UBC Social Ecological Economic Development Studies (SEEDS) Student Report

An Investigation into Using Electricity Harvesting Exercise Equipment as a Competition-Based Game

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ABSTRACT

This report investigates the feasibility of installing electricity harvesting exercise equipment as part of a display in the atrium of the new Student Union Building. This display's purpose is to increase energy awareness, fit the exercise-needs of students, and produce renewable electricity. Three companies that provide electricity harvesting exercise equipment that are investigated in this report are ReRev, PlugOut, and Human Dynamo.

After performing a triple bottom-line assessment, it is concluded that installation of electricity harvesting exercise equipment would promote physical fitness, be reasonable to implement, and work well with other displays in encouraging energy conservation awareness at the new Student Union Building. The PlugOut visCycle is chosen as the best option for implementation as it is economical, environmentally friendly, easily installable, and students surveyed have shown interest in stationary bikes over the elliptical machines or the human dynamo system.

This report recommends that two PlugOut visCycles be purchased for integration into a display at the atrium of the new Student Union Building that allows students to race, keep track of the electricity they have produced, and keep track of the amount of carbon emissions that they have offset. A recommendation is also made that discounts at the new building's vendors based on electricity generated be offered to students as an incentive. However, contacting vendors for particular discounts has been determined to be beyond the scope of this paper.

Overall, this paper predicts a significant social impact, at a price much lower than other displays with similar goals such as the Pavogen step system currently being investigated for implementation. Surveys show a strong student interest in the implementation of the recommendations of this report, supporting its predicted success.

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LIST OF ABBREVIATIONS

EHEE	Electricity Harvesting Exercise Equipment
SUB	Student Union Building
NFC	Near Field Communication
DC	Direct Current
AC	Alternating Current
CAD	Canadian Dollars

1 INTRODUCTION

This report will examine the possibility of installing Electricity Harvesting Exercise Equipment (EHEE) in the form of a competition-based game, as part of an interactive display in the atrium of the new Student Union Building (SUB), slated to open its doors in 2014. The nature of this concept and its implementation push for a strong social impact; economic sacrifices are expected to ensure the correct implementation with favoured social impacts, but research is made to seek the most economical and environmentally-friendly solution.

Barois, Caverly, and Marshall (2010) reported in *An Investigation into Using Electricity Harvesting Elliptical Machines as a Renewable Energy Source* the feasibility of implementing EHEE into the gym of the new SUB; the conclusion was to recommend the installation of 15 ReRev machines in the new gym. The incorporation of these machines is to be expanded in this report by investigating a different implementation with a stronger emphasis on the social impact of EHEE.

The next section reveals a small amount of background on EHEE and how it has been successfully implemented elsewhere, followed by an overview of the best ways to reasonably maximize social impact. A comparison of different EHEE companies will then be presented, with compatibility with the concept, environmental impacts, and economic impacts as its main criteria. Finally, this report will present a recommendation on whether the idea is feasible to implement, and if it is, make further recommendations as to the best way to implement it.

1.1 EHEE and Its Significance

EHEE falls into the much broader category of Micro Renewable Energy Systems (Barois et al., 2010). The system uses kinetic energy provided by a human user to spin a flywheel, from which electricity can be harvested, and is either stored in a battery or put back into the grid. Figure 1 ("Electricity Forum," 2011) shows how electricity is harvested from the flywheel.

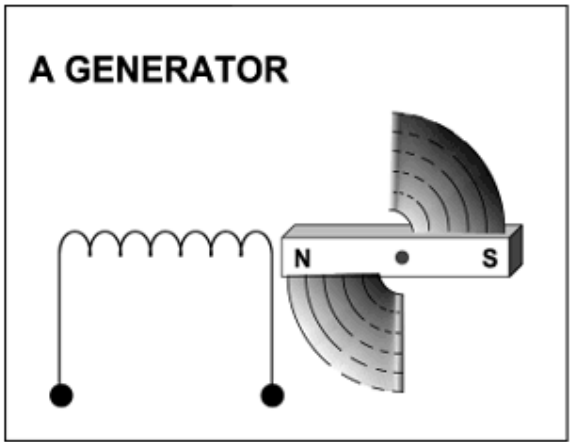

Figure 1: "To generate electrical power, a coil is mounted close to a magnet that is spinning on a shaft. As the poles of the magnet sweep past the coil, voltages of alternating polarity are induced in the coil" ("Electricity Forum," 2011)

In recent years, EHEE has emerged along with many other green technologies as a way for businesses and consumers to lessen their impact on the environment, and reduce their electricity usage. Since 2007, there has been an emergence of "green gyms" that contain a significant amount of EHEE, and successfully market themselves to environmentally conscious consumers (Alden, 2007). A typical user can generate, on average, 200 Watts of electricity, which can have a significant impact on green gyms energy consumption if enough of the EHEE is in use (Strzelecki et al., 2007). More recently, a report by Tom Gibson (2011) entitled "Turning Sweat into Watts" discusses the social impact of green gyms on their clientele. His report shows significant public interest in green gyms, and shows that it encourages thought and discussion about energy generation among its users.

2 FACTORS FOR IMPLEMENTATION

2.1 Social Assessment and Implementation Strategy

Surveys (Appendix A) suggest that most students enter the current SUB with the purpose of having a meal, socializing with friends, attending an event, or completing errands. In order to successfully add new features to the new SUB, ideas must do so by following two simple guidelines; the first is that it must follow the similar principle goals of the new building. The second is that it must benefit or interest its users when intruding them from their reason for entering the building. The baseline for this project idea, to have EHEE implemented as a competition-based game, was created with both of these concepts in mind by creating a new reason for entering the new SUB, while promoting the concepts of sustainability and healthy living.

The degree of intrusion to the user works negatively towards the likeliness of a feature being used. However, in order to effectively promote concepts such as sustainability or healthy living to users of the new SUB, there must be a high level of intrusion involved; this is precisely why the idea to implement EHEE as a competition-based game was developed, as it has a high level of attraction. It is perceived as a game first, and with this change of perspective, these machines are no longer an intrusion, as it is a new activity found exclusively at the new SUB rather than an intrusion. 85% of participants of the survey conducted showed interest in using the device to race against a friend or colleague (Appendix A).

UBC's spirit of competition is revealed to the students on the first day at the university on Imagine Day, when students wear their faculty colours to show their pride. It exists among our culture from sports teams to students striving for a better grade in their classes. By using competition as a fuel for interest, users of these machines will be compelled to repeat visits in an attempt to best original scores. 85% of participants of the survey agreed that a leaderboard showing the top scores would benefit this idea, supporting the positive effect of competition (Appendix A).

2.2 Modifications and Other Incentives

2.2.1 Recommended Modifications

One appeal of the EHEE would be its user-interactivity; custom software and hardware designed to promote the competitive nature of the game would not only encourage users to use the machines, but is crucial in educating its users with lessons of sustainability and healthy-living. Depending on the brand of EHEE decided on, displays of the electricity generated may be pre-installed individually, purchased separately, or not included at all. For this reason, it should be noted that it is recommended that custom software and hardware is made to highlight the features of these machines. This will also allow for a more personalized set of machines, as it could include other incentives that UBC may be able to implement.

2.2.2 Other Incentives

Many possible incentives have been considered that could be included to promote the use of these machines. One option could include a scoreboard for the highest amount of electricity generated in a set amount of time. This promotes competition among all the users that use the machines, not only the competition among competing racers at the time. This can be implemented through the use of scanning Student Cards. A reasonable input device could be the Near Field Communication (NFC) chip inside the UBC Student Card that allows the identification of students and faculty members. Other implementations of identification include live photo-capture, or basic name inputs via keyboard.

95% of students indicated very high levels of interest in having discounts on vendors in the new SUB, based on the amount of electricity generated by the user (Appendix A). If the new SUB is to have EHEE installed in the upper gym, as recommended in the previous report by Barois, Caverly, and Marshall (2010), it is recommended that the user information are to be shared within the EHEE in the new SUB for consistency. This idea will go well towards promoting the use of these machines as well as precisely educating users of the electricity produced, but will impact the time it will take to recuperate the investments made into implementing these devices.

2.3 Desired Social Impact

The new SUB is to be a beacon the well-being of its students and faculty members, as well as for the promotion of sustainability and healthy-living, as it has demonstrated with features like the Pavogen Step System, Climbing Wall, and numerous displays of power usage in the building to help increase awareness of the consumption rates. All participants of the survey in the current SUB agree that an EHEE competition game would complement the existing features of the new SUB.

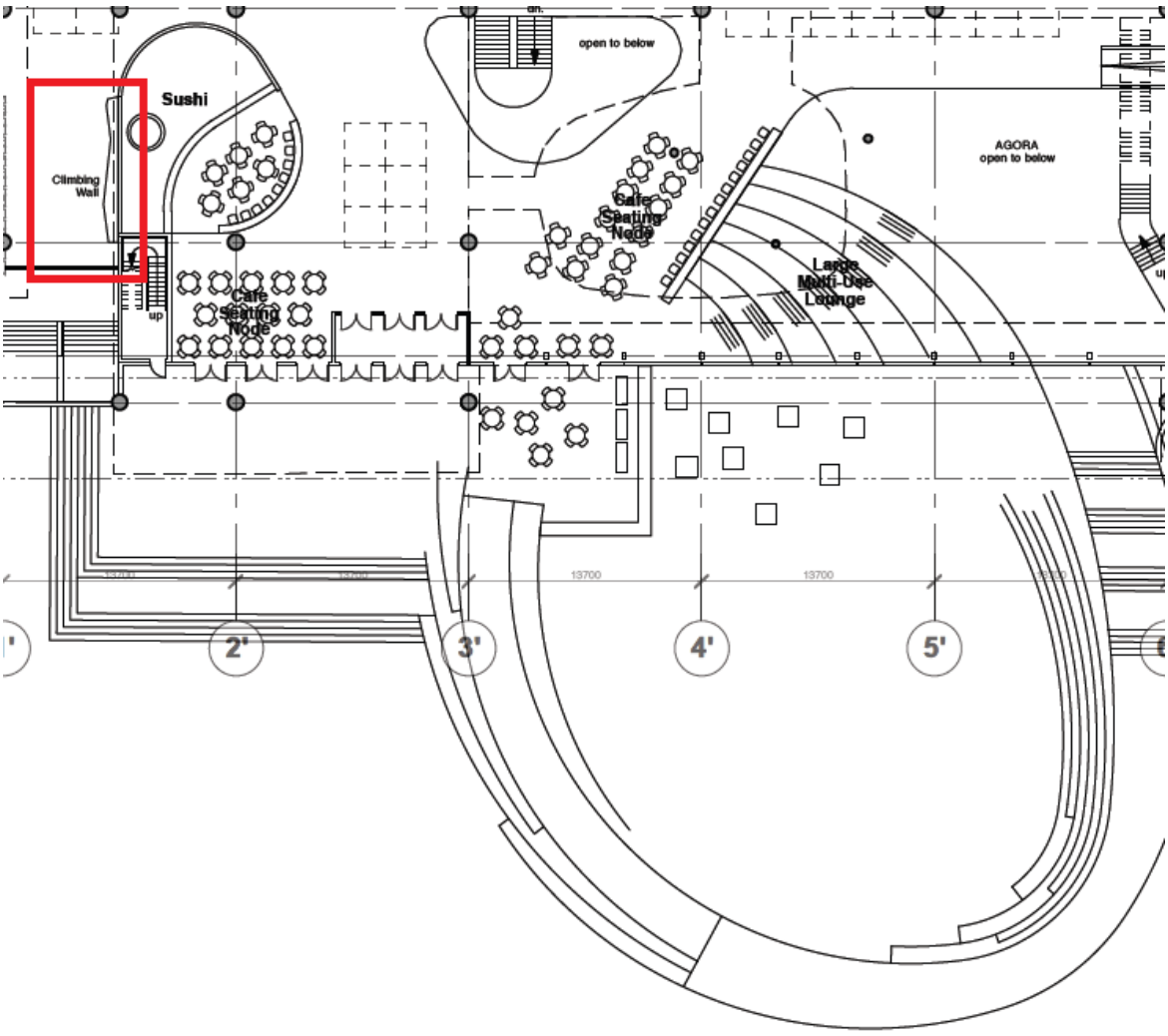

Figure 2: New SUB level 2 (Main Floor) floor plans. Climbing Wall is showed in red ("UBC," 2011)

A competition-based game featuring EHEE will significantly impact the awareness of sustainability, while creating a new activity for its users. 75% of users of the current SUB often enter to join one or more friends together during common breaks (Appendix A). Similar to the

new Climbing Wall projected to be on Floor 2 of the new SUB showed in Figure 2, friends will have a new healthy activity to pursue together with this competition-based game. With its own display of the amount of energy generated (in Watts), the display will educate its users with energy saving tips, promote the extended use of these machines, and, most importantly, suggest the correlation between everyday activities with producing electricity. In doing so, this idea will inspire for change and the development of new green ideas that encompasses the everyday activities of our society.

This implementation of EHEE will be able to address all the major goals of the new SUB. Having a competitive-based fitness game for students proves to be interesting to students based on the survey conducted for this investigation. The prominent placement of the EHEE in the main floor can also promote users of the gym located in the upper floors in the SUB, encouraging users to maintain a healthy lifestyle.

2.4 Desired Environmental and Economic Impact

When considering the environmental impacts and economic assessments for purchasing new features for the new SUB, consideration is made to minimize the expenses of acquiring the machines and the consumption of materials used in its construction. EHEE are excellent technologies that will immediately begin working towards recovering the expenses used and producing clean electricity. The next section discusses the long-term life-cycle of three individual EHEE company's products to declare the option that offers the most environmental benefit and the least overall cost.

3 OPTIONS OF EHEE

Three companies that sell EHEE are investigated in this report: ReRev, Human Dynamo, and PlugOut. As this is a fairly new commercial field, there are relatively few companies that sell EHEE, and even fewer that are in full scale production with public-use certification. ReRev, Human Dynamo, and PlugOut were selected for further investigation not only because they featured these aspects, but also because they are reputable, have information about their products available, and are reasonably priced.

3.1 ReRev

ReRev was founded by engineer Hudson Harr, and is based out of Clearwater Florida (Barois et al., 2010). ReRev sells retrofits for electricity harvesting elliptical machines, and since their inception have retrofitted machines at 31 different gyms and universities across the United States, totalling 469 machines ("ReRev," 2011). They utilize a patent pending system to generate and return electricity into the building's electrical system.

3.1.1 Social Analysis

The ReRev system produces DC power, but can be sent to an inverter to be converted into AC electricity, suitable for use in the new SUB (Barois et al., 2010). The Precor EFX546i elliptical trainer, recommended for the ReRev retrofit, displays Watts generated, making it easy to implement into a larger display ("Precor," 2011).

3.1.2 Economic Analysis

As the ReRev system is a retrofit, the purchase of two Precor EFX546i trainers at a cost of $2899 to $5995 CAD each (depending on whether or not it is used) would be necessary (Barois et al., 2010). A typical ReRev retrofit costs well in excess of $1000, but if 15 retrofits are to be ordered for the new SUB gym as recommended in the report by Barois et al. (2010), the cost can be reduced to approximately $900 per unit by ordering in bulk. This would include the installation of a specialized panel transformer, necessary for the ReRev system. Taxes and shipping costs would have to be added to this estimate, however, as well as the extra installation expenditures of running cable (Barois et al., 2010). Calculating shipping and taxes, and assuming somewhat conservatively that the extra installation cost for the 2 machines would be $200, an estimate for an upper bound of the initial cost is $7200 CAD per unit (or $14400 CAD for both), assuming the Precor EFX546i units are purchased new; an estimate for the lower bound is $4200 CAN per unit (or $8400 CAD for both), assuming the Precor EFX546i units are purchased used.

Although the new SUB will undoubtedly be very eco-friendly, assumptions can be made that its energy usage will be, at the least, comparable to buildings of a similar size. The new SUB is planned to be around 250,000 square feet (West, 2011), which, according to Jerry Jackson's "Energy Budgets at Risk: A Risk Management Approach to Energy Purchase," could place its energy use as high as 280,000 kWh/month. In B.C. this would place the new SUB under the LGS billing rate ("BC Hydro," 2011), which would mean paying $.885 CAD per kWh. Research performed by ReRev showed that a single retrofitted unit in what they describe as a "typical gym setting" generated an average 1 kWh of electricity every two days, which means the two retrofitted units could reasonably save approximately $.885 CAD on electricity per day ("ReRev," 2011).

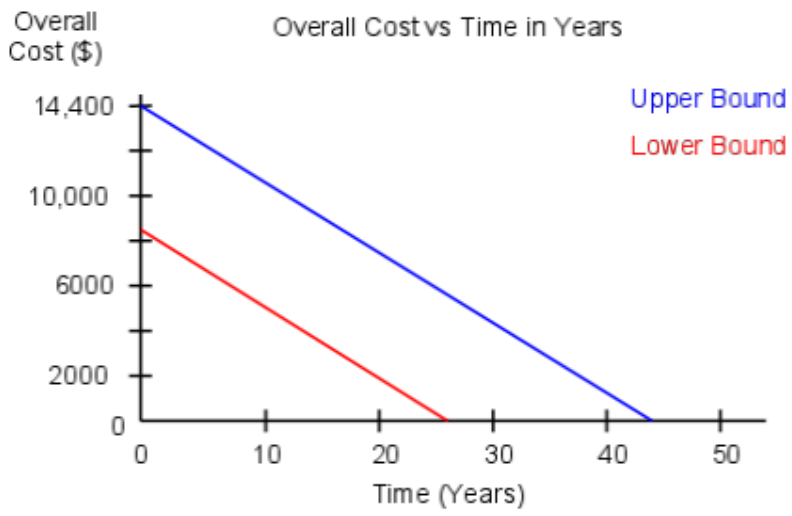

Figure 3: Overall Cost vs. Time for ReRev refitted elliptical machines

Figure 3 reveals a rate of return of (0.885 x 365) CAD per year, it will take the 2 ReRev retrofitted units 26 years to pay for themselves, if the elliptical machines can be purchased used for $2899 CAD and 44 years to pay for themselves if purchased new for $5995 CAD. The warranty for a new Precor EFX546i elliptical machine is 5 years (Precor, 2011), which means it is highly unlikely the machines will remain in use long enough to pay for themselves.

3.1.3 Environmental Analysis

During the manufacturing of a Precor EFX546i elliptical machine, the report by Barois et al. (2010) estimates that 312.5 kg of CO_2 is released from the production of the steel in the unit alone. It is estimated that 19 kg of plastic is contained in the unit, which would contribute another 114 kg of CO_2 if the plastic is new, or 66.5 kg of CO_2 if the plastic is recycled. 25 tons of CO_2 are emitted per GWh of power consumed , which means that at 1 kWh per 2 days, a ReRev retrofitted elliptical machine could offset .0125 kg of CO_2 emissions per day, or 45.6 kg of CO_2 every 10 years (“BC Hydro,” 2011).

ReRev machines can be completely recycled at the end of their lifetime: the steel frame can be turned into scrap metal, the plastic components can be melted down and re-casted, and all electronic waste is accepted for recycling by non-profit organizations (Conner, 2011).

3.2 Human Dynamo

Human Dynamo is a US company led by Mike Tagget, who has expertise in solar thermal energy, diesel co-gen, thermo-electrics, and especially human power. While no evidence could be found to support the use of its prototype bikes being used in the US, the more mature product, "Team Dynamo," has been installed in several US gyms during 2009-2010 ("Human Dynamo," 2011).

3.2.1 Social Analysis

The Team Dynamo bicycles are built into an incorporated system that allows multiple users to ride at the same time, which will allow for easy implementation into the competition-based game design. Furthermore, this system can be incorporated into the design with very few hardware modifications; the original system is equipped with a display panel that can shows the electricity in Watts that is currently being produced, and with authorized permission from the manufacturer, the output of the machines can be switched to a customized display. Team Dynamo bicycles also share a common generator among several machines, given that they are installed on a line. Lastly, Team Dynamo bicycles encourage riders to act collaboratively and competitively, which complements the social impacts of the concept implementation of this report.

3.2.2 Environmental Analysis

Similar to the ReRev Precor EFX546i elliptical machine, the Team Dynamo is constructed using steel and plastic as main materials. The key difference between Team Dynamo and other products is that it shares a common DC generator and Voltage inverter. This indicates that Team Dynamo has the potential to produce less CO_2 emissions; however, due to the lack of information

on the product's life-cycle, no comparison can be made between Human Dynamo and its competitors in the environmental analysis.

3.2.3 Economic Analysis

While effort had been placed into contacting Human Dynamo, the pricing information remains unknown. The bicycles are custom made to order and not mass produced, making the costs unavailable until the order is specifically customized. An assumption can be made that the cost for Team Dynamo bikes would be higher than market price, as they are handmade. However, since the Team Dynamo bike shares a common generator, it is reasonable to assume that the pricing for a single generator would be lower than its competitors.

3.3 PlugOut

PlugOut is a manufacturer of EHEE based in Seattle, Washington, and began selling the first version of their developed bicycles in June 2010 ("PlugOut Fitness," 2011). Originally named Resource Fitness, PlugOut produces several machines including a variety of elliptical machines and bicycles. Their devices are used throughout many different locations in the United States, notably The Green Microgym in Portland, Oregon, and various other gym facilities. PlugOut Fitness machines are not only attractive due to their simplistic installation processes and competitive price points, but also from its well-designed touch-screen interface and social media integration in certain models.

3.3.1 Social Analysis

PlugOut's elliptical fitness machines allow for many included social features that are not available from any of its competitors. For example, a web-connected touch-screen interface with internet connectivity via Wi-Fi ("PlugOut Fitness," 2011); this technology will prove to be attractive with easier implementation of the options discussed in this report. A particular feature of the PlugOut elliptical machines is that users are able to login using social-media web accounts, such as Twitter, to post information and statistics regarding their workouts. This aspect has to potential to spread virally online, increasing its popularity among peers.

PlugOut's stationary bike, the PlugOut visCycle, does not boast the same social connectivity, but the simplicity of design allows for custom hardware to be easily implemented. These basic units do not have an integrated display, or any excess hardware; they are made with the sole intention of generating electricity, and designed for durability. PlugOut has stated future models of the cycle will have an integrated display, but has yet to confirm a release date or pricing information on these later models ("PlugOut Fitness," 2011).

It should be noted that PlugOut machines do not have a feature for connecting devices such as cell phones or laptops for charging purposes, as it will cause overheating. Thus, options such as battery banks and power packs are also deemed inefficient and unfeasible. All electricity generated by the user must be directly fed back via the wall outlet into the grid. Ultimately, this is not detrimental, as the competition-based game concept calls for all electricity generated by EHEE to be returned to the electrical grid in the new SUB, before either assisting in powering users' electronics or other building necessities.

3.3.2 Economic Analysis

The PlugOut visCycle is priced at $1199 USD each, which is much more reasonable than ReRev, and likely Human Dynamo as well. Since PlugOut Fitness is based in Seattle, not only would shipping prices be reduced, maintenance and repairing would be much more convenient should any technical issues arise.

During a typical workout of around 30 minutes, the visCycle can generate 50-150 Watts per user, with a maximum of around 250 Watts depending on the intensity of the workout. With sufficient usage, the recuperation of costs in these machines could be few as 7 years; the results for average to low usage are comparable to its competitors. While implementing these machines as a competitive-based game could slow the economic impact, the social integration of these machines is a major advantage over its competitors.

3.3.3 Environmental Analysis

Weighing 44 kg, the vast majority of which is attributable to steel, the visCycle is much more environmentally friendly to manufacture than the comparatively cumbersome 125 kg of steel in the Precor EFX546i ("PlugOut," 2011; Barois et al., 2010). Using the same calculations as Barois et al. (2010), the CO_2 emissions from manufacturing a PlugOut visCycle can be calculated to be only 112.5 kg, significantly less mass than the 312.5 kg in manufacturing a Precor EFX546i. Since the power generation is similar to the ReRev system, a similar rate of emission offset can be expected.

4 CONCLUSION

From a social, economic, and environmental standpoint, the PlugOut visCycle would be ideal for implementing EHEE as a competition-based game. Surveys suggest that an overwhelming majority of students prefer the cycle over the elliptical machines (Appendix A). ReRev, as of now, only offers elliptical machines; Human Dynamo machines are currently not commercially available, and are not the preferred exercise equipment. PlugOut's visCycle is an economical solution, begins and ends with a smaller carbon foot-print, and does way without excess hardware. The lack of integrated display and simplicity allows the PlugOut visCycle to be ideal for this report's concept through building custom hardware and software; however, custom hardware and software results in a more difficult implementation process.

The integrated display of the Cross-Trainer elliptical machine by PlugOut would be the second choice, as its ease of implementation makes it difficult to deny. Its built-in social media and connectivity perfectly encapsulate all the possible implementation suggestions discussed in this report. Because participants of the surveys did not prefer the elliptical machines over the cycles, it poses as a solution that isn't ideal, but is easier to implement.

The initial investments of implementing EHEE as a competition-based game using PlugOut's visCycle and customized system parts is returned through the operating profits. If the recommended incentive to initiate discounts on vendors in the new SUB, through the use of these devices, is followed, it should be noted that the investment returns will come at a slower rate. However, the added incentive raised a significant amount of interest in this concept, and will help educate users in the new SUB of sustainability in a fun and interactive way that rivals other features sporting similar goals. The push for "social green" is emphasized and maintained throughout the life-time of the building.

APPENDIX A

Results of survey conducted on UBC students.

People surveyed: 20

Question 1: Which of the following prompted for your visit to the SUB?

Lunch (or Meal)	Socializing	Errands	Other
19	15	2	3

Question 2: Would you rather exercise using a cycle, a cycle with hand cranks, or an elliptical machine?

Cycle	Cycle with hand cranks	Elliptical machine
16	1	3

Question 3: Typically, how long would you use one of these machines at one time?

<10 minutes	10 to 20 minutes	20 to 30 minutes	>30 minutes
2	8	7	3

Question 4: How would you rate from 1 to 10 the following incentives to use the machines?
i) Display that allows you to race against friends.

Score	1	2	3	4	5	6	7	8	9	10
# Answered	1			1			7	6	5	

ii) Ability to charge ipod, phone, or computer

Score	1	2	3	4	5	6	7	8	9	10
# Answered	2		2	2	3	3	3	3	2	

iii) Leaderboard system

Score	1	2	3	4	5	6	7	8	9	10
# Answered				3		2	1	3	5	6

iv) Ability to keep track of Watt-hours generated and carbon emissions offset.

Score	1	2	3	4	5	6	7	8	9	10
# Answered					1	2	2		6	9

v) Discounts at SUB restaurants based on electricity produced.

Score	1	2	3	4	5	6	7	8	9	10
# Answered					1			1	5	13

Question 5: How likely would it be for you to use one of these machines?

Score	1	2	3	4	5	6	7	8	9	10
# Answered	2	1			1	2	6	2	2	4

Question 6: The new SUB will feature a rock climbing zone, Pavogen steps (explanation), and other activities. Do you feel that this idea would complement the mentioned features?

- All participants answered “yes.”

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