THE BUSINESS MODEL FOR ELECTRICAL ENERGY STORAGE WITHIN THE REGULATORY FRAMEWORK OF THE POWER SYSTEM

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Introduction

This paper considers a process where electricity is either stored as electricity, or converted into a different form of energy (mechanical, electrochemical, thermal etc) and then converted back to electricity. In many analyses this starts with an assessment of the cost difference between electricity at different times of the day, and the value that can be created from arbitrage, (actually this is inter-temporal arbitrage). It is now well known that this provides a substantial under-estimate of the true value of storage on a power system. Before time-of-day pricing for bulk electricity became common place, the value of storing electrical energy for several hours, for use at a later stage, was quantified by cost savings from the avoidance of peaking power plant and other reserves. Equally, an important value was gained from the protection of value of the base load supply, reducing the need for curtailment of generation. Much previous work has highlighted the theoretical need for energy storage as a proportion of power systems total generating capacity and as replacements for alternative generating types.[i] An efficient power system would contain enough generation sources of different cost bases which would perfectly match the variable demand placed upon it by consumers. Given the variability of electricity generation from renewable resources and the constantly changing requirements of consumers, most power systems should be planned with a range of power plant that can be ramped up and down in line with demand, unless there is a high proportion of some form of electrical energy storage. A power system would be at its most effective, both financially and environmentally, if a proportion of storage of around 30% of generating capacity was installed (assuming negligible capital and operating costs). There are additional benefits to be gained from the optimisation of the transmission and distribution networks. When storage is used, networks can be built to meet average loads, not peak loads resulting in cost savings across the system. However there is a difference between the theoretical purpose of electricity storage and the practical and commercial implementation in a project. Examples of successful and stalled projects illustrate the challenges to develop successful energy storage projects. [ii]

Commercial Development

It is necessary to link an application, with a strong technical and commercial case. Small scale demonstrations of technology are often immune from a commercial analysis and hide the true cost of creating an energy storage business. While it is common to consider the capital cost of the storage medium, such as batteries, or flywheels, the true capital project cost is frequently orders of magnitude higher, as it must include all the related equipment costs such as power conversion equipment, engineering costs, as well as the costs of connection to the network. These costs are often not linear, and mid size projects are frequently disadvantaged when a metric of € / kW is used. Other factors such as consents or permitting, application for connection, further add to the project cost. Once installed, the operation and maintenance costs as well as the costs of transactions within the energy business and the assessment of the value of the proposed storage system all influence the outcome of the project.

Any activity that includes ongoing purchases and sales involves an additional cost for the purpose of making the transactions. For example a battery system of 50 MW and 300 MWh will require the purchase and sale of more than 40,000 MWh of electricity each year. An energy trader will charge a significant fee for this, especially if there is an element of variability in the times and volumes of each trade. Smaller projects may lie outside the scope of an energy trader, but this may mean reduced margins. One area where this does not apply is in the use of energy storage to reduce peak demand in order to lower the overall energy tariff. Here the financial trade is simple, as the reduced demand is reflected by the reduction in tariff and no external trading with associated costs is required.

In the future, we can expect medium and large scale energy storage to be used mainly to provide ancillary services to the power network, and for bulk storage of electricity produced at "off peak" times, typically from renewable resources, and which is available at almost zero or even negative prices.

The business models

The author has worked with developers and potential users of electricity storage, and examined numerous financial models and associated business cases for the development of storage. Few of these indicate a "break even" point, unless specific grants, support or discounts are applied. Although there are many merchant developers, particularly in the USA, who are indicating that it should be possible for an independent operator to buy some storage, install it on the network, and then operate it at a profit, it appears that much of this is being subsidised under the American Reconstruction and Recovery Act.[iii]

At the present time, much storage development is held back, not because it is unprofitable, but because it is less profitable and at higher risk than other energy projects, particularly in the renewable sector. Feed in tariffs dissuade many from using storage, although processes are now in hand in Germany to correct this imbalance.

In order to meet the theoretical future requirements for energy storage it will be necessary to adapt the existing business practices and develop new business models. The regulatory framework within the power business is under pressure to change as a result of broad goals to reduce emissions, improve security of supply and to provide economic sources of power. The method of operation for future energy storage will have to take these factors into account, typically with most emphasis on the incorporation of more renewables into the network and more efficient and effective use of renewable energy. The GB market for electricity does not envisage wide spread introduction of energy storage for the public good, as illustrated by the SET plan[iv], unless and until the cost of storage can be reduced to the point where the regulator can allow it as an equivalent to other network reinforcements. This represents a typical capital value of around £50 / kW (€60 / kW).

It therefore can be assumed that while distribution companies should be the most prolific users of energy storage, they are unlikely to be so, under the current market regulations. We therefore propose four business models for consideration:

a) Extensions of existing power businesses;
b) Entrepreneurial developers[v];
c) Sole benefit models;
d) Societal operators.

By analysing the conditions for each business model, we can approach an understanding of the future market entry strategy for energy storage which would support system planning and operation.

a) Extensions of the existing power businesses

Power businesses may be grouped according to the degree of separation of the parts of the business. In some countries, there is a complete separation of the transmission and distribution activities from the generation and supply side, but elsewhere this separation is either an artificial internal barrier or is nonexistent. Small systems, such as small islands, often operate as an integrated utility, simply because there would be no economy gained from attempting to introduce competition.

For companies which are already commercially active in the power industry, adding energy storage to the portfolio represents a relatively simple process. For a large company, a small investment in storage can be charged to the R&D or development budget, and the investment does not necessarily have to have a high rate of return.

There are clearly a number of sub divisions of this model;

i) Generating companies can add electricity storage as a means of optimising the output from traditional or novel generation types, or can improve the flexibility of such plant, such as using the storage device as a means to provide ancillary services at lower cost or higher efficiency than by varying the output of conventional (fossil fired) generation. As well as developing financial savings, the use of energy storage can have significant environmental savings, by transferring generation from high emission peaking plant to more sustainable base load plant; [vi]

ii) Transmission and distribution utilities can use storage as a means of improving the operational efficiency of existing or planned assets. In many cases, new investment can be deferred. The savings from deferral can be significant, as the nature of reinforcement may mean that a 5 MW storage device can defer an upgrade of 50 MW by a number of years, providing considerable leverage on the investment;

iii) The most value for an existing business comes from companies which can operate as vertically integrated businesses. While the trend in Europe is to disaggregate such companies, (especially under the Third Energy Package), this is a value destroyer for storage. However smaller companies, such as Stadtwerke in Germany are often able to gain benefits across the business as if there were vertically integrated. Indeed, it is these smaller, integrated utilities who can gain most from using storage, especially in the introduction of the smart grid.

b) Entrepreneurial developers

The business model of the power generation industry was changed in the 1980's and 1990's (particularly in North America) by the work of merchant or independent power producers (IPPs). These organisations developed power projects outside the traditional utility sector, by buying fuel and selling power, either through long term contracts or through a power exchange or spot market. When there is a shortage of power in an area, these IPP projects represented a rapid way of increasing power sector capacity without the need for governments or utilities to make long term investments in power plant. Typically these projects were owned ultimately by banks or other financial institutions, and the investment was backed by long term agreements.

In the storage area, a similar model has been proposed, and already there are a number of companies which are seeking to exploit such opportunities. The difficulties here lie with the size and scale of the project, and the ability to identify and gain a future known income stream. This will depend heavily on the intended operation of the plant. A business model which depends on arbitrage will have little certainty about the peak / off peak price spread, unless it is able to secure both long term contracts for purchase and sale of power. This would seem to be unsatisfactory, as it seems to destroy one of the principal reasons for using storage, which is to manage uncertainty or risk. [vii]

The higher values for storage are to participate in the near real time markets, such as frequency response and reserve (sometimes known as primary and secondary response). Already a number of operators are building energy storage projects, such as flywheels used for frequency regulation in the NY ISO region.

A particular issue here has been to clarify the role of energy storage with respect to either regional or national legislation for operation in the electricity markets. More recently, legislation has been passed in a number of American jurisdictions removing any restrictions on the operation of energy storage. [viii]

In some parts of Europe, these restrictions either remain in place, or may well be instigated under market reforms. Classifying energy storage as generation can place additional licensing requirements on the industry. Many pumped storage facilities, for example, operate under a generation licence, creating a precedent for other storage facilities to have the same degree of control.

The business model is further limited by the margins available in the power sector. The storage project is competing against other forms of generation or supply, and this places pressure on the sales margins for the manufacturers of the storage device as well as the contractors and other suppliers.

c) Sole benefit models

A business, which generates or uses power, may use storage in order to trade (or exchange) energy within its own business. For example a company with its own generation may use storage to deliver firm power from variable sources, or a user may use storage as a means to reduce peak demands. This model is financially attractive as it may mean that the value of power sold or purchased may be realised without incurring excessive trading costs.

d) Societal operators

In the long term, energy storage will be needed to provide power stability over longer periods, of perhaps days or weeks, in order to balance substantial shifts in the availability of energy from renewable resources. Under the present market rules, it seems financially unlikely that such a business model could be successful. (This is because of the low market price for primary energy and the high capital and operating costs of energy storage.) The introduction of a capacity payment, which includes payment for the latent capacity of an energy storage facility, would be a valid means of rewarding investment in long term storage, which will be of societal value, rather than direct financial value.

In much the same way as pumped storage was built and operated by vertically integrated utilities, acting for and on behalf of society, we expect that the big issue of balancing supply and demand for energy over longer time periods can only be made by a societal investment in storage, which places a reward on the facility to provide energy at a time when there are only limited other resources available. Such a societal reward may be through a tariff paid to storage operators, a direct capital grant or subsidy or through a strategic payment such as a capacity or availability tariff.

Conclusions

Because of existing market distortions, and the relatively high price of new energy storage in comparison to alternative sources of energy, the adoption of energy storage in a regulated environment is subject to strict financial appraisal, based on a comparison against other types of generation. Often this appraisal does not permit the project to proceed. Because of the strategic importance of security of supply for individual societies (towns, regions, or states) and because of a shared environmental responsibility, either market pressures will result in higher prices to reward storage developers, or the price of traditional energy resources will be driven up to bring energy storage into the competitive space. A third option, which is to subsidise storage, either directly in its own right, or indirectly through a capacity payment seems the most credible route for the large scale deployment of energy storage.[ix]

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[i] A Price, Why Store Energy …? Proceeding s of EESAT 1998

[ii] Price, Bartley, Cooley, Male; A novel approach to utility scale energy storage, Power Engineering Journal, June 1999

[iii] www.recovery.gov, accessed February 2011

[iv] http://ec.europa.eu/energy/technology/set_plan/set_plan_en.htm accessed February 2011

[v] Symons, Price; Market development for large scale battery energy storage, Proceedings of the 5th International Battery Conference, Gelsenkirchen 1999

[vi] Emissions comparison for a 20 MW Flywheel based frequency regulation plant. KEMA 2007, available at http://www.electricitystorage.org/images/uploads/docs/KEMA-CO2_Reduction.pdf, accessed February 2011.

[vii] The low value of arbitrage has been described in a number of papers including:
R Thorne: The value of electricity storage, The Claverton Group, accessed from website August 2010
F Graves, T Jenkin, D Murphy, Capturing Value with Energy Storage in the energy and reserve markets, Brattle Group, 2002

[viii] FERC Notice of Proposed Rulemaking 17 February 2011

[ix] Capacity payments for storage and other forms of reserve capacity are proposed in the Great Britain electricity market. Electricity Market Reform, DECC, 16 December 2010, http://www.decc.gov.uk/en/content/cms/consultations/emr/emr.aspx accessed December 2010