DON'T FORGET THAT: PAST, PRESENT, AND FUTURE PHILOSOPHY FOR ENERGY STORAGE

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ABSTRACT

Most of the deployment of large-scale electrical energy storage took place between 20 and 30 years ago under different commercial and regulatory regimes. As pressure increases to access specific applications for electricity storage, it is appropriate to consider the role of storage in power system planning and the similarities between electricity storage and other storage processes.

Keywords: history, economics, practice

BACKGROUND

The purpose of electricity storage is to store electricity because it is better than producing it at the moment of delivery. The first sources of electricity were electrochemical; stored potential chemical energy was converted into a voltage and used for electroplating and, later, lighting. The advent of large-scale generators, and, later, alternators offered new paradigms in the method of operation of power networks.

EARLY DEPLOYMENT OF ELECTRICITY STORAGE

DC systems had an air of both simplicity and complexity. Simplicity, because accumulators could be used to provide a reserve of power. At first, some DC battery systems were used to provide a nighttime lighting supply, although some historical sources describe nighttime load (primarily for lighting) being supplemented by accumulators to meet the peak power requirement. Complexity, because of the need to provide very local services in order to avoid voltage loss and the lack of opportunities for changing voltage with transformers. The switch to AC systems and large interconnected networks led to large-scale storage, typically pumped hydro.

Many observers comment on the economic cycle, and how investment opportunities and expectations arrive in waves, fuelled by emotion and sometimes technology. The current wave of enthusiasm for energy storage technologies is now aligned closely to the development of green technologies, in contrast to the investment cycle of a decade ago when alignment was closer to cost reduction and resilience against man-made attack or natural disasters. Before that, other reasons were prevalent for the deployment of electricity storage.

Investment in large-scale pumped hydro during the period 1960 to 1980 was driven by an interest in cost reduction for peaking plant against low costs of baseload plant. Centralized, often government-owned, integrated utilities, with a very low cost of capital and investment rates of return timed against 40-year payback periods were able to justify apparently expensive projects. Those utilities with nuclear power stations could gain additional benefits from pumped hydro as these storage plants could offer valuable nighttime load (which maintained the minimum must run capability) as well as services such as ramping, frequency and black start. The Electric Power Research Institute (EPRI) (among others) had an extensive energy storage program and both technical and economic research was ongoing.

During the 1980s. there was a near-universal decision to change from centrally planned and regulated utilities to a market-based, but no less regulated, industry structure, relying on new participants to construct low-cost generating capacity. This coincided with a decline, although not a withdrawal, in the construction of large-scale pumped hydro storage.

The slow start by battery storage developers in getting project commitment during the period 2000 to 2010 shows the variety of pressures that existed at that time. In marked contrast, the past two years have shown that alternative methodologies can bring substantial rewards. However, the recent successes are not because the rules have changed, but the externalities have been approached in a different way.

ECONOMICS AND ELECTRICITY STORAGE

The economic and commercial drivers for electrical energy storage can be summarized by comparing the storage of electricity to the storage of other goods and the use of other time-sensitive services, such as fresh bread, hotel rooms, or airline seats.

The economics of just-in-time manufacture depend on maintaining a constant throughput of raw materials and dispatch of the finished product. Stocks are typically held at the lowest levels, perhaps to avoid the financing cost. But while continuous 24-hour-day manufacturing may be possible in order to avoid underutilized manufacturing assets, there are few products that can be dispatched on a continuous basis. Even the main water supplies use storage at key parts of the system to act as buffers.

Like any other commercial asset, warehouses need to be financed, located, and used to maximum advantage if maximum economic value is to be obtained. In its simplest form, electricity storage may be considered as a warehouse for electricity and some simple laws of warehousing as applied to electrical storage can be expressed as follows:

(1) Storage should only be sited once on a power system [1]. Maximum benefit is gained from the store if the system is optimized for both technical and commercial efficiency. Usually this means that there should only be one store on a path between a generator and a consumer. More storage on the same path will decrease its value.

(2) Storage should be located as close to an end consumer as possible [2]. The maximum benefits accrue from increased utilization of all the components of the system, generation, transmission, distribution, and supply. Counter to this argument is the issue of cost and size of the storage plant. As storage is moved closer to the consumer its specific cost will increase. There is therefore an optimum point of connection.

(3) The ownership of the store determines its value [3]. If a consumer owns a store, it indicates that the tariffs of the utility are less than optimum. If the store, in the same place as before, is owned by the utility it indicates that they are seeking to offer the lowest-cost tariffs to the consumer.

(4) Storage is a system benefit. Just as the early developers of electricity sought to use storage to improve the efficiency of the whole system, the same is true in the modern context. Therefore maximum value is seen by a vertically integrated utility. Portfolio players usually obtain more value than sole operators of storage [4]. Following this thinking leads to the proposal that premium sites for electricity storage are frequently either geographical or electrical islands, which operate either as a vertically integrated utility or a proxy portfolio.

(5) Finally, storage is subjected to the rules of warehousing: build the warehouse at the lowest cost; site it at the optimum point on the network; move the goods in and out fast; when it is worth buying stock, buy at the maximum rate; and, conversely, discharge at the maximum rate at the optimum price [5].

There are a number of extensions to these rules that are very applicable to electricity storage. For example, the true cost of the warehouse includes the access roads, maintenance costs, property taxes, and the like. Warehouse security normally limits losses in transit, but electricity storage often has 20 or 25% “transit losses.” This loss, if repeated several times in the system by many electricity stores in series, would be devastating to the economics of electricity.

The effect of choosing the correct location can be significant. A warehouse (or buffer) in the supply chain for time-sensitive goods can advantageous to the utilization factor of the upstream supply chain. If it is essential to meet a continuously variable demand, using high-asset-value production equipment, it is more economically viable to use the production equipment operating at average demand and use the buffer to meet the peaks, but only if the asset and operating cost of the production plant is less than the asset and operating cost of the store. This is a fundamental point, and should be an integral part of the electricity arbitrage models as they are frequently used to model storage. But the equally important point is that if the storage plant is also operated by either the producer or the supply company, then a whole system benefit can also be achieved. When this axiom is acknowledged it becomes possible to use storage as a means of optimizing the whole system by reducing the total system operating costs. This point is significant in the consideration of integrating electricity storage with renewable generation.

In a commercial electricity supply system, which is operated for the public good, it would be logical if the energy storage system was placed as close to the end consumer as possible and owned and operated by the utility company, and the resulting savings passed onto the consumers as a whole.

THE PRESENT

Substantial progress in the past two years has been achieved, mainly through the deployment of demonstration projects, but in most cases by focusing on a specific niche application that exploits the value-added nature of one of these rules. While initially the system benefit is seen to the main driver for electricity storage, the value creation for the owner of storage arises from the ability to move the stock in and out of the warehouse as fast and as efficiently as possible – or to use the ability to change the continuous supply of electricity into a variable supply by providing fast-acting upwards and downwards reserves and frequency controls.

REFERENCES

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BIOGRAPHICAL NOTE

Conference presenter: Anthony Price established Swanbarton as a consultancy business specializing in electrical energy storage in 2003 and has since consulted for battery and energy storage developers, users of storage, utilities, and government departments, in the United Kingdom (UK) and overseas. He is interested in the commercial aspects of all types of energy storage, market acceptability, and commercial development and has had many papers and journal articles published on these subjects. He is a contributor to Escovale's management report on flow batteries and has written a number of published papers and journal articles, particularly on electricity storage. He served as a director of the European Space Agency (ESA) for seven years and has organized a number of meetings for the ESA in Europe, and is now the Director of the Electricity Storage Network, the industry body for electricity storage in the UK. In 2010, he initiated the International Flow Battery Forum, a conference series that brings together researchers, developers, and users of flow batteries.