UBC Social Ecological Economic Development Studies (SEEDS) Student Report

Designing a Root Cellar for the Alma Mater Society's New Student Union Building

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Abstract

The Alma Mater Society (AMS) is building a new Student Union Building (SUB) to be a leader in green building technology by achieving LEED certified platinum status by the Canada Green Building Council. As part of the designs, a root cellar is to be included in this plan. The goal of this project and paper is to design and evaluate the benefits of having a root cellar. The benefits of a root cellar were evaluated by considering the economic, environmental and social benefits and challenges of storing large quantities of produce purchased in bulk wholesale versus weekly purchase orders. Conceptual design of the cellar was based on the goal of achieving a net zero energy consumption to fit with LEED Certification. A needs assessment was performed for the AMS Food and Beverage department to determine what crops would be best suited for storage in the root cellar. A seasonal buying guide was then prepared for the root cellar based on the findings of the needs assessment report. The final product presented is a medium to large size, roughly 300 square foot facility used to store primarily root vegetables. The cellars construction and physical design parameters are based off of BC government recommended building guide lines for a small root cellar.

Introduction

The University of British Columbia's (UBC) Alma Mater Society (AMS) is currently in the development stages for designing a brand new centrally located Student Union Building (SUB). As part of the new SUB design, there are plans to include a root cellar for the potential storage of vegetables and fruits. It was our job in this project to design the root cellar, perform a needs assessment, analyze our design with a triple bottom line evaluation, and present a seasonal buying guide for the produce to be stored in the cellar.

According to Nancy Toogood, one of our stakeholders in this project, the AMS has plans to make the new SUB a leader in environmental design. In order to achieve this goal, the AMS is following the Leadership in Energy and Environmental Design (LEED) “New Construction” guidelines set by the Canada Green Building Council and is aiming for its highest level of certification, platinum status.

The LEED rating system and certification is a credit based system; guidelines are set in the categories: sustainable sties, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality, innovation in design and regional priority. Within each of these categories are specific requirements for earning credits and in total there 110 available to be earned. New construction buildings that earn between 40-49 credits will be awarded certified status. To achieve the AMS goal of platinum status, at least 80 credits must be earned (Canada Green Building Council, 2010). As a result, our design goals for the root cellar were to be simple, built with sustainable materials and with an operating net zero energy consumption.

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In context of the UBC Food System, the implementation of a root cellar will largely influence distribution. The selected produce for storage will be centralized and net food transportation costs will be reduced due to the extended shelf-life a root cellar provides. On a North American and global scale the direct impact is small in terms of reducing carbon footprint/greenhouse gas emissions. However the new SUB will be a role model for other universities and green building development strategies for the future and as a result the potential for international impact is high when the sustainable benefits of having a root cellar are recognized. More details on the sustainable impact of a root cellar will discussed later on in the triple bottom line evaluation of our root cellar design.

Methodology

This UBC Food Systems project had a very clear outlined set of goals for us:

- Learn what is a root cellar and how does it function.
- Conduct a needs assessment for the AMS with the goal of creating a list of potential produce to be stored in the root cellar.
- Conduct a triple bottom line (environmental, economic and social) analysis on the storage of large volumes of produce versus the current conventional method of weekly purchase orders.
- Report on our final design factors for the implementation, function and maintenance of a root cellar facility
- Explore and report on any potential alternative facility uses.
- Develop a seasonal buying guide for produce to be stored at the root cellar.

The following are the steps we took to achieve these end product goals.

The first task of defining a root cellar and learning how it works was the simplest and was achieved through general online research. There is a plethora of information available on the internet regarding what a root cellar is, the history of use, modern day uses, and how they function.

The first step in performing the needs assessment for the AMS Food and Beverage department was to qualitatively determine which products are most commonly used and purchased by all of the AMS food vendors. Through meeting with our stakeholders we learned what major common items are frequently required by all of the food outlets. However in order to perform a proper needs assessment, we needed quantitative data on their total produce purchasing habits. Our stakeholder Nancy Toogood was able to provide us with the AMS food outlets "Transfers" files. These files outlined the exact food purchasing habits for each AMS run vendor. We combined the total monthly purchase volumes from each vendor for each of the major products learned in our qualitative analysis. This left us with our needs assessment: we knew what major products the AMS requires and how much on a monthly basis.

Comparatively analysing environmental, economic and social aspects of a root cellar and specifically, the challenges and benefits of large volume storage versus weekly purchasing was a research and group discussion exercise to justify the validity of a root cellar as part of the new SUB design. In the end, we had six main topics to research, the environmental, economic and social benefits and challenges of large volume storage in a root cellar, and the environmental, economic and social benefits and challenges of weekly purchasing. The product of our research and group discussion indicated which method of purchasing is the better choice from a sustainability perspective.

Conceptual design factors were determined very early on in the project. As mentioned earlier, we knew that the new SUB was aiming for LEED platinum status and as a result would be looking for a low tech facility with little to no energy input requirements to keep it maintained and functioning as intended. For detailed building and design parameters we relied on British Columbia government building recommendations.

The seasonal buying guide is a derivative of the needs assessment and compiled transfers list. Products on the transfers list were grouped based on their temperature and humidity requirements which enabled us to look at which types of crops can be stored together. From there we simply looked at which groups of crops occupied the greatest monthly requirement need of the AMS. Selected crops became part of the seasonal buying guide, and the volumes to be purchased were based on the maximum shelf life storage under root cellar conditions.

Alternative uses for the root cellar facility were determined through group discussion, and research on what types of facilities have similar temperature and/or humidity requirements.

Findings and Outcomes

What is a root cellar and how does it function?

Root cellars are underground storage rooms for the purpose of keeping fruits and vegetables fresh. Before the invention of high energy costing modern refrigerators, many households relied on root cellars in order to keep their food fresh to last throughout the winter months. A root cellar can be specifically defined as a storage facility that uses natural sources of cooling, insulation and humidity. Cool temperatures assist in keeping produce fresh by reducing microorganism activity and the release of ethelyne gas necessary for decomposition (Newton, 2003). Humidity levels prevent moisture loss, due to natural evapotranspiration processes (Newton, 2003). A typical root cellar is underground and uses insulated walls to keep heat from entering the unit. In addition a ventilation system is integrated for fresh air intake and stale air exhaust. During the winter, the ventilation system would be closed to keep the root cellar from freezing (Maxwell, 2009: p.74). A properly designed root cellar can keep a variety of vegetables fresh for an entire off-season, up to 8months long (Cavagnaro, 2009/2010: p.48)

Needs Assessment

The following table is the combined transfers list for the various AMS food outlets for the major crops required. Specifically, these are the crops in demand and the monthly quantity of each required for smooth operation.

Crop	Unit	Monthly Unit Requirement
Alfalfa Sprouts	5oz	7
Basil	LB	6.5
Bean Sprouts	5 LB	35
Beets	LB	204.09
Bok Choy	CS	4
Broccoli Crowns	LB	74.2
Broccoli Crowns	14/CS	34
Cabbage Green	LB	225.01
Cabbage Red	LB	3.67
Carrots	LB	310.5
Carrots	Bag	18
Cauliflower	Each	155.46
Celery	Each	146
Cilantro	Bunch	13
Cucumbers	Each	208
Dill Weed	½ LB	3
Eggplant	Each	46
Fennel	Each	24
Garlic WHL/Peel	LB	41.8
Ginger	LB	8.12
Green Beans	6 x 2 KG	5
Jalapenos	LB	25
Lettuce Fancy Leaf	Each	18
Lettuce Iceberg	Each	196
Lettuce Romaine Chopped	5 LB Bag	47
Lettuce Shredded	5 LB Bag	22
Mushroom Food Service	10# CS	68
Mushroom Food Service	LB	20.32
Onions Sliced	5 LB Bag	15
Onions	LB	908.29
Onions-Green	Bunch	869
Onions-Red	LB	108.03

Parsley	Bunch	34
Peas	Bag	19
Peppers-Green Med	LB	252.2
Peppers-Green Med	25#/CS	16.25
Peppers-Red	LB	420.89
Potatoes Baker	Each	1356
Potatoes Peeled	Each	140
Potatoes New Red	50# Case	3
Spinach	2.5 LB Bag	51
Squash	LB	120.53
Tofu Red Label	Each	624
Tofu X Firm	Each	19
Tomatoes	LB	150.45
Tomatoes	CS	59
Tomatoes Sliced	5 LB	23
Yams	CS	15
Zucchini	LB	82.4

Triple Bottom Line Analysis (Environmental, Economic and Social Sustainability Review)

The goal here was to determine if a root cellar will benefit the new SUB from an environmental, economic and social perspective. The main key difference a root cellar will have on the UBC food system is it will allow produce to be purchased wholesale and in bulk supply for long term storage as opposed to being forced to purchase on a weekly basis as the products are needed.

The main environmental benefits of a root cellar will come in the form of reduced greenhouse gas emissions as a direct result of less frequent transportation and increased energy savings. The reduction of net greenhouse gas emissions are a direct result of the reduced frequency of food transportation by delivery trucks. Energy savings are a direct result of replacing commercial refrigerators with root cellars that are reliant on natural properties of the earth to keep the facility at the right temperature and humidity. In general refrigeration is bad for the environment, traditional refrigerators use chlorofluorocarbons (CFCs) which have a serious impact on the environment contributing to global warming and depletion of the stratospheric ozone layer (Dutt, 1995: p.57). However, there is ongoing development of refrigerators that do not use CFCs (Dutt, 1995: p.57).

From an economic standpoint, wholesale purchasing is favoured so long as there is no food wastage. By purchasing products in large quantities, suppliers can offer discounts that reduce the average cost per unit. Throughout the life time of a root cellar, the total savings as a result of wholesale purchase can be very significant. Again because root cellars can replace commercial refrigerators, monetary savings can be made not only in energy costs but also in start-up costs; commercial refrigerators can cost several thousand dollars. Furthermore the maintenance and upkeep costs of a root cellar are drastically smaller than those costs associated with commercial refrigerators.

The social benefits of having a root cellar are a little more subtle and depend on how one alternatively uses the facility. The root cellar can be used to field educational programs (potential program with University Hil), academic research projects, and help the new SUB promote sustainable ways of life through community involvement. In general the goal is to bring people closer to the food they eat to develop an appreciation for the resources and effort it takes to grow, transport and store food.

Alternative Uses

The economic, ecological and social impacts of having a root cellar as part of a sustainable food system are an interesting concept. Unfortunately root cellars are not common in urban communities like university campuses and as a result there is no quantitative analysis of how effective the economic, ecological and social benefits are. This ties in with the alternative uses of the root cellar; it can be used as a field project to determine the impact on overall sustainability.

Other alternative uses include:

- Renting the space to other local restaurants for food storage during the university off-season
- Use as a wine cellar (albeit the campus already has a state-of-the-art wine cellar)
- Animal Feed Storage
- Cheese aging

Seasonal Buying Guide

The following table is our seasonal buying guide recommendation. It contains the most needed crops based on what crops can be stored together and have a combined highest monthly purchase requirement.

Crops	Max Volume to be purchased	when to be purchased	shelf life	Humidity	Temperature (F)
red onion	864 lb	spring	1-8 months	below 65%	36 - 40
green onion	6952 bunches	spring	1-8 months	95%	36 - 40
regular onion	755 lb	spring	1-8 months	below 65%	36 - 40
green pepper	250 lb	late spring/summer	3-5 weeks	95%	41 - 45
red pepper	421 lb	late spring/summer	3-5 weeks	95%	41 - 45
squash	723 lb	winter	4-6 months	below 65%	50 - 60

yam	105 cases	summer	6-7 months	70%-80%	55 - 60
garlic	54 lb	fall	6-8 months or longer	below 65%	60 - 65
peas	9.5 bags	spring/fall	1-2 weeks	95%	32
cucumber	104 units	summer	10-14 days	90%	45 - 55
zucchini	41lb	summer	1-2 weeks	below 65%	50 - 60

The important things to note with regards to the seasonal buying guide, is that the max volume to be purchased is assuming two things: maximum storage efficiency and consistent product need throughout the duration of the given crop's maximum storage potential. For example, Red Onions have a maximum potential shelf life of eight months meaning the most Red Onions they could possibly need and store at anyone one time is 864 pounds. It is probably not likely that the AMS will need the same amount of red onions consistently for a whole eight month period but having an understanding of what the maximum possible storage requirement, helps us frame the size requirement for the cellar.

Design Parameters

For the design of the root cellar, we followed the design that we obtained from the handbook of British Columbia Ministry of Agriculture, Food, and Fisheries. The size of the root cellar provided by the handbook is about 140 square feet. Based on the quantity of the crops purchased by the AMS in a month, the size of UBC's root cellar should be at least twice the size of the root cellar mentioned in the handbook.

Root cellars are best kept in darkness with no light access whatsoever. Light has the ability to reduce the quality of some crops (Poole, 2003: p.3). Since some crops require high humidity, drainage should be constructed inside the root cellar in order to drain excess water (Poole, 2003: p.3). Lastly, if shelving is used to stack up products in the root cellar to maximize space efficiency, materials of the shelves should be able to tolerate the cold and damp conditions of the root cellar, for example oak wood (Poole, 2003: p.3).

For construction details recommendations refer to page 3 of the handbook, but keep in mind we are recommending a facility roughly double in size and measurements should account for that. We recommend following these details for construction because it is a low energy input style root cellar that does not conflict with the goal of achieving LEED platinum status. The only additional recommendation is that it be built using sustainable materials as outlined by the LEED program requirements.

Summary of Results and Discussion

Based on the goal of the AMS to reach LEED platinum status with the new SUB, we recommend focusing on building a low energy input root cellar. The size of the root cellar should be from medium to large size based on the maximum potential storage needs of the AMS. We estimate the size of the root cellar should be approximately 300 square feet and constructed following the guidelines of the Small Root Cellar Agricultural Building Systems Handbook presented by the BC ministry of Agriculture.

We recommend that vegetables such as onions, green/red peppers, garlic, yams, squash, and zucchini, should be stored in the root cellar because they have similar storage requirements and are the most needed crops at the AMS food outlets. Bulk, wholesale purchasing of these crops should be practiced to maximize the use of the root cellars storage capabilities. While we have presented a seasonal buying guide, the volumes to be purchased are not realistic – we lacked certain data to determine accurate purchase volumes for a full year cycle.

As a result of this food systems project a very important key point has been raised. Food storage is and always has been a key component of survival. In the past, humans relied on systems like root cellars to keep food fresh and available during the off-season. Currently we rely on refrigeration systems to support the transport and storage of food goods to support our urbanized communities. What was not immediately evident before this project is that this is a very unsustainable aspect of our food system. Refrigeration systems have serious negative impacts on our atmosphere through the release of CFCs (Dutt, 1995: p.57) By reintroducing root cellars to our food systems we can take another step towards a system that is sustainable.

Stakeholder Recommendations

The next recommended step in this UBC Food Systems Project is to perform a more quantitative analysis of the sustainable impact a root cellar will have on the UBC food system. Some questions to be answered are:

- What is the net reduction in greenhouse gas emissions as a result of transportation savings?
- What are energy savings versus using conventional refrigeration?
- What are the cost savings per month?

If at all possible, we think it would be very beneficial if students were given the opportunity to visit a working root cellar so that more detailed information on running and maintaining a root cellar can be learned and presented.

The final steps for implementation of this project would be to determine a site location and a construction budget. With this information, exact blueprints for construction can be made for the final design.

Project Evaluation, Successes and Challenges of the Project

One of our group challenges was having a hard time getting a hold of our stakeholders at the early stages of the project. Our main stakeholder was away for the first two months of the term and as a result we had a hard time getting the project started. We were able to meet with our second stake holder to get a few questions answered, but when our questions were passed to the new SUB design team, they informed us that while they do plan to incorporate a root cellar into the building, they wanted to wait for another month to hire their new food and beverage design consultants to specifically determine the role that the root cellar would play in the building. Thus, no detailed information could be given instead they wanted us to focus on why a root cellar was needed, which did not help much with the progress of our project.

Our first breakthrough in this project came in with the arrival of the transfers lists for the different AMS vendors from our main stakeholder Nancy Toogood. With this vital data we were able to start working on our needs assessment, and following that, the seasonal buying guide.

The second breakthrough for this project came when we were told the goal of the new SUB was to reach LEED platinum status. This framed our conceptual design goals for the root cellar and as a result we were able to eliminate several more complicated cellar constructions.

Conclusion

The root cellar we recommend for the new SUB is medium to large in size, is low maintenance, simple, and has a net zero energy consumption. The main crops to be stored are the vegetables detailed in the seasonal buying guide. Evaluating the on campus use of a root cellar has lead us to the conclusion that it would be a great addition to the UBC Food System by brining economic, environmental and social benefits to the community.

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