Facilitating energy storage
to allow high penetration of variable
Renewable Energy

stoRE
www.store-project.eu

Energy Storage Action List

Promoting Energy Storage in Ireland

Co-funded by the Intelligent Energy Europe
Programme of the European Union

The work for this report has been coordinated by University College Cork.

Authors	Organisation	Email
Annicka Wänn	UCC	annicka.wann@gmail.com
Paul Leahy	UCC	paul.leahy@ucc.ie

Table of Contents

Introduction

The power system on the island of Ireland is already operating with one of the highest percentages of RES anywhere in the world. This level of renewable power plant penetration is unprecedented and poses significant challenges to the real time operation of the power system. The two TSOs, EirGrid and SONI, have carried out comprehensive pioneering studies, to better understand the changing behaviour of the power system with increasing numbers of renewable power plants. These studies, which are reported in the Facilitation of Renewables (FoR) studies and the follow up "Ensuring a Secure, Sustainable Power System", indicate that efficient management of the power system with large volumes of renewable plant power plants is possible.

One solution is that of bulk energy storage technologies (EST), such as pumped hydro energy storage (PHES) and compressed air energy storage (CAES). These technologies are once again gaining a lot of traction in Europe. In Ireland, the discussion of energy storage as a means to facilitate variable renewable energy is slowly coming to the foreground. However, there are several barriers to the further development of these technologies, both within the regulatory and market framework and the environmental framework.

This report investigates the barriers within the Irish regulatory and market framework to furthering the development of bulk energy storage technologies (EST). It is structured into two main sections; the first section is on the current status of the regulatory and market framework; the second will discuss the barriers to further sustainable energy storage and potential strategies to overcome these.

The information and discussions presented in this report are part of the European project stoRE[1], which aims to facilitate the realisation of the ambitious objectives for high penetration of variable renewable energies in the European grid by 2020 and beyond. This report is part of a European wide analysis taking place in the following countries: Austria, Denmark, Germany, Greece, Ireland and Spain.

Stakeholder Consultation

The information discussed in the section on barriers to further development of bulk EST is based on an extensive stakeholder process, which included questionnaires and structured interviews with Irish stakeholders. The consultation process finished with a workshop held in October 2013, where the potential strategies/actions to overcome the barriers were thoroughly discussed.

[1] For further information and published reports please see www.store-project.eu

Current status of the electricity market

The single electricity market

The SEM (single electricity market), the wholesale electricity market, was established in 2004 between Ireland and Northern Ireland. It is a Gross Mandatory Pool (GMP) physical market operating with dual currencies and in multiple jurisdictions. Participation in the pool is mandatory for all licensed generators and suppliers, with the exception of generators with a maximum export capacity of below the de-minimis threshold of 10MW, for whom participation is voluntary. Due to this almost all electricity is sold into and purchased from the GMP. Under the pool arrangements, all generators and suppliers receive and pay the same price for electricity sold into and purchased from the pool. The Single Electricity Market Operator (SEMO) facilitates the continuous operation and administration of the SEM.

The Commission for Energy Regulation (CER) and Northern Ireland Authority for Utility Regulation (NIAUR) define the Trading and Settlement Code (TSC) as the trading and settlement rules and procedures for participation in the SEM. The latest TSC was published on the 15th of November 2013[2]. The implementation and operation of the TSC is carried out by SEMO. EirGrid and SONI issue Grid Codes, the codes by which the generation of electricity is regulated on a near real time basis. The grid codes ensure the safety and power quality of the system and provide for ancillary services.

Since 2012, the SEM Committee has been working on how best to implement the European Electricity Target Model in the SEM. The deadline for the implementation is 2016. ***As part of the ongoing work, the following progress has been made so far: the SEM Committee issued a proposal (SEM-12-004) in January 2012, a stakeholder information session was held and a draft decision letter was published in November 2012; and almost 20 responses were submitted from stakeholders.***

[2] http://www.sem-o.com/MarketDevelopment/Pages/MarketRules.aspx

Energy Storage in the SEM

For the purposes of the market each pump/turbine within a PHES plant is treated separately, referred to as a Pumped Storage Unit. Within the market each Pumped Storage Unit is settled as a Generator Unit irrespective of whether its net output in any Trading Period is positive or negative. Additionally, each Pumped Storage Unit must be classified as a Predictable Price Maker Generator Unit.

The scheduling of Pumped Storage Units is performed by the MSP Software (Market Scheduling and Pricing Software) with the aim of minimising the total MSP Production Cost over all scheduled generator units across a given optimisation time horizon. *Note that the objective function is not to maximise profit for PHES or any plant.* The operators of a PHES site do not have control over the scheduling of the PHES units once they are declared as available. The unit is scheduled on the basis of least cost for the overall system to meet demand during each trading period. Therefore, the PHES operator has little control over the times and thus prices at which energy is bought and sold which will directly affect overall profits.

Revenue Streams for PHES

The only existing PHES operating in the SEM, Turlough Hill, has three main sources of revenue: Energy payments, Capacity Payments and Payments for Ancillary Services. Other payments are "uninstructed imbalances"[3] and "make-whole payments"[4]. Furthermore, PHES **do not** pay or receive constraint payments.

Energy Payments

PHES units submit PQ pairs equal to zero; are scheduled to minimise total daily system production costs; receive SMP for energy exported to grid; pay SMP for energy imported from the grid.

Capacity Payments

All generators must recover both their short-run costs (e.g. fuel, staffing, maintenance, etc) and long-run costs (e.g. capital expenditure, etc) through the price of energy. Therefore, peaking generation would only cover its short-run and long-run costs if energy prices were sufficiently high during those short periods (i.e. winter peak, etc.) when it runs to cover both categories of cost. It is considered that this would require spikes in energy prices, as all in-merit generators would receive payments at these energy prices. Capacity Payments consequently form an important part of the SEM and possible revenue streams for EST.

[3] Payments or charges due as a result of deviation from the TSOs dispatch instructions by generators

[4] Compensate the generator if energy payments over a Billing Period (one week) are less than their Production Costs (taken to be zero in the case of PHES)

The SEM CPM pays for generation availability throughout the year, thus providing for a stable revenue stream for all generators. The CPM pays out a fixed pot of money *("the total pot")* to be shared amongst all generation. The total pot is tailored to ensure that it would pay a Best New Entrant (BNE) peaker generator at a sufficient rate to cover its long-run costs, given forward looking estimates of its running costs and all its other revenues. The rate at which the BNE peaker is paid per installed kW is multiplied by an amount of generation capacity to maintain security of supply to normal standards. The resulting sum of money becomes the CPM total pot.

The fixed pot is divided year-ahead into 12 monthly pots weighted against forecast maximum demand.. Within each month, availability is priced under three "streams": (i) The fixed stream (30% of the total pot) values the required availability calculated prior to the start of the year; (ii)The variable stream (40% of the total pot) values the required availability more during periods of low margin than high margin; (iii) the ex-post stream (the remaining 30% of the total pot) values each trading periods' availability based on the system conditions present at any given time. The ex-post stream comes closest to reflecting the volatility in energy prices that would be seen in an energy only market. The fixed stream and the variable stream provide more stable revenues to generators.

In March 2012, the SEM Committee published the final decision paper on the CPM Medium Term Review (SEM-12-016). The decisions made are described in full in the decision paper[5]. A summary of the highlights are given below:

- Previously, the Forced Outage Probability ("**FOP**") was defined as 4.23%. The revised targeted FOP was set at 5.91%.
- The SEMC decided that Infra Marginal Rent ("**IMR**") should be deducted from the BNE through the following calculation:

  IMR DEDUCTED IN €/KW = [PCAP-BID]/100 * OUTAGE TIME * (1-FOP)
- The BNE will remain constant for three years. The BNE has been set for 2013 and will remain constant till 2015 (taking inflation of 2% into account).
- The expected revenue the BNE is expected to earn from Ancillary Services will continue to be deducted from the annualised cost of the BNE.

It is still unclear whether or not the CPM will exist in the new market due to be implemented in 2016. However, the ongoing discussions between TSOs and Industry seem to indicate a favouring of keeping the CPM.

[5] http://www.allislandproject.org/en/cp_decision_documents.aspx?page=1&article=5ce2db5f-6c79-4454-9779-53dd7fae8dba

Ancillary services

Currently three ancillary services are paid for from a pot of roughly €60m: Black start, reactive power and operating reserve. These services are separate from the SEM and are contracted via bilateral agreements with the TSOs directly. The services are currently under review as part of the DS3 programme. In addition to the existing services Eirgrid are recommending new services: Synchronous Inertial Response, Fast Frequency Response, Ramping (1, 3 and 8 hour), Fast Post Fault Active Power Recovery and Dynamic Reactive Response.

Although the Single Electricity Market Committee (SEMC) agree with the new services being added, they have expressed reservations in regard to the proposed economic rational and commercial arrangement recommended by the TSOs. The TSOs and the RA's Consultant Poyry expect to have completed the additional economic analysis early 2014, and hope to be moving towards a decision on economic aspects of System Services in Q1 2014 (dependent on final modelling).

Barriers to further development of bulk EST

This section discusses the six main barriers deemed to be the most important to further development of bulk energy storage technologies in Ireland. It also lists a number of possible solutions in the form of "actions" and the organisations that should tackle each specific issue. The actions are a result of the discussions and suggestions made during the stoRE consultation process. The six main barriers are:

1. A lack of definitive storage needs
2. Lack of investment motivations and incentives
3. Strong interdependence between energy storage and system development
4. Double or uncertain grid access fees
5. Competition with other technologies for grid flexibility
6. Siting and planning constraints

1. A lack of definitive storage needs

The Concern:

The key question for Ireland to answer, is **if and at what level grid-scale energy storage is needed**. Definitive determination of this need in the Irish electricity system is a great challenge but is necessary for any further steps. The report published by stoRE "Recommendations for furthering the sustainable development of bulk Energy Storage Facilities"[6] states that without a clear indication of storage needs, relevant policy cannot be prepared, which creates a void in the planning system resulting in an inefficient developer led project development process.

Energy storage need estimates vary depending on the particular grid and future electricity plans. The island of Ireland's power system is already operating with one of the highest percentages of RES anywhere in the world. The study published by stoRE on "The Needs

[6] http://www.store-project.eu/documents/results/en_GB/recommendations-for-furthering-the-sustainable-development-of-bulk-energy-storage-facilities

for Energy Storage in Ireland" [7] shows clear benefits for additional energy storage capacity by 2020, including increased overall RES-E share and a reduction in curtailment of wind energy.

Storage power and storage capacity are the two main parameters that need to be determined in order to conclude to what extent energy storage can contribute in addressing the needs of the Irish grid system, including high RES integration. Their optimum values may be partially independent, ranging from high power – short term storage to lower power – long term storage.

Possible Solutions:

Actions	By whom
Further investigation of initial energy storage needs for Ireland.	DCENR
National requirements should be assessed and run in parallel with renewable energy targets, with further detail to establish a more accurate need for energy storage.	EU stoRE (project partner UCC)and SEAI
Investigate Ireland as part of a bigger region (with the UK) →Perhaps it is better to see Scotland as the right place for storage and Ireland for wind resources.	European Commission

2. Lack of investment motivations and incentives

The Concern:

The uncertainties surrounding energy storage regulation do not provide any motivation for future investments. Most renewable portfolio standards or government investment or production incentives are written for renewable generation only and exclude energy storage.

Moreover, no incentives are given to energy storage in recognition of its important contribution to enable higher penetration of variable RES production in the grid. In contrast, such incentives are for the same reason provided to both RES power plants and transmission infrastructure (e.g. feed-in-tariffs, subsidies etc.).

[7] http://www.store-project.eu/documents/target-country-results/en_GB/energy-storage-needs-in-ireland

Possible Solutions:

Action	By whom
Clarity needed around investment environment and returns: • Ensure framework is in place now for 2017 without constraining current investments; • The new market needs to accommodate whatever investments are being made now; • Need a strategic view for 2030+ market.	SEMC/CER/TSO
Investigate the impact of Turlough hill being out of commission and the level of curtailment	Eirgrid
Create a predictable future market and penetration of intermittent renewable energy forecast to enable a solid business case	Policy Makers (EU and National)
Need for different entry route into market for new technologies (difficult for new technologies to enter market under same route as conventional technologies)	SEMC/CER/TSO
Examine support schemes (capfit, refit, etc?)	ESRI/SEAI
Create an updated model of the energy market to show the benefit of storage in regard to the impact of different levels of wind generation on pumping/generating of storage.	Eirgrid
Market and ancillary services should encourage energy storage	Eirgrid

3. Strong interdependence between energy storage and system development

The Concern:

The optimal market regulatory framework for energy storage depends on the future development plans and targets of the entire electricity system, and can greatly affect both the size and capacity, and also the type of future energy storage systems (ESS) (e.g. stand alone storage units or hybrid schemes), which in turn contribute decisively to the realization of future plans for high RES integration.

Consequently, it is not possible to schedule the future ESS deployment in the same independent way as other parts of the electricity system (wind and solar deployment, decarbonisation, nuclear removal etc.). Decisions to invest in energy storage are closely linked to developments such as (a) electricity supergrids with large-scale RES and possible export to the UK combined with distributed/regional RES solutions; (b) penetration of electric vehicles; (c) improvements in demand response/demand side management/smart grids.

Possible Solutions:

Actions	By whom
Determine the future energy system, which will in turn determine the type of energy storage and other technologies that are needed, which will be beneficial in the long term.	EirGrid/DCENR/ Stakeholders
Site selection for storage needs to consider grid constraints and power quality. (overlap with recommendations in Barrier no.6)	EirGrid/CER
A strategic development plan should be determined for storage to ensure grid strength and flexibility and also to ensure future development of the variable RES industry in Ireland	DCENR

4. Double or uncertain grid access fees

The Concern:

PHES is seen as an electricity consumer and electricity generator. Therefore, in most EU countries, PHES pays double fees (tariffs) for access to the network; some TSOs charge nothing for the pumped hydro storage's role as electricity consumer; other TSOs charge nothing for the little net consumption of PHES (withdrawal / injection) or recognize it as a renewable based generator. There is no EU legislation or common rules to regulate this issue and TSOs treat pumped hydro storage as they see it fit to their local market circumstances.

In Ireland, PHES only pays Demand Transmission Use of System (TUoS) charges. However in other jurisdictions, for example Texas, storage facilities do not pay any grid access charges in recognition of the services provided to the grid by EST. Even though EST uses grid infrastructure similar to any other generator or load, a case could be made for reduced or zero charges as storage can reduce grid congestion and therefore help to defer investments in costly new grid infrastructure. It may also be worth following the ongoing discussions in the natural gas sector, as a new entrant is lobbying for gas storage to be exempt from access fees.

Possible Solutions:

Actions	By whom
Investigate best practise in managing access fees.	DCENR

5. Competition with other technologies for grid flexibility

The Concern:

Energy storage is one of many technologies proposed to increase grid flexibility and enable greater use of intermittent RES production. Utilities can have many "flexibility" options for incorporating greater amounts of RES into the grid, many of which may cost less than using energy storage (e.g. supply & reserve sharing, flexible generation or demand, RE curtailment, new loads like hydrogen, vehicle electrification, etc.). The cost of energy storage needs to be compared to the alternatives, considering also the efficiency losses in the storage cycle that may be avoided by using other enabling technologies.

Possible Solutions:

Action	By whom
Energy Storage needs to be on the EirGrid DS3 agenda	EirGrid
A comprehensive cost benefit analysis is needed to investigate a holistic view of energy storage in Ireland (including economic, environmental, security of supply, flexibility, possible support mechanisms)	DCENR
Question conventional wisdom policies favouring grid strength only	EirGrid

6. Siting and planning constraints

The Concern:

Energy storage technologies may face siting and planning challenges that may delay the projects and increase expense.

PHES systems require particular topological features and possible commitment of large land areas for reservoirs, hence limiting the number of appropriate sites. An estimate made by Malachy Walsh and Partners indicates that there are approximately 20 physically viable sites in Ireland.

Once an appropriate site has been selected the developer may proceed to project development stage during which the project is designed in the context of the site constraints. Once the design is finalised, a planning application may be lodged together with an Environmental Impact Statement and often a Natura Impact Statement to the competent authority for consideration. The competent authority overseeing the planning approval process is usually the local authority or in the case of SID projects, An Bord Pleanála. The planning approval process can be lengthy, expensive and result in delays.

Furthermore, large ESS units typically require new high-voltage transmission, which adds additional siting challenges. Transmission planning today considers the location of generation units and centres of demand, but not of remote ESS facilities, which may have limited access to the grid.

Possible Solutions:

Actions	By whom
Conduct Strategic Environmental Assessment (SEA) → The size and scale means that storage facilities should be considered strategic. (best site should also include grid issues)	DCENR
Create national guidelines or guidance in relation to energy storage schemes	DECLG
Clear policy stipulating the overriding public importance of bulk EST based on reduction of current dependency on fossil fuels → allow for siting in suitable areas which may support Natura 2000 designations subject to Article VI Stage 3 & 4 assessments.	DCENR

Further Reading

All stoRE reports can be downloaded at http://www.store-project.eu/documents/results/

- Wänn et al: “Environmental Performance of Existing Energy Storage Installations” Deliverable 3.1 of the project “stoRE”, 2012
- Wänn, Reidy et al: “Recommendations for furthering the Sustainable Development of Bulk Energy Storage Facilities”, Deliverable 3.2 of the project “stoRE”, 2012
- Zach et al: “The Role of Bulk Energy Storage in Facilitating Renewable Energy Expansion”, Deliverable 2.4 of the project “stoRE”, 2012
- Papapetrou et al: “European Regulatory and Market Framework for Electricity Storage Infrastructure”, Deliverable 4.2 of the project “stoRE”, 2013
- Kane (nee Reidy): “Development of Bulk Energy Storage & Natura 2000”, Deliverable 3.3 of the project “stoRE”, 2014
- Weiss, Wänn et al: “Does Ireland need more storage?”, Deliverable 5.2 of the project “stoRE”, available at http://www.store-project.eu/en_GB/target-country-results, 2013

This report has been produced as part of the project “Facilitating energy storage to allow high penetration of intermittent renewable energy”, stoRE. The logos of the partners cooperating in this project are shown below and more information about them and the project is available on **www.store-project.eu**.