José Manuel Barroso
President of the European Commission

Brussels, 0 3 JUIN 2014

Subject: ***Complaint by Mr Joseph CAULFIELD,***
ref. 181/2013/(JF)(RT)AN

Dear Ms O'Reilly,

Thank you for the letter of 22 January 2014 regarding the above-mentioned case.

I am pleased to enclose the comments of the Commission on this complaint. I regret that a certain delay has occurred in the transmission of this reply.

I draw your attention to the fact that this file has been treated confidentially.

Naturally, the Commission remains at your disposal for any further information you may require.

Yours sincerely,

José Manuel BARROSO

Enclosures

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FINAL

Comments of the Commission on a proposal for a friendly solution from the European Ombudsman
- Complaint by Mr Joseph CAULFIELD, ref. 181/2013/(JF)(RT)AN

1. MAIN PRELIMINARY FINDINGS OF THE OMBUDSMAN

In her preliminary assessment, the Ombudsman noted that:

- *The Commission has failed to show how business secrets of the undertakings concerned were endangered by the disclosure of each piece of the redacted information*[1].

- *It was not entirely clear whether the redacted paragraphs should or should not be disclosed*[2].

- *The Commission cannot blindly follow the view of the providers of the information as to whether a particular exception is applicable, but it needs to make its own assessment*[3].

- *It was not possible to establish whether the Commission carried out the public interest test*[4].

- *The estimated costs of the projects might, if approved, have an impact on the environment and thus could constitute 'environmental information' in the sense of the Aarhus Convention*[5].

2. THE OMBUDSMAN'S PROPOSAL FOR A FRIENDLY SOLUTION

In view of the above, the Ombudsman suggested that the Commission could grant full access to the questionnaires by disclosing the redacted paragraphs.

3. POSITION OF THE COMMISSION

3.1. The Commission recalls that the complainant's request for access to the questionnaires completed by the project promoters was handled by the Directorate-General for Energy (DG ENER) at the initial stage.

[1] Paragraph 32 of the friendly solution proposal

[2] Paragraph 35 of the friendly solution proposal

[3] Paragraph 36 of the friendly solution proposal

[4] Paragraph 38 of the friendly solution proposal

[5] Idem.

3.2. On 22 April 2013, the complainant received partial access to the said questionnaires. DG ENER explained that it had redacted (i) personal data and (ii) certain commercially sensitive information from the questionnaires. The complainant did not submit a confirmatory application but instead decided to directly pursue this issue in the context of the present complaint before the Ombudsman.

3.3. In light of the above-mentioned proposal for a friendly solution from the Ombudsman, the Commission has reassessed the content of the requested questionnaires with a view to considering the possibility of granting either full access, as requested by the Ombudsman, or wider access to the parts which had been redacted. The results of its assessment are set out below.

Concerning the personal data redacted:

Article 2(a) of Data Protection Regulation 45/2001[6] provides that *'personal data' shall mean any information relating to an identified or identifiable person* […]. The Commission maintains its view that personal names, e-mail addresses and telephone numbers redacted from the questionnaires constitute personal data in the sense of Article 2(a) of Regulation 45/2001.

The Commission notes that the applicant has not established the need to obtain these personal data, and that it cannot be excluded that the release thereof would prejudice the privacy and integrity of the individuals concerned. In accordance with the exception laid down in Article 4(1)(b) of Regulation 1049/2001 as interpreted by the Courts[7], access to these elements can therefore not be provided.

The Commission understands that the Ombudsman agrees with the above assessment, as she did not question it in her proposal for a friendly solution.

Considering that only personal data had been redacted from the following questionnaires (E150, E152, E153, E154, E155, E156 and E291), the Commission consequently understands that these questionnaires are not covered by the Ombudsman's friendly solution proposal.

Concerning the commercially sensitive information:

Based on an assessment of the input received from the project promoters who had provided the replies to the project questionnaires, DG ENER had redacted additional information (other than personal data) from the following three completed project questionnaires:

(i) Questionnaire E149a Natural Hydro Energy Ireland 'Project Highway';

(ii) Questionnaire E149b Natural Hydro Energy Ireland 'Project Store';

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6 Regulation (EC) No 45/2001 of the European Parliament and of the Council of 18 December 2000 on the protection of individuals with regard to the processing of personal data by the Community institutions and bodies and on the free movement of such data, Official Journal L 8 of 12.1.2001, p. 1.

7 Judgment of 29.6.2010 in Case C-28/08 P, *Bavarian Lager.*

(iii) Questionnaire E151 (an update to the original submission).

According to Regulation 1049/2001 and its implementing rules[8], it is the Commission who takes the final decision whether to disclose the documents in its possession.

Nevertheless, following the Ombudsman's friendly solution proposal the Commission decided to re-consult the project promoters that had submitted the above-mentioned questionnaires in order to discuss the possibility of granting either full or wider partial access to the latter.

Taking into account this further dialogue with the project promoters and in light of its own assessment of the documents concerned, the Commission is pleased to inform the Ombudsman that it has decided to grant wider public access to the requested questionnaires (see enclosures 1 and 2) by maintaining only very limited redactions, as the remaining parts are not covered by any of the exceptions of Article 4 of Regulation 1049/2001.

Questionnaires 149a and 149 b:

The only information that is still redacted from questionnaire 149a are the following two figures: the level (amount) of access to funding (on page 3) and the estimated project costs (on page 4).

The only information that is still withheld from questionnaire 149b is the level (amount) of access to funding (on page 3), the estimated project costs (on page 4), the cost per unit power and the energy storage cost, with a related brief explanation (on page 13) .

The remaining sections of the said questionnaires that had been previously redacted are now disclosed.

Questionnaire 151:

As for questionnaire 151, the Commission recalls that DG ENER provided partial public access to the updated and additional information sent by the project promoter on 8 February 2013. The reason for this was that the project promoter's original submission was no longer up-to-date. The Commission re-consulted the project promoter in the context of the present friendly solution proposal and for the sake of completeness it considered also the possibility of granting access to the original submission, which the promoter had previously sent to DG ENER.

The Commission concludes that the following redactions from the original submission and from the additional and updated information sent on 8 February 2013 should be maintained:

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8 OJ L 345/94 of 29.12.2001.

- information on the possible subsequent phases of the project containing reference to certain follow-up actions and the type of resources to be invested, as provided under letters b, f, g, h, i and k, was redacted from both the original submission and the update;

- a summary of the ownership of shares of the holding concerned (presented as a chart) (letter d).

The Commission considers that the redacted parts relating to project questionnaires 149a, 149b and 151 (original submission and an update) referred to above fall within the exception laid down in Article 4(2), 1st indent of Regulation 1049/2001 concerning the protection of commercial interests of the legal entities concerned, including their intellectual property.

Indeed, the redacted estimated costs of the project, available construction funding and the cost per unit power and the energy storage cost are individual to each project promoter and reflect its business model, genuine use of resources and possible competitive advantage. Disclosure of this information would reveal details about its way of operating to its competitors, which could use this information to the project promoter's disadvantage. Therefore, if the corresponding parts of the questionnaires 149a and 149b were to be released, there is a real and non-hypothetical risk that the commercial interests of the project promoter concerned would be negatively affected.

The Commission notes in this regard that it attempted to provide as wide a public access to the requested questionnaires as possible. When the project promoters did not specifically object to the estimated project costs to be made public, the Commission did grant public access to these data. However, in cases, such as the one concerning project questionnaires 149a and 149b, where the project promoter specifically objected to the disclosure of this financial information, the Commission considers that it has sufficient elements to conclude that access to it is protected under the commercial interest exception of Regulation 1049/2001.

The redactions maintained in the project questionnaire 151 concern the exact ownership of the shares of the holding in question. In the present case, the project promoter has asked the Commission not to reveal the specific ownership structure of the holding concerned. On the basis of this feedback, the Commission takes the view that there is a real and non-hypothetical risk that public knowledge of this information would undermine the commercial interest of the holding on the market and in particular its market value.

The other element redacted from 151 concerns information on the possible subsequent phases of the project. Given that these data reveal the future commercial and research strategy of the promoter, references to works to be considered and the resources to be envisaged, the Commission considers that there is a real and non-hypothetical risk that disclosure of this information would undermine the commercial interests of the promoter and its intellectual property, for similar reasons as those set out above for the other undisclosed elements of the documents requested.

Further to the above-mentioned exception of Regulation 1049/2001, the Commission would like to draw the Ombudsman's attention to the following specific provisions, which were also considered in the context of the complainant's request for access and the Ombudsman's friendly solution proposal.

Article 339 of the Treaty on the Functioning of the European Union requires members of the staff of the EU institutions to refrain from disclosing *"information of the kind covered by the obligation of professional secrecy, in particular information about undertakings, their business relations or their cost components"*.

Furthermore, a special confidentiality requirement was laid down in Regulation 347/2013 on guidelines for trans-European energy infrastructure. More specifically, Annex III, point 2(2) of Regulation 347/2013 provides that *"*[a]*ll recipients shall preserve the confidentiality of commercially sensitive information"*.

The application of Regulation 1049/2001 cannot have the effect of rendering these provisions ineffective. It follows that the exceptions of Article 4 of Regulation 1049/2001 have to be read in light with the confidentiality requirements defined in the TFEU and in Regulation 347/2013. The project promoters that have submitted information to the Commission on the basis of privileged access rules have the legitimate expectation that the institution will not divulge that information to the public and that it will protect commercially sensitive data contained in their submissions. The Commission is of the view that if commercially sensitive information were to be disclosed, this would be also contrary to the confidentiality requirements defined in Regulation 347/3013, which aims to protect commercially sensitive information dealt with under that Regulation. It is evident that this would also negatively impact the stakeholders' confidence in the Commission's services and, consequently, the Commission's decision-making process protected under Article 4(3) of Regulation 1049/2001, as its stakeholders would be less likely in the future to submit commercially sensitive information to the Commission, which is necessary for the institution in order to decide on the related project proposals.

Overriding public interest in disclosure and the issue of an 'environmental information' in the sense of the Aarhus Convention:

The Commission recognises that it has not specifically informed the complainant of whether it had carried out a public interest test.

The complainant referred in this regard to the Convention on access to information, public participation in decision-making and access to justice in environmental matters ('the Aarhus Convention'). This convention has been transposed into Union law by Regulation 1367/2006[9] (The 'Aarhus Regulation').

As illustrated by the content itself of the disclosed documents at stake, the exception provided under Article 6 of Regulation 1367/2006 which obliges the divulgation of information only when it is information on emissions, is not relevant at all given that the content of the requested documents concerns information on proposals from project promoters for European Projects of Common Interest (PCIs) (key infrastructure projects in the energy sector, i.e. electricity transmission lines and electricity storages) and they do not contain any information on emissions into the environment. Therefore, an overriding public interest is not deemed to exist in this case.

The Commission recalls that the Court of Justice in its *TGI* and *Bavarian Lager* judgments[10] confirmed that administrative activities are to be clearly distinguished from legislative procedures, for which the Court has acknowledged the existence of wider openness.

In the Commission's view, the limited redactions maintained are justified in order to safeguard the commercial interests and the intellectual property of the legal entities concerned, as well as the Commission's decision-making process, and they prevail over the public interest in transparency in this case. The fact that the documents concern an administrative procedure, and not a legislative procedure for which wider openness is presumed to exist, only reinforces this conclusion.

4. PROPOSAL TO SETTLE THE CASE

In replying to the Ombudsman's friendly solution proposal, the Commission has now provided the complainant with the widest possible access to the requested questionnaires. For the reasons explained above the Commission is not in a position to grant full public access.

Encl.: (2)

(1) Questionnaire E149a Natural Hydro Energy Ireland 'Project Highway' and Questionnaire E149b Natural Hydro Energy Ireland 'Project Store' (partial access)

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9 Regulation (EC) 1367/2006 of the European Parliament and of the Council of 6 September 2006 on the application of the provisions of the Aarhus Convention on access to information, public participation in decision-making and access to justice in environmental matters to Community institutions and bodies, OJ 2006 L 264, p.13.

10 Judgment of the Court (Grand Chamber) of 29 June 2010 in case C-139/07 P, *European Commission v Technische Glaswerke Ilmenau Gmbh*, paragraphs 53-55 and 60; Judgment of the Court (Grand Chamber) of 29 June 2010, European Commission v the Bavarian Lager Co. Ltd., paragraphs 56-57 and 63.

(2) Questionnaire E151 Project Caes Larne NI (electricity, storage) – original submission and the updated information (partial access)

Natural Hydro Energy Ireland

Questionnaire II response (Project Highway)

Interconnection with the UK Market via DC link 1,200MW (this project NHE "Project Highway") to serve Large Scale Hydro Storage (90,000MWhrs) (separate project NHE "Project Store" subject of a separate application)

Please NOTE

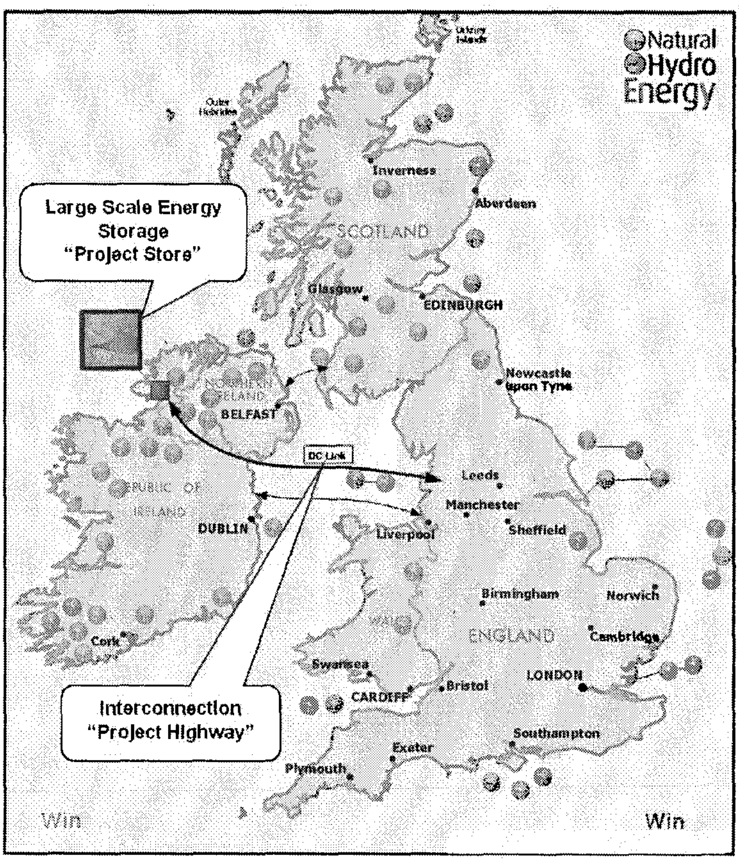
The Natural Hydro Energy overall project consists of two parts:

1. HVDC cable Interconnection between Ireland and the UK, not included in current TYNDPs, is covered by Questionnaire II (NHE Project Highway) and

2. Large scale Hydro Storage facility (NHE Project Store) is covered by Questionnaire III.

This overall project has been in development for three years. It is at an advanced stage of planning.

In this response, for clarity of understanding, Natural Hydro Energy (NHE) gives details of both aspects of this project. NHE responds to the similar questions raised in both questionnaires and the one additional question raised in Questionnaire III as a separate project.



Natural Hydro Energy

Only the DC Transmission link relevant to Questionnaire II need be considered in this response. This is designated NHE "Project Highway"

Ireland's energy resources are large and essential to EU Carbon Free Energy Security.

NOTE EU questions required to be answered in Questionnaires are shown in **BLUE PRINT.**

Responses are in BLACK PRINT

Title of the project: Natural Hydro Energy Project Highway

**** 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: Natural Hydro Energy

☐ TSO ☐ DSO ☒ Other project promoter[1] Other Promoter

Contact person: [redacted]

E-mail address: [redacted]

Telephone number: [redacted]

Type of project

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

Priority corridor

For the implementation of which energy infrastructure priority corridor is the project necessary? Northern Seas Electricity Corridor

II. Questionnaire for transmission projects not included in TYNDP

1. Reason for non-inclusion of project in TYNDP 2012

☐ No transmission license or no exemption from regulated regime; please explain:

☒ Other, please specify: Change in National Policy and economic imperative to drive energy export from Ireland to other EU countries as a means of meeting EU objectives and driving Ireland's economic recovery

2. General information

a) Name of project

Natural Hydro Energy "Project Highway"

b) Brief description

1,200MW interconnection to UK from Ireland coupling a large hydro energy store to both markets

c) Are any other project promoters involved in the project? (list each)

- Countries: ☒ EU ☐ Non-EU, please specify: United Kingdom
- Name of undertaking: Natural Hydro Energy UK Ireland Strategic Energy Infrastructure
- Contact details: Natural Hydro Energy Ltd.

d) Situation of the project promoter(s):

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

  Private company with anticipated participation by large EU utilities

- 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.

  This information will be provided in confidence

- What is the share capital of this undertaking?

  €40m with access up to [redacted] construction funding as required

e) Project type

☒ New

☐ Upgrade

☐ Extension

☐ Replacement

f) Key physical characteristics ***[please submit map indicating existing and new lines]***

- Start point (area): North West Ireland
- End point (area): Midlands UK
- Length (km): approximately 450km
- Route type: ☒ Onshore ☒ Offshore

g) Key technical characteristics

- Transmission capacity (MW for DC/ MVA for AC): 1,200MW
- Voltage (kV): 320 - 400kV
- Current: ☒DC ☐AC
- Line type: ☐ OHL ☒ Underground cable

h) Estimated project cost (capital expenditure in million euros) [redacted]

i) Planned date of commissioning (year) 2017

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):

☐Regulatory treatment (please explain):

☐Financing (please explain):

☒Other (please explain): Market integration planning to be completed. This will provide greater commercial certainty

☐None

Please provide:

A list of all studies carried out so far for the project;

List of all studies carried out so far on project

Wind Studies

10 years wind generation data every 15 minutes was analysed initially from the records of Eirgrid the Transmission System Operator for the Republic of Ireland and after the introduction of the Single Electricity Market (SEM) for the combined grids of Northern Ireland and the Republic from the records of the Single Electricity Market Operator (SEMO). The total generation was divided by the installed wind turbine capacity at the appropriate time to give average wind generation per 15 min period per MW of generation over the entire grids.

The resulting data formed the basis of accurate modelling of expected wind generation. Seasonal variations, differences from year to year and in particular values for typical variations of wind generation output over time were all derived from the basic data. These results were used to model wind generation expected to be available for export and also to power pumping for hydro storage reservoirs.

Hourly wind strength records for several years were analysed from the meteorological observatories of the Irish Meteorological Service Met Eireann. Results from these studies were used to determine local wind patterns and variation between regions

Irish Demand Studies

10 years of 15 minute total national grid demand were also analysed initially from Eirgrid and later from SEMO. The demand data was used in conjunction with the wind generation data to determine, when wind generation would have to be curtailed to comply with grid stability constraints. These studies were carried out to model grid operation including potential curtailment, both with and without the National Hydro Energy Hydro Storage project in operation.

System Marginal Price Analysis

10 years of the half hourly System Marginal Price data for every trading period from Eirgrid and SEMO records was also analysed

Operational Modelling

The wind generation, demand and SMP data were three of the principal inputs used in extensive, stochastic, deterministic, modelling of operation of the Natural Hydro Energy project. A full inventory of conventional plant available for generation, the storage capacity of the hydro storage reservoir and the operational characteristics of the NHE plant permitted accurate modelling of how all components would interact together. The output performance in terms of MWh produced from all categories of plant at appropriate prices determined by standard tariff structures permitted projected financial revenues to be calculated under all possible operational scenarios.

Equipment Pricing

Prices for all major electro-mechanical plant components were obtained from an extensive cross section of international suppliers.

Financial Modelling

The outputs from the operational modelling were combined with cost projections for construction of the NHE plant under different equity and loan scenarios to predict financial returns. These have been validated by Morgan Stanley London and Evercore Partners London.

Storage Sites Investigation

The fundamental concept of the Natural Hydro Energy Project sprang from the realisation of the massive, low cost hydro storage potential of particular glacial valleys created on the west coast of Ireland, as a result of the last ice age. Three dimensional cartographic analysis was undertaken initially on 54 valleys to ascertain accurate storage potential. Following detailed geological and hydrological analysis, this was reduced to three. Of these, one is being brought to full project build status.

Dam and Power Station Design

Extensive preliminary civil works and engineering design and costing studies were undertaken for the dam and power station structures by prominent Irish and international consultants Knight Piesold based in Vancouver Canada.

Land Acquisition and Pricing

The necessary land, approximately six square kilometres has been leased for 299 years. Detailed negotiations have been undertaken with both land owners and local communities to ensure agreement from all parties to construction of the project subject to agreed conditions.

Cable Routing

Studies into possible routes for cables linking the NHE Reservoir and power station to the greater Dublin area for interconnection to the Irish national grid and from Ireland to the UK have also been completed and are in detailed discussion with Eirgrid.

Transmission Facilities

Preliminary studies for transmission substations, AC/DC converter stations and cable design and costing have also been completed

Curtailment Studies

The most difficult problem facing Ireland's ability to meet its target of 40% of electricity generation from renewable sources in 2020 is the reduction of satisfactory economic returns to wind farm developers, due to increased curtailment of wind generation to maintain satisfactory grid stability at high levels of wind penetration. This problem has received extensive study, together with the solutions offered by the NHE project

A list of interactions with all concerned transmission system operators (TSO) and/or national regulatory authorities (NRAs): e.g. letter from TSO acknowledging receipt of application for grid connection or landing point, technical and financial proposal from TSO for connection, letter from NRA concerning the applicable legal regime for the project

Discussions and interactions began with Eirgrid Ireland in 2009 and with National Grid UK in 2011. The Storage facilities herein described are of considerable value to both TSOs. The exact nature of its operation acting separately in and between the two systems are a matter of very detailed technical analysis. This is ongoing and can be confirmed by the TSOs.

3. Specific information

a) Which EU Member States are involved or affected by the project with respect to grid transfer capability, at which borders?

Ireland and UK

b) Which non-EU Member States are involved or affected by the project with respect to grid transfer capability, at which borders?

None

c) Does the project cross borders directly or does it have a cross-border impact? Yes

Please specify the impact of the project on the grid transfer capability of each concerned border (in MW) 1,200MW

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

This project very clearly meets all EU objectives for producing Carbon Free, Price Stable, Secure Power. As such, it is a perfect exemplar of integrated transnational thinking and co-operation.

The particular substantive reasons for proposing the Natural Hydro Energy project from Ireland for consideration as a PCI arise from the following factors:

- Energy sources from the periphery of the EU need to be developed to their full potential. Ireland has 6% of all of the renewable resources of the EU with 1% of the population. Ireland can make a very valuable contribution to EU needs and security.

- The availability of extensive, low cost, high wind strength, onshore wind generation sites in Ireland, far in excess of domestic requirements, to assist satisfying EU renewable generation targets is a low cost, low risk, highly secure strategy.

- This project allows for greatly increased penetration of renewable energy in the Irish market above the 40% target level.

- It allows cross border large scale energy trading.

- This, in turn, allows effective competition, with lower projected costs, for increasing renewable generation in all EU Member States, but particularly in the UK and Ireland, to meet 2020 target values.

- There are considerable economic advantages from enhanced energy trading between Ireland, UK and mainland EU.

- NHE provides greatly enhanced security of supply advantages in Ireland and UK arising from large scale hydro storage reservoirs, increased, indigenous, price stable, renewable generation and reduced reliance on imported fossil fuels.

- The project represents considerable technical advances in terms of evolution of a very cost effective design for large scale hydro storage reservoirs.

- Easing integration of intermittent renewable generation by use of large scale hydro storage reservoirs to replace parallel operation of conventional thermal generation to compensate for fluctuation in renewable output.

- Creates <u>essential</u> dispatchability of renewable generation.

- Increasing the arbitrage value of stored, night time, off peak, renewable generation by releasing it during high demand, day time periods.

EU Proposals for Renewable Generation

All EU Member States have agreed target levels of electricity generation from renewable sources by 2020 to reduce emissions of harmful green house gasses and combat climate change. Most member states will need to considerably increase investment in renewable generation, in order to meet these targets. The cost and effectiveness of investments will depend on the category, capacity and strength of the sources of renewable energy available in each Member State.

Trading mechanisms have been evolved to permit States with large amounts of cost effective renewable energy, in excess of their own projected requirements, to export power to countries facing shortages or more costly generation technologies. Hydro electric schemes have traditionally been the largest source of renewable generation worldwide. They currently supply around 19% of electricity generated in the EU. However, throughout Europe, the most economic sites have already been exploited. Limited increases in hydro capacity are planned prior to 2020, but these will fall well short of the overall increase in renewable generation needed to meet the 2020 targets.

Other than hydro, wind generation has become the most successful and cost effective source of renewable generation in recent years. Extensive new large scale wind farms are under construction.

Examination of the TYNDPs for all EU Member States covering the period up to 2020 and beyond, shows that apart from moderate increases in hydro capacity, large amounts of increased wind generation is expected to constitute the main increase in renewable generation.

Economics of Renewable Generation in the EU

Because of the large scale future role envisaged for wind generation, it is important to consider site availability and wind energy levels available across the full range of Member States. Onshore wind is rapidly approaching similar costing per MWh produced to hydroelectric power, on sites with good capacity factors. However, wind generation suffers from an important disadvantage. It, like marine and solar power, is intermittent and can not be dispatched as easily as hydro.

The relative costs of both hydro and wind generation are very dependent on capacity factors. These vary considerably across the EU. Good onshore wind sites have capacity factors in the range 35% - 40%, with exceptional sites producing over 40% of rated capacity per annum. Hydro capacity factors depend strongly on the available head height on the site. High head Alpine and Nordic sites have capacity factors up to 55%. Medium and lower head run of the river sites lie more in the range 20% - 35%.

The working life spans of both hydro and wind generation are also important in determining cost per MWh produced. Realistic lifetimes of 80 to 100+ years are well established for hydroelectric stations, with major refurbishment intervals of around 40 years. Wind turbines have an expected economic life of 20 – 25 years.

Onshore wind and hydroelectricity are currently much less expensive than other competing forms of renewable generation such as offshore wind, marine or solar energy. However examination of the EU TYNDPs up to 2020 indicate that sites for onshore wind are becoming scarcer in many Member States, after available onshore sites have been developed. Towards 2020, it is expected, there will be greater migration to much more expensive, but more readily available offshore sites.

The UK NREAPS show plans for a very large increase in wind power from 5,430MW in 2010 to 22,450MW in 2020. This includes an increase in onshore wind of 10,850MW. However, a large increase of 10,210MW in offshore wind is also included. This will be associated with a significant increase in renewable generation costs.

Capital costs of offshore wind farms are much more expensive (currently in the range 2.5 to 3 times) than the equivalent cost per MW installed capacity of onshore sites. Erection and foundation costs increase rapidly in deeper water. Grid connection costs increase as turbines are located further offshore. Operation and maintenance costs are also much higher for offshore sites, particularly during adverse weather conditions. These increased costs are not offset by slightly higher offshore capacity factors, generally expected to be in the range 40% - 45%, off suitable coasts.

Cost / MWh produced and site availability will largely determine the increased capacity of EU renewable generation. Wind generation is expected to supply the greatest increase. Countries such as Ireland, with extensive availability of low cost, onshore sites, with high capacity factors, significantly above domestic renewable target requirements will have considerable advantages over areas with lower wind strengths and countries, where limited onshore site availability forces migration towards more extensive, but higher cost offshore locations.

Role of Energy Storage in Increasing Penetration of Renewable Generation

One of the major difficulties experienced with integrating sources of renewable generation in large scale electricity grid structures is intermittency. Wind, solar and marine generation are all subject to large scale variation in output over quite short time scales, depending on the intensity of the energy input. These sudden fluctuations can threaten security of supply on grids, unless output from conventional generation can be adjusted sufficiently rapidly, to compensate for the output variation from renewable sources.

In order to safely integrate intermittent, fluctuating, renewable generation, grid operators (Transmission and Distribution System Operators [TSOs & DSOs]) must ensure sufficient reserves of conventional generation are operated in parallel to the renewable sources, so that they can be ramped up or down to compensate, within adequate time response limits, for the worst potential variation in renewable output. Different categories of conventional generation exhibit greater or lesser flexibility in response time to load variation.

Conventional hydro generators and pump/turbines in pumped storage schemes have the fastest response time ranging from less than 1 minute to 2 minutes from no load to full load depending on machine size.

Ramping conventional generation to compensate for parallel variation in renewable output and providing sufficient standby spare conventional capacity introduces significant increased costs. Operating efficiency is lower at part load and fuel consumption is higher per MWh of electricity generated. Ramping plant up and down subjects it to greater wear and tear and maintenance costs increase. Operating plant at part load increases fixed costs such as depreciation over a reduced amount of MWh output. All of these additional charges must all be evaluated in comparing the costs of alternative competing sources of renewable generation

Either conventional hydro generation or pumped storage generation can compensate for intermittent renewable energy very effectively. Both have very rapid response times, which permit them to compensate for sudden changes in renewable output. Efficiency losses under part load operation and increased maintenance charges due to load ramping are less than for thermal plant. Hydro energy stored during high wind conditions can be released, when wind strength is low, so that the combined wind and hydro output is smoothed and in effect provides controlled amounts of dispatchable renewable energy.

Curtailment Constraints on Renewable Penetration

At the early stages of integrating intermittent renewable energy to large scale electricity grids, transmission system operators were concerned with the potential of severe excursions in renewable output to cause instability in grids. If for example, a sudden drop in wind output should occur, before sufficient conventional generation can be brought on line to compensate for the reduction, instability could occur, resulting in load shedding or possible black outs.

To avoid these problems, either sufficient fast acting reserve capacity must be available or renewable generation output may have to be curtailed. Curtailment results in undesirable loss of potential renewable generation. Isolated or lightly interconnected grids are most vulnerable to these conditions. The island grids of Ireland and the UK will be more prone to curtailment than the much more extensive grids in mainland Europe. Stronger interconnection will alleviate this problem, but will not eliminate it.

As the smaller of these two island grids, Ireland offers an interesting insight into the possible effects of curtailment. Renewable energy is allocated priority dispatch status over conventional generation in Ireland to encourage its usage. At the early stages of introducing renewable generation, the Irish TSO was reluctant to permit more than 10% of renewable generation to operate on the grid under any demand conditions.

Increased introduction of fast reacting open cycle gas turbine plant in recent years and greater experience of operating and more accurate forecasting of renewable (primarily wind) generation has permitted this constraint to be extended considerably. Ireland now permits 50% renewable generation on the grid in normal demand conditions, but this has to be reduced to 30%, when demand is lowest.

Ireland has accepted a high target of 40% of electricity generation from renewable sources by 2020. At present, nearly 15% of total generation is supplied by renewable sources. Low levels of curtailment are already necessary on the grid in strong wind conditions, when demand is low, particularly at night time. This is expected to increase considerably as renewable generation approaches the 40% target value. Curtailment will heavily reduce the economic returns from renewable sources, unless a solution to this problem is introduced.

Unique Storage Attributes of Natural Hydro Energy Project Design

The Natural Hydro Energy project will introduce very large capacity, low cost hydro storage reservoirs. These will help eliminate / reduce curtailment constraints on wind generation. The first 1500MW pumped storage station will accommodate 90,000MWh of stored hydro energy in its reservoir. The magnitude of this storage capacity can be appreciated, when compared to schemes in other countries. The UK has 2800MW of pumped storage generation with 14,000MWh storage. France has 7 schemes totalling 184,000MWh. Natural Hydro Energy plans a number of reservoirs in the longer term, any two of which will equal the total French hydro storage capacity.

Most pumped storage schemes have capacity to generate at full load for between 5 to 8 hours. The first NHE project at Kilcar on the North West coast of Co. Donegal, operating under its planned 13 hour daytime generating cycle and 11 hour night pumping regime will be able to generate continuously at full load for 2 weeks, even if there is no wind input. Pumping energy can be supplemented from unused off peak conventional generation in light wind conditions.

Natural Hydro Energy is planning to purchase wind generation daily, from a number of sources for direct export on its HVDC interconnector to the UK and supplement this with hydro generation pumped previously, primarily from off peak wind sources. NHE plans to have 700MW of wind generation contracted from wind farm operators to supply wind generation to NHE for direct export to the UK. This will be in excess of renewable generation planned to meet the Irish 2020 target. NHE will agree to take the total generation from these wind operators without curtailment.

In high wind conditions during daytime export hours, when some wind would normally have to be curtailed to maintain grid stability, NHE will purchase as much of this wind as possible, with the aim of filling the NHE interconnector capacity from Ireland to the UK. This will avoid wind curtailment and wastage of valuable renewable generation.

If insufficient curtailed wind is available together with the directly contracted wind to fill the interconnector, NHE will supplement both these sources by generating from released hydro energy from its large storage reservoir. Wind curtailment is expected to be much higher at night, when system demand is low. NHE plans to purchase large amounts of this wind generation, which would otherwise be curtailed and wasted.

This will improve the economics of off peak wind generation considerably. The increased demand needed for pumping will increase the level at which curtailment would otherwise be required. Large amounts of wind generation, which would otherwise be wasted, will be bought in to supply pumping operations

Interaction of the Interconnection with very large NHE storage capacity will provide a number of important advantages.

- Because much of the hydro generation will be pumped by wind generation, which would otherwise be curtailed, the overall electricity exported to the UK both directly from onshore, high capacity factor wind generation, supplemented by hydro pumped by onshore wind, will contain a very high percentage of renewable energy content. This will involve lower production costs and subsidisation than offshore wind production in the UK.

- The large storage capacity will permit variable wind generation to be supplemented by hydro electricity, ensuring fully controllable / dispatchable power throughout all export periods.

- The value of off peak renewable generation will be increased to high demand day time values

- Much less generation will be wasted due to curtailment

- The interconnector will operate at a high capacity factor and at 100% capacity during export hours

- Much lower interconnector capacity will be needed to export the steady state, average 1500MW of combined wind and hydro generation, than would be needed for the same MWh capacity of volatile wind generation, where interconnector capacity would have to match peak wind generation, while average generation may only be equivalent to 35% of peak.

- Large storage capacity will greatly increase security of supply, in ways which will be described later.

- The greater dispatchability and controllability of NHE generation, reduced difficulty and cost of parallel operational costs for conventional compensating generation, increased day time value achieved from the large capacity hydro storage combined with the low cost of high capacity factor onshore wind sites will all contribute to greater penetration of cost effective, reliable, secure, renewable generation.

Advantages of Unique Design Features of NHE Hydro Storage Reservoir

Many of the advantages of the NHE project are due to the low storage cost per MWh associated with the hydro storage reservoir. The low storage cost is a result of a combination of unusual design features, which can be exploited in glacial valley sites on the west coast of Ireland. It is expected that, subject to environmental approval and legal permitting, that the first of these projects will be sited near Kilcar in Co. Donegal in North West Ireland. The main concepts of the design, which contribute to the low cost of these large scale reservoirs are described below.

The project will use sea water as a working medium, instead of fresh water used in nearly all other pumped storage schemes. A sea water based scheme has been operating successfully in Okinawa in Japan for the last 15 years. The ocean will be used as the lower reservoir in the scheme. This greatly reduces construction costs normally associated with artificially created lower reservoirs in conventional pumped storage schemes.

The projects rely on the use of naturally occurring glacial formations created in the last ice age, which in a few rare instances created high valleys suitable for energy storage. Since Ireland has a very low level of seismic activity, a rock fill dam can safely be used to form an upper reservoir for the scheme. This is a less expensive form of construction than traditional concrete dam construction methods.

The dam is expected to be approximately 1.3km in length and will have a possible height of 120m at mid point. It will be constructed at the mouth of a long glacial valley. Having to dam only one end of a long narrow valley provides very large capacity in the upper reservoir in comparison to many conventional pumped storage schemes, where the reservoir is formed by a curtain dam, which completely encircles the reservoir. The geology of the valley floor is made up of primarily impermeable rock.

Water will be carried from the dam in multiple steel penstocks. The distance from the dam to the power house varies from 1 to 3 km on the sites selected by Natural Hydro Energy. The ground slopes gently over the intervening territory and provides heads ranging from 180 to 230m. The penstocks will be laid close to the surface of the ground in shallow covered trenches to minimise environmental impact. Using penstocks greatly reduces excavation and tunnelling costs for machine hall caverns, water head and tail race, access and cable tunnels frequently associated with conventional pumped storage schemes.

The first Natural Hydro Energy power station will be located in the North West of Ireland and will have 10 x 150MW Francis type pump/turbines totalling 1500MW capacity. It will be located approximately 2.5km from the dam. The head between the dam and the powerhouse will be approximately 230m on this site. The storage capacity of the reservoir with approximately 4 square km surface area will be 90,000MWh.

The power station will be connected to the ocean by a short channel. Rock for construction of the dam will come from excavations for the channel and the power station site, which must be located in a cutting to accommodate water transit from the draught tubes of the pump/turbines to the ocean 25m below minimum tide level. This local source of rock minimizes dam construction costs by eliminating the need to transport rock from outside the site.

This unusual design provides exceptionally large storage capacity of 90,000MWhs. Ireland has the potential for up to 300,000 MWhrs. This compares very favourably to the storage capacity of pumped storage schemes in the following countries.

	MWh
Spain	1,530,000
Switzerland	369,000
France	184,000
Austria	125,000
Portugal	107,000
Lithuania	49,000
Germany	39,000
UK	33,000
Greece	21,000
Poland	11,000
Belgum	8,000
Czech Republic	7,000
Luxemborg	6,000
Slovakia	4,000
Ireland	2,000
Bulgaria	1,000

Eurelectric 2020 Report "Hydro in Europe" Powering Renewables"

The Natural Hydro Energy design provides very large, low cost storage capacity to compensate for intermittent wind generation. Two of these Irish schemes would provide equivalent storage to all 7 of the pumped storage schemes in France, which provide important peak capacity in addition to France's 78% nuclear generation capacity.

The Natural Hydro Energy design has a cost per unit power of around €733 per kW installed. This is at the lower end of typical pumped storage scheme costs, which normally range from €700/kW to €2000/kW. The exceptional advantage of the Natural Hydro Energy design arises from its extremely low energy storage cost of €15/kWh, which compares with typical costs ranging from €80/kWh to €200/kWh for conventional energy storage schemes. This is an exceptional and ground breaking result.

This provides the advantage of an exceptional storage cycle length of a minimum of 2 weeks in zero wind conditions, which effectively eliminates intermittency. The Natural Hydro Energy power station can operate indefinitely in only intermittent light to moderate wind conditions. This advantage arises from the unique geographic topography of the long, narrow, sloping, Irish glacial valley sites.

UK Generation Capacity Plans

The UK faces two major challenges to generation capacity up to 2020 and shortly beyond. The existing UK nuclear stations are approaching the end of their economic working life. Most of the first generation Magnox stations have already been closed. All of the remaining 9.3GW Magnox and second generation Avanced Gas Cooled Reactor stations with the exception of Sizewell B are planned to close by 2023.

The remaining 3 oil fired stations and a number of old coal fired stations have chosen to opt out of the requirements for flue gas desulphurization imposed by the EU Large Combustion Plant Directive. A total of 12GW of these stations will have to close by the end of 2015. The continued economic viability of the remaining 20GW of more modern coal fired stations will depend on the costs of new Carbon Capture and Storage technology, which is currently undergoing pilot scheme evaluation.

In addition to the requirements to replace the nuclear and conventional stations facing closure, the UK must greatly increase generation from renewable sources to meet its 2020 target of 30%. This includes NREAP plans to increase onshore wind capacity by 10,850MW and offshore wind by 10,210MW. The migration to more offshore sites as onshore capacity approaches saturation will significantly increase cost of renewable generation.

The closure of the UK nuclear and fossil fuel fired stations together with the large requirement for increased renewable generation will open the UK market to possible imports of cost effective, renewable energy up to 2020. Ireland, with a large surplus of high capacity factor onshore wind farm sites on land with low agricultural and commercial value, well in excess of its own renewable target requirements, will be in a strong position to compete for this potential market.

Ireland has two further important advantages. Its proximity to the UK reduces the length and hence cost of interconnectors. The advantages of the large scale hydro storage reservoirs proposed by the NHE project will also enhance the attraction of dispatchable, cost effective renewable energy imports from Ireland over interconnectors operating at high load factors during high demand day time trading periods.

Renewable Generation from Ireland Aided by Large Scale Storage

Finally, the main reasons, why the NHE project should be proposed for consideration as a PCI are as follows:

- It exploits extensive availability of economic, high strength, onshore wind resources in Ireland with offshore and wave available long term. This will earn valuable revenue for Ireland and greatly assist the UK meet its renewable generation targets benefiting emissions reduction and suppressing climate change in both countries

- Plentiful land with low agricultural or commercial value remains in Ireland, which offers the strongest wind and wave strengths in Europe. These are ideal conditions to expand cost effective sustainability between two cooperating Member States within the EU.

- The Irish home market for power generation is saturated. The only possible utilization of the valuable Irish renewable site potential is for export.

- Limited interconnection capacity is currently available out of Ireland. Much higher capacity would be required to fully exploit Ireland's valuable renewable assets. The NHE project offers a large increase in capacity, which will operate at very high load factors due to the benefits of high capacity storage smoothing peaky export flows from renewable generation.

- Ireland's population density is low on the west coast, which resulted in appropriate grid capacity, when they were constructed. The strong sites for renewable generation are also on the Atlantic coast. Extensive grid reinforcement is needed from wind and wave rich resource western areas to the east coast for export to the UK or Mainland Europe. The NHE project will make major contributions to grid reinforcement at no cost to the state.

- Due to the economic recession, the Irish state would have difficulty in providing funding for this size of project. NHE proposes to arrange funding from private sources, in a manner that will still provide substantial benefits to Ireland.

- The proximity of the UK to Ireland will require moderate interconnection costs to exploit Irelands valuable renewable resources combined with large scale, low cost storage.

e) How will the project facilitate market integration, elimination of isolated markets, competition and system flexibility? Please specify in particular the impact on energy system-wide generation and transmission costs.

Market Integration

The NHE project will immediately provide a large increase in interconnection capacity between Ireland and UK. In the longer term, it opens potential for further future interconnection between Ireland, France and mainland Europe via the UK.

The UK is facing difficulties with adequate overall future generation capacity, due to closure of both nuclear and fossil fuel fired plant. In addition, it expects to implement a very large expansion in renewable plant to meet its 2020 target. As the renewable construction programme progresses, the UK plans indicate increased development of around 50% of new wind capacity on expensive offshore sites, after its onshore sites are fully exploited. NHE could assist UK solve some of its generation shortfall and or meet its renewable targets economically.

Ireland has the potential to offer a large export capacity of surplus, dispatchable, low cost, onshore wind generation well in excess of Ireland's own foreseeable home market requirements. Ireland's onshore wind sites have some of the highest wind strength conditions in the World. This advantage coupled with low land values can provide wind generation at very competitive prices.

In addition to high quality onshore sites, the long storage cycle, high capacity, low cost, hydro storage potential will complement strong wind sites. The combined output from both sources will be dispatchable. The value of off peak wind generation will be greatly increased by dispatching it during high cost trading periods, when demand is highest. The large economic storage capacity of the Irish storage reservoirs will ensure that both wind and hydro can complement each other indefinitely, even during protracted periods of low wind strength. Losses due to curtailment will be minimised, which will further improve the economics of NHE generation.

Both Irish onshore wind site and hydro storage capacity is far in excess of Irish home market requirements. The only means by which Irelands valuable assets can be exploited is through export. Many Member States will face more expensive solutions to reach their 2020 targets. There has already been controversy in the UK over the cost of offshore wind sites combined with the additional cost of parallel operation of conventional generation at part load to compensate for wind intermittency. Availability of large amounts of dispatchable, renewable generation from Ireland at attractive prices will further market integration and encourage increased penetration of renewable generation.

Elimination of Isolated Markets

Ireland is no longer strictly speaking an isolated market, since one interconnector to the UK has been in operation for some time and a second is due for commissioning shortly. However, in comparison to the highly interconnected networks of mainland Europe, Ireland's island market is still relatively isolated to a large degree.

The NHE project will greatly reduce this isolation by providing extensive new interconnection capacity. This increased capacity will be essential to exploit Ireland's valuable wind and hydro capacity. By smoothing out peaks and valleys in wind output, the complementary hydro storage will ensure high load factors on interconnectors during export periods. This will minimise interconnection costs.

Competition

One of the primary aims of opening the electricity market is that competition will encourage cost effective prices. The 2020 targets for renewable generation will introduce a new aspect of competition to the open market. Not only will market competition continue between all suppliers, because of the large increases in renewable generation required to meet targets, specialised competition is likely to develop in this sector for the most cost effective renewable sources.

Future increases in fossil fuel prices and renewable technology improvements will continue to improve the competitive position of cost effective, renewable generation, with no fuel costs, in comparison to conventional sources Renewable generation has no fuel costs. Not only are continuously rising fuel prices effecting the electricity market with knock on effects to other industries, concern is increasing in many countries over security of future fuel supplies. This is most acute among countries with limited or no indigenous fossil fuel supplies.

These two important market forces will continue to increase competition between conventional generation and secure, emissions free, price stable renewable energy. Dispatchable, renewable energy will provide an additional bonus. Most Member States will be under pressure to increase renewable generation to meet 2020 targets initially and increasing targets beyond 2020. Competition for cost effective sources is likely to increase. Not only will generation companies seek competitive renewable sources, these will also be attractive to many industries under pressure to reduce emissions.

Limited availability of high capacity factor, low cost, onshore wind sites in many member states will increase migration of renewable generation towards more expensive offshore sites. This trend will continue to improve the competitive position of onshore sites, with good wind strengths, on land with low agricultural or commercial value.

Ireland has the highest onshore and offshore wind strengths in Europe, plus the strongest wave energy levels. It has abundant sites for high capacity factor, low cost onshore wind generation. There is extensive availability of low value land. The NHE project will avail of all of these competitive advantages to the fullest extent.

The NHE design combined with low seismic activity and unique Irish glacial valley topography, geography and geology offers exceptionally large capacity hydro storage capacity at low cost. NHE hydro storage reservoirs can absorb and store low value, off peak, surplus wind generation to pump hydro into storage and release it later during high demand periods. This is a very important competitive advantage of NHE over conventional onshore generation, without access to storage facilities.

NHE hydro storage will eliminate wastage of curtailed surplus generation in high strength wind conditions above safe grid acceptance levels resulting in further increase in advantages. In low wind conditions, NHE reservoirs can store valuable, high efficiency, low cost, conventional generation, which would otherwise be displaced/unused at night by increased wind penetration.

NHE hydro generation backed up by long term storage will smooth out peaks and valleys in wind generation. This will ensure highly efficient use and low cost design of transmission facilities connecting NHE combined wind and hydro generation to the UK grid. The close proximity of Ireland to the UK market will contribute to low interconnection costs. Low transmission costs will increase NHEs competitive position for exports.

System Flexibility

The NHE project offers a number of important enhancements to flexibility in the Irish grid as well as excellent flexibility in its own internal operations. Conventional hydro turbines and pump/turbines used in hydro storage schemes have the fastest ramping speeds to increase load in emergency situations of any generation category. This makes them ideal for fast reaction to compensate for rapid load changes in intermittent/volatile renewable generation.

The NHE pump/turbines can offer this rapid response flexibility indefinitely, because of the very large capacity of the hydro storage reservoirs and the long pump/generation cycles this storage can support. Most conventional pumped storage schemes have only generation capacity at full load of around 5 to 8 hours. NHE can effectively offer fast response continuously for indefinite periods of time.

In addition to flexible load following services, NHE will offer 1500 MW of the highest reaction speed of spinning reserve to both Irish and UK grids. This is a very valuable asset to both systems to assist recovery from serious fault conditions and protect against catastrophic grid failures and blackouts.

Pumped storage plant has another important inherent spinning reserve advantage over equally fast reacting conventional hydro generators and all other generation categories. It has the ability, under serious grid fault conditions, when operating in pumping mode, to stop pumping and eliminate this demand. It can then change to generation mode and supply the same amount of additional generation. In this way, it effectively doubles the amount of spinning reserve that can be offered to recover from faults.

There is significant concern about inertia on the Irish grid system as penetration of new wind farms increases. Modern direct drive wind turbines are decoupled from the grid through AC/DC converters used for frequency conversion and do not supply any inertia to the grid. As new wind penetration increases, this reduces the effective inertia supplied to the grid by conventional generators, which are displaced by the new wind turbines. Reduction in inertia, decreases the reaction time available for spinning reserve to compensate for serious faults. This increases the risk of load shedding or even catastrophic blackouts.

Finally, the NHE hydro generators will supply large amounts of reactive power to the grids to which it is connected. This is valuable for accurate voltage regulation and improving supply quality.

Impact on energy system-wide generation and transmission costs.

The primary source of energy in the NHE project is onshore wind on high capacity factor sites using low cost land. This combination produces very low cost renewable energy. Clearly, EU renewable generation costs to meet targets will benefit to the maximum extent from this approach.

The impact on overall generation costs will depend on the ratio of renewable and conventional generation adopted by each Member State, to meet 2020 targets, as well as the technologies used. Hydro and onshore wind are the cost leaders in the renewable sector. Combined Cycle Gas Turbine (CCGT) technology leads the fossil fuel sector. Nuclear costs are much more difficult to compare, due to the diverse manner in which decommissioning, waste handling costs and depreciation over various claimed economic lifetimes are charged.

Recent improvements in wind turbine technology, resulting in better performance and reduced cost per MW installed, have contributed to lower costs per MWh produced. Increasing European gas prices, after the severe price drop immediately after the start of the economic recession, have increased CCGT price per MWh produced. These two opposing trends have tended to close the gap between renewable and conventional costs.

Future values will naturally be influenced by fuel prices and availability. Renewable costs have no fuel costs and capital costs are expected to fall slowly due to design improvements and cost reduction due to economies of scale from increased production volumes.

The advantages of the NHE storage facilities in smoothing peaks and valleys in transmission capacities have already been explained. The proximity of Ireland and the UK provide a second saving arising from short cable lengths.

f) How will the project facilitate sustainability, inter alia through the transmission of renewable generation to major consumption centres and storage sites? Please specify in particular, which capacity of renewable generation will be connected directly and indirectly (in GW/1000 km^2). Please specify also the type of renewable generation capacity concerned.

In the longer term, Ireland has both sufficient potential onshore wind site and hydro storage capacity to supply 100% of its foreseeable electricity demand from renewable sources and still have a large surplus for export. More wind and storage capacity is expected be employed in the future to satisfy Irish demands as existing economic conventional generation is retired. The potential surplus of Irish capacity can only be seriously deployed by export via DC undersea cables to the UK and or France and possibly onward to major consumption centres in Europe.

The large hydro storage sites on the west coast of Ireland are adjacent to areas with strongest wind resources. Hence no long transmission links are needed between the contracted NHE wind generation and storage sites. Wind generation on the National Grid that must be curtailed for system security could in theory be absorbed at any connection point between the national grid and the NHE DC link from the hydro storage site to the UK. In practice, the two systems will need to connect at a suitable strong point in the grid, capable of handling the large 1200MW load. This is most likely to be in the greater Dublin area.

All NHE renewable onshore generation will be both directly connected and indirectly connected via the hydro storage reservoirs to the HVDC transmission interconnecting cables linking the natural energy power generation and storage stations to major demand centres in the UK.

The nature of the NHE project makes it more difficult to specify the capacity and type of renewable generation that will be connected. Two sources of primarily onshore wind generation are planned to be used. Purely onshore wind generation totalling 700MW is planned to be contracted exclusively to NHE for export from suppliers.

The second major source of wind is planned to be generation imported from the national grid that would otherwise have to be curtailed. This will be drawn from the full National wind generation pool, which is expected to total around 6400MW for the SEM to meet 2020 targets. This wind will be primarily onshore, but may have some small offshore content. Both wind sources are expected to have 12MW installed capacity per km^2.

The first NHE pumped storage station will be rated at 1500 MW. The associated reservoir is expected to occupy approximately $4km^2$.

These parameters are only for the first NHE project. The application backlog for new wind generation licences in Ireland indicates availability of up to 15,000MW of potential onshore capacity between existing and potential new sites and much more offshore capacity. Five good, viable hydro storage reservoir sites have been identified, totalling around 300GWh storage or around 150% of total French capacity. A primary site has been agreed and initial negotiations with land owners are progressing with the next two sites.

g) How will the project contribute to security of supply and secure and reliable system operation? Please specify the impact of the project on the loss of load expectation for the area of analysis as defined in point 10 of Annex V of the draft Regulation in terms of generation and transmission adequacy for a set of characteristic load periods, taking into account expected changes in climate-related extreme weather events and their impact on infrastructure resilience

Although the primary aim of the project is for energy export, an agreement has been made with the Irish authorities that priority will be assigned to assisting the Irish grid in times of difficulties. The worst failure condition envisaged for the Irish grid is failure of the largest generating set. This is a 450MW CCGT unit. Hence, the NHE 1500MW can supply far more fast reacting spinning reserve than was ever envisaged for the Irish grid. Under normal operation services on the Irish grid, this spinning reserve can be availed of on the UK grid.

In addition to the valuable spinning reserve capability offered by NHE, the pump turbines will supply 1500MW of additional inertia to whichever grid they are connected. This service is of considerable value due to the reduction in inertia arising from increasing penetration of modern direct drive wind turbines, which provide no inertia.

The increase in wind energy provided by the project reduces dependence on imported fossil fuel on which the UK and Ireland are dependent. This in turn increases security of supply.

Increased wind strengths may increase curtailment. This will be countered by using the excessive wind generation to power pumping for hydro storage. This valuable energy, which would otherwise be wasted can be released for use later, when required.

The limit on the project output will be determined by the capacity of the DC transmission cable to the UK. This is designed for continuous operation at 1200MW. Under fault conditions, on one of the two DC cables, standby service can be maintained on the second cable at 600MW. In terms of impact on the UK grid, this is equivalent to the loss of one large generator on the very extensive UK grid.

Ireland has a temperate climate. It is not subject to extreme weather events such as hurricanes, tornadoes or ice storms. It is therefore not anticipated that the NHE project will be subject to extreme weather conditions. The large storage capacity of the hydro storage reservoirs will ensure continuous operation for a minimum period of 2 weeks with no wind generation, under the operational cycle planned for the project. No wind for 2 weeks is an extremely rare occurrence in Ireland.

h) 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 and Competition

The NHE project will provide 1200MW increased interconnection capacity between Ireland and UK. This is more than the combined existing Moyle and the planned EWIC interconnectors. It will react to a window of opportunity to ease potential UK generation shortfalls from the closure of nuclear and older fossil fuelled stations and may assist UK meet its renewable target. Power will be traded over interconnectors operating very efficiently at high load factors during trading periods. This effective use of interconnector capacity by smoothing out fluctuations in wind generation by supplementary hydro will reduce the cost of interconnection capacity and encourage more trading of renewable energy.

The high capacity factors of onshore Irish wind farms, built on low cost land will make the cost of this energy very competitive. This will be further enhanced by the benefits accruing from the hydro storage in curtailment reduction and increased value of wind generation stored in off peak periods and resold during high demand. NHE will also provide the additional advantage of converting intermittent wind power into dispatchable energy.

ii) Sustainability

Sustainability will be enhanced by increased integration of high levels of renewable, emissions free generation. Energy wastage due to curtailment will be reduced. High load factors on interconnectors will reduce associated costs and encourage more renewable trading

iii) Security of Supply

NHE will supply 1500MW of very fast response spinning reserve. This pumped storage, spinning reserve will have twice the reserve effects of conventional generation due to its ability to change from pumping to generating mode. NHE will also supply large inertia and extensive reactive power to assist stability and voltage control.

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

The existing 500MW Moyle undersea interconnector already links the UK and Irish grids. A new East West 500MW interconnector (EWIC) nearing completion by Eirgrid the Irish TSO between Ireland and the UK is to enter service shortly. These were both planned to provide normal interconnection services between the two national grids prior to plans for the 1200MW NHE interconnector. NHE is specifically planned to provide export of new renewable generation to the UK over the Irish requirement needed to meet its 2020 target. This is not expected to interfere with the services planned for the Moyle and EWIC links. On the contrary, it is hoped that spare capacity on these links may be used to export more NHE hydro generation.

The NHE project will have one very important interdependency with all other intermittent renewable generation projects in Ireland. Grid security constraints on the Irish grid have already introduced the need for curtailment of wind generation in strong wind conditions, even though only around 15% of generation is being supplied from renewable sources. Curtailment will have to increase significantly as renewable generation approaches its 40% 2020 target. The reduced income from curtailed wind generation will inevitably reduce the incentives for new wind farm construction. The large hydro storage content of the NHE project will greatly reduce curtailment and support further construction of renewable energy in Ireland.

The questions raised in sections d) to i) of Questionnaire II have been answered above. These are very similar to the questions e) to j) in Questionnaire III listed below, with the exception of g). This is answered separately below.

The additionality of the project is large amounts of internationally traded low cost renewable generation. This is further enhanced by large capacity low cost hydro storage.

Conclusion

Integration of Ireland's extensive energy resources (6% of 27 member states) into the union makes complete economic, technical and political sense. This is s project of considerable importance.

Thank you.

Natural Hydro Energy

Natural Hydro Energy Ireland

Questionnaire III response (Project Store only)

Large Scale Hydro Storage (90,000MWhrs) NHE "Project Store" to be interconnected with the UK Market via DC link 1,200MW (NHE "Project Highway" subject of a separate application)

Please NOTE

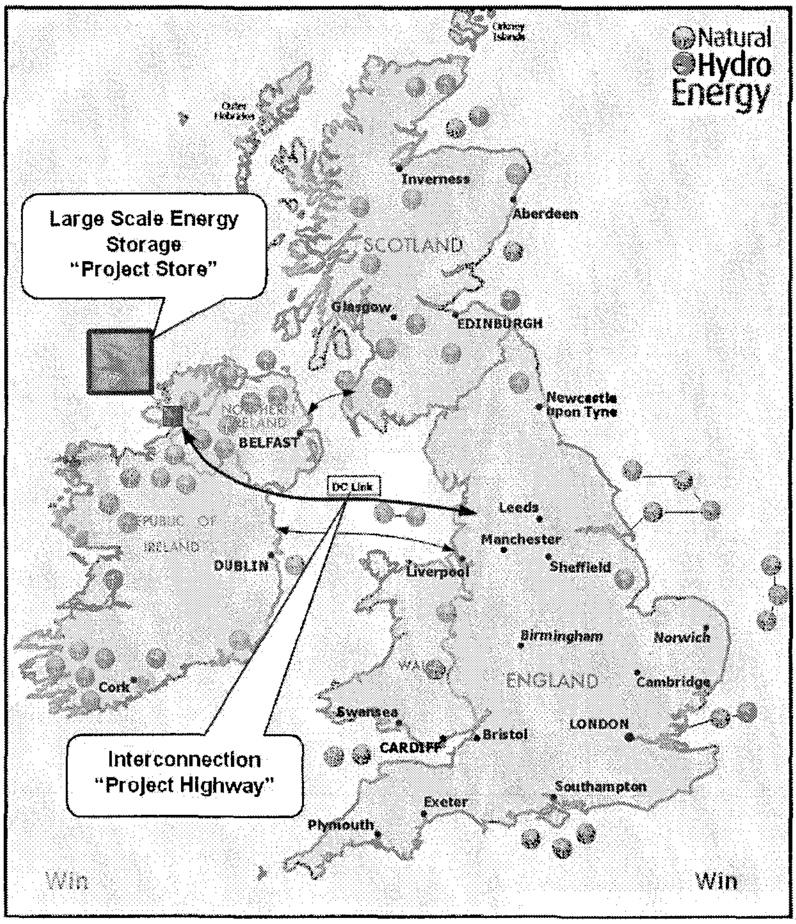
The Natural Hydro Energy overall project consists of two parts:

1. HVDC cable Interconnection between Ireland and the UK, not included in current TYNDPs, is covered by Questionnaire II (NHE "Project Highway") and

2. Large scale Hydro Storage facility (NHE "Project Store") is covered by Questionnaire III.

The overall project has been in development for three years. It is at an advanced stage of planning.

In this response, for clarity of understanding, Natural Hydro Energy (NHE) gives details of both aspects of this project. NHE responds to the similar questions raised in both questionnaires as a separate project.



Only the hydro storage reservoir and associated power station relevant to Questionnaire III need be considered in this response. This is designated NHE Project Store. Details of the transmission link are for information purposes only.

Ireland's energy resources are large and essential to EU Carbon Free Energy Security.

NOTE EU questions required to be answered in Questionnaires are shown in **BLUE PRINT.**

Responses are in BLACK PRINT

Title of the project: Natural Hydro Energy Project Store

**** 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: Natural Hydro Energy

☐ TSO ☐ DSO ☒ Other project promoter[1] Other Promoter

Contact person: [redacted]

E-mail address: [redacted]

Telephone number: [redacted]

Type of project

☒ Storage project – please refer to Questionnaire III

Priority corridor

For the implementation of which energy infrastructure priority corridor is the project necessary? Northern Seas Electricity Corridor

III. Questionnaire for electricity storage projects

1. General information

a) Name of project

Natural Hydro Energy "Project Store"

b) Brief description

90,000MWhrs fast acting Hydro Energy Storage primarily serving the Irish and UK markets

c) Are any other project promoters involved in the project? (list each)

- Countries: ☒ EU ☐ Non-EU, please specify: United Kingdom
- Name of undertaking: Natural Hydro Energy UK Ireland Strategic Energy Infrastructure
- Contact details: Natural Hydro Energy Ltd.

d) Situation of the project promoter(s):

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

  Private company with anticipated participation by large EU utilities

- 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.

  This information will be provided in confidence

- What is the share capital of this undertaking?

  €40m with access up to [redacted] construction funding as required

e) Project type

☒ New

☐ Upgrade

☐ Extension

☐ Replacement

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

- Location: North West Ireland
- Connection point to transmission network: North West Ireland

g) Key technical characteristics

- Technology (please describe as necessary) Hydro Storage
- Installed generation power (MW) 1,500MW

- Installed generation capacity (GWh) 90 GWhrs.
- (for hydro-pumped storage) Net pumping power (MW) 1500MW
- Response time (seconds) 15 seconds
- Energy rating of storage (minutes) 5,400,000 MW minutes
- Power density of storage (W/kg) Not applicable
- Energy density of storage (Wh/kg) Not applicable
- Round-trip efficiency (charging-discharging) (%) 81%
- Lifetime (years) – for new installations, please specify expected lifetime from start of operation; for upgraded, repowered, retrofitted or extended installations, please specify how this will affect remaining expected lifetime. 40 years before refit in a lifetime of in excess of 80 years.
- 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). Normally 1 cycle per day in standard operating mode for in excess of 80 years. Multiple cycles may be used under certain circumstances.
- Voltage at connection point (kV): 320kV DC converted to 400kV AC

h) Estimated project cost (capital expenditure in million euros) [redacted]

i) Planned date of commissioning (year) 2019

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)

☐ Regulatory treatment (please explain):

☐ Financing (please explain):

☒ Other (please explain): Market integration planning to be completed.

This will provide greater commercial certainty

☐ None

2. Specific information

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

Ireland and United Kingdom

b) Are any non-EU Member States involved or affected by the project, at which borders?

None

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

13GWh per year Generation capacity over first 20 years 260GWhrs over 20 years

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

This project very clearly meets all EU objectives for producing Carbon Free, Price Stable, Secure Power. As such, it is a perfect exemplar of integrated transnational thinking and co-operation.

The particular substantive reasons for proposing the Natural Hydro Energy project from Ireland for consideration as a PCI arise from the following factors:

- Energy sources from the periphery of the EU need to be developed to their full potential. Ireland has 6% of all of the renewable resources of the EU with 1% of the population. Ireland can make a very valuable contribution to EU needs and security.

- The availability of extensive, low cost, high wind strength, onshore wind generation sites in Ireland, far in excess of domestic requirements, to assist satisfying EU renewable generation targets is a low cost, low risk, highly secure strategy.

- This project allows for greatly increased penetration of renewable energy in the Irish market above the 40% target level.

- It allows cross border large scale energy trading.

- This, in turn, allows effective competition, with lower projected costs, for increasing renewable generation in all EU Member States, but particularly in the UK and Ireland, to meet 2020 target values.

- There are considerable economic advantages from enhanced energy trading between Ireland, UK and mainland EU.

- NHE provides greatly enhanced security of supply advantages in Ireland and UK arising from large scale hydro storage reservoirs, increased, indigenous, price stable, renewable generation and reduced reliance on imported fossil fuels.

- The project represents considerable technical advances in terms of evolution of a very cost effective design for large scale hydro storage reservoirs.

- Easing integration of intermittent renewable generation by use of large scale hydro storage reservoirs to replace parallel operation of conventional thermal generation to compensate for fluctuation in renewable output.

- Creates essential Dispatchability of renewable generation.

- Increasing the arbitrage value of stored, night time, off peak, renewable generation by releasing it during high demand, day time periods.

EU Proposals for Renewable Generation

All EU Member States have agreed target levels of electricity generation from renewable sources by 2020 to reduce emissions of harmful green house gasses and combat climate change. Most member states will need to considerably increase investment in renewable generation, in order to meet these targets. The cost and effectiveness of investments will depend on the category, capacity and strength of the sources of renewable energy available in each Member State.

Trading mechanisms have been evolved to permit States with large amounts of cost effective renewable energy, in excess of their own projected requirements, to export power to countries facing shortages or more costly generation technologies. Hydro electric schemes have traditionally been the largest source of renewable generation worldwide. They currently supply around 19% of electricity generated in the EU. However, throughout Europe, the most economic sites have already been exploited. Limited increases in hydro capacity are planned prior to 2020, but these will fall well short of the overall increase in renewable generation needed to meet the 2020 targets.

Other than hydro, wind generation has become the most successful and cost effective source of renewable generation in recent years. Extensive new large scale wind farms are under construction.

Examination of the TYNDPs for all EU Member States covering the period up to 2020 and beyond, shows that apart from moderate increases in hydro capacity, large amounts of increased wind generation is expected to constitute the main increase in renewable generation.

Economics of Renewable Generation in the EU

Because of the large scale future role envisaged for wind generation, it is important to consider site availability and wind energy levels available across the full range of Member States. Onshore wind is rapidly approaching similar costing per MWh produced to hydroelectric power, on sites with good capacity factors. However, wind generation suffers from an important disadvantage. It, like marine and solar power, is intermittent and can not be dispatched as easily as hydro.

The relative costs of both hydro and wind generation are very dependent on capacity factors. These vary considerably across the EU. Good onshore wind sites have capacity factors in the range 35% - 40%, with exceptional sites producing over 40% of rated capacity per annum. Hydro capacity factors depend strongly on the available head height on the site. High head Alpine and Nordic sites have capacity factors up to 55%. Medium and lower head run of the river sites lie more in the range 20% - 35%.

The working life spans of both hydro and wind generation are also important in determining cost per MWh produced. Realistic lifetimes of 80 to 100+ years are well established for hydroelectric stations, with major refurbishment intervals of around 40 years. Wind turbines have an expected economic life of 20 – 25 years.

Onshore wind and hydroelectricity are currently much less expensive than other competing forms of renewable generation such as offshore wind, marine or solar energy. However examination of the EU TYNDPs up to 2020 indicate that sites for onshore wind are becoming scarcer in many Member States, after available onshore sites have been developed. Towards 2020, it is expected, there will be greater migration to much more expensive, but more readily available offshore sites.

The UK NREAPS show plans for a very large increase in wind power from 5,430MW in 2010 to 22,450MW in 2020. This includes an increase in onshore wind of 10,850MW. However, a large increase of 10,210MW in offshore wind is also included. This will be associated with a significant increase in renewable generation costs.

Capital costs of offshore wind farms are much more expensive (currently in the range 2.5 to 3 times) than the equivalent cost per MW installed capacity of onshore sites. Erection and foundation costs increase rapidly in deeper water. Grid connection costs increase as turbines are located further offshore. Operation and maintenance costs are also much higher for offshore sites, particularly during adverse weather conditions. These increased costs are not offset by slightly higher offshore capacity factors, generally expected to be in the range 40% - 45%, off suitable coasts.

Cost / MWh produced and site availability will largely determine the increased capacity of EU renewable generation. Wind generation is expected to supply the greatest increase. Countries such as Ireland, with extensive availability of low cost, onshore sites, with high capacity factors, significantly above domestic renewable target requirements will have considerable advantages over areas with lower wind strengths and countries, where limited onshore site availability forces migration towards more extensive, but higher cost offshore locations.

Role of Energy Storage in Increasing Penetration of Renewable Generation

One of the major difficulties experienced with integrating sources of renewable generation in large scale electricity grid structures is intermittency. Wind, solar and marine generation are all subject to large scale variation in output over quite short time scales, depending on the intensity of the energy input. These sudden fluctuations can threaten security of supply on grids, unless output from conventional generation can be adjusted sufficiently rapidly, to compensate for the output variation from renewable sources.

In order to safely integrate intermittent, fluctuating, renewable generation, grid operators (Transmission and Distribution System Operators [TSOs & DSOs]) must ensure sufficient reserves of conventional generation are operated in parallel to the renewable sources, so that they can be ramped up or down to compensate, within adequate time response limits, for the worst potential variation in renewable output. Different categories of conventional generation exhibit greater or lesser flexibility in response time to load variation. Conventional hydro generators and pump/turbines in pumped storage schemes have the fastest response time ranging from less than 1 minute to 2 minutes from no load to full load depending on machine size.

Ramping conventional generation to compensate for parallel variation in renewable output and providing sufficient standby spare conventional capacity introduces significant increased costs. Operating efficiency is lower at part load and fuel consumption is higher per MWh of electricity generated. Ramping plant up and down subjects it to greater wear and tear and maintenance costs increase. Operating plant at part load increases fixed costs such as depreciation over a reduced amount of MWh output. All of these additional charges must all be evaluated in comparing the costs of alternative competing sources of renewable generation

Either conventional hydro generation or pumped storage generation can compensate for intermittent renewable energy very effectively. Both have very rapid response times, which permit them to compensate for sudden changes in renewable output. Efficiency losses under part load operation and increased maintenance charges due to load ramping are less than for thermal plant. Hydro energy stored during high wind conditions can be released, when wind strength is low, so that the combined wind and hydro output is smoothed and in effect provides controlled amounts of dispatchable renewable energy.

Curtailment Constraints on Renewable Penetration

At the early stages of integrating intermittent renewable energy to large scale electricity grids, transmission system operators were concerned with the potential of severe excursions in renewable output to cause instability in grids. If for example, a sudden drop in wind output should occur, before sufficient conventional generation can be brought on line to compensate for the reduction, instability could occur, resulting in load shedding or possible black outs.

To avoid these problems, either sufficient fast acting reserve capacity must be available or renewable generation output may have to be curtailed. Curtailment results in undesirable loss of potential renewable generation. Isolated or lightly interconnected grids are most vulnerable to these conditions. The island grids of Ireland and the UK will be more prone to curtailment than the much more extensive grids in mainland Europe. Stronger interconnection will alleviate this problem, but will not eliminate it.

As the smaller of these two island grids, Ireland offers an interesting insight into the possible effects of curtailment. Renewable energy is allocated priority dispatch status over conventional generation in Ireland to encourage its usage. At the early stages of introducing renewable generation, the Irish TSO was reluctant to permit more than 10% of renewable generation to operate on the grid under any demand conditions.

Increased introduction of fast reacting open cycle gas turbine plant in recent years and greater experience of operating and more accurate forecasting of renewable (primarily wind) generation has permitted this constraint to be extended considerably. Ireland now permits 50% renewable generation on the grid in normal demand conditions, but this has to be reduced to 30%, when demand is lowest.

Ireland has accepted a high target of 40% of electricity generation from renewable sources by 2020. At present, nearly 15% of total generation is supplied by renewable sources. Low levels of curtailment are already necessary on the grid in strong wind conditions, when demand is low, particularly at night time. This is expected to increase considerably as renewable generation approaches the 40% target value. Curtailment will heavily reduce the economic returns from renewable sources, unless a solution to this problem is introduced.

Unique Storage Attributes of Natural Hydro Energy Project Design

The Natural Hydro Energy project will introduce very large capacity, low cost hydro storage reservoirs. These will help eliminate / reduce curtailment constraints on wind generation. The first 1500MW pumped storage station will accommodate 90,000MWh of stored hydro energy in its reservoir. The magnitude of this storage capacity can be appreciated, when compared to schemes in other countries. The UK has 2800MW of pumped storage generation with 14,000MWh storage. France has 7 schemes totalling 184,000MWh. Natural Hydro Energy plans a number of reservoirs in the longer term, any two of which will equal the total French hydro storage capacity.

Most pumped storage schemes have capacity to generate at full load for between 5 to 8 hours. The first NHE project at Kilcar on the North West coast of Co. Donegal, operating under its planned 13 hour daytime generating cycle and 11 hour night pumping regime will be able to generate continuously at full load for 2 weeks, even if there is no wind input. Pumping energy can be supplemented from unused off peak conventional generation in light wind conditions.

Natural Hydro Energy is planning to purchase wind generation daily, from a number of sources for direct export on its HVDC interconnector to the UK and supplement this with hydro generation pumped previously, primarily from off peak wind sources. NHE plans to have 700MW of wind generation contracted from wind farm operators to supply wind generation to NHE for direct export to the UK. This will be in excess of renewable generation planned to meet the Irish 2020 target. NHE will agree to take the total generation from these wind operators without curtailment.

In high wind conditions during daytime export hours, when some wind would normally have to be curtailed to maintain grid stability, NHE will purchase as much of this wind as possible, with the aim of filling the NHE interconnector capacity from Ireland to the UK. This will avoid wind curtailment and wastage of valuable renewable generation.

If insufficient curtailed wind is available together with the directly contracted wind to fill the interconnector, NHE will supplement both these sources by generating from released hydro energy from its large storage reservoir. Wind curtailment is expected to be much higher at night, when system demand is low. NHE plans to purchase large amounts of this wind generation, which would otherwise be curtailed and wasted.

This will improve the economics of off peak wind generation considerably. The increased demand needed for pumping will increase the level at which curtailment would otherwise be required. Large amounts of wind generation, which would otherwise be wasted, will be bought in to supply pumping operations

Interaction of the Interconnection with very large NHE storage capacity will provide a number of important advantages.

- Because much of the hydro generation will be pumped by wind generation, which would otherwise be curtailed, the overall electricity exported to the UK both directly from onshore, high capacity factor wind generation, supplemented by hydro pumped by onshore wind, will contain a very high percentage of renewable energy content. This will involve lower production costs and subsidisation than offshore wind production in the UK.

- The large storage capacity will permit variable wind generation to be supplemented by hydro electricity, ensuring fully controllable / dispatchable power throughout all export periods.

- The value of off peak renewable generation will be increased to high demand day time values

- Much less generation will be wasted due to curtailment

- The interconnector will operate at a high capacity factor and at 100% capacity during export hours

- Much lower interconnector capacity will be needed to export the steady state, average 1500MW of combined wind and hydro generation, than would be needed for the same MWh capacity of volatile wind generation, where interconnector capacity would have to match peak wind generation, while average generation may only be equivalent to 35% of peak.

- Large storage capacity will greatly increase security of supply, in ways which will be described later.

- The greater Dispatchability and controllability of NHE generation, reduced difficulty and cost of parallel operational costs for conventional compensating generation, increased day time value achieved from the large capacity hydro storage combined with the low cost of high capacity factor onshore wind sites will all contribute to greater penetration of cost effective, reliable, secure, renewable generation.

Advantages of Unique Design Features of NHE Hydro Storage Reservoir

Many of the advantages of the NHE project are due to the low storage cost per MWh associated with the hydro storage reservoir. The low storage cost is a result of a combination of unusual design features, which can be exploited in glacial valley sites on the west coast of Ireland. It is expected that, subject to environmental approval and legal permitting, that the first of these projects will be sited near Kilcar in Co. Donegal in North West Ireland. The main concepts of the design, which contribute to the low cost of these large scale reservoirs are described below.

The project will use sea water as a working medium, instead of fresh water used in nearly all other pumped storage schemes. A sea water based scheme has been operating successfully in Okinawa in Japan for the last 15 years. The ocean will be used as the lower reservoir in the scheme. This greatly reduces construction costs normally associated with artificially created lower reservoirs in conventional pumped storage schemes.

The projects rely on the use of naturally occurring glacial formations created in the last ice age, which in a few rare instances created high valleys suitable for energy storage. Since Ireland has a very low level of seismic activity, a rock fill dam can safely be used to form an upper reservoir for the scheme. This is a less expensive form of construction than traditional concrete dam construction methods.

The dam is expected to be approximately 1.3km in length and will have a possible height of 120m at mid point. It will be constructed at the mouth of a long glacial valley. Having to dam only one end of a long narrow valley provides very large capacity in the upper reservoir in comparison to many conventional pumped storage schemes, where the reservoir is formed by a curtain dam, which completely encircles the reservoir. The geology of the valley floor is made up of primarily impermeable rock.

Water will be carried from the dam in multiple steel penstocks. The distance from the dam to the power house varies from 1 to 3 km on the sites selected by Natural Hydro Energy. The ground slopes gently over the intervening territory and provides heads ranging from 180 to 230m. The penstocks will be laid close to the surface of the ground in shallow covered trenches to minimise environmental impact. Using penstocks greatly reduces excavation and tunnelling costs for machine hall caverns, water head and tail race, access and cable tunnels frequently associated with conventional pumped storage schemes.

The first Natural Hydro Energy power station will be located in the North West of Ireland and will have 10 x 150MW Francis type pump/turbines totalling 1500MW capacity. It will be located approximately 2.5km from the dam. The head between the dam and the powerhouse will be approximately 230m on this site. The storage capacity of the reservoir with approximately 4 square km surface area will be 90,000MWh.

The power station will be connected to the ocean by a short channel. Rock for construction of the dam will come from excavations for the channel and the power station site, which must be located in a cutting to accommodate water transit from the draught tubes of the pump/turbines to the ocean 25m below minimum tide level. This local source of rock minimizes dam construction costs by eliminating the need to transport rock from outside the site.

This unusual design provides exceptionally large storage capacity of 90,000MWhs. Ireland has the potential for up to 300,000 MWhrs. This compares very favourably to the storage capacity of pumped storage schemes in the following countries.

Natural Hydro Energy

	MWh
Spain	1,530,000
Switzerland	369,000
France	184,000
Austria	125,000
Portugal	107,000
Lithuania	49,000
Germany	39,000
UK	33,000
Greece	21,000
Poland	11,000
Belgum	8,000
Czech Republic	7,000
Luxemborg	6,000
Slovakia	4,000
Ireland	2,000
Bulgaria	1,000

Eurelectric 2020 Report "Hydro in Europe" Powering Renewables"

The Natural Hydro Energy design provides very large, low cost storage capacity to compensate for intermittent wind generation. Two of these Irish schemes would provide equivalent storage to all 7 of the pumped storage schemes in France, which provide important peak capacity in addition to France's 78% nuclear generation capacity.

[redacted]

This provides the advantage of an exceptional storage cycle length of a minimum of 2 weeks in zero wind conditions, which effectively eliminates intermittency. The Natural Hydro Energy power station can operate indefinitely in only intermittent light to moderate wind conditions. This advantage arises from the unique geographic topography of the long, narrow, sloping, Irish glacial valley sites.

UK Generation Capacity Plans

The UK faces two major challenges to generation capacity up to 2020 and shortly beyond. The existing UK nuclear stations are approaching the end of their economic working life. Most of the first generation Magnox stations have already been closed. All of the remaining 9.3GW

Magnox and second generation Advanced Gas Cooled Reactor stations with the exception of Sizewell B are planned to close by 2023.

The remaining 3 oil fired stations and a number of old coal fired stations have chosen to opt out of the requirements for flue gas desulphurization imposed by the EU Large Combustion Plant Directive. A total of 12GW of these stations will have to close by the end of 2015. The continued economic viability of the remaining 20GW of more modern coal fired stations will depend on the costs of new Carbon Capture and Storage technology, which is currently undergoing pilot scheme evaluation.

In addition to the requirements to replace the nuclear and conventional stations facing closure, the UK must greatly increase generation from renewable sources to meet its 2020 target of 30%. This includes NREAP plans to increase onshore wind capacity by 10,850MW and offshore wind by 10,210MW. The migration to more offshore sites as onshore capacity approaches saturation will significantly increase cost of renewable generation.

The closure of the UK nuclear and fossil fuel fired stations together with the large requirement for increased renewable generation will open the UK market to possible imports of cost effective, renewable energy up to 2020. Ireland, with a large surplus of high capacity factor onshore wind farm sites on land with low agricultural and commercial value, well in excess of its own renewable target requirements, will be in a strong position to compete for this potential market.

Ireland has two further important advantages. Its proximity to the UK reduces the length and hence cost of interconnectors. The advantages of the large scale hydro storage reservoirs proposed by the NHE project will also enhance the attraction of dispatchable, cost effective renewable energy imports from Ireland over interconnectors operating at high load factors during high demand day time trading periods.

Renewable Generation from Ireland Aided by Large Scale Storage

Finally, the main reasons, why the NHE project should be proposed for consideration as a PCI are as follows:

- It exploits extensive availability of economic, high strength, onshore wind resources in Ireland with offshore and wave available long term. This will earn valuable revenue for Ireland and greatly assist the UK meet its renewable generation targets benefiting emissions reduction and suppressing climate change in both countries

- Plentiful land with low agricultural or commercial value remains in Ireland, which offers the strongest wind and wave strengths in Europe. These are ideal conditions to expand cost effective sustainability between two cooperating Member States within the EU.

- The Irish home market for power generation is saturated. The only possible utilization of the valuable Irish renewable site potential is for export.

- Limited interconnection capacity is currently available out of Ireland. Much higher capacity would be required to fully exploit Ireland's valuable renewable assets. The NHE project offers a large increase in capacity, which will operate at very high load factors due to the benefits of high capacity storage smoothing peaky export flows from renewable generation.

- Ireland's population density is low on the west coast, which resulted in appropriate grid capacity, when they were constructed. The strong sites for renewable generation are also on the Atlantic coast. Extensive grid reinforcement is needed from wind and wave rich resource western areas to the east coast for export to the UK or Mainland Europe. The NHE project will make major contributions to grid reinforcement at no cost to the state.

- Due to the economic recession, the Irish state would have difficulty in providing funding for this size of project. NHE proposes to arrange funding from private sources, in a manner that will still provide substantial benefits to Ireland.

- The proximity of the UK to Ireland will require moderate interconnection costs to exploit Irelands valuable renewable resources combined with large scale, low cost storage.

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

Market Integration

The NHE project will immediately provide a large increase in interconnection capacity between Ireland and UK. In the longer term, it opens potential for further future interconnection between Ireland, France and mainland Europe via the UK.

The UK is facing difficulties with adequate overall future generation capacity, due to closure of both nuclear and fossil fuel fired plant. In addition, it expects to implement a very large expansion in renewable plant to meet its 2020 target. As the renewable construction programme progresses, the UK plans indicate increased development of around 50% of new wind capacity on expensive offshore sites, after its onshore sites are fully exploited. NHE could assist UK solve some of its generation shortfall and or meet its renewable targets economically.

Ireland has the potential to offer a large export capacity of surplus, dispatchable, low cost, onshore wind generation well in excess of Ireland's own foreseeable home market requirements. Ireland's onshore wind sites have some of the highest wind strength conditions in the World. This advantage coupled with low land values can provide wind generation at very competitive prices.

In addition to high quality onshore sites, the long storage cycle, high capacity, low cost, hydro storage potential will complement strong wind sites. The combined output from both sources will be dispatchable. The value of off peak wind generation will be greatly increased by dispatching it during high cost trading periods, when demand is highest. The large economic storage capacity of the Irish storage reservoirs will ensure that both wind and hydro can complement each other indefinitely, even during protracted periods of low wind strength. Losses due to curtailment will be minimised, which will further improve the economics of NHE generation.

Both Irish onshore wind site and hydro storage capacity is far in excess of Irish home market requirements. The only means by which Irelands valuable assets can be exploited is through export. Many Member States will face more expensive solutions to reach their 2020 targets. There has already been controversy in the UK over the cost of offshore wind sites combined with the additional cost of parallel operation of conventional generation at part load to compensate for wind intermittency. Availability of large amounts of dispatchable, renewable generation from Ireland at attractive prices will further market integration and encourage increased penetration of renewable generation.

Competition

One of the primary aims of opening the electricity market is that competition will encourage cost effective prices. The 2020 targets for renewable generation will introduce a new aspect of competition to the open market. Not only will market competition continue between all suppliers, because of the large increases in renewable generation required to meet targets, specialised competition is likely to develop in this sector for the most cost effective renewable sources.

Future increases in fossil fuel prices and renewable technology improvements will continue to improve the competitive position of cost effective, renewable generation, with no fuel costs, in comparison to conventional sources   Renewable generation has no fuel costs. Not only are continuously rising fuel prices effecting the electricity market with knock on effects to other industries, concern is increasing in many countries over security of future fuel supplies. This is most acute among countries with limited or no indigenous fossil fuel supplies.

These two important market forces will continue to increase competition between conventional generation and secure, emissions free, price stable renewable energy. Dispatchable, renewable energy will provide an additional bonus. Most Member States will be under pressure to increase renewable generation to meet 2020 targets initially and increasing targets beyond 2020. Competition for cost effective sources is likely to increase. Not only will generation companies seek competitive renewable sources, these will also be attractive to many industries under pressure to reduce emissions.

Limited availability of high capacity factor, low cost, onshore wind sites in many member states will increase migration of renewable generation towards more expensive offshore sites. This trend will continue to improve the competitive position of onshore sites, with good wind strengths, on land with low agricultural or commercial value.

Ireland has the highest onshore and offshore wind strengths in Europe, plus the strongest wave energy levels. It has abundant sites for high capacity factor, low cost onshore wind generation. There is extensive availability of low value land. The NHE project will avail of all of these competitive advantages to the fullest extent.

The NHE design combined with low seismic activity and unique Irish glacial valley topography, geography and geology offers exceptionally large capacity hydro storage capacity at low cost. NHE hydro storage reservoirs can absorb and store low value, off peak, surplus wind generation to pump hydro into storage and release it later during high demand periods. This is a very important competitive advantage of NHE over conventional onshore generation, without access to storage facilities.

NHE hydro storage will eliminate wastage of curtailed surplus generation in high strength wind conditions above safe grid acceptance levels resulting in further increase in advantages. In low wind conditions, NHE reservoirs can store valuable, high efficiency, low cost, conventional generation, which would otherwise be displaced/unused at night by increased wind penetration.

NHE hydro generation backed up by long term storage will smooth out peaks and valleys in wind generation. This will ensure highly efficient use and low cost design of transmission facilities connecting NHE combined wind and hydro generation to the UK grid. The close proximity of Ireland to the UK market will contribute to low interconnection costs. Low transmission costs will increase NHEs competitive position for exports.

Elimination of Isolated Markets

Ireland is no longer strictly speaking an isolated market, since one interconnector to the UK has been in operation for some time and a second is due for commissioning shortly. However, in comparison to the highly interconnected networks of mainland Europe, Ireland's island market is still relatively isolated to a large degree.

The NHE project will greatly reduce this isolation by providing extensive new interconnection capacity. This increased capacity will be essential to exploit Ireland's valuable wind and hydro capacity. By smoothing out peaks and valleys in wind output, the complementary hydro storage will ensure high load factors on interconnectors during export periods. This will minimise interconnection costs.

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

In the longer term, Ireland has both sufficient potential onshore wind site and hydro storage capacity to supply 100% of its foreseeable electricity demand from renewable sources and still have a large surplus for export. More wind and storage capacity is expected be employed in the future to satisfy Irish demands as existing economic conventional generation is retired. Despite this increased future usage, the potential surplus of Irish capacity can only be seriously deployed by export via DC undersea cables to the UK and or France and possibly onward to major consumption centres in Europe.

The renewable generation that can be exported from Ireland can be produced economically primarily from highly cost effective onshore wind farms constructed on land with low agricultural or commercial value, which is subject to exceptionally strong wind conditions. This large surplus of cost effective renewable generation can be of considerable assistance, initially to the UK in meeting its 2020 and possible future increased renewable generation targets at lower cost than UK offshore wind projects. It will also be available to assist the UK address generation capacity needs to replace closures of existing nuclear and fossil fuel fired stations.

In addition to having a large surplus of cost effective onshore wind capacity available for export, a large hydro storage scheme is planned to alleviate/eliminate the intermittency effects of wind generation. By merging intermittent, real time wind generation with supplementary dispatchable hydroelectricity, NHE can ensure export of steady state dispatchable generation on its 1200MW DC transmission link in its associated "Highway" project. Planning application procedures are expected to commence shortly on the first site subject to completion of finance availability, which is currently in progress. The site is planned to have power station with 1500MW generation/pumping capacity with 90,000MWh storage capacity.

NHE hopes to construct several of these hydro storage facilities in the future. A large number of 57 sites were examined at the beginning of the project. Five of these are most suitable for development. They would total 300,000MWh of storage capacity. Agreement has been reached with landowners on one site and is progressing on two others. The unique features of the design of the hydro storage projects have already been described. The resulting low cost of €15/MWh of hydro energy stored and the very long cycle time of a minimum of 2 weeks are the key features in overcoming the intermittency problem of renewable generation and facilitating greater integration of cost effective onshore wind generation.

NHE plans to utilise wind generation from two sources. It is planned to agree contracts with producers to supply 700MW of contracted onshore wind generation capacity to NHE on a continuous basis. NHE will guarantee to purchase these supplies in full, with no curtailment. As a second source, NHE plans to import wind generation from Eirgrid, which would otherwise have to be curtailed to maintain grid stability. Both these sources are planned to supply real time wind generation for export to the UK on the NHE 1200MW DC "Highway" interconnector during daytime trading periods. If these two sources have insufficient available output to fill the cable capacity, NHE will release sufficient stored hydro to generate the balance needed to fill the cable.

Export is planned for 13 day time hours each day. During the remaining primarily night time period, NHE will use both contracted wind generation and imported wind generation from Eirgrid, which would otherwise be curtailed, to supply power for pumping water into the storage reservoir. In the event of shortage of wind energy, NHE can use imported conventional power for pumping. This can be sourced either from unused, efficient Irish CCGT or coal fired base load plant or from UK imports on the NHE interconnector.

The Republic of Ireland currently has around 3800MW of efficient, economic CCGT and coal fired plant. Total night demand ranges from minimum night time values of 1800MW in Summer to around 2300MW in Winter. Hence, there will always be significant unused conventional capacity available at night. In addition, significant amounts of this capacity will be displaced by wind generation, which is allocated priority status. The amount of conventional plant dispatched at night will depend on wind strength, but considerable unused capacity will available even under low wind conditions. This can compete with night time prices for imports from the UK of conventional generation or possibly curtailed UK wind if some is available.

The effective reduction in curtailed renewable generation that the large NHE storage capacity will provide will reduce the cost of wind generation. This will encourage greater expansion. It will also substitute for and reduce the cost of parallel operation of conventional generation to compensate for renewable intermittency. This will further contribute to reducing renewable generation costs as well as contributing to increased system security.

Hydro generators have the fastest reaction speed of all categories of generators. They can ramp from zero to full load In as little as 15 seconds, which takes the next fastest open cycle gas turbine plants 15 minutes. This can supply large amounts of the highest quality spinning reserve capacity to whichever grid it is connected, which is very valuable in assisting fault recovery. The 1500MW NHE potential reserve will make an important contribution to system security.

The fast response time of hydro plant is also very useful in rapid load following to compensate for short term minute to minute changes in renewable output. This is becoming more important as volatile renewable capacity increases. Fast load following ability is being awarded premium prices in many utilities experiencing increasing difficulties with effective short term load following ability.

Increased penetration of the latest direct drive wind turbines is causing concern on the Irish grid over reduction in inertia on the grid. The direct drive machines are decoupled from the grid by AC/DC converters used for frequency conversion between the slow rotor/generator rotational speed and the 50HZ electrical output from turbine/generators to the grid. Because no inertia is supplied by these turbines, their increased deployment instead of conventional generation is reducing the overall level of inertia on the grid.

Inertia slows the reduction in generator speed after a fault on the grid causes generation to fall below demand. Balance between generation and demand on a grid maintains stable frequency. Inertia slows down generator speed reduction and fall in frequency under fault conditions and permits more time for spinning reserve to come into operation to relieve the problem. The NHE hydro generators will provide large inertia to help overcome this problem.

In addition to the advantages described above, the NHE project will provide one further important boost to renewable generation. Renewable generation must follow the available wind conditions throughout the full 24 hour daily cycle. Demand for electricity is much lower at night than during the day. Power prices fall heavily at night, when there is plenty of the most efficient, lowest cost plant available to compete for the low demand. The UK Renewable Operation Certificates offer a fixed subsidy per MWh to wind generation on top of the basic system marginal price. Hence, night time wind is less valuable than day time wind.

This is currently under review. However, regardless of the commercial outcome of the review, night wind is inherently less valuable than day wind, particularly during peak demand. Because demand is lower at night, curtailment is more likely to arise for intermittent renewable energy. NHE offers a major advantage of absorbing potentially curtailed wind at night for pumping operations. This pumped hydro capacity can be "time shifted"/"arbitraged" and released during the day to provide generation at much higher day time prices. This will greatly increase the value of wind generation and make renewable generation more attractive as well as much easier to integrate.

The large hydro storage sites on the west coast of Ireland are adjacent to areas with strongest wind resources. Hence no long transmission links are needed between the contracted NHE wind generation and storage sites. Grid imports that would otherwise be curtailed for system security could in theory be absorbed at any connection point between the national grid and the NHE DC link from the hydro storage site to the UK. In practice, the two systems will need to connect at a suitable strong point in the Irish grid, capable of handling the large 1200MW load. This is most likely to be in the greater Dublin area.

The hydro generation from NHE storage reservoirs can be used to ensure high load factors on both the NHE cables from the storage reservoir site to Dublin and on the onward link to the UK. By eliminating the peaks and valleys normally associated with transmission of volatile renewable generation, NHE will ensure operation of its transmission cables at high load factors close to 100% during trading hours in comparison t around 35%, when carrying volatile, intermittent wind generation alone. This is the final benefit NHE can provide to encourage greater penetration of the most economic form of renewable generation.

The advantages described above are only for the first NHE project. The application backlog for new wind generation licences in Ireland indicates availability of up to 15,000MW of potential onshore capacity between existing and potential new sites and much more offshore capacity. Five good, viable hydro storage reservoir sites have been identified, totalling around 300GWh storage or around 150% of total French capacity. A primary site has been agreed and initial negotiations with land owners are progressing with the next two sites.

g) What is the additionality of the project? Please list the installed capacity of each existing storage installation using a technology similar to the one of the project in a radius of 200 km from the project.

[please submit map showing location and size of each existing storage installation

The additionality of the project is primarily as follows:

- It will capitalise on the large surpluses of internationally tradable, low cost, dispatchable, renewable generation that can be made available for export from Ireland by exploitation of the extensive inventory of suitable sites.

- The increase in wind energy provided by the project reduces dependence on imported fossil fuel on which the UK and Ireland are dependent. This in turn increases security of supply.

- The potential wind capacity is further enhanced by 1500MW of hydro generation/pumping with a storage capacity of 90,000MWh and minimum load cycle of 2 weeks and an exceptionally low storage cost of €15/MWh.

- The large, low cost storage capacity will greatly alleviate the difficulties and integration costs of increased wind penetration by providing a dispatchable output of combined real time wind and supplementary hydro generation.

- Hydro storage can time shift low value night time wind generation to meet high value day time demand.

- Increased wind strengths may increase curtailment. This will be countered by using the excessive wind generation to power pumping for hydro storage. This valuable energy, which would otherwise be wasted can be released for use later, when required.

There is no storage installation within 200km of the NHE site. The nearest is the 292MW Turlough Hill scheme which is over 250km distant.

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

Although the primary aim of the project is for energy export, an agreement has been made with the Irish authorities that priority will be assigned to assisting the Irish grid in times of difficulty. The worst failure condition envisaged for the Irish grid is failure of the largest generating set. This is a 450MW CCGT unit. Hence, the NHE 1500MW can supply far more fast reacting spinning reserve than was ever envisaged for the Irish grid. Under normal operation services on the Irish grid, this spinning reserve can be availed of on the UK grid.

Pumped storage plant has another important inherent spinning reserve advantage over equally fast reacting conventional hydro generators and all other generation categories. It has the ability, under serious grid fault conditions, when operating in pumping mode, to stop pumping and eliminate this demand. It can then change to generation mode and supply the same amount of additional generation. In this way, it effectively doubles the amount of spinning reserve that can be offered to recover from faults.

In addition to the valuable spinning reserve capability offered by NHE, the pump turbines will supply 1500MW of additional inertia to whichever grid they are connected. This service is of considerable value due to the reduction in inertia arising from increasing penetration of modern direct drive wind turbines, which provide no inertia.

The hydro generators will supply large amounts of reactive power, which has an important role in ensuring voltage stability 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 and Competition

The NHE project will provide 1200MW increased interconnection capacity between Ireland and UK. This is more than the combined existing Moyle and the planned EWIC interconnectors. It will react to a window of opportunity to ease potential UK generation shortfalls from the closure of nuclear and older fossil fuelled stations and may assist UK meet its renewable target. Power will be traded over interconnectors operating very efficiently at high load factors during trading periods. This effective use of interconnector capacity by smoothing out fluctuations in wind generation by supplementary hydro will reduce the cost of interconnection capacity and encourage more trading of renewable energy.

The high capacity factors of onshore Irish wind farms, built on low cost land will make the cost of this energy very competitive. This will be further enhanced by the benefits accruing from the hydro storage in curtailment reduction and increased value of wind generation stored in off peak periods and resold during high demand. NHE will also provide the additional advantage of converting intermittent wind power into dispatchable energy.

The principal urgency of expediting the NHE project is to alleviate serious potential curtailment of renewable generation on the Irish grid, to avoid stability problems as wind penetration approached closer to the 2020 target

ii) Sustainability

Sustainability will be enhanced by increased integration of high levels of renewable, emissions free generation. Energy wastage due to curtailment will be reduced. High load factors on interconnectors will reduce associated costs and encourage more renewable trading

iii) Security of Supply

NHE will supply 1500MW of very fast response spinning reserve. This pumped storage, spinning reserve will have twice the reserve effects of conventional generation due to its ability to change from pumping to generating mode. NHE will also supply large inertia and extensive reactive power to assist stability and voltage control.

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

The existing 500MW Moyle undersea interconnector already links the UK and Irish grids. A new East West 500MW interconnector (EWIC) nearing completion by Eirgrid the Irish TSO between Ireland and the UK is to enter service shortly. These were both planned to provide normal interconnection services between the two national grids prior to plans for the 1200MW NHE interconnector. NHE is specifically planned to provide export of new renewable generation to the UK over the Irish requirement needed to meet its 2020 target. This is not expected to interfere with the services planned for the Moyle and EWIC links. On the contrary, it is hoped that spare capacity on these links may be used to export more NHE hydro generation.

The NHE project will have one very important interdependency with all other intermittent renewable generation projects in Ireland. Grid security constraints on the Irish grid have already introduced the need for curtailment of wind generation in strong wind conditions, even though only around 15% of generation is being supplied from renewable sources. Curtailment will have to increase significantly as renewable generation approaches its 40% 2020 target. The reduced income from curtailed wind generation will inevitably reduce the incentives for new wind farm construction. The large hydro storage content of the NHE project will greatly reduce curtailment and support further construction of renewable energy in Ireland.

Conclusion

Integration of Ireland's extensive energy resources (6% of 27 member states) into the union makes complete economic, technical and political sense. This is a project of considerable importance.

Thank you.

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):

- o 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.

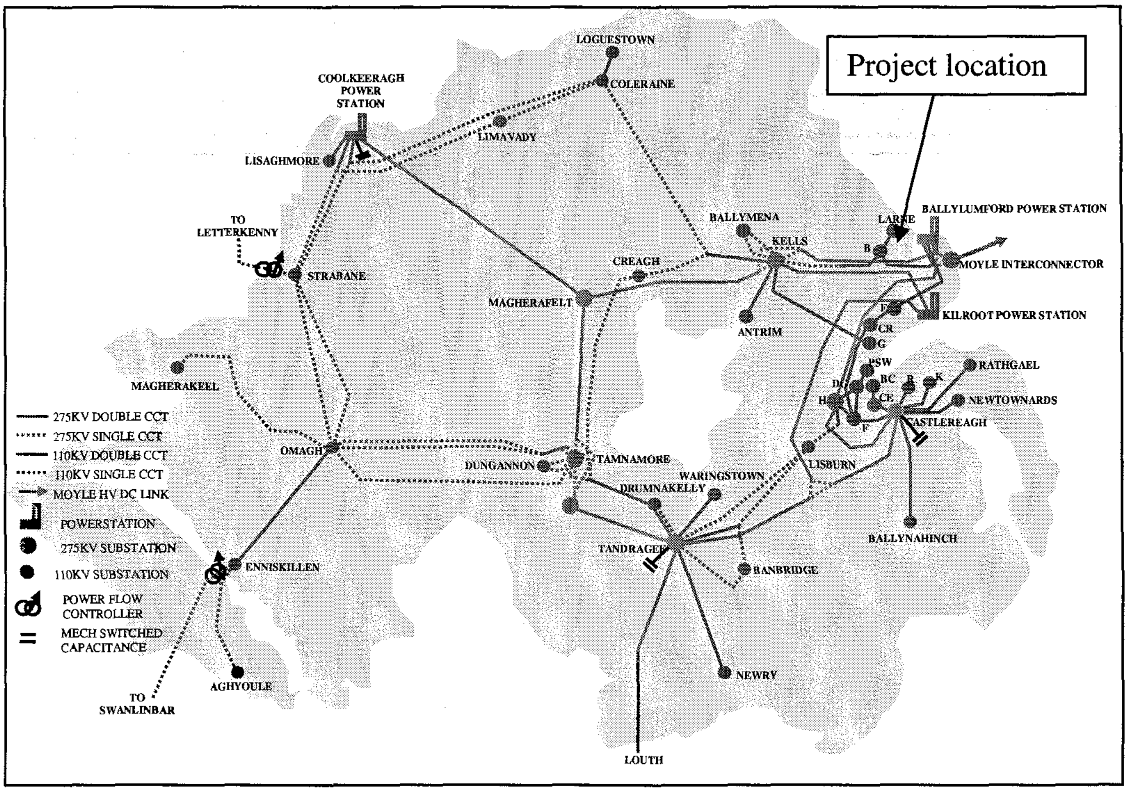


Figure 1: Proposed NIE network in 2015 showing location of the project

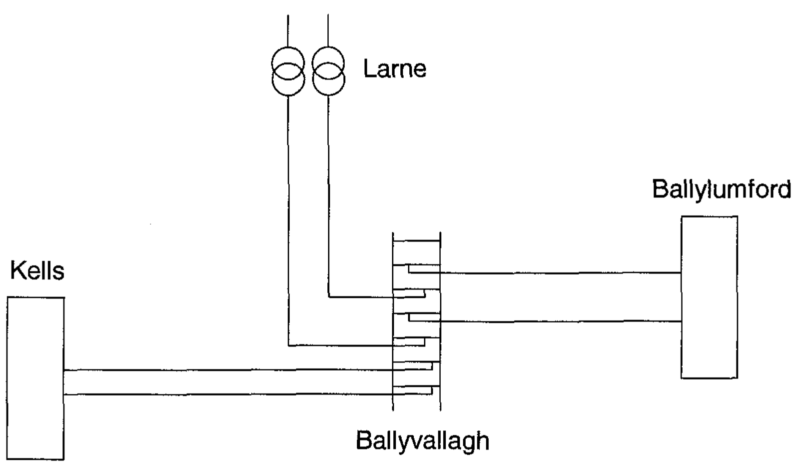


Figure 2: Existing 110 kV network in the Larne/Ballyvallagh area

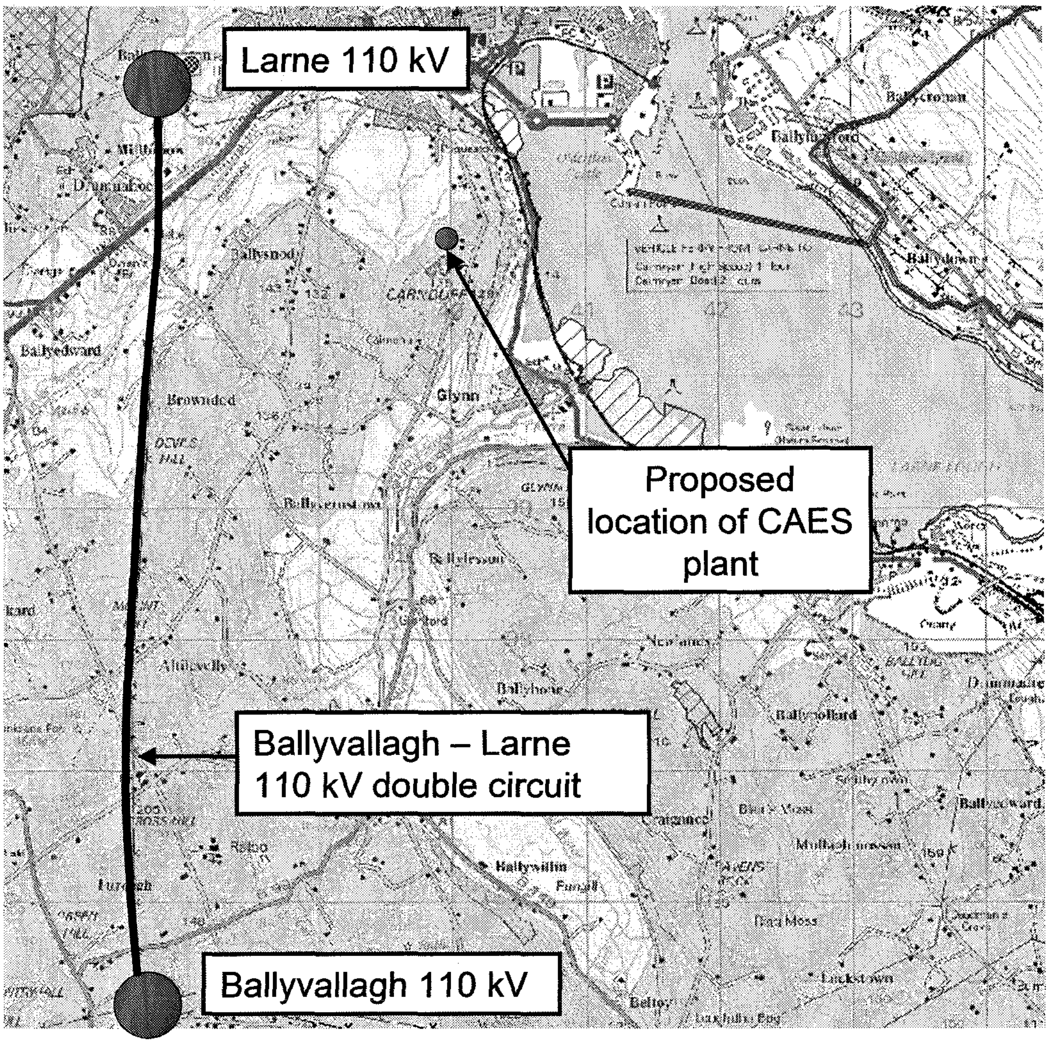


Figure 3: Proposed location of CAES plant in relation to existing 110 kV network

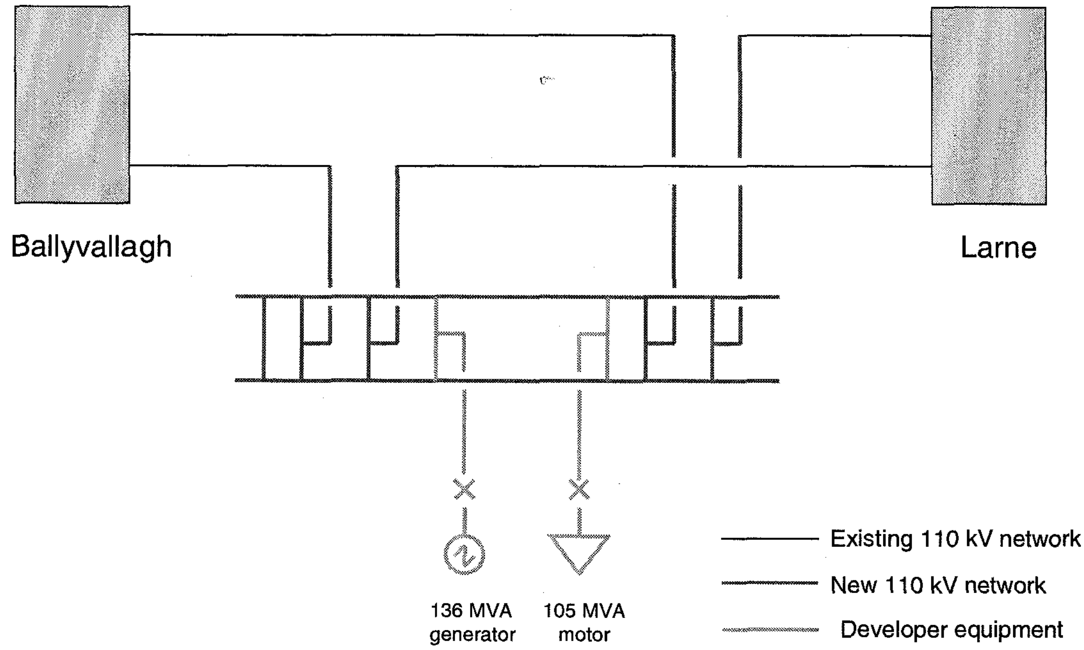


Figure 4: Option 1, Looping into the existing Larne – Ballyvallagh 110 kV double circuit tower line.

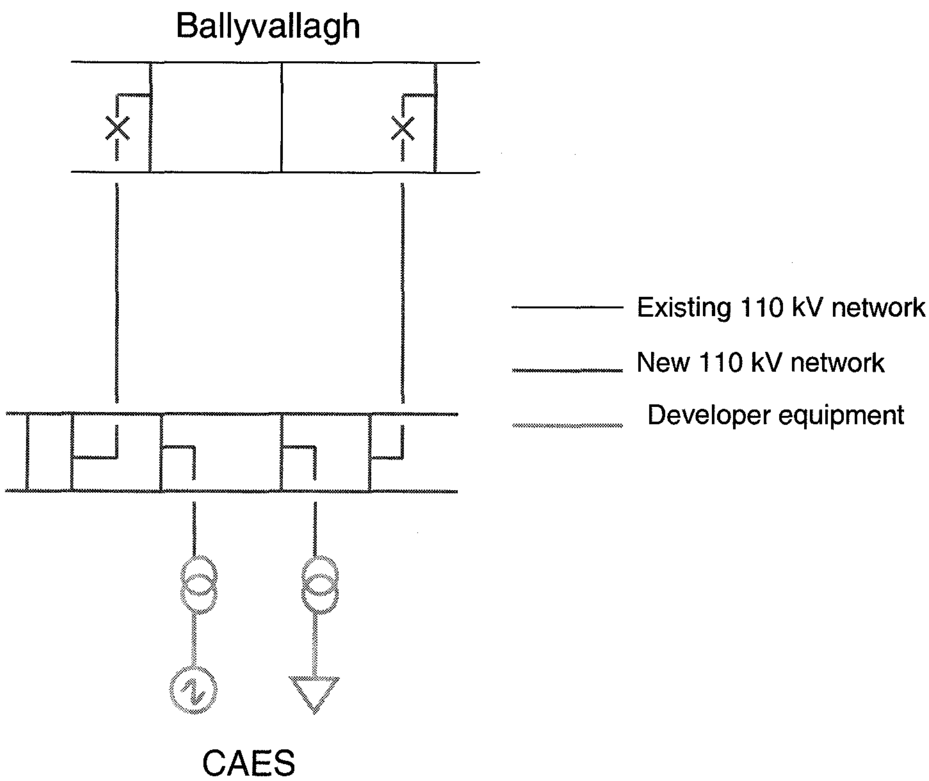


Figure 5: Option 2, Connect into Ballyvallyagh 110 kV substation. Ballyvallagh 110 kV substation consists of a double busbar. This connection would involve creating two new bays at Ballyvallagh.

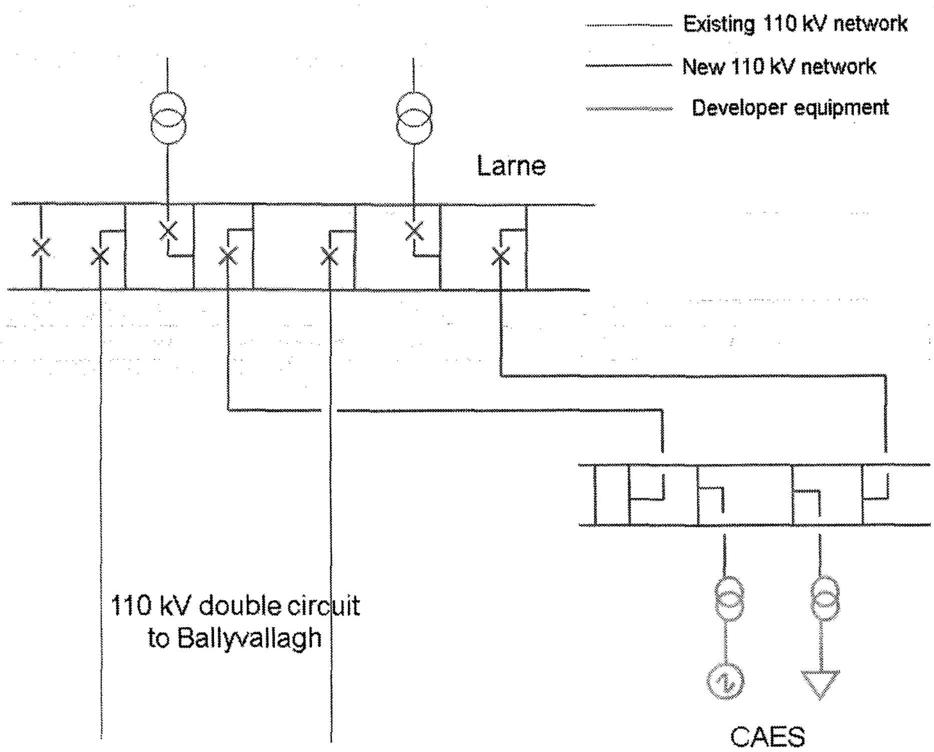


Figure 6: Option 3, Connect into Larne 110 kV substation (indicated as single bus). The existing Larne 110 kV substation consists of two transformer feeders, and no switchgear. Connecting the CAES plant into Larne would require the establishment of a double busbar switch board at Larne along with circuit 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.

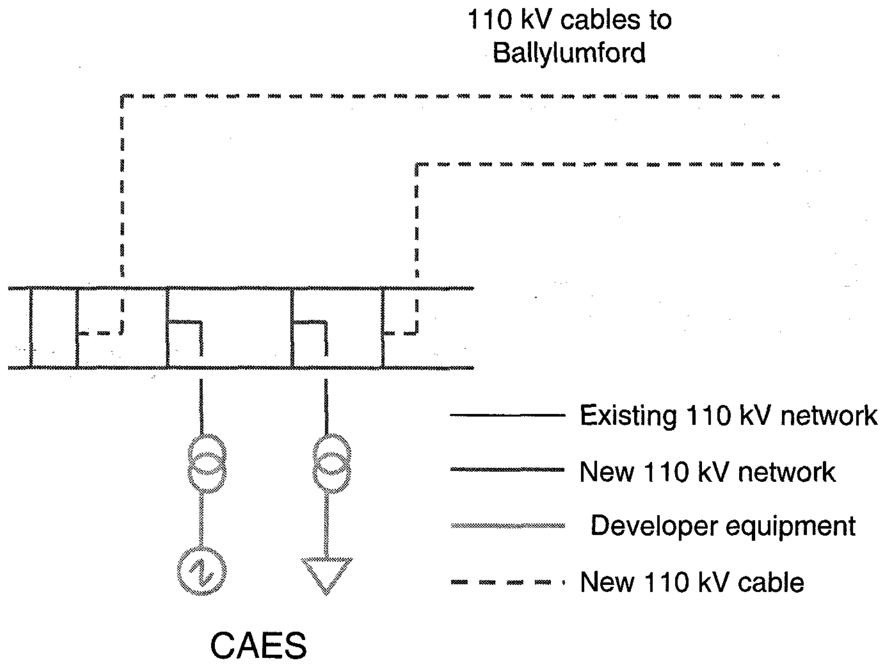
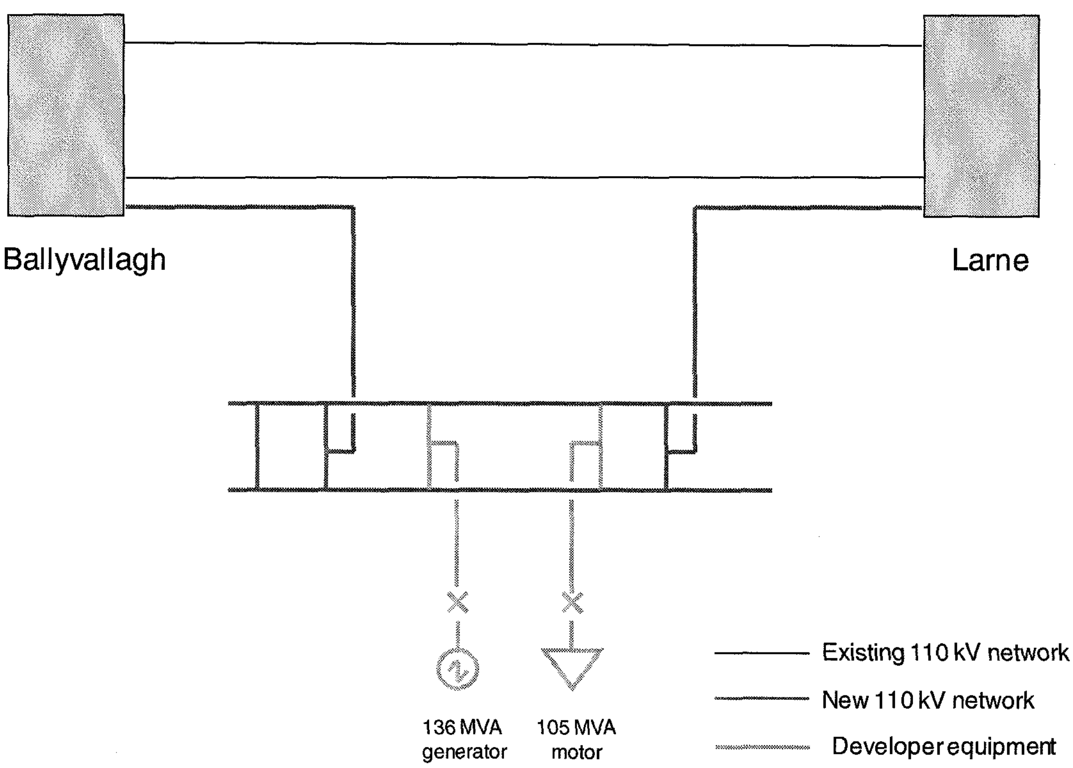


Figure 7: Option 4, Establish a new 110 kV substation at CAES and connect to Ballylumford by 2x110 kV cables. This would involve taking 110 kV cables from Ballylumford across Larne Lough to the CAES plant, and establishing a new substation there into which the Ballyvallagh – Larne circuits would be diverted.



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.

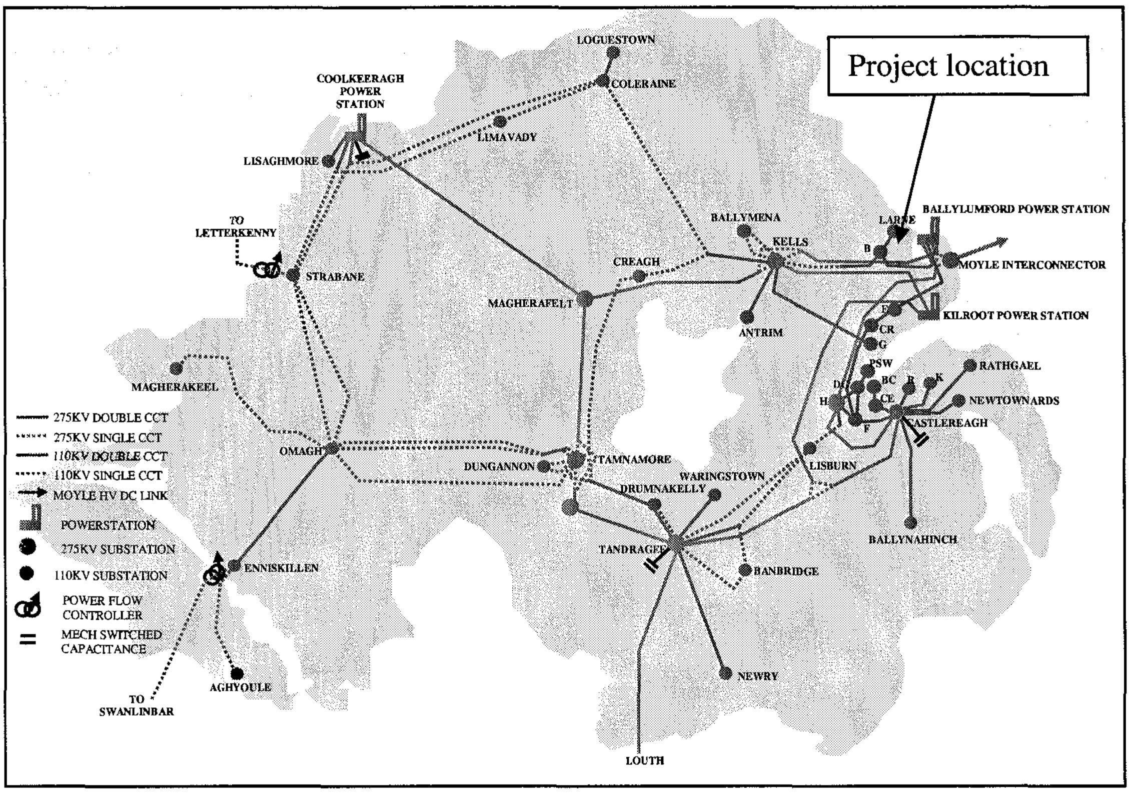


Figure 1: Proposed NIE network in 2015 showing location of the project

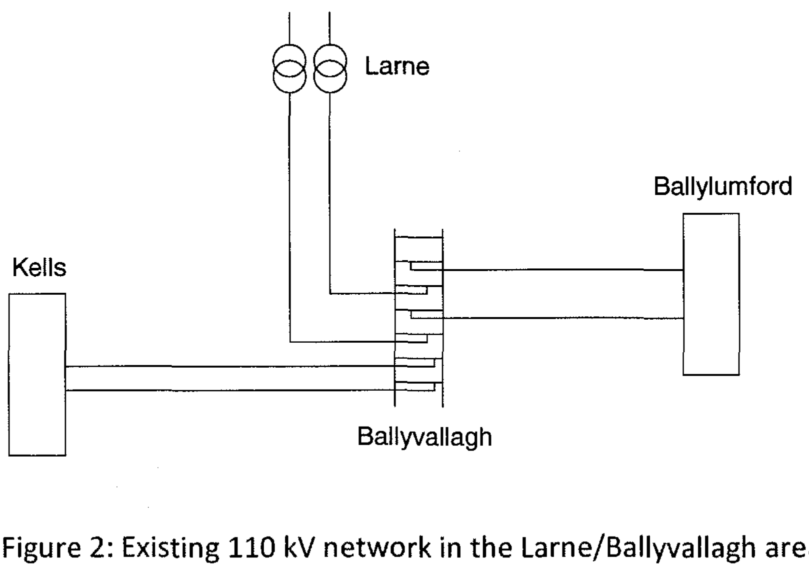


Figure 2: Existing 110 kV network in the Larne/Ballyvallagh area

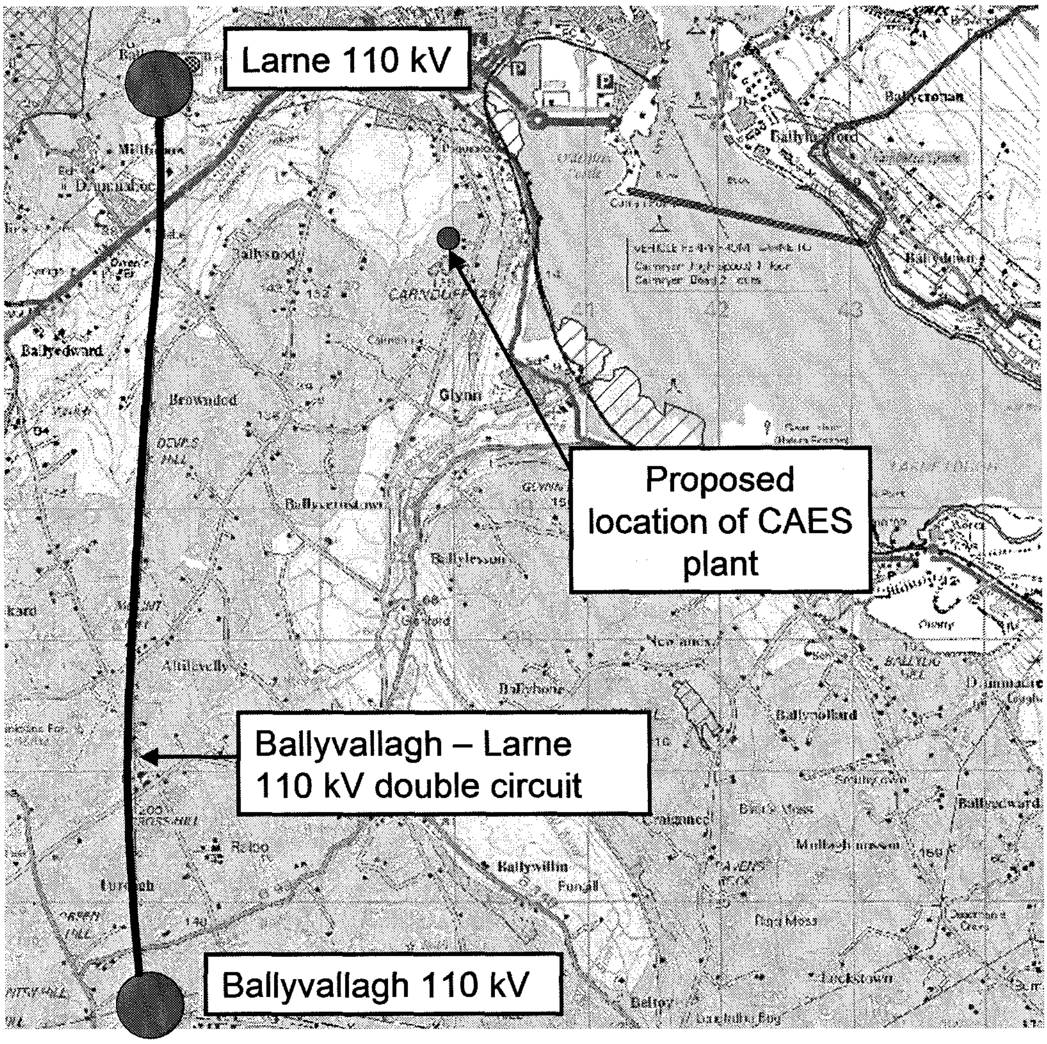


Figure 3: Proposed location of CAES plant in relation to existing 110 kV network

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).

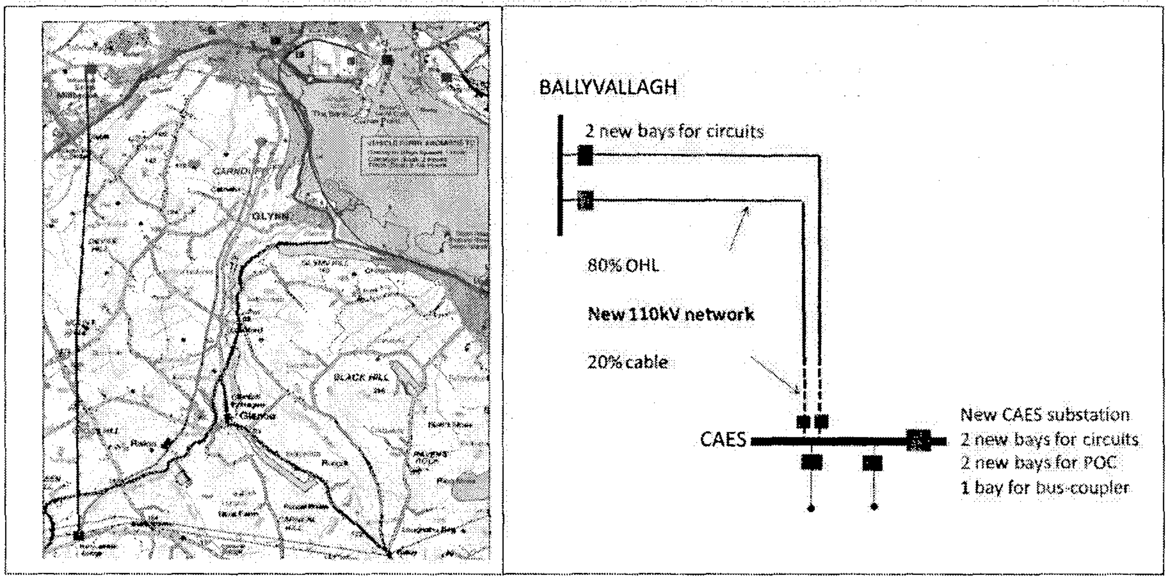


Figure 4. Preferred option for connection of Larne CAES Unit 1

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.

- 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.

- 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).

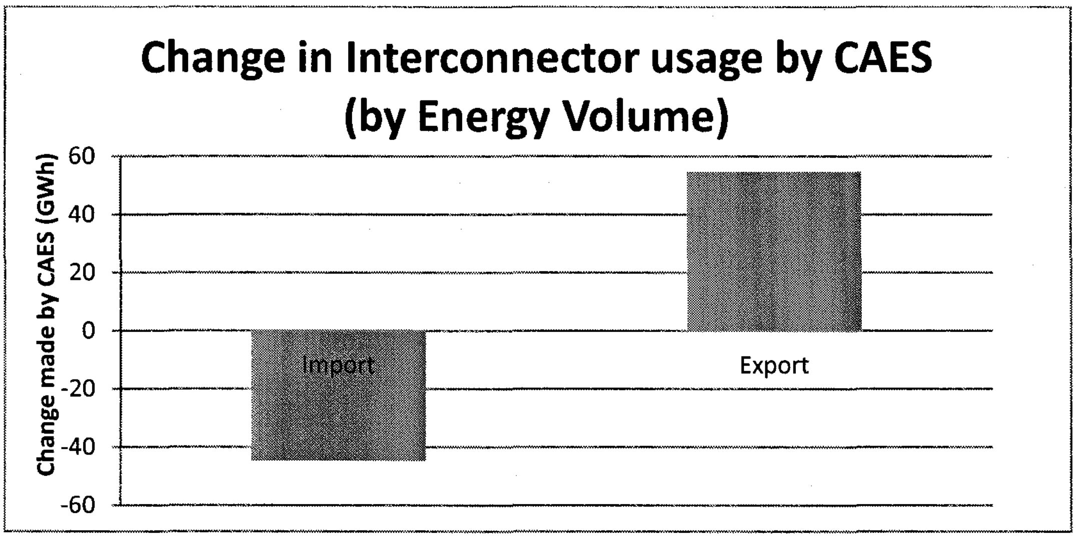
The nearest market neighbour to the SEM is the BETTA market in Great Britain. Using WILMAR, the project promoter has conducted unit dispatch modelling that examines the effect of the CAES facility operating in SEM including activity on the Moyle and East-West Interconnectors, at an hourly resolution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

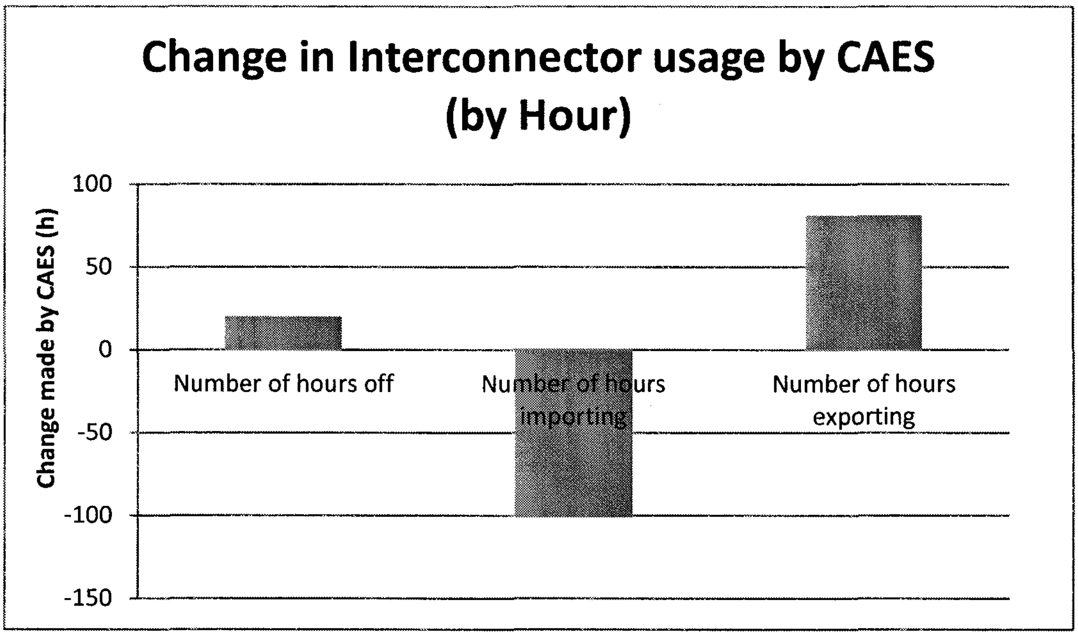
Interconnection between Ireland and GB consists of two interconnectors, each with 500 MW of capacity giving a total interconnection capacity of 1000 MW between the two systems. The Moyle Interconnector connects Northern Ireland and Scotland, and the East-West Interconnector connects the Republic of Ireland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