Review of the Security of Energy Supply of Ireland's Electricity and Natural Gas Systems

The Department of the Environment, Climate and Communications

28 April 2023

FINAL REPORT

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EXECUTIVE SUMMARY

This appraisal has been commissioned by DECC in the context of its review of the security of energy supply of Ireland's electricity and natural gas systems and concerns surrounding Ireland's dependency on pipeline imports of natural gas from GB. Ireland is one of the most energy import dependent countries in the EU and currently fails the EU N-1 Infrastructure Standard, which requires that EU Member States are able to serve exceptionally high gas demand in the event of a loss of the largest single piece of gas infrastructure.

As part of a broad package of measures being developed to mitigate risks to security of energy supply in Ireland, this report presents an appraisal of two policy proposals designed to enhance Ireland's energy security.

- **Policy Option 1**: Under this policy option, the private sector is enabled to develop and operate new commercial gas infrastructure in Ireland. The type of new gas infrastructure that may be developed under this option includes commercial gas storage and/or LNG import facilities in Ireland.
- **Policy Option 2**: Under this policy option, the State will support the development of strategic gas infrastructure in Ireland as a way to enhance security of energy supply. The 'strategic' element of this option means that the gas infrastructure developed would only be used as a means to avoid unmet energy demand in Ireland.

This appraisal explores the extent to which new gas infrastructure (either commercial or strategic) can help mitigate the impact of disruptions to pipeline imports of natural gas from GB, and help Ireland meet the legal standards related to security of supply as well as the potential environmental and cost impacts associated with this new infrastructure.

Selection of projects for appraisal

A wide range of potential projects could emerge under each high-level policy option. For example, the commercial policy option could include the development of underground gas storage (UGS), onshore LNG storage, or an LNG import facility. Similarly, DECC could pursue a range of strategic projects to mitigate the impact of a loss of pipeline gas supplies from GB. We illustrate some of the potential options in Table 1 below.

Table 1: Potential infrastructure mitigation options under the commercial and strategic policy approaches.

	Commercial Infrastructure Options	Strategic Infrastructure Options
Potential infrastructure developments	• Underground Gas Storage • Onshore LNG Terminal • Offshore FSRU • Onshore LNG Storage	• Underground Gas Storage • Onshore LNG Terminal • Offshore FSRU • Onshore LNG Storage • Jetty infrastructure capable of accommodating an FSRU

Source: CEPA

In addition to the above policy options, other measures to enhance gas security of supply could include demand-side response and increased production of domestic biomethane or hydrogen gas. We understand that DECC is in the process of undertaking an assessment of a wide range of policy options. This report is intended to complement DECC's wider assessment.

For the purpose of this appraisal, we select just one reference project for each policy option.

- **Policy Option 1 – Commercial FSRU**: A FSRU is a floating terminal that can convert imported LNG back into its gaseous state, and then inject it directly into the onshore gas network. It can be refilled by other LNG ships that dock next to it. The development of a commercial FSRU in Ireland would provide a new entry point for the large-scale importation of natural gas, in addition to the existing gas interconnectors with GB.

- **Policy Option 2 – Strategic LNG Storage**: This project aligns with a proposal made by Gas Network's Ireland (GNI) in their consultation response to the Security of Supply Review. GNI's response proposed the creation of an onshore LNG storage facility that would maintain LNG stocks as a strategic reserve for periods when they are needed to avoid unmet demand. The facility could be filled via direct importation of LNG from global markets or by withdrawing natural gas from the existing onshore transmission network in Ireland.

The selection of each project was made in conjunction with DECC and was informed by a range of considerations, including the feasibility of that project in Ireland and its expected impact on security of supply. For each project, we specified a set of reference technical specifications (e.g., the volume of gas that can be held by a gas storage project) that was necessary for the appraisal This selection was also designed to provide insights into the impacts of different project features – for example, to compare strategic or commercial policy options. We note that many of these findings are transferable to other policy options not included in this appraisal.

This selection necessarily meant that other feasible projects which could bring material security of supply benefits to Ireland are not included within our appraisal. We have not formed any views on the merits of any such other projects.

Appraisal approach

We appraise each policy option against the three dimensions of the energy trilemma.

- **Security:** We appraise the ability of each project to mitigate against disruptions to pipeline gas supplies from GB. This includes a review of Ireland's performance against the key security of supply standards set out in EU Regulation 2017/1938.
- **Sustainability:** We consider the potential environmental impact of each project in terms of global emissions and emissions generated in Ireland. For emissions generated in Ireland, we assess how each project may affect Ireland's ability to meet the decarbonisation objectives set out in the Climate Act 2021 and the Sectoral Emissions Ceilings (SEC) set by the Government.
- **Affordability:** We assess the potential cost of each project, including the potential cost impacts on gas consumers and on the exchequer.

Findings

A summary of our appraisal of the selected projects under each heading of the energy trilemma is outlined below.

Security of supply

We find that both options can generate significant security of supply benefits and enable Ireland to pass the N-1 Infrastructure Standard from 2028/29 to the end of the horizon included in GNI's 2022 Gas Forecast Statement. Ireland may continue to fail the N-1 test under the introduction of the Strategic LNG Storage facility as the N-1 test in this case would be based on Ireland's ability to meet peak-day demand in the absence of this mitigation option.[1] GNI's central forecasts show that peak-day gas demand will exceed all available supply sources over this horizon in the absence of any new supply source.

We find several key differences regarding the security of supply benefits offered by the two mitigation options. In particular, there is a higher degree of uncertainty regarding the volume of gas that would be immediately available for use from the commercial FSRU. For example, the disruption to pipeline supplies could coincide with a period in

[1] Based on the specifications set out for this appraisal, the Strategic LNG storage facility would become the largest single piece of gas supply infrastructure in Ireland upon introduction (replacing IC2 which is the current largest supply source). As such, the N-1 test would transpose into an assessment of Ireland's ability to meet peak-day gas demand in the absence of this strategic policy proposal.

which limited LNG stocks are held within the working capacity of the FSRU. In contrast, the volume of gas that is held in the strategic LNG storage facility is determined by policy and will not fluctuate according to commercial decision making.

Table 2 below illustrates the number of days in which demand can be met, by drawing on gas stored within the commercial FSRU or strategic LNG storage (in addition to gas available from other sources – i.e., biomethane and Corrib), when there is a disruption to pipeline imports through IC2. The range presented for the commercial FSRU represents the uncertainty regarding the volume of gas that is held within the FSRU working capacity at the start of the disruption period.

Table 2: Number of days that 1-in-50 peak-day gas demand can be met in the event of a disruption to pipeline imports from GB, 2029/30

No. of days before additional LNG imports are required to avoid demand curtailment (2029/2030)	Commercial FSRU	Strategic LNG Storage
Assuming 1-in-50 peak-day gas demand (GNI Best Estimate)	• 1 to 12 days	• 25 days

Source: CEPA

To continue meeting demand beyond the duration outlined in Table 2, new imports of LNG would need to be sourced, transported, and offloaded into the FSRU. For example, new supplies of LNG would need to be injected into the commercial FSRU within 12 days in 2029/30, following a disruption to IC2 in order to continue meeting annual average demand levels. In contrast, there would be up to 25 days to source new supplies of LNG for the strategic LNG storage facility.

Finally, we highlight that this analysis is highly dependent on the assumed specifications of both the FSRU and the strategic LNG storage facility. For example, in principle a FSRU could be developed alongside a dedicated storage facility or could be used as a strategic facility, while the strategic LNG storage terminal could be scaled up or down in size.

Sustainability

The development of a commercial FSRU facility would allow the direct importation of LNG to Ireland for the first time. Our appraisal highlights that while the lifecycle emissions intensity of LNG can exceed that of pipeline natural gas due to the energy-intensive steps associated with the liquefaction, tanker transport, and re-gasification, the impact of direct LNG imports to Ireland on global emissions is unclear. For example, we expect that LNG imports to Ireland may be associated with lower LNG imports to GB or other European zones.

Furthermore, the introduction of a commercial FSRU could result in higher emissions being incurred in Ireland. For example, the operation of an FSRU can generate additional emissions through regasification, flaring, fugitive emissions and stationary energy. While our appraisal highlights that FSRU emissions are highly dependent on the technical characteristics of the facility (e.g., on the ability of a FSRU to use seawater for heating (regassification)), two global FSRU operators have estimated emissions of between 70,000-80,000 tCo2e per FSRU per annum. This is the equivalent of 2% of the total Electricity SEC between 2026 and 2030.

Our appraisal also highlights the possibility that the introduction of a commercial FSRU may also stimulate higher gas demand in Ireland. For example, introducing new alternative gas supplies may reduce the incentive for some consumers to invest in energy efficiency measures or to switch to other energy solutions (e.g., industrial or commercial heat pumps). Similarly, increased gas import capacity may reduce constraints on future large-energy user (LEU) growth in Ireland. However, we note that any such increases in gas demand may be constrained by Government policies designed to meet the legally binding SECs.

If the introduction of a FSRU stimulates more gas consumption in Ireland, this may have a material impact on Ireland's SEC commitments. For example, research by MaREI indicates that annual gas consumption in Ireland

must fall to between 28 and 42 TWh by 2030 to remain compliant with the SEC commitments. All scenarios included in GNI's 2022 Gas Forecast Statement forecast demand in excess of this range (e.g., the Low gas demand scenario forecasts demand of 45 TWh in 2030). Meeting the SEC in 2030 is already a significant existing challenge. An increase in gas demand in Ireland may therefore have a material impact on Ireland's SEC commitments.

In contrast, the introduction of the strategic LNG storage facility is likely to have a limited impact on emissions. Since the strategic facility would only be used under exceptional circumstances, we would not expect regular imports of LNG or regular demand for regassification services. Further, we would not expect that the strategic facility would have a significant impact on gas demand in Ireland, since the gas held in store will only be used to mitigate significant energy shocks. However, we note that there may be future political pressure to utilise the strategic LNG facility to alleviate price effects for Irish consumers (e.g., pressure on the operator of the strategic reserve to withdraw gas during periods of high gas prices) and/or to enable increased gas consumption in Ireland (i.e., from LEUs).

Affordability

The upfront cost of a commercial FSRU is likely to vary depending on global supply and demandfor such assets, as well as on the scale of onshore infrastructure required to connect the FSRU to the onshore transmission pipeline. A considerable source of additional uncertainty relates to the increase in global demand for FSRU capability following Russia's invasion of Ukraine in February 2022.

While there is uncertainty regarding the upfront cost of a commercial FSRU, our appraisal suggests that a purely commercial FSRU would not necessarily result in additional costs for Irish gas consumers or for the Irish exchequer. Up-front costs would instead be supported and recovered by the commercial developer through the provision of an alternative supply of natural gas to Irish consumers. Given average gas demand in Ireland is expected to fall over time, a successful commercial FSRU project would be required to displace some of the pipeline supplies of natural gas from GB through IC1 and IC2.

Our appraisal also noted that there were a number of additional risks associated with a commercial FSRU project:

- **Revenue risk**. A commercial business model rests on the proposition that LNG supplies can displace some pipeline gas imports from GB. Failure to do so generates a risk of under-recovery for the commercial operator. This could generate a risk that the commercial FSRU would exit the Irish market and/or require public support.
- **Pipeline revenue risk**. As noted above, the introduction of a commercial FSRU may result in a decline in pipeline gas imports to Ireland. A decline in pipeline imports may result in a revenue shortfall for IC1 or IC2 (i.e., via entry and exit tariffs).

There is a significant up-front cost associated with the strategic LNG storage facility that is proposed by GNI. These costs include the construction of the jetty infrastructure, liquefaction facility, LNG storage, and gas stocks, estimated to reach a cost in [redacted]. We note that the upfront cost of the strategic storage facility is highly dependent on the specifications of that facility. For example, the liquefaction plant proposed by GNI is estimated to cost [redacted]. Developing LNG storage without this feature would therefore generate significant cost savings relative to GNI's proposal, however it could also alter the security of supply benefits or the environmental impact of the option. For example, the removal of the liquefaction facility would mean that the storage facility could only be filled using LNG imports.

Further, we note that other, potentially lower cost, strategic gas infrastructure options could also theoretically be delivered. For example, a FSRU could be procured to serve as a strategic source of gas imports in the event of a loss of pipeline supplies from IC1 and IC2.

1. INTRODUCTION

The Department of the Environment, Climate and Communications (DECC) is conducting a review of the security of energy supply of Ireland's electricity and natural gas systems ("Security of Supply Review"). To inform this review, CEPA was commissioned by DECC to undertake a technical analysis of physical security of supply shocks and potential policy mitigation options.[2]

Following an extensive consultation process, DECC has commissioned CEPA to undertake a further, targeted appraisal into a limited number of policy options that may mitigate against a disruption of pipeline imports of natural gas from Great Britain (GB).

1.1. CONTEXT

This analysis is undertaken in the context of concerns raised in the Security of Supply Review regarding Ireland's dependency on pipeline imports of natural gas from GB. Ireland is one of the most energy import dependent countries in the EU, with 71% of all natural gas supplies being imported via two gas interconnector pipelines from GB (IC1 and IC2) in 2020/21.[3] This share is expected to increase as Ireland's indigenous gas supplies from Corrib decline over the next decade. Ireland currently fails the EU N-1 Infrastructure Standard which requires that EU Member States are able to serve exceptionally high gas demand in the event of a loss of the largest single piece of gas infrastructure.[4]

Security of supply risks surrounding pipeline imports of natural gas to Ireland was also identified in CEPA's technical analysis for DECC. That analysis showed that the loss of pipeline gas imports from GB would likely result in widespread demand curtailment of electricity and natural gas consumers. The reliance of Ireland's energy system to pipeline imports of natural gas from GB was also highlighted as a key risk by a range of other stakeholders in their consultation responses to the Security of Supply Review consultation.

These concerns around security of supply occur within a rapidly evolving energy landscape. Russia's invasion of Ukraine, as well as Ireland's objective to decarbonise its energy systems, are driving major changes to electricity and natural gas systems in Ireland and beyond.

- The 2020 Programme for Government (PfG)[5] set a target to reduce total emissions in Ireland by 51% by 2030, relative to 2018 levels. This target became legally binding as part of the Climate Action and Low Carbon Development (Amendment) Act 2021. In September 2022, the Irish Government established a legally binding Sectoral Emissions Ceiling for sectors such as electricity, transport, and agriculture. Each Ceiling acts as limit on the maximum quantity of emissions that each sector is permitted to produce over a specific period of time.
- To meet the Government's emissions targets, Ireland's electricity supply will become increasingly dependent on variable renewable generation (wind and solar) and on electricity imports through interconnectors. The 2023 Climate Action Plan (CAP)[6] set out a plan for this transition which includes

[2] The technical analysis undertaken by CEPA is available online on gov.ie

[3] GNI (2021) Winter Outlook, available on gasnetworks.ie

[4] The N-1 Infrastructure Standard is set out in Regulation (EU) 2017/1938 of the European Parliament and the Council and is available on europa.eu. A 2018 assessment by the CRU found that Ireland only passes the N-1 Infrastructure Standard if assessed on a regional basis along with the UK. Subsequent to UK's exit from the EU, Ireland can no longer be assessed along with the UK for the purpose of the N-1 Infrastructure Standard.

[5] 2020 Program for Government, available on gov.ie

[6] Climate Action Plan 2023, available on gov.ie

adding new zero-carbon electricity generation capacity, electrifying demand from heat and transport, and phasing out coal and peat from electricity generation.

- The 2020 PfG also set out that the Government does not support the importation of fracked gas[7] from other countries as Ireland moves towards carbon neutrality.[8] This stance was reiterated in the Policy Statement on the Importation of Fracked Gas published by DECC in May 2021.[9] Additionally, the statement noted that it would not be appropriate to allow the development of a liquified natural gas (LNG) terminal in Ireland until the outcome of the Security of Supply Review was understood.

- Ireland's indigenous natural gas production has ceased at the Kinsale field and is expected to decline at Corrib over the next decade. However, since gas will be needed as the principal source of non-variable electricity generation, and exploration of new fields will not be allowed, Ireland's dependency on pipeline gas imports from GB is expected to increase.

- EirGrid forecast significant increases in electricity demand in Ireland. The increase in demand is driven by faster electrification of heat and transport and by increasing demand from Large Energy Users (LEUs), such as data centres. GNI have forecast increases in gas demand from the power sector (i.e., from gas-fired power stations), which will mean that peak-day gas demand could soon exceed the maximum import capacity across all supply sources in Ireland by 2023/24. We note that GNI's 2022 Gas Forecast Statement[10] also highlights that a series of short-, medium-, and long-term proposals to mitigate constraints across IC1 and IC2 are being considered.

- The Russian invasion of Ukraine in February 2022 has caused major disruptions to global energy markets. Russian exports of natural gas, oil, and coal to European markets has significantly reduced or ceased. As a result, European gas markets are increasingly meeting demand through the importation of LNG cargoes. This shift in the pattern on gas imports into Europe has been facilitated by the rapid development of LNG import facilities across European markets, such as in Italy and Germany.

- In response to the global energy market disruption caused by Russia's invasion of Ukraine, the European Commission has developed a REPowerEU plan which sets out an increased ambition around energy saving measures, the production of clean renewable energy, and the diversification of energy supplies.[11] The plan includes the development of a platform for the common purchase of gas, LNG, and hydrogen for all Member States.

- In June 2022, EU Member States adopted new legislation that defined gas storage facilities as critical infrastructure. In November 2022, the European Commission set out a new target that underground gas storage (UGS) levels should reach 90% of capacity by the 1 November 2023.[12] A filling trajectory based on separate intermediary targets are set for each Member State with UGS for February, May, July, and September.

Finally, we note that this study should be interpreted in the context of the broader programme for security of energy supply in Ireland. While CEPA's technical analysis for DECC found that the Irish energy transition (e.g., the delivery

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[7] Fracking is a method of oil and natural gas extraction which involves injecting fluid into subterranean rock formations at high pressure to produce a fracture network that allows crude oil and natural gas inside dense rocks to be extracted at the surface. The approach can lead to detrimental environmental impacts in terms of water consumption, water contamination, seismic inducement, and air pollution.

[8] Programme for Government: Our Shared Future, October 2020

[9] DECC (2021) 'Policy Statement on the Importation of Fracked Gas', available on gov.ie

[10] GNI (2023) Gas Forecast Statement – 2022, available on gasnetworks.ie

[11] European Commission (2021) RePowerEU affordable, secure, and sustainable energy for Europe. Available on Europa.eu

[12] European Commission (Nov 2022) 2022/2301. Available on Europa.eu

of new RES capacity and indigenous biomethane production) is likely to make a significant contribution to future energy security, a series of near-term steps to protect security of supply are also being taken. For example, we note the CRU has put in place a programme to protect electricity supply, which includes the direct procurement of back-up generation, as well as exploring the option to retain older electricity generation units on a temporary basis.[13] The analysis set out in this study to appraise a limited number of additional policy options should be understood within this broader context.

1.2. OBJECTIVE

The objective of this report is to conduct an appraisal of two policy proposals from DECC designed to enhance Ireland's physical security of electricity and gas supply against a disruption of pipeline gas imports from GB.

- **Policy 1**: Enabling the private sector to develop commercial gas storage and/or commercial LNG import facilities in Ireland.
- **Policy 2**: Direct the development of strategic gas storage and/or strategic LNG import facilities in Ireland.

While both options could cover a diverse range of projects (e.g., UGS or an LNG import terminal), this study is limited to the appraisal of one assumed reference project that could be developed under each policy option. This appraisal will cover each aspect of the energy trilemma.

- **Security**: The extent to which each project can mitigate a series of physical energy supply risks that may arise in Ireland due to its current reliance on gas imports from a single supply source using a limited amount of infrastructure.
- **Sustainability**: Greenhouse gas emissions and other wider environmental impacts of each project. This assessment also examines impacts from each project on the 2022 Sectoral Emissions Ceilings.
- **Affordability**: The cost of each project for energy consumers and taxpayers in Ireland.

This assessment is primarily qualitative, informed by technical analysis that has already been conducted by CEPA in support of the security of supply of Ireland's electricity and natural gas systems review.

1.3. REPORT STRUCTURE

The rest of this report is structured as follows:

- **Section 2** defines the assessment methodology that has been adopted for this report.
- **Section 3** outlines the policy options and reference projects that will be included in our appraisal.
- **Section 4** presents our assessment of each project.

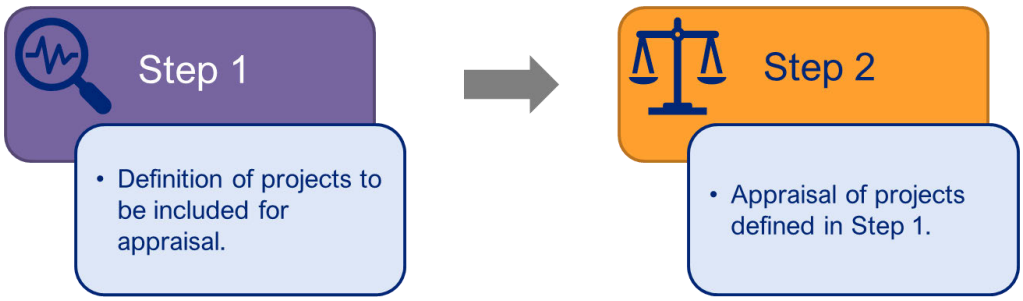
[13] CRU (2021) Electricity Security of Supply Program of Work Update, available on cru.ie

2. ASSESSMENT METHODOLOGY

This section outlines our approach to meeting the aims of this project. The approach is based on two distinct steps:

- Step 1 – setting out the policy options considered by DECC and identifying example projects that are to be included in our appraisal.
- Step 2 – appraisal of each project that is defined in Step 1.

Figure 2.1: Assessment stages



Source: CEPA

Step 1: Describe the policy options and example projects for appraisal

DECC wish to understand the impact of two high-level policy options in Ireland:

- **Policy option 1 ("Commercial"):** Under this policy option, the private sector is enabled to develop and operate new commercial gas infrastructure in Ireland. The type of new gas infrastructure that may be developed under this option includes gas storage and/or LNG import facilities in Ireland. It is assumed that, under this option, projects are developed and operated on a purely commercial basis, with no direct financial support from the Government. It is important to note that, as part of this project, we assess the impacts on this option against three dimensions of the energy trilemma, however we do not assess the commercial viability of these projects.
- **Policy option 2 ("Strategic")**: Under this policy option, the State will support the development of strategic gas infrastructure in Ireland as a way to enhance security of energy supply. The 'strategic' element of this option means that the gas infrastructure developed under this option would only be used as a means to avoid unmet energy demand in Ireland.

There are a wide range of potential projects that could emerge under each high-level policy option. For example, the commercial policy option could result in the development of underground gas storage (UGS), onshore LNG storage, or a LNG import facility. Similarly, DECC could pursue a range of strategic projects that would help mitigate the impact of a loss of pipeline gas supplies from GB.

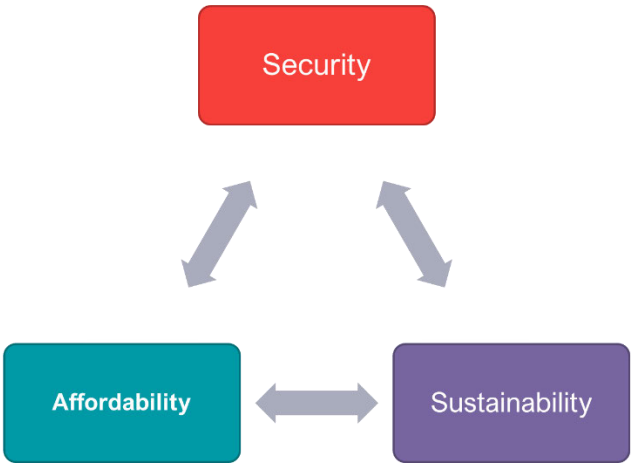
For the purpose of this study, we compare one notional reference project that could potentially be developed under the commercial policy proposal, with a selected project under the strategic policy proposal. This selection was made in conjunction with DECC and is informed by a range of considerations, including the feasibility of that project in Ireland and the expected impact from that project on security of supply. For each project, we specify a set of reference technical specifications (e.g., the volume of gas that can be held by a gas storage project) that is necessary for the appraisal. This exercise was also meant to provide insights into the impacts of key project features – for example, to compare the impact of a strategic versus commercial policy option. We note that many of these findings are transferable to other policy options not included in this appraisal.

This approach necessarily means that other potentially feasible projects which could bring material security of supply benefits to Ireland are not included within our formal appraisal. In drafting this report, CEPA have not formed any views on the merits of any project which is not included within the formal appraisal process.[14]

Step 2: Appraisal

This report appraises each project selected in Step 1 against all three dimensions of the energy trilemma, as illustrated in Figure 2.2 below.

Figure 2.2: Dimensions of the energy trilemma



Source: CEPA analysis

We also consider **risks and deliverability challenges associated with each policy option** in Ireland. Our approach to assessing each dimension is outlined in detail below.

Security

Under this dimension, we evaluate each project's ability to mitigate against a series of physical energy supply risks that may arise in Ireland.[15] First, we consider the potential to mitigate against the risk that peak-day gas demand in Ireland may soon exceed all available gas supply capacity. GNI forecast that peak-day gas demand may exceed all available supply sources from 2023/24.

Next, we appraise the contribution of each project to Ireland's ability to meet the key security of supply standards set out in EU Regulation 2017/1938[16]. This Regulation sets out the measurements used across the EU to assess if security of supply is adequate.

- The **gas supply standard** stipulates that EU Member States must be capable of supplying gas to meet demand from protected consumers in the case of an ongoing disruption to the single largest piece of gas infrastructure under a range of demand conditions – e.g., over a 7-day period of extreme temperatures and over a 30-day period of average winter conditions. In Ireland, protected customers are defined as 'all residential gas customers, SMEs, hospitals, nursing homes, high-security prisons, district heating schemes and other essential social services.

[14] Similarly, the selection of projects for appraisal should not be understood as an endorsement by CEPA as to the relative merits of these projects versus other alternatives.

[15] We note that, for the purpose of this report, we do not assess all potential security of energy supply risks facing Ireland. A detailed identification and analysis of security of supply risks for both gas and electricity systems in Ireland was conducted for the technical analysis underpinning DECC's Security of Supply Review consultation in 2022. In this paper, we consider a subset of the key risks affecting physical gas security of supply in Ireland that the options analysed in this paper are aimed to mitigate against.

[16] Regulation (EU) 2017/ 1938 of the European Parliament and of the Council, available on europa.eu

- The **infrastructure standard** incorporates the N-1 criteria which requires that EU Member States should be capable of meeting exceptionally high gas demand in the event of a loss of Ireland's largest single piece of gas infrastructure. A 2018 assessment has found that Ireland only passes the N-1 calculation if assessed on a regional basis along with the UK.[17]

Finally, we also appraise the mitigation offered by each project in the case of a **total loss of pipeline imports of natural gas from GB**. This assessment formed a key risk within the technical analysis undertaken by CEPA for DECC to inform the Security of Supply Review.

Sustainability

We appraise the potential environmental impact of each project in terms of global emissions and emissions generated in Ireland. For emissions generated in Ireland, we assess how each project may affect Ireland's ability to meet the decarbonisation objectives set out in the Climate Act 2021 and the Sectoral Emissions Ceilings approved by the Government. This assessment covers emissions from the consumption of gas by end consumers in Ireland alongside any direct emissions generated by each project – e.g., emissions incurred from the consumption of energy to maintain liquid gas supplies in storage.

To assess the sustainability of each option, we also review the extent to which each option could increase emissions outside Ireland – e.g., by importing gas from more carbon-intensive supply sources. We also briefly review the impacts of each option on wider environmental indicators in Ireland including air-quality, water quality, noise, and biodiversity.

Affordability

We assess the potential cost of each project including the potential cost impacts on gas consumers and on the exchequer. This requires assumptions regarding how the likely cost of each policy option will be recovered – i.e., through gas tariffs or through general taxation. We also assess secondary cost impacts associated with each policy option on gas and electricity prices in Ireland.

[17] CRU (2018) *National Preventive Action Plan Gas, 2018 – 2022*

3. DESCRIPTION OF POLICY OPTIONS

This section describes the two policy options which are under consideration for this study. In all cases, we describe the technical characteristics of each option in the context of evolving gas demand in Ireland, the key statistics of which are presented in Table 3.1 below.

Table 3.1: GNI gas demand forecasts

GNI forecasts (Best Estimate)	2023 / 2024	2029 / 2030
Annual average daily gas demand (GWh/day)	187	152
Peak-day gas demand[18] (GWh/day)	350	316

Source: GNI Gas Forecast Statement 2022

3.1. POLICY 1: COMMERCIAL MITIGATION

Overview of policy option

Under this policy option, private developers build new commercial gas infrastructure (e.g., seasonal gas storage or an LNG import terminal) in Ireland.[19] Under this approach, we assume that decisions regarding the use of the new facility (e.g., importation, storage, and withdrawal) are determined according to the market forces facing the asset operator. For example, a commercial storage facility would be expected to store gas during periods when the price is low (typically in the summer) and withdraw gas during periods when the price is high (typically in the winter). Similarly, LNG import flows to an LNG entry point in Ireland would be dictated by the relative price of LNG imports compared to pipeline imports from GB.

Seasonal storage and LNG import facilities are currently in operation across Europe. For example, UGS facilities are in operation in eighteen EU Member States[20] and in GB.[21] Similarly, LNG import capabilities are available to twelve EU Member States and GB.

These facilities can provide significant security of supply benefits:

- **Gas storage** typically provides 25-30% of all gas consumed in the EU during the winter. Gas storage can help balance supply and demand by withdrawing gas during periods when supply is plentiful and injecting gas during periods when supply is more constrained. In periods where demand and supply are out of balance (e.g., during periods when other supply sources are unavailable or insufficient), gas held in storage can be withdrawn to avoid demand curtailment. Following the Russian invasion of Ukraine, new EU regulations have defined the minimum level of gas that must be held in UGS facilities.[22]
- **LNG import capability** provides a country with direct access to global gas market. European Member States significantly increased their consumption of LNG from the USA and Qatar following Russia's invasion

[18] All peak-day gas demand figures included in this report relate to 1-in-50 peak day demand levels forecast by GNI. This level of gas demand exceeds what is set out in EU Regulation 2017/1938 which assumes peak-day gas demand is calculated on a 1-in-20 basis. GNI do not publish peak-day gas demand figures in 1-in-20 terms. However, we understand from discussions with GNI that 1-in-50 peak-day gas demand in Ireland is similar to 1-in-20 demand.

[19] This assessment has not reviewed the deliverability of any commercial project in Ireland or reviewed the extent to which changes to Government policy would be required in order to increase the likelihood of any commercial project materialising.

[20] Including Austria, Belgium, Bulgaria, Croatia, Czechia, Denmark, France, Germany, Hungary, Italy, Latvia, Netherlands, Poland, Portugal, Romania, Slovakia, Spain, Sweden.

[21] There are currently eight gas storage facilities operated by private companies in GB, with a combined storage capacity of 3,030 million cubic meters (mcm) or 272 GWh. Available on ofgem.gov.uk

[22] For example, UGS facilities must be filled to 90% of their capacity by 1 November of 2023. Details are available on europa.eu

of Ukraine in April 2022, reducing their reliance on Russian gas. Having LNG import capability can help reduce strategic risks associated with reliance on a single gas supply source or a critical piece of infrastructure.

Ireland does not currently have any gas storage or LNG import capabilities. We note, however, that there are a range of projects proposed for development related to both commercial storage and LNG in Ireland.

Selection of reference project for appraisal

In agreement with DECC, we selected a commercial LNG terminal in the form of a Floating Storage and Regasification Unit (FSRU) as the reference project for this policy option. We provide more detail on the selection of this project in the text box below.

A FSRU is a floating terminal that can convert imported LNG back into its gaseous state, and then inject it directly into the onshore gas network. It can be refilled by other LNG ships that dock next to it. The development of a FSRU in Ireland would provide a new entry point for the large-scale importation of natural gas, in addition to the existing interconnectors with GB.

Box 1: Commercial Gas Storage vs Commercial LNG

The commercial policy option could result in the development of several forms of gas infrastructure in Ireland, such as UGS, onshore LNG terminal or FSRU.

Commercial UGS and commercial LNG qualitatively differ in the following ways.

- **Access to diversified supply sources**. An LNG terminal provides direct access to a diverse set of gas producing regions, such as the USA, Qatar, and Australia. UGS must be filled with gas sourced via the existing pipeline network.
- **Protection against longer-term supply shocks**. Both UGS and LNG can protect against short-term supply shocks (e.g., the sudden loss of pipeline imports of natural gas from GB). However, if the supply disruption continued for an extended period of time, the UGS facility would eventually be depleted as its stores are used to meet demand, while an LNG terminal could secure new supplies from the global market over an extended period.
- **Daily export capacity**. The withdrawal rate from UGS is typically lower than the withdrawal rate of gas held as LNG. This means that a UGS facility may not be able to meet all domestic gas demand in the event of a loss of pipeline supplies from GB. For example, the Kinsale storage facility which was in operation in Ireland until 2017 had a withdrawal rate of 2.6 mcm/day (29 GWh/day) which is significantly below the 350 GWh/day 1-in-50 peak-day gas demand estimated by GNI for 2023/24.
- **Sustainability and cost**. The development of an LNG terminal in Ireland would likely result in the direct importation of fracked gas to Ireland which would run counter to the commitments set out in the 2021 PfG.[23] The importation of LNG may also generate additional emissions in Ireland through energy consumed for re-gasification services. Both options will also differ in their upfront and ongoing cost.

Commercial UGS and commercial LNG can both bring significant security of supply benefits. For example, both facilities can help mitigate the impact of a disruption of gas supplies to Ireland by providing additional volumes of gas when supply would otherwise be insufficient to meet demand (e.g., during a disruption to pipeline imports from GB). However, an LNG facility is more likely to be able to provide the daily export capacity needed to substantially mitigate the impact of a full disruption to pipeline imports from GB.

Recent experience also shows that several FSRUs have been delivered in Europe within a short timeframe, especially following Russia's invasion of Ukraine in February 2022, in places such as Poland, Italy, the Netherlands, Finland, and Germany. Compared to a permanent onshore LNG terminal, a FSRU could be delivered in a shorter time frame and could be sold if not needed, reducing stranded asset risk.

Therefore, in agreement with DECC, we considered that a commercial FSRU project is the most likely option to be delivered commercially in the near term and that has the potential to provide sufficient mitigation against the most severe gas supply disruption risks that may arise in Ireland.

[23] Department of the Taoiseach (2021) 'Programme for Government, available on gov.ie

FSRUs can come in a range of sizes[24] which will each bring a range of impacts and trade-offs within our appraisal framework. For the purposes of this study, we base the characteristics of the commercial FSRU project on a notional facility with the following core characteristics:

- The FSRU re-gasification capability is equivalent to 50 terawatt hours (TWh) of energy per annum. This is the equivalent of 73% of Irish natural gas demand forecast by GNI for 2023/24.
- The working capacity of the FSRU is equivalent to 1,200 GWh of natural gas. This refers to the maximum volume of LNG that can be held within the FSRU facility itself – i.e., LNG that has been imported into the FSRU, but which has not been re-gasified and injected into the onshore gas transmission network. The volume of gas that is held within the working capacity at any point in time will depend on commercial import/export decisions made by the FSRU operator. This volume is equivalent of three days of peak-day gas demand in Ireland forecast by GNI for 2023/24.

This FSRU is assumed to not have any storage facilities outside of the working capacity held within the FSRU. This means that the volume of gas that is immediately available from the FSRU in the event of an unforeseen security of supply event (e.g., the sudden loss of gas supplies from Corrib or GB) is not guaranteed. For example, LNG stocks would be driven solely by market fundamentals, such as the spread between gas prices in Europe versus Asia which determines how much LNG can be attracted to European markets. If the market conditions are adverse, the LNG stocks of the FSRU may be at a depleted state at the point at which a supply shock occurs.

In practice, commercial gas infrastructure could be combined with a strategic facility. For example, a commercial FSRU developer could be required to maintain a certain volume of gas in storage at all times until such a point that it is needed to mitigate risks to Irish gas demand. We also note that current EU regulation already requires UGS to maintain a certain volume of gas at different points in time – for example, all UGS in the EU is required to be at 90% capacity on 1 November 2023.Technical specification of the project for appraisal.

3.2. POLICY 2: STRATEGIC MITIGATION

Overview of policy option

Under this policy option, the Irish Government enables the development of new strategic gas infrastructure in Ireland. Strategic infrastructure in this case refers to new gas infrastructure that is used exclusively for security of supply purposes. For example, a strategic gas storage facility is assumed to hold gas in store until a point in time when its supply is required in order to avoid load shedding.[25]

The primary benefit of developing a strategic mitigation option relative to a commercial mitigation option is that strategic infrastructure can guarantee that a certain volume of gas will be available in the event of an unanticipated supply shock. As noted above, the volume of gas held in commercial gas storage or in the working capacity of a FSRU is dependent on decision-making made by the commercial infrastructure operator. This means that any commercial option does not necessarily guarantee that gas will be available in sufficient quantities to meet demand in the event of an unexpected supply shock.

CEPA's technical analysis for DECC to inform the security of energy supply consultation reviewed the security of supply impacts of introducing both strategic UGS and a strategic FSRU to Ireland. This analysis showed that the introduction of both mitigation measures can provide significant mitigation against the total loss of pipeline imports of natural gas from GB.

[24] For example, we note that new European FSRU projects commissioned since the Russian invasion of Ukraine in March 2022 have varied by import size from 32 TWh/year (KrK FSRU in Croatia) to 89 TWh/year (Eemshaven FSRU in the Netherlands).

[25] This follows a similar model for natural gas as Ireland's National Oil Reserves Agency (NORA) which was founded in 1995 and which is responsible for maintaining strategic supplies of oil in Ireland in line with EU and IEA obligations.

Selection of reference project for appraisal

In agreement with DECC, we select a strategic onshore LNG storage facility as the project for appraisal under this policy option. This project aligns with a proposal made by Gas Networks Ireland (GNI) in their consultation response to the Security of Supply Review.

GNI have proposed the creation of an onshore LNG storage facility that would maintain LNG stocks as a strategic reserve for periods when it is needed to avoid demand curtailment. GNI say that this facility could be filled in two ways:

- **Direct importation of LNG through a jetty**. The facility would initially be accompanied by a FSRU which would have the capability to directly import LNG from global markets. After this initial period, onshore re-gasification capability would be developed and the FSRU would not be retained. However, the jetty and associated infrastructure would remain which means that Ireland would retain the capability to import LNG from global markets which would be gasified in the onshore terminal.
- **Liquifying natural gas drawn from the existing transmission network**. The storage facility would be filled on a long-term basis by drawing gas from the onshore transmission network in Ireland. This would be cooled and liquified at the storage facility itself.

Box 2: Other strategic mitigation options

The strategic mitigation option proposed by GNI covers a broad range of technical features including LNG storage, LNG importation, re-gasification, and slow liquefaction. We note that there are a range of feasible strategic options which do not cover all of these features, but which can still provide various degrees of security of supply benefits at different levels of costs. For example:

- **Storage sizing**: The storage component of the facility could be sized to a higher or lower level to what was proposed by GNI. Higher levels of storage would increase the security of supply benefits in the case of a sudden loss of pipeline gas imports from GB but would also increase costs (e.g., infrastructure costs and stock gas costs). Similarly, a smaller storage facility could still mitigate against a disruption to pipeline gas imports, but for a more limited period of time and/or only be able to meet a portion of the expected peak-day gas demand. However, the costs associated with the construction and operation of a smaller facility are also likely to be lower.
- **No slow liquefaction**: The LNG storage facility could be filled through global LNG imports only. This would mean that shipments of LNG imports would need to be delivered to the facility on an enduring basis.
- **No global LNG imports**: The storage facility could be developed so that it is not connected to global LNG markets. Under this approach, the facility would be filled through the onshore liquefaction facility only – i.e., as per conventional UGS. This could reduce the costs associated with building the LNG import infrastructure, however it would also mean that the gas stock levels cannot be replenished in the case of a severe and prolonged disruption to pipeline gas imports to Ireland.
- **Jetty infrastructure facility only**: A strategic facility that consists of jetty infrastructure to accommodate a FSRU only could be developed. Under this approach, an FSRU would need to be connected in order for LNG supplies to be injected into the Irish transmission network. For example, Ireland could buy an FSRU which is then leased to another country on condition that it is returned to Ireland if needed for security of supply purposes (i.e., a disruption to IC1 or IC2). This approach would minimise the level of infrastructure needed in Ireland but would increase risks to consumers around the length of time that it would take for an FSRU to connect to the jetty facility in Ireland.

Technical specifications for this assessment

The specifications of this project for the purposes of our appraisal are all based on the specifications proposed by GNI:

- The storage capacity consists of two LNG tanks with a volume of 180,000 cubic meters each. This equates to 2,459.8 GWh of natural gas equivalent or over 7 days of continuous peak-day demand in Ireland forecast by GNI for 2023/24.

- The daily send-out capacity is 360 GWh/day of natural gas. This send-out capacity exceeds peak-day gas demand under any demand scenario included in GNI's 2022 Gas Forecast Statement.
- Based on the liquefaction rate stated by GNI in their proposal, we estimate that it will take 27 weeks to fully refill the storage facility using gas that is liquified and withdrawn from the onshore transmission network. However, GNI say that the facility will be capable of injecting 170,000 cubic meters of LNG imports into storage within 36 hours.

We note that GNI's proposals imply that for relatively short disruptions, the volume of gas held in storage may be sufficient to avoid any demand curtailment in Ireland. For longer disruptions, additional import of LNG may be required for the facility to continue to meet demand. This could be done by acquiring an LNG shipment from the global market.

GNI say that the onshore storage facility can be built so that it is hydrogen-ready and thus compatible with the development of a future hydrogen industry in Ireland. GNI say that their proposal is capable of handling hydrogen gas blends and that the facility can be converted to enable its use for the storage, import, and export of hydrogen in the future.

3.3. SUMMARY

Table 3.2 summarises the technical characteristics of the two projects which are appraised in this paper.

Table 3.2: Reference projects assessed in this study.

Criteria	Commercial Policy Option	Strategic Policy Option
Project	Commercial FSRU	Combined strategic LNG storage, gas liquefaction, and LNG import facility
Access to global LNG markets	Yes	Yes
Dedicated storage	No	Yes
Storage capacity	Between 0 and 1.2 TWh of natural gas equivalent held within the working capacity of the FSRU.	2.5 TWh of natural gas equivalent held in strategic storage.
Export capacity per day	137 GWh of natural gas per day.	360 GWh of natural gas per day.

Source: DECC, CEPA analysis

4. FINDINGS

This section summarises the results of our appraisal of each policy option against the three dimensions of the energy trilemma.

4.1. SECURITY OF SUPPLY

We appraise the impact of each project selected in Section 3 on the security of energy supply in Ireland. In order to inform this appraisal, we first assess the level of security of supply in Ireland in the absence of either project being developed.

4.1.1. Security of Supply: no mitigation measures

This section outlines Ireland's performance against the security of supply risks outlined in outlined in Section 2, assuming no new mitigation measures are put in place.

Peak-day gas demand risk

GNI's most recent forecasts[26] show that peak-day gas demand may soon exceed all available supply sources in Ireland. This risk is driven by both demand-and supply-side factors.

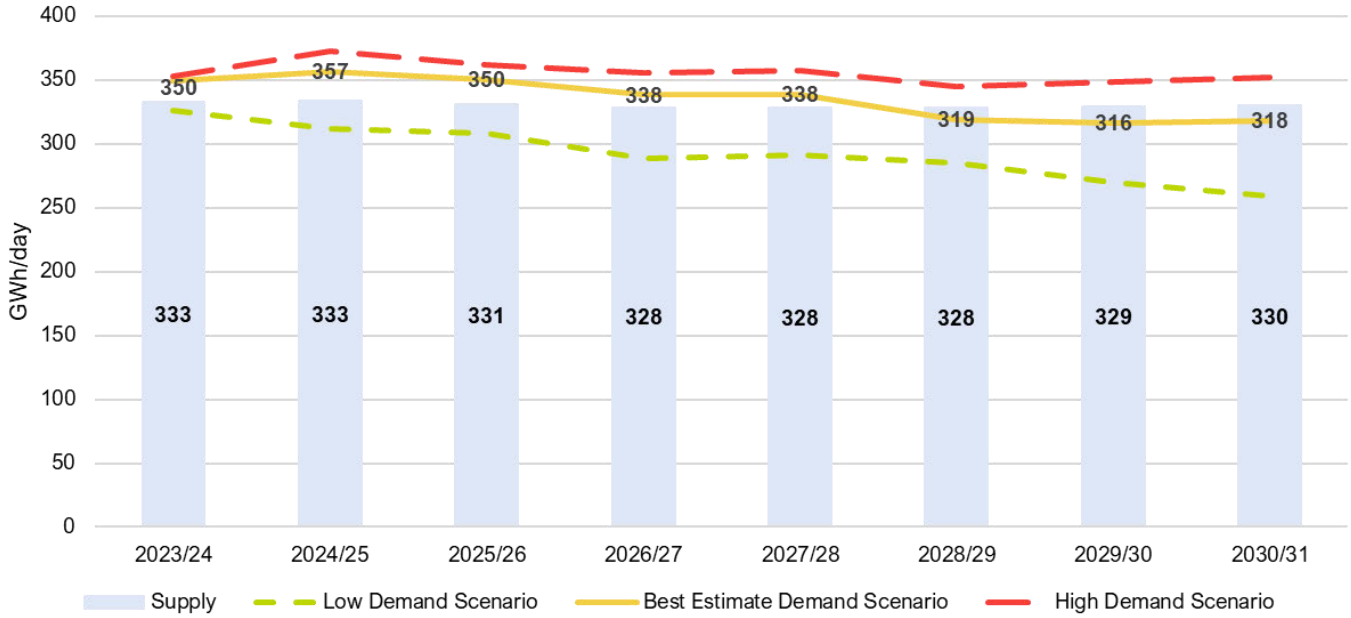
- **Supply-side:** Indigenous supplies of natural gas from Corrib are expected to fall, while Ireland's import capacity allocation across IC1 and IC2 is currently limited to 29.8 mcm/day (300 GWh/day). Potential increases in indigenous supplies of biomethane are not expected to compensate for the fall in supplies from Corrib. We understand that GNI are exploring options to increase this import capacity allocation.[27]
- **Demand-side:** While annual gas demand is expected to fall between 2023/24 and 2030/31, peak-day gas demand is expected to remain relatively robust over the next decade. The peak-day gas demand is driven by the power sector's reliance on gas-fired generation on days when the availability of intermittent renewable generation (e.g., wind and solar) and electricity imports via interconnectors are low, as well as gas demand for space heating when temperatures are very low.

The evolution of peak-day gas demand relative to supply in Ireland is illustrated in Figure 4.1 below. The figure shows that Ireland faces a near-term risk of a material imbalance between peak-day demand and supply. Under GNI's Best Estimate scenario, peak-day gas demand exceeds all available supply capacity between 2023/24 and 2027/28. Declines in peak-day gas demand from 2028/29 onwards mitigate against this risk in the medium term.

[26] GNI (2023) 2022 Gas Forecast Statement

[27] The likelihood or impact of such a change is outside of the scope of this appraisal.

Figure 4.1. Supply capacity and 1-in-50 peak-day gas demand in Ireland, 2023/24 – 2030/31



Source: CEPA analysis, GNI Gas Forecast Statement 2022

The figure above also illustrates how the evolution of domestic gas demand can help mitigate or exacerbate this risk. For example, under GNI's Low demand scenario all peak-day gas demand can be served through available supply sources across the forecast period. We understand that the range of peak-day demand forecasts is predominantly driven by variations in gas demand from the power sector.[28]

Gas Supply Standard

Ireland is currently compliant with all three requirements set out under the EU Gas Supply Standard. The Standard requires that Irish gas demand from protected consumers can be met in the case of:

a. extreme temperatures during a 7-day peak period occurring with a statistical probability of 1-in-20 years;

b. any period of 30 days of exceptionally high gas demand, occurring with a statistical probability of 1-in-20 years; and

c. for a period of 30 days in the case of disruption of the single largest gas infrastructure under average winter conditions.

In all cases, Ireland meets the requirements set out by the EU Gas Supply Standard. This result is robust to using any gas demand forecast published by GNI in its 2022 Gas Forecast Statement. We also note that the EU security of supply standards are defined based on 1-in-20 peak-day gas demand conditions. As GNI do not publish 1-in-20 demand forecasts, we have reviewed each of the conditions outlined above based on the 1-in-50 peak-day demand forecasts published in the 2022 Gas Forecast Statement. We understand from discussions with GNI that 1-in-20 and 1-in-50 peak-day gas demand forecasts for Ireland are likely to be similar.

Our assessment of the third condition set out under the EU Supply Standard is based on Ireland's ability to meet all protected demand in the event of a loss of all pipeline imports from IC2 (the largest single gas infrastructure in Ireland). We find that all protected demand can be met through combined supplies from IC1, Corrib, and biomethane sources.

[28] The High peak-day demand forecast is based on EirGrid's high electricity demand scenario; the Best Estimate peak-day gas demand forecast is based on EirGrid's median demand scenario; and the Low peak-day demand forecast is based on EirGrid's Low electricity demand scenario.

N-1 Infrastructure Standard

We find that Ireland fails to meet the requirements set out under the N-1 infrastructure standard when assessed on a national level – i.e., when it is not assessed on a regional basis with the UK.[29] In the event of a loss of gas supplies from the IC2 interconnector, Ireland is unable to meet peak-day gas demand via supply from other available supply sources (IC1, Corrib, biomethane).

For example, Table 4.1 below illustrates that just 64% of peak-day gas demand can be met in 2023/24. While this proportion is expected to increase to 69% by 2029/30, this shows that Ireland will continue to fail the N-1 Infrastructure Standard in the medium term with the gas infrastructure currently available.

Table 4.1: Best estimate 1-in-50 peak-day gas demand and supply in Ireland in the event of a loss of supply from IC2, 2023/24 and 2029/30

GNI forecasts **(Best Estimate)**	2023 / 2024	2029 / 2030
Daily supply capacity excluding IC2 (GWh/day)	222	218
Peak-day demand (GWh/day)	350	316
% of demand met	63%	69%

Source: CEPA analysis, GNI Gas Forecast Statement 2022

We note that the N-1 test does not take into account additional mitigations that could be provided by the use of linepack or secondary fuel switching by gas-fired electricity generators in Ireland.

CEPA's technical analysis for DECC highlighted that up to 207 GWh[30] of linepack could be drawn down in the event of an outage of IC2 before minimum operating conditions are met[31] and that all gas-fired electricity generators with capacity of more than 10 MW in Ireland are required to maintain a supply of backup fuel equivalent to 5 days of continuous running at full output.[32] CEPA's previous analysis for DECC showed that these mitigations can help protect Irish gas consumers from the worst physical impacts of a time-limited loss of all pipeline gas supplies from IC2.

Loss of all pipeline imports from GB

The loss of all pipeline imports of natural gas from GB would result in severe disruption to gas consumers in Ireland. Indigenous gas supplies from Corrib and biomethane would not be sufficient to meet direct gas demand, while the loss of gas supplies to the electricity sector may also result in severe disruptions to electricity consumers (i.e., gas-fired electricity generation will be unavailable).

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[29] CRU (2018) *National Preventive Action Plan Gas, 2018 – 2022*

[30] This is based on information provided to us by GNI and reflects assumptions used in the hydraulic modelling for the 2018 National Risk Assessment. The value excludes linepack in the Northern Ireland gas transmission network and associated interconnectors (Scotland-Northern Ireland Pipeline, South-North Pipeline).

[31] Linepack refers to the physical volume of gas contained within the gas pipeline network. A portion of this gas can be drawn down to supply additional gas when there is a supply shortfall. GNI's Natural Gas Emergency Plan includes use of linepack as a Stage 1 and Stage 2 measure, meaning that linepack would be used before, and in parallel with load shedding. Nevertheless, we note that drawing on linepack should not be considered as a standard measure of gas system operation. We would expect drawing on linepack to be used as a last resort. GNI has also emphasised that it should be used as a temporary measure while other solutions can be identified. They noted that depletion of linepack towards minimum operating conditions would reduce network pressure and leave less time to manage the network through load shedding. The Natural Gas Emergency Plan can be found on gasnetworks.ie.

[32] With some exceptions – plants expected to operate less than 2,630 hours per year (broadly in line with how the majority of OCGT plants operate) are required to hold stocks equivalent to 3 days, while CHP units are required to hold fuel stocks equivalent to 1 day of continuous running

As shown in Table 4.2 below, we find that the loss of pipeline gas imports from GB would result in widespread unmet demand in Ireland, including for protected customers. We show that just 19% of annual average gas demand and 77% of protected gas demand could be met by indigenous supply sources in 2029/30 in the event of a loss of IC1 and IC2 under GNI's Best Estimate demand forecasts.

Table 4.2. Average daily gas demand and supply in the event of a loss of all supplies from GB, 2023/24 and 2029/30

GNI forecasts **(Best Estimate)**	2023 / 2024	2029 / 2030
Daily supply capacity (GWh/day)	33	29
Annual average demand: all gas consumers		
Average daily demand (GWh/day)	187	152
% of demand met	18%	19%
Annual average demand: protected gas consumers only		
Average daily protected demand (GWh/day)	38	37
% of demand met	86%	77%

Source: CEPA analysis, GNI Gas Forecast Statement 2022

This finding aligns with the technical analysis undertaken by CEPA which showed that a loss of gas supplies from IC1 and IC2 would result in significant demand curtailment for both gas and electricity consumers in Ireland. In conditions where a substantial portion of gas demand from protected consumers is unmet, we would expect no gas to be available to I&C consumers or to the power sector.

4.1.2. Security of Supply: Option 1 – commercial FSRU

In this section, we appraise the impact of introducing the commercial FSRU outlined in Section 3.1 on the security of Ireland's gas supply.

Peak-day demand risk

Introducing the commercial FSRU would result in a material increase in Ireland's daily supply capacity, as shown in Table 4.3 below. However, IC2 would remain Ireland's single largest supply source by capacity.

Table 4.3. Daily gas supply capacity in Ireland with introduction of Option 1 – Commercial FSRU, 2023/24 and 2030/31

GNI forecasts **(Best Estimate)**	2023 / 2024	2029 / 2030
Existing supply capacity (GWh/day)	333	329
Additional supply capacity from commercial FSRU (GWh/day)	137	137
Total gas supply incl. the commercial FSRU	**470**	**466**

Source: CEPA analysis, GNI Gas Forecast Statement 2022

Introducing the commercial FSRU means that available daily supply capacity would be able to comfortably meet peak-day gas demand under any demand scenario included within the 2022 Gas Forecast Statement. The highest peak-day gas demand forecast included in the 2022 Gas Forecast Statement reaches 373 GWh/day. As shown above, daily supply capacity in Ireland would exceed this level when the commercial FSRU is included.

N-1 Infrastructure Standard

Based on the reference FSRU that is included in this appraisal, the IC2 interconnector would remain the largest single supply source in Ireland.[33] As such, the N-1 Infrastructure Standard remains based on Ireland's ability to meet peak-day gas demand in the event where the IC2 interconnector is unavailable.

We find that the introduction of the reference FSRU means that Ireland meets the the N-1 infrastructure standard when assessed on a national level – i.e., when it is not assessed on a regional basis with the UK.[34] In the event of a loss of gas supplies from the IC2 interconnector, supply from the FSRU means that Ireland is able to meet peak-day gas demand. This is illustrated in Table 4.4 below.

Table 4.4: N-1 Infrastructure Standard after the introduction of the commercial FSRU facility, 2023/24 and 2029/30

GNI forecasts **(Best Estimate)**	2023 / 2024	2029 / 2030
Daily supply capacity from existing sources but excluding IC2 (GWh/day)	222	218
Daily supply capacity from commercial FSRU (GWh/day)	137	137
Total supply (GWh/day)	**359**	**355**
Peak-day demand (GWh/day)[35]	350	316
% of demand met (%)	100%	100%

Source: CEPA analysis, GNI Gas Forecast Statement 2022

We note that this finding is highly dependent on the technical characteristics assumed for the commercial FSRU in this appraisal. For example, smaller daily regassification capacity could mean that the FSRU is not able to supply enough natural gas to fully mitigate for the loss of the IC2 interconnector under conditions of peak-day gas demand, in particular in the 2023/2024 reference year.

The level of immediate mitigation provided by this option is also dependent on the volume of gas that is held within the working capacity of the commercial FSRU and the length of time that it takes for the FSRU operator to acquire, transport, and offload new supplies of LNG. For example, the loss of supply from IC2 may coincide with a period in which there are limited stocks of LNG stocks held within the working capacity of the commercial FSRU.

Table 4.5 shows the number of days in which peak-day gas demand could be met by drawing on gas held in the FSRU (along with all other supply sources) before new supplies of LNG need to be imported when no supplies are available through IC2. We illustrate this using a range of assumptions regarding the volume of LNG that is held within the working capacity of the FSRU when pipeline imports from GB are disrupted.

[33] We note that different project specifications could result in the commercial FSRU facility becoming the largest single supply source in Ireland. If the regassification capacity of the FSRU exceeded the import capacity of the IC2 interconnector then the N-1 Infrastructure Standard would transpose to an assessment of Ireland's ability to meet peak-day gas demand under a condition where the commercial FSRU is unavailable – i.e., when only the current supply capacity is available. We have already shown in Section 4.1.1 that Ireland would be unable to meet peak-day gas demand in the near-term in such a situation (i.e., where supply comes from IC1, IC2, Corrib, and biomethane sources only) under GNI's Best Estimate demand scenario.

[34] CRU (2018) *National Preventive Action Plan Gas, 2018 – 2022*

[35] Based on GNI's Best Estimate scenario.

Table 4.5: Number of peak gas demand days that demand can be met in the event of a loss of all pipeline imports from GB through IC2 before new shipments of LNG are required under Option 1, 2023/24 and 2030/31[36]

No. of days before additional LNG imports are required to avoid demand curtailment	2023 / 2024	2029 / 2030
Starting volume of gas in FSRU working capacity = 10%	1	1
Starting volume of gas in FSRU working capacity = 50%	5	6
Starting volume of gas in FSRU working capacity = 90%	8	10
Starting volume of gas in FSRU working capacity = 100%	9	12

Source: CEPA analysis, GNI Gas Forecast Statement 2022

We find that the gas held within the working capacity of the FSRU can help meet between 1 and 12 days of peak day gas demand in 2029/30 when no pipeline gas supplies from GB are available. To continue meeting demand beyond this duration, new imports of LNG would need to be sourced, transported, and offloaded into the FSRU.[37]

The speed with which new LNG imports can be accessed in a shock situation will primarily depend on two factors.

- **Regularity of contracted LNG imports**. The commercial FSRU will need to regularly import new cargoes of LNG to meet domestic natural gas demand. For example, we show in Section 4.2.1, that new shipments of LNG could be expected at the commercial FSRU every 7 to 8 days under peak-day demand conditions (GNI Best Estimate) and under an assumption that LNG imports displace 50% of all pipeline imports in Ireland. More regular imports of LNG could mean a lower expected wait time for new LNG cargos to arrive in Ireland in case of a sudden disruption to pipeline gas imports to Ireland and therefore a lower chance of existing LNG stocks being depleted before new LNG imports arrive.[38]
- **Ability to attract flexible LNG shipments**. The commercial FSRU could also procure new unplanned shipments of LNG at short notice. For example, new shipments of LNG from Norway can reach northwest European markets within 3 days (though we note that LNG supplies from other sources can take significantly longer). Similarly, the FSRU operator may be able to acquire LNG supplies from carriers that are already in transit (e.g., LNG carriers *en route* to GB) [39]

We note that this analysis assumes that daily demand remains at peak levels for consecutive days despite the loss of imports from IC2. In practice, we would expect to see a significant demand-side response from consumers in response to the supply disruption. For example, we would expect some consumers to voluntarily reduce demand during a severe security of supply event (e.g., due to price signals and/or non-market signals).

[36] All figures are rounded to the nearest day.

[37] To continue meeting peak-day demand under an ongoing disruption to IC2, ongoing shipments of new LNG supplies will be required. We note that the majority of LNG vessels hold between 125,000 and 175,000 cubic meters of LNG which represents between 70% and 100% of the working capacity of the FSRU. This means that the stock of gas held in the FSRU working capacity could be replenished by between 70-100% from a single shipment. Once this volume of LNG has been regasified and drawn down, new supplies would be needed.

[38] We also note that the expected wait time for new LNG shipments may be negatively correlated with the volume of LNG held within the working capacity of the FSRU. For example, if the volume of gas in the FSRU has fallen to 10% of the working capacity, we would expect a new LNG shipment to arrive in the near term. In contrast, if the volume of gas in the FSRU is near capacity, then we would expect a longer wait time for a new LNG shipment to arrive.

[39] For example, we note that the Milford Haven LNG terminal in Pembrokeshire Wales receives around 100 shipments of LNG each year. If GB is not experiencing any supply constraints during the disruption to IC2, it may be possible for LNG shippers bound for Milford Haven (or other nearby LNG terminals) to divert to Ireland. We note that the ability of LNG shippers to flexibly alter their destination mid-voyage in response to dynamic price signals has been demonstrated throughout 2021 and 2022. For example, in December 2021 the Hellas Diana carrier which was bound for Asian markets made a U-Turn in the Pacific Ocean to carry LNG to the UK in response to higher UK gas prices.

If the disruption to IC2 were to take place during a period of moderate gas demand (defined as average daily demand expected during the year), instead of peak gas demand, then supplies from IC1, Corrib, and biomethane alone would be sufficient to meet all demand based on GNI's Best Estimate scenario. In other words, under average demand conditions, **supplies from the FSRU are not required to avoid demand curtailment**.

Loss of all pipeline imports from GB

The introduction of a commercial FSRU can also significantly improve Ireland's resilience to a simultaneous disruption of IC1 and IC2. However, the introduction of the FSRU alone would not enable Ireland to avoid all instances of unserved gas demand in the event of a loss of all pipeline imports of natural gas across all demand scenarios and years.

For example, we find that the re-gasification capacity supplied by the FSRU alone would not be capable of compensating for the loss of IC1 and IC2 under annual average demand conditions in 2023/24. However, reductions in average gas demand by 2029/30 means that the capacity supplied by FSRU would be sufficient to meet all gas demand in Ireland by 2029/30 in the event of a full disruption to all pipeline gas supplies from GB. The introduction of this FSRU would not be sufficient to meet all gas demand in Ireland under conditions of peak-day gas demand in any time period.

Table 4.6: Best estimate 1-in-50 peak-day gas demand and supply in Ireland in the event of a loss of supply from IC2, 2023/24 and 2029/30

GNI forecasts **(Best Estimate)**	2023 / 2024	2029 / 2030
Daily supply capacity from existing sources but excluding IC1 and IC2 (GWh/day)	33	29
Daily supply capacity from commercial FSRU (GWh/day)	137	137
Total supply capacity (GWh/day)	**170**	**166**
Annual average gas demand		
Annual average demand (GWh/day)	187	152
% of demand met (%)	91%	100%
Peak-day gas demand		
Peak-day demand (GWh/day)	350	316
% of demand met (%)	49%	52%

Source: CEPA analysis, GNI Gas Forecast Statement 2022

We note that the appraisal included in Table 4.6 above is based on the conservative assumption that natural gas demand in Ireland is unaffected by the loss of all pipeline supply capacity from GB. In practice, we would expect a material demand-side response which would provide further mitigation against this shock. For example, between 50-60% of natural gas demand under annual average conditions comes from the power sector in the 2023/24 and 2029/30 spot years. We would expect fuel switching and the use of back-up generation available to Ireland's fleet of gas fired generation to enable a material short-term reduction in gas demand from the power sector.

In this context we consider that the appraisal outlined in Table 4.6 shows that a commercial FSRU can provide a material mitigation against a full disruption to all pipeline imports of natural gas from GB. However, as noted above the level of mitigation provided by this option is dependent on the volume of gas that is held within the working capacity of the commercial FSRU and the length of time that it takes for the FSRU operator to acquire, transport, and offload new supplies of LNG.

The characteristics that we have assumed for the FSRU included in this appraisal means that 137 GWh of natural gas could be continuously exported from the FSRU into the onshore transmission system for up to 9 days under an assumption that the FSRU working capacity was full at the start of the shock period (i.e., if the working capacity was

50% full at the start of the shock period then 137 GWh of natural gas could be continuously exported from the FSRU for up to 4.5 days). To continue supplying any natural gas beyond this duration, new imports of LNG would need to be sourced, transported, and offloaded into the FSRU.

4.1.3. Security of Supply: Option 2 – strategic LNG storage

In this section, we appraise the security of supply impacts of introducing strategic onshore LNG storage, as outlined in Section 3.2.

Peak-day demand risk

Introducing the strategic onshore storage facility set out in Section 3.2 would result in a doubling of Ireland's daily supply capacity, as shown in Table 4.7.

Table 4.7. Daily gas supply sources in Ireland with introduction of assumed onshore strategic LNG storage, 2023/24 and 2029/30

GNI forecasts **(Best Estimate)**	2023 / 2024	2029 / 2030
Existing supply capacity	333	329
Additional supply capacity from strategic LNG storage	360	360
Supply capacity incl. strategic LNG storage	**693**	**689**

Source: CEPA analysis, GNI Gas Forecast Statement 2022

Introducing the strategic storage facility means that daily supply capacity would be able to comfortably meet peak-day gas demand under any demand scenario included within the 2022 Gas Forecast Statement. This aligns with our findings regarding the introduction of the commercial FSRU outlined in Section 4.1.2.

N-1 Infrastructure Standard

Upon introduction, the strategic LNG storage facility specified in this appraisal would become the largest single supply source in Ireland (i.e., its supply capacity would exceed Ireland's current supply allocation across IC2). As a result, the N-1 Infrastructure Standard would be based on Ireland's ability to meet peak-day gas demand assuming that the strategic storage is unavailable - i.e., when only the current supply capacity is available. We already showed in Section 4.1 that Ireland would be unable to meet peak-day gas demand in the near-term under GNI's Best Estimate scenario. On the same basis, Ireland would continue to fail the N-1 Infrastructure Standard between 2023/24 and 2027/28 even after the strategic LNG storage facility is introduced, under the Best Estimate demand scenario. From 2028/29, Ireland would be expected to pass the N-1 Infrastructure Standard following the introduction of the commercial FSRU.

However, we also note that the near-term impact on demand of an N-1 event would also be significantly reduced if the strategic LNG storage facility were introduced. For example, Table 4.1 shows that only 63% of peak-day gas demand would be met in 2023/2024 in case of a disruption to gas supplies from IC2 (i.e., the current N-1 infrastructure standard). However, 95% of peak day gas demand could be met in 2023/24 based on GNI's Best Estimate forecast if all existing gas supply sources were available, as shown in Figure 4.1 (i.e., this assessment would equate to the N-1 Infrastructure Standard following the introduction of the strategic LNG storage facility specified in this report). Given the potential for demand response and other mitigation measures, Ireland could be considered effectively meeting the requirements of the N-1 standard under Option 2.

Loss of pipeline imports from IC2

The introduction of strategic LNG storage can significantly improve Ireland's resilience against a disruption to pipeline gas imports via IC2. In particular, we note that the introduction of the strategic storage facility means that supply capacity in Ireland would be comfortably above peak-day gas demand (under any demand forecast scenario included in the 2022 Gas Forecast Statement) even when no gas supplies are available from IC2.

As outlined in Section 3, one of the primary benefits of strategic storage relative to a commercial infrastructure option is that a strategic facility will have a guaranteed volume of gas available when needed to mitigate against a supply disruption. As such, a strategic LNG storage facility removes uncertainty regarding the level of gas that is held in storage in the event of an unforeseen disruption to supplies from IC2. For example, we find that the introduction of the strategic LNG storage facility would enable Ireland to meet peak-day gas demand for 19 consecutive days in 2023/24 and for 25 consecutive days in 2029/30 despite the loss of pipeline supplies via IC2. To continue meeting demand beyond this duration, new imports of LNG would need to be sourced, transported, and offloaded into the strategic storage facility.

As noted in Section 4.1.2, the availability of LNG supplies at short notice may be uncertain. Accessing LNG supplies at short notice may be even more challenging under the strategic LNG storage option compared to the commercial FSRU, as the strategic LNG storage facility, under normal circumstances, would not seek to have a regular supply of LNG shipments. Therefore, it would need to suddenly engage with the LNG market in order to source new supplies at short notice.

As noted in the sections above, this analysis is also based on the strong assumption that there is no reduction in demand following the total loss of pipeline imports from GB. In practice, we would expect that such an occurrence would be accompanied by a reduction in gas demand. This would increase the length of time available to procure additional imports of LNG.

Loss of all pipeline imports from GB

The introduction of strategic onshore LNG storage is also able to provide a significant degree of protection against the loss of all pipeline gas imports from GB. For example, the introduction of the strategic storage facility means that supply capacity in Ireland is able to meet peak-day gas demand (under any demand forecast scenario included in the 2022 Gas Forecast Statement) even when no gas supplies are available from IC1 and IC2.

Table 4.8 below shows the number of days when gas demand could be met by drawing down the volume of gas held in storage (along with all other supply sources) before new supplies of LNG would need to be imported.

We find that the introduction of the strategic LNG storage facility would enable Ireland to meet peak day demand for eight days and annual average demand for 16 consecutive days in 2023/24 and for 20 consecutive days in 2029/30 in the event of a full loss of supplies from GB. To continue meeting demand beyond this duration, new imports of LNG would need to be sourced, transported, and offloaded into the strategic storage facility.

Table 4.8: Number of days that demand can be met in the event of a loss of all pipeline imports from GB before new shipments of LNG are required under Option 2, 2023/24 and 2029/30[40]

No. of days before additional LNG imports are required to avoid demand curtailment	2023 / 2024	2029 / 2030
GNI Best Estimate: Peak day demand	8	8
GNI Best Estimate: Annual average daily demand	16	20

Source: CEPA analysis, GNI Gas Forecast Statement 2022

As noted above, accessing fresh LNG supplies at short notice may be uncertain and will likely depend on a range of factors highlighted in the preceding sections. The number of days when demand can be met will also depend on the degree of demand response in the event of a supply disruption of this magnitude.

4.2. SUSTAINABILITY

In this section, we appraise the sustainability of each project based on their:

[40] All figures are rounded to the nearest day

- global environmental impacts;
- emissions impacts in Ireland; and
- other environmental impacts in Ireland

4.2.1. Sustainability: Option 1 – commercial FSRU

In this sub-section, we appraise the sustainability impact of introducing a commercial FSRU in Ireland.

Impacts outside of Ireland

The development of a commercial FSRU facility would allow the direct importation of LNG to Ireland for the first time. Lifecycle emissions intensity of LNG can exceed that of pipeline natural gas due to the energy-intensive steps associated with the liquefaction, tanker transport, and re-gasification.[41] For example, the UK North Sea Transition Authority has estimated that the emissions intensity of LNG imports into GB are almost 170% greater than the emissions intensity of gas extracted from the UK continental shelf (UKCS), and almost 230% higher than the emissions intensity of gas imported from Norway.[42]

A further sustainability impact associated with LNG relative to other sources of natural gas is that its production often involves the use of hydraulic fracturing ("fracking").[43] While the 2020 PfG set out the Government's opposition to the importation of fracked gas, the prevalence of fracked gas within some major LNG supply hubs[44] means that the introduction of a commercial FSRU to Ireland would likely result in the importation of material volumes of fracked gas.[45]

While the above impacts can be material, the direct importation of LNG to Ireland may not necessarily result in additional material environmental impacts on a global basis, especially given the size of the Irish gas market relative to global LNG production. For example, the introduction of direct LNG imports to Ireland is unlikely to lead to a global increase in LNG production and transport. Instead, we would expect that direct imports of LNG to Ireland would reduce LNG shipments to other markets (e.g., to GB or to other north-western European countries).

This point can be best understood through the interconnectivity of global gas markets. Ireland imports most of its gas supplies from GB and at the same time, LNG plays an increasingly important role in the GB gas supply mix. The introduction of LNG imports to Ireland would likely result in a reduction in pipeline gas flows from GB to Ireland (all else being equal). This could, in turn, result in a reduction in overall gas flows to GB (as total GB gas demand including demand from Ireland for pipeline flows would reduce). At least part of this reduction in gas flows to GB could come from lower LNG imports. As such, the introduction of direct LNG flows to Ireland would be associated with lower LNG flows to GB.[46]

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[41] For example, a study by the NRDC found that the liquefaction, transport, and re-gasification steps required to export LNG to global markets can account for up to 21% of lifecycle emissions of LNG. NRDC (2020) Sailing to Nowhere: Liquefied Natural Gas is not an Effective Climate Strategy, available on nrdc.com

[42] North Sea Transition Authority (2020) 'Natural Gas Carbon Footprint Analysis', available on nsathority.co.uk

[43] Fracking is a method of oil and natural gas extraction which involves injecting fluid into subterranean rock formations at high pressure to produce a fracture network that allows crude oil and natural gas inside dense rocks to be extracted at the surface. Fracking can generate local impacts in terms of water consumption, water contamination, seismic inducement, and air pollution.

[44] For example, the use of fracking is common in the production of natural gas in the USA, a major global supplier of LNG. The US Energy Information Administration has predicted that the vast majority of natural gas produced in the USA will be developed from shale gas by 2030.

[45] We note that the Office of the Attorney General concluded in 2021 that it is not possible for Ireland under the European Treaties or EU Directive to ban the import into Ireland of fracked.

[46] This example could be expanded and applied to the wider northwest European region. For example, lower gas flows from GB to Ireland could result in higher exports from GB to other European markets (or less pipeline gas imports from European markets). Higher net pipeline gas flows from GB to continental markets could also displace some direct LNG flows to those markets. As such, LNG imports to Ireland would displace LNG imports to other European markets (e.g., Germany).

As a result, we do not consider that direct imports of LNG to Ireland would necessarily result in an increase in global LNG flows.

Emissions impacts in Ireland

The introduction of a commercial FSRU can generate additional carbon emissions in Ireland in two key ways:

- through the direct operation of a FSRU in Ireland (i.e., through the generation of energy required to operate a FSRU); and
- by potentially stimulating higher gas demand in Ireland.

We discuss each of these points in turn below and consider their impact on the Sectoral Emissions Ceilings.

Operational impacts

The operation of a FSRU can generate emissions in four ways:

- Regasification – the process by which LNG is heated and converted to natural gas.
- Flaring / venting – the process of de-pressuring the FSRU by either burning excess natural gas (flaring) or directly releasing natural gas into the atmosphere (venting).
- Fugitive emissions – leaks from pipes or from the storage facility.
- Stationary energy – emissions associated with the energy consumed for ongoing operation of the FSRU facility – i.e., the energy required to maintain the LNG at a cooled and pressurised stated.

The exact distribution of emissions across each of the four areas outlined above will depend on a range of technical and climactic considerations. For example, the technical approach to regasification can have a significant impact on emissions. Open-loop heating utilises heat from seawater for regasification, while closed-loop heating typically uses gas-fired heating only. To illustrate the impact of this distinction, we note that Viva Energy Gas Terminal have estimated that emissions generated from their FSRU fleet are almost four times greater when closed-loop heating is used relative to open-loop heating.[47] This choice of regassification system is however somewhat dependent on climactic conditions. The International Group of Liquefied Natural Gas Importers note 15°C as the temperature where seawater may be too cold for efficient LNG vaporisation.[48] Average monthly seawater temperatures in Ireland exceeded this level only once in 2022 when the average temperature reached 15.1°C.[49] This could mean that an open-loop regassification system would not function reliably in Ireland.

The distribution of emissions will also depend on a range of other broader factors:

- The more gas that is flown through the commercial FSRU each year will result in higher energy use and emissions generated in Ireland.
- Further decarbonisation of the Irish energy system will lower the emissions impact of any energy consumed by the FSRU facility. For example, the decarbonisation of the Irish electricity system will lower scope 2 emissions associated with electricity consumed by the FSRU. Similarly, the use of renewable gasses (e.g., biomethane or hydrogen) by the FSRU will further lower ongoing emissions.

The range of above factors means that it is challenging to estimate the likely volume of emissions that would be generated by a commercial FSRU in Ireland. However, we note that the owner of the Klaipéda FSRU facility (Hoëgh

[47] Viva Energy Gas Terminal have estimated that their FSRU emissions (Scope 1, 2, and 3) are 47,906 t CO2e when open-loop heating is used, 178,985 t CO2e when closed-loop heating is used, and 65,280 t CO2e when a combined system is used. Information available on vivaenergy.com.au

[48] GIIGNL (2021), LNG Information paper no. 7, available on giignl.org

[49] Average monthly sea temperatures in Ireland are available on met.ie

LNG) have estimated average Scope 1 emissions of 80,168 t CO_2e per FSRU within their fleet in 2021.[50] Golar LNG reported similar emissions of 70,150 t Co2e across their fleet of FSRU's in 2020.[51] While ongoing decarbonisation of Ireland's energy system could be expected to push down average operational emissions over time, we would expect that a commercial FSRU in Ireland would likely generate emissions within a similar range to these benchmarks.[52]

Impact on Irish gas demand

The introduction of a commercial FSRU can also generate emissions impacts to the extent that it may stimulate higher gas demand in Ireland. This could occur in two ways:

- **Price effects**. A potential reduction in gas prices due to the introduction of the FSRU may result in higher gas demand from some consumers. For example, lower gas prices could reduce the incentives for some consumers to invest in energy efficiency measures or to switch to non-natural gas energy solutions (e.g. industrial or commercial heat pumps).
- **Other effects**. The addition of new supply infrastructure in Ireland may also enable higher gas demand growth from LEUs. For example, the growth of energy demand from LEUs in Ireland is currently constrained by the availability of gas supplies in Ireland. Increasing the gas supply through the addition of a commercial FSRU may relieve this constraint.

We note that any increases in gas demand may be constrained by Government policies designed to meet the legally binding SECs.

Impact on the Irish Sectoral Emissions Ceiling

Introducing a commercial FSRU may also have an impact on Ireland's ability to meet its Sectoral Emissions Ceiling (SEC) commitments. SEC accounting rules means that emissions generated through the operation of a commercial FSRU will be recorded within the Electricity SEC, while any emission impacts due to changes in gas compression within the Irish transmission network will be recorded in the Transport SEC.

Table 4.9 below illustrates that Ireland is committed to limiting its emissions to 20 million tonnes of CO_2e within the Electricity SEC between the period from 2026 to 2030. The cumulative emissions generated by an FSRU operating within the Golar LNG or Hoëgh LNG fleets (as noted above) over a five-year period would equate to 2% of this budget.

Table 4.9. Impact of commercial FSRU operation on Ireland's SEC

Sectors	SEC budget	Impacts from introducing a commercial FSRU to Ireland on each SEC budget
Electricity	• 2021-2025: 40 Mt CO2e • 2026-2030: 20 Mt CO2e	• FSRU operations – including compression for storage and regasification operations. • Fugitive emissions from the FSRU
Transport	• 2021-2025: 40 Mt CO2e • 2026-2030: 37 Mt CO2e	• Changes in gas compression within the Irish transmission network*

Source: CEPA analysis

[50] Hoëgh LNG (2021) Sustainability Report, available here.

[51] This is calculated by CEPA as the average emissions within Golar LNG's fleet. Details are available on golaring.com.

[52] We note that the annual level of emissions released by FSRUs within the Hoëgh and Golar LNG fleets are roughly equivalent to what would be released by a notional 400 MW combined-cycle gas turbine (CCGT) electricity generation plant that is operating at maximum capacity in 6% of all hours across a year.

** this excludes any gas compression associated with the pumping of natural gas from GB to Ireland which takes place in GB. We only consider any impact of the commercial FSRU's addition on the volume of gas compression that needs to take place within the Irish transmission network.*

As noted above, there is also the possibility that the introduction of a FSRU may also stimulate higher gas demand in Ireland. This may also have a material impact on Ireland's SEC commitments. For example, research by MaREI has indicated that gas consumption in Ireland must fall to between 28 and 42 TWh by 2030 in order for Ireland to remain compliant with the SEC commitments. All scenarios included in GNI's 2022 Gas Forecast Statement forecast demand in excess of this range (e.g., the Low gas demand scenario forecasts demand of 45 TWh in 2030). As such, Ireland's ability to meet the SEC in 2030 is already therefore subject to a significant existing challenge.

Any development which could increase gas demand above what has been forecast by GNI will serve to increase this challenge. We note that a range of other supply-side or demand-side policies could also mitigate this risk.

Other environmental impacts in Ireland

We note that there may be a range of localised environmental impacts associated with the development of a commercial FSRU facility in Ireland. For example, the LNG FSRU typically uses sea water to heat its LNG reserves back into a gaseous state. When operating, this process can result in impacts on local ecosystems through the injection of seawater being returned which is cooler than the surrounding ambient temperatures.[53]

FSRUs are also often required to combat the biofouling of its internal piping systems by using chemical disinfectants. While not all FSRU's follow this process[54], this form of biofouling can lead to residual chloride content being injected into the surrounding water system. The potential for FSRU's to discharge residual chloride content into the surrounding water system has been a major source of environmental concern in a number of recent FSRU projects. For example, we note that a FSRU development in Australia was rejected by the Victoria State Government due to concerns regarding marine discharges (including cold water and residual chloride)[55].

Similarly, the introduction of a commercial FSRU may generate localised noise and light pollution which may impact on local populations and ecosystems. The scale of impact is likely to depend on the regularity by which new LNG cargoes are imported. We show in Table 4.10 below that new LNG shipments would need to be accepted at the FSRU every 7 to 8 days under peak-day demand conditions (GNI Best Estimate) and under an assumption that LNG imports displace 50% of all pipeline imports in Ireland during those days.[56]

Table 4.10. Gas supply sources in Ireland with introduction of assumed FSRU, 2023/24 – 2030/31

No. of days before additional LNG supplies are required	2023 / 2024	2029 / 2030
If LNG imports displace **10%** of all pipeline imports	38	42
If LNG imports displace **50%** of all pipeline imports	8	8
If LNG imports displace **90%** of all pipeline imports	4	5

Source: CEPA analysis, GNI Gas Forecast Statement 2022

[53] For example, we note that the Viva Energy FSRU in Geelong cools seawater roughly 5-7°C below ambient temperature as part of its regasification process. Information available on Viva Energy (2020), Seawater Use in a FSRU and the Geelong Refinery, available here.

[54] For example, the Krk FSRU in Croatia follows a mechanical cleaning process which avoids the discharge of chloride chemicals into the water system. Information available at: LNG Hrvatska (2018), Environmental protection measures, available here.

[55] Minister for Planning (2021) Crib Point Gas Import Jetty and Crib Point – Pakenham Gas Pipeline Project, available on gov.au.

[56] This analysis is on the basis that imports of LNG would not displace any natural gas supplies from Corrib or biomethane sources.

4.2.2. Sustainability: Option 2 – strategic LNG storage

In this sub-section, we appraise the sustainability impact of introducing of strategic LNG storage in Ireland.

Impacts outside of Ireland

The introduction of the strategic LNG storage facility in Ireland could result in direct imports of LNG to Ireland. GNI's proposal sets out that the strategic facility would be initially accompanied by a FSRU which would fill the storage facility through direction importation of LNG from global markets. After this initial period, the storage facility could be refilled by liquifying gas that is drawn from the existing transmission network.

As a result, we note that some of the global impacts associated with the importation of LNG to Ireland outlined in Section 4.2.1 may also be generated under the strategic LNG storage option, albeit at a significantly reduced level.

Emissions impacts in Ireland

The introduction of a strategic storage facility can generate additional carbon emissions in Ireland in two key ways:

- Through the ongoing operation of the strategic storage facility; and
- By stimulating higher gas demand in Ireland.

We discuss each of these points in turn below and consider their impact on the Sectoral Emissions Ceilings.

Operational impacts

The main distinction between the emissions impact of the strategic LNG storage facility and the commercial FSRU is that we would expect gas to be withdrawn from strategic storage on rare occasions. We would expect gas to remain within the strategic storage facility except under exceptional conditions whereby there is a major disruption to supplies or a major increase in demand. As such, we would not expect significant levels of regassification or liquefaction services to be required from the strategic facility on an ongoing basis.

Any emissions that are generated from the strategic facility (e.g., during periods where gas withdrawals from storage is required) are likely to align with similar categories outlined in 4.2.1. For example, emissions can be generated through fugitive emissions or through regasification activities. Additional emissions may be generated by the strategic LNG storage facility through liquefaction services.

We note that the magnitude of emissions generated from these activities will also depend on a similar range of technical considerations outlined in Section 4.2.1. For example, the extent to which the strategic LNG storage facility is capable of utilising an open-loop heating for regasification will have a major impact on the volume of emissions that is produced when gas is being withdrawn from the storage facility.

Impact on Irish gas demand

We would not expect the strategic LNG storage facility to have any impact on domestic gas prices (except during periods where it is needed to avoid demand curtailment). As such, we would not expect the strategic facility to have a significant direct impact on gas demand in Ireland.

However, we note that the facility may have some impact on gas demand through its provision of increased supply security to domestic Irish gas consumers. In addition, we also note that there may be future political pressure to utilise the strategic storage facility to alleviate price effects for Irish consumers (i.e., pressure on the strategic storage operator to withdraw gas from storage during periods of high gas prices).

Impact on the Irish Sectoral Emissions Ceiling

The net impact of a strategic LNG storage facility in Ireland on Ireland's ability to meet each SEC is highly uncertain. For example, the impact will depend on the extent to which gas is be drawn down from storage and the technical characteristics of the storage development. We would expect any additional emissions generated from the storage facility to be reflected in the Electricity SEC, as per the commercial FSRU that is outlined in Section 4.2.1. We do not expect that the strategic LNG storage facility will generate a material increase in emissions due to higher gas consumption in Ireland.

Other environmental impacts in Ireland

There may be a range of localised environmental impacts associated with the development of strategic LNG storage in Ireland. For example, during period when an FSRU is connected to the facility we would expect similar environmental impacts to that set out in Section 4.2.1. Other impacts associated with the strategic LNG storage facility may arise from the gas facility to liquify gas that is drawn from the existing transmission network.

The expectation that gas would not be routinely drawn from the strategic LNG storage facility may help reduce localised impacts relative to the commercial FSRU. For example, we would expect lower noise and light pollution impacts associated with new LNG deliveries to the facility.

4.3. AFFORDABILITY

In this section, we appraise the affordability of each project selected in Section 3 based on their:

- total project costs;
- cost recovery; and
- other risks and impacts

4.3.1. Affordability: Option 1 – commercial FSRU

In this sub-section, we appraise the affordability of introducing a commercial FSRU in Ireland.

Total cost of project

The cost of developing a commercial FSRU project can vary widely depending on a range of project specific considerations. For example:

- **Existing onshore infrastructure**. The costs of developing the onshore infrastructure required to connect the FSRU to the existing transmission network may exceed the cost of the FSRU itself. For example, the port infrastructure around the FSRU must be capable of accommodating regular deliveries of LNG from global carriers. Similarly, the jetty and connecting pipeline to link the FSRU to the transmission network must be constructed. If the FSRU is not located near a transmission access point, the costs of such a connection may be significant.
- **FSRU build type**. A FSRU can be developed with a purpose-built hull or converted from an older LNG carrier ship. New-build FSRU's are typically more expensive and can take longer to build but offer increased design flexibility.[57]
- **Commercial terms**. FSRUs can be purchased up-front or leased for a period of time – e.g., for a duration of 10 years. The cost of a FSRU will therefore be reflected through the upfront purchase of the facility or else through an ongoing payment from the operator of the facility to its owner as per a contractual lease agreement.
- **Global demand and supply**. The cost of a FSRU can be influenced by global supply and demand for such facilities. For example, at the end of 2020 there were a total of 37 FSRUs in operation globally. Following Russia's invasion of Ukraine in March 2022, global demand for FSRU projects increased materially as European countries sought alternative access to global gas supplies.
- **Ongoing costs**. A range of factors will influence the operational costs of the facility including access to skilled labour and cheap energy supplies.

[57] IGU (2021) *World LNG Report*, page 66, available online at igu.org

The above factors mean that it is difficult to estimate the cost of a hypothetical FSRU project with any degree of certainty, and existing projects have varied widely in costs. For example, the costs of Germany's planned FSRU terminals increased from €2.94bn stated in the 2022 budget to €6.56bn, due to additional operating costs and land infrastructure.[58]

Cost recovery

We would not expect the development of a commercial FSRU to generate any additional costs for Irish consumers or for the Irish exchequer, assuming no public financial support is offered to the facility. While a commercial FSRU can operate under a range of different business models[59], the commercial facility must be able to supply gas at a competitive rate relative to existing supplies. For example, Irish gas consumers will only be willing to switch their consumption to gas supplied through the FSRU if that gas is at least no more expensive than supplies sourced from existing sources.

We note that this is likely to be particularly true in cases where total gas demand is expected to fall over time. As total demand in Ireland is forecast to decline over the next decade, supplies from the FSRU must come at the expense of supplies from other sources (e.g., via imports from GB).

Risks and unintended consequences

We consider that there are two key cost risks associated with the introduction of a commercial FSRU to Ireland.

- **FSRU revenue risk**. As noted above, the commercial operation of a FSRU in Ireland is likely to depend on its ability to supply gas at a competitive rate relative to other existing supplies. As such, changes to global LNG supply and demand could have a material impact on this commercial business model. A risk to revenue recovery by the FSRU in Ireland could result in a request for public support and/or generate a risk that a commercial FSRU would exit the Irish gas market.
- **Pipeline revenue risk**. In the context of declining annual gas demand in Ireland, the introduction of a commercial FSRU may result in a decline in pipeline gas imports to Ireland. This finding aligns with technical modelling undertaken by CEPA in advance of the Security of Supply consultation. A decline in pipeline imports may result in a revenue shortfall over IC1 or IC2 (i.e., entry and exit tariffs).

In addition to the above, we note that there may be a minor stranded asset risk associated with parts of a commercial FSRU project in Ireland. For example, we would expect natural gas demand in Ireland to fall to zero over time in line with the Government's net zero commitments. While the FSRU itself would be capable of transferring to another location once it is no longer needed in Ireland, part of the onshore infrastructure (e.g., the jetty and onshore connecting pipeline infrastructure) would remain.[60]

4.3.2. Affordability: Option 2 – strategic LNG storage

In this sub-section, we appraise the affordability of introducing a strategic LNG storage facility in Ireland.

Total Costs

GNI have estimated that the total capital cost of the onshore strategic LNG storage facility could reach [redacted] (including inflation and contingencies) while total operating expenditure is estimated at [redacted] per annum.[61] However, GNI's proposal assumes that EU grants could cover up to [redacted] which would result in the

[58] Reuters (2022), *Germany's LNG terminals to cost more than double earlier estimate,* November, available here

[59] For example, a commercial FSRU may sell access to regasification services without taking any title to the natural gas or LNG that flows in and out of the facility or else will directly purchase LNG from global markets which it then regasifies and sells to domestic consumers. Other typical approaches are centered around more vertically integrated models whereby the FSRU supplies gas directly to integrated entity such as a gas distribution company or a power station.

[60] Though we note that onshore jetty infrastructure could be repurposed for future hydrogen import and export.

[61] GNI's total capex estimate includes [redacted] of contingency, equivalent to 59% of the cost estimate before contingency.

net capital cost falling to [redacted]. In addition, we also note that GNI's proposal excludes stock gas costs (i.e., the cost of acquiring gas to sit within the storage facility). We estimate the cost of stock gas in Table 4.11 below by multiplying the size of the storage facility (360,000 m^3 of LNG) by a range of gas price estimates.

Table 4.11 Estimated cost of filling the strategic LNG storage facility under different price scenarios

Gas price source	Gas price (€/MWh)	Cost of stock gas (€m)
TYNDP National Trend scenario (2030 forecast)	22.3	54.7
TYNDP Global Ambition / Distributed Energy scenario (2030 forecast)	14.4	35.3
Dutch TTF Natural Gas Futures Intraday price (27/02/2023)	49.4	121.5

Source: TYNDP, TTF Natural Gas Futures, CEPA analysis

The table above includes long-run gas price estimates developed by ENTSO-E as well as an estimate of European spot-prices at the time of writing this report (Dutch TTF Natural Gas Futures Intraday index accessed on 27/02/2023). As illustrated, acquiring stock gas for the storage facility may generate additional and material costs.

Cost recovery

As mentioned above, the total capital cost of the project would amount to around [redacted]. GNI propose that [redacted] of the project's capital costs could be funded by EU grants. GNI also propose that they would require around [redacted] per annum in funding to cover the remaining capital and operating costs.

The strategic storage facility could be funded under a range of options that include direct support by the Irish exchequer and funding through charges levied on Irish energy consumers. For example, one approach would be to recover these costs through GNI's gas transmission charging structure, however the implication of this for different types of consumers in terms of their contribution to the overall cost of the project would have to be considered. Another potential approach would be to adopt the public service obligation (PSO) levy to recover the cost of the gas storage facility from both electricity and gas consumers. The PSO levy is a fixed charge which differs between domestic and industrial consumers and is currently charged on electricity consumers. GNI's proposal highlighted that their scenario testing of this approach has shown that recovering costs through an extended PSO levy would add around 1.5% to 2.5% to energy consumer bills.

Risks and unintended consequences

We note that there may be a stranded asset risk associated with parts of a strategic LNG storage facility in Ireland. As natural gas demand in Ireland falls and as indigenous supplies of biomethane and hydrogen gas grow over time, the services provided by the strategic storage facility may no longer be required. To address this risk, GNI have proposed that the facility could be designed to be hydrogen-ready.

In addition, we note that some services within the strategic LNG storage facility may be underutilised over time. For example, the ability of the storage facility to liquify natural gas that is withdrawn from the onshore gas transmission network will only be required in an event where the storage facility first discharges natural gas to avoid load shedding (as GNI's proposal sets out that the storage facility will initially be filled through imports of LNG). As we expect gas to be withdrawn from storage in exceptionally rare circumstances, consumers may end up paying for a liquefaction facility that is rarely used.

UK

Queens House

55-56 Lincoln's Inn Fields

London WC2A 3LJ

T. **+44 (0)20 7269 0210**

E. **info@cepa.co.uk**

www.cepa.co.uk

Australia

Level 20, Tower 2 Darling Park

201 Sussex Street

Sydney NSW 2000

T. **+61 2 9006 1308**

E. **info@cepa.net.au**

www.cepa.net.au

cepa-ltd @cepaltd