ENERGY STORAGE: THE MISSING LINK
AN FTI CONSULTING DISCUSSION PAPER

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Energy Storage: the missing link

1. FOREWORD

On his recent visit to Ireland, UN Secretary General Ban Ki-moon warned:

“For too long, the response to climate challenge has been hindered by entrenched interests, national interests and those who question the science. … science has made it simply clear that climate change is happening because of human behaviour. … nature does not negotiate, nature does not wait. Nature goes on its own path. It is us — we have to adjust ourselves to this changing situation.” ¹

He added that action on climate change is not inconsistent with economic progress and the moral case is clear:

“Putting our economies on a low-carbon pathway will create new markets, provide energy security and improve our health. … The world’s poorest and most vulnerable countries are the first to be impacted and the most impacted because they don’t have any capacity to mitigate and adapt.” ²

Global warming, and a failure to limit increases in temperatures to 2°C above average pre-industrial levels by the year 2100, have been described as a “ticking bomb”. With little or inadequate action, global warming could exceed +2°C, bringing with it increased risks of abrupt or irreversible changes to the Earth’s climate.

Energy lies at the heart of the warming of the Earth’s atmosphere and the climate effects this is triggering. But the sources and use of energy also hold the solution.

“The actions we need to take to address climate change also give us the chance to create a better society. Climate action sets us on a compass bearing to a better way of living. More equal. More secure.” ²

The Earth has an abundance of energy sources that do not generate net additions to greenhouse gases emissions. Many of these have proven technologies that are getting better. Wind, solar and bioenergy now, and wave in the future. These clean and sustainable sources of power have their own characteristics, including varying degrees of intermittence and predictability. As their share of our energy mix increases, we need tools to help manage this; to help us match supply with demand without waste or generating further damaging greenhouse gas emissions.

This is where storing energy safely and efficiently comes in. But not as a rudimentary repository to dump excess power and pour it out when needed. What is needed are energy storage projects that aid our current energy systems to become more sustainable, secure, efficient and cost effective.

The Larne CAES Project is one such project. It is unique to Northern Ireland and will provide bulk, grid-level storage that is responsive, safe, effective and supports the integration of Northern Ireland’s renewable energy resource. Given the unique opportunity presented for Northern Ireland, the proposed project is more than a power/energy project; it is also an infrastructural asset for Europe, providing a blueprint for the expansion of CAES technology to other locations and having the potential to help transform the economy of Northern Ireland to become a more competitive business and investment location.

¹ UN Secretary General Ban Ki-moon delivering the Iveagh Lecture, Dublin, May 25th 2015
Concern about the impact of man’s activities on the environment is not new. However, what precisely these impacts are, and what their long term effects may be, has taken time to understand. We now know that the Earth’s climate is warming and at an accelerating pace. This is affecting people in real ways, including where we live, how we grow our food and get our water, our health and the diseases we are prone to and how we can make our living.

The United Nations through its Framework Convention on Climate Change has sought collaboration and agreement among nations on the causes and responses to global warming with a clear focus on limiting further increases in mean pre-industrial era temperatures to within 2°C by 2100. The UNFCCC has identified reductions in greenhouse gas emissions as the mechanism to achieve this. However, we are already at 0.8°C and are likely locked-in to an increase in temperature of 1.4°C from the emissions that have already taken place. The window we have to act and make a difference is closing rapidly.

The Earth Summit of 1992 held in Rio de Janeiro established the UNFCCC which was adopted in 1994. Further Conventions of the Parties established baseline greenhouse gas emission levels of 1990 and set targets to stop further growth in greenhouse gases by 2020 and reduce emissions by 60% by 2050. Nations have reconvened under the UNFCCC on a number of occasions since in attempts to secure agreement on GHG reduction targets with the next summit (COPs 21) scheduled for Paris in December 2015.

The scientific consensus is that with little or no action, global warming will exceed 2°C by 2100. Without concerted action to reduce greenhouse gas emissions we are more likely to be on-track for 4°C of global warming. Without controlling increases in global temperatures the risks of severe impacts also increases, including potentially catastrophic changes to the global environment with real consequences for communities across the globe.

These risks of abrupt or irreversible changes increase as the magnitude of the warming increases.
Climate action at a governmental level is variable. Across the developed world, there is general acknowledgement of the threat and the challenge. There are also ambitious targets for reductions in the emissions of greenhouse gases. The United Kingdom’s Climate Change Act 2008 seeks to achieve reductions in emissions of 80% by 2050.

The European Union in its Europe 20-20-20 climate change strategy seeks to achieve reductions in GHG emissions of 20%, 20% of power demand from renewables and 20% improvement in energy efficiency by 2020. These targets have been revised to 40-27-27 by 2030. Its 2050 target is to secure reductions in GHG emissions of 85% to 90%.

However, other responses are more lacklustre. There is a reluctance to sign up to binding obligations on targets and delays in taking decisive actions. While debate and analysis is important, the science of global warming and climate change is still being questioned.

There is equivocation on the policy requirements in planning and markets measures in the transition to greater penetration of renewable energy sources in our power systems. The international fossil fuel industry stands at a cross roads where one path leads to opposing change, defending past practices, and forestalling policy changes that support renewables. The other path requires re-assessing their role and contribution to energy markets and public good, working with communities, planning for and running down their sale of fossil fuels and embracing renewables with much greater urgency. Adopting the first path while laying claim to the second has far reaching consequences. Downward trends in the costs of wind and solar power also threaten the status quo.

Despite this, there are beacons that are guiding governments and businesses to a sustainable future. Actions being taken by leading companies and individual states are a testament to what can be achieved. Technology companies such as Apple, Google are not waiting to be compelled or regulated into action. They realise that climate change action makes business as well as climate and moral sense. It drives innovation, reduces costs and improves well-being and collaboration on something important.
Significant structural changes have been underway in energy markets over the last three decades. The traditional model comprised fully integrated, monopoly providers that built and owned energy infrastructure, generated power, and controlled the transmission and distribution of that power to customers. These organisations were the historic monoliths of the energy business. Some were also fully state-owned or at least with a significant sovereign state participation in their ownership.

Their approach to ensuring sufficient generation capacity was to build more, often carrying a significant surplus capacity over maximum system demand. Energy utilities operated a ‘cost plus’ approach to charging their customers for power. Consumers of electricity paid for the costs of supplying that power and the energy infrastructure that carried it, plus a rate of return on the energy companies’ capital invested. In many jurisdictions, competition did not exist. While pollution controls were often quite rigorous, broader environmental and climate considerations where minimal.

Energy markets in Europe have been reformed on a phased basis commencing in earnest during the 1990s. This process commenced with the breaking up of State-owned energy utilities into their separate operating units, then moving to the establishment of regulated transmission system and distribution operators and finally the opening of power markets to competition.

Over a similar period, the development of renewable energy sources has increased. The increased availability of wind power and its priority dispatch on power systems has disrupted energy markets and presented challenges to system management by transmission system operators (TSOs). Wholesale power markets are adapting with greater emphasis on flexibility within the generation set, the provision of systems services and the re-allocation of risk among participants in the power market.

However, markets need to adapt further to ensure consumer benefit.

### Consumer Benefits:

#### I-SEM
INTEGRATED SINGLE ELECTRICITY MARKET

#### DS3
Delivering a Secure, Sustainable, Electricity System

#### SOS
SECURITY OF SUPPLY

### Sum of the Parts

Consumer Benefits in new power systems is a ‘sum of the parts’ calculation. They are at their maximum when we optimise the relationship between the need for flexibility in the I-SEM, the integration of renewables (facilitated by the DS3 process) and Security of Supply as an island market with limited interconnectivity.

The current market changes within I-SEM, the DS3 process and to the system of supports for sources of renewable energy (RO) are the opportunity to re-address the allocation of risk away from consumers and towards market participants. However, in addition to a consensus among participants, this will also require the system tools that will provide the mechanisms to reallocate risks and the consequent benefits to consumers.
2050 is a date frequently associated with the energy transition and the diversification from fossil fuels to generation by sustainable means. This change could increase the penetration of variable renewable energy (VRE) through wind and solar power to levels above 60% (IEA, 2014) in areas such as the EU, with higher penetrations on a national or state basis across Europe, North America, the Middle East & Asia. 

EU sponsored studies such as stoRE (stoRE Project, 2015) and HyUnder (HyUnder Study, 2015) reflect the EU’s long terms strategy which envisages an 85% to 90% reduction in greenhouse gas emissions compared to 1990 CO2 emission levels by 2050. HyUnder has suggested that countries such as Germany, the UK and Romania will have a surplus of intermittent renewable generation of around 3%-9% for intermittent penetrations of 30%-42% by 2025. At 2050 the intermittent renewable penetration rises as high as 70% in Germany, coupled with substantially higher levels of surplus intermittent renewable energy rising from 6% to 30% in some countries.

Inflexible power systems such as Japan will struggle with intermittent renewable energy penetrations above 25% without enabling technology. Most systems begin to present challenges at penetration levels of 30 -40% variable generation. It is at this point that storage solutions find their market niche, integrating variable renewables by utilising excess renewable energy through storage and through the provision of ancillary services to grid system operators such as spinning reserve, fast acting frequency response and reserve capacity.

A range of system level energy storage options exist, differing in duration and scale as depicted by the Siemens Pictures of the Future website - Fig 1 below (Siemens, 2015).

**ENERGY STORAGE SYSTEMS BY DURATION AND POWER**

<table>
<thead>
<tr>
<th>Days / weeks</th>
<th>Hydrogen (e.g. for combustion in gas turbines)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours</td>
<td>Redox flow batteries</td>
</tr>
<tr>
<td></td>
<td>Lithium-ion batteries</td>
</tr>
<tr>
<td></td>
<td>Sodium-sulfur batteries</td>
</tr>
<tr>
<td>Minutes</td>
<td>Flywheel storage devices</td>
</tr>
<tr>
<td></td>
<td>Supercapacitors</td>
</tr>
<tr>
<td>Seconds</td>
<td>1 kW</td>
</tr>
<tr>
<td></td>
<td>10 kW</td>
</tr>
<tr>
<td></td>
<td>100 kW</td>
</tr>
<tr>
<td></td>
<td>1 MW</td>
</tr>
<tr>
<td></td>
<td>10 MW</td>
</tr>
<tr>
<td></td>
<td>100 MW</td>
</tr>
<tr>
<td></td>
<td>1.000 MW</td>
</tr>
</tbody>
</table>

**Technologies**

- Chemical storage systems
- Electrochemical storage systems
- Mechanical storage systems
- Electrical storage systems
  - * Compressed-air storage systems
  - ** Superconducting magnetic energy storage systems

FIG 1: SIEMENS ENERGY STORAGE DASHBOARD
Battery storage can be considered a ‘bottom-up’ energy storage solution focused primarily on providing system services solutions of fast frequency response and local distribution-level grid stability.

Coming from the other end of this spectrum, cavern or depleted gas field bulk Hydrogen storage may very well become a reality towards the latter end of the energy transition from fossil fuels to renewables in and around 2050 (Siemens, 2014). Such storage solutions will be required to achieve 60-80% variable renewable energy penetration by providing energy time shifting on a seasonal basis and security at a national transmission level. Bulk energy storage solutions are considered a ‘top-down’ storage offering.

CAES sits in the middle between the ‘bottom-up’ and ‘top-down’ offerings. It’s an existing technology which provides both robust system services and energy storage suitable for renewable energy integration at the midpoint of the transition from fossil fuels (i.e. at penetration levels of 30%-40% variable renewable energy). Penetration of renewable energy at these levels are just around the corner in a number of jurisdictions.

Compressed Air Energy Storage (CAES) is a particularly useful technology in geographical areas restricted by topographical, hydrological and environmental constraints limiting pump storage, or indeed markets which require very rapid deployment of a supporting infrastructure on a modular basis to meet system requirements as they arise.

Storage technologies present a spectrum of solutions in terms of power and duration, from Lithium Ion battery (minutes) through CAES and pumped hydro (hours/days) to Hydrogen (weeks/months).
Compressed Air Energy Storage (CAES) is an innovative large scale energy storage technology. A CAES facility stores excess energy from the grid by converting it to compressed air which is then stored in caverns created within salt layers deep underground from where it can be released through an electricity generator for later use by system operators. CAES is an established and well-proven technology with facilities in Germany and in Alabama, USA that have demonstrated high operational reliability for several decades.

The Larne CAES Project applies proven CAES technology in a novel and innovative way to the integration of renewable energy sources such as wind and solar.

The salt deposits in East Antrim have unique potential on the island of Ireland for development of storage caverns suitable for CAES. The high levels of renewable power generation within the Northern Ireland Energy market, in its own right and within the Single Electricity Market on the island of Ireland, combine to present a unique opportunity to show grid-level energy storage with CAES which will become a market leading example for the integration of renewable power.

Gaelectric will submit its planning application for the Project in Q3 2015 with a target to be ‘shovel ready’ by Q4 2016.

The Larne CAES Project is being developed in the context of the EU’s 20-20-20 plan, the Energy Framework 2030 and the Ireland-Northern Ireland common target of 40% of electricity demand to be met by renewable energy sources (RES) by 2020. The project will use storage caverns developed in deep salt deposits, which on the island of Ireland are unique to the East Antrim region. The CAES facility can provide several of the system services needed by the system operator (SONI-EirGrid) for continuous, secure operation of the power system with increasing levels of renewable energy.

Energy prices in Ireland and Northern Ireland are amongst the highest in the EU, which threatens competitiveness and inward investment. The Larne CAES Project provides a technically feasible and economic means to integrate more renewable energy on the island-wide transmission grid and enhance the effective management of the power system to address imbalances between supply and demand. This will result in lower system-wide electricity production costs leading in turn to reduced electricity costs and prices for businesses and households.

“Such an energy storage facility could potentially act as an ancillary services and balancing facility for renewable generation... This technology could be applied to store surplus renewable energy, whilst also enabling variability balancing on the transmission system.”

SONI-EirGrid, All-Island Generation Capacity Statement 2014-2023

### HOW CAES WORKS

<table>
<thead>
<tr>
<th>FRESH AIR</th>
<th>RENEWABLE POWER &amp; EXCESS POWER</th>
<th>COMPRESSOR</th>
<th>STORAGE CAVERN CREATED IN GEOGRAPHICAL SALT DEPOSIT</th>
<th>GENERATION</th>
</tr>
</thead>
</table>

CRITICAL THINKING AT THE CRITICAL TIME
In addition, Northern Ireland is at risk of generation deficits from 2016 as existing plants are retired in compliance with the Industrial Emissions Directive. This has security of supply implications for the all-Island system. The Larne CAES Project will substantially enhance security of supply in Northern Ireland and within the all-island Single Electricity Market.

**Project of Common Interest**

The Larne CAES Project has been included in the EU list of Projects of Common Interest (PCI) under the European Regulation supporting the development of trans-boundary energy infrastructure. It will be the first CAES facility in the world to be optimised for the integration of high levels of intermittent renewable energy. It is the only CAES project in Europe with PCI designation and the only electricity storage PCI on the island of Ireland that aims to integrate, rather than export, renewable energy.

The European Commission has established a policy framework to create a European Energy Union by 2030. This proposes that Europe should use energy more wisely. A framework for Energy and Climate is proposed and an initial project pipeline including Projects of Common Interest (PCI) is being established.

Using energy more wisely is the central objective of energy storage; energy storage enhances the sustainable, competitive and affordable use of energy. The Larne CAES Project provides such an opportunity.

The Larne CAES Project has significant innovation value and will demonstrate the role of future CAES projects in Europe in providing system tools and facilitating the integration of renewable energy sources. The Project will support the goals of Northern Ireland’s Economic Strategy particularly in the areas of innovation and sustainability.

**The Larne CAES Project**:

- Innovative application of a proven storage technology
- Affordable and climate friendly
- Safe and efficient
- Supports the Northern Ireland Economic Strategy
- Generating jobs and economic activity

“As Northern Ireland is dependent on a small number of large generating units, the difference between being in or out of standard is finely balanced... an unexpected prolonged outage could place the system under stress and substantially increase the risk to security of supply.”

SONI-EirGrid, All-Island Generation Capacity Statement 2014-2023

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Methodological Approach - Relevant Impacts

PMCA Economic Consulting has carried out an independent economic impact assessment of the likely economic and socio-economic benefits that the implementation of a future CAES Project in the Larne area are likely to have. A wide-ranging economic impact assessment has been conducted, comprising the Project’s macroeconomic impacts, system-wide impacts and its social impacts. The approach to estimating the macroeconomic impacts is illustrated in FIGURE 1.

**FIGURE 1: APPROACH TO ESTIMATING THE MACROECONOMIC IMPACTS OF THE PROPOSED CAES FACILITY**

In each of the construction and operational phases, the macroeconomic impacts comprise the following four variables, which are briefly explained:

- **Economic activity** – this refers to the value of output arising from the new investment and new economic activity, and is captured through the capital expenditure in the construction phase (capex) and the operations and maintenance expenditure (opex) during the operational phase;
- **Gross value added (GVA)** – this is the additional value of output beyond the spending associated with the economic activity variable and the estimate of GVA in the construction and operational phases is derived from the economic activity variable plus independent relevant data on GVA relating to relevant sectors of the Northern Ireland economy;
- **Employment** – new employment would be created in both the construction and operational phases; and
- **Exchequer contribution** – owing to the additional economic activity resulting from the Project, extra revenue would be generated for Northern Ireland, which in turn would be available for public investment in productive and/or social infrastructure, like roads, broadband, schools, sports and leisure facilities etc.
Associated with each of the macroeconomic variables would be knock-on economic impacts as well as direct economic impacts. For example, in regard to the economic activity variable, the construction phase would entail capital expenditure of £250m, from which 30% would be incurred in the Northern Ireland economy (the other 70% would be necessarily allocated to sourcing specialist plant and machinery from abroad), meaning that the direct capex in the Northern Ireland economy would be £75m. This spend would in turn trigger additional economic impacts in the local economy, through local businesses in the construction supply chain benefiting through the investment and also higher spending by households through more employment and income power as a result of the construction phase.

To estimate these knock-on impacts, PMCA Economic Consulting has employed Type II economic impact multipliers, which are capable of capturing both the intermediate supply chain knock-on impacts (generally termed indirect effects) and the household spending knock-on impacts (induced effects) from new investments like the Larne CAES Project under consideration. Type II multipliers for output, GVA, employment and income are applied in estimating the knock-on economic effects in both the construction and the operational phases of the proposed project.

The macroeconomic impacts of the proposed project are likely to be even wider than those implied by the estimated economic activity, GVA, employment and exchequer contribution impacts. For example, as the only Project of Common Interest (PCI) of its kind in Europe, it is considered that the positive signal regarding the Northern Ireland economy emitted by the Larne CAES Project would be considerable; not least in regard to foreign direct investment (FDI). At the present time, FDI into advanced host countries like Northern Ireland, Ireland, Scotland, Wales and the English regions is becoming more services-driven (e.g. internationally-traded services and IT/tech-oriented enterprises). These FDI companies are increasingly espousing the benefits of sourcing their energy requirements from renewable sources and so host locations with significant renewable infrastructure may be seen as gaining a competitive advantage in respect of attracting FDI in the coming years, other things being equal.

The proposed CAES facility may be viewed as potentially very significant in this regard – it would act as a major differentiator for Northern Ireland relative to other host locations with which it is, and will be, competing for inward investment. Accordingly, the CAES facility would be a wider infrastructural and economic asset for the region, helping Northern Ireland to broaden its economic base and ensure greater private sector employment, in line with the 2012 Economic Strategy for Northern Ireland.

In addition to the macroeconomic impacts, the proposed project would also give rise to system-wide economic impacts, where the ‘system’ is the Single Electricity Market (SEM) on the island of Ireland, which has been in operation since 2007 and regarded as one of the principal dividends of the Peace Process.

The system-wide economic impacts due to CAES would include the following:
- System production cost savings;
- Enhanced security of electricity supply; and
- Reduction in carbon dioxide (CO2) emissions.

The system production cost savings would arise from the greater flexibility that the CAES facility would bring to the SEM, by capturing and storing clean electricity when the wind is blowing and demand is low (off-peak) and re-releasing it when needed (on-peak). The CAES installation would act to make the SEM more efficient, and the system production cost savings capture the differential impact that the new facility would have in respect of: (a) reduction in the cost of generating electricity; (b) lower interconnection costs; (c) reduced volatility of system prices (by increasing off-peak prices and decreasing on-peak prices) and (d) lower unused energy.

Turning to the potential for the proposed CAES plant to enhance security of supply, it is relevant to note that security of electricity supply is a significant issue in Northern Ireland. The transmission system operators within the SEM have highlighted this issue and have warned of the risks to security of supply arising from prolonged power outages in Northern Ireland. The proposed project would serve to address this concern by enabling additional capacity value (through creating more room on the grid for electricity from onshore wind).

As a new source of clean electricity, the proposed project would also serve to moderate CO2 emissions, a benefit also incorporated into the economic impact assessment through reduction in the social cost of carbon (SCC).
The three sources of system-wide economic impacts which can be attributed to the proposed CAES facility have been quantified and monetised by PMCA, with the assistance of specialist engineering software capturing the SEM and independent market data for the coming years.

In addition to the aforementioned macroeconomic and system-wide economic impacts, CAES would also give rise to a wide range of social impacts: for instance, the employment impacts from the Project would contribute towards lowering deprivation, making for a more cohesive local community and greater opportunities for people over the lifetime of the project, and beyond. Furthermore, Gaelectric is proposing to provide a Community Gain Fund, which would be available to fund social infrastructure in the local community from commencement of the proposed project. This initiative would be administered and run independently of the project promoter.
**MACROECONOMIC IMPACTS**

**CONSTRUCTION PHASE**

The estimated macroeconomic impacts during the construction phase are shown in TABLE 1 below. The estimates show the direct impacts, to which the indirect and induced impacts are added (using Type II economic impact multipliers), leading to the total impacts presented in the last column of the table.

### TABLE 1: MACROECONOMIC IMPACT ESTIMATES OF THE CONSTRUCTION PHASE OF THE PROPOSED CAES FACILITY

<table>
<thead>
<tr>
<th>Macroeconomic Impact Variable</th>
<th>Direct*</th>
<th>Indirect and Induced**</th>
<th>Total: Direct, Indirect and Induced**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic Activity (£m)</td>
<td>75.00</td>
<td>85.83</td>
<td>160.83</td>
</tr>
<tr>
<td>Gross Value Added (GVA) (£m)</td>
<td>22.59</td>
<td>22.92</td>
<td>45.51</td>
</tr>
<tr>
<td>Employment (FTEs)</td>
<td>200</td>
<td>332</td>
<td>532</td>
</tr>
<tr>
<td>Exchequer Contribution (£m)</td>
<td>4.36</td>
<td>3.85</td>
<td>8.21</td>
</tr>
</tbody>
</table>

Source: * Gaelectric; ** PMCA Economic Consulting analysis.

Additional sources used to inform the PMCA analysis:

During the construction phase, the Larne CAES Project would:

- Boost economic activity in Northern Ireland by £161m, comprising £75m in direct spending and a further £86m in indirect and induced effects through supply-chain and household spending effects;
- Result in additional GVA to the local economy of £46m, made up of £23m in direct GVA that the new facility would bring and the same amount again in knock-on GVA through indirect and induced effects in other sectors of the Northern Ireland economy;
- Lead to new employment of 532 full-time equivalent (FTE) jobs, made up of 200 FTEs directly attributable to the project and a further 332 FTEs created or sustained in other sectors through indirect and induced effects; and
- Yield extra revenue to the Northern Ireland Exchequer of £8.2m (from the income tax, national insurance and VAT contributions during the construction phase).

While the construction phase would be relatively short in duration, the estimated macroeconomic impacts nevertheless portray a significant new investment for Northern Ireland, and the potential employment impact of 532 FTEs is substantial when set in the context of the 2,077 unemployment claimants in the new Mid & East Antrim Local Government District (LGD) in January 2015 (the new LGDs came into effect from 1 April 2015 and there were 1,401 claimants in the former Ballymena LGD and 676 claimants in the former Larne LGD).
In each year during the operational phase, the CAES project would give rise to:

- Economic activity boost of £13m, composed of £7m in direct expenditure and an additional £6m in indirect and induced effects.
- Further GVA to the Northern Ireland economy of almost £3m, comprising in the region of £1.5m each in direct and knock-on GVA as a result of the activities at the proposed CAES facility.
- Job creation of 43 FTEs, made up of 15 FTEs at work within the new facility and a further 28 FTEs in other sectors through indirect and induced effects of the proposed project.
- Exchequer contribution of almost £3m (including local authority rates as well as income tax, national insurance and VAT contributions during the construction phase).

In regard to the employment impact during the operational phase, the 15 direct FTEs at the CAES facility would constitute high value employment, bringing new skills and added value to the region.

### System-Wide Economic Impacts (Operational Phase)

A summary of the system-wide economic impacts is presented in TABLE 3.

The results of the analysis show that the system production cost savings from the Larne CAES Project to the SEM would range between around £32m and about £52m per annum, depending on the rate of progress regarding the adoption of renewable energies on the island of Ireland (the lower estimate pertains to a “Slow Progress” scenario and the higher estimate of cost savings due to CAES arises from the “Green Transition” scenario).

The enhancement to security of electricity supply attributable to CAES (through facilitating greater capacity value to the system) is estimated at almost £5m per year and it is calculated that the new facility would be capable of abating 64,000 tonnes of carbon dioxide per year, or the equivalent of a £2.3m reduction in the SCC per annum (using estimates of the SCC per tonne of CO2 from the US Environmental Protection Agency).

### TABLE 2: MACROECONOMIC IMPACT ESTIMATES OF THE OPERATIONAL PHASE OF THE PROPOSED CAES FACILITY (PER YEAR)

<table>
<thead>
<tr>
<th>Macroeconomic Impact Variable</th>
<th>Direct*</th>
<th>Indirect and Induced**</th>
<th>Total: Direct, Indirect and Induced**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic Activity (£m)</td>
<td>7.24</td>
<td>5.63</td>
<td>12.87</td>
</tr>
<tr>
<td>Gross Value Added (GVA) (£m)</td>
<td>1.30</td>
<td>1.35</td>
<td>2.64</td>
</tr>
<tr>
<td>Employment (FTEs)</td>
<td>15</td>
<td>28</td>
<td>43</td>
</tr>
<tr>
<td>Exchequer Contribution (£m)</td>
<td>1.25</td>
<td>1.65</td>
<td>2.90</td>
</tr>
</tbody>
</table>

Source: * Gaelectric; ** PMCA Economic Consulting analysis.

### TABLE 3: SUMMARY OF SYSTEM-WIDE ECONOMIC IMPACTS DURING THE OPERATIONAL PHASE OF THE PROPOSED CAES FACILITY

<table>
<thead>
<tr>
<th>System-Wide Economic Impacts</th>
<th>Estimate (Per Year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>System Production Cost Savings</td>
<td>£32.33m</td>
</tr>
<tr>
<td>&quot;Slow Progress&quot; Scenario</td>
<td>£52.86m</td>
</tr>
<tr>
<td>&quot;Green Transition&quot; Scenario</td>
<td>£4.96m</td>
</tr>
<tr>
<td>Enhanced Security of Supply</td>
<td></td>
</tr>
<tr>
<td>Reduced Carbon Dioxide Emissions</td>
<td>64,000 tonnes</td>
</tr>
</tbody>
</table>

Source: Gaelectric; PMCA Economic Consulting analysis.
AGGREGATED ECONOMIC IMPACTS DURING THE LIFETIME OF THE PROPOSED PROJECT

The system-wide economic impacts shown in TABLE 3 above pertain to each year of the operational phase of the proposed CAES project. The next exhibit (FIGURE 2) brings together both the system-wide and the macroeconomic impacts during the whole project period to give a sense of the significance of the new facility from an economic perspective. The figures in blue at the top of the exhibit summarise the total monetary impacts and the reader’s attention is drawn specifically to the monetary impact scenario in which the estimates are expressed in real values (to account for the effects of anticipated future inflation, using independent data on the UK GDP deflator) and discounted to the commencement of the Project (discounting controls for the opportunity cost of funds and a discount rate of 3% per annum has been applied).

The analysis reveals that, over the lifetime of the project (both construction and operational phases):

- There will be a boost to economic activity and GVA in Northern Ireland of £316m and £77m respectively;
- The Project will contribute almost £45m to the Exchequer;
- The Project has the potential to reduce the cost of producing electricity on the island of Ireland by up to nearly £670m, which would in turn assist in improving competitiveness through lower electricity prices and costs to consumers and businesses;
- The CAES facility has the scope to enhance security of electricity supply equivalent to £63m; and
- It would also serve to reduce the social cost of carbon by £28m over its lifetime.

Given that GVA is derived from economic activity, by adding together the (1) GVA, (2) Exchequer contribution, (3) system-wide production cost savings, (4) enhanced security of supply and (5) the reduced social cost of carbon impacts (i.e. omitting the economic activity impact to avoid the risk of double-counting and overestimating the overall monetary economic impact), we arrive at the following estimate of the overall monetary economic gain (real and discounted) from the proposed CAES project, namely:

£880m monetised economic gain during the lifetime of the project.

But even this significant estimate is not the complete picture of economic impact. Also shown in FIGURE 2 are the employment impacts (green), estimated at 575 in total during both the construction and the operational phases, and (in purple) the positive signal that the CAES facility would send out regarding Northern Ireland as an investment location cannot, in our view, be overstated. It is considered that the proposed project would be a major infrastructural asset for Northern Ireland, with the scope to enhance the region’s attractiveness for inward investment/FDI companies, which would in turn serve to diversify and broaden the economic base of Northern Ireland, in line with the goals of the 2012 Northern Ireland Economic Strategy.

FIGURE 2: SUMMARY OF THE AGGREGATED ECONOMIC IMPACTS DURING THE CONSTRUCTION AND OPERATIONAL PHASES OF THE PROPOSED CAES FACILITY

<table>
<thead>
<tr>
<th>Scenario-Monetary Impacts</th>
<th>Construction and Operational Phases</th>
<th>System Production Cost Savings (£m)</th>
<th>Enhanced Security of Supply (£m)</th>
<th>Reduction in the Social Cost of Carbon (£m)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Boost to Economic Activity (£m)</td>
<td>Additional Gross Value Added (GVA) (£m)</td>
<td>Extra Exchequer Contribution (£m)</td>
<td>“Slow Progress” Scenario</td>
</tr>
<tr>
<td>Nominal and Undiscounted</td>
<td>482.58</td>
<td>111.57</td>
<td>80.70</td>
<td>808.31</td>
</tr>
<tr>
<td>Real and Undiscounted</td>
<td>398.12</td>
<td>93.98</td>
<td>62.24</td>
<td>604.36</td>
</tr>
<tr>
<td>Real and Discounted</td>
<td>315.79</td>
<td>76.72</td>
<td>44.47</td>
<td>408.78</td>
</tr>
</tbody>
</table>

Source: Gaelectric; PMCA Economic Consulting analysis.
SOCIAL IMPACTS OF THE PROPOSED PROJECT

Adding the likely social impacts to the preceding set of analysis gives the aggregated economic and social impacts of the proposed CAES facility in FIGURE 3. The social impacts at the bottom of the exhibit are wide-ranging, stemming from the substantial economic impacts, and include tackling socio-economic deprivation, helping to build a more cohesive community and society (through greater economic and employment opportunities and giving young people a greater incentive to do well at school) and contributing to cross-community relations. The social impacts also illustrate the Community Gain Fund, which Gaelectric would provide for social infrastructure in the local community on commencement of the Project (the fund would be administered independently of the project promoter).

FIGURE 3: SUMMARY OF THE AGGREGATED ECONOMIC AND SOCIAL IMPACTS DURING THE CONSTRUCTION AND OPERATIONAL PHASES OF THE PROPOSED CAES FACILITY

<table>
<thead>
<tr>
<th>Scenarios-Monetary Impacts</th>
<th>Construction and Operational Phases</th>
<th>System Production Cost Savings (£m)</th>
<th>Enhanced Security of Supply (£m)</th>
<th>Reduction in the Social Cost of Carbon (£m)</th>
</tr>
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</tr>
</tbody>
</table>

Overall Monetary Economic Gain (£m)

Employment Impacts

- 532 FTEs during construction phase, comprising 200 direct FTEs and an additional 332 FTEs from indirect and induced effects
- 43 FTEs per annum during operational phase, composed of 15 direct FTEs and a further 28 FTEs from indirect and induced effects per year

Other Economic Impacts

Positive signal for NI, enhancing prospects for more inward investment (FDI)

In line with the 2012 Economic Strategy for Northern Ireland - diversifying and broadening economic base

Social Impacts

Tackling socio-economic deprivation, including unemployment and income deprivation

Cleaner and more sustainable environment

More cohesive community and society

Galvanising the Peace Process

Lower cost of electricity

Tackling fuel poverty

Community Gain Fund available for various good causes, including local community building

Source: Gaelectric; PMCA Economic Consulting analysis.
OVERALL SUMMARY OF SOCIO-ECONOMIC IMPACTS

The Larne CAES Project is estimated to have significant beneficial socio-economic impacts during both its construction phase and its operational phase.

The analyses of the economic and social impacts reveal that the proposed new facility for Northern Ireland would deliver the following estimated benefits:

- 575 full-time equivalent jobs during the lifetime of the Project, comprising 532 FTEs during the construction phase and 43 per year during the operational phase;
- The 532 FTEs in the construction phase would be made up of 200 FTEs directly attributed to the Project and a further 332 FTEs from the knock-on effects of the direct employment yielded by the new facility;
- Similarly, the 43 FTEs per annum during the operation phase would consist of 15 direct FTEs at the new facility and an additional 28 FTEs created or sustained in other economic sectors through the Project’s indirect and induced effects;
- Bringing together the estimates of the various monetary impacts of the Project, which include additional gross value added (GVA), extra Exchequer contribution, system-wide electricity production cost savings, enhanced security of electricity supply and reduction in the social cost of carbon, the overall monetary gain would be £880m during the Project’s lifetime.

Further socio-economic impacts would include:

- The positive signal regarding inward investment into Northern Ireland that the Larne CAES Project would emit by virtue of the fact that it would be a major infrastructural asset for the region;
- FDI companies are now emphasising the importance of renewable energies in their activities and the differential impact of the Larne CAES Project would confer a competitive advantage for Northern Ireland in regard to becoming more attractive, and competitive, in the eyes of potential inward investors;
- The direct and knock-on employment and economic activity impacts from the Project would serve to diversify and broaden the economic base of Northern Ireland, in line with the aims and objectives of the Northern Ireland Economic Strategy (2012);
- Skills – enhanced skills acquisition and technical know-how as a result of the CAES facility;
- Social impacts – including tackling deprivation, contributing to cross-community relations and the Community Gain Fund, which would be available for social infrastructure in the local community and administered independently of the Project promoter.

Finally, given the significance of the proposed project, and Northern Ireland’s comparative advantages in renewable energies, it is considered that there is a unique opportunity to harness the private sector interests in such technologies and work towards promoting Northern Ireland as an international centre of excellence in renewable energy technologies, with consequent multiple long-term socio-economic benefits.
Founded in 2004 with a vision to harness the Power from Nature, Gaelectric has become a leading independent renewable energy group and one of the largest wind energy developers on the island of Ireland. Gaelectric is also a developer of energy storage projects in Northern Ireland and Great Britain, and on the European mainland.

Gaelectric is the European leader in CAES development and its Larne CAES Project is the only one under commercial development in Europe. It will act as a blueprint for globalising a modular CAES system for renewables integration. The Project utilises the unique geological salt deposits located on the island of Ireland on the east Antrim coast. This project is Europe’s only CAES facility designated by the European Commission as a Project of Common Interest (PCI) under EU Regulations to support trans-boundary energy infrastructure.\(^1\)

\(^1\) Weblink - https://ec.europa.eu/energy/en/topics/infrastructure/projects-common-interest
8. ABOUT FTI CONSULTING

ABOUT FTI CONSULTING

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With the global expertise of leading professionals, combined with our sector knowledge we are committed to protecting and enhancing the enterprise value of our clients. We organise and implement results-focused, research-driven programmes and campaigns that support your business objectives.

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Managing and mitigating political risk is an essential component of corporate governance and strategic business planning.

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Present in all key policy and regulatory capitals, our public affairs teams are composed of former regulators, policymakers, lawyers, politicians, journalists and industry experts. They work hand-in-hand to deliver tailored multi-jurisdictional government and regulatory engagement strategies and help clients navigate the policy environment.

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Working jointly with our in-house economic consultants, financial communications experts, sector specialists, risk experts, tax advisers and competition economists FTI Consulting’s public affairs team offers a unique suit of services to enhance and protect reputations.
CRITICAL THINKING AT THE CRITICAL TIME

Mark Kenny has three decades of experience in financial and capital market communications, public affairs and governance advisory work for many of Ireland’s leading public and private companies, together with a range of listed and large private companies in the UK, Europe and the United States. Prior to founding K Capital Source, Mark was executive vice president with Jefferson Smurfit Group (JSG), now Smurfit Kappa Group. Mark worked with investment bank NCB prior to joining JSG in 1995.

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Dr. Pat McCloaghan is a leading commentator on economic trends and regulation, economic strategy and public policy, competition, corporate communications and special situations. Dr. McCloaghan advises clients on multimarket regulatory issues. He is a founding member of the Global Competition Lawyers and Economists published jointly by Who’s Who Legal and Global Competition Review. He is a named authority on translating regulatory issues into politically palatable campaigns, crisis management and building campaigns that stretch from the local to the international. He studied Politics at Edinburgh University.

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Jonathan has over 15 years’ experience in financial and capital market communications, public affairs and governance advisory work. Jonathan works with a range of major international public and private companies on capital market communications, public affairs and corporate governance including Aer Lingus, Avolon, C&C Group, Shire and Perrigo. Prior to founding K Capital Source in 2002, Jonathan was previously Investor Relations Manager for Jefferson Smurfit Group (JSG). He worked with the JSG investor relations and financial communications programme since its inception in 1992. Jonathan has a Primary Degree in Business Studies from DCU and Master’s Degree in Business Studies from University College Dublin.

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Energy Storage: the missing link
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ENERGY STORAGE: THE MISSING LINK
AN FTI CONSULTING DISCUSSION PAPER

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FTI Consulting is a global business advisory firm dedicated to helping organizations protect and enhance enterprise value in an increasingly complex legal, regulatory and economic environment. FTI Consulting professionals, who are located in all major business centers throughout the world, work closely with clients to anticipate, illuminate and overcome complex business challenges in areas such as investigations, litigation, mergers and acquisitions, regulatory issues, reputation management and restructuring.

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