UBC Social Ecological Economic Development Studies (SEEDS) Student Report

An Investigation Into Energy Storage Options For the New SUB

Ryan Kingston, Andrew Porritt

University of British Columbia

APSC261

November 30, 2010

An Investigation into Energy Storage Options for the New SUB

Ryan Kingston, Andrew Porritt

November 30th, 2010, APSC 261, Submitted to: Dr. Dawn Mills

Abstract

The new SUB is being built to be as green as possible, with a goal of achieving LEED Platinum status. As part of this goal the developers, the Alma Matter Society (AMS) has asked the architect to provide a pathway towards becoming net zero. Accordingly the AMS has asked that this report be written to investigate possible energy storage options.

This report outlines the results of a triple bottom line assessment of two energy storage options and a third option of not storing energy in the building electing instead to sell any potential energy back to the grid.

The findings of this analysis conclude that from a social, environmental and economic choice the best option for the AMS to proceed with is two-way metering. If a significant amount of power is ever generated this option could be improved upon by selling power to neighbouring buildings instead of the directly to the grid allowing the AMS to set their own rates rather than having them dictated by BC Hydro.

Table of Contents

Table of Figures

Glossary

Two-way meter – (aka Net meter, unidirectional meter) – power meter capable of tracking net power used allowing power to flow to and from the power grid

Abbreviations

BCH – BC Hydro

AMS – Alma Matter Society

SUB – Student Union Building

PPE- Personal Protective Equipment

1.0 Introduction

Two main storage options are considered in this report, batteries and flywheels. Both of these options have been used in building design before and both have strengths and weaknesses. Another option to storing energy in the SUB is to use two-way metering and either sell the energy back to BC Hydro, or use it to power other buildings on campus. In the following sections, each of these options is investigated from a social, environmental and economic perspective.

2.0 Energy Storage Options

2.1 Rechargeable Batteries

Rechargeable batteries could be a viable energy storage option. They are well known and are used to store energy in a variety of situations already. Energy densities of batteries are high compared to other storage options. Lithium ion batteries as an example have a storage density range of about .46 - .72MJ/kg [**1**].

2.1.1 Social Issues

Battery manufacturing involves the use of very harsh chemicals. Workers must wear special PPE (personal protective equipment) when working in battery manufacturing plants, but this does not guarantee their safety from the effects of the chemicals. The United States department of labour has set guidelines that must be followed to protect workers working in battery factories [**2**]. Most batteries that are sold in Canada and the United States are manufactured in Asia. Many Asian countries do not have the same health and safety standards that exist in western countries;workers overseas may not be protected properly from the harsh chemicals in batteries.

2.1.2 Environmental Issues

Rechargeable batteries have a large number of environmental issues associated with their construction, life and disposal.

They are manufactured using harmful chemicals. If these chemicals are not handled properly they could reach a stream or river and cause large environmental problems. This problem is magnified because batteries are generally manufactured in countries that do not have high environmental standards for manufacturing processes.

Another large environmental problem with batteries is that they have a finite life. Most batteries only last between 200-400 cycles before they must be replaced due to a large decrease in their capacity [**1**]. Since batteries cannot be disposed of easily this could case a disposal problem.

Batteries contain heavy metals, once these metals come into contact with a liquid some compounds will dissolve. If the heavy metals contained in batteries are allowed to enter the water supply, there will be environmental consequences [**3**]. The hazardous chemicals contained in batteries account for a long list of issues associated with disposing of batteries in an environmentally friendly matter.

2.1.3 Economic Issues

The cost of batteries varies, but overall they are expensive. Some common battery prices are listed in figure 1.

Figure 1- Common Battery Prices [4]

	NiCdAA Cell	**NiMHAA Cell**	**Lead Acid (Plastic)**	**Li-ion 18650 Cell**	**BB-390 for military**
Energy per discharge	4.5Wh	7.5Wh	24Wh	8.6Wh	130Wh
Cycle life (best cases)	1500	500	250	500	250
Cost per battery (ref. only)	$50	$70	$50	$100	$260
Cost per kWh ($US)	$7.50	$18.50	$8.50	$24.00	$8.00

Battery selection will depend on how much power the building is able to generate. At this point there is no intention of the new SUB being net zero at the time of commissioning and there is no guarantee that it will ever generate any power all be it a significant amount.

Batteries also require control systems. These systems must control the charge and discharge of batteries at all times. Over charging or under charging batteries will have a negative impact on their capacity and will cause their capacities to deteriorate faster [**5**].. As batteries charge and discharge the exothermic reaction that takes place within them will cause them to heat up [**5**]. Proper cooling systems will need to be designed in order to ensure that the batteries cannot over heat, which would lead to reduced performance and fire risk.

All of these extra systems are costly and will require maintenance, they will all add to the cost of storing the energy produced by the SUB in batteries. Since there is no guarantee that the SUB will ever generate any power, all be it a significant amount of power this would be a very expensive system with no guarantee of return

2.2 Flywheels

Flywheels are used to store energy in a variety of mechanical systems. There are many articles and journals written on this subject because flywheels are a relatively mature technology. Their capacity to store energy depends on their moment of inertia and their angular velocity [**6**]. Typical energy density ranges are 36 - .50MJ/kg [**1**], which is lower than most batteries.

2.2.1 Social

Manufacturing flywheels poses no large health risks to the public and would also create jobs. An interesting advantage to flywheels is that they could be placed so that they are visible to the public inside or outside the building. This could provide an interesting device for people to look at and discuss inside the SUB. The public could physically see when the building was storing the energy that could provide awareness about how environmentally friendly the new SUB is. However since the SUB does not intend on being net zero at the time of commissioning there would just be a large stationary flywheel in the middle of the SUB until the building did start generating energy.

2.2.2 Environmental

Flywheels pose minimal environmental problems. Manufacturing should be done to minimize wasted material. As long as the flywheels are made of recyclable materials, disposal should not pose any large environmental list.

2.2.3 Economical

The largest problem with flywheels is that they can only store energy for a relatively short period of time compared to batteries or other storage options. They are not a good way to store energy for an extended period of time. Flywheels like any mechanical system will also need maintenance to ensure they operate at optimum levels. Their high wear components such as belts and bearings will need to be replaced in regular intervals in order to ensure that performance is optimized. If the flywheels are neglected, large amounts of friction could develop in the system that would result in an decrease in efficiency.

2.3 Two-way Metering

Two-way metering refers to the ability for a building to sell any excess power that is generated back to the grid. In order for a building in BC to engage in two-way metering it has to meet two requirements:

- Has to be certified by BC Hydro to ensure that the building cannot damage the grid (ie. The technical systems are compatible and everything is in phase, at the right voltage and the right frequency)
    - In 2010 *Grouse Mountain* brought a 1.5 megawatt wind turbine online [**7**] however the turbine's connection to the grid was stalled while completing approval by BC Hydro [**8**]
- Has to have a meter capable of tracking power flow both in and out of the building

The first of the two requirements is a technical exercise that needs to be tackled whether two-way metering is planned or not. For electrical generating devices to be connected to the BCH grid the interconnection must be commissioned by BCH [**9**].

One way to mitigate the technical challenge involved in this process is to design isolated systems that are powered completely by internal systems, for example solar panels might generate power that is exclusively used to make hot water and additional heating could be provided by separate electrical coils or natural gas in this way no interconnection would be required.

The second requirement is a device capable of two-way metering. These devices are common and are relatively inexpensive (when compared with any scale of energy storage). As part of the Liberal government's clean energy plan [**10**], the BCH has begun rolling out smart metering technology and plans on having it in all homes by the end of 2012 [**11**]. Smart metering technology provides a range of advantages over traditional meters including accommodation for power transfer to the grid [**12**].

Installing two-way metering technology has been simplified in the past couple years. The largest challenge is BCH certification of interconnections however this needs to be addressed regardless of whether two-way metering is employed or not.

2.3.1 Social Issues

The BCH smart metering program will create jobs throughout the province [**13**] however installing smart metering technology or two-way metering in the new SUB will not create many jobs by itself. Utilizing two-way metering technology in the new SUB does not directly offer any social benefits however it is in keeping with the AMS mission to serve the concerns of students. Two-way metering meets the social responsibility that the AMS has to UBC students of serving their concerns; UBC students are concerned with the environment and they want to see their fees used responsibly.

2.3.2 Environmental

The environmental impact of using two-way meteringcan best be seen by its lack of impact. The new SUB has no intention of being net zero when it is first commissioned, the architects are supplying the AMS with a "pathway" to become net-zero someday [**14**] however there is no guarantee that the new SUB will generate more power than it consumes for any length of time. With the low amount of power that will ever be generated other systems such as batteries, flywheels, and gravitational storage represent large environmental costs without a net lifetime payoff. The construction of each of these systems does large environmental damage through the use of hazardous chemicals, large amounts of raw materials and emissions burned during manufacturing and transportation.

In contrast, two-way metering does not have a high environmental cost associated with installation. The majority of the infrastructure required to institute two-way metering is already present in modern buildings. Compared to a traditional building the only additional equipment is meters capable of two-way recording and communication with BCH.

BCH generates most of its power from Hydro Dams; an advantage to hydro dams is that they are flexible to changing loads, as an example of this, BC exports power to the United States at times of peak load and then imports it from during times of reduced load [**15**]. BCH can do this because BC's dams can handle the fluctuating load where as the American power plants are either on or off and don't handle partial loads well. As a result of BCH's flexibility to fluctuating loads there is no environmental downside to two-way power flow (even if it was employed on a large scale in BC).

There is a very small environmental cost to setup two-way metering, a fraction of the environmental cost to installing energy storage devices. Selling power back to the grid ensures that all of the generated power is used by other consumers without the inefficiencies associated with energy storage.

2.3.3 Economic

The economic advantages to two-way metering follow the same theme established in the environmental section. The economic gains to using two-way metering opposed to full scale power storage options come as a result of the lack of additional equipment and infrastructure required during construction. If the new SUB is to have power generating devices connected to the power system inside the building the electrical design will have to account for BCH requirements that these devices be connected in a way that will not harm the overall grid. This needs to be designed into the building regardless of whether the AMS plans to sell power to the grid or not. With the BCH requirements taken care of the only additional cost is a special, net power meter (which it is possible BCH would require to commission a building with power generating abilities regardless of the net zero intentions). The additional construction costs incurred as a result of setting the building up for two-way metering would be insignificant in the overall cost.

If the new SUB were to generate a significant amount of power there would eventually be trade off where the lifetime cost of a full scale energy storage system would be below the lifetime cost of relying solely on net metering. This is because BCH purchases power for less than it sells it so the SUB could potentially save more in the long run by completely avoiding taking power from the grid by storing electricity on site.

3.0 Conclusion

The AMS actively engages in social programs aimed at the benefit of students, these programs include the AMS foodbank, the walk safe program, tutoring and the advocacy office [**16**]. When considering the existence of the AMS it is clear that for the AMS to be socially responsible it must represent the students' interests; this means that the new SUB must be constructed fiscally and environmentally conscious as well as built using sustainable materials and practices.

Full scale energy storage systems such as batteries and flywheels have a large green buzz surrounding them however upon closer examination they aren't very environmentally friendly when you consider the lifetime cost of these options. Ethanol and electric cars have a similar green buzz surrounding them however they also are widely criticized for not being as green as they are promoted [**17**]. In contrast, net metering has none of the lifetime issues associated with other methods while still ensuring that all the clean energy generated in the new SUB is used to offset the use of non-renewables.

A major concern of students is how their money is being spent on the new SUB. Construction costs are going to be higher than average as a result of the goal of achieving LEED Platinum certification. Installing large scale energy storage facilities would add significantly to this ballooning cost. On the flip side, utilizing two-way metering instead of energy storage would have reduce the construction cost. The only possible fiscal downside to two-way metering is that if the SUB were to start producing a large amount more power than it consumes there would be a loss in savings because the SUB would be selling power back to the grid for less than it can be purchased for.

Considering the social, environmental and economic concerns it is clear the best energy storage option in the new SUB is not to store energy at all. Uni-directional metering is in keeping with the social responsibilities of the AMS and has much lower environmental and fiscal implementation costs than full scale storage options.

The only trade off to using two-way metering is that if the SUB were ever to become a significant power producer there could be lost opportunities due to the fact that BCH pays less for power than it sells it for. To overcome this obstacle, the AMS could collaborate with neighbouring buildings such as the pool to sell excess electricity at negotiated rates above what BCH pays.

4.0 Epilogue

If the AMS does truly want to build as green a building as possible they should think outside the box. The current approaches being discussed such as wind turbines and solar panels on the roof, small scale power generation from human interactions and grey water recycling are all examples of small scale solutions that have very high costs without significant benefits and no chance of lifetime payoffs.

Options that the AMS should look at are heat recovery on the neighbouring pool exhaust and using that energy to heat the new SUB. If the new SUB does want to be net zero it should be accepted that the energy will not be generated within the confines of the SUB.The AMS should investigate building a Wind Mill in Northern BC (or another suitable location) and collaborating with BCH to become and independent power provider; if an option like this were used the new SUB itself would not be net zero however the entire system could be. The AMS should look beyond the SUB itself and look and being a true leader in green development.

Bibliography

[1] Battery University. (2010) [Online]. http://batteryuniversity.com/learn/article/how_to_prolong_lithium_based_batteries

[2] United States Department of Labor. (2006, November) United States Department of Labor: Battery manufacturing. [Online]. http://www.osha.gov/SLTC/batterymanufacturing/index.html

[3] M Bernardes A, C. R. Espinosa D, and A. S Tenório J, "Recycling of batteries: a review of current processes and technologies," *Journal of Power Sources 130* , no. 130, pp. 291–298, December 2003.

[4] Isidor Buchmann. (2001, December) Batteries in a Portable World. [Online]. http://www.buchmann.ca/article20-page1.asp

[5] Isidor Buchmann. (2001, December) Batteries in a Portable World: FAQ. [Online]. http://www.buchmann.ca/faq.asp

[6] Bjo¨rn Bolund, Hans Bernhoff, and Mats Leijon, "Flywheel energy and power storage systems," *Renewable and Sustainable Energy Reviews*, no. 11, pp. 235-258, January 2005.

[8] (2010, April) CBC News. [Online]. http://www.cbc.ca/canada/british-columbia/story/2010/04/14/bc-grouse-mountain-wind-turbine-stalled.html)

[7] BC Hydro. (2010, September) BC Hydro congratulates Grouse Mountain Resort on The Eye of the Wind turbine's successful clean energy generation. [Online]. http://www.bchydro.com/news/articles/press_releases/2010/grouse_wind_turbine.html

[9] BC Hydro. (2010, Oct) Generator Interconnections. [Online]. http://www.bchydro.com/planning_regulatory/acquiring_power/generator_interconnections.html

[10] BC Government Clean Energy Plan. (2009, April) Energy Plan. [Online]. http://www.energyplan.gov.bc.ca/PDF/BC_Energy_Plan.pdf

[11] BC Hydro. (2010, November) Smart Metering Program FAQ. [Online]. http://www.bchydro.com/planning_regulatory/projects/smart_metering_infrastructure_program/faqs.html#10

[12] BC Hydro. (2010, October) Smart Technology. [Online]. http://www.bchydro.com/planning_regulatory/projects/smart_metering_infrastructure_program/smart_meter_and_grid_technology.html

[13] BC Hydro. (2010, April) New Act powers B.C. forward with clean energy and jobs. [Online]. http://www.bchydro.com/news/articles/press_releases/2010/new_act_powers_bc_forward.ht

ml

[14] Sustainability Report Introduction Interviews, 2010.

[15] Christopher Mallon George Hoberg. (2009, March) Electricity Trade in British Columbia: Are We a Net Importer or Exporter? [Online]. http://greenpolicyprof.org/wordpress/?p=51

[16] AMS. AMS Student Services. [Online]. http://www.ams.ubc.ca/services/

[17] Andrew Kantor. (2005, June) Green technology isn't always very green. [Online]. http://www.usatoday.com/tech/columnist/andrewkantor/2005-06-24-green-tech_x.htm