The Value Of Large-Scale Electricity Storage

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Introduction

While the investigation into the causes of Blackout 2003 continues, it is safe to surmise that an underlying contributor was the speed at which events spiraled out of control. Indeed, as Bruce Nussbaum states in *Business Week*, September 8, 2003, “Power systems have become so complex that they exceed man’s ability to react to them. They must be designed to give people adequate time to manage failure.” Large-scale electricity storage offers the opportunity to insert “firebreaks” into the electrical infrastructure, slowing the rate at which cascading events occur, providing critical minutes for the humans operating the system to make the right decisions. The ability to store bulk electricity efficiently, economically, and in a distributed fashion promises significant additional benefits, including:

- Better system-wide asset utilization
- Improved reliability
- Enhanced power quality
- Reduced emissions
- Renewable capacity firming

These benefits can be further defined as specific value streams as shown in Table 1, each with its own monetary value as shown in Figure 1.

Table 1. Benefits Defined as Specific Value Streams

Benefit	Description
Tariff Optimization	Eliminate load swings and reduce peak demand.
Ancillary Services	Regulation – Continually adjust charging load or output in response to AGC1 signals from the grid.
Arbitrage	Buy low, sell high.
Investment Deferral	Defer investments in generation and transmission & distribution (T&D) by load management.
Reliability	Provide ride-through capability during grid failures.
Power Quality	Eliminate sags, surges, and power factor problems.
Throughput Enhancement	Mitigate low/unstable voltage and transient conditions to increase transmission line throughput.

To achieve economic viability, early applications of large-scale electricity storage will be those where three or more of these value streams can be leveraged by the customer. In general, these early applications will also be those where alternatives to electricity storage are limited. Two such applications have been identified—industrial end-users, whose primary value stream would be tariff optimization, supplemented by reliability and power quality, and electric utilities, whose primary value stream would be ancillary services (specifically, regulation), supplemented by arbitrage and investment deferral. Detailed examples of how these applications can benefit from large-scale electricity storage are described below.

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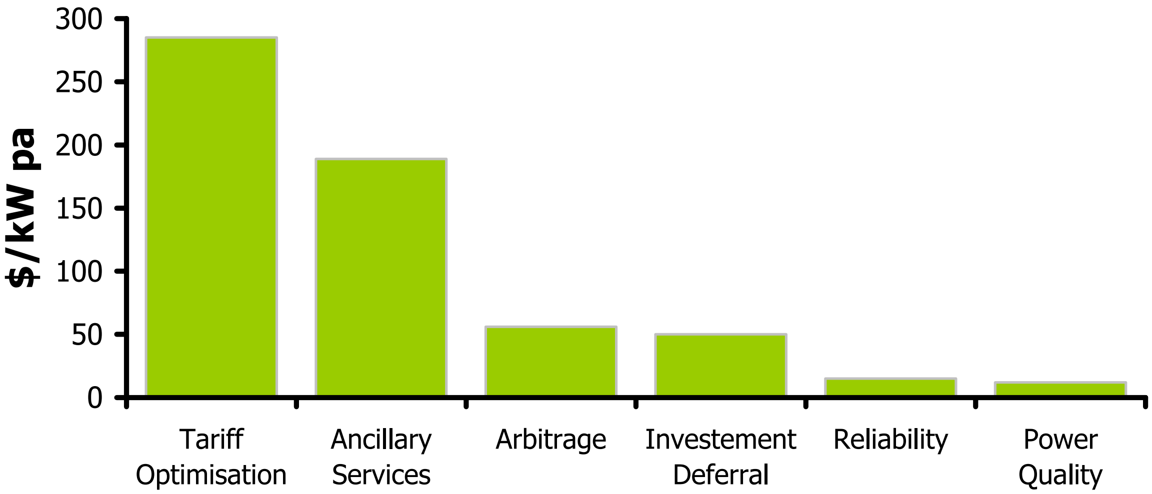

Figure 1. Monetary comparison of value streams.

Large-scale Electricity Storage for Industrial End-users

When used in demand-side applications, large-scale storage improves power quality for both the customer and the grid. Overall grid reliability and, therefore, customer productivity are also enhanced by strategic use of large-scale electricity storage. However, as mentioned above, the primary value stream for this application is tariff optimization. Consequently, electricity storage will have the greatest impact on customers with “difficult” load profiles. For load profiles with large changes in demand and high demand during peak hours, large-scale storage can level or shift the load to minimize demand charges. A review of the load profiles from representative types of industrial end-users (based on the U.S. Census Bureau’s Standard Industrial Classifications, or SICs) indicated that many of them could benefit from adding large-scale electricity storage (see Figure 2).

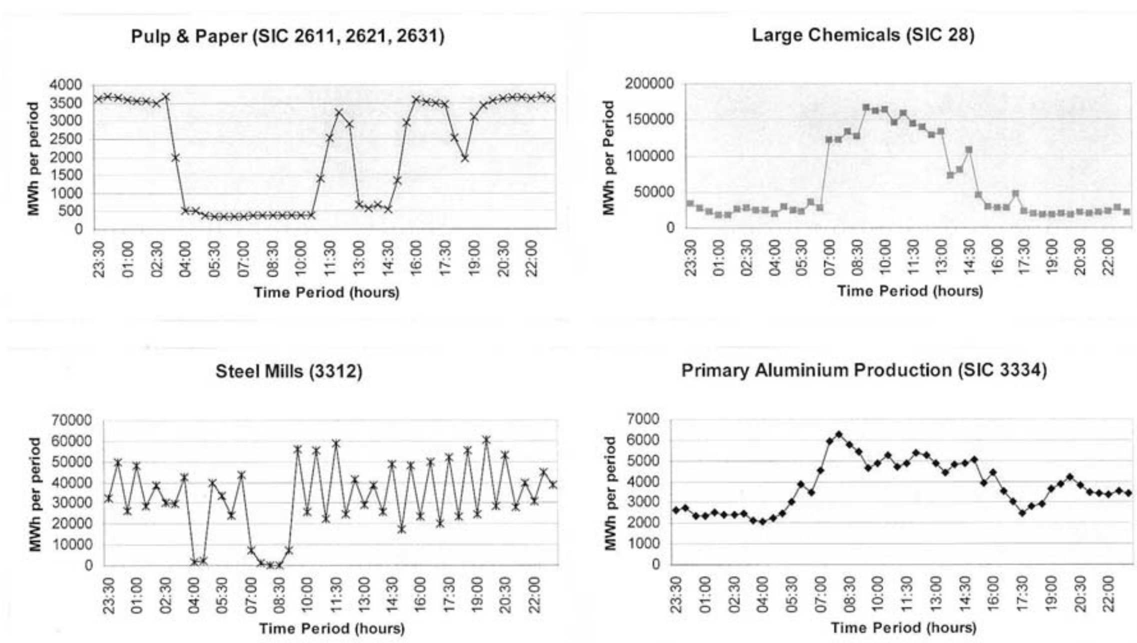

Figure 2. Industrial end-user representative load profiles.

A strategic partnership with Steelco, a producer of specialty high-carbon steel, provided an opportunity to more fully evaluate the benefits of large-scale storage in one such industry. Steelco operates six days per week, fifty weeks per year. It produces 21 batches of steel per day for a total of 261,000 tons of steel per year. A 138-kV transmission line crosses Steelco's property and the company owns the corresponding substation. Their daily maximum load is 57 MW and their operating minimum load is 8 MW (non-operating load is 6 MW). An average weekly load profile is shown in Figure 3.

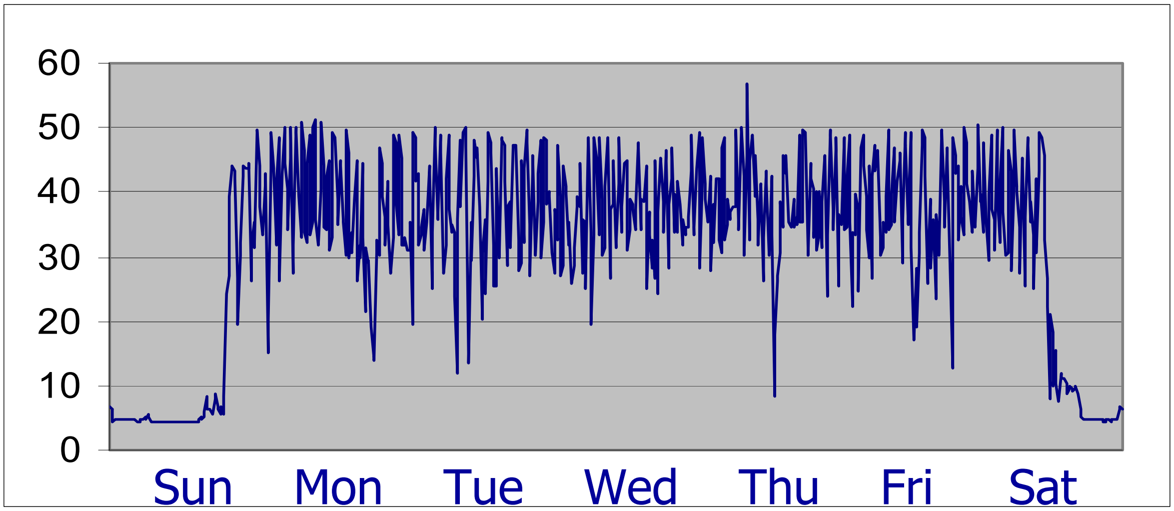

Figure 3. Steelco average weekly load profile (in MW).

Figure 4 shows Steelco's load per hour over a 24-hour period both with and without added electricity storage. The load leveling provided by the storage solution resulted in several sources of value. Steelco estimates a one-time avoided cost of power factor compensation at $2 million. Eliminating the loss of six production cycles each year would result in an additional $450,000 of revenue generated. Finally, increased process control (a direct result of improved power quality) would be expected to enable .5 to 1 extra batch per day, or a 4% to 9% increase in production. These estimates result in the annual value per kW-yr shown in Table 2. Based on the assumptions provided in Table 3, tariff optimization value, supplemented by reliability and power quality improvements would yield a value of $1,516/kw over the life of the storage system.

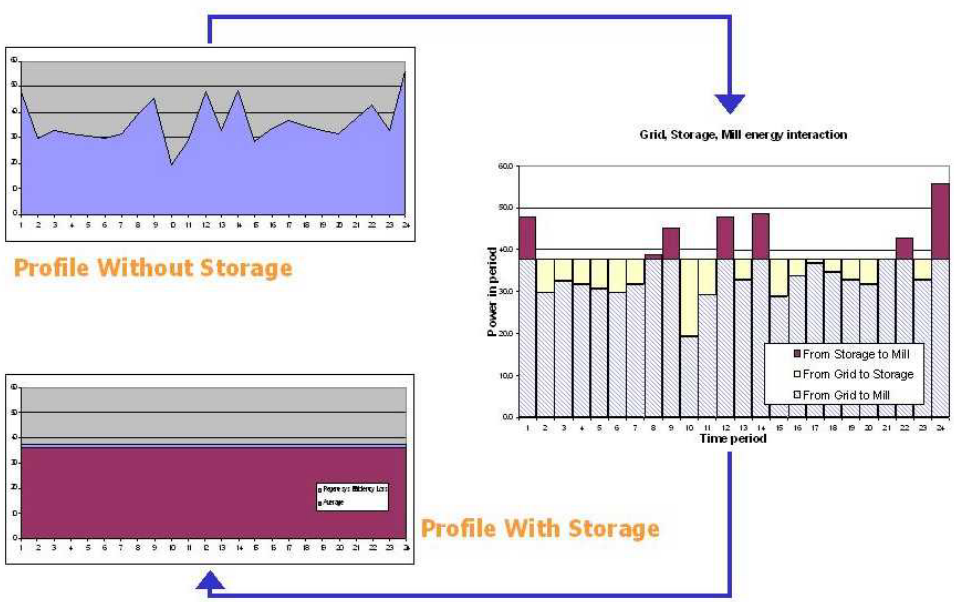

Figure 4. 24-hour load profile with and without added electricity storage.

Table 2. Annual Cost Savings per Value Stream for Industrial End-users

Value Stream	Annual Value $/kW-yr
Tariff Optimization	285
Power Quality	12
Reliability Enhancement	15
Increased Productivity	Incremental
Total	**312**

Table 3. Value Yield Assumptions for Industrial End-users

Cost of Capital: 13%	Off-peak Energy Cost: $21/MWh
Capacity: 30 MW	On-peak Energy Cost: $33/MWh
Efficiency: 60%	Scheduled & Forced Outages: <90/year on peak
Plant Life: 15 years	Variable & Fixed O&M: $48/kW annually

Large-scale Electricity Storage for Electric Utilities

For electric utilities, an electricity storage plant located in a load pocket can relieve throughput constraints, enhance reliability, and provide services to the grid operator. As mentioned earlier, the primary value streams for this application are ancillary services, arbitrage, and investment deferral (see Table 4). Ancillary services (specifically, regulation) have the greatest potential for added value. Based on the assumptions shown in Table 5, with ancillary services (specifically, regulation) as the primary value stream, supplemented by arbitrage and investment deferral, adding a large-scale electricity storage system in a load pocket would yield a value of $1,407/kw over the life of the storage system.

Table 4. Annual Cost Savings per Value Stream for Electric Utilities

Value Stream	Annual Value $/kW-yr
Regulation	189
Arbitrage	56
T&D Deferral	49
Total	**312**

Table 5. Value Yield Assumptions for Electric Utilities

Cost of Capital: 13%	Build Time: 22 months
Capacity: 30 MW	Availability: >95%
Efficiency: 60%	Variable & Fixed O&M: $48/kW annually
Plant Life: 15 years	

Conclusion

Large-scale electricity storage offers significant benefits to grid operators, utilities, and end-users, with early adopters taking advantage of multiple, concurrent value streams. Widespread deployment of large-scale electricity storage can lead to a future with improved security, reliability, economic efficiency and sustainability for the world's electrical infrastructure. In the final analysis, however, the greatest value may in fact be the enabling of grid operators to take back control of their systems.