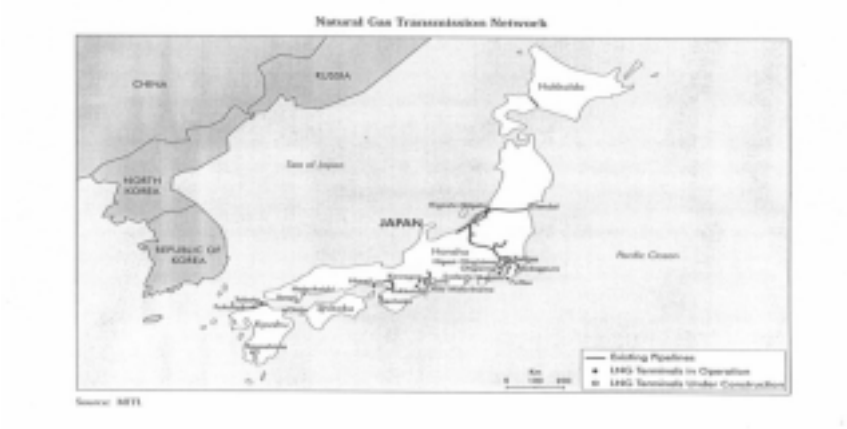

Fig 6 Natural Gas Transmission Network in Japan

To promote use of natural gas, it is essential to construct a trunkline network which connects source and demand area. JAPEX is now heavily involvedinto the Sakhalin Pipeline project. It is a project to install an international pipeline between Japan and Sakhalin Island, Russia, where huge reserves (485 billion cubic meters) have already been estimated. The pipeline will supply natural gas to meet demand in the northern half of Japan, including Tokyo metropolitan area.

In the longer term, completion of an international pipeline such as the Sakhalin pipeline and/or an east-Siberia pipeline is expected to help diversify Japan's natural gas sources and enhance the security of the country's gas supply. Long distance pipeline will require buffer function to solve gas volumetric imbalance caused by take-or-pay contract, peak and off-peak gas demand and build up period of gas sales contracts formation. As the mater of fact, it is imperative for pipeline operation management to utilize UGS together with long distance pipelines for peak shaving, gas balancing, and gas trading, reducing the burden of take-or-pay and ensuring security of gas supplies. Storage might eventually compete with other traditional tools such as swing supplies, interruptible contracts, and both spot and futures markets in helping to balance supply and demand. Near in the future UGS will offer unbundled services even in Japan.

3.2 Scenario for UGS Utilization

According to our analysis of a city gas demand of a some city in northern Japan, 13% of annual gas demand is required for peak shaving and equivalent volume of gas needs to be stored during off-peak season. Withdrawal capacity would be 44% more than annual daily average load as shown in Fig 7. As mentioned above, the working gas of the Shiunnji is evaluated as 300 million SCM, which means Shiunji UGS can meet a market size of 2,400 million SCM of city gas demand when gas transportation is effective. And additional 3 wells with TBG size of 5 1/2” would be required in order to cope with high withdrawal rate.

When natural gas is utilized as fuel for electric generation, demand pattern is different from that of city gas. As shown in Fig 7, the gas demand pattern of gas power generation has twin peaks, summer and winter, of gas annual demand. This fact mitigates required gas volume for peak shaving and increase utilization factor of UGS facilities. A 1200 MW power generator requires 1800 million SCM (LNG 1.2 million ton per year) of fuel gas when efficiency is 35% and load factor is 70% respectively. Gas shortage of summer season, compared with annual average demand, is 37 million SCM. Suppose that a constant volume of gas is imported from a foreign country, and UGS is utilized as a buffer to absorb seasonal gas demand fluctuation. In case the UGS capacity would be large enough, surplus storage capacity can be secured for gas supply security. As explained above, Yoshii gas field has huge capacity to store gas for power generation.

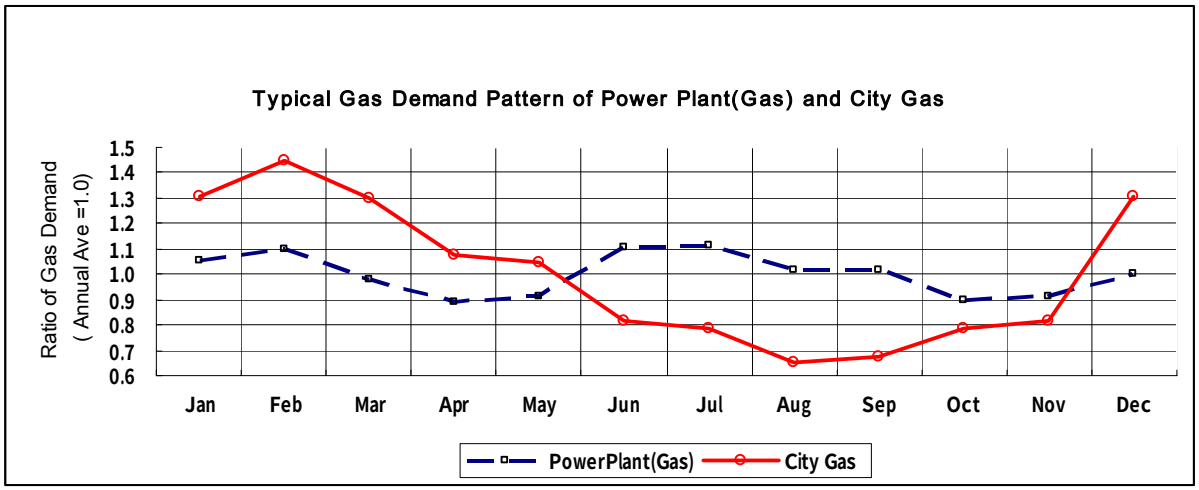

Fig 7 Seasonal Fluctuation of Gas Demand

Sample calculation of the CAPEX and OPEX for relatively large scale UGS is as follows, (1US$=¥120)

	Specification	Cost Million US$	Remarks
Design Condition			
Injection Capacity	5 million Sm3/D		
Withdrawal Capacity	5 million Sm3/D		
Capital Expense			
Well Drilling	3,000m Depth 4”TBGx, 7wells	35	
Gas Turbine Compressor	3Mpa-30Mpa 9,200kW/unit 3 sets of 2.5 million Sm3/D	51	
Dehydorator	7Mpa, 5 million Sm3/D,	23	
Others		13	
Total CAPEX		122	
Operating Expense			
Operation&Maintenance		16	Per year

Table 3 Sample calculations of the investment and operation expense for UGS

Working Gas Volume Million Sm3/per year	Investment Cost for UGS Million US$	Unit cost of Gas Storage US$/Sm3 /10 years
300	90	0.083
500	122	0.056

Table 4: Development cost of UGS

Unit cost of gas storage shows relatively low cost. Gas storage to depleted gas reservoir has big potential for significant cost saving and plays big role when gas is imported from a foreign country through pipelines.

4. CONCLUSION

Though a little too late compared with Europe and US, the Japanese government has indicated that it plans to deregulate the retail natural gas sector in over the next several years to promote increased competition and lower prices by introducing third party access (TPA) of pipelines, liberalization of retail gas sale and TPA of LNG terminals. In addition boundary between power generation and gas industry has been breaking down, it is expected that an integration of the UGS into a pipeline network system will go a long way toward lowering gas price. To develop gas further would require overcoming two major barriers: developing the network and lowering the cost of supplying natural gas. Market liberalization, including third party access and better gas load management, which might improve the performance of the gas market, simultaneously will enhance security of gas supply together with the UGS.

Because of the absence of an effective gas pipeline network system, furthermore the proposed UGS are situated in Niigata Prefecture where is remotely located from densely populated area such as in and around Tokyo, the utilization of the depleted gas reservoirs is not economical solution for the time being because gas delivery cost, including storage expenses, accounts for most of transportation cost by the pipeline. The high construction cost of pipeline due to expensive land cost and narrow plains means that the gas storage field developments cannot be considered in isolation, but need to be developed in conjunction with investment in pipelines and the related demand markets. However if UGS, whose working gas would be equivalent to more than 2,000 million SCM, is integrated into the gas transportation and distribution system, it would be possible to cope with not only seasonal fluctuations of gas demand but also temporarily gas parking of imported gas and storage of inexpensive spot LNG. Though order of priority will be given to establishment of the transportation infrastructure, installation and expansion of the gas pipeline network system will create a chance to

utilize UGS as an economical solution and huge benefits in greater reliability of supply and gas delivery cost reduction in the gas markets.