# The Energy Impacts of Self Generating Electrical Cardiovascular Equipment on the Quonset Hut at Boston College

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**Abstract**

The vast majority of fitness and recreational centers across the United States provide users with a variety of machines for cardiovascular exercise, including treadmills, ellipticals, stair masters, and stationary bicycles, some of which require electricity inputs from the facility. We investigate the possibility of replacing this energy-taking equipment with energy-generating, user-powered cardio machines at the Quonset Hut recreational facility on Boston College's Newton Campus. Our research goal centered around determining whether or not these self-generating machines could provide a significant amount of energy to feed back into the Quonset Hut in order to justify higher initial purchasing costs. Upon comparing the standard cardio machines with the Eco-Powr's product line—the brand that we are focusing on—we found two significant conclusions. First, there are substantial cost differentials in the short-term in favor of standard equipment. Second, this cost differential can be recovered relatively quickly through the energy savings achieved. We also identify benefits of implementing these machines that go beyond the question of finance, including sustainability advantages regarding sourcing student-powered renewable energy at BC, health benefits from a predicted increased utilization factor of cardio machines in the Quonset Hut, and a unique opportunity for BC to add to its prestige as an innovative institution.

**Table of Contents**

# I. Introduction

## A. Background on Electric-Generating Cardio Equipment

Electricity generation is undeniably crucial to our modern society's function. The basics of electricity generation were first discovered in 1831 through scientist Michael Faraday, whose experiment discovering the link between magnetism and electric current flow led to the creation of the electromagnetic generator system used in modern electricity generation (EIA.gov). This basic structure is the cornerstone of all modern electrical generators, aside from photovoltaic solar and internal combustion engines, including wind turbines, coal-fired power plants and more (EIA.gov). Workout machines such as bikes and elliptical machines have the potential to generate electricity on the same principles but they currently are not being utilized in such a way today. While these machines typically can be self-generating and utilize the energy of the individual to run the machinery, there is also an untapped potential to generate excess electricity for the grid as well (Megalingam, 2012). This principle has led to the development of workout equipment which not only utilizes the exercise which an individual does for its own energy needs, but also is able to generate electricity for the energy grid in the way a solar panel would (Bidwai, et al., 2017; Chalermthai, et al., 2015). This new technology has the potential to reduce the overall energy consumption of a given gym by allowing the guests to generate electricity for their own device and for the grid at large. Currently, there are options which exist for common cardio equipment such as treadmills, stationary bikes, ellipticals, and rowing machines (Chalermthai, et al., 2015). Boston College's gyms do take advantage of the existing technology for self-generating cardio machines for some of their equipment, but do not have any equipment capable of generating electricity for the building and energy grid writ large (Wetherbee, 2021).

## B. Background on the Quonset Hut and its Energy Needs

Officially annexed and integrated into Boston College's Campus Recreation in September of 2010, the Quonset Hut is a small fitness facility located on the school's Newton Campus. Given the relatively small population of freshmen who live on Newton Campus, the Hut is itself a small facility but it features the full range of typical gym equipment such as cardio machines, weight training equipment, and more to serve their population of students (*About- Quonset Hut*, n.d.). The Hut does not operate during the summer and winter months in which school is not in session and therefore has a limited operating window. In terms of its energy usage, its small size makes it easy to identify much of the energy demands of the Hut. The treadmills are currently the only cardio equipment in the Hut which need to be plugged in and the rest of the equipment is self-generating. Given its location and age, the Hut typically gets much less usage than the Margot Connell Recreation Center at the school's main campus, but it is still a well-utilized asset on Newton's campus. Currently, the Hut has recently replaced approximately half of the fluorescent tube lighting it has been using with more efficient LED lighting, however, this tube lighting still remains in a portion of the Hut. This lighting is also controlled manually, not with the aid of any sensors (Wetherbee, 2021). This means that the facility staff will keep them on during the entirety of its operation. Another important source of electricity usage in the Hut is its cooling needs. The Hut does not have any air-conditioning unit and so its source of cooling during warm months are a series of old Hurricane brand fans which run during the entire operating hours during the warm months (Wetherbee, 2021). The above information highlights that the main energy draws present at the Hut are its lighting, the treadmills, fans, and the employees corner in the entrance which includes a tv, minifridge, and computer.

**C. Self-Powered Gyms and College Cases**

If Boston College were to invest in energy-generating cardio equipment, it would not be the first university or gym and many others can act as case studies to demonstrate the merits of such a project for Boston College. It would be following the lead of many colleges and universities across the country in investing in such devices for their school's gyms. Across the country, 25 colleges and universities have invested in such devices to differing degrees in their school's recreation centers (Anthony, n.d.). Amongst these schools are the two major public Universities in Oregon, University of Oregon and Oregon State University. In the case of the University of Oregon, they admitted the relatively small impact such devices have on the energy grid as a whole, however, their investment filled the student body with a sense of pride that their school was looking to address an issue they viewed as important (Barnard, 2009). Such a sense of pride was furthered by the inter-school rivalry between the University of Oregon and Oregon State University when the latter joined their fellow state school in purchasing their own power generating equipment (Barnard, 2009). This case study also presents the potential of a school like Boston College to create a partnership with outside entities to pay for such equipment. The University of Oregon partnered with their regional energy provider to share the cost of purchasing the equipment which may lessen the financial burden placed on the school for investing in these devices.

Drexel University and the University of California at Irvine (UC Irvine) are two other schools that have purchased similar devices for their own school recreation centers. While they both highlighted the economic benefits of such an investment on their respective energy bills, each emphasized the opportunity for further education in their decisions (Brennan, 2012; Anthony, n.d.). As a part of Drexel University's decision making, the opportunity to passively educate students on the basics of climate change and energy production through these machines and accompanying educational graphics was an important factor (Anthony, n.d.). UC Irvine, on the other hand, took their educational approach to social media. They managed to create a competition amongst the student population about who would be able to produce the most electricity in 30-days which was promoted on social media (Brennan, 2012). This promotion naturally would entertain students and their social media posts would also contain important educational material on climate change itself. Both of these education approaches fall in line with the overall goal which each University naturally strives to achieve, furthering their students' education.

Case studies involving private businesses also provide information for the potential of such an investment at Boston College. These case studies provide an insight into the economic potential of such a concept. A part of a wider net-zero mixed income development, Rochester, New York's Eco-Gym combines the electricity produced by their 21 cardio machines as well as rooftop solar and micro-wind energy to create a gym which produces enough electricity for its own energy needs (Love, 2018). One of Britain's "largest independent gyms," invested heavily into the technology and viewed it as simply an investment into the technology of the future (Moore, 2015). These are just two of many other examples of private businesses pursuing the installation of such technology into their facilities, a promising sign of the technology's maturity. Universities may be able to run their gyms and recreational facilities at what may otherwise be a deficit because of the guaranteed funding they receive by virtue of their students' set tuition. However, a private facility making such an investment must do so by considering the economic feasibility of such an undertaking. By purchasing this equipment, each of the gyms discussed above made a financial decision that these machines would provide them more economic benefit which would overcome their higher cost. These two categories of workout facilities investing into energy producing cardio equipment acts as a proof of concept for any other institution, such as Boston College, which may consider such an expense.

### D. A Potential Application: Energy Generating Cardio Machines in the Quonset Hut

Multiple factors have caused the Hut to become an intriguing case to study. First, the current equipment's age, especially relative to the Connell Center, means that an investment into cardio equipment makes more sense in the immediate future. The equipment at the Hut is typically replaced every five to six years by old equipment handed down to it from the Connell Center (Wetherbee, 2021). The cardio equipment in the Hut is approximately four years old, meaning that this study will be able to influence its replacement since it is likely to happen in the immediate future (Wetherbee, 2021). The Connell Center's recent opening in the 2019-2020 academic year means that the equipment itself is newer and will not be expected to be replaced soon, limiting the potential influence of the study. The Hut's size also factored into the decision to center it in this study. The small size is indicative of the smaller energy footprint it has in comparison to the Connell Center, meaning that any individual piece of equipment which generates energy will have a greater impact on reducing the Hut's overall energy consumption than it would in the Connell Center. In terms of marketability, having a building such as the Hut which is able to be incredibly energy efficient as a result of its ability to generate electricity could be incredible for Boston College.

These two realities influence the two research focuses of this study. The primary focus will be on assessing the feasibility of equipping the Hut with electricity generating cardio machines by addressing the following research questions:

1. What is a reasonable assumption on the potential energy production of these cardio machines?
2. How does this impact LCOE and the economic viability of these machines? What is the potential period of time needed to pay back the machine in full? Pay back the difference in cost between it and a standard machine?

Accompanying this more straightforward economic assessment, we will also be hoping to answer how this purchase can become more feasible by answering:

1. How may additional practices or current equipment of the Hut be adjusted to reduce energy consumption and aid in bringing the Hut closer to net-zero?

## II. Methods

The energy generation and cost-benefit analysis are dependent upon multiple scenarios that could be applied to the Quonset Hut in the future. First, the following section will outline the data collection methods for equipment energy usage. These will be based on historical collections and current set-ups. Then, in order to determine the effectiveness of the project as a whole, there will be multiple scenario analyses that will consider different aspects of changes that could be implemented in the future. The energy savings and the cost-benefit analysis will be applied based on these different scenarios.

It is first important to consider the number of students in the Hut and the cardiovascular machine utilization factor. Since the Quonset Hut on Newton Campus was not open for student use this year due to COVID-19, there is no data from the 2020-2021 academic year for energy usage at the Hut. Therefore, we accessed the February 2020 energy use data for the Hut which most closely represents current information given it was the most recent full month prior to the onset of the pandemic, when the building was closed. The Quonset Hut hours during February 2020 are as follows:

Sunday: 11:45am-10:00pm (10.25 hours)

Monday-Thursday: 7:30am-10:30pm (15 hours for 4 days)

Friday: 8:00am-5:30pm (9.5 hours)

Saturday: 11:45am-5:45pm (6 hours)

This is a total of 85.75 hours/week the Quonset Hut is open during a regular operating week. During this month there were 2,619 individuals entering the Quonset Hut. Since this data was collected over the standard calendar year it did not take into account that there were 29 days in February 2020 as opposed to the traditional 28 days. Regardless, the 2,619 individuals were taken from 28 days so the average number of individuals entering the hut in February 2020 was approximately 94 individuals/day. It is important to determine how many students would be in the Hut at any time during the day. This value would fluctuate as there is not a consistent stream of students entering and exiting the Hut throughout the day. Therefore, the best approximation is the average. The average number of students in the Hut at any one particular time during the week is estimated to be 7.67. This value will be important when looking at the utilization factor of the cardio machines.

The 2020-2021 academic year is scheduled to have 230 operational days in which the Margot Connell Recreation Center is open. This begins when students arrived on campus in August of 2020 until graduation in May 2021. This also takes into consideration days in which the Recreation Center is closed for semester break and holidays. This value is more accurate than the 2019-2020 academic year since campus was closed in March so students were not on campus for a traditional year. Therefore, the 230 operational days in a year is an accurate value.

The assumptions that follow should not be taken as confidently accurate. Therefore, it is essential to consider multiple scenario analyses because there is no best accurate way to measure some of these variables. Based on various informal questions asked to students and casual observations of student behavior, it is determined that the average student exercises for 1 hour during the day. This does not include time it takes to change and transportation but does include time between sets of strength work and stretching. Some students will use the Hut strictly for cardio exercise, some will use the Hut strictly for strength work and others will be a combination of the two forms of exercise. An assumption made is that 50% of a student workout will be on a cardiovascular machine. Therefore, since the average length of a student workout is 1 hour, then the average amount of time spent doing cardio exercise is 0.5 hours or 30 minutes. Since there are 7.67 students on average in the hut at a particular time, then there are 3.84 students exercising on a cardiovascular machine at any particular time. It should be reiterated that this is an average calculation and not representative of every point throughout the day. This value would fluctuate throughout the day.

There were 4 treadmills, 4 indoor cycles and 2 ellipticals in the Quonset Hut in February 2020. This set-up of the Hut is very tight with minimal additional space for more equipment. If more cardio equipment were to be added, it would likely require some removal of some strength equipment. This means there are essentially a maximum of 10 potential spaces for cardio equipment. The utilization factor for the cardio equipment is percent of time the cardio machines are in use during the day. Assuming that students have an equal likelihood to use either the treadmill, indoor cycle or the elliptical then the utilization factor is determined to be 38%. The utilization factor is important to consider when determining whether there will be an available machine for an individual to use when they are in the Hut. If the utilization factor is 100% then all the machines in operation at all times. Theoretically the utilization factor could be greater than 100% if there was more demand for a machine than machines available at that moment, but practically it is impossible for this factor to be greater than 100%. Even though the utilization factor given the 10 machine set-up is well below 100%, there is still likely a large degree of standard deviation from the value considering the variability in individuals using the cardio machines throughout the day. Ideally, the Hut would want the utilization factor to be close to 100% as possible since then they have the appropriate number of machines. If the utilization factor is too low then they might have too many machines since they could reduce the number of machines while still ensuring that an individual could use a cardio machine if desired. This is an important factor to consider when considering multiple scenario analyses in the future. It is important to note that the most granular level of data we were able to acquire was student sign-in data throughout the month of February--we were not able to receive a more accurate measurement, e.g. the number of minutes each cardio machine was used. However, the Hut does not currently collect this information. We then decided to collect additional data ourselves to try to get more thorough information.

The following data was accumulated from an energy tracking device. The Kuman KWE-PM01-US Power Meter can be plugged into an outlet with the corresponding cardiovascular machine plugged into the device to determine how much energy is being generated from the machine over a period of time. One issue with the device was the outlet requirements for usage. Most recently designed cardio equipment requires a 20 amp, 125 volt outlet for increased energy usage. Yet, the energy tracking device was only compatible with a 15 amp, 125 volt outlet. Therefore, the cardio equipment plug could not be inserted into the energy tracking device without an adaptor. Yet, we were able to obtain data from some of the older machines in the Margot Connell Recreation Center which are a better representation of current Quonset Hut machines. We were unable to take data directly from the Quonset Hut cardio machines since it is not open this year due to COVID-19. The cardio equipment in the Recreation Center very closely resemble those in Hut from an energy output perspective. The first machine was a Life Fitness Stairmaster. There are seven functioning stair masters in the Recreation Center. The energy device was plugged into the machine for 165 hours (nearly 7 days). During that time period it yielded an energy output of 2,639 Watts. The device was then placed in a Life Fitness upright bicycle for 68 hours in the Recreation Center. The energy output during that time period was 1,489 Watts.

Although this data was calculated correctly from a practical point of view, it does not accurately represent and translate into energy usage at the Quonset Hut. First, the device does not track individual user output. It only tracks total output over a certain time period. Therefore, the daily output can be calculated but is not very informative. There is no account over how many individuals used the cardio machines during this time period. Therefore, the energy output per each user can only be speculated. Additionally, the Recreation Center has different hours than the Quonset Hut so the comparisons are not similar as far as total potential time available for cardio usage. The current situation in the Center only allows for a certain limited number of members during specific 1 hour and 30 minute time intervals so the machines can be cleaned. This creates highly variable demand in machines. Usage would likely be the highest during the beginning of the time period when members first arrive at their time slot. It would then fall as members begin to leave later in the slot and would be left idle during the 30 minutes of cleaning. This is not representative of the typical Quonset Hut machine usage behavior. It is also important to consider the utilization of these machines at the Recreation Center. These would not be similar from the Recreation Center to the Hut. There are only a total of 10 cardio machines in the Hut, but significantly more in the Recreation Center. There are many more kinds of machines as well which gives members more options. Since there are many more users of the Recreation Center than the Hut and more cardio machines, it would be very difficult and highly speculative to determine the utilization factors of the cardio machines.

Therefore, it is more beneficial to determine energy usage on an individual basis. The easiest cardio machine to perform these analyses on is a treadmill. This is because the output generated from a treadmill is completely linear and non-variable because unless the user were to change the speed, then its energy output is constant. For example, the energy output from a bicycle or an elliptical is always changing because the power is dependent upon the user creating the energy which is inherently variable since humans cannot maintain a perfectly consistent pace. The Life Fitness treadmill with the Discover SE3HD Console allows the user to see their speed, pace and power during the run. The table in Exhibit 1 shows the energy output when changing the running speed on the treadmill. As to be expected, the faster a user is running results in higher energy. Now there are many different assumptions that can be made for these values which is why various scenario analyses are essential for these calculations. In our standard scenario analysis, the assumption is made that the average individual runs at a 10 minute/mile pace for a 30 minute workout. Since we assumed that the average workout was 30 minutes, this would correlate to a 3 mile run. There are many factors to consider in this analysis. First, there is deviation away from the 30 minutes since some people will run less and others will run more. Also, some individuals are in better shape than others and can run at a faster pace over a time period. This value averages out the differences between males and females. Running at a 10 minute/mile pace equates to 6 miles/hour on the treadmill. The corresponding power generated from this pace is 196 Watts. Therefore, over an hour the estimated energy generation would be 196 Wh. This value is after consideration of many assumptions and will be altered in various scenarios.

The power for both an indoor cycle and elliptical is more variable because the energy output is user generated and does not remain constant like the treadmill. Therefore, using calculations is extremely difficult to estimate the energy. There are converters that can translate biking speed into wattage based on various factors such as user weight, bike weight, tire frontal area, drag and drivetrain loss. Most of these can be eliminated because of the indoor bike and these elements are not a factor. Wattage and power are much more common metrics used for assessing fitness than running due to these various other factors that can change the result, but not necessarily the effort. Therefore, there is more data to access for wattage on a bike. The table in Exhibit 2 shows the power generation based on different bike speeds. Once again, there are many assumptions that can be made over the average speed a user will ride at over a 30 minute time period. Our assumption for a 30 minute ride is that the average user can ride 18 miles/hour indoors. This translates to roughly 131 Watts or 131 Wh over an hour.

The power generated from an elliptical is the most difficult of the three machines to determine. Power is not an often used metric when using the elliptical machine. The elliptical as a cardiovascular exercise is easier on the joints than running since there is no pounding on the legs. Also, the elliptical incorporates more of a full body workout since the user must pump their arms as well as mimic a running type motion. This results in the user being slower on average compared to running since arms are typically not as strong as legs for the average person. The treadmill is the closest comparable exercise for the elliptical so taking a percentage of this output is the best predictor. Therefore, our assumption is to take a percentage of the wattage from the treadmill at the same 6 mph speed or 10:00 mile previously assumed. The table shown in Exhibit 3 shows the power generation based on different percent efforts from the treadmill power. Taking 70% of the energy output from the treadmill yields a corresponding power of 137 Watts. This value is lower than the treadmill primarily due to the user not generating as much energy due to greater resistance from the equipment as well as having a greater source for the energy coming from the weaker upper body than lower body.

The energy estimates for each of these three machines have now been assumed. They can be equally averaged to yield an average amount of energy generated for all cardio machines. This assumes that these three machines have equal demand and there is no preference of a certain cardio machine. The average cardio equipment energy generation can then be determined for both a weekly and operational yearly amount. The number of machines is not a direct factor into this calculation since it has already been analyzed using the utilization factor which is well under 100%. The total amount of energy generated in a week based on these standard assumptions is 50,885 Wh or 50.885 kWh. The total amount of energy generated in an operational year based on these standard assumptions is 1,671,947 Wh or 1,671.947 kWh. This is the amount of energy that could be put back into the energy grid to offset the uses from other energy producing parts of the Hut. These energy assumptions are all outlined and summarized in the table in Exhibit 4.

The energy generation for the Hut has now been determined based on standard assumptions. Now there will be a discussion of the cost-benefit analysis of installing these cardio machines. SportsArt does not disclose their prices publicly. Therefore, the sales representatives were contacted in order to obtain pricing for their Eco-Powr line products. It is important to note that all machines were offered at their standard university discount rate of 40% off the list price. The prices for these products after the discount for the G690 Eco-Powr treadmill is $6,414, the G510 Eco-Powr indoor cycle is $1,797 and the G876 Elliptical is $5,277. In order to determine the cost-benefit analysis, these prices must be compared to the prices of current Life Fitness equipment that the Margot Connell Recreation Center would likely purchase if they were not to invest in the Eco-Powr line. It should be noted that this is not the same Life Fitness equipment that would be put in the Quonset Hut. Yet, for an accurate comparison the Eco-Powr products should be compared to newer and better Life Fitness cardio machines since the Margot Connell Recreation Center would not purchase the cheaper equipment. Even though the Eco-Powr products would be placed in the Quonset Hut if they were to invest in this project when the older and cheaper Life Fitness equipment would be transferred to the Hut from the Recreation Center does not matter for this calculation. The list prices for the newest product lines from Life Fitness that the Recreation Center has purchased are as follows. The platinum club series treadmill is listed at $9,449, the IC6 indoor cycle is listed at $2,399 and the platinum series cross trainer is listed at $8,399. All of these prices are greater than the Eco-Powr line respective products. Yet, it can most likely be assumed that these prices could be negotiated down to the same 40% university discount prices. Therefore, the discounted prices for machines are $5,669 for the platinum club series treadmill, $1,439 for the IC6 indoor cycle and $5,039 for the platinum club elliptical. These price differences are shown in the table in Exhibit 5. The total price difference can then be determined based on how many new machines the Quonset Hut would purchase based on their current machine capacity of 10 total machines with 4 treadmills, 4 indoor cycles and 2 ellipticals.

In order to determine the cost-benefit analysis, the financing for these machines must be accurately calculated. The Eco-Powr machines could either be paid entirely up-front or leased through monthly installments. In the leasing option the purchaser pays an upfront cost which is essentially a down deposit and then the monthly payments begin. It is assumed that BC would pursue the leasing option since the overall cost would be lower because the payments are over a period of time. In order to accurately compare the Eco-Powr machines and the Life Fitness machines the assumption must be made that they can be financed in the same manner over the same period of time and with the same up-front cost percentage. This is likely to deviate slightly in practice since it would be unlikely that the terms of the lease would be exact across both options. Nonetheless, it would still not be significantly different and could probably be negotiated in BC's favor. The Eco-Powr equipment is warranted on parts for 5 years and 3 years on labor. Yet, the useful life of the equipment could be doubled to 10 years if it is well maintained. Considering that the equipment will be used heavily and is being leased for a public gym, it is assumed that the 5 year warranty accurately represents the useful life of the equipment. Yet, this can be changed in scenario analysis. For the financing calculation, the assumption is made that 20% of the total cost will be paid before the monthly payments begin. Additionally, it is assumed that the discount rate on the monthly installments is 10%. This is based on historical market returns over the S&P 500 in recent decades and is a traditionally used discount rate for financing projects. Therefore, the price difference and discounted price difference taking into consideration the 10% rate can be calculated each month over 5 years.

Boston College may also approach this cost issue from a different perspective. Investing in this energy producing equipment will also come down to whether the energy itself is able to make up the higher cost. Boston College's staff are going to purchase cardio equipment to replace older models over the course of a given time period either way, which raises the importance of considering the relative cost of an energy-producing cardio machine as opposed to the standard cardio machine. Two potential scenarios would benefit the school financially: the machines are able to pay back the difference in price between the standard machine or the machines are able to pay themselves back in full. In either scenario, the school saves money on its purchase. In order to determine whether these criteria can be met in a reasonable time for the school, a multi-phased cost-analysis must be conducted. This process will be conducted through four steps: utilizing energy production from these machines to determine the amount of energy produced in a typical time frame, determining the cost of electricity for the Boston area, calculating the savings per year which result from the energy production, using these savings estimates to calculate the time needed to achieve both of these conditions. This determination will shed light on another cost consideration angle for the school to consider.

## III. Results

The levelized cost of energy (LCOE) is an important value to determine the cost-benefit analysis for the project. The LCOE compares the costs of an energy source over its energy output to determine which is the most cost efficient for energy generation. It is essentially an equation of costs over energy output. A lower LCOE is better because less cost goes into energy production. When calculating the LCOE for the Eco-Powr project there are assumptions that must be made. First, since the Life Fitness machines do not generate any electricity themselves, the only energy generation is derived from the Eco-Powr equipment. Therefore, the energy generation can be taken from the previously calculated total energy generation over the academic year and equally distributed across the 12 months during the year. This is not the most accurate way to allocate the energy usage since the Quonset Hut is not open during the summer months and various months may have more cardio equipment usage than others, but it is a close enough approximation for the purposes of this analysis. The monthly discounted price can then be used as the cost for the energy in the LCOE calculation. The LCOE is then determined for each month which can then be calculated for each of the 5 years. The first year has the highest LCOE because of the 20% down payment prior to the start of the monthly payments. Each year subsequently has a lower LCOE due to the impacts from the discount factor over longer time horizons. The energy output remains constant, but the cost for the energy decreases each month. The total project LCOE can be calculated from averaging the 5 years together to yield an LCOE of $0.468/kWh. The LCOE values over the 5 years are shown in the table in Exhibit 6.

These LCOE values now need to be compared to the LCOE of other energy sources. Lazard publishes yearly unsubsidized LCOE values for renewable and conventional sources of energy. These values are summarized in the graphic in Exhibit 7. In general, the LCOE for renewables has been declining as the price for solar panels has generally been decreasing. Many of these technologies are now at a financially comparable level to other conventional sources of energy. This is a promising step forward for the future of renewable energy since the LCOE takes into consideration all costs of the project including the higher up-front cost from renewable energy. Therefore, it is more difficult to argue from a financial perspective that renewables could become a greater energy source for the future when these LCOE costs are dropping rapidly. Lazard gives the LCOE values in units of $/MWh so each price must be divided by 1,000 to compare with the Eco-Powr LCOE in $/kWh. When comparing the Eco-Powr LCOE with the renewable and conventional energy sources LCOE it is apparent that Eco-Powr energy source is significantly more expensive than any of the other sources. For example, assuming BC receives the majority of its energy from natural gas under the gas combined cycle from Lazard analysis. Even using the lower LCOE of $0.044/kWh is a magnitude of over 10 times cheaper than the $0.468/kWh from the Eco-Powr project. Therefore, after determining the energy generation and the costs for this renewable energy project, it can be determined that using standard assumptions it would not be economically feasible to invest in the Eco-Powr project strictly from a financial perspective.

Now that the energy generation and cost-benefit analysis under the standard assumptions are complete, it is important to discuss some of these implications and expand the potential possibilities through scenario analysis. Although the standard assumptions yield a negative financial outcome, it should be put in perspective that the amount invested in these machines is small in magnitude compared to other projects on BC's campus. Even though the project would result in a net loss from a financial perspective, the magnitude of this loss is very small compared to the college's total net income. In addition, this economic loss should instead be considered a valuable investment opportunity to make BC a more sustainable campus, and work towards long-term financial benefits through energy savings from no longer requiring the treadmills in the Hut to be plugged in. This project would not put BC in significant financial distress if it were to invest in these machines. Nonetheless, as mentioned multiple times previously these calculations were made under some standard assumptions that can be adjusted considering the natural variability in the data. Therefore, it is now crucial that we consider multiple different scenarios using different but still highly plausible assumptions that would decrease the LCOE of the Eco-Powr project.

The first scenario is to assume that individuals do cardio exercise for 70% of the time opposed to the original 50%. This could be for various reasons such as individuals wanting to get in better shape or because there is this new Eco-Powr equipment so then students would be more likely to engage in cardio activity. This would lower the LCOE because the equipment would be in use more and therefore more energy would be generated. The utilization factor increases to 54% which is still significantly below the 100% maximum utilization so this is practically possible. The overall project LCOE for this scenario is $0.334/kWh. The energy generation and cost-benefit analysis are shown in Exhibit 8.

Each subsequent scenario will build upon the previous scenario. Therefore, the 70% change in activity time will also be implemented in this second scenario. In this scenario there is one less Eco-Powr cardio machine purchased for the three different cardio exercises. Instead of 4 treadmills, 4 indoor cycles and 2 ellipticals there would be only 3 treadmills, 3 indoor cycles and 1 elliptical. This would decrease the total price difference for these Eco-Powr machines. This increases the utilization factor to 77% which is still below 100% making this scenario feasible from a practical manner. The overall project LCOE for this scenario is $0.243/kWh. The energy generation and cost-benefit analysis are shown in Exhibit 9.

The third scenario is to assume that there will be an increase in the number of students exercising in the Hut. This could be due to more awareness about the Hut with the new Eco-Powr equipment and a greater desire to give energy back to the grid. If the average number of students entering the Hut were to increase to 120 per day, then the utilization factor would increase to 98% which is just slightly below the practical 100% maximum. This means that essentially the cardio machines are in use at all times during the operational hours. This could create issues in demand fluctuations where there may be more than 7 students wanting to use the cardio equipment at one time and therefore they would have to wait or change their workout which is not ideal. The overall project LCOE for this scenario is $0.190/kWh. The energy generation and cost-benefit analysis are shown in Exhibit 10.

The fourth scenario focuses on the user energy generation for the machines. Theoretically, over the academic year it would be hopeful that students would get in better shape from continuous exercise. Therefore, their speed and corresponding energy generation would increase as well. This scenario will assume that the energy generation output would increase by 20% for each of the three machines. The energy generation for the treadmill, indoor cycle and elliptical would now be 235 kWh, 157 kWh and 164 kWh respectively. This would result in an overall project LCOE value of $0.158/kWh. The energy generation and cost-benefit analysis are shown in Exhibit 11.

In the fifth scenario it is important to look at the corresponding price differences among machines and their respective energy output. For example, the treadmill generates the most amount of energy of the three machines but has a significantly higher price difference compared to the indoor cycle and the elliptical. Therefore, looking at the price difference per energy can determine which machine would generate the lowest LCOE. The price difference/energy for the treadmill is $3.80/kWh, $2.73/kWh for the indoor cycle and $1.74/kWh for the elliptical. Therefore, the elliptical is the most cost-effective machine for generating energy. This scenario will assume that 5 of the machines would be ellipticals with only 1 treadmill and 1 indoor cycle. Although it would be best to have all 7 of the machines be ellipticals, it would not be the best for the Hut to only have one type of cardio equipment since students may want to use a treadmill or an indoor cycle. The LCOE for this scenario is $0.102/kWh. The energy generation and cost-benefit analysis are shown in Exhibit 12.

The final scenario will change the financing factors of the project. In this scenario it is assumed that the equipment is maintained very well and the useful life extends beyond the 5 year warranty and doubles to 10 years. Then the terms of the lease could hopefully be negotiated such that BC would pay these monthly installments now over a 10 year period. Since the cost of energy is now spread out over a longer time frame with the 10% discount factor greatly contributing to the reduction of discounted cash flow, then the LCOE will drop significantly. The LCOE for this scenario is $0.044/kWh. The energy generation and cost-benefit analysis are shown in Exhibit 13.

Each of these scenarios built upon each other and progressively lowered the project LCOE. The LCOE values under the different scenarios are summarized in Exhibit 14. The sixth scenario has an LCOE of $0.044/kWh which is the same value at the lower range for gas combined cycle previously discussed. Therefore, under the best-case scenario assumptions for this project, the LCOE can drop to a financially comparable level where there is no income difference between the Eco-Powr investment compared to business-as-usual energy consumption from conventional sources. Yet, as noted previously, the LCOE for some renewable energy sources is decreasing over recent years and is already lower than conventional sources. Therefore, these renewable sources would still have a lower LCOE than the Eco-Powr project. It should also be reiterated that Sports Art is the first company to release a product line that creates a net generation of energy. This industry will likely expand in the near future with more exercise equipment competitors looking to enter this niche market. Additionally, the technology will likely continue to improve for these machines and it will be easier to manufacture in the future. This will cause the price to decrease making it more financially comparable from the LCOE perspective.

The first part of the process is determining what assumptions to make on the amount of energy which can be generated by these machines. This can be done by once again referencing the figures previously used in the discussion of LCOE. This analysis will not be conducted with the intent of determining an optimal number of each type of machine, the most important factor is how much the machine gets used and the energy it produces. In this portion of the study, the two scenarios which will be studied will be the standard scenario (Exhibit 4) and scenario one (Exhibit 8). The standard scenario was chosen to highlight the potential payback times under a more conservative estimate which takes the most recent usage of the Hut into account. Scenario one provides a wonderful comparison point to the standard scenario and highlights the potential difference that can be made if students are more active in the Hut and encouraged to make use of the energy producing equipment more frequently. While more optimistic than the standard scenario, it is not completely out of the realm of possibility given the proper campaign for it. Under the standard scenario, the cycle would produce 472.037 kWh in a year, the treadmill would produce 706.253 kWh in a year, and the elliptical would produce 493.657 kWh in a year (Exhibit 4). By following the first scenario, the amount of electricity generated by the machines in an academic year can be 660.851 kWh for the cycle, 988.755 kWh for the treadmill, and 691.119 kWh for the elliptical (Exhibit 8). These are the energy estimates which will determine the amount of money saved every year from electricity costs.

After determining the amount of energy produced by the machines, the next step is to determine the cost of electricity for the area. According to the US Energy Information Administration (EIA), the average retail electricity price in Massachusetts in 2019 was 18.40 ¢/kWh or 0.184 $/kWh (*State Electricity Profiles*, 2020). Using this as the baseline price of electricity, data from the EIA will then be used to estimate the change in the price of electricity in the coming years. In the past 20 years, there has been about a 2.31% inflation rate on the price of electricity (Sonnichsen, 2020). While electricity prices can fluctuate quite a bit from year to year given certain economic events, this average rate of change will be utilized to create a more accurate estimate of the price of electricity over time. The price of electricity will be estimated over a 30-year time span to better estimate the cost savings each year by taking into account the potential change in electricity cost over time. This will yield a chart, Exhibit 15, which tracks the estimated cost of electricity from 2021 to 2051.

With this chart produced, the previous two steps will be utilized in a final step in order to determine the approximate time it will take to pay back the machine in full and to pay back the difference between an energy-producing machine and a standard machine. Since this analysis is being conducted for three machines and two scenarios, each result will be tallied in a separate exhibit. The energy produced in each scenario is highlighted in Exhibits 4 and 8. The estimated electricity saved each year will be multiplied by each estimate of the cost of electricity which will be tracked in six separate exhibits (Exhibits 16-21) that gives two values: the year's savings and a cumulative amount of money saved by the device over said time period. These results will be compared with that device's cost and the difference in cost between the energy-saving device and the standard equipment as shown in Exhibit 5 to determine the amount of time needed to pay back the device according to both criteria. This also must be done for all three energy-producing machines in both scenarios, creating a total of six payback scenarios to be shared in Exhibit 22 below:

Exhibit 22

| Machine | Scenario | Cost Difference Payback time (years) | Total Payback time (years) |
|---|---|---|---|
| Indoor Cycle | Standard | 3-4 | 17-18 |
| | 1 | 2-3 | 12-13 |
| Treadmill | Standard | 5-6 | 30+ |
| | 1 | 4-5 | 26-27 |
| Elliptical | Standard | 2-3 | 30+ |
| | 1 | 1-2 | 29-30 |

The above results highlight an interesting economic factor for Boston College to consider. Under the realistic standard assumption scenario, paying off these machines in full is seemingly unattainable with times that are approximately 20 or even over 30 years. Even in the more optimistic scenario one, times still range from 12 to 30 years. This makes the prospect of producing enough energy to pay back the machine entirely bleak. However, these machines will make up the cost difference between the two devices quickly in each of the above cases. These values range from 1 to 6 years, a much more reasonable time horizon for Boston College to consider. This means that, aside from the standard scenario for the treadmill, the difference in price between the energy-producing machines and the standard machines could be made up in a standard 5-year lease. Any lease period beyond this would certainly allow the difference in price to be paid off.

## IV. Discussion

While it is important to acknowledge the current identified financial drawbacks of the Eco-Powr workout products, there are several caveats that are worth emphasizing. First, as mentioned, the LCOE values for the renewable, self-generating sources are currently significantly more expensive than the alternatives. However, it is also critically important to call out that these LCOE values have demonstrated a decreasing trend in price throughout recent years, and are expected to continue to become less and less expensive. At the same time, coal and natural gas are expected to eventually become more expensive as they are finite resources that are subject to scarcity in the long-run. As a result, at some point in the future, these two LCOE's will become equal, and the renewable sources will actually become cheaper alternatives, similar to the expected trend for solar and wind energy to eventually become less expensive than nonrenewable energy sources. In conclusion, while the current higher costs should be taken into consideration, it should also be noted that these renewable, self-generating machines will continue to become less and less expensive, especially as additional products become available from more brands other than Eco-Powr.

A second caveat worth mentioning also relates to the financial barrier to installing equipment like Eco-Powr machines. Again, while we have established that they are overall significantly more expensive compared to current equipment used at The Hut, it is important to view this financial gap as an investment rather than a significant expense. By purchasing machines that students can power themselves and feed energy back into the building, BC would be investing in their university as an innovative institution, investing in the future of their students and how they utilize recreational facilities, and investing in unique and exciting sustainability opportunities. In addition, the actual cost differential between the self-powering machines and the current equipment is not very significant in the big picture at an institution like BC. Plus, as demonstrated, these machines will reasonably quickly pay off the difference between what the Eco-Powr products cost versus the standard machines that will inevitably need to be re-purchased in the coming years, while being able to contribute electricity back into the building.

In addition, there are several other important benefits to installing these machines and committing to a more sustainable recreation center that surpass the demonstrated cost considerations. First, there is a sustainability argument to be made. While the short-term costs are more expensive than current alternatives, this is an investment opportunity with long-term energy savings. By removing the need to plug-in treadmills and instead replace them with equipment that feeds energy back into the building, energy consumption will decrease as renewable production increases. Furthermore, this provides an interactive, uniquely engaging source of renewable energy that is produced by the students and for the students. Second, there is a student health argument to be made. Based on successful case studies of other university gyms implementing similar energy-producing machines, more students are more likely to visit recreational facilities and use these machines to workout. By having more students maintain active lifestyles and exercise more often than they would otherwise, the Eco-Powr products have the potential to provide very real health benefits to BC’s student population. As demonstrated in other universities that have taken this initiative, students are excited about the opportunity to contribute to a more sustainable recreational center through exercise, feel better about their workouts, and are more likely to exercise more frequently. As a result, by attracting more students to exercise at The Hut, the 38% estimation for the current utilization factor will likely increase, which in turn will produce larger and larger quantities of renewable energy within The Hut. Finally, another noteworthy benefit of investing in a sustainable gym is the effect that it will have on BC's reputation. Proving to be an innovative institution with technologically up-to-date facilities that embrace sustainability will enable BC to stand out among other colleges and competitors in the Boston area. Furthermore, this is a valuable opportunity for the school to receive positive press and for the student body to take pride in their institution, which can contribute to BC's overall standing and prestige as a university. In conclusion, there are several significant benefits that make investing in self-powering fitness equipment an attractive opportunity, ranging from health benefits to sustainability progress to positive press and reputation for the university and its students.

## V. Recommendations

### A. Recommendations for a Future Replicated Study

Initially, the goals of this research project were to identify the percentage of electricity that self-powering cardio machines could produce for the Quonset Hut (with respect to the building's total energy consumption), and how long it would take for these machines to pay themselves off. However, upon realizing that the granularity of the data required in order to make these specific calculations is not collected by management at The Hut and was therefore unavailable to us, we pivoted the focus of our research. The main goals became to analyze several varying scenarios based on different assumptions made on student exercise behavior and the types of cardio machines being used to determine the economic feasibility of implementing these machines using LCOE compared to current equipment, and to determine how long it would take the equipment to pay off the extra financial cost of the more expensive self-powering equipment versus the standard machines. While we have met these goals, we suggest that an additional study be carried out in the near future to more accurately revisit our initial research goals.

Specifically, we suggest that another study should be conducted within the next year, given the immediate timeline of when new cardio equipment will be purchased for The Hut. In order for this study to be as accurate as possible, we strongly recommend that management at The Hut starts tracking more specific use of the equipment. For example, while the most specific data we were able to access was a log of student sign-ins across fifteen-minute time periods, we hope that future research groups will be able to receive a full breakdown of energy consumption of The Hut across different cardio machines. This level of granularity would greatly reduce the number of assumptions needed to be made and would allow us to calculate the percentage of energy that the self-powering machines could provide in order to create a more detailed economic analysis. If this were the case, then the several hypothetical scenarios that we created would not be needed as a proxy for reality. By improving data collection in The Hut, a very detailed and accurate recreation of this study can be performed.

**B. Additional Sustainability Recommendations for The Quonset Hut**

While the main focus was determining if it is feasible to replace old cardio equipment machines with electricity-generating equipment to feed back into The Hut, we have identified four additional actions that management can take to both decrease electricity consumption within the gym and increase the percentage of energy sourced from renewables.

First, we identified an opportunity to decrease energy consumption by replacing non-LED lighting with LED bulbs. Specifically, half of the lighting in The Hut uses old, non-LED bulbs. We strongly suggest implementing LED lighting in the rest of the gym--especially in the large, open space in the back rooms containing the cardio equipment and half-sized basketball court. According to the United States Office of Energy Efficiency and Renewable Energy, LEDs use at least 75% less energy and last 25 times longer compared to incandescent lights (Energy.gov). In addition, LEDs emit very little heat, versus having up to 90% of incandescent lights' energy released as heat and essentially being wasted. Overall, LED bulbs are more durable, last longer, and use significantly less energy compared to their older alternatives (*ibid*). Substantial energy savings can be achieved due to the combination of a large spacial area needing LED replacements and the massive amounts of time that the lights are kept on in the building. Specifically, the lights are kept on during all hours that The Hut is open--meaning that they are kept on for a total of 85.75 hours per week during operation hours (see Results section for a day-by-day breakdown). Plus, the lights are kept on for four additional hours each Monday through Friday after closing to allow for housekeeping services to come in for cleaning. This sums to the lights being on and running for 105.75 hours per week, or approximately 423 hours per month (for February with 28 days). If 100% of the building's lighting is LED-sourced instead of incandescent, up to 75% of the energy used during this time could be conserved. Since we found that half of the lights are LED and half are not, this means that the energy consumption equivalent of 158.63 hours ((0.75*423)*0.5) = 158.63 hours) of these lights being on could be conserved just by switching to all LEDs.

Second, The Hut has nine large Hurricane brand fans mounted throughout the gym--two in the first weight room, two in the second weight room, four in the cardio and basketball court room, and one in the front office. These fans are used to keep the gym cooler during warm weather, as there is no air conditioning, and also to prevent the floors from getting moist and sticky due to lack of airflow in the building. The Hurricane fans are kept on throughout the entire day when the gym is open for the months of May through September, when the weather is expected to be warm. Again, the gym is open for 85.75 hours per week, or approximately 343 (85.75* 4 weeks) hours per month, meaning that the fans are kept on for this entire duration. In addition, the fans are old and outdated, meaning that there is a multitude of energy-efficient alternatives available. For example, there are 1,000 ventilating fans listed on Energy Star's offerings website that are energy-efficient, with varying speeds, sizes, and types (energystar.gov). By meeting the Energy Star efficiency requirements, these products meet the efficiency guidelines that are set by the U.S. Environmental Protection Agency (*ibid*). By simply updating the current energy-inefficient fans with Energy Star-certified alternatives, The Hut can achieve additional significant energy and cost savings during the hours of operation.

Third, we suggest installing solar panels on the roof of The Hut. Installing solar panels has been a long-resisted idea at Boston College due to university concerns that the classic BC buildings' aesthetics would be negatively affected by large, clunky paneling. However, The Hut is a strong candidate for an exception to be made. First, it is on Newton Campus, meaning that it is not located on main campus where the classic gothic buildings exist (Fulton, Devlin, Gasson, Stokes South and North, etc.). Second, The Hut is already considered to be an older, less impressive building, meaning that its aesthetics are not at risk of being harmed. By implementing solar panels, The Hut can rely on solar energy to power the lights and fans within the building, drastically reducing energy costs over time, as well as decreasing energy consumption in the future.

Finally, we identified an easy solution that involves a simple change in management practices rather than a change in equipment. We found it surprising that the lights are kept on throughout each room in the building during the entire day, even when no students are using the facility. Based on the February 2020 data of student sign-ins, from February 1st to February 28th, there were 389 fifteen-minute time slots where only one student swiped into the building, and 257 fifteen-minute time slots where only two students swiped into the building. With a conservative assumption that these two sample students completed their workouts in separate rooms within The Hut (e.g. one student in the weight room and one student in the cardio room), there is still at least one extra room where the lights are kept on with zero students occupying the space. In the future, if there is ever any time slot where no students are in a given room, the lights should be switched off. While this may not seem to have large energy saving potential, the accumulation of hours would quickly add up. Turning off the lights when no one is in the room, combined with switching to 100% LED lighting, would result in significant energy savings and cost savings. Most importantly, this solution requires $0 to implement: no extra equipment is needed. The only change is purely behavioral in nature, requiring whichever employee is working during a shift to turn the lights off in empty rooms, and put up signage telling students to turn the lights off when leaving whichever room in which they are working out.

As a result, our ideal model for how The Hut will operate in a future, post-pandemic scenario is as follows: first, all cardio equipment that requires energy consumption will be replaced with self-powering equipment that feeds energy back into The Hut, to power lighting and fans. Second, all non-LED lighting--including the cardio and basketball room as well as the weight rooms--will be replaced with LED lighting to improve cost and energy efficiency. Third, the large, outdated Hurricane fans in each room will be replaced with Energy Star-certified alternatives, again to improve cost and energy efficiency while increasing ventilation and reducing moisture accumulation. Fourth, The Hut will have solar panels on the roof, as these panels will not risk negatively impacting the building’s aesthetics on Newton Campus. Finally, building management will turn off the lights in the cardio and weight rooms (four rooms total) when there are no students occupying the space, which potentially occurs often according to the data pulled from February of 2020. As a result, BC could become known for achieving reputable, forward-looking sustainability goals in its Newton Campus recreational facility.

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# VIII. Appendices

Exhibit 1: Treadmill power output for various running speeds

## Treadmill Power Output

| Speed (mph) | Pace (min/mile) | Power (Watt) |
|---|---|---|
| 4.5 | 13:20 | 146 |
| 5.0 | 12:00 | 163 |
| 5.5 | 10:54 | 180 |
| 6.0 | 10:00 | 196 |
| 6.5 | 9:13 | 213 |
| 7.0 | 8:34 | 230 |
| 7.5 | 8:00 | 246 |
| 8.0 | 7:30 | 263 |
| 8.5 | 7:03 | 280 |

Exhibit 2: Indoor Cycle power for various biking speeds

## Bike Power Output

| Speed (mph) | Power (Watt) |
|---|---|
| 15 | 83 |
| 16 | 97 |
| 17 | 113 |
| 18 | 131 |
| 19 | 151 |
| 20 | 173 |
| 21 | 197 |
| 22 | 224 |

Exhibit 3: Elliptical power for various treadmill power effort percentages

## Elliptical Power Output

| Treadmill power: | 196 |
|---|---|
| **Percent power compared to treadmill** | **Power (Watt)** |
| 50% | 98 |
| 60% | 118 |
| 70% | 137 |
| 80% | 157 |
| 90% | 176 |
| 100% | 196 |
| 110% | 216 |
| 120% | 235 |

Exhibit 4: Standard energy assumptions

## Quonset Hut Energy Statistics

| Standard Assumptions | Value |
|---|---|
| Operational Hours/Week | 85.75 |
| Operational Days/Academic Year | 230 |
| Total Operational Hours/Academic Year | 2,818 |
| Entrants/Day | 94 |
| Average Students in Hut | 7.67 |
| Average Workout Duration (hours) | 1 |
| Average Percent Time Spent on Cardio Equipment | 50% |
| Average Cardio Workout (hours) | 0.5 |
| Average Students in Hut doing Cardio Exercise | 3.84 |
| Number of Treadmills | 4 |
| Number of Indoor Cycles | 4 |
| Number of Ellipticals | 2 |
| Cardio Equipment Utilization Factor | 38.37% |
| Average Energy Generated (treadmill) (Watts/hour) | 196 |
| Average Energy Generated (indoor cycle) (Watts/hour) | 131 |
| Average Energy Generated (elliptical) (Watts/hours) | 137 |
| Average Energy Generated (all cardio) (Watts/hour) | 155 |
| Average Cardio Equipment Energy Generation (Watts/Operational Week) | 50,885 |
| Average Cardio Equipment Energy Generation (Watts/Operational Academic Year | 1,671,947 |
| Treadmill Energy Generation (Watts/Operational Academic Year) | 706,253 |
| Indoor Cycle Energy Generation (Watts/Operational Academic Year) | 472,037 |
| Elliptical Cycle Energy Generation (Watts/Operational Academic Year) | 493,657 |

Exhibit 5: Price differences between Eco-Powr and Life Fitness cardio equipment

| Cardio Equipment | Price |
|---|---|
| Life Fitness Platinum Club Series Treadmill Price | 5,669 |
| G690 Eco-Powr Treadmill Price | 6,414 |
| Treadmill Price Difference | 745 |
| | |
| Life Fitness IC6 Indoor Cycle Price | 1,439 |
| G510 Eco-Powr Indoor Cycle | 1,797 |
| Indoor Cycle Price Difference | 358 |
| | |
| Life Fitness Platinum Club Series Elliptical Cross-Trainer | 5,039 |
| G876 Elliptical Price | 5,277 |
| Elliptical/Cross Trainer Price Difference | 238 |
| | |
| Total Cardio Machine Price Difference | 4,888 |

# Exhibit 6: LCOE values for 5 years under standard assumptions

| Cost-Benefit Analysis | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Cardio Machine Price Difference | 4,888 | | | | | | | | | | | | | |
| Estimated Useful Life of New Equipment (Years) | 5 | ** | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| Total Project LCOE ($/kWh) | 0.468 | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| Year | | Year 1 | | | | | | | | | | | | |
| Month | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | Total |
| Total Price Difference (monthly) | 978 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 1,760 |
| Discounted Price | 978 | 65 | 64 | 64 | 63 | 63 | 62 | 61 | 61 | 60 | 60 | 59 | 59 | 1,719 |
| LCOE ($/kWh) | 7.016 | 0.464 | 0.460 | 0.456 | 0.452 | 0.449 | 0.445 | 0.441 | 0.438 | 0.434 | 0.431 | 0.427 | 0.423 | 0.949 |
| | | | | | | | | | | | | | | |
| Year | | Year 2 | | | | | | | | | | | | |
| Month | | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | Total |
| Total Price Difference (monthly) | | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 782 |
| Discounted Price | | 59 | 58 | 58 | 57 | 57 | 56 | 56 | 55 | 55 | 54 | 54 | 53 | 671 |
| LCOE ($/kWh) | | 0.4199 | 0.4165 | 0.4130 | 0.4096 | 0.4062 | 0.4029 | 0.3995 | 0.3962 | 0.3930 | 0.3897 | 0.3865 | 0.3833 | 0.4014 |
| | | | | | | | | | | | | | | |
| Year | | Year 3 | | | | | | | | | | | | |
| Month | | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | Total |
| Total Price Difference (monthly) | | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 782 |
| Discounted Price | | 53 | 53 | 52 | 52 | 51 | 51 | 50 | 50 | 50 | 49 | 49 | 48 | 607 |
| LCOE ($/kWh) | | 0.3801 | 0.3770 | 0.3739 | 0.3708 | 0.3677 | 0.3647 | 0.3617 | 0.3587 | 0.3557 | 0.3528 | 0.3499 | 0.3470 | 0.3633 |
| | | | | | | | | | | | | | | |
| Year | | Year 4 | | | | | | | | | | | | |
| Month | | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | Total |
| Total Price Difference (monthly) | | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 782 |
| Discounted Price | | 48 | 48 | 47 | 47 | 46 | 46 | 46 | 45 | 45 | 44 | 44 | 44 | 550 |
| LCOE ($/kWh) | | 0.3441 | 0.3412 | 0.3384 | 0.3356 | 0.3329 | 0.3301 | 0.3274 | 0.3247 | 0.3220 | 0.3193 | 0.3167 | 0.3141 | 0.3289 |
| | | | | | | | | | | | | | | |
| Year | | Year 5 | | | | | | | | | | | | |
| Month | | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | Total |
| Total Price Difference (monthly) | | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 782 |
| Discounted Price | | 43 | 43 | 43 | 42 | 42 | 42 | 41 | 41 | 41 | 40 | 40 | 40 | 498 |
| LCOE ($/kWh) | | 0.3115 | 0.3089 | 0.3064 | 0.3038 | 0.3013 | 0.2988 | 0.2963 | 0.2939 | 0.2915 | 0.2891 | 0.2867 | 0.2843 | 0.2977 |

Exhibit 7: 2020 Lazard's LCOE values

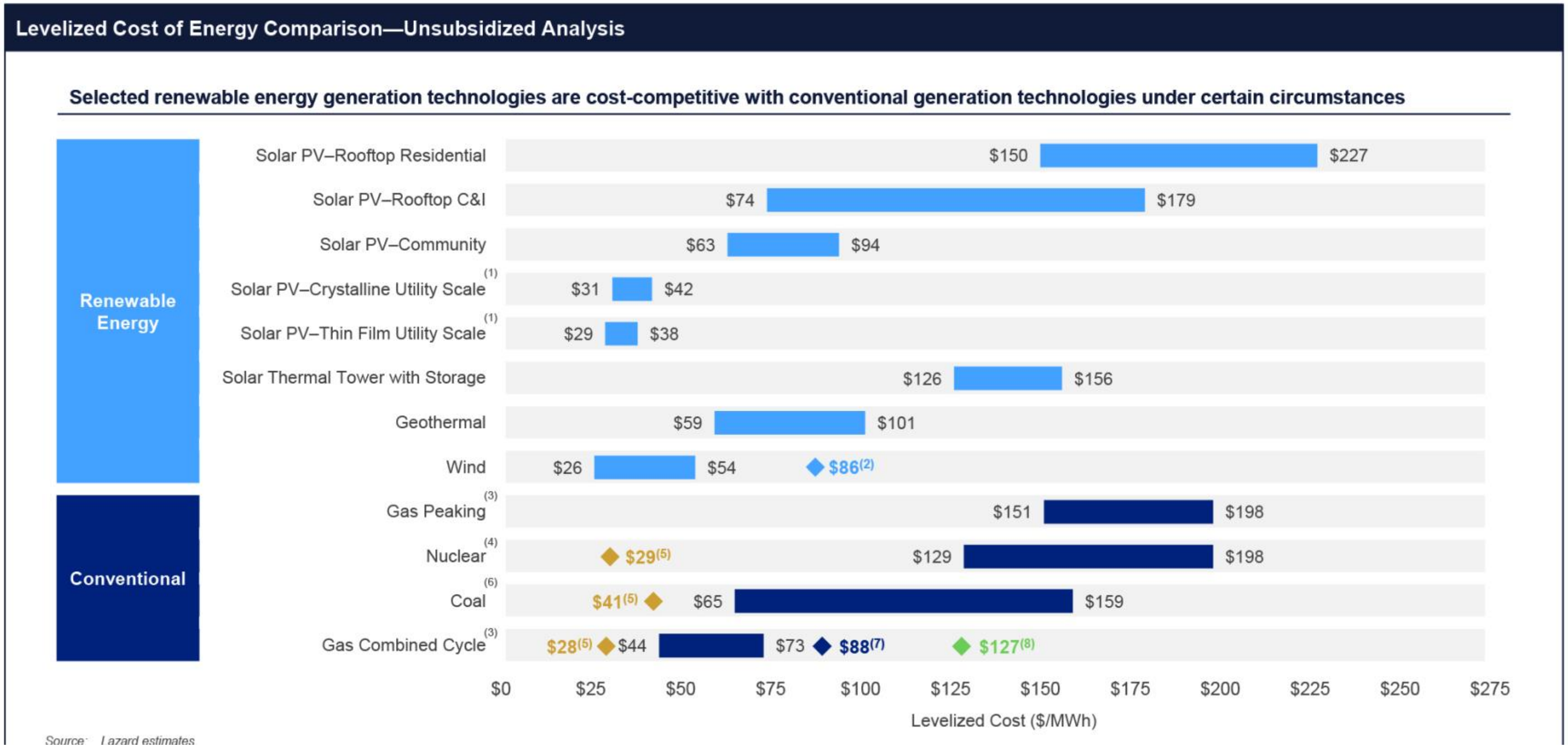

Exhibit 8: Scenario 1 energy generation and cost-benefit analysis

| Scenario 1 Assumptions | Value |
|---|---|
| Average Percent Time Spent on Cardio Equipment | 70% |
| Average Cardio Workout (hours) | 0.7 |
| Average Students in Hut doing Cardio Exercise | 5.37 |
| Cardio Equipment Utilization Factor | 53.71% |
| Average Cardio Equipment Energy Generation (Watts/Operational Week) | 71,239 |
| Average Cardio Equipment Energy Generation (Watts/Operational Academic Year | 2,340,725 |
| Treadmill Energy Generation (Watts/Operational Academic Year) | 988,755 |
| Indoor Cycle Energy Generation (Watts/Operational Academic Year) | 660,851 |
| Elliptical Cycle Energy Generation (Watts/Operational Academic Year) | 691,119 |

| Cost-Benefit Analysis | |
|---|---|
| Total Cardio Machine Price Difference | 4,888 |
| Estimated Useful Life of New Equipment (Years) | 5 |
| | |
| Total Project LCOE ($/kWh) | 0.334 |

Exhibit 9: Scenario 2 energy generation and cost-benefit analysis

| Scenario 2 Assumptions | Value |
|---|---|
| Average Percent Time Spent on Cardio Equipment | 70% |
| Average Cardio Workout (hours) | 0.7 |
| Average Students in Hut doing Cardio Exercise | 5.37 |
| Number of Treadmills | 3 |
| Number of Indoor Cycles | 3 |
| Number of Ellipticals | 1 |
| Cardio Equipment Utilization Factor | 76.73% |
| Average Cardio Equipment Energy Generation (Watts/Operational Week) | 71,239 |
| Average Cardio Equipment Energy Generation (Watts/Operational Academic Year | 2,340,725 |
| Treadmill Energy Generation (Watts/Operational Academic Year) | 988,755 |
| Indoor Cycle Energy Generation (Watts/Operational Academic Year) | 660,851 |
| Elliptical Cycle Energy Generation (Watts/Operational Academic Year) | 691,119 |

| Cost-Benefit Analysis | |
|---|---|
| Total Cardio Machine Price Difference | 3,547 |
| Estimated Useful Life of New Equipment (Years) | 5 |
| | |
| Total Project LCOE ($/kWh) | 0.243 |

Exhibit 10: Scenario 3 energy generation and cost-benefit analysis

| Scenario 3 Assumptions | Value |
|---|---|
| Entrants/Day | 120 |
| Average Students in Hut | 9.80 |
| Average Workout Duration (hours) | 1 |
| Average Percent Time Spent on Cardio Equipment | 70% |
| Average Cardio Workout (hours) | 0.7 |
| Average Students in Hut doing Cardio Exercise | 6.86 |
| Number of Treadmills | 3 |
| Number of Indoor Cycles | 3 |
| Number of Ellipticals | 1 |
| Cardio Equipment Utilization Factor | 97.96% |
| Average Cardio Equipment Energy Generation (Watts/Operational Week) | 90,944 |
| Average Cardio Equipment Energy Generation (Watts/Operational Academic Year | 2,988,160 |
| Treadmill Energy Generation (Watts/Operational Academic Year) | 1,262,240 |
| Indoor Cycle Energy Generation (Watts/Operational Academic Year) | 843,640 |
| Elliptical Cycle Energy Generation (Watts/Operational Academic Year) | 882,280 |

| Cost-Benefit Analysis | |
|---|---|
| Total Cardio Machine Price Difference | 3,547 |
| Estimated Useful Life of New Equipment (Years) | 5 |
| | |
| Total Project LCOE ($/kWh) | 0.190 |

Exhibit 11: Scenario 4 energy generation and cost-benefit analysis

| Scenario 4 Assumptions | Value |
|---|---|
| Entrants/Day | 120 |
| Average Students in Hut | 9.80 |
| Average Workout Duration (hours) | 1 |
| Average Percent Time Spent on Cardio Equipment | 70% |
| Average Cardio Workout (hours) | 0.7 |
| Average Students in Hut doing Cardio Exercise | 6.86 |
| Number of Treadmills | 3 |
| Number of Indoor Cycles | 3 |
| Number of Ellipticals | 1 |
| Cardio Equipment Utilization Factor | 97.96% |
| Average Energy Generated (treadmill) (Watts/hour) | 235 |
| Average Energy Generated (indoor cycle) (Watts/hour) | 157 |
| Average Energy Generated (elliptical) (Watts/hours) | 164 |
| Average Energy Generated (all cardio) (Watts/hour) | 186 |
| Average Cardio Equipment Energy Generation (Watts/Operational Week) | 109,133 |
| Average Cardio Equipment Energy Generation (Watts/Operational Academic Year | 3,585,792 |
| Treadmill Energy Generation (Watts/Operational Academic Year) | 1,514,688 |
| Indoor Cycle Energy Generation (Watts/Operational Academic Year) | 1,012,368 |
| Elliptical Cycle Energy Generation (Watts/Operational Academic Year) | 1,058,736 |

Cost-Benefit Analysis

| | |
|---|---|
| Total Cardio Machine Price Difference | 3,547 |
| Estimated Useful Life of New Equipment (Years) | 5 |
| | |
| Total Project LCOE ($/kWh) | 0.158 |

Exhibit 12: Scenario 5 energy generation and cost-benefit analysis

| Scenario 5 Assumptions | Value |
|---|---|
| Entrants/Day | 120 |
| Average Students in Hut | 9.80 |
| Average Workout Duration (hours) | 1 |
| Average Percent Time Spent on Cardio Equipment | 70% |
| Average Cardio Workout (hours) | 0.7 |
| Average Students in Hut doing Cardio Exercise | 6.86 |
| Number of Treadmills | 1 |
| Number of Indoor Cycles | 1 |
| Number of Ellipticals | 5 |
| Cardio Equipment Utilization Factor | 97.96% |
| Average Energy Generated (treadmill) (Watts/hour) | 235 |
| Average Energy Generated (indoor cycle) (Watts/hour) | 157 |
| Average Energy Generated (elliptical) (Watts/hours) | 164 |
| Average Energy Generated (all cardio) (Watts/hour) | 186 |
| Average Cardio Equipment Energy Generation (Watts/Operational Week) | 109,133 |
| Average Cardio Equipment Energy Generation (Watts/Operational Academic Year | 3,585,792 |
| Treadmill Energy Generation (Watts/Operational Academic Year) | 1,514,688 |
| Indoor Cycle Energy Generation (Watts/Operational Academic Year) | 1,012,368 |
| Elliptical Cycle Energy Generation (Watts/Operational Academic Year) | 1,058,736 |

| Cost-Benefit Analysis | |
|---|---|
| Total Cardio Machine Price Difference | 2,293 |
| Estimated Useful Life of New Equipment (Years) | 5 |
| | |
| Total Project LCOE ($/kWh) | 0.102 |

# Exhibit 13: Scenario 6 cost-benefit analysis

| Cost-Benefit Analysis | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Cardio Machine Price Difference | 2,293 | | | | | | | | | | | | | |
| Estimated Useful Life of New Equipment (Years) | 10 | ** | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| Total Project LCOE ($/kWh) | 0.044 | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| Year | | Year 1 | | | | | | | | | | | | |
| Month | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | Total |
| Total Price Difference (monthly) | 459 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 642 |
| Discounted Price | 459 | 15 | 15 | 15 | 15 | 15 | 15 | 14 | 14 | 14 | 14 | 14 | 14 | 632 |
| LCOE ($/kWh) | 1.535 | 0.051 | 0.050 | 0.050 | 0.049 | 0.049 | 0.049 | 0.048 | 0.048 | 0.047 | 0.047 | 0.047 | 0.046 | 0.163 |
| | | | | | | | | | | | | | | |
| Year | | Year 2 | | | | | | | | | | | | |
| Month | | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | Total |
| Total Price Difference (monthly) | | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 183 |
| Discounted Price | | 14 | 14 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 157 |
| LCOE ($/kWh) | | 0.0459 | 0.0455 | 0.0452 | 0.0448 | 0.0444 | 0.0441 | 0.0437 | 0.0433 | 0.0430 | 0.0426 | 0.0423 | 0.0419 | 0.0439 |
| | | | | | | | | | | | | | | |
| Year | | Year 3 | | | | | | | | | | | | |
| Month | | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | Total |
| Total Price Difference (monthly) | | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 183 |
| Discounted Price | | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 11 | 11 | 142 |
| LCOE ($/kWh) | | 0.0416 | 0.0412 | 0.0409 | 0.0406 | 0.0402 | 0.0399 | 0.0396 | 0.0392 | 0.0389 | 0.0386 | 0.0383 | 0.0379 | 0.0397 |
| | | | | | | | | | | | | | | |
| Year | | Year 4 | | | | | | | | | | | | |
| Month | | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | Total |
| Total Price Difference (monthly) | | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 183 |
| Discounted Price | | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 10 | 10 | 10 | 129 |
| LCOE ($/kWh) | | 0.0376 | 0.0373 | 0.0370 | 0.0367 | 0.0364 | 0.0361 | 0.0358 | 0.0355 | 0.0352 | 0.0349 | 0.0346 | 0.0343 | 0.0360 |
| | | | | | | | | | | | | | | |
| Year | | Year 5 | | | | | | | | | | | | |
| Month | | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | Total |
| Total Price Difference (monthly) | | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 183 |
| Discounted Price | | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 9 | 9 | 9 | 117 |
| LCOE ($/kWh) | | 0.0341 | 0.0338 | 0.0335 | 0.0332 | 0.0330 | 0.0327 | 0.0324 | 0.0321 | 0.0319 | 0.0316 | 0.0314 | 0.0311 | 0.0326 |

Exhibit 13 cont.

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | | Year 6 | | | | | | | | | | | | |
| Month | | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | Total |
| Total Price Difference (monthly) | | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 183 |
| Discounted Price | | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 8 | 8 | 106 |
| LCOE ($/kWh) | | 0.031 | 0.031 | 0.030 | 0.030 | 0.030 | 0.030 | 0.029 | 0.029 | 0.029 | 0.029 | 0.028 | 0.028 | 0.029 |
| | | | | | | | | | | | | | | |
| Year | | Year 7 | | | | | | | | | | | | |
| Month | | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | Total |
| Total Price Difference (monthly) | | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 183 |
| Discounted Price | | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 96 |
| LCOE ($/kWh) | | 0.0279 | 0.0277 | 0.0275 | 0.0272 | 0.0270 | 0.0268 | 0.0266 | 0.0263 | 0.0261 | 0.0259 | 0.0257 | 0.0255 | 0.0267 |
| | | | | | | | | | | | | | | |
| Year | | Year 8 | | | | | | | | | | | | |
| Month | | 85 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 | 95 | 96 | Total |
| Total Price Difference (monthly) | | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 183 |
| Discounted Price | | 8 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 87 |
| LCOE ($/kWh) | | 0.0253 | 0.0251 | 0.0249 | 0.0246 | 0.0244 | 0.0242 | 0.0240 | 0.0238 | 0.0236 | 0.0234 | 0.0233 | 0.0231 | 0.0241 |
| | | | | | | | | | | | | | | |
| Year | | Year 9 | | | | | | | | | | | | |
| Month | | 97 | 98 | 99 | 100 | 101 | 102 | 103 | 104 | 105 | 106 | 107 | 108 | Total |
| Total Price Difference (monthly) | | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 183 |
| Discounted Price | | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 6 | 6 | 6 | 6 | 6 | 78 |
| LCOE ($/kWh) | | 0.0229 | 0.0227 | 0.0225 | 0.0223 | 0.0221 | 0.0219 | 0.0218 | 0.0216 | 0.0214 | 0.0212 | 0.0211 | 0.0209 | 0.0219 |
| | | | | | | | | | | | | | | |
| Year | | Year 10 | | | | | | | | | | | | |
| Month | | 109 | 110 | 111 | 112 | 113 | 114 | 115 | 116 | 117 | 118 | 119 | 120 | Total |
| Total Price Difference (monthly) | | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 183 |
| Discounted Price | | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 71 |
| LCOE ($/kWh) | | 0.0207 | 0.0205 | 0.0204 | 0.0202 | 0.0200 | 0.0199 | 0.0197 | 0.0195 | 0.0194 | 0.0192 | 0.0191 | 0.0189 | 0.0198 |

Exhibit 14: Summary LCOE values for the scenarios

## Summary of Scenarios

| Scenario | LCOE ($/kWh) |
|---|---|
| Standard Assumption | 0.468 |
| Scenario 1: 70% average time spent on cardio equipment | 0.334 |
| Scenario 2: One less machine for each type of cardio exercise | 0.243 |
| Scenario 3: 120 entrants/day in the Hut | 0.190 |
| Scenario 4: 20% increase in Energy Generation for each cardio machine | 0.158 |
| Scenario 5: 5 ellipticals, 1 treadmill and 1 indoor cycle | 0.102 |
| Scenario 6: 10 year financing | 0.044 |

Exhibit 15: Estimated Cost of Electricity 2021-2050

| Year | ($/kWh) in X year |
|---|---|
| 2021 | 0.184 |
| 2022 | 0.1882504 |
| 2023 | 0.1925989842 |
| 2024 | 0.1970480208 |
| 2025 | 0.2015998301 |
| 2026 | 0.2062567861 |
| 2027 | 0.2110213179 |
| 2028 | 0.2158959103 |
| 2029 | 0.2208831059 |
| 2030 | 0.2259855056 |
| 2031 | 0.2312057708 |
| 2032 | 0.2365466241 |
| 2033 | 0.2420108511 |
| 2034 | 0.2476013018 |
| 2035 | 0.2533208918 |
| 2036 | 0.2591726044 |
| 2037 | 0.2651594916 |
| 2038 | 0.2712846759 |
| 2039 | 0.2775513519 |
| 2040 | 0.2839627881 |
| 2041 | 0.2905223285 |
| 2042 | 0.2972333943 |
| 2043 | 0.3040994857 |
| 2044 | 0.3111241838 |
| 2045 | 0.3183111525 |
| 2046 | 0.3256641401 |
| 2047 | 0.3331869817 |
| 2048 | 0.340883601 |
| 2049 | 0.3487580122 |
| 2050 | 0.3568143223 |

Exhibit 16: Electricity Cost Savings Over Time; Indoor Cycle, Standard Scenario

| Year | In X Year ($) | Cumulative total ($) |
|---|---|---|
| 2021 | 86.854808 | 86.854808 |
| 2022 | 88.86115406 | 175.7159621 |
| 2023 | 90.91384672 | 266.6298088 |
| 2024 | 93.01395658 | 359.6437654 |
| 2025 | 95.16257898 | 454.8063444 |
| 2026 | 97.36083455 | 552.1671789 |
| 2027 | 99.60986983 | 651.7770487 |
| 2028 | 101.9108578 | 753.6879066 |
| 2029 | 104.2649986 | 857.9529052 |
| 2030 | 106.6735201 | 964.6264253 |
| 2031 | 109.1376784 | 1073.764104 |
| 2032 | 111.6587588 | 1185.422863 |
| 2033 | 114.2380761 | 1299.660939 |
| 2034 | 116.8769757 | 1416.537914 |
| 2035 | 119.5768338 | 1536.114748 |
| 2036 | 122.3390587 | 1658.453807 |
| 2037 | 125.1650909 | 1783.618898 |
| 2038 | 128.0564045 | 1911.675302 |
| 2039 | 131.0145075 | 2042.68981 |
| 2040 | 134.0409426 | 2176.730752 |
| 2041 | 137.1372884 | 2313.868041 |
| 2042 | 140.3051597 | 2454.173201 |
| 2043 | 143.5462089 | 2597.719409 |
| 2044 | 146.8621264 | 2744.581536 |
| 2045 | 150.2546415 | 2894.836177 |
| 2046 | 153.7255237 | 3048.561701 |
| 2047 | 157.2765833 | 3205.838284 |
| 2048 | 160.9096724 | 3366.747957 |
| 2049 | 164.6266858 | 3531.374642 |
| 2050 | 168.4295622 | 3699.804205 |

Exhibit 17: Electricity Cost Savings Over Time; Indoor Cycle, Scenario 1

| Year | In X Year ($) | Cumulative total ($) |
|---|---|---|
| 2021 | 121.596584 | 121.596584 |
| 2022 | 124.4054651 | 246.0020491 |
| 2023 | 127.2792313 | 373.2812804 |
| 2024 | 130.2193816 | 503.500662 |
| 2025 | 133.2274493 | 636.7281113 |
| 2026 | 136.3050034 | 773.0331147 |
| 2027 | 139.4536489 | 912.4867636 |
| 2028 | 142.6750282 | 1055.161792 |
| 2029 | 145.9708214 | 1201.132613 |
| 2030 | 149.3427474 | 1350.475361 |
| 2031 | 152.7925648 | 1503.267925 |
| 2032 | 156.3220731 | 1659.589999 |
| 2033 | 159.933113 | 1819.523111 |
| 2034 | 163.6275679 | 1983.150679 |
| 2035 | 167.4073647 | 2150.558044 |
| 2036 | 171.2744748 | 2321.832519 |
| 2037 | 175.2309152 | 2497.063434 |
| 2038 | 179.2787493 | 2676.342183 |
| 2039 | 183.4200884 | 2859.762272 |
| 2040 | 187.6570925 | 3047.419364 |
| 2041 | 191.9919713 | 3239.411336 |
| 2042 | 196.4269859 | 3435.838321 |
| 2043 | 200.9644492 | 3636.802771 |
| 2044 | 205.606728 | 3842.409499 |
| 2045 | 210.3562434 | 4052.765742 |
| 2046 | 215.2154726 | 4267.981215 |
| 2047 | 220.1869501 | 4488.168165 |
| 2048 | 225.2732686 | 4713.441433 |
| 2049 | 230.4770811 | 4943.918515 |
| 2050 | 235.8011017 | 5179.719616 |

Exhibit 18: Electricity Cost Savings Over Time; Treadmill, Standard Scenario

| Year | In X Year ($) | Cumulative total ($) |
|---|---|---|
| 2021 | 129.950552 | 129.950552 |
| 2022 | 132.9524098 | 262.9029618 |
| 2023 | 136.0236104 | 398.9265722 |
| 2024 | 139.1657558 | 538.092328 |
| 2025 | 142.3804848 | 680.4728128 |
| 2026 | 145.669474 | 826.1422867 |
| 2027 | 149.0344388 | 975.1767256 |
| 2028 | 152.4771344 | 1127.65386 |
| 2029 | 155.9993562 | 1283.653216 |
| 2030 | 159.6029413 | 1443.256157 |
| 2031 | 163.2897692 | 1606.545927 |
| 2032 | 167.0617629 | 1773.60769 |
| 2033 | 170.9208896 | 1944.528579 |
| 2034 | 174.8691622 | 2119.397741 |
| 2035 | 178.9086398 | 2298.306381 |
| 2036 | 183.0414294 | 2481.347811 |
| 2037 | 187.2696864 | 2668.617497 |
| 2038 | 191.5956162 | 2860.213113 |
| 2039 | 196.0214749 | 3056.234588 |
| 2040 | 200.549571 | 3256.784159 |
| 2041 | 205.1822661 | 3461.966425 |
| 2042 | 209.9219764 | 3671.888402 |
| 2043 | 214.7711741 | 3886.659576 |
| 2044 | 219.7323882 | 4106.391964 |
| 2045 | 224.8082064 | 4331.20017 |
| 2046 | 230.0012759 | 4561.201446 |
| 2047 | 235.3143054 | 4796.515752 |
| 2048 | 240.7500659 | 5037.265817 |
| 2049 | 246.3113924 | 5283.57721 |
| 2050 | 252.0011855 | 5535.578395 |

Exhibit 19: Electricity Cost Savings Over Time; Treadmill, Scenario 1

| Year | In X Year ($) | Cumulative total ($) |
|---|---|---|
| 2021 | 181.93092 | 181.93092 |
| 2022 | 186.1335243 | 368.0644443 |
| 2023 | 190.4332087 | 558.4976529 |
| 2024 | 194.8322158 | 753.3298687 |
| 2025 | 199.33284 | 952.6627087 |
| 2026 | 203.9374286 | 1156.600137 |
| 2027 | 208.6483832 | 1365.24852 |
| 2028 | 213.4681608 | 1578.716681 |
| 2029 | 218.3992753 | 1797.115957 |
| 2030 | 223.4442986 | 2020.560255 |
| 2031 | 228.6058619 | 2249.166117 |
| 2032 | 233.8866573 | 2483.052774 |
| 2033 | 239.2894391 | 2722.342213 |
| 2034 | 244.8170251 | 2967.159239 |
| 2035 | 250.4722984 | 3217.631537 |
| 2036 | 256.2582085 | 3473.889745 |
| 2037 | 262.1777731 | 3736.067519 |
| 2038 | 268.2340797 | 4004.301598 |
| 2039 | 274.4302869 | 4278.731885 |
| 2040 | 280.7696265 | 4559.501512 |
| 2041 | 287.2554049 | 4846.756917 |
| 2042 | 293.8910048 | 5140.647921 |
| 2043 | 300.679887 | 5441.327808 |
| 2044 | 307.6255924 | 5748.953401 |
| 2045 | 314.7317436 | 6063.685144 |
| 2046 | 322.0020468 | 6385.687191 |
| 2047 | 329.4402941 | 6715.127485 |
| 2048 | 337.0503649 | 7052.17785 |
| 2049 | 344.8362283 | 7397.014079 |
| 2050 | 352.8019452 | 7749.816024 |

Exhibit 20: Electricity Cost Savings Over Time; Elliptical, Standard Scenario

| Year | In X Year ($) | Cumulative total ($) |
|---|---|---|
| 2021 | 90.832888 | 90.832888 |
| 2022 | 92.93112771 | 183.7640157 |
| 2023 | 95.07783676 | 278.8418525 |
| 2024 | 97.27413479 | 376.1159873 |
| 2025 | 99.52116731 | 475.6371546 |
| 2026 | 101.8201063 | 577.4572608 |
| 2027 | 104.1721507 | 681.6294116 |
| 2028 | 106.5785274 | 788.207939 |
| 2029 | 109.0404914 | 897.2484304 |
| 2030 | 111.5593267 | 1008.807757 |
| 2031 | 114.1363472 | 1122.944104 |
| 2032 | 116.7728968 | 1239.717001 |
| 2033 | 119.4703507 | 1359.187352 |
| 2034 | 122.2301158 | 1481.417468 |
| 2035 | 125.0536315 | 1606.471099 |
| 2036 | 127.9423704 | 1734.41347 |
| 2037 | 130.8978391 | 1865.311309 |
| 2038 | 133.9215792 | 1999.232888 |
| 2039 | 137.0151677 | 2136.248056 |
| 2040 | 140.1802181 | 2276.428274 |
| 2041 | 143.4183811 | 2419.846655 |
| 2042 | 146.7313457 | 2566.578001 |
| 2043 | 150.1208398 | 2716.69884 |
| 2044 | 153.5886312 | 2870.287472 |
| 2045 | 157.1365286 | 3027.424 |
| 2046 | 160.7663824 | 3188.190383 |
| 2047 | 164.4800858 | 3352.670468 |
| 2048 | 168.2795758 | 3520.950044 |
| 2049 | 172.166834 | 3693.116878 |
| 2050 | 176.1438879 | 3869.260766 |

Exhibit 21: Electricity Cost Savings Over Time; Elliptical, Scenario 1

| Year | In X Year ($) | Cumulative total ($) |
|---|---|---|
| 2021 | 127.165896 | 127.165896 |
| 2022 | 130.1034282 | 257.2693242 |
| 2023 | 133.1088174 | 390.3781416 |
| 2024 | 136.1836311 | 526.5617727 |
| 2025 | 139.3294729 | 665.8912456 |
| 2026 | 142.5479838 | 808.4392294 |
| 2027 | 145.8408422 | 954.2800716 |
| 2028 | 149.2097657 | 1103.489837 |
| 2029 | 152.6565112 | 1256.146348 |
| 2030 | 156.1828766 | 1412.329225 |
| 2031 | 159.7907011 | 1572.119926 |
| 2032 | 163.4818663 | 1735.601793 |
| 2033 | 167.2582974 | 1902.86009 |
| 2034 | 171.1219641 | 2073.982054 |
| 2035 | 175.0748814 | 2249.056935 |
| 2036 | 179.1191112 | 2428.176047 |
| 2037 | 183.2567627 | 2611.432809 |
| 2038 | 187.4899939 | 2798.922803 |
| 2039 | 191.8210128 | 2990.743816 |
| 2040 | 196.2520781 | 3186.995894 |
| 2041 | 200.7855012 | 3387.781395 |
| 2042 | 205.4236462 | 3593.205042 |
| 2043 | 210.1689325 | 3803.373974 |
| 2044 | 215.0238348 | 4018.397809 |
| 2045 | 219.9908854 | 4238.388694 |
| 2046 | 225.0726748 | 4463.461369 |
| 2047 | 230.2718536 | 4693.733223 |
| 2048 | 235.5911334 | 4929.324356 |
| 2049 | 241.0332886 | 5170.357645 |
| 2050 | 246.6011576 | 5416.958802 |

Exhibit 22: Payback Periods for Each Machine and Scenario

| Machine | Scenario | Payback time (years) | Total Payback time (years) |
|---|---|---|---|
| Indoor Cycle | Standard | 3-4 | 17-18 |
| | 1 | 2-3 | 12-13 |
| Treadmill | Standard | 5-6 | 30+ |
| | 1 | 4-5 | 26-27 |
| Elliptical | Standard | 2-3 | 30+ |
| | 1 | 1-2 | 29-30 |