8.4 ELECTRICITY INTERCONNECTOR

The Isle of Grain is the landing point for a 260km, 1000MW electricity interconnector with the Netherlands, a €600m investment by National Grid and TenneT in the Netherlands, operated by BritNed. The subsea cable surfaces near Grain village and is routed underground to the High Voltage Direct Current (HVDC) converter station adjacent to elements of the Grain LNG facility.

The development of an airport in proximity to the HVDC converter station is understood to introduce a number of potential risks, though further examination would be required to determine their materiality

and the extent to which they could be mitigated:

- Aircraft collision with the HVDC would have an impact on electricity supply security in the short medium term until the facility could be repaired. The buildings are not thought to impact upon the Obstacle Limitation Surfaces beyond those of Grain CHP or Grain LNG.
- The HVDC converter station emits electromagnetic fields (EMF) which could theoretically interfere with aircraft communications and navigation equipment. The range and altitude at which interference might be observed are not known at this stage.

Overall, the electricity connector does not appear incompatible with the siting of a hub airport on the Isle of Grain.

8.5 GRAIN LNG

8.5.1 Background

Grain is home to the largest LNG importation terminal in Europe in terms of capacity, and the eighth largest in the world.

Grain LNG is a facility for the importation, storage and regasification of Liquefied Natural Gas, owned and operated by National Grid.

The site opened in 2005 as an LNG importation and storage facility with the capacity to receive and process up to 3.3 million tonnes of LNG per annum.

Since then, the capacity of the terminal has increased to 14.8 ~~tripled to 9.8~~ million tonnes of LNG per annum with the construction of four ~~three~~ above-ground storage tanks, each with a usable capacity of 190,000 cubic metres.

The facility can supply up to 20% of the UK's natural gas demand. Approximately £1 billion has been invested in developing the facility to date.

Several companies have the rights to import LNG and utilise the capacity of the facility:

- BP~~/~~
- Sonatrach
- Centrica
- GDF SUEZ
- E.on Ruhrgas
- Iberdrola

The LNG terminal has two jetties which can berth LNG vessels simultaneously. The second jetty opened in 2010 and can accommodate the world's largest LNG vessel type, the Q-Max, operated by Qatar Gas. Q-Flex vessels can also be accommodated.

- Q-Max vessels measure around 345m, with a breadth of 54m, a height of 35m and a draft of around 12m. They have an LNG capacity of 266,000 cubic metres.
- Q-Flex vessels measure 315m, with a breadth of 50m, a draft of around 12m, and LNG capacity of between 210,100 and 217,000 cubic metres.

8.5.2 Location of the Site

Grain LNG is located on the south-east of the Isle of Grain, 35 miles east of London. The site occupies approximately 300 acres ~~one square mile~~ and currently has four of the world's largest above ground storage Tanks~~vessels~~, each with a of volume of 190,000m3 , height 50m and diameter of around 90m. Four smaller Tanks~~vessels~~ with a volume of 50,000m3 from the original development in 2005 remain and are in use.

Commented [a1]: Changed wording to reflect the common term throughout documents

To the north of the site, land is predominantly agricultural with mudflats, creeks and marshland. To the east is the site of the Grain oil-fired power station (now decommissioned) and CCGT plant, both owned by E.on. To the west are Medway CCGT, operated by SSE, and Kingsnorth dual-fired coal and oil power station, owned by E.on and now decommissioned.

The River Medway and its approach by sea are deep enough for the largest LNG vessels, the Q-Max and Q-Flex.

Grain is connected to the National Gas Transmission System via the Grain-Shorne gas pipeline.

8.5.3 Planned Development of Grain

A major expansion of up to 6 million tonnes per annum of LNG importation capacity is planned. The project, valued at over £300 million, consists of one further 190,000m3 tank (located between the existing tanks and the B2001 Grain Road), associated process equipment (in the same vicinity) and a second cryogenic unloading line (running from the jetties to the tanks and running parallel to the existing unloading line). With planning consents in place and an exemption from regulated Third Party Access requirements received from Ofgem and the EU, some construction has already commenced including ground clearance and drainage works associated with the tank.

Construction of the cryogenic line is well advanced and is due for completion in 2014. The additional storage tank is planned to be available from 2018. Timing of the final investment decision on the remainder of the plant is dependent on market appetite.

In the longer term, National Grid is considering further expansion of the facility, shown in Figure 26, to develop three further 190,000m3 storage tanks, liquefaction plant, and a power generation facility making use of boil-off gas. TfL's submission states that a significant proportion of the storage facilities will be nearing the end of their life by 2029; however, the majority of the storage tanks were constructed since 2005 and could be expected to have a longer operational life than 24 years. National Grid's future development strategy indicates that the entire facility is expected to have a much longer lifespan.

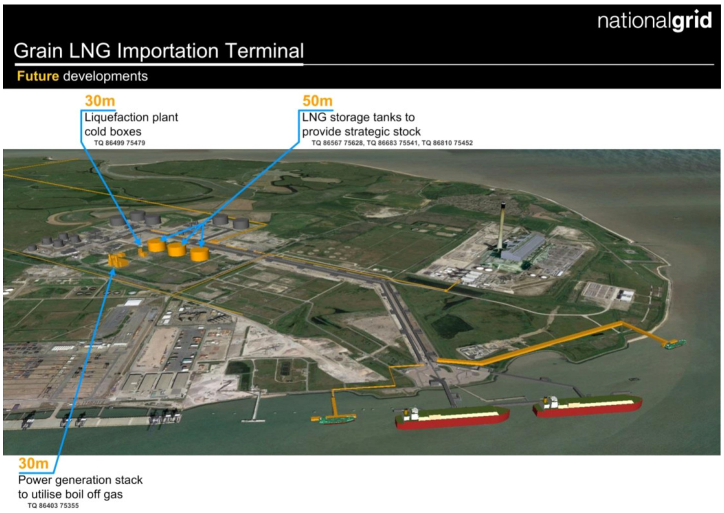

Figure 26: National Grid's long term expansion plans for Grain LNG

National Grid has recently announced that it is developing a road tanker loading facility at Grain LNG to cater for commercial, industrial and road tanker markets. Demand for LNG as a road fuel in the UK is forecast to grow significantly and has Government support. Grain LNG is well positioned to become one of the most important distribution facilities for LNG road tankers.

8.6 BACKGROUND ON LNG

Liquefied Natural Gas is natural gas that has been cooled to -162°C, shrinking its volume so that it takes up 600 times less space, making it economically viable to transport over long distances.

LNG is transported to the UK in dedicated vessels, typically of membrane type with double-wall metal containers, which require navigation and berthing in deep water ports. From the berth, the LNG is extracted using the ships pumps located inside the ~~compressors into~~ cryogenic storage tanks where it is stored at -162°C.

LNG is stored in tanks specially designed to maintain the very low temperature of the liquid and to mitigate the risk of loss of containment. A full containment design is employed, comprising an inner tank made of a nickel alloy and an outer tank made of pre-stressed concrete with a reinforced concrete base slab and roof. The outer tank provides containment in the event of a leak from the inner tank. A certain amount of warming of the liquid occurs due to less than 100% thermal efficiency of the insulation material. This gas is collected and distributed into the local Gas Distribution system~~used by the nearby Combined Cycle Gas Turbine power generation facility at Grain~~.

According to demand, the liquid can be extracted from storage tanks and returned to gaseous state at around 5°C at a regasification plant before being fed into the National Gas Transmission System.

The regasification process can require the addition of nitrogen to ensure the product meets UK gas quality specifications.

8.7 LNG'S SAFETY RECORD

LNG has an excellent safety record during transport, offloading, storage and regasification. According to the International Group of Liquefied Natural Gas Importers (GIIGNL, 2011), there have been no instances of LNG ships experiencing major accidents or safety or security problems in over 45 years and 135,000 voyages.

There have been very few accidents related to the storage and transmission of LNG. The most significant accident occurred in 1944 in Cleveland, Ohio, USA, when a tank failed and spilled its contents into the street and storm sewer system. The resulting explosion and fire killed 128 people. The accident was found to be due to the materials used to construct the inner tank, and the lack of fire resistance of the legs supporting the adjacent tank. Since then, significant advances in the design, construction and safe operation of LNG facilities have been made.

Where accidents have occurred involving pipelines or other infrastructure, such as steam boilers, the resulting impact has tended to be very localised although fatalities and casualties have resulted. LNG, as a liquid, will not explode or burn. When it leaks, it initially sinks to the ground (being denser than air), where it begins to vaporise and thus rise into the atmosphere. It is flammable within an approximate concentration of 5-15% gas in air. Outside this range, it does not burn. The circumstances in which LNG presents the greatest risk are when LNG leaks, vaporises, and gases are allowed to build up in such a way that they reach a flammable concentration.

The most recent LNG accident occurred on 31st March 2014 in Washington State, USA. Whilst still under investigation it is thought that a gas vessel ~~A gas pipeline~~ adjacent to an LNG storage tank of a similar scale, but using a different design, to those at Grain LNG exploded and the resulting shrapnel caused a breach in the tank walls. LNG leaked from the tank and vaporised, but it did not ignite or explode. A two-mile evacuation zone was set up as a precautionary measure. Research undertaken for this study has not identified any instances of an LNG storage tank igniting or exploding, even in the event of an adjacent pipeline explosion and fire.

8.8 GRAIN LNG SAFETY

Grain LNG falls under the Control of Major Accident Hazards (COMAH) regulations and is a top-tier registered establishment. The aim of the regulations is to prevent major accidents involving dangerous substances and to limit the consequences of any accident to people and the environment. The regulations cover the unloading equipment at the jetty, the site itself, and the feed up to the National Gas Transmission System.

Grain LNG is overseen by the Competent Authority, which comprises the Health & Safety Executive (HSE) and the Environment Agency (EA). The Health and Safety Executive (HSE) is responsible for scrutinising the site in relation to Planning Advice for Developments near Hazardous Installations (PADHI) guidance which advises on planning decisions within hazardous areas. The local authority, Medway Council, is responsible for giving Hazardous Substances Consent. Consent for the site to store an increased quantity of LNG and gas following Phase 4 expansion was awarded in early 2013.

The HSE has defined a Land Use Planning (LUP) Consultation Distance (CD) around the Grain site, based upon a detailed assessment of the hazards and risks associated with the site. Three zones within the CD are defined: inner, middle and outer, derived from an assessment of the probability of a ‘dangerous dose’ occurring. A ‘dangerous dose’ is defined as an incident resulting in severe distress to all; a substantial number requiring medical attention; some requiring hospital treatment; and about 1% fatalities.

The Consultation Zones for Grain LNG are shown in Figure 27 and Figure 28, below. Note that the zones have been derived from an assessment of the existing infrastructure and storage capacity, including that which is currently in development. They do not reflect the additional capacity that forms part of the longer term plans for expansion.

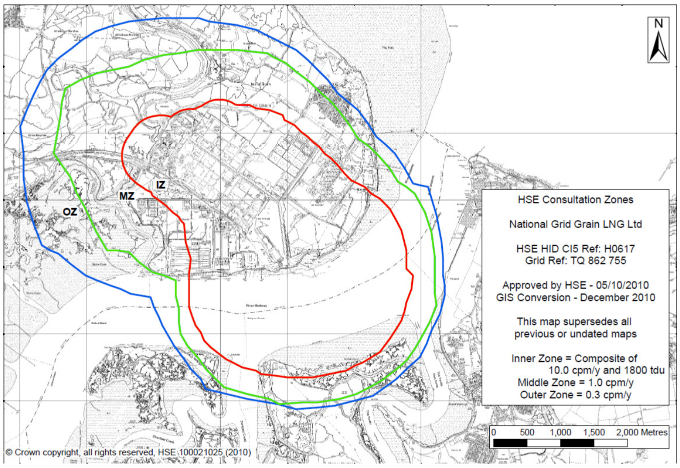

Figure 27: Grain LNG HSE Consultation Zones

PADHI is a methodology that gives Land Use Planning (LUP) advice on proposed developments near

hazardous installations. The approach takes into account the zone in which the proposed development is located, and the ‘sensitivity’ of the proposed development:

- Sensitivity 1 includes people at work and parking
- Sensitivity 2 includes the general public (e.g. housing, transport links, indoor and outdoor facilities)
- Sensitivity 3 includes developments for use by vulnerable people (e.g. institutional accommodation, education, prisons)
- Sensitivity 4 includes very large and sensitive developments (e.g. football ground, large hospital)

A matrix, shown in Table 3, is used to decide the type of advice that the HSE would give to the Local Planning Authority in relation to the scheme.

Table 3: PADHI risk matrix

Level of Sensitivity	Inner Zone	Middle Zone	Outer Zone
1	Don't advise against development	Don't advise against development	Don't advise against development
2	Advise against development	Don't advise against development	Don't advise against development
3	Advise against development	Advise against development	Don't advise against development
4	Advise against development	Advise against development	Advise against development

Table 3: PADHI risk matrix

The HSE uses the above table to determine whether it would advise against development or not. The HSE has an advisory role rather than the power to refuse consent or a planning application. It provides advice to the local planning authority which will make a planning decision weighing Health & Safety against other considerations.

The absence of substantive data on the probability of an incident occurring means that the focus of a risk assessment shifts towards assessing impact rather than likelihood. The specification of the LNG facility is designed to manage the likelihood of an incident to a level that is As Low As Reasonably Practicable (ALARP). Further mitigations are focused on reducing impact, i.e. reducing the number of vulnerable people within the vicinity and reducing the risk of a 'domino effect' in which an explosion could be triggered at a neighbouring facility.

There is currently little or no housing within the Grain LNG Inner Zone, and only a small settlement of 1,648 (2011 census data) within the Middle and Outer Zones.

8.9 RISKS RESULTING FROM POTENTIAL AIRPORT DEVELOPMENT

The development of an airport adjacent to the Grain LNG facility introduces reciprocal risks:

- The risk of a fire or explosion at Grain LNG resulting in loss of life, casualties, damage to property, and/or causing disruption to airport operations; and
- The risk of an aircraft colliding with part of the Grain LNG infrastructure, causing fatalities, casualties, loss of availability of critical infrastructure, and potentially a fire or explosion.

The complexity of these risks means that they require thorough investigation by the HSE. An airport development of the scale of an inner Thames Estuary hub does not readily fit into the PADHI model. Informal advice from the HSE suggests that the main development, the airport terminal and all associated buildings (those for indoor use by the public) may be sensitivity level 3 in the PADHI system, while other areas such as runways and taxiways could be level 2 or 3 depending on the number of people present and the length of time they are present. The precise location of the facilities will then form a material part of the decision-making to determine which facilities, if any, fall within the Consultation Distance.

Recognising the shortcomings of the PADHI system for this application, HSE would have operational concerns about the close proximity of the airport to the terminal and its presence could lead to HSE revising its LUP zones, which could place the Estuary airport scheme within HSE's consultation distance.

Figure 28, below, shows the location of the existing Consultation Zones in relation to the proposed airport locations.

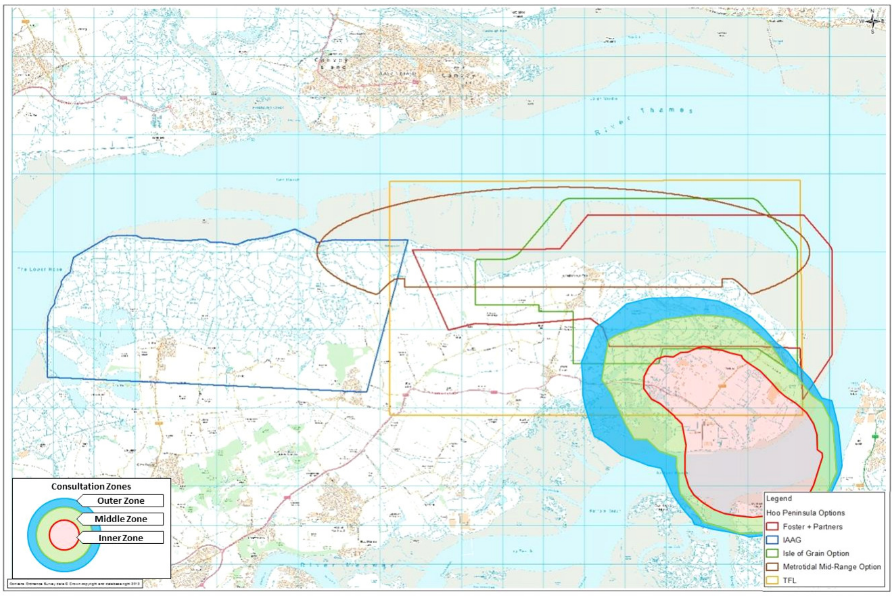

Figure 28: Grain LNG HSE Consultation Zones and proposed airport locations

Historical data suggest that if a fire or explosion were to occur at Grain LNG then it would not have an immediate impact on the airport and terminal buildings (i.e. it is unlikely that they would be immediately damaged by an explosion); however, the airport would likely fall within an evacuation area that would be set up, and were the incident to develop into a full LNG facility fire then damage may be caused to airport infrastructure. The evacuation itself would result in significant disruption to airport operations as some or all of the airport would probably be required to close. Facilities that fall outside the exclusion zone would be unlikely to be able to be operated independently from those that fall within it.

The risk of an aircraft colliding with part of the Grain LNG infrastructure cannot be calculated; nevertheless it is recognised to exist. The flight phases that carry the greatest risk are departure and approach. The inner Thames Estuary airport schemes propose an east-west parallel runway alignment to the north of Grain LNG, therefore an incident following aircraft departure would be extremely unlikely. With Grain LNG located potentially less than a mile from the southern runway, only a small course deviation for an arriving aircraft would be necessary for a collision with the LNG facility to occur. It must be emphasised that this would be an extremely unlikely event and that we are not aware of any incidents in which a commercial aircraft has made a controlled or uncontrolled flight into terrain at such a deviation from intended course. Additionally, the go-around procedure for an aircraft on a westerly approach to the southern runway would ordinarily take it over Grain LNG; such an event might occur as frequently as once per day and may therefore present a material risk.

LNG tanks are designed to withstand ground movement, blast overpressure and missile impact. It is reasonable to assume, however, that neither the tanks nor the adjacent pipelines and other infrastructure would withstand an aircraft impact and that a fire and/or explosion would be likely to occur as a result, potentially on a scale never witnessed in any other LNG accident to date.

It cannot be ruled out that an aircraft might be deliberately flown into the LNG facility. Its proximity to the proposed airport means that it would present both an attractive target to terrorists and a target of opportunity. In common with safety risk assessment methodologies, given that it is not possible to assess the probability of such an event occurring, security risk assessment methodologies tend to focus on establishing the scale of the impact and on implementing measures to reduce the risk to people and property as far as reasonably practicable.

Importantly, it may not be necessary for an actual incident at Grain LNG to take place in order for disruption to result. An increased risk of an accident, perhaps because of a small local fire, or the threat of an explosion, for example from a suspect package or coded bomb warning, could be sufficient to result in substantial disruption to normal airport operations.

8.10 ROLE OF GRAIN LNG IN IMPORTING AND SUPPLYING NATURAL GAS TO THE UK

8.10.1 Grain LNG's Importation role

The UK has four LNG importation facilities which, in 2011, provided up to 47% of the UK's total natural gas imports:

- Grain (20.4bcm/yr);
- Dragon LNG (7.6bcm/yr) and South Hook LNG (21bcm/yr), both located at Milford Haven in Pembrokeshire, are importation and storage facilities; and
- Teesside GasPort (4.1bcm/yr) is an importation-only facility which uses regasification equipment on board the ship to deliver natural gas into the onshore pipeline and into the National Gas Transmission System.

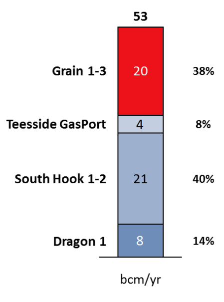

Figure 29: Contribution of each LNG import facility capacity

(Total = 53.1 billion cubic metres per year)

Grain provides up to 38% of the UK's LNG import capacity and 13% of total natural gas import infrastructure capacity. It has the capacity to supply around 20% of the UK's requirement for natural gas.

In 2012, 97% of the UK's LNG imports were supplied by Qatar, with Norway, Algeria, Nigeria and Egypt supplying the remainder. The nature of importing LNG by ship means that the UK's terminals are, in effect, connected to any LNG supplying country, providing much greater purchasing flexibility. In terms of energy security, the facility provides access to ship-borne gas on global markets, which means that in the event of pipeline failure (or geopolitical dispute such as has been observed recently between Russia and Ukraine), LNG can be sought from a wide range of global producers.

LNG import volumes were much lower in 2012 (14.0bcm) than 2011 (24.6bcm), principally because higher demand in Asian markets caused prices to rise above European levels. The UK's gas demand was therefore met to a larger degree in 2012 by gas pipelines from Norway, the Netherlands and Belgium.

Domestic North Sea production continues to be the UK's largest single source of natural gas at 54% of 2012 demand. However, North Sea gas production from the UK and Norway is forecast to decrease over time. At the same time, the UK will become less reliant upon coal-fired power stations and more reliant upon renewable sources such as wind. CCGT plants are typically used to produce on-demand electricity generation to supplement renewable sources.

Therefore, although the Department for Energy and Climate Change forecasts a gradual decline in gas consumption over the period to 2030, a greater proportion of the UK's gas will be met by imports. These imports will be met by a combination of LNG imported by ship and natural gas imported through interconnectors with Belgium and the Netherlands.

There are also some plans to construct additional LNG importation infrastructure, including a regasification plant at Teesside, a floating storage and regasification facility (similar to that currently operating at Teesside), and a facility to take LNG from sea tankers at Amlwch, regasify it and distribute it by pipeline for storage at Preesall in Lancashire. These projects would provide less capacity than Grain and would be developed to meet an already identified need. There is also no confirmation that these projects will materialise.

TfL's submission to the Call for Evidence states that both the LNG shipping terminal and the link to the underground national LNG pipeline structure outside the perimeter fence of the airport could be retained. This would appear to overlook the requirement to regasify the LNG before it is pumped into the National Gas Transmission System, which distributes natural gas rather than LNG.

Grain, therefore, continues to form a key component of the UK's current plans to meet the UK's gas needs over the forecasting period.

8.10.2 Grain's LNG Storage Role

The UK uses a combination of gas storage and LNG storage to meet its gas demands. The various gas storage facilities shown in Table 4, below, offer not only a very wide range of capacities but also differ in their role.

- Depleted gas fields are typically injected with gas in the summer which is withdrawn in the winter, since they have slow injection and withdrawal rates (Long Range)
- Salt caverns can be used to store gas and offer high injection and withdrawal rates, enabling them to be refilled and emptied several times a year (Medium Range)
- Peak shaving is the name given to highly deliverable storage such as LNG which can be used to meet very high demands for short periods of time (Short Range)

Type	Site Name	Type	Accessibility	Maximum Capacity (kWh)
LNG Storage	Isle Of Grain	Peak Shave	Short Range	6,450,197,230
	South Hook	Peak Shave	Short Range	5,220,000,000
	Dragon	Peak Shave	Short Range	2,066,359,801
Gas Storage	Rough	Depleted field	Long Range	40,256,100,000
	Aldbrough	Salt cavity	Medium Range	1,498,319,536
	Holford	Salt cavity	Medium Range	2,383,571,904
	Hill Top	Salt cavity	Medium Range	417,000,000
	Humbly Grove	Depleted field	Medium Range	2,772,360,852
	Hornsea	Salt cavity	Medium Range	2,855,555,546
	Holehouse Farm	Salt cavity	Medium Range	492,000,000
	Avonmouth	LNG	Short Range	551,506,679
Total				64,962,971,548

Table 4: UK gas storage facilities (Source: National Grid, June 2014)

As Table 4 shows, the only short range source of gas is from LNG storage. Salt caverns provide medium range, while Rough, a partially depleted gas field in the North Sea, provides slow access to a very large supply of gas. One of the reasons that access to gas stored in salt cavities and depleted fields is slow is that the gas must travel some considerable distance before being processed and introduced into the National Gas Transmission System. LNG, on the other hand, needs only to be regasified and to have nitrogen added so that it reaches the required specification – a comparatively quick process.

8.11 POTENTIAL ALTERNATIVES TO GRAIN LNG

Grain LNG fulfils a number of criteria that make it ideally suited to its LNG importation and storage role. It has a very low local population, it is sited on a large area of brownfield land for development; it has a deepwater port, an existing connection to the National Gas Transmission System, and it is close to the main source of gas demand in the south east.

The examination of Grain LNG's role for both importing and storing gas demonstrates the significant challenge that would be faced if it were necessary to relocate the facility. Despite an appetite to develop further LNG importation facilities in the UK, few suitable alternative locations have been identified either by the National Grid or by other energy companies, and indeed none that combine both importation and LNG storage. Alternative approaches can be envisaged, such as using onboard regasification ships, feeding natural gas directly into the National Gas Transmission System, and cooling it for storage elsewhere (as at Avonmouth). However, this would incur operational inefficiencies by being limited to smaller vessels equipped with onboard regasification equipment, and the operating costs of recondensing the gas for storage as LPG on land. Market position would also be weakened by constraining the market to only those suppliers equipped with onboard regasification vessels. A key constraint remains the access to a deepwater port, able to accept the largest LNG vessels, that is within reasonable reach of the National Gas Transmission System. Were an alternative site to be found, the National Grid's view is that it would be necessary to construct and commission the new site before decommissioning Grain LNG, so as to retain the supply which has strategic importance for the UK's energy security. The Department for Energy and Climate Change has also highlighted the importance of the UK remaining in compliance with the EU security of gas supply regulation (EU 9994/2010).

The storage tanks used at Grain LNG are understood to take around 42 months to construct. According to National Grid's submitted evidence, the costs of rebuilding Grain LNG would be significant and the site could take up to ~~would take~~ 10 years to replicate. Therefore, if the Grain LNG site were to be vacated in favour of part of the airport development then a strategy to replace Grain would be required with some urgency. National Grid is not aware of another suitable site available in the UK that meets all of the requirements of the Grain LNG facility.

According to National Grid, over £1bn has been invested in Grain LNG and a further £300m is committed. Given the investment, it seems likely that the facility's operational life will continue well beyond 2029, and some asset renewal can be foreseen. It is reasonable to assume that a replacement facility would cost at least as much as has been invested at Grain LNG, potentially much more once land acquisition and any works required to enable access by deepwater vessels were carried out.

8.12 CONCLUSIONS

The Isle of Grain is home to a number of energy assets of strategic national importance as well as some brownfield sites with redevelopment potential as electrical power generation facilities. At present, the energy facility that poses the greatest potential barrier to airport development on the Isle of Grain is the Grain LNG terminal.

Current HSE advice is inconclusive as to whether Grain LNG and an airport could satisfactorily co-exist and if so, the specific location of the airport that would be acceptable. The current risk assessment is based upon the existing facility, taking into account the short-term development work but not the longer term planned expansion. The reciprocal risks that the airport might introduce are not readily accommodated within existing risk assessment frameworks.

From a security perspective, the co-location of the facilities could provide an attractive target to terrorists with a significant impact upon the UK's energy security and the operation of the UK's hub airport. Indeed, the threat of a safety or security incident would most probably be sufficient to cause major disruption to the airport and surrounding service providers.

Even if it were decided that the energy facilities and the airport could coexist, their location would inhibit the expansion of the airport in a southerly direction, undermining the attraction of the Isle of

Grain as a site that provides relatively unconstrained airport expansion opportunity. Similarly, the existence of an airport would be likely to deter or prevent further energy infrastructure development on the Isle of Grain. The energy facilities at Grain potentially impinge upon the Obstacle Limitation Surfaces of the IAAG airport scheme located to the west of the peninsula; given the height of the power station stacks, they may also have an impact on the airport locations to the east.

Grain LNG is a facility of strategic importance, providing nearly 40% of the UK's LNG importation capacity, storing the equivalent of around 600 million m^3~~mcm~~ of natural gas, which is the equivalent to 100 million m^3 of LNG, and able to supply 20% of the UK's gas demand in a short range, peak shave capacity. Given the UK's forecast growth in demand for imported gas and its desire to maintain a competitive position with regard to gas pricing, it would be necessary to find an alternative site that provides similar capabilities. However, suitable sites with deepwater berthing, space to develop a large scale facility away from residential areas and with reasonable access to the National Gas Transmission System, are not readily available.

It can be expected that the scale of investment into Grain LNG, which will total £1.3bn once the current development phase is complete, would be exceeded by the costs of locating, obtaining approvals, and developing a replacement facility.