



GB Electricity Market
Reform

Submission to

Department of

Energy and Climate Change

Gaelectric Energy Storage Ltd – 28th February 2011

Strictly Private & Confidential

Purpose of this document

Gaelectric Energy Storage Ltd. (GES) would like to thank the Department for Energy and Climate Change (DECC) for the opportunity to contribute to the Consultation Document on Electricity Market Reform. Our response is presented in four sections: an executive summary, an introduction to the company, responses to specific questions raised in the consultation and an annex containing supporting information.

Given the nature of our activities this submission addresses consultation questions raised specifically in the section on proposed reforms for Capacity payments and Emissions Performance Standards (EPS) as they specifically relate to the area of Storage.

We welcome this consultation document as we feel that for too long the market has failed to incentivise adequately low-carbon technologies appropriate to supporting renewable integration and that little focus has been placed by the regulators of the markets on the contradictory practice of allowing 'high emitting' generation to support renewable. This is evidenced by the failure of National Grid to place any incentive or limitation with respect to carbon reduction or emissions for the Short Term Operating Reserve Tender (STOR).

Executive Summary

The development of renewables and the necessary electricity infrastructure requires a coordinated approach to achieve the successful integration of variable generation, grid stability and the development of the smart grid in a decarbonised power sector over the coming years. Failure to adopt such a coordinated approach with the necessary market reforms will result in a lost opportunity for developing the smart grid, an inability to meet renewable penetration targets, failure to reduce our carbon intensity and ultimately an increased cost to consumers.

Internationally it is recognised that storage has a major role to play in the decarbonisation of the power sector and can help to achieve this at a reduced cost to the consumer. High wind penetration without the deployment of adequate storage will result in grid instability and excessive levels of spilled or curtailed renewable energy. The grid must have the tools to manage generation and supply in a balanced, low-carbon way while at the same time reducing our reliance on imported fossil fuels, particularly natural gas. In this respect we are disappointed that the consultation process has not facilitated a discussion on a development framework for storage.

Development of storage requires engagement with the Transmission System Operators (TSOs), Regulators and Government in a proactive way so that all parties can fully understand the services and benefits that storage provides to the grid. Following this, appropriate market reforms, incentives and regulatory framework must be put in place to incentivise investment in storage. We would encourage DECC to consider various ownership models and review regulations where necessary – including ownership of storage by the system operator – to ensure the full benefits of storage are realised by the system and the consumer.

Any attempt to assess storage under the same valuation methodologies and business model as conventional generation would result in a failure to recognise the full value of storage to all stakeholders. This is now acknowledged by many of the Independent System Operators (ISOs) and balancing authorities in the United States. In fact the European Strategic Energy Technology (SET) Plan specifically refers to storage as a strategic energy infrastructure.

GES is encouraged by the proposed market reforms and would welcome the opportunity to engage directly with DECC on the challenges it sees to developing storage in the GB Market.

While we feel the proposed reforms in general are a move in the right direction, we are concerned with a number of aspects of the consultation document and proposed reforms.

Firstly, a number of statements in the document suggest that DECC appears to be uninformed about currently available storage technology that is proven to deliver multiple system and consumer benefits.

Secondly, the consultation is not technology neutral but rather favours certain technologies at the expense of others. In particular, the consultation document clearly sets out a 'route to market' for CCS but fails to do this for storage, leaving storage to find its own commercial route to market.

In fact we would argue that this CCS-centred approach is in fact contradictory to the low-carbon power sector being proposed as the catalyst for the market reform and will not lead to reduced prices for consumers, because the overall costs (and carbon footprint) of CCS have not been established and its practical efficacy is a matter of speculation. We would further add that a number of high profile proposed CCS projects have been cancelled for various reasons.

Thirdly, GES believes that the effect of a capacity mechanism on storage would depend on the exact structure of the mechanism coupled with incentives in other areas such as the deliverability of flexibility and potential barriers to entry.

The introduction of capacity payments will reduce the volatility in wholesale prices, which will threaten the viability of storage in GB under traditional business models. GES feels that storage needs to develop new business models as the traditional model is unsustainable and therefore is also encourage by DECC proposal to allow the TSO to contract directly with certain generators outside the market is welcome. GES has been advocating such a model for a couple of years and would see such a model has been the ideal route to market for storage which will allow the many benefits and services of storage to be monetised in the market to the benefit of consumers.

With this in mind we would encourage DECC to build upon their proposed market reform and substantially encourage a new business model for storage as part of its white paper. We would strongly recommend that in their white paper DECC adopt a more technology neutral stance for the sake of market integrity and investor confidence.

Gaelectric

Gaelectric is a group of companies, each active in the different fields of Renewable Power Generation and Energy Storage with experienced teams specialised in all aspects of project planning, permitting, finance, engineering and management. The Gaelectric Team comprises specialists in all relevant fields of mechanical and power engineering, GIS and remote sensing, environmental engineering and consulting, market analysis, finance and acquisition. Key personnel in Gaelectric have many years of experience in the international energy and renewable energy sector. Members of our Senior Management Team have held senior positions at some of Ireland's most successful wind and power development companies and were involved in the construction of the first onshore and first offshore windfarms in Ireland. They also bring considerable experience developing renewable projects internationally

To date we have accumulated a wind energy portfolio of projects in various stages of development in Ireland. Projects totalling circa 350 MW are currently at various stages in the planning and permitting process, making Gaelectric a significant wind developer in Ireland. In the State of Montana in the USA, Gaelectric currently controls a portfolio of 6,000MW of land options. Recently the company announced a plan to invest \$2 billion under a transmission interconnect and services agreement to move 960MW of power across the North Western Energy and Bonneville Power Administration network regions. This latest announcement complements previous agreements, announced last year with Tonbridge Power to jointly develop transmission solutions in Montana and negotiations are ongoing to develop T&D solutions with Trans Canada.

Gaelectric Energy Storage

Currently the Gaelectric Energy Storage (GES) Team is involved in the development of bulk storage, specifically Compressed Air Energy Storage (CAES). Our flagship project is the CAES project in Larne, Northern Ireland. GES is seeking other prospects for CAES in the US, UK and Europe. More recently GES has begun investigating opportunities to introduce short term grid support storage into the UK and Ireland. Over the past three years Gaelectric has undertaken leading studies in the area of energy storage and is considered by many to be a leading authority in energy storage development in Ireland and will advance market assessment in the GB Market later this year.

Responses to specific Questions

GES is responding to questions which affect our interests in developing electricity storage in the UK, given that we are not answering questions in the order asked we have numbered the questions for accuracy and ease of reference.

Options for Market Efficiency and Security of Supply

19. Do you agree with our assessment of the pros and cons of introducing a capacity mechanism?

In the context security of supply, capacity adequacy is one requirement. Typically two schools of thought exist with respect to how the market should incentivise capacity adequacy. The first is efficient market theory which expects the market to provide a price signal when capacity is tight. However the development of capacity to address such a signal can take several years to plan and commission yet the signal from the market can be short and aggressive in nature, resulting in a potential under build in the short term and an over build in capacity in the long term.

Alternatively, a capacity mechanism could be utilised in the market to provide a long term signal which is stable in nature and provides investors with a clear signal going forward. While we agree with this approach we would highlight the need for the capacity mechanism to not only provide a capacity adequacy signal it should also provide a signal for flexibility. Security of supply is not just about adequacy it is also about having the necessary flexibility. We would also highlight that from an investor point of view the risk signal has merely moved from being a market signal from which an investor can take a view to one of regulatory risk which is less transparent.

Electrical storage can offer capacity into the market to cover various scenarios by both absorbing and discharging energy. Rules around the capacity mechanism need to appreciate this unique attributes and flexibility which storage brings to the market.

20. Do you agree with the Government's preferred policy of introducing a capacity mechanism in addition to the improvements to the current market?

Yes this is the appropriate way forward; however we would emphasise a number of areas which need careful consideration.

- Need to provide flexibility
- Adequate long term signals to provide investment certainty
- Transparent signals and framework for timing and introduction of new capacity
- Emphasis on the need to provide low carbon generation
- Rules to prevent disincentive such as storage having to pay capacity when charging.

21. What do you think the impacts of introducing a targeted capacity mechanism will be on wholesale electricity markets?

Capacity payments by their design and nature reduce the volatility of prices in wholesale markets. However the introduction of a capacity payment does not necessarily equate into reduce costs for the consumer as the regulated price of capacity could exceed the scarcity rent that would have be derived from the wholesale market in the absence of a capacity market.

Customer can benefit from the introduction of a capacity payment in the wholesale market if that payment is priced correctly, rewards flexibility and reduces carbon while allowing for the increased integration of renewable and increases the efficiency of the entire electricity system, while at the same time providing an adequate investment signal.

22. Do you agree with the Government's preference for the design of a capacity mechanism?

Which is designed around three criteria, namely:

- A central body holding the responsibility;
- Volume based, not price based; and
- A targeted mechanism, rather than market-wide.

Currently the market has a central buyer for Ancillary Services in the form of the National Grid. We assume therefore that National Grid would be the procurer of capacity and feel this is a prudent way forward. We favour a volume based approach to procuring capacity but would again highlight that care should be taken in constructing as a market that is based purely on volume can result in incentivising large low cost technology at the expense of flexibility and does not fully reward flexibility.

A targeted capacity mechanism, which seeks to offer incentives in a range of categories, providing a range of availability and utilisation payments has the advantage that flexible capacity can be sought and rewarded at a premium to traditional capacity. This is analogous to evolving arrangement for

ancillary services in world power markets where a premium is paid for fast acting services above those of traditional assets¹.

1 – FERC NPOR dated 17th Feb 2011

23. What do you think the impact of introducing a capacity mechanism would be on incentives to invest in demand side response, storage, interconnection and energy efficiency? Will the preferred package of options all these technologies to play more of a role?

We assume the capacity market is designed in such a way as to recognise the various forms of flexibility. We therefore assume for example that a demand side response unit be paid a capacity payment for reducing load and under the same mechanism could a storage facility to be paid a capacity payment to charge? It is conceivable that a capacity payment mechanism could result in those technologies providing a greater role in the future.

From a storage perspective the introduction of a capacity market can be detrimental to the investment case for storage as it reduces the extrinsic value of volatility in the wholesale power market. However it can also be a positive move if it rewards the multiple operational modes of storage and fully appreciate its flexibility.

Increasing flexibility is the key to security of supply in the future generation mix. Energy Storage should be the preferred option for all stakeholders as it:

- Allows for dual modes of operation (charge/discharge)
- Has high technical specification (Fast response, low min gen, fast ramping)
- Allows for the efficient use of existing power generation, reduces cycling of plants which reduces costs and emissions.
- Increases the efficiency and operation of the entire system which increases societal benefits.

Section 40 of the study highlights the challenges for storage in terms of future investment. GES would agree that the areas highlighted are challenges but would disagree with DECC as to the extent of those challenges.

- Uncertainty over future levels of volatility** – Wholesale Price Volatility is a requirement for commercial success of storage, the challenge is that while storage needs volatility to make a return under traditional business models the presence of storage in the wholesale market also reduces the level of volatility in the market, which is of benefit to the consumers. GES understands this challenge and is therefore keen to develop a new business model for storage in the market. A business model which would work along similar lines as the traditional gas storage model, whereby stakeholder would pay for the utilisation of the facility to inject/withdraw energy as required. This will provide a more stable investment signal for storage and allow both investors and consumer to monetise the significant benefits the characteristics and flexibility storage brings to the market. GES feels that such a business model could be tendered for under contract with the TSO and developed as PPP/PFI projects to provide financial and electrical efficiency to the market.

- **High capital costs –** GES has been working with many providers of storage technology over the last two years; GES can say categorically that publicly available information with respect to capital cost of storage is misinformed. GES would also question why “high capital costs” are highlighted as a barrier for storage surely DECC would agree that the cost of Nuclear and CCS is higher. GES would encourage DECC to focus on the cost benefit analysis of various technologies as well as the absolute capital cost, It would encourage DECC to work closely with industry to achieve this.

- **Geographic Limitations –** The consultation refers to pumped hydro specifically when it refers to storage and from that perspective we can agree that pumped hydro in the UK is geographically constrained. Pumped hydro has delivered substantial benefits to the GB grid over the decades - however it is not the only storage technology. And while further development may be constrained for geographical reasons, other technologies exist today which are modular in nature and can easily placed on the grid as and when required. Also a number of sites have been identified by GES in the UK which are suitable for CAES. CAES is a proven technology which can deliver the MW SIZE similar to pumped hydro at a significantly reduced cost, higher flexibility and less environmental concerns.

GES sees the ownership model of storage as being the biggest obstacle to development of storage and would therefore specifically ask DECC to begin a proposal in the white paper to address this obstacle.

Annex

Storage in a wider context

The absence of readily available electricity storage options has shaped the nature of the power system design globally. Contrary to popular belief, technology was never the largest obstacle to using storage on the grid as various forms of storage have been available for years. Storage was simply not needed in a world where energy resources were abundantly available, carbon emissions were not taken into consideration and the cost of construction of electrical infrastructure was not a matter of public interest.

In recent years, the situation has changed. Environmental concern has increased the cost of securing reliable and available electricity supply. Not only is the use of carbon-intensive generation increasingly penalised by national and international regulations, the planning and approval cycle for power plants and transmission lines is becoming longer and even more cumbersome. In a parallel development, deregulation and liberalisation have created liquid markets that increase the transparency of electricity supply costs and show that electric energy storage today has the potential of becoming a viable contributor to power system efficiency.

GES would firstly like to take exception to observation 22 on page 64 of the consultation, *“another factor in the development of storage is the technological readiness of storage technologies (today, the only market-ready technology available for large-scale deployment is pumped storage 67)”*

Many international experts are of the view that pumped hydro and CAES are currently the only technologies suitable for providing reliable storage of electricity on a large scale. In fact many

storage technology providers and investors are of the opinion that pumped hydro and CAES will be the only suitable large scale storage methods for at least the next 10 years. Utilising such available technology will greatly reduce the carbon intensity of our power system.

GES has identified sites in both NI and the UK which present the right geological conditions to develop CAES and with the correct regulatory support and incentives, could present a low carbon technology to the power sector at substantially reduce capital cost to what is widely reported and at a significant saving to the consumer.

The consultation in GES opinion fails to adequately address the increasing benefit that other storage technologies are bringing to power systems internationally, many short term storage technologies are operating commercially throughout the world, such as Beacon Power 20mw Flywheel facility in the NYISO. Such technologies are delivering the significant market efficiency and savings to the consumer sought by DECC.

In a study commissioned by GES and Beacon Power last year, we found that allowing flywheel technology to provide reserve in the Single Electricity Market (Ireland and Northern Ireland) increased the efficiency of the market substantially resulting in a projected saving to the consumer of €108m yearly from 2015 onwards and a reduction in carbon emissions from the power sector of per year of 10%.

DECC would appear to be dismissing the need for storage until post 2030 and would appear to be only tentatively highlighting a need to address some of the obstacles rather than coming to a definitive position with respect to storage. This is despite the obvious benefit pump hydro brings to the GB Market and the volumes of academic studies and demonstration plants which point to the benefits of storage in low carbon power systems. Rather DECC is seeking to incentives low carbon technologies and renewable which by their nature are either intermittent or inflexible and will only heighten the need to storage pre 2020.

GES would question why DECC feels it appropriate to incentivise CCS in such a explicit way as is detailed in the consultation but storage does not receive the same treatment. When in fact storage is a proven technology which CCS is not, with substantially lower capital cost compared to CCS and is in fact a low carbon technology which CCS is not, in fact GES would go as far as to say that incentivising CCS as a low carbon technology in the way proposed by this consultation is contradictory and perverse in the extreme.

GES would call on DECC to extend their market reform to incorporate a market entry strategy for storage along the same lines as is outlined in this consultation for CCS. The opportunity for storage encompasses many stakeholders and interests. Storage must be considered as much more than a stand-alone “wind curtailment avoidance tool” or “arbitrage trading tool”. In a recent report, Sandia National Laboratories (Feb 2010) listed 29 benefits that storage can provide to a grid, 14 of which apply to bulk storage with a duration of at least one hour. Understanding how these benefits complement each other is the key to modelling storage on an electrical system in order to assess the system benefits accurately. The Sandia report highlighted that storage is set to become an important element of the electricity infrastructure of the future and a key component of the Smart Grid.

Compressed Air Energy Storage (CAES)

To date two CAES projects have been commissioned in the world; 110MW McIntosh Alabama Plant which went into commercial operation in May 1991 and the 290MW Plant in Huntorf, Germany which went into commercial operation in 1978. Both plants to this day have availability exceeding 90%. Thus CAES technology is proven today and new projects announced recently will advance the technology further, providing the grid with greater flexibility and greater value at a lower cost.

Previously CAES Plants were constructed on a project specific basis i.e. to support a nuclear plant (Huntorf) or coal portfolio (McIntosh). Market deregulation and increased renewable penetration have altered the landscape considerably and in the last few years various CAES projects worldwide have been announced with a combined capacity of approximately 2,000MW. These projects are being built with the full grid and market benefits of CAES in mind. For example in Germany, a project was recently announced by RWE and GE to develop 300MW of advanced adiabatic CAES based on its ability to ramp fast and support wind and also to reduce Germany's reliance on natural gas plants for wind support.

A number of factors are converging in many electricity markets to make CAES a viable option in the very short term. These include high penetration of intermittent renewables onto the market, the need to reduce our dependence on natural gas and widespread resistance to the build out of Transmission and Distribution infrastructure. Studies have shown that utilising a conventional CAES system as support for wind reduces natural gas consumption considerably when compared to a Combined Cycle Gas Turbine ("CCGT") while offering ramping rates, heat rates and flexibility considerably better than Open Gas Combined Turbine ("OCGT"), (Generation ramp rate 24MW/Min and Compression ramps at 22MW/Min). Second generation (adiabatic) CAES, which is currently in development, will require no gas firing and thus will provide even greater emissions savings².

CAES addresses the need for a continuous power balance between generation and load in the operation of power systems. In periods of low load, CAES may be used to increase the overall system load by storing energy which can be delivered to the system in subsequent high load periods. From a market perspective, this means that energy will be stored at lower prices (usually corresponding to low load) and generated at higher prices (peak load).

² Sandia Report - Energy Storage for the electricity Grid: Benefits and Market Potential Assessment Guide – Feb 2010

In terms of short-run marginal cost, CAES reduces peak loads and increases base load hours. This load levelling effect, combined with increased load following efficiency, reduced ramping of conventional plant and reduced system CO₂ results in an overall reduction of cost to the system and ultimately reduced electricity prices. Gaelectric has evidenced these effects by introducing CAES into the All-Island Grid Study.

CAES can be used to reduce fossil fuel use in three ways. Firstly, stored energy from more efficient fossil fuel plants or renewables can be used to replace older, less efficient fossil fuel plants during peak hours. Secondly, fuel use may be reduced due to the dynamic operating characteristics of storage - a CAES plant has a flat heat rate curve. Thirdly, fossil fuel plants tend to operate most efficiently when ambient temperatures are low. Operating an efficient fossil fuel plant during the day when ambient temperatures are high increases the use of fossil fuel.

CAES Project in Larne Northern Ireland

GES is currently investigating the possibility of developing a CAES Plant of between 140MW and 300MW in Larne, Northern Ireland. As part of a due diligence GES has undertaken a number of studies with world leading advisors in the field. The studies conducted by GES in conjunction with independent assessors on the potential for CAES in Ireland are the first of its kind to evaluate

comprehensively the potential for CAES in Ireland. The work in this area coupled with our extensive energy experience has provided GES with a broad range of skills encompassing a unique understanding of the geological, plant, system operational and market aspects of CAES.

This work has included:

- A study of the geological potential for CAES in Ireland.
- An assessment of the potential for CAES in the salt deposits of eastern County Antrim, by KBB-UT, Europe's leading consultancy on salt cavern development.
- System modelling of CAES using WILMAR, in conjunction with RISOE and ECAR (Electricity Research Centre, University College Dublin).
- Financial modelling of CAES in Ireland, in conjunction with PricewaterhouseCoopers, utilising proprietary modelling techniques developed in-house by GES.
- Techno Economic Analysis of CAES in SEM, in conjunction with ECAR and Dresser Rand

As a result of this work, GES is now undertaking feasibility studies into developing and coupling CAES with short term storage solutions for Grid Stability and Wind Integration.

We can conclude from the above studies that a CAES Plant in Ireland offers a number of stakeholders a potentially rich value proposition. This is because of the specific characteristics of the Irish electrical system coupled with the numerous complementary benefits of bulk storage. A detailed briefing of our studies is outside the scope of this submission but we would be interested in meeting with you to present our findings in greater detail at a later date.

Of particular interest is the system modelling work of CAES in the All-Island Market in conjunction with RISOE (National Sustainable Energy Institute in Denmark) and ECAR (University College Dublin) utilising WILMAR. WILMAR is a stochastic linear optimisation program used extensively throughout Europe to model the impacts of high renewables penetration on power systems. It is considered a leading academic / industry model to understand system metrics with renewables and was the basis of the All-Island Grid Study (AIGS).

The purpose of our WILMAR modelling was to examine the likely operation of a CAES plant in the Irish (All-Island) system during the period 2015-2025, by which time large amounts of wind power are expected to be installed.

To examine the likely usage of the CAES plant in the time frame proposed, it was necessary to model the hourly operation of the electricity system. The WILMAR model was also used in the AIGS to examine the operation of the Irish power system – therefore results seen here will be consistent with the AIGS. WILMAR optimises over a 36 hour period to produce the least cost schedule for the hourly unit commitment and economic dispatch of the system, accounting for the reserve demands that are likely to be seen. This is similar to the Single Electricity Market in Ireland which aims to minimise costs over the day. Storage is used to optimise system costs, and can also be used to provide reserve to the system. The filling of the store and generation from CAES are therefore both included in the optimisation.

The following extract from the final report prepared by ECAR describes the societal/system benefits that CAES in the Irish system can provide:

CAES is shown to have a significant impact in terms of system costs, emissions, change in net import, curtailment and shadow price. Cost change is in the region of €6m to €11m beyond 2020 for modern CAES units. Change in system costs is not explicitly valued in SEM at present- this reduction in costs means CAES has a clear societal benefit when compared to the open cycle gas turbines it

replaces in the plant mix assumed. Again, the full benefits of CAES cannot be captured in an hourly model with 36 hour look ahead like WILMAR – this gives the floor value of what CAES may be worth to society. What can again be assumed is that as CAES is used more, whether through increased wind penetration, better efficiency or a reduction in system flexibility, the system costs will be reduced.

CAES significantly reduces curtailment – by 3.5% in 2025 for the base case. Again, this will increase for those cases where CAES is used more, such as with a lower energy ratio. This reduction in curtailment can be viewed in two ways. It can enable more wind to be used on the system. For a given installed MW capacity, it will increase the energy penetration from that capacity. This increase will grow as installed capacity grows. Alternatively, CAES could be seen to reduce the amount of installed wind that is needed to reach a given target of penetration level. For example, to reach the 40% penetration set for 2020, less installed capacity will be needed as curtailment will be decreased. This clearly means less capital costs for wind turbines, and therefore this may bring a societal benefit in this way.

Another impact on the system is an increase in net import as CAES usage increases. While imports are higher, this does not necessarily mean a bad thing for Ireland. It means that more of the wind can be used in Ireland and advantage can be taken of cheaper GB prices. This assumes that the security of supply in GB is sufficient, and that it continues to remain a cheaper source of off-peak power than the Irish system. Another point to note is that the change in net import due to adding CAES decreases as wind increases – therefore the effect of CAES on net imports decreases with increasing wind (as CAES is now being used more to reduce curtailment instead of to take advantage of cheap power). Thereby CAES adds efficiency to the system in terms of interconnection.

The value of these system benefits will increase as wind penetration increases and as a clearer understanding of optimum operation of CAES in the system is developed. This can be only being achieved through direct engagement between the TSOs, equipment manufacturers and GES.

The Larne CAES project involves a number of risk factors, including:

- Technology:** Technology has been proven and operates with reliability levels in excess of 90%.
- Geology:** GES has done a considerable amount of work with KBB Underground Technologies in assessing the geology of its project and is satisfied that the risk is understood. Over the next 12 to 18 months both companies will carry out further work to continue de-risking this aspect of the project.
- Plant/cavern optimization:** Understanding the optimum size and components of the plant with respect to generation size, number of compressors, cavern size etc is not a challenge as manufacturers of the technology work with clients to optimize the project.
- Operational strategy:** The greatest obstacle to development is the lack of a clear understanding of and strategy for storage in the Irish power system within the TSOs and regulatory bodies. Storage is still incorrectly valued based on one revenue stream (i.e. Energy) when in fact it brings a number of benefits to the system. Classical business models developed and used for assessing the value of conventional generation are inadequate for assessing the value of energy storage. New business models are needed to take into account the accumulation of diverse revenue streams derived from the numerous value elements for all stakeholders. It will be necessary to develop dedicated simulation tools and conduct demonstration projects to validate these new business models, with the support and direction of the State, Regulators and the TSO.

Finally, GES believes that a number of actions are required to overcome barriers to entry for energy storage:

- **Reduce uncertainties on the future economic value of energy storage.**
 - Develop new energy storage business models;
 - The development of a storage operator, acting on behalf of the network and financed through PPP/PFI structures with private developers.
 - Technological R&D (reducing cost and increasing performance);
 - TSO led simulation & demonstration studies;
 - Long term contracts for bundled services.
- **Provide an incentive policy**
 - Review rules for energy storage access tariffs;
 - Renewable energies should be made commit to grid stability and security of power;
 - Clarify energy storage ownership status – right to TSO/DSO to own & operate energy storage;
 - Change market rules to integrate the energy storage operator.
- **Accelerate the process**
 - Public funding for simulation and demonstration projects and support at National level to secure demonstration funding from the EU for large-scale storage.

Flywheel

Following the successful collaboration of GES and Beacon Power to study the benefits of flywheel on the Irish Power system, the parties are seeking to collaborate on further studies on the UK markets and to physically demonstrate the technology in both Ireland and the UK.

A flywheel is a device which stores electrical energy by the use of a rotor spinning inside a sealed, airless container (i.e. a vacuum). The speed at which the rotor spins is related to the amount of stored energy it contains. The faster a flywheel spins, the higher the amount of stored energy it holds.

The key components of the flywheel are:

- A cylindrical shaped rim (which acts as the rotor in this design).
- A shaft situated in the centre which is connected to the rim
- A dual purpose motor/generator which can either generate or consume electricity.

These components are all contained in a vacuum chamber. This is to eliminate friction losses between the rim and air. The rim would slow down in air, similar to a moving object losing speed due to wind resistance.

The device absorbs and stores electrical energy from the grid by allowing the motor to increase the speed of the shaft and rotor. Conversely, allowing the rotor and shaft to run the generator injects electricity back into the grid.

Flywheel plants can be scaled from single megawatts to tens of megawatts. A 3MW flywheel plant is currently operational in New England, whilst a 20MW facility in operation in New York and a 1MW demonstrate plant has been announced by North Western Energy in Montana.

Power System Challenges with Increasing Wind – Opportunities for Flywheel:

Effect of Wind on System Operation

A significant amount of wind power is expected to come onto the All-Island system in coming years. Wind generation is unpredictable and variable by nature. For this reason, precautions must be taken, as wind penetration increases, to maintain system stability. Two such precautions are:

- Introduce new reserve requirements on the system.***
- Restrict high levels of wind penetration by curtailing the output of wind farms.***

Reserve

On an electrical network, reserve is a term which refers to electrical energy which is held back to act as a contingency to imbalances between supply and demand. To ensure the stability of the system, system operators require that reserve energy is available to call upon within seconds. On the All-Island system this reserve is generally provided by fossil fuelled power plants that are already running (i.e. spinning) but are not providing electricity to the system. If an event causes an unexpected imbalance between supply and demand (e.g. tripping of a large generator), a reserve plant injects electricity into the grid immediately to correct the imbalance. It can react quickly because the electrical generator is already spinning and thus is consuming fuel as a consequence. Operating power plants in this manner results in relatively high carbon emissions and running costs for the entire power system. Is there a cheaper, cleaner way of providing reserve? Gaelectric's study has shown that flywheel can satisfy the requirement for reserve with significant savings on emissions and operational costs.

Wind Curtailment and System Flexibility

The Facilitation of Renewables Study recommended that no more than 75% of system demand should be provided solely by wind at any time to ensure a stable grid. To maintain this limit, wind generation would have to be prohibited or curtailed in instances of where the 75% limit was reached.

The GES / Beacon study has shown that flywheel would eliminate the need for a large amount of spinning reserve to be provided predominantly by fossil fuelled generators with substantial savings in emissions and operating costs to the system. In addition the ability of flywheel to provide fast reserve during periods of high wind penetration would mitigate the need to curtail large amounts of wind energy by introducing major flexibility to the grid. Further work has shown that if reserve were to be provided by a combination of flywheel and Compressed Air Energy Storage (CAES), larger reductions in system costs, emissions and wind curtailment could be achieved

The combined benefits of flywheel, against business as usual approaches illustrate a smarter way to provide reserve and management of higher wind penetration levels. The technology could enable

the achievement of the renewables and emissions targets for Ireland by 2020, whilst reduce the cost of operating the system relative to conventional methods. A suitably scaled flywheel pilot project would demonstrate the performance of the system for these reserve and curtailment management services, while providing an opportunity for Ireland to take a lead in flexible grid-level storage technologies.

Summary Results:

The study found that the implementation of up to 200MW of flywheel on the All-Island System could:

- Reduce system costs by €108 million and €94 million in 2015 & 2020 respectively. Approximately, this represents a 10% reduction in total system costs for each year.
- Reduce carbon emissions in the power sector by about 1.7 million tonnes, or approximately 15% of total emissions of the system in each study year. This saving is equivalent to the emissions which approximately 1 million people on the island of Ireland contribute annually.³
- Reduce wind curtailment from a high of 17.5% to 11% by 2020. This reduction in curtailment would be equivalent to approximately 1.1TWh of wind energy in 2020.
- Enable the system to achieve wind penetration of up to 75% of electricity demand.

Flywheel Demonstration Plant:

GES and Beacon Power seek to demonstrate this technology under a pilot framework on the All-Island Grid. The key objectives of the demonstration would be to verify the performance of the technology as a system support tool that enables higher levels of wind penetration and reduces reliance on fossil fuelled plants from providing reserve.

To encourage demonstration of such technology, the following measures are recommended.

- TSO involvement in carrying out a connection study for a suitable location.
- Advancement of a connection offer
- Regulatory support with respect to avoidance of costs (TUOS, DUOS) under a demonstration framework.
- Demonstration tariffs to compensate for system benefits attributable to such technology and to accurately assess the system benefits cost trade-off.
- Regulatory engagement as to the licensing requirement and ownership status of such technology.
- Stakeholder engagement on a route to market approach for such technology following demonstration.
- Existing Public Private Partnership mechanisms should be investigated to deliver such infrastructure for the grid.
- Initiate a carbon offset mechanism for the technology.

GES and Beacon would be very interesting in providing DECC with the details of its work with the intention or replicating the work in GB Markets and following this demonstrating the technologies in GB



Gaelectric Energy Storage Ltd. GB Market Reform

As part of this reform we would encourage DECC to put in place a framework under which the above issues can be address, this will help greatly in reducing the barriers of entry for storage and other similar technology.

We thank you for the opportunity to contribute to the GB Electricity Market reform consultation and we look forward to all stakeholders developing a coordinated plan for the coming years to the benefits of all.

[Redacted]

[Redacted]

[Redacted]

