Projects of Common Interest
Project CAES Larne NI (electricity, storage)

**** Please send to ENER-B1-PROJECTS@ec.europa.eu and specify the priority corridor in the subject line ****

Introductory information

Contact details of the project promoter(s) (if several, please fill in for each project promoter)

Company: **Gaelectric Energy Storage Ltd**..

☐ TSO ☐ DSO ☒ Other project promoter[1]

Contact person: [redacted] ....

E-mail address: [redacted] ....

Telephone number: [redacted] ....

Type of project

☐ Transmission project included in TYNDP 2012 – please refer to Questionnaire I

☐ Transmission project not included in TYNDP 2012 – please refer to Questionnaire II

☒ Storage project – please refer to Questionnaire III

Priority corridor

For the implementation of which energy infrastructure priority corridor is the project necessary? **NSOG**..

[NB: A separate questionnaire has been prepared for smart grid projects as well and has been discussed in the relevant ad hoc working group under the Smart Grid Task Force.]

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[1] Project promoter is defined in Article 2.5 of the draft Regulation COM(2011) 658 of 19.10.2011. 'projectpromoter' means:
a) transmission system operator or distribution system operator or other operator or investor developing a project of common interest; or
b) if there are several transmission system operators, distribution system operators, other operators, investors, or any group thereof, the entity with legal personality under the applicable national law, which has been designated by contractual arrangement between them and which has the capacity to undertake legal obligations and assume financial liability on behalf of the parties to the contractual arrangement.

III. Questionnaire for electricity storage projects

1.	General information

a) Name of project

Project CAES Larne NI

b) Brief description

Compressed Air Energy Storage using caverns/chambers to be created in bedded salt deposits.

Phase 1: 134MW generation capacity, 80-100 MW compression. Environmental baseline studies in progress. Planning application Q3 2013, expected Commercial Operation Date 2016. This will require innovation around the business model and also the optimisation of storage caverns and surface plant to facilitate integration and operation of onshore wind in Northern Ireland (UK) and Ireland (EI) to provide necessary storage and ancillary services to the TSO. Phase 1 will use caverns created in the salt deposits by the standard method of solution mining. The project promoter has conducted

- extensive geological and geotechnical work to establish the suitability of the salt deposits to host CAES caverns and provide cavern design
- detailed modelling of the operation of the CAES technology in its interplay with the caverns
- detailed economic, commercial and financial modelling of the project to identify and quantify system benefits and derive a business model for the particular requirements of the TSOs in Northern Ireland and Ireland in the context of the high renewable energy targets.

Phase 2: Will double the generation capacity and substantially increase compression capacity to augment the facility's capability to provide grid services in Northern Ireland and Ireland. Phase 2 will also use caverns created in the salt deposits by the standard method of solution mining. The expected commercial operation date is 2019-20.

[redacted]

c) Are any other undertakings involved in the project? **No**

d) Situation of the project promoter(s):

- What is legal status of the project promoter(s)? Please specify (registered undertaking, group of companies, other).

Gaelectric Energy Storage Ltd is a company registered in Ireland.

Company registered number: 428818

Date of incorporation: 26 October 2006

Registered address: Portview House, Thorncastle Street, Ringsend, Dublin 4, Ireland

If you are a registered undertaking, please provide the list of all shareholders, information on their main activity and their respective shares in the undertaking.

Name of shareholder: Gaelectric Holdings plc holds 100% of Gaelectric Energy Storage Ltd

Activity: Renewable energy and energy storage in UK, Ireland and North America

Class of holding: Ordinary Shares

Amount: €2.00

Nationality: Company registered in Ireland, Registered number 418730

[redacted]

- What is the share capital of this undertaking?

  Class of capital: Ordinary Shares (€1)

  Amount issued: €2.00

  Amount authorised: €100,000.00

e) Project type

☒New

☐Upgrade / Repowering / Retrofitting

☐Extension

f) Key geographical characteristics ***[please submit map indicating information given below]***

- Location: **Larne, Northern Ireland, UK**
- Connection point to transmission network:

  Phase 1: In April 2012 the System Operator for Northern Ireland (SONI) requested Northern Ireland Electricity (NIE) to carry out feasibility studies for connection of Phase 1 of the project. This request identifies five options for connecting the CAES facility, which are summarised below.

Figure 1 shows the proposed NIE network in 2015 and the project location. Figure 2 shows the existing 110 kV network in the Larne area. Figure 3 shows the location of the project and existing 110 kV network. Figures 4 to 8 show the five connection options considered by SONI.

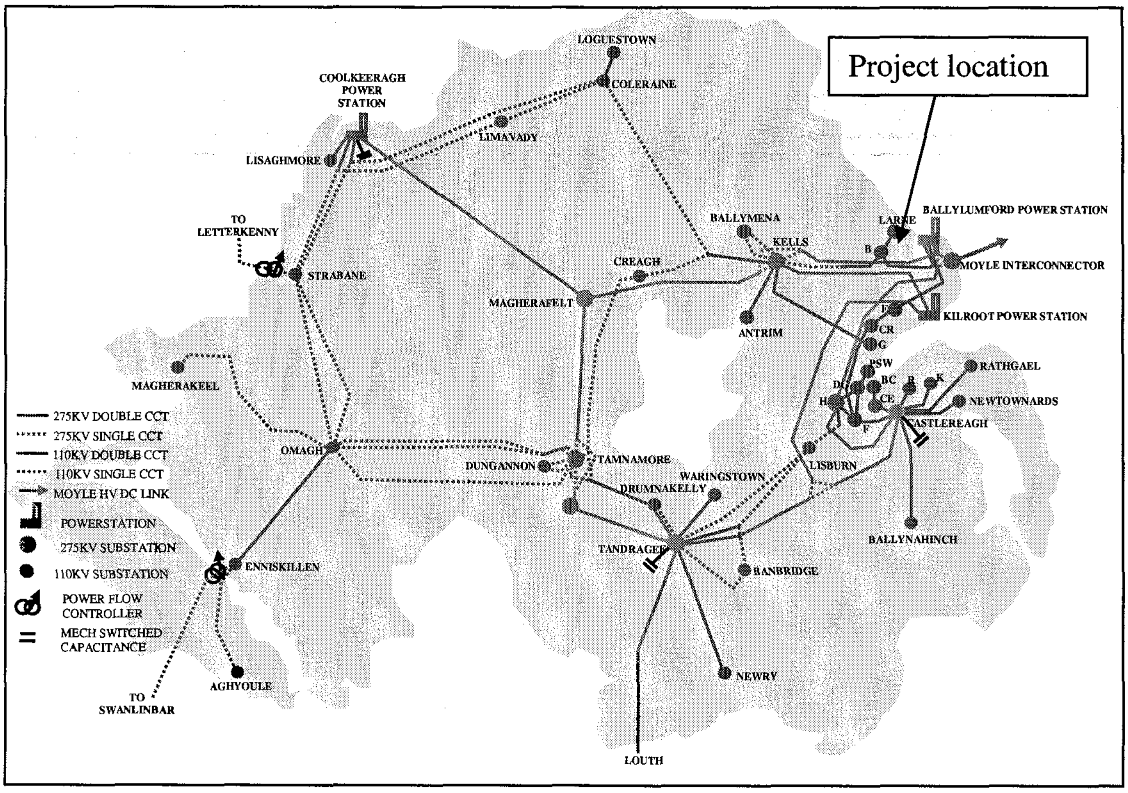


Figure 1: Proposed NIE network in 2015 showing location of the project

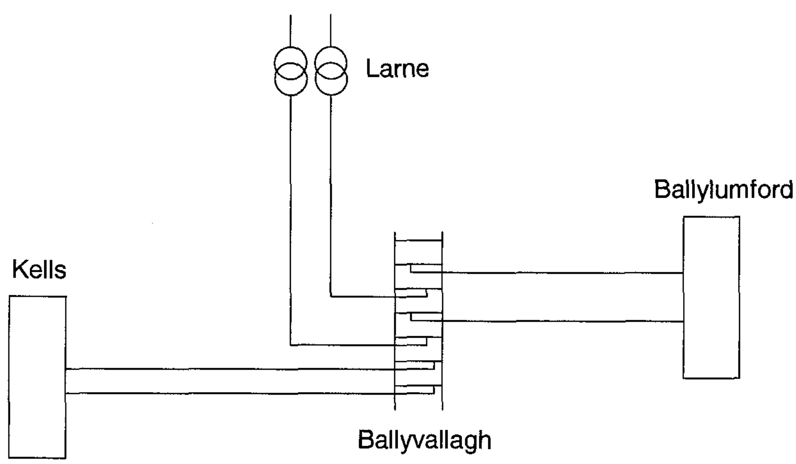


Figure 2: Existing 110 kV network in the Larne/Ballyvallagh area

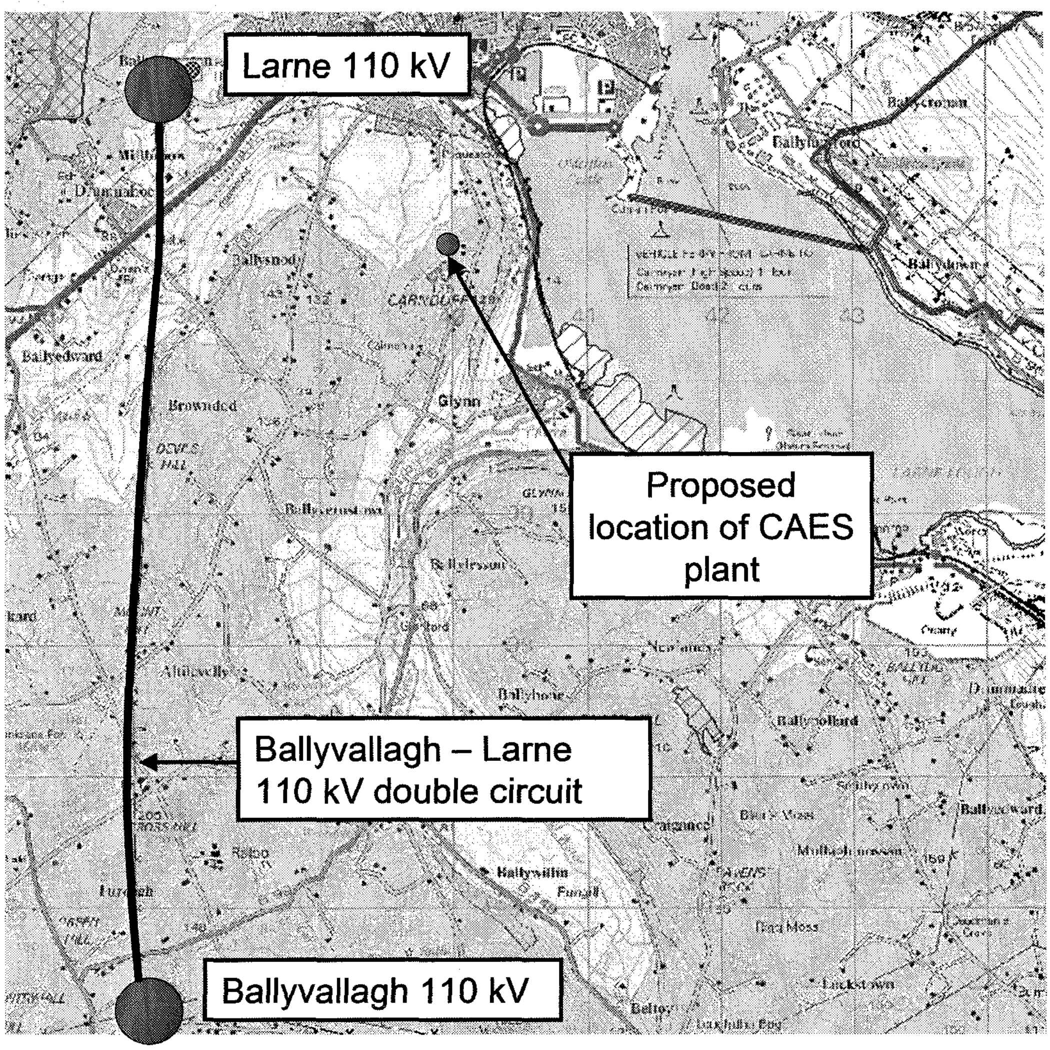


Figure 3: Proposed location of CAES plant in relation to existing 110 kV network

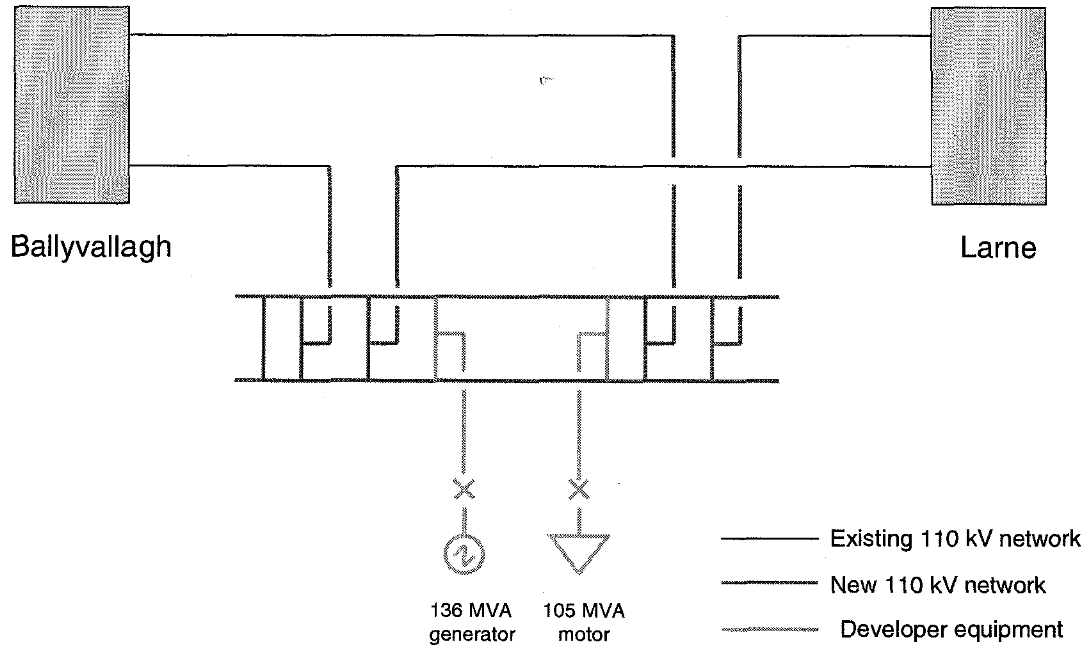


Figure 4: Option 1, Looping into the existing Larne – Ballyvallagh 110 kV double circuit tower line.

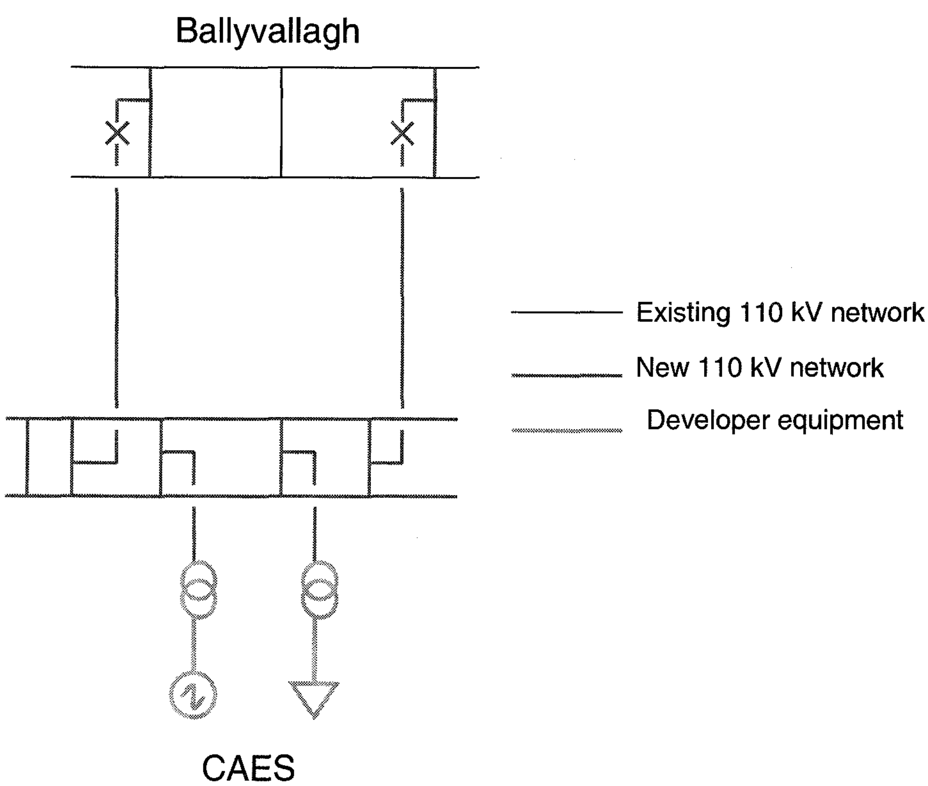


Figure 5: Option 2, Connect into Ballyvallyagh 110 kV substation. Ballyvallagh 110 kV substation consists of a double busbar. This connection would involve creating two new bays at Ballyvallagh.

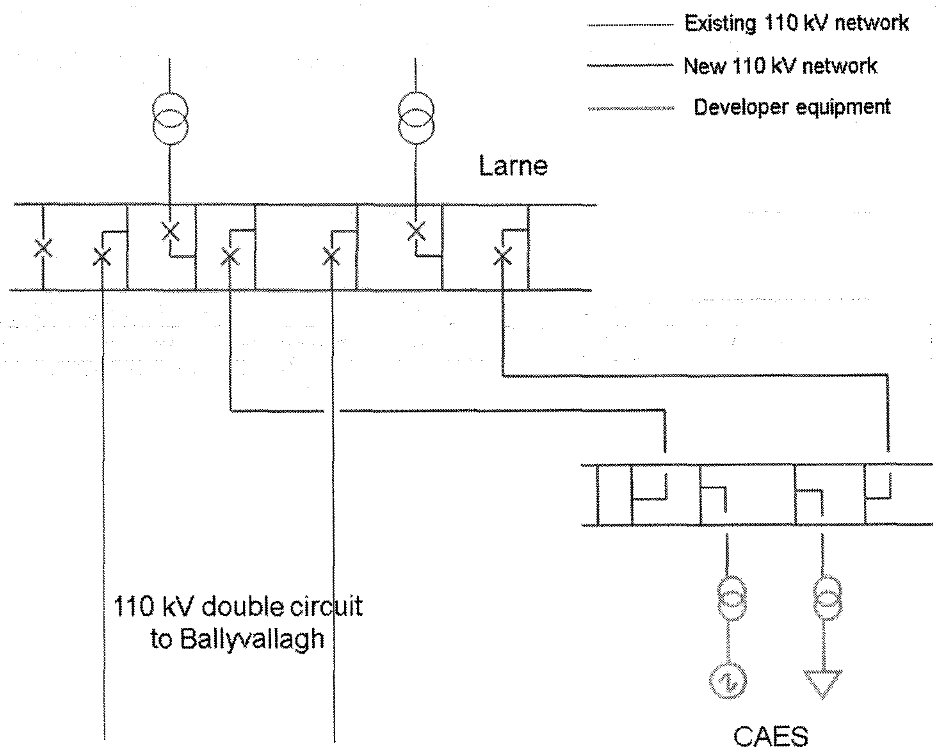


Figure 6: Option 3, Connect into Larne 110 kV substation (indicated as single bus). The existing Larne 110 kV substation consists of two transformer feeders, and no switchgear. Connecting the CAES plant into Larne would require the establishment of a double busbar switch board at Larne along with circuit breaker bays for the two transformers, two lines to Ballyvallagh and two lines to the CAES plant. Two new 110 kV lines are required out to the CAES plant at which there will be a three switch mesh.

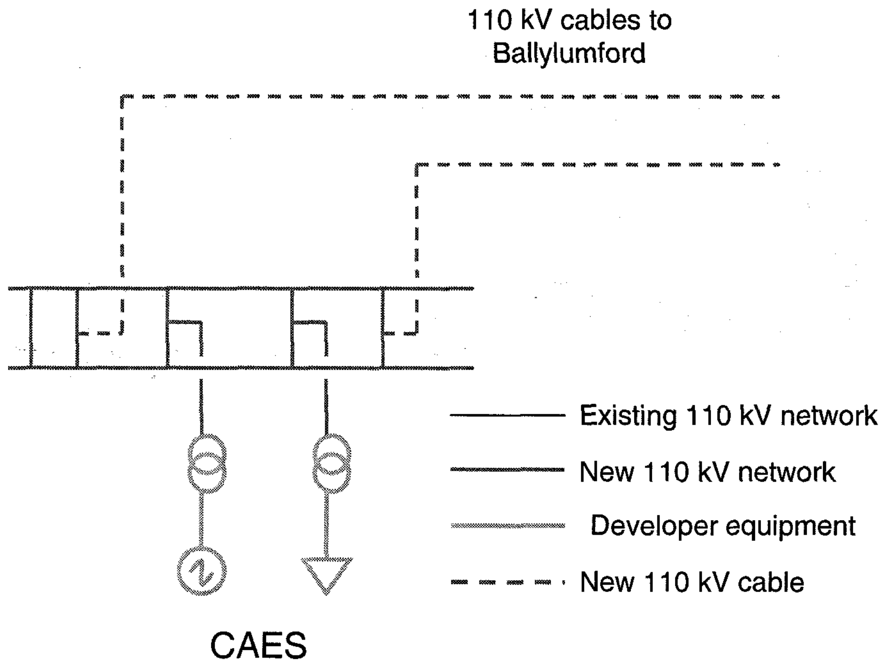
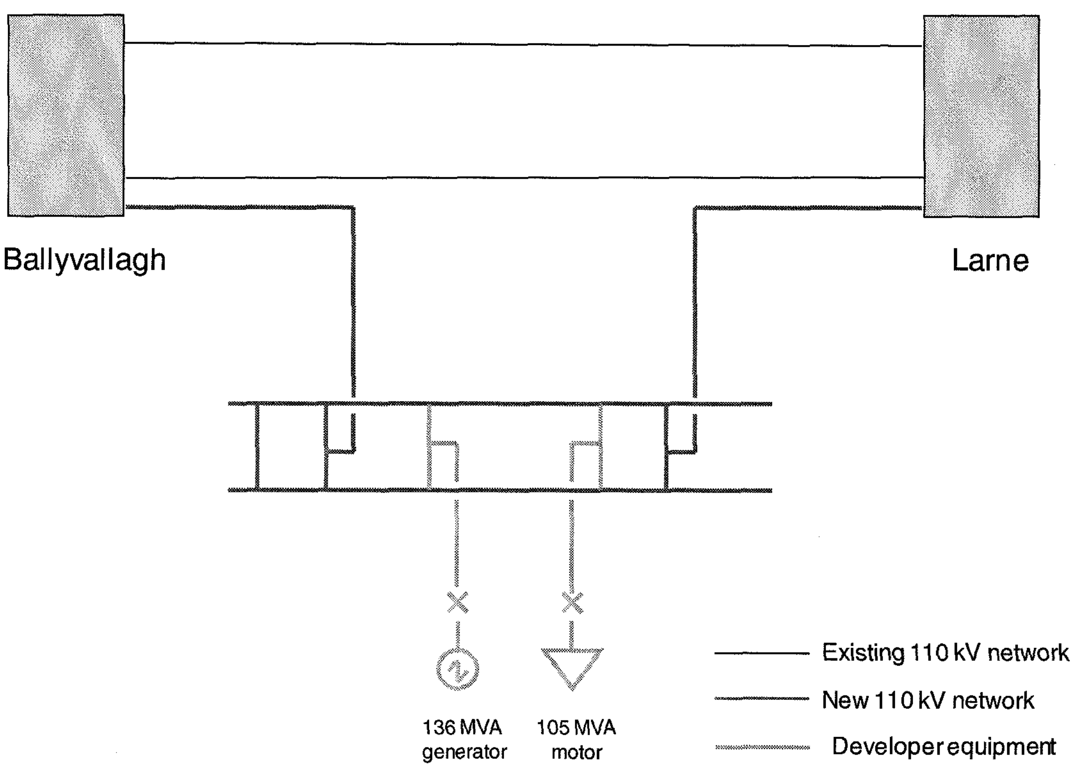


Figure 7: Option 4, Establish a new 110 kV substation at CAES and connect to Ballylumford by 2x110 kV cables. This would involve taking 110 kV cables from Ballylumford across Larne Lough to the CAES plant, and establishing a new substation there into which the Ballyvallagh – Larne circuits would be diverted.



Option 5. A new connection to Larne and a new connection to Ballyvallagh.

SONI has acknowledged that deep reinforcements may be required for some of these options.

Phase 2: This phase is likely to involve similar options for grid connection as Phase 1. It would require additional transmission build and would almost certainly require deep reinforcement. A further grid connection study will be required to identify the optimal transmission solution.

[redacted]

g) Key technical characteristics

- Technology (please describe as necessary)

  Compressed Air Energy Storage.

  For Phases 1 and 2, we intend to deploy existing CAES technology, which at present is only provided by Dresser-Rand. The generation train offered is modular and fixed at 134MW. A range of compressors can be provided. The project promoter is considering compressor options in the 80 to 100MW range for each phase. In future years, other technology providers are likely to offer plant with a range of generation capacities and these will be considered for Subsequent Phases.

- Installed generation power (MW)

  Phase 1: 134MW
  Phase 2: 134MW additional

  [redacted]

- Installed generation capacity (GWh)

  Phase 1: c550GWh annually

- Net compression power (MW)

  Phase 1: 80-100MW
  Phase 2: 80-100MW additional

  [redacted]

- Response time (seconds) 600 seconds (generation)
  300 seconds (compression).

- Energy rating of storage (minutes) **Phase 1:** 630 minutes

- Power density of storage (W/kg) 205 W/kg

- Energy density of storage (Wh/kg) 26 Wh/kg

- Round-trip efficiency (charging-discharging) (%)

Phase 1 and Phase 2: 53.0%.

Note that round-trip efficiency may not be an appropriate metric for describing efficiency of CAES due to its use of electricity for compression and natural gas combined with compressed air for generation. An energy ratio is therefore typically used. The energy ratio for phases 1 and 2 is approximately 78%.

- Lifetime (years) – for new installations, please specify expected lifetime from start of operation; [redacted]

  New installation. Phase 1: 30 years from start of operation in 2016.

- Cycles – for battery storage, please specify the expected number of cycles over the lifetime of the battery; for pumped hydro storage, please specify the number of cycles per day (for a given expected lifetime).

  Phase 1 and Phase 2: 1 to 2 compression-generation cycles per 24 hours are anticipated at present (for 30 year expected lifetime). Additional cycling may be required depending on TSO requirements.

- Voltage at connection point (kV): **Phase 1:** 110kV

h) Estimated project cost (capital expenditure in million euros)

Phase 1: €150M

Phase 2: €130M

[redacted]

i) Planned date of commissioning (year)

Phase 1: 2016

Phase 2: 2019-20

[redacted]

j) Implementation status

☐Pre-feasibility

☒Feasibility/FEED

☐Final Investment Decision (FID)

☐Permitting

☐Construction

k) Obstacles for the implementation of the investment item

☒Permit granting (please explain):

(1) In Northern Ireland, a grid connection offer can only be made after Planning Permission has been granted. This may affect timely delivery of the project.

(2) The location of the CAES facility is constrained by the geological salt resource. As the CAES-usable portion of the salt deposit is located under farmland rather than industrial land, this may present an obstacle when Planning Approval is applied for. [redacted]

(3) Transmission may represent an additional Planning obstacle, particularly if deep reinforcements are necessary.

(4) The gas supply pipeline to the facility is likely to be in the order of 10-20km. As a private developer, the project promoter does not have powers of Compulsory Purchase Order and landowner consent may add considerable cost and time to project delivery.

☒Regulatory treatment (please explain):

- Treatment and incentives under the Trading and Settlement Code
- Treatment with respect to capacity payments and network charges
- The Grid Code does not specify requirements for CAES technology
- Inadequate incentives for provision of Ancillary Services, no provision for long term reliability contracts
- Unfavourable treatment of green attributes from RES directly connected to storage

☒Financing (please explain):

- Phase 1 is likely to be the first CAES plant built since 1991, and the first to be optimised specifically to facilitate high levels of wind integration on an island grid.
- Due to uncertainty in regulatory treatment as described above, financing risk remains high, especially lack of long term contracts
- Optimising the plant for provision of ancillary services to the TSO may add to financing risk due to regulatory treatment and possible increased capital cost
- Probable high integration cost to satisfy grid requirements compared to conventional thermal plant
- Project insurance (in construction and operation) likely to be expensive and may be prohibitive
- Excessive cost of mezzanine finance in the context of the above
- The technology has insufficient track record to attract adequate levels of senior debt.

☐Other (please explain):...

☐None

2. Specific information

a) Which EU Member States are involved or affected by the project, at which borders?

The project is located in Northern Ireland, UK.

Member States affected by the project are UK and Ireland:

- across the border between Northern Ireland and Ireland and
- between the Island of Ireland and Great Britain.

b) Are any non-EU Member States involved or affected by the project, at which borders? **No**

c) Does the project cross borders directly or does it have a cross-border impact? Please specify the installed generation capacity and the average net annual electricity generation capacity over the first 20 years of the project (GWh/year), using appropriate modelling results.

The project has cross-border impacts as follows:

(i) across the border between Northern Ireland and Ireland, via

- the existing All-Island Grid
- the North-South Interconnector (PCI number E155)
- the Single Electricity Market that operates across Northern Ireland and Ireland

and

(ii) between the Island of Ireland and Great Britain, via

- the existing Moyle Interconnector (NI-Scotland)
- the East-West Interconnector (Ireland-Great Britain, in construction)
- the proposed new Ireland-Great Britain Interconnector (PCI number E154).

Installed generation capacity:

Phase 1 of the project provides storage capacity allowing a net annual electricity generation of up to 550 GWh/year. Unit commitment modelling indicates a capacity factor (generation) of about 20%. The actual usage of the facility is highly dependent on TSO requirements for ancillary services.

d) What are the main reasons for you to propose this project for consideration as a PCI?

The project meets the PCI qualification criteria:

- the project is necessary for the implementation of the NSOG energy infrastructure priority corridor
- the project displays economic, social and environmental viability

- the project involves Member States UK and EI, by being located on the territory of UK and having a significant cross-border impact in UK and EI
- the project contributes significantly to:
  - market integration, competition and system flexibility
  - sustainability
  - interoperability and secure system operation.

The project faces obstacles to delivery:

All phases of the project will require the significant support that PCI designation may provide due to the obstacles to permitting, regulatory issues and financing as outlined in the reply to Q 1 k above.

e) How does the project contribute to the integration of the internal energy market, competition and / or eliminate isolated markets?

The project provides necessary storage and ancillary services to the grid which facilitate the integration of renewable sources, in particular onshore and offshore wind.

The internal market also requires intraday solutions facilitating responses closer to real time. The project provides flexible, fast acting plant which has the benefit of not only being far less exposed to gas price volatility than conventional generation, but it can ramp faster than the vast majority of conventional gas generators in the grid, thereby achieving increased efficiency in the intra-day market and increasing the grid's capability of moving gate closures to real time.

In terms of competition, the characteristics of CAES, i.e. flexibility, fast ramping, storage, low & flat heat rate and demand side attributes all contribute towards driving competition in the market.

f) How does the project facilitate integration of renewable generation? Please describe, using appropriate modelling results.

The Single Energy Market faces challenges with respect to the level of the inertia on the system, primarily caused by the significant amounts of variable wind energy on the grid system. Storage will prove to be a valuable asset to the system, but it is the demand side of CAES which provides the system with major benefit with regards to its synchronous demand side capability which can increase demand, thereby creating more "room" on the grid for wind, and in so doing, reduce curtailment. This is done whilst maintaining the system integrity through keeping inertia on the system at all times.

Further to this, the project will provide numerous Ancillary Services in both generation and demand side (compression). These system services will be increasingly relied upon given the future system issues which will be encountered through increased integration of renewables. By providing these services in a fast, efficient and competitive manner, the project will facilitate integration of renewable energy. Preliminary unit commitment modelling carried out by GES has shown that a single train CAES plant of 134 MW generation output could avoid 70 GWh of curtailment in the year 2020 on the island of Ireland . This modelling is not inclusive of transmission constraints etc and is at an hourly resolution.

Therefore it is likely that the project would allow even more curtailment avoidance in actual operation, especially if it is optimised to provide ancillary services for curtailment avoidance. This modelling is ongoing.

g) What is the additionality of the project? Please list the installed capacity for each existing storage installation using a technology similar to the one of the project in a radius of 200km from the project ***[please submit map showing location and size of each existing storage installation]***

There are no existing storage installations using a technology similar to the one of the project, or pumped hydro storage facilities, within a radius of 200km from the project.

h) How does the project ensure security of supply and a secure and reliable system operation? Please describe, using appropriate modelling results.

Security of Supply is ensured through the ability to call on flexibility in tight market scenarios, which occurs due to supply/demand imbalance. CAES has shown itself in the Alabama plant which was built in 1991 to have a reliability rating in excess of 97% running, and the technology is proven to an extent that it can provide numerous ancillary services on both the generation and demand side. In Ireland, certain conventional power plants must remain synchronised to the grid at all times to allow a sufficient amount of inertia to be retained on the system. Since the Project will be synchronous on the demand side, it can help to prevent this constraint from being breached while simultaneously allowing more wind to come online.

Furthermore, dispatching the plant in the balancing and intraday markets at very short notice lead times will serve to increase the ability of the TSOs to ensure security of supply at all times on the grid.

i) Why is the realisation of this project particularly urgent with regard to the EU energy policy targets of i) market integration and competition, ii) sustainability and iii) security of supply?

i) Market Integration has Renewable Integration at the heart of its objectives. In order to realise a fully integrated European Market, Renewables must be accommodated and a sustainable business case needs to be presented. Interconnectors are shown to go some way to achieving this, and storage is providing another opportunity. The demand side characteristics of CAES (synchronous, fast ramping, variable) have the capability of ensuring reduced curtailment and therefore increasing the business case for, and promoting the use of renewable energy (in line with Directive 2009/28/EC), whilst also serving to depress system marginal pricing, by utilising cheap energy on the demand side, thereby increasing competition in UK-EI, and in the European Market as a whole.

Furthermore, CAES is not as exposed to natural gas price volatility as conventional generators given that gas is not required on the demand side. Thus the project promotes further competition on the generation side in energy markets.

ii) Sustainability of markets will be achieved through procuring significant quantities of energy from indigenous resources. This can only be achieved by supporting these technologies, which are often disruptive with bespoke services such as synchronous demand response (notably required in the SEM) and fast acting, flexible generation services such as fast ramping, low minimum generation, inertial response, and voltage control.

CAES has the attributes to provide bespoke system services and will act as an integral tool for TSOs to effectively dispatch the market, whilst supporting renewables, and in so doing, maintaining and fostering a sustainable market place.

iii) Security of supply in energy markets is intrinsically linked to the services which the TSO can call upon from generators. In the SEM particularly, these system services are vital to the integrity of the grid and to continue to ensure adequate security of supply.

Additionally, the project will provide services to the grid which maintain system security, most notably for the SEM, Synchronous response on both the demand and generation side, which is crucial to the continued integration of renewables. Typically when wind penetration is increased, system inertia levels drop, often to a minimum allowed level which is provided by the minimum online plants. CAES can increase room for wind on the system whilst also increasing system inertia.

a) Are there any interdependencies and/or complementarities with other projects? If yes, which?

Complementarities:

The project facilitates investment in and operation of onshore & offshore wind projects

The project enhances the optimisation of existing interconnectors and helps to justify economically the investment in new interconnectors (PCI numbers E154 and E155), thus enhancing market integration and cross-border trading of renewable energy.

[NB: Additional technical information might be requested for storage projects for further evaluation.]

Projects of Common Interest

Project CAES Larne NI (electricity, storage)
PCI NUMBER E151
ADDITIONAL AND UPDATED INFORMATION
8th February 2013

**** Please send to ENER-B1-PROJECTS@ec.europa.eu and specify the priority corridor in the subject line ****

Introductory information

Contact details of the project promoter(s) (if several, please fill in for each project promoter)

Company: **Gaelectric Energy Storage Ltd**...

☐ TSO ☐ DSO ☒ Other project promoter[1]

Contact person: [redacted] ....

E-mail address [redacted] ....

Telephone number: [redacted] ....

Type of project

☐ Transmission project included in TYNDP 2012 – please refer to Questionnaire I

☐ Transmission project not included in TYNDP 2012 – please refer to Questionnaire II

☒ Storage project – please refer to Questionnaire III

Priority corridor

For the implementation of which energy infrastructure priority corridor is the project necessary? **NSOG**

---

[1] Project promoter is defined in Article 2.5 of the draft Regulation COM(2011) 658 of 19.10.2011. 'projectpromoter' means:
a) transmission system operator or distribution system operator or other operator or investor developing a project of common interest; or
b) if there are several transmission system operators, distribution system operators, other operators, investors, or any group thereof, the entity with legal personality under the applicable national law, which has been designated by contractual arrangement between them and which has the capacity to undertake legal obligations and assume financial liability on behalf of the parties to the contractual arrangement.

III. Questionnaire for electricity storage projects

1.	General information

a) Name of project

Project CAES Larne NI

b) Brief description

Compressed Air Energy Storage using caverns/chambers to be created in bedded salt deposits.

Phase 1: Two Dresser-Rand CAES units each of 134MW generation capacity and 80-100 MW compression, for a total of 268 MW generation capacity and 160-200 MW of compression. Environmental baseline studies are in progress. Planning application is scheduled for Q3 2013. Expected Commercial Operation Date: Unit 1, 2016; Unit 2, 2019-20. This project will require innovation around the business model and also the optimisation of storage caverns and surface plant to facilitate integration and operation of onshore wind in Northern Ireland (UK) and Ireland (IE) to provide necessary storage and ancillary services to the TSO. Phase 1 will use caverns created in the salt deposits by the standard method of solution mining. The project promoter has conducted

- extensive geological and geotechnical work to establish the suitability of the salt deposits to host CAES caverns and provide cavern design
- detailed modelling of the operation of the CAES technology in its interplay with the caverns
- detailed economic, commercial and financial modelling of the project to identify and quantify system benefits and derive a business model for the particular requirements of the TSOs in Northern Ireland and Ireland in the context of the high renewable energy targets.

[redacted]

c) Are any other undertakings involved in the project? The project includes connection to the transmission grid which may involve deep reinforcement.

d) Situation of the project promoter(s):

- What is legal status of the project promoter(s)? Please specify (registered undertaking, group of companies, other).

  Gaelectric Energy Storage Ltd is a company registered in Ireland.

  Company registered number: 428818

Date of incorporation: 26 October 2006

Registered address: Portview House, Thorncastle Street, Ringsend, Dublin 4, Ireland

If you are a registered undertaking, please provide the list of all shareholders, information on their main activity and their respective shares in the undertaking.

Name of shareholder: Gaelectric Holdings plc holds 100% of Gaelectric Energy Storage Ltd

Activity: Renewable energy and energy storage in UK, Ireland and North America

Class of holding: Ordinary Shares

Amount: €2.00

Nationality: Company registered in Ireland, Registered number 418730

[redacted]

- What is the share capital of this undertaking?

  Class of capital: Ordinary Shares (€1)

  Amount issued: €2.00

  Amount authorised: €100,000.00

e) Project type

☒New

☐Upgrade / Repowering / Retrofitting

☐Extension

f) Key geographical characteristics ***[please submit map indicating information given below]***

- Location: **Larne, Northern Ireland, UK**
- Connection point to transmission network:

  Phase 1, Unit1: In April 2012 the System Operator for Northern Ireland (SONI) requested Northern Ireland Electricity (NIE) to carry out feasibility studies for connection of Unit 1 of the project.

  TNEI has conducted the Connection Feasibility Study on behalf of NIE.

Figure 1 shows the proposed NIE network in 2015 and the project location. Figure 2 shows the existing 110 kV network in the Larne area. Figure 3 shows the location of the project and existing 110 kV network.

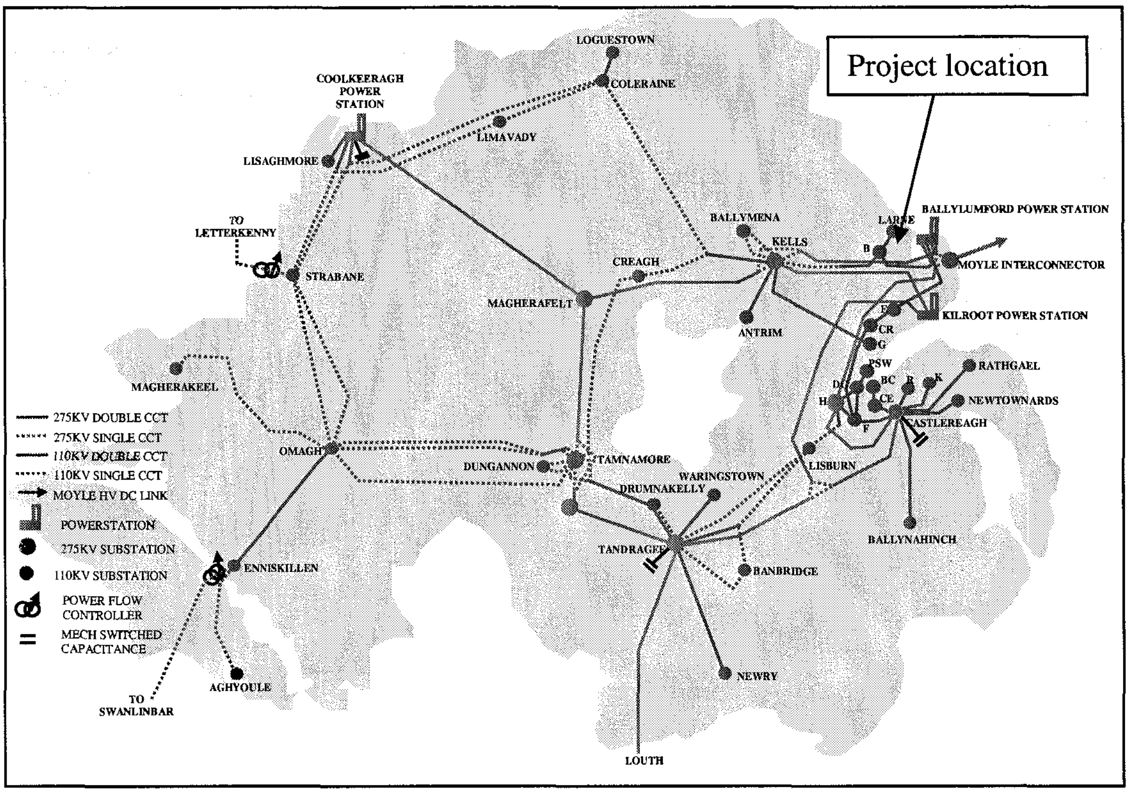


Figure 1: Proposed NIE network in 2015 showing location of the project

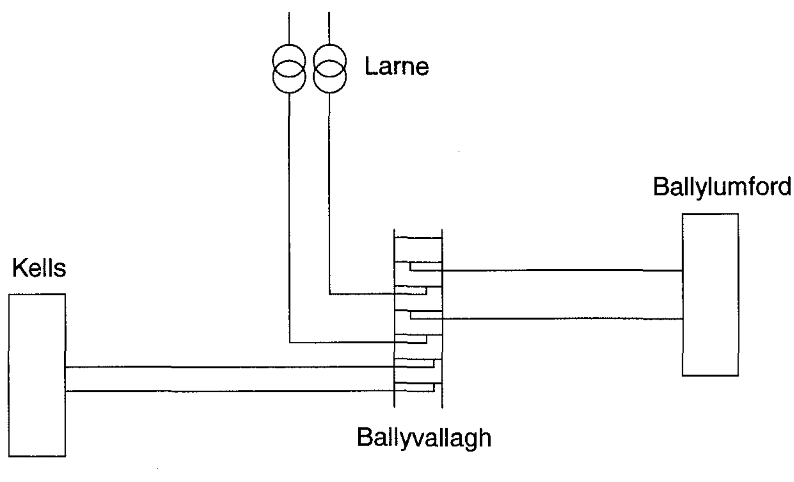


Figure 2: Existing 110 kV network in the Larne/Ballyvallagh area

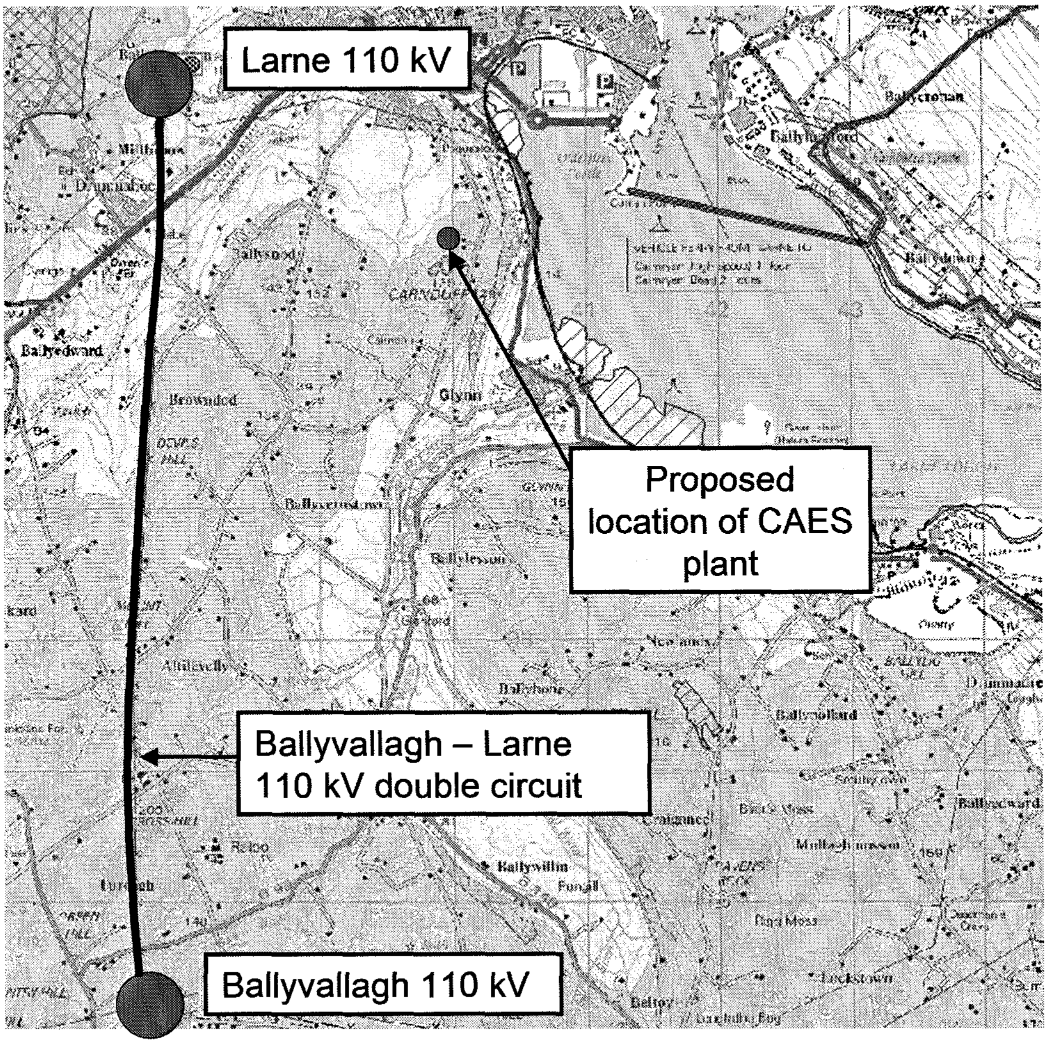


Figure 3: Proposed location of CAES plant in relation to existing 110 kV network

The study by TNEI considers five connection options suggested by SONI. Each connection option has been studied to identify:

- thermal overloads
- voltage violations
- motor starting voltage steps outside statutory limits
- generator trip voltage steps outside statutory limits
- fault levels exceeding switchgear rating.

TNEI, NIE and SONI have selected a preferred connection option at Ballyvallagh (Figure 4).

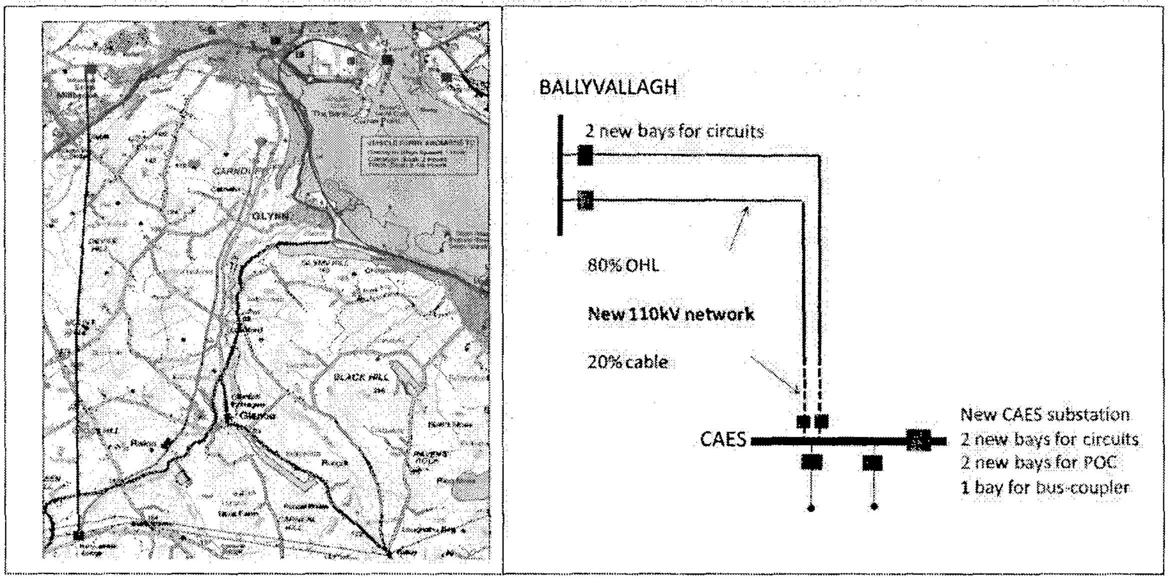


Figure 4. Preferred option for connection of Larne CAES Unit 1

Phase 1, Unit 2: Will connect at Kells (Figure 1). It will require additional transmission build and deep reinforcement.

[redacted]

g) Key technical characteristics

- Technology (please describe as necessary)

  Compressed Air Energy Storage.

  For Phase 1, CAES Units 1 and 2, we intend to deploy existing CAES technology, which at present is only provided by Dresser-Rand. The generation train offered is modular and fixed at 134MW. A range of compressors can be provided. The project promoter is considering compressor options in the 80 to 100MW range for each unit.

  [redacted]

  In addition the project promoter will assess the viability of partially adiabatic CAES, using heat storage technologies to maximise energy efficiency. This would involve storing some of the heat of compression to contribute to the generation mode, thereby minimising gas consumption during generation. This would require a trade-off between energy efficiency and the provision of inertia as provided by currently offered Dresser-Rand CAES compression technology which produces low-grade heat with little potential for contributing to generation.

- Installed generation power (MW)

Phase 1: 268 MW

[redacted]

- Installed generation capacity (GWh)

  Phase 1: 1,047 GWh annually
- Net compression power (MW)

  Phase 1: 160-200 MW

[redacted]

- Response time from de-synch to full load (seconds)

  600 seconds (generation)

  300 seconds (compression).
- Energy rating of storage (minutes) **Phase 1:** 600 minutes
- Power density of storage (W/kg) 18 W/kg
- Energy density of storage (Wh/kg) 205 Wh/kg
- Round-trip efficiency (charging-discharging) (%)

  Phase 1: 53.0%.
  Note that round-trip efficiency may not be an appropriate metric for describing efficiency of CAES due to its use of electricity for compression and natural gas combined with compressed air for generation.
  It can be represented by the equation:

$$\eta_{th} = \frac{E_G}{E_C + E_F}$$

Where: E_G = Generated energy

E_c = Compression energy

E_F = Gas fuel Energy

For CAES, a metric termed *energy ratio* is generally used to describe and quantify the electrical energy balances alone. It is represented by the compression energy divided by the generated energy:

$$ER = \frac{E_C}{E_G}$$

The energy ratio for Phase 1, Units 1 and 2 is approximately 0.78.

[redacted]Lifetime (years) – for new installations, please specify expected lifetime from start of operation; [redacted]

New installation. Phase 1: 30 years from start of operation.

- o Cycles – for battery storage, please specify the expected number of cycles over the lifetime of the battery; for pumped hydro storage, please specify the number of cycles per day (for a given expected lifetime).

  Phase 1: 1 to 2 compression-generation cycles per 24 hours are anticipated at present (for 30 year expected lifetime). Additional cycling may be required depending on TSO requirements.

- o Voltage at connection point (kV): **Phase 1: Unit 1,** 110kV at Ballyvallagh. **Unit 2**, 110kV at Kells.

h) Estimated project cost (capital expenditure in million euros)

Phase 1: Unit 1, €180 million. **Unit 2,** €130 million

[redacted]

i) Planned date of commissioning (year)

Phase 1: Unit 1 2016. **Unit 2** 2019-20

[redacted]

j) Implementation status

☐Pre-feasibility

☒Feasibility/FEED

☐Final Investment Decision (FID)

☐Permitting

☐Construction

k) Obstacles for the implementation of the investment item

☒Permit granting (please explain):

(1) Grid Connection Offer: At present in Northern Ireland, a grid connection offer can only be made after Planning Permission has been granted. Timely delivery of the project requires alignment of grid connection with Planning.

(2) The location of the CAES facility is constrained by the geological salt resource. As the CAES-usable portion of the salt deposit is located under farmland rather than industrial land, this may present an obstacle when Planning Permission is applied for. [redacted]

(3) Transmission may represent an additional Planning obstacle, particularly if deep reinforcements are necessary.

(4) The gas supply pipeline to the facility is likely to be in the order of 10-20km. As a private developer, the project promoter does not have powers of Compulsory Purchase Order and landowner consent may add considerable cost and time to project delivery.

☒Regulatory treatment (please explain):

- Existing market structures do not currently consider or address the unique characteristics of CAES, particularly with respect to the treatment of such plant in the Trading & Settlement Code, Generation Licence and the Bidding Code of Practice.

- Treatment with respect to Capacity Payments and network charges must be resolved
- The Grid Code does not specify requirements for CAES technology
- Inadequate incentives for provision of Ancillary Services, no provision for long term reliability contracts
- Unfavourable treatment of green attributes from RES directly connected to storage.

☒Financing (please explain):

- Phase 1 is likely to be the first CAES plant built since 1991, and the first to be optimised specifically to facilitate high levels of wind integration on an island grid. This is likely to present a barrier to attracting adequate finance for the project.
- Due to uncertainty in regulatory treatment as described above, especially lack of long term contracts, financing risk remains high.
- Optimising the plant for provision of ancillary services to the TSO is likely to add to financing risk due to uncertainty in regulatory treatment and probable increased capital cost.
- Compared to conventional thermal plant, a CAES facility is likely to be subject to high integration cost to satisfy grid requirements.
- The project is likely to incur insurance costs in construction and operation that may be prohibitive, particularly in the context of early stage (cavern) construction and associated long lead items.
- The cost of mezzanine finance in the context of the above is likely to be excessive. In particular, cavern construction would require a dedicated mezzanine financing at a relatively high cost.
- The technology has insufficient track record to attract adequate levels of senior debt.

☐Other (please explain):……………………………………………………………..

☐None

2.	**Specific information**

a) Which EU Member States are involved or affected by the project, at which borders?

The project is located in Northern Ireland, UK.

Member States affected by the project are UK and Ireland:

- across the border between Northern Ireland and Ireland and
- between the Island of Ireland and Great Britain.

b) Are any non-EU Member States involved or affected by the project, at which borders? **No**

c) Does the project cross borders directly or does it have a cross-border impact? Please specify the installed generation capacity and the average net annual electricity generation capacity over the first 20 years of the project (GWh/year), using appropriate modelling results.

The project has cross-border impacts as follows:

(i) across the border between Northern Ireland (UK) and Ireland (IE), via

- the existing All-Island Grid
- the planned North-South Interconnector (PCI number E155)
- the Single Electricity Market, the first cross-border electricity market of its kind that operates between EU member states, across Northern Ireland (UK) and Ireland (IE).

and

(ii) between the Island of Ireland and Great Britain, via

- the existing Moyle Interconnector (NI-Scotland)
- the East-West Interconnector (Ireland-Great Britain, recently completed)
- the proposed new Ireland-Great Britain Interconnector (PCI number E154).

Installed generation capacity:

Phase 1 of the project provides storage capacity allowing a net annual electricity generation of more than 1,000 GWh/year. Unit commitment modelling using WILMAR indicates a capacity factor (generation) of about 20%. The dispatch of the facility's compression and generation is highly dependent on TSO requirements for ancillary services.

In conjunction with SONI/EirGrid the project promoter is conducting modelling of the project in the Single Electricity Market and All-Island Grid using PROMOD and PLEXOS. Results of this modelling which will be will be available in Q2 2013 will provide a more accurate dispatch profile and will also form the basis of a cost benefit analysis which will allow a structured means of assessing the merits of the project as a PCI candidate.

d) What are the main reasons for you to propose this project for consideration as a PCI?

The project meets the PCI qualification criteria:

- the project is necessary for the implementation of the NSOG energy infrastructure priority corridor
- the project displays economic, social and environmental viability

- the project involves Member States UK and IE, by being located on the territory of UK and having a significant cross-border impact in UK and IE
- the project contributes significantly to:
  - market integration, competition and system flexibility
  - sustainability
  - interoperability and secure system operation.

The project faces obstacles to delivery:

All phases of the project will require the significant support that PCI designation may provide due to the obstacles to permitting, regulatory issues and financing as outlined in the reply to Q 1 k above.

e) How does the project contribute to the integration of the internal energy market, competition and / or eliminate isolated markets?

The energy storage and ancillary services to the grid provided by the project facilitate the integration of the internal energy market, reduce isolation of the SEM and promote competition as follows:

The internal market requires intraday solutions facilitating responses closer to real time. The project provides flexible, fast acting plant which has the benefit of not only being far less exposed to gas price volatility than conventional generation, but it can ramp faster than the vast majority of conventional gas generators in the grid, thereby achieving increased efficiency in the envisaged power markets and increasing the grid's capability of moving gate closures to real time.

The technical characteristics of CAES, i.e. flexibility, fast ramping, storage, low & flat heat rate and demand side attributes all contribute towards driving competition in the market, particularly in provision of Balancing services.

In addition, unit dispatch modelling using WILMAR indicates increased flows across the Moyle and East-West Interconnectors between the Island of Ireland and Great Britain.

f) How does the project facilitate integration of renewable generation? Please describe, using appropriate modelling results.

The Single Energy Market faces challenges with respect to the level of the inertia on the system, primarily caused by the significant amounts of variable wind energy on the grid system. CAES will prove to be a valuable asset to the system, as the compressor train provides the system with major benefit due to its synchronous demand side capability which can increase demand rapidly, thereby creating more "room" on the grid for wind, and in so doing, reduce curtailment. This is done whilst maintaining the system integrity through keeping inertia on the system at all times.

Further to this, the project will provide numerous Ancillary Services in both generation and demand side (compression). These system services will be increasingly relied upon given the future system issues which will be encountered through increased integration of renewables. By providing these services in a fast, efficient and competitive manner, the project will facilitate integration of renewable energy.

The following text (in italics) is an excerpt from a letter provided to the project promoter and to DG Energy by SONI:

The recently published "Facilitation of Renewables Study" and subsequent "Programme for a Secure Sustainable Power System" (the DS3 Program) highlight the challenges for the operation of the power system with high renewable penetration. The System Operator of Northern Ireland (SONI) and EirGrid (the TSOs on the island of Ireland) are committed to achieving the safe, secure and economic operation of the power system to enable the management of variable energy sources that will facilitate the achievement of both governments' 40% renewable target by 2020.

As new and innovative ways to manage the system with increasing renewable generation will be required, the TSOs have recommended targeted review and revision of ancillary service payments. This is being pursued through the DS3 Program to achieve the required portfolio capability of the future power system. Under consideration are future new ancillary services which may include inertial response, negative reserve, ramping services and other forms of flexibility.

SONI understands the potential benefits of bulk storage to a small system such as Ireland and Northern Ireland and notes that CAES could offer a broad range of existing and new ancillary services that may enable greater levels of wind generated electricity to operate economically on the Island of Ireland. In particular, it may be economic to reduce wind curtailment by increasing synchronous demand with CAES and this could lead to increased wind penetration. Furthermore, favourable technical characteristics such as its minimum stable generation, part-load operation and ramping capability makes the technology an attractive provider of reserve and ramping services to enable wind balancing. As evidenced in the All-Island Grid Study, such flexibility to facilitate high wind penetrations have the potential to reduce system costs, enhance security of supply and reduce reliance on imported fossil fuels.

Given the potential of CAES to deliver such benefits, SONI would like to express its support for Gaelectric's Project CAES-Larne.

SONI will continue to work with the project sponsor to deliver its Licence responsibilities on a number of fronts such as grid connection, system integration, plant design, Grid Code compliance and market reward mechanisms.

The following table summarises ancillary services currently existing and under consideration by the DS3 Program (in which the project promoter is actively involved) which can be provided by the CAES facility in generation and/or compression (demand) mode:

(Key: G = Generation, D = Demand, ***B*** = Both Demand and Generation)

	Method of Provision	Applicability to CAES	D/G
	Existing		
Primary Operating Response (POR)	Automatic Response to be fully available from 5-15 seconds after event	CAES will provide when synchronised to the grid.	***G***

Secondary Operating Response (SOR)	Additional (and/or reduction demand) output compared to pre incident output. Available from 15-90 seconds following an event	As above	*G*
Tertiary Operating Response 1 (TOR 1)	Additional output compared to pre incident output. Available from 90-300 seconds following an event	As Above	*G*
Tertiary Operating Response 2 (TOR 2)	Additional compared to pre incident output. Available from 5-20 minutes following an event	When synched and operating. CAES can also provide approx. 10MW from de-synch.	*G*
Replacement Reserve	Additional (and/or reduction demand) output compared to pre incident output. Available from 20mins-4 hours following an event	CAES can provide this and be ramped up to full power from off within this timeframe.	*B*
Reactive Power	The provision by a generator (or demand customer) of leading and lagging power to the grid.	CAES can provide this on both Generation and Demand Side.	*B*
Black Start	The procedure necessary to energise part of a system in shutdown without an external supply	CAES can provide this service	*G*
	New		
Minimum Generation	Incentivising the portfolio and newer facilities to be able to perform at lower min gens.	CAES can provide this service, and can move to min gen of 10 or 20% MEC.	*G*
Synchronous Compensation	The provision reactive power (MVAr) and Automatic Voltage Regulation (AVR) without providing active power (MW)	CAES can provide this service should clutches be specified for the trains.	*B*
Reduced Time to Synchronisation (warming)	The synchronisation time for plants may be introduced into the market schedule, incentivising plants to reduce it where possible.	CAES is a fast acting plant, with a very low minimum time to synch	*G*
	DS3 Proposed		
Synchronous Intertial Response (SIR)	Payment for generators with ability to provide inertia when generating/consuming. This will be further incentivised with lower min generation levels (Payment is inversely proportional to the % min gen of a unit). Encourages units with very low min gen levels and synchronous demand units.	CAES provides inertia on both generation/demand side and would receive payment for both. (Min Gen of 10 or 20% on generation side). The compression train supplies	*B*
Fast Frequency Response	The ability to provide an increase in power within 2 seconds after event and sustain for at least 8 seconds. The extra energy provided in the 2-10 second window must be greater than subsequent reduction in power in the following 10-20 seconds.	Currently being assessed whether CAES can provide this service	*B*
Post-Fault Active	The ability of a plant to recover 90%	As above.	*B*

Power Recovery	of its pre-fault value within 250ms and remain connected for at least 15mins		
Ramping Option 1	1,3,8 hour ramping products (RM1, RM3, RM8)	CAES ramps at a higher rate than most generators on the island. Will be a reliable provider of this service	*B*
Ramping Option 2	1,3,8 hour ramping products (RM1, RM3, RM8) with associated durations of 2,5,8 hours respectively	As above.	*B*
Dynamic Reactive Power Capability	A reactive power service defined as the generators capability to deliver a response that is proportionate to the magnitude of the voltage drop. Like the SIR product, payment will also be scaled by how low the %min. gen of a unit is.	Both the compression and generation train can provide this service. The low minimum generation level of CAES and presence of synchronous demand allows CAES be a favourable provider of this service.	*B*
In Discussion			
Negative Reserve	Ability of Generation to reduce output and demand side to increase demand in response to high wind/low demand.	CAES can provide both services. Minimum generation contracts may result in Neg. Reserve becoming a demand only service	*B*

Preliminary unit commitment modelling carried out by GES using WILMAR has shown that a single train CAES plant of 134 MW generation output could avoid 70 GWh of curtailment in the year 2020 on the island of Ireland. This modelling does not incorporate transmission constraints etc and is at an hourly resolution. Therefore it is likely that the project would allow even more curtailment avoidance in actual operation, especially if it is optimised to provide ancillary services for curtailment avoidance. Results of further modelling of the project using PROMOD and PLEXOS, being conducted in conjunction with SONI/EirGrid, will be available in December 2012.

g) What is the additionality of the project? Please list the installed capacity for each existing storage installation using a technology similar to the one of the project in a radius of 200km from the project ***[please submit map showing location and size of each existing storage installation]***

There are no existing storage installations using a technology similar to the one of the project, or pumped hydro storage facilities, within a radius of 200km from the project.

This project is unique and particularly innovative in several respects:

- It is the most advanced CAES project in Europe and is the only CAES project that is eligible for PCI designation.
- It is the only storage project proposed for PCI designation in the UK
- It is the only PCI candidate storage project in the NSOG region that proposes to address the needs of the System Operators with regard to integration of high

levels of wind (see 2(f) above), rather than simply providing a means of storing excess wind energy for export.

h) How does the project ensure security of supply and a secure and reliable system operation? Please describe, using appropriate modelling results.

Introduction

Security of Supply is ensured through the ability to call on flexibility in tight market scenarios, which occurs due to supply/demand imbalance. CAES has shown itself in the Alabama plant which was built in 1991 to have a reliability rating in excess of 97% running, and the technology is proven to an extent that it can provide numerous ancillary services on both the generation and demand side. In Ireland, certain conventional power plants must remain synchronised to the grid at all times to allow a sufficient amount of inertia to be retained on the system. Since the Project will be synchronous on the demand side, it can help to prevent this constraint from being breached while simultaneously allowing more wind to come online.

Furthermore, dispatching the plant in the balancing and intraday markets at very short notice lead times will serve to increase the ability of the TSOs to ensure security of supply at all times on the grid.

Modelling Storage in the SEM

In 2012 the project promoter conducted a unique study for the Sustainable Energy Authority of Ireland, using PLEXOS to examine the effects of installing new storage of a similar size to CAES Larne within the SEM. Key results of the study include:

- System costs are reduced by up to €30 million (2.1%), carbon emissions are reduced by up to 9 t/GWh (3.4%) and curtailment is reduced from 6.7% to 5.4% (178 GWh);
- While an increase of the Non-Synchronous Penetration Limit from the current level of 50% up to 75% decreases curtailment levels substantially, storage still provides similar levels of cost reduction to the system;
- The value of storage is intrinsically linked to its flexibility and the provision of system services such as reserve;
- A 16 % increase in the installed wind capacity doubles wind curtailment without new storage; as more wind is installed the benefits of storage are greater;
- Storage reduces cycling of conventional plant – baseload plant start ups are reduced by up to 35% and the ramping capability of the system at a 5 minute time horizon improves significantly.

Modelling CAES Larne on the Island of Ireland

In conjunction with SONI, the project promoter is conducting modelling of the project in the Single Electricity Market and All-Island Grid using PROMOD and PLEXOS. Results of this modelling will be available in Q2 2013. Initial results for the year 2013 indicate savings in system production costs of up to €6 million. Substantial savings are to be expected for future years.

All-Island Generation Capacity Statement 2013-2022

The GCS (EirGrid-SONI 2013) identifies the risk of serious generation deficits in Northern Ireland:

- NI is at risk of generation deficits from 2016 onwards in the event of a prolonged outage of a large generation plant or of the Moyle Interconnector;
- There is uncertainty as to when the current ongoing fault on one cable of the Moyle Interconnector will be repaired;
- In a number of different scenarios, e.g. the loss of a major generator or of the Moyle Interconnector, NI fails to meet the generation adequacy standard post 2015;
- Capacity Margins in NI fall to 200 MW in 2016 with the closure of 510 MW at Ballylumford;
- Capacity Margins in NI go negative in 2021 as Killroot (476 MW) is restricted in compliance with the Industrial Emissions Directive;
- In the absence of Project CAES Larne, Northern Ireland is totally reliant on the additional North-South tie line to ensure that the security of supply position is fully compliant with generation adequacy standards.

Other

See excerpt from SONI letter in reply to Q 2 (f) above.

i) Why is the realisation of this project particularly urgent with regard to the EU energy policy targets of i) market integration and competition, ii) sustainability and iii) security of supply?

The realisation of this project is particularly urgent with regard to market integration and competition, sustainability and security of supply because of the challenges faced by the system operators (SONI and EirGrid) in integrating high levels of wind in order to meet the ambitious RES targets for Northern Ireland and Ireland. These challenges, referred to in the excerpt from the SONI letter (Q 2 (f) above), are described in detail in the Facilitation of Renewables Study and are being addressed by the DS3 Program in which the project promoter is an active participant.

i) Market integration and competition: The requirement for member states to comply with the EU directive on Capacity Allocation and Congestion Management through market integration has placed a greater burden on the Single Energy Market (SEM) than on other markets, with respect to multiple gate closures.
The introduction of a plant onto the island with the attributes that CAES has can contribute significantly towards achieving market integration through improving the ability of the market to adhere to target model requirements such as harmonised gate closures closer to real time, which require flexible and fast acting plant. The firming of renewables is a further requirement of the target model, which can be optimised using fast acting bulk storage, through time shifting. In addition, CAES offers multiple products into the market and will improve market

liquidity and hence competition on the island in terms of offering a wider array of sources for traders to purchase energy.

The demand side characteristics of CAES (synchronous, fast ramping, variable) have the capability of allowing reduced curtailment and therefore increasing the business case for, and promoting the competitive edge for renewable energy sources as against thermal plant (in line with Directive 2009/28/EC).

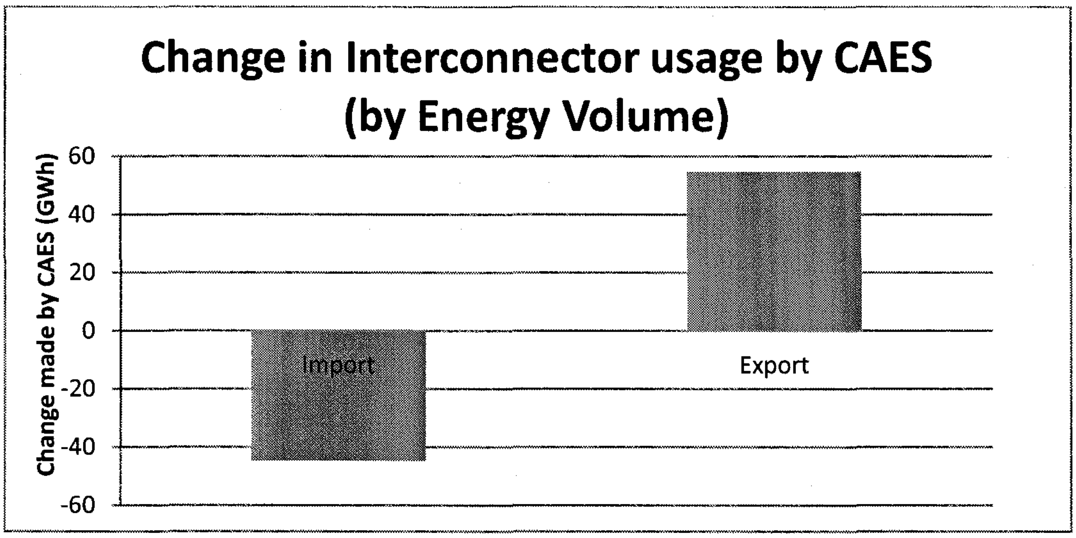
The nearest market neighbour to the SEM is the BETTA market in Great Britain. Using WILMAR, the project promoter has conducted unit dispatch modelling that examines the effect of the CAES facility operating in SEM including activity on the Moyle and East-West Interconnectors, at an hourly resolution for the study year of 2020. The model was run for a base case scenario that included predicted plant mix and fuel prices.

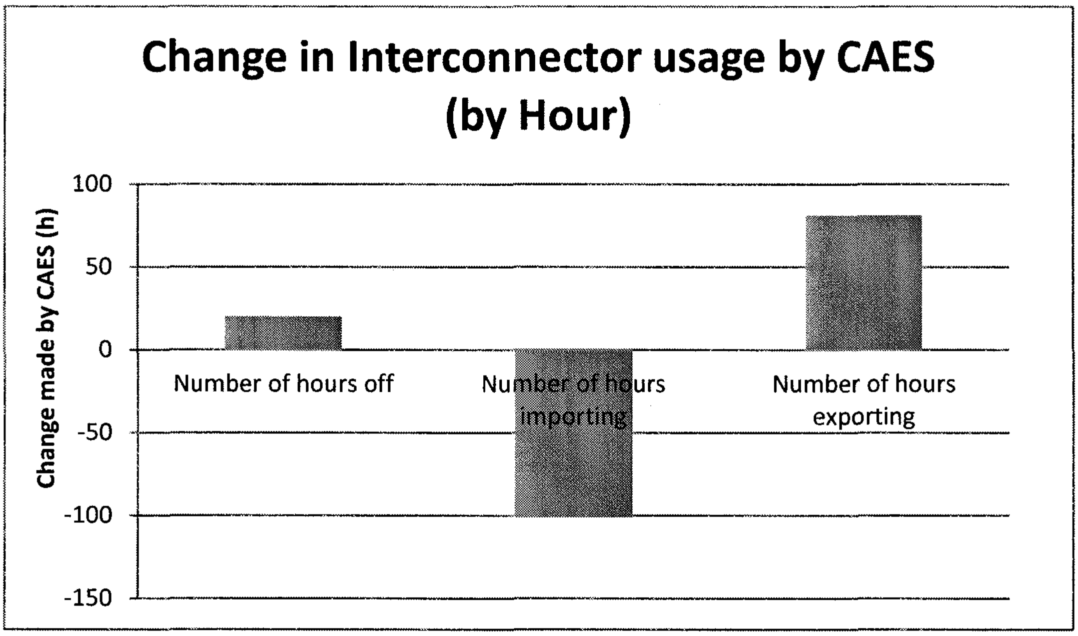
Interconnection between Ireland and GB consists of two interconnectors, each with 500 MW of capacity giving a total interconnection capacity of 1000 MW between the two systems. The Moyle Interconnector connects Northern Ireland and Scotland, and the East-West Interconnector connects the Republic of Ireland and Wales.

While transmission constraints were not modelled in the study, some operational constraints were assumed in the modelling to represent characteristics of constraints between Northern Ireland and the Republic of Ireland (for example, there is minimum number of large units that must remain online in each jurisdiction).

The objective function of the WILMAR model is to minimise system costs in all jurisdictions (Northern Ireland, Republic of Ireland and Great Britain), therefore any change in model output when a new unit is added compared to the base case scenario is reflective of a reduction in costs.

The charts below show the difference in interconnector flows when CAES is added within SEM. Exports from the Island of Ireland (SEM) increase and imports from GB to SEM decrease (by both energy volume and number of hours of flow) due to the addition of the project. Thus the project increases net electricity export from Ireland to GB, which reduces system costs across both markets.





While interconnectors transfer energy from one area or market to another, storage transfers energy from one time period to a later time period. There is therefore a natural symbiotic relationship between the two technologies.

CAES in SEM allows excess wind energy to be stored during times of maximum export to GB and will allow this stored energy to be exported at a later time. Thus the project enhances the trade in electricity, in particular renewable-sourced electricity, between the two markets.

Furthermore, the Island of Ireland, and Northern Ireland in particular, is at present heavily reliant on generation fuelled by imported gas. CAES is not as exposed to natural gas price volatility as conventional generators as gas is not required for the compression phase. Thus the project promotes further competition on the generation side in energy markets in terms of the price of procuring power.

ii) Sustainability: As described above in response to Q 2 (f), in particular the excerpt from the SONI letter, integration of high levels of wind is already presenting a serious challenge to the TSOs. These technical issues, described in detail in the Facilitation of Renewables Study, will become increasingly challenging without the introduction of flexible plant such as CAES.

CAES has the attributes to provide bespoke system services and will act as an integral tool for the TSOs to effectively dispatch plant in the market, whilst supporting renewables, and in so doing, maintaining and fostering a sustainable market place.

The Island of Ireland, and Northern Ireland in particular, is at present heavily reliant on generation fuelled by imported gas. The ability of CAES to provide ancillary services reduces the requirement to ramp thermal plant, thereby enhancing the sustainability of the system.

iii) Security of supply: See all responses above and in particular the points raised in the **All-Island GCS 2013-2022** and the excerpt from the SONI letter with regard to the impact on the grid of integrating high levels of wind.

Security of supply in energy markets is intrinsically linked to the services which the TSO can call upon from generators. In the SEM particularly, these system services are vital to the integrity of the grid and to continue to ensure adequate security of supply.

Additionally, the project will provide services to the grid which maintain system security, most notably for the SEM, Synchronous response on both the demand and generation side, which is crucial to the continued integration of renewables. Typically when wind penetration is increased, system inertia levels drop, often to a minimum allowed level which is provided by the minimum online plants. CAES can increase room for wind on the system whilst also increasing system inertia. The issues of low system inertia and reserve will become more critical in Northern Ireland in 2016 with the decommissioning of 510 MW of conventional generation at Ballylumford.

j) Are there any interdependencies and/or complementarities with other projects? If yes, which?

Complementarities:

Phase 1 of the project facilitates investment in and operation of all onshore wind projects that are connected to or intend to connect to the grid on the island of Ireland to participate in the Single Electricity Market between Northern Ireland (UK) and Ireland (IE).

[redacted]

The project enhances the optimisation of existing interconnectors (see in particular answer to Question 2 (i) above) and therefore helps to justify economically the investment in new interconnectors (PCI numbers E154 and E155), thus enhancing market integration and cross-border trading of renewable energy.

[redacted]

[NB: Additional technical information might be requested for storage projects for further evaluation.]