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THE CASE FOR UNDERGROUND GAS STORAGE (UGS) – A REPORT SUBMITTED BY THE BGS TO THE HOUSE OF LORDS INQUIRY INTO EUROPEAN UNION ENERGY POLICY: GAS SUPPLY AND ACCESS

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Foreword

This report is the published product of a study and submission by the British Geological Survey (BGS) to the House of Lords Inquiry into European Union energy policy: gas supply, access and infrastructure.

THE CASE FOR UNDERGROUND GAS STORAGE (UGS)

Background

1. In Western Europe, gas penetration in the residential and commercial sectors has now reached about 44%. In line with this trend, UK gas consumption has more than doubled over the past ten years, and gas now holds a key position as an energy source, both as a primary fuel (for heating and cooking) and for electricity generation.

2. The gas supply industry has to adjust to very wide seasonal variations in consumption due to rapidly changing electricity, heating and air conditioning requirements.

3. Thanks to its huge reserves of North Sea gas and oil, Britain is the only G7 country other than Canada still largely self-sufficient in energy. The UK continues to enjoy a high level of diversity and security of supply, but this is changing rapidly.

4. Although the UK is still a net exporter of natural gas, there are times during peak demand when it has to import foreign gas to meet its needs. In the course of 2000, the UK imported about 2% of its gas demand of about 97 bcm (billion cubic metres) per year. The DTI projections are of UK gas import dependency rising to more than 58% of demand by 2010, and 90% of demand by 2020. National Grid Transco predicts that net imports of gas will exceed domestic production in 2008-9 and will reach 70% by 2014.

5. Our coming reliance on "less secure" external supply sources makes it necessary to be on guard against any risk of supply shortages or major disruption, be it technical as in an accident (such as the explosion at the Esso Longford gas plant in 1998 in Victoria, Australia, which disrupted supplies across the State for nearly two weeks), or political such as following a terrorist attack.

UK gas demand and likely trends

6. Fifty years ago Britain's coal mines supplied almost 90 % of our energy needs, with crude oil providing the rest. This changed rapidly with the advent of nuclear power plants in the mid-1950s, and the subsequent discovery of North Sea gas. The ‘dash for gas’ occurred in the power generation sector in the 1980’s, when coal-fired power stations were replaced with gas-fired equivalents. There was a continued shift in the balance between gas and coal in the period 1996-2001, due to the abundance of gas supplies from the North Sea combined with low gas prices on international markets.

7. The recent rise in gas prices has led to some generating companies considering the option of mothballing gas-fired plants, and at least one UK coal-fired power station has been brought back into service. Despite this, gas is, and will remain, an increasingly important fuel for electricity generation. The DTI predict that gas could form the energy source for 70-80% of the UK's electricity generation needs by 2020. This is not only because it has been cheap and easy to obtain, but also because it is not clear that alternative fuels will be available. Nuclear energy production is predicted to decline over the next 15 to 20 years unless circumstances, including Government policy towards that energy source, change. At present, the significant contribution to energy needs from coal-fired electricity generation will become increasingly difficult to reconcile with the Government's environmental targets for the reduction of carbon dioxide emissions, as well as more stringent EU directives which will affect other emissions, such as particulates, sulphur oxides and nitrous/nitrogen oxides, in addition to carbon dioxide.

8. The DTI expects demand for gas, both for electricity generation and for direct (domestic and commercial) use, to rise gradually, from about 108 bcm (90 Mtoe [million tonnes of oil equivalent]) in 1999 to more than 144.6 bcm (120 Mtoe) by 2020, although demand will depend on changes in the cost of alternatives on international markets. On this basis, annual UK demand is predicted to exceed production capacity on the UKCS by 2005 (2 years earlier than National Grid Transco predict), with imports concentrated in the winter months. As indicated above, the DTI projections are of UK gas import dependency rising to more than 76 bcm (63 Mtoe), or 58% of demand by 2010, and to 133 bcm (110 Mtoe) or 90% of demand by 2020.

The need for more underground gas storage facilities

9. These projections, if realized, will require the creation of an infrastructure capable of dealing with the problem of fluctuating demand and guaranteeing security of supply. France, Germany and Italy each have gas storage capacity in excess of 20% of annual consumption. Compared to these countries, the UK has very limited purpose-built natural gas storage facilities, providing for less than 4% of annual consumption. What is more, more than 450 surface gas holders ("gasometers"), with a total storage capacity of 24 million cubic metres of gas at low pressure for delivery to domestic and industrial consumers, are scheduled to be phased out over the next ten years or so, reducing total gas storage capacity.

10. There is currently no statutory requirement for the provision of strategic gas reserves, unlike in the coal and oil sectors. In the past, ready accessibility to UK gas reserves in our offshore gas fields may have justified the relatively low priority that has been attached to the development of strategic gas storage in the UK. However, given that the UK will become a major net gas importer in the near future and to guard against the unforeseen disruption of external supplies, government, together with the industry, may wish to give serious consideration to the development of strategic storage capability. Among the solutions that might be considered, subsurface geological storage best fits the bill as the most reliable long-term storage option. Underground gas storage is safe, secure and reliable. Some countries, e.g. Hungary, which has to import all its gas, relies solely on underground natural gas storage to maintain grid supplies and hold strategic reserves. In comparison to liquefied natural gas (LNG) storage, there is little surface expression from the facility, lower fire and explosion risk, and less energy is expended in storage. Underground storage sites are already located within and around cities (e.g. Berlin and Paris).

Underground Gas Storage Facilities

11. Natural gas is stored at surface in liquefied natural gas (LNG) receiving terminals, and underground gas storage facilities. The latter form strategic reserves and peak-shaving units, which can supply gas at a high rate in the cold season and over a short interval. In 1996/1997, there were 580 underground storage sites worldwide, with a working capacity of 262 10^9 m^3. Storage in porous and permeable formations (hydrocarbon reservoirs and aquifers), represents 98% of the working capacity of all the storage facilities in the world.

12. The goal of underground gas storage is to balance gas consumption and resources at all times (seasonal, daily and hourly fluctuations) chiefly in the residential and commercial sectors, where demand is especially sensitive to changes in temperature. In addition, storage makes it possible to meet peak winter demand. The relative peak demand on the coldest day of the year is a very important parameter for the gas industry, because it conditions the size of the gas distribution network. In the UK the need to meet peak electricity demand accentuates peak gas demand because so much of the UK's electricity is now generated from gas rather than coal.

UK potential for the development of further natural gas storage facilities

13. There are three types of large-scale underground natural gas storage facilities: salt caverns, depleted/depleting gas or oil fields, and aquifers:

14. **Salt caverns.** Salt cavities have been used to store liquid petroleum gas (LPG) for many years, but the technique (with respect to salt caverns) is relatively recent for pressurized natural gas. It was first introduced in the United States in 1961. Today, there are 54 storage facilities of this type worldwide, 26 of which are in the United States. This type of storage is developing rapidly and is particularly well suited to shallow underground storage where the need is to meet daily swing demand and intra-day peaks in demand Caverns are created in the salt by solution mining (pumping fresh- or sea water down a well drilled into the salt, dissolving it, and then recovering the produced brine via the well). These caverns can then be filled with pressurised natural gas. Thick natural deposits of salt are found underground in certain parts of the UK. UK storage facilities of this type include the caverns operated by Scottish and Southern Energy at Atwick, near Hornsea on the east coast. In the near term there are potential opportunities for further facilities of this type in salt deposits in the Hornsea area, Cheshire, West Lancashire (Preesall and Walney Island areas), Northern Ireland, Teeside, Dorset and possibly North Somerset.

15. The future potential of hydrogen storage in salt caverns is shown by the construction of a cluster of hydrogen production storage and distribution facilities, operated by Huntsman Petrochemicals at Teeside

16. **Depleting or depleted gas or oil fields.** Gas storage in depleted fields is the most widespread method in the world and often the least expensive. Along with aquifer storage (see below) they are capable of storing very large volumes of gas and are particularly suitable for strategic storage and storage to meet seasonal demand swings. An advantage of using depleted natural gas, or oil fields, for underground storage is that they are known to be capable of storing natural gas or oil for geological timescales - in many cases millions of years, and they can require less "cushion gas" (see below) than other underground storage scenarios. Furthermore, they have commonly been well characterized as a result of the gas or oil extraction programme. Today, there are 448 storage facilities located in depleted reservoirs worldwide. UK storage facilities of this type include Hatfield Moors gas field (Edinburgh Oil & Gas plc), which stores gas 1800 metres below ground onshore to the East of Sheffield and the Rough gas field off the East Coast (Centrica Storage Ltd) that has been developed to store natural gas 3,000 metres underground. There are plans to develop some of the UK's onshore oil fields as natural gas storage facilities, e.g. Star Energy's Humbly Grove oil field, near Basingstoke and the Welton oil field, near Lincoln. These locations will also have the advantage of stimulating further oil production through restoring the oilfield pressure. Further opportunities are likely to exist amongst Britain's onshore oil and gas fields and offshore in the Southern North Sea.

17. **Aquifers.** Aquifers are porous and permeable sedimentary rocks, the pore spaces of which are filled with water rather than oil or gas. The principle of aquifer storage is to create an artificial gas field by injecting gas into the voids of an aquifer formation. Many deeper aquifers contain saline water that cannot be used for potable water supply or agriculture. Where they are confined beneath cap rocks (impermeable rocks which prevent escape of gas), they have the potential to store natural gas if a trap for buoyant substances, such as gas (such as a dome) is present. Injection and retrieval of the gas would be similar to a facility in a depleted natural gas field. More testing and development may be required than for depleted oil or gas fields. However, aquifers are more widely distributed than oil and gas fields or thick salt deposits, so they may provide opportunities where there is no potential for the other types of storage. There are 76 storage facilities in aquifers in the world today, most of them in the United States, the former Soviet Union and France.

Research needs.

18. The main research needs for developing gas storage in UK salt caverns are to more closely locate and characterize thick salt deposits in order to better define areas of potential.

19. The main research needs for gas storage in oil and gas fields are to determine their geological suitability, e.g. some fields may not have sufficient permeability to allow gas to be recovered at appropriate rates, others may be too large, too small, or too deep to develop economically for gas storage purposes.

20. The main research needs for aquifers are to identify the location of suitable traps for buoyant gases within aquifers, which otherwise have the correct characteristics for gas storage.

21. A further research need is to create a Geographic Information System (GIS) for UK natural gas storage, which will locate and characterize potentially suitable sites in relation to other elements of the UK gas infrastructure. This could form an important national decision support tool for use by policymakers, regulators, planners and operators.

Barriers to deploying UGS in the UK

22. **Public perception** is an issue with underground natural gas storage - see for example the web sites: http://www.overwyrefocus.co.uk/gas_storage/gas_articles.htm and http://www.nogasplant.co.uk/. Opposition is likely to be at the local level, given that the main perceived risks are local (e.g. risk of fire or explosion from a leaking facility, risk of ground movement). It is hard to see why security of energy supply and seasonal peak shaving (the main drivers for underground natural gas storage) could be perceived negatively. However, from a local perspective these benefits may be outweighed, or ignored,

especially by property owners, as they are concerned that a new storage facility could impact on the value of house prices (a significant factor in other infrastructure planning such as onshore windfarms). There is no obvious upside to living above, or near, an underground gas storage facility, but neither is their any significant downside, as surface facilities are very unobtrusive, quiet and easily hidden by careful landscaping and/ or tree planting. Research into public perception could be commissioned if it is felt that the UK underground natural gas storage facilities should be expanded.

23. When asked in March 2004, about the development of gas storage facilities in underground caverns formed within deep rock salt deposits, the Secretary of State for Trade and Industry replied that “as Great Britain becomes increasingly dependent on imported gas it will be important that the market continues to provide sufficient flexibility to meet demand. Gas storage projects help do this. The Government therefore welcomes proposals for new projects. They must, of course, obtain necessary planning and other regulatory consents.”

24. **Cushion gas:** Cushion gas refers to the gas injected into the underground storage facility to bring it up to operating pressure. This gas is held permanently in the facility and is therefore not available for distribution, hence the cost of this gas cannot be recovered in sales. When natural gas is stored in porous formations, cushion gas accounts for the largest part of the investment, representing about 30 to 40% of the development cost of aquifer gas storage facilities. It is possible to reduce significantly this cost by replacing the natural gas with an alternative cushion gas, such as nitrogen. The cost saving principally depends on the price of natural gas relative to an alternative cushion gas.

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