# REVELSTOKE COMMUNITY GREENHOUSE FEASIBILITY STUDY

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JULY 2017

# EXECUTIVE SUMMARY

This feasibility study was conducted to evaluate community interest and the viability of a greenhouse in Revelstoke. This study researched opportunities for a community greenhouse with prospects for future expansion as well as examining a commercial greenhouse operation.

Some of the objectives of this study were to affirm the community's commitment to food security and to provide methods to continue to achieve increased food production in Revelstoke. Many fantastic initiatives have been put in place or have been identified pertaining to food security. Through the findings of this study, it was determined that there is a strong desire to have a community greenhouse in Revelstoke. A greenhouse would not only facilitate individuals to grow more of their own food but it would support goals for many community organizations surrounding food and food security.

The benefits of a greenhouse would provide innumerable opportunities to the community including increasing food security, creating jobs, economic diversification, and providing mentorship and education opportunities. The development of a greenhouse would build new partnerships and facilitate organizations to achieve their objectives.

Two different greenhouse options were examined; a 4000 square foot community greenhouse and a 9000 square foot commercial greenhouse. The community greenhouse would be constructed with a polyethylene covering with no supplemental heating or lighting. It would operate from March until the end of October. The community greenhouse would have 150 raised and accessible beds that would be rented for a yearly fee. The fees raised each year from the plot rentals would cover the annual maintenance and operating costs. Grants or fundraising could take place in order to raise capital funds for future expansion or development. A commercial greenhouse would operate year round and be constructed out of polycarbonate utilizing supplemental heating and lighting.

Climate data for Revelstoke was analyzed to evaluate the anticipated amount of supplemental heating and lighting that would be required in a year round operation. It was determined that if a greenhouse were to operate year round, that it would be necessary to have a heat and lighting source installed as there are five months of the year, October through February, where the natural light is not conducive to growing most crops. The most cost effective lighting source that was identified was the installation of high pressure sodium lighting. This recommendation would be applicable to a year round community or commercial greenhouse operation.

A broad range of potential energy systems were identified and examined to assess what would be the most viable option for a greenhouse in Revelstoke. It was determined after considerable evaluation of a range of variables that a propane heating system would be the most cost effective selection as it has low costs for connection and heating costs. If resources could be secured for additional capital costs, a biomass system would be an excellent alternative. A biomass system is costly to install but has low operation costs with a low carbon foot print which was something that was identified by the community as an important consideration in the construction of a greenhouse. High pressure sodium lighting was found to be the best choice in a greenhouse as a result of their cost, lighting qualities, and longevity. LED lighting would be an alternative but the initial cost to purchase is much higher.

An assessment of the market was conducted and a variety of crops were identified for commercial greenhouse production. Each one was evaluated for its practicality and sustainability. The crops that were examined were cucumber, lettuce, tomato, peppers, and annual bedding plants. The list was determined by feedback from surveying the community as well as information that was gathered from Statistics Canada pertaining to the greenhouse industry in British Columbia. It was concluded that crops that would be in demand locally, are lettuce, tomatoes, cucumbers and annual bedding plants. The crops that would provide the most profit are cucumbers, tomatoes and annual bedding plants.

Sources of funding for a greenhouse will dependent on a variety of factors; for example, is it a community or commercial greenhouse, what is the business structure (non-profit, for profit), and who are the partners in the greenhouse ( is it the school district or City of Revelstoke). Being able to answer some of these questions will best direct which funding sources to explore. Below in Appendix B is a list of potential funding streams.

## ANALYSIS

After reviewing all of the information in this study, two potential scenarios emerged as most likely to be successful:

A) Community greenhouse

B) Commercial greenhouse with community rental plots

Scenario A – Community Greenhouse

A season extender, community greenhouse would have the initial capital cost of $38,565.08 for the 40 x 100 foot polyethylene structure, site preparation and materials. There would be an additional cost of $24,446 for a new tractor if it was identified as a necessary purchase. The recommendation is to write grants, organize fundraisers or seek in-kind donations for the capital costs. If the capital costs could be fully funded, then the annual operating costs of the

greenhouse would be covered each year from membership fees with an annual profit of $906. If the capital costs were not fully funded, then annual fundraising events and grants would need to be written to contribute to the operating costs so the membership fees could go towards the paying down the capital costs (debt). A community greenhouse would be most successful if multiple partnerships are formed to develop the greenhouse and as a result would provide opportunities for a broader base of community use.

Scenario B- Commercial Greenhouse

A year round commercial greenhouse could have a capital cost of $372,126 for a 9000 square foot polycarbonate structure, land, tractor, material costs and outbuilding. The cost could be reduced to $222,126 if the land could be leased and would decrease the time to pay down the capital costs. The economic model is based upon growing two cucumber crops a year which would not be economically feasible, however if only one crop of cucumbers were grown and replaced with one crop of annual bedding plants, an annual profit could be made. It would be advantageous to consider the business model for a commercial greenhouse such as a co-operative business structure, in order to qualify for grants which could make the greenhouse more profitable, paying off debt faster and providing opportunity for expansion. This would benefit the community to create more jobs and provide more fresh produce that could be available to the community. Within the commercial structure, there would be space put aside for the construction of 150 community rental plots.

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# ACKNOWLEDGEMENTS

Thank you to the BC Rural Dividend Fund for their generous financial contribution towards making this Community Greenhouse Feasibility Study possible. The feasibility study would not have been possible without the overwhelming support from the community in taking time to provide feedback, insight and expertise. The individuals, businesses, and organizations that took part provided invaluable information, and the time and effort that was contributed was remarkable.

Technical Analysis - local climate heating and lighting conditions and energy systems, Site Recommendations, Financial Model and Sources of Funding was developed and provided by Kim Vinet of Epoch Energy Development

The expertise from Kristina Geidt was instrumental in her contributions and guidance to completing this project.

Christina Delaney for her help with focus groups

Revelstoke Local Food Initiative team and the Greenhouse Feasibility Study Steering Committee for your time and feedback in guiding this feasibility study.

The project would not have been possible without the groundwork that has already been done by many community members and organizations that are committed to initiatives such as a community greenhouse.

## GREENHOUSE FEASIBILITY STUDY STEERING COMMITTEE

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# 1. OVERVIEW

The Revelstoke Community Greenhouse feasibility study was commissioned by the Revelstoke Local Food Initiative (LFI) aimed at exploring the viability of a community greenhouse. A steering committee was assembled and comprised of a broad range of organizations and community members to help guide the process.

Initially the following questions that were proposed were;

1. Where could a community greenhouse be located?
2. What types of social enterprise could be developed?
3. What types of heating systems could be used and the type of structure?
4. How would a community greenhouse be financially stable?
5. What type of education component could be developed?
6. What initiatives and opportunities are available in a community greenhouse for youth, seniors and individuals with disabilities?
7. What type of business model would be best (i.e., cooperative, non-profit)?

The objective of the feasibility study was to explore the possibilities for a community greenhouse with a similar model to the existing community gardens in Revelstoke, with successional plans for further development phases or expansion. The feasibility study analyzed options for different scales of greenhouse operating models, partnership opportunities and the development of a business case that was inclusive of market, technical and local economic assessments. An inventory of potential locations was collected and a detailed list of site priorities for securing a future location was compiled.

When determining viable options for a greenhouse, the following factors were prioritized:

- community engagement
- market analysis
- economic analysis
- resources and technology

The feasibility study amassed research and data in order to provide comprehensive information to act as a guiding document for the next phases of this project.

## 1.1 BACKGROUND

The LFI is a collection of concerned citizens who aim to cultivate a vibrant and resilient local food system. In recent years, the community has recognized the importance of becoming more food secure which has been addressed through many initiatives and organizations. The Revelstoke Food Charter, Revelstoke Food Security Strategy and the Integrated Community Sustainability Plan (ICSP) outline community goals in regards to food security. Some of the highlights from each study include access to nutritious affordable food, economic sustainability related to local food production, and education on healthy eating as well as increasing knowledge surrounding food security.

Revelstoke has a long and rich history spanning the last 130 years as an area that has been abundant with local food production. The area used to be home to hundreds of farms and many large dairy operations. During the mid-1960's hydroelectric dams were built in the area and resulted in flooding of many of the agricultural lands surrounding Revelstoke. The loss of agriculture has impacted people's perceptions of what used to exist in the Revelstoke area and generated a fallacy that there is no arable land to grow food on anymore and the Revelstoke climate is not conducive to having a greenhouse. Many organizations continue to try to dispel these myths and are working towards developing greenhouses and creating opportunities for more fields growing of crops.

In 2013 an initiative was taken by the North Columbia Environmental Society - Local Food Initiative (LFI) to develop the Revelstoke Food Charter in collaboration with the City of Revelstoke Department of Community Economic Development and Revelstoke Community Connections. A steering group, which was comprised of local residents and specialists in food security was assembled, to help develop the food charter. The vision for the Revelstoke Food Charter was to increase food security and support the economic, ecological, and social well-being of the community through; access to nutritious healthy food, food that is produced locally and sustainably and increase local food production. The Food Charter offered recommendations for how the community could create a more sustainable food system, including improving access to healthy food, identifying educational opportunities to promote food knowledge ,and supporting local and regional farmers and food producers. [1]

The Revelstoke Food Charter was followed by the development of the Revelstoke Food Security Strategy, which identified gaps and made recommendations for different groups and organizations within Revelstoke to enhance the food security in the isolated mountain town. The LFI continues to use the Food Charter and Food Security Strategy, as well as internal strategic planning documents, to guide their initiatives and the behind-the-scenes work.

Revelstoke's Integrated Community Sustainability Plan (ICSP) is a future-oriented document that looks for new opportunities and builds upon the existing framework that has been established. It is a community based plan for all individuals and organizations to come together to problem solve and achieve goals. An element of the ICSP is a commitment to achieve climate resilience and a healthy ecosystem, minimal waste, responsible water use, and carbon neutrality. It also continues to pursue and support priorities that Revelstoke has a healthy, active population and a locally diverse economy.

All styles of greenhouses from home, community or commercial, permit food to be grown either as an extension of the growing season or year round. Food in a greenhouse is grown more efficiently and takes up less space than field crops, contributes towards sustainable practices and provides access to healthy and nutritious food. Most people understand the merits of a greenhouse; however the cost to establish and maintain the structure long term can be a barrier, especially in smaller communities. A modest greenhouse can be a good starting point to meet the needs of the local community. Once a greenhouse project has proven to be successful, it has the ability to expand and evolve to a larger scale at any point. To ensure greater success, foresight to allow for future development should be considered in the initial planning of a greenhouse in the community.

## 1.2 KEY FINDINGS

There were many common themes from the analysis that was completed on successfully established community greenhouses in Canada and the United States. Some of the key points that were summarized as to why a community greenhouse was explored or developed was the contribution towards food security, creating a neutral and inclusive space, providing learning opportunities about growing food and being connected to where food comes from.
The most successful community greenhouses involved collaboration with community organizations and partnerships. All of the community greenhouses required an annual membership, annual plot rental, and a set amount of mandatory volunteer hours.
The majority of season extender greenhouses were able to pay for their yearly maintenance and operating costs by the fees collected from membership and plot rentals.

**LEARNINGS FROM OTHER GREENHOUSE PROJECTS**

In discussions with other community greenhouses in British Columbia and Alberta, initial capital funds were raised for the development and building of the greenhouses. Once established, the monies received from annual membership fees and plot rentals cover the yearly cost to maintain and run the greenhouses. Supplemental fundraisers or grants are commonly requested to raise additional costs for new capital investments (such as expansion or structural upgrades). The average size of a community greenhouse is 6000-10000 square feet and has an annual cost of $5500-6000 to operate and maintain. The average plot rental in a community greenhouse is $50 which includes a raised bed with soil, access to manure/compost, water and often the seeds. The most common size of a garden plot is 18 square feet. Each greenhouse has a set number of volunteer hours that are required from each member to assist in maintaining the community greenhouse.

**COMMUNITY GREENHOUSE FUNDING SOURCES**

The community greenhouses in Invermere, Hinton, Banff and Whistler became established through a variety of ways, some capital costs were donated such as greenhouses, lumber for boxes and cement foundations, grant money was received and fundraising events were organized. Most of the greenhouses are situated on land owned by the local city or town which have reduced the operating costs by not paying for the land. Every established community greenhouse would have not been possible without tremendous community support. Large amounts of volunteer hours were put in to build each community greenhouse, with jobs such as installing water lines, building garden boxes and putting up the structures. Once the greenhouses were established greenhouse members continue on a yearly basis to volunteer their time to help maintain and keep the greenhouses running.

## FUTURE GREENHOUSE CONSULTATION SOURCES

Groundswell in Invermere has successfully established a year round community greenhouse with a partnership with the local school district. They provide consultation services in supporting communities establish community greenhouses that could be a good resource once a community greenhouse project gets to the next phase. There are other organizations that have consulted on community and commercial greenhouses such as Epoch Energy Development that would also be good resources to consult for next steps in a greenhouse in the community.

## COMMUNITY FEEDBACK

There was a lot of beneficial feedback and insight provided from speaking with members of community greenhouses and growers. When speaking with a greenhouse grower, their experience with the structural tubing which makes up the frame of the greenhouse, they found that round tubing was more durable and stronger than square tubing. The experience of greenhouse growers found that if a greenhouse was heated, the snow slipped off of the structure much easier. One of the community greenhouses only installed doors on one end of the greenhouse and consequently have had air circulation issues This greenhouse is currently in the process of installing doors on the other end so that doors on each end of the building that can be opened for better airflow. The greenhouse in Banff does not allow tall or spreading vegetables such as corn or zucchini to be grown due to the size of the plants. School groups who have garden beds during the school year are maintained by parents during the summer. The garden beds for the students are lower to the ground so the students can access them more easily. The greenhouse in Whistler has an area with a sandbox within the greenhouse that is a space for children to play while the adults they are with are tending to their garden beds. This creates an inclusive space to have children involved in the greenhouse.

A survey was made available to the residents of Revelstoke to provide feedback about a community greenhouse and received 67 responses from the community. The priorities identified by participants of the survey were:

a) Food security
b) Increased access to fresh local year round produce
c) Providing a connection to their food
d) Green energy and sustainable building practices were very important considerations for the design of a community greenhouse

Individuals felt that there were considerable opportunities to have a greenhouse incorporated in schools curriculum and to provide education to the community on growing their own food. There is also broad community support for a community greenhouse that is an inclusive space with opportunities for seniors and persons with intellectual disabilities for therapy gardens or a place for mentorship. One comment from the survey about having a community greenhouse was *`Think of the future and of our children. Our small community can make ripples in our province, country and world. Be the change we want to see. We have the world's best water, best mountains, and soils. Why not have the produce to match?`*

The key findings from the survey were:

1. 91% indicated that food security was the top priority
2. 87% wanted more opportunity for community learning
3. 73% of people surveyed would like to have a year round greenhouse for growing as opposed to a season extender greenhouse from March to October
4. 70% felt that mentoring was something they would like as part of a community greenhouse
5. 97% would buy produce if it was available for purchase
6. 84% would like to see sustainable and green energy included in the greenhouse design

A series of focus groups and one-on-one interviews were conducted in the community to discuss the prospects of a community greenhouse. The scope of people involved in the process were youth, seniors, non-profit organizations, departments within the City of Revelstoke, restaurants, businesses that sell local food, local agriculture producers, and individuals in the school district. Outside of Revelstoke, consultations took place with businesses that sell greenhouses and other community greenhouses.

The feedback received from consultations within the community was very positive. Lots of very constructive and useful feedback was provided from all that participated. Food security was the highest priority from respondents and the concept of a community greenhouse appeared to be a natural progression in achieving food security in Revelstoke. It is important to many organizations in the community to have access to more local food. Having a community space for education and mentorship opportunities was something that was identified as being very important. A community greenhouse would support education around growing food, healthy eating and even the prospect of entrepreneurship skills. A community or commercial greenhouse would create jobs and contribute towards economic diversity.

The key priorities identified from the community consultations were:

1. Food security
2. Access to more local food
3. Community learning
4. Job creation and economic diversity

## 1.3 POTENTIAL IMPACTS TO THE COMMUNITY

### COMMUNITY GREENHOUSE POTENTIAL IMPACTS

A community greenhouse would provide opportunities to increase food security, facilitate people to grow their own food and provide a greater connection to the food one eats. The greenhouse would be an accessible space to be utilized by any individuals who would like to take part. There are opportunities to develop an assortment of programs to meet the interest and needs of the users, making the space inclusive for all those who wish to take part. A community greenhouse has the potential to provide many supplemental benefits to the residents of Revelstoke. There are opportunities for synergies to be created with many stakeholders in the community. Some of the identified opportunities could be mentorship, horticulture therapy, workshops, school programming, and entrepreneurship.

**MENTORSHIP**

Revelstoke has a rich knowledge base of gardeners who range from youth to seniors. The information gathered from the surveys and the focus groups identified mentorship as one of the top priorities. An equal amount of individuals indicated that they would either like to provide or receive mentorship in a community greenhouse. Mentoring provides the possibility of knowledge transfer but also can present other definite outcomes such as increased confidence, building relationships and intergenerational interaction which can positively strengthen a community.

**HORTICULTURE THERAPY**

Gardening is an activity that has been found to have many health and wellness benefits. Some positive outcomes can be the improvement of physical, social and emotional wellbeing. Horticulture therapy is beneficial to all ages and abilities through the interaction between individuals and plants.

**WORKSHOPS**

There are many organizations dedicated to sustainability and food security in Revelstoke. A community greenhouse would provide a space where groups or individuals could learn more about growing in a greenhouse, sustainable practices and even about entrepreneurship.

**SCHOOL CURRICULUM**

The benefits to school-aged students from being in a greenhouse can be infinite. Through hands-on learning a student can be provided with a connection to their food and education about healthy eating. Students have the opportunity to apply many integrated school subjects in a greenhouse. There are many opportunities for plant based experiments, skills about growing plants and entrepreneurship that could be transferred to a home garden or growing plants to be sold as a school fundraiser. A greenhouse would support the curriculum that has been implemented as well as many initiatives taken by teachers within the district surrounding food and growing. There is also the opportunity to connect Aboriginal Education as part of the

enhancement agreement includes food security, connection to land, student independence and mastery.

`When school gardens are incorporated into different subjects, the garden can be very familiar and real, providing "real life applications" of the concepts they are learning in class, such as perimeter, area, spacing, planning, design and yield. The list of these real life applications can go to "Infinity and Beyond!" The informal and unstructured format of garden learning is flexible enough for all different kinds of learners to benefit – and not just in math and science. Gardening can bring any curriculum category to life – from Language Arts to Lifestyle and Nutrition. The research of McCormick et al (1989) showed that students learn more and better when they are actively involved in the learning process – and this is exactly the kind of experiential, hands-on learning school garden activities provide.` [2]

**ENTREPRENEURSHIP**

A community greenhouse has the opportunity for micro farming. Micro farming is similar to SPIN farming; it is a low cost, small plot of space that is used intensively to grow crops and sold for profit. In a community greenhouse, individuals could grow a crop and sell it through the greenhouse or farmers market. They could have the opportunity to learn about how to choose the appropriate crops, how to maximize yield and then how to market and sell the product for profit. There have been many successful growers of micro greens who have been able to sell to local restaurants. Most of their set ups are in home basements but a greenhouse could provide an alternate space for the production of microgreens.

## COMMERCIAL GREENHOUSE POTENTIAL IMPACTS

A commercial greenhouse in Revelstoke would provide some similar benefits as a community greenhouse by contributing to food security and provide opportunities for mentorship for other growers. Having a commercial greenhouse could limit the amount of food transported to Revelstoke, which would reduce the community's food-transport miles and be better for the environment. It would contribute to the local economy by bringing in a new business and also creating more diversity in the business sector. There would be opportunities for collaboration between other organizations to support a commercial greenhouse from green energy, employment and education opportunities.

**FOOD SECURITY**

One of the key points that was identified from existing studies that have been done and feedback from the community is the importance of becoming a more food secure community. A project that would grow food to feed the residents would contribute to greater food security and assist in achieving this goal. In Revelstoke, there are community organizations whose mandate is to provide regular distribution of fresh produce. A greenhouse would provide greater opportunities to provide fresh local food and support these organizations in achieving these objectives.

**ECONOMY**

Business development within the community builds the local economy and reduces the amount of money that leaves the community to go to larger corporations. A commercial greenhouse would keep more money in the community if the produce was priced at a competitive price point. The development of a commercial greenhouse in Revelstoke could stimulate the development of other commercial greenhouses or complementary businesses such as food processing to start up and get established. These would contribute to job creation that could be either seasonal or year round.

**DIVERSITY**

Since there is currently not a commercial greenhouse in Revelstoke, this would be an opportunity for a new type of business to start up and contribute towards more diverse business opportunities. The agriculture sector in Revelstoke is relatively small and future development of this sector would be beneficial to the local economy as well as the products available to the community.

**EDUCATION**

A commercial greenhouse could provide opportunities for short and long courses to take place, teaching individuals about production growing. There could be partnership opportunities with the high school as well as Okanagan College. The greenhouses in Banff and Invermere have partnered with the local schools to provide yearly garden plots for school classes, harvested food to be utilised within the schools and used the space for classes pertaining to greenhouse growing. In Inuvik the community greenhouse partnered with Aurora College to incorporate students from a variety of college courses such as carpentry, plumbing and electrical, to do installation and maintenance projects in the greenhouse. College of the Rockies in Creston worked in partnership with the community greenhouse to utilize the space during the permaculture certificate course.

**TECHNOLOGY**

Commercial greenhouses have a tendency to have very technical systems installed in order to obtain an efficient and effective growing environment. Technologies are always changing and improving which will always provide opportunity for new and better systems to be installed and maintained.

## 1.4 COMMUNITY ORGANIZATION GOALS

A community greenhouse could help advance many organizations in Revelstoke to achieve greater results in the work that they are already doing. A few identified goals are:

- Increase food security and provide hands on opportunities to educate individuals and families about healthy eating.
- Create more access to fresh and nutritious food
- Provide more local food options to individuals, restaurants and stores that sell produce
- Increase economic development opportunities through job creation, education and training opportunities and economic diversity
- Program continuity and accessibility is important as lots of programming stops during summer, such as school, community groups, a season extender greenhouse would provide more access to learn such as people with mental health issues or in poverty
- Opportunities to support the school district curriculum
- An inclusive and safe space for everyone

# 2. GREENHOUSE STRUCTURES

There are several types of structures that could be considered for a community or commercial greenhouse. Some considerations that should be made are how many months a year will a greenhouse be used, is it for commercial or community use, what type of land ownership in regards to permanent or non-permanent structure and available capital.

In a community or home greenhouse, plants are placed into raised beds or directly into the soil in the ground. There is typically no supplemental heating or lighting used and watering is done manually. These structures are often simple and utilized as an extension of the growing season, are easy to set up and can be easily moved.

In a commercial greenhouse, the greenhouse environment is often climate controlled by simple to highly technical computerized systems which reduce and monitor the amount of inputs such as water and nutrients. It is important to consider integrated pest management (IPM) plans which require good record keeping practices and monitoring of pests. A good IPM plan will reduce the use of pesticides by using cultural, physical or biological control of insects. Some of the most common growing mediums in commercial greenhouses are sterile potting soil or hydroponics which is when plants are grown in soilless mediums such as Rockwool, perlite or coconut fibre. The use of bumble bees for pollination with an IPM plan can be a common practice depending on the size of a greenhouse. [3]

**POLYETHYLENE - GOTHIC ARCH**

Polyethylene is a plastic like film covering for a greenhouse that is cost effective. A gothic arch is a good structure for climates that get snow as it naturally allows the snow to slide off. If the structure is heated it will shed the snow off of the structure more easily. To increase the snow load capabilities, additional arches are added as well as horizontal purlins. A double poly layer can increase the thermal qualities. The polyethylene cover will last 3-4 years before needing to be replaced. Doors can be put on one side of the greenhouse with a solid wall on the other end or can be constructed to have doors on each end. The sides of the greenhouse can have the option of roll up curtains from the bottom for better air circulation. The plastic can be removed for the winter if the structure is not in use and it is easily moved. These greenhouses can be installed on a foundation or directly on top of the soil.

Polyethylene – Gothic arch



Photo credit: www.bwgreenhouse.com

## POLYCARBONATE - GOTHIC ARCH

Polycarbonate is a very durable, sturdy and long lasting material that has a lifespan of 22-25 years. It can withstand impact and does not scratch easily. There is excellent light transmission in a polycarbonate greenhouse. The thermal qualities can be increased by adding layers to twin or triple the walls. A gothic arch is a good structure for climates with snow loads as it naturally allows the snow to slide. To increase the snow load capabilities, additional arches are added as well as horizontal purlins. Doors can be put on one side or on both ends of the greenhouse. These greenhouses can be installed on a foundation or directly on top of the soil.

Poly carbonate - Gothic arch


Photo credit: www.bwgreenhouse.com

## GLASS

Glass is one of the oldest and most used coverings for a greenhouse. The panels are durable and long lasting in comparison to other greenhouse covering. It is the most costly type of covering and does have the potential for panel breakage. Many people like the aesthetics of a glass greenhouse. Glass that is insulated has similar thermal qualities to double polyethylene or twin walled polycarbonate. There is good light transmission provided to the plants into a glass greenhouse. As with other structures, doors can be on one end or both ends. Most glass greenhouses are put onto some kind of foundation which makes it a more permanent structure.

Glass Greenhouse

Photo Credit: www.everlastgreenhouses.com

## SOLAR GREENHOUSE

This type of structure is commonly used in China. The two long sides of the greenhouse are comprised of a permanent thick wall usually made of cement or bricks on one side and the other side of the greenhouse use arches and is covered in polyethylene or polycarbonate. The thermal mass of the solid wall captures the heat from the sun during the day and continues to keep the greenhouse warm during the night. The greenhouse should be south facing to capture the solar benefits. An insulated covering sheet can be placed over the poly side at night to help retain heat. These types of greenhouses do not use supplemental heating but depend on the sun to heat the thermal wall. Fans are used for air circulation and cooling of the building. If a solar greenhouse was to be developed in Revelstoke, there has been a suggestion of approaching the local highway department to get their old cement barriers to use for a heat sink.

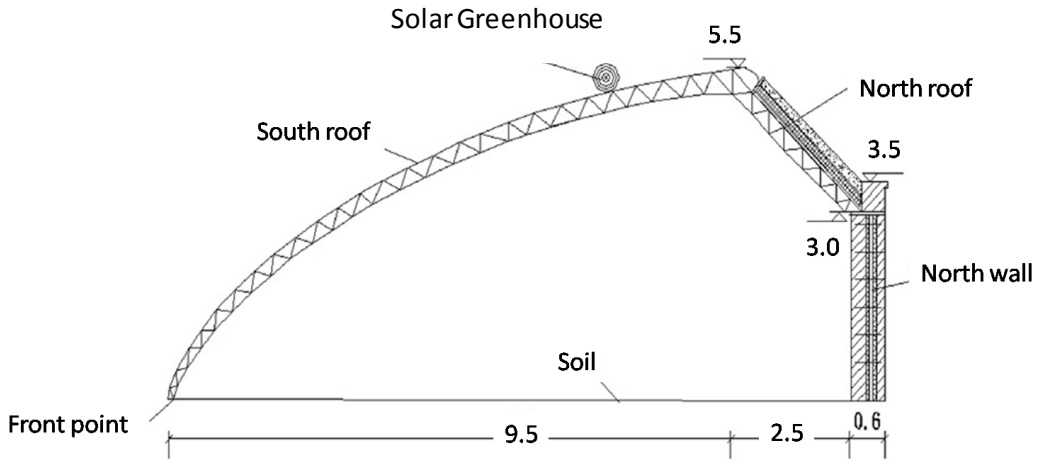



Photo credit: https://energyfarms.files.wordpress.com/2010/04/greenhouse-specs.png


Photo Credit:https://solaralberta.ca/sites/default/files/events/documents/ColdClimateSolarGreenhouseDesign_0_0.pdf

## VERTICAL FARMING

Vertical Farming is the future of modern day agriculture which is completely done in indoor agriculture labs. The vertical Farming market is expected to cross USD 6 Billion by 2022. [4]

The types of food that are grown in a vertical system are generally fast growing crops such as micro greens and lettuce. Many established vertical farms utilize existing structures such as old warehouses and buildings or retro fitted shipping containers to grow food vertically instead of the traditional way of planting horizontally. The appeal of vertical farming is that it yields more produce per square metre in comparison to a greenhouse, is more efficient in water use and crops grow faster. The technology systems that support vertical farming are relatively new which can be cost prohibitive.

Vertical farming has been proposed as an engineering solution to increase productivity per area by extending plant cultivation into the vertical dimension, thus enhancing land use efficiency for crop production. [5]

Vertical Farming

Photo credit: https://www.roboticsbusinessreview.com/agriculture/vertical-farm-lets-growers-apply-right-amounts-automation-iot/

Photo credit: http://static2.businessinsider.com/image/57bc67bfdb5ce94e008b84ab-1500/square_roots_1.jpg

| Type of structure | Price | Durability | Longevity | Operating costs | Total score |
|---|---|---|---|---|---|
| Gothic arch polyethylene | 5 | 3 | 2 | 5 | 15 |
| Gothic arch polycarbonate | 3 | 5 | 5 | 3 | 16 |
| Glass | 2 | 4 | 5 | 3 | 14 |
| Solar greenhouse | 1 | 5 | 5 | 5 | 16 |
| Vertical farming | 1 | 4 | 4 | 4 | 13 |

Table 1 Rated on a scale of 1-5, 1 the least best option and 5 is the best option

Table 1 uses a decision matrix to rate each greenhouse structure. The matrix is used to evaluate the best overall option based upon the some of the key factors that would be considered in the decision making process.

## 2.1 MATERIAL AND CAPITAL COSTS

The material requirements for a community greenhouse and a commercial greenhouse can widely vary, depending on specifics such as the type of structure, what is being grown and for how many months of the year.

Scenario A: Small (4000 square feet or 371 square metres), community-focused greenhouse (with 150 plots) that self-funds via membership and plot rentals. Seasonal operation (March-October). No supplemental heating or lighting required.

- Material for raised beds was quoted from a local business at $35 per bed
- Irrigation supplies, either garden hoses with watering wands was priced out at $100 for each 100 foot hose and $40 per watering wand
- The soil for the raised beds would be a cost of $30 per cubic metre
- Amendments such as fertilizer or compost for raised beds
- Tools for gardening such as small trowels and hand rakes

Scenario B: Larger (9000 square feet or 836 square metres) commercial greenhouse with a smaller, community component (with 50 plots). This structure would be year round operation with supplemental heating and lighting.

- The cost of a concrete pad would be $215 per cubic metre
- Benches for putting plants if crop requires them at a cost of $6.66 per square metre
- Media for planting, pots, bags, plugs or trays to hold plant media and fertilizer can be averaged at $16.90 per square metre
- Sand Filter(dependent on water source)
- Lighting for high pressure sodium lights $350 per light
- Heating and cooling infrastructure $7,500
- Irrigation system $1.78 per square metre
- Fans for ventilation and air circulation

## 2.2 OTHER EQUIPMENT

Depending on the scope of the operation, other types of structures and equipment might be required.

- For a large commercial greenhouse that plants into potting soil, a potting room might be needed. This room would be equipped with a system to mix and wet the potting soil and possibly a machine to fill the pots.
- A forklift for loading and unloading materials into trucks and moving things around the property
- A tractor could also be equipped to do similar tasks as a forklift but would be able to clear snow as well
- A propagation area or room with heated mats, if plants are being started from seed.
- Storage area or building for pots, fertilizer and tools
- Refrigeration/Cooler

When factoring in the costs for a commercial greenhouse, the following figures can be used as a starting point to estimate these costs.

- Labour requirements - Generally 25% of total operating cost, [6] 1.6 hours/$m^2$/year, at a recommend starting rate of $12/hour for greenhouse workers
- Maintenance, depreciation, repair – depreciation can be calculated by dividing the cost of the structure by the anticipated number of years it is expected to be in use before it needs to be replaced
- Material inputs for example, fertilizer, soil, seeds, and starts can be calculated at 15% total operating costs per year
- Annual insurance fees can be estimated at $1.64 per square metre

# 3. TECHNICAL ASSESSMENT

An assessment was conducted with the available data on the climate and lighting conditions for Revelstoke. The conclusions from the data, determined there is a requirement for supplemental lighting in the months of October to March and supplemental heating during the months of October to May, to maintain necessary light and temperature levels required for the commercial production of cucumber, peppers and tomatoes.

## 3.1 LIGHTING

The most cost effective and efficient lighting source that was identified are High Pressure Sodium lights. The recommendation for a 9000 square foot commercial greenhouse would be 1000 watt HPS bulbs that would be utilized during October to March. Supplemental lighting in a community greenhouse could be with HPS bulbs or LED lighting; however the initial investment of LED is much higher.

## 3.2 ENERGY SYSTEMS

An extensive analysis was completed on the types of energy systems that could be used in a greenhouse. The feedback from the community indicated there is a keen interest in green energy sources being utilized in the greenhouse. Energy sources were identified and evaluated based upon the availability, cost to operate the system and initial capital expense.

**BIOMASS HEATING SYSTEMS**

A biomass central heating system uses organic matter (such as wood) to fuel a boiler, which provides space and water heating. Emissions generated through combustion of biomass are considered carbon neutral since carbon in the organic matter would eventually be released through decomposition. Biomass is considered a renewable fuel source because the plants can grow back. Biomass is used directly to produce heat and can be converted to "biofuel" to create electricity or be used as fuel in vehicles.

**REVELSTOKE BIOMASS DISTRICT ENERGY SYSTEM**

The Revelstoke Community Energy Corporation (RCEC) has a biomass boiler system located at Downie Timber Sawmill. RCEC also operate a district energy system (DES), which provides heat to various municipal buildings through a closed loop pipeline distribution system. Each building on the DES uses a heat exchanger and ventilation system to distribute the heat energy throughout the building. At the present time there is abundant heat energy available to supply even a large-scale, commercial greenhouse. Use of the RCEC's DES for the greenhouse would provide long term stability in heating cost, prevent the necessity for an on-site boiler,

supervision and maintenance and decrease the required space dedicated to building utilities. RCEC require annual scheduled maintenance for 1-2 weeks in August, which is generally compensated for by a backup boiler. DES costs vary based on proximity to the greenhouse site due to the cost of installation of infrastructure. Large, consistent loads are best serviced by the DES. As such, the system is generally reserved for loads of >50MWh annually and may cost between $75-110/MWh (stabilized over long term contracts). Recommendation would be to locate the greenhouse as close as possible to existing DES infrastructure (map attached in Appendix I).

**STANDALONE BIOMASS HEATING SYSTEM**

The Revelstoke Greenhouse could install its own automated or semi-automated biomass boiler system. Within a fully automated system, biomass is stored in a holding tank; conveyors transport the biomass to the boiler at a designated rate. The system automatically turns on and off to maintain preferred pressure and temperature within the boiler. Semi-automated or non-automated systems are very similar but require an operator or supervisor where automation is not present. Semi-automated systems are often smaller and cheaper than fully automated systems (which rely on computers and monitoring systems). Common practice is to heat water or a heat transfer agent (such as Ethylene glycol), which is distributed in a closed loop system. $CO_2$ released during combustion in the boiler could be ventilated directly to the greenhouse as a feedstock for crops and excess heat could be used for dehydration or processing of crops. The smallest system generally available provides 150kW (enough to heat approximately 10,000 square feet).

**PROPANE HEATING SYSTEM**

In the city of Revelstoke, propane is supplied by Fortis BC. Propane heating systems would necessitate installation of a boiler and HRV system. A greenhouse at Revelstoke would fall into Fortis BC's Small Commercial Rate category, as outlined in Table 2 (approximately $49.40/MWh pre-tax, with all fees and services included). Use of propane as a heat source is presently the most cost-efficient and appropriate means of heating a greenhouse in Revelstoke. The disadvantage of using propane as a heating source is the long-term cost volatility, which makes budgeting for greenhouse operational costs more difficult further into the future.

| FORTIS BC - PROPANE | Fixed Basic & Admin Charges | | | Variable Cost/GJ/Demand Charges | | |
|---|---|---|---|---|---|---|
| **Residential (Individually Metered)** | Daily | $ | 0.3890 | Delivery | $ | 4.299 |
| | | | | Cost of Gas | $ | 11.088 |
| | Annual | $ | 141.99 | Total | $ | 15.387 |
| **Small Commercial (Up to 2000 GJ/Year)** | Daily | $ | 0.816 | Delivery | $ | 3.544 |
| | | | | Cost of Gas | $ | 9.997 |
| | Annual | $ | 297.87 | Total | $ | 13.541 |
| **Large Commercial (Over 2000 GJ/Year)** | Daily | $ | 4.3538 | Delivery | $ | 2.997 |
| | | | | Cost of Gas | $ | 9.997 |
| | Annual | $ | 1,589.13 | Total | $ | 12.994 |

Table 2: Fortis BC's rate categories and prices. [7]

## ELECTRICAL ENERGY PROVIDER

In the city of Revelstoke, electricity is supplied by BC Hydro. Electricity provided by BC Hydro can be used for lighting as well as to provide power for HVAC systems. A greenhouse at Revelstoke would fall into BC Hydro's Medium General Service Rate category, as outlined in Table 3 (approximately $94.96/MWh pre-tax, with all fees and services included).

| | **Unit price** |
|---|---|
| **Residential Service Rate** | |
| *Basic Charge* | $0.1899/day ($69.31 annually |
| *Energy Charge* | 0.0858/kWh < 1350kWh |
| | 0.1287/kWh > 1350kWh |
| *Minimum Charge* | basic charge |
| *Rate Rider* | 5% pre-tax |
| **Small General Service Rate** | |
| *Description* | peak demand <35kW |
| *Basic Charge* | $0.3312/day ($120.89 annually) |
| *Energy Charge* | $0.1139/kWh |
| *Minimum Charge* | basic charge |
| *Rate Rider* | 5% pre-tax |
| **Medium General Service Rate** | |
| *Description* | <550 MWh per year (peak demand 35-150kW) |
| *Basic Charge* | $0.2429/day ($88.66 annually) |
| *Demand Charge* | $4.92/kW |
| *Energy Charge* | $0.0880/kWh |
| *Minimum Charge* | 50% of the highest Demand Charge during the previous November 1 to March 31 period. |
| *Rate Rider* | 5% pre-tax |
| **Large General Service Rate** | |
| *Description* | >550 MWh per year (peak demand >150kW) |
| *Basic Charge* | $0.2429/day ($88.66 annually) |
| *Demand Charge* | $11.21/kW |
| *Energy Charge* | $0.055/kWh |
| *Minimum Charge* | 50% of the highest Demand Charge during the previous November 1 to March 31 period. |
| *Rate Rider* | 5% pre-tax |

Table 3: BC Hydro's rate categories and prices. [8]

**MICRO-HYDROELECTRIC SYSTEMS**

Micro-hydroelectric systems use the natural flow of water to produce electricity. This system would be site-specific, where access is available to flowing surface water (creek, stream, river or waterfall). The system requires an intake where water is diverted from the source through a filter (to prevent entry of debris, organic material or ice). Water is delivered to a turbine, which uses the mechanical energy of the stream to create electricity in a generator. The water is then returned to the stream. Micro-hydroelectric systems provide a mechanically simple, environmentally friendly, renewable, off-grid energy solution. Total deliverable electricity (generally between 5-100kW) is dependent on the flow rate and hydraulic head available. The system requires a minimum elevation drop of 2 feet to acquire the water pressure (hydraulic head) necessary to create electricity. The system will be affected by seasonal availability of water and available energy will decrease due to turbine efficiency and friction within the piping system. Given the relatively low hydraulic head pressure available in the Revelstoke area (due to topography in the valley), a micro-hydroelectric system would have to have a very large flow rate to attain the number of watts necessary to power supplemental heating and lighting systems in the greenhouse.

**GEOEXCHANGE HEATING SYSTEMS**

Geoexchange systems use the relatively consistent temperature in the top few meters of soil to assist with heating and cooling. During the winter, the ground is warmer than the outside air, while the inverse is true in the summer. Water circulated through an underground closed loop system will emerge warmer than it entered in the winter and cooler than it entered in the summer. Once the water emerges, the required indoor temperature is produced by further heating or cooling using a heat pump. The geoexchange system does not replace the heat pump system but increases its efficiency significantly reducing the amount of energy needed to heat and cool a greenhouse. Geoexchange systems require installation of relatively shallow, underground horizontal loops (2-10m depth) or vertical loops (approximately 50m depth) that facilitate the exchange between the indoor space and the ground. No power is generated through the geoexchange process. Geoexchange systems can be relatively expensive, especially given that supplemental energy will be needed to achieve ideal greenhouse temperatures. A standard residential geoexchange system can cost anywhere from $20,000 to $40,000. More detailed cost analysis is worth doing if up-front capital is available for installation of a geoexchange system as geoexchange systems provide reliable and cost stabilized energy over the long-term.

**GEOTHERMAL**

Geothermal energy refers to the heat produced by radioactive decay of elements in the Earth's crust and conduction of heat from the Earth's core. Geothermal heat can be used to provide heat directly and if hot enough, can be converted to electricity. Wells that are not hot enough to produce electricity can still produce enough heat to heat indoor spaces, such as the greenhouse. Hotter wells can employ a binary or flash power plant to create electricity (geothermally heated water releases steam, which turns a turbine to create electricity). Waste heat from this electricity generation can also be used to heat the greenhouse. Geothermal heat and power requires significant up-front capital investment to drill the necessary wells (often between 1-5km), but after installation provides consistent and reliable heat and/or power. Since it is so expensive to install the infrastructure necessary to utilize geothermal power (costing upwards of millions of dollars to drill a well), it is most practical for projects that provide an economy of scale. Given the geological characteristics of the Revelstoke area, a geothermal system has the potential to meet both heat and power demands in conjunction with a larger-scale development (requiring >200MW of energy).

**SOLAR POWER (PHOTOVOLTAIC CELLS)**

Solar power converts sunlight directly into electricity using photovoltaic cells arranged in panels. The cost of solar panels has dropped significantly in recent years, while efficiency of the sunlight to electricity conversion has increased. Solar has become popularized as a low carbon-solution to electricity production. Government policy encouraging solar power may further reduce costs via incentives and rebates. Solar power production is heavily dependent on the amount and intensity of daylight, so battery storage (usually using deep-cycle lead-acid batteries) is necessary to more consistently meet electricity demands. Some form of backup power generation is necessary to supplement a solar system; especially considering Revelstoke's lower than average annual sunlight hours. Unfortunately, because the electricity provided will also be used to supplement lighting, solar power may not provide an appropriate energy source as it is not readily available during times of high demand. Costs are highly dependent on whether solar panels are connected to the local grid or other customers (and power can be sold back into it) or if the system is disconnected from the local power grid and battery storage is required. A 5.6 kW system connected the local grid costs an average of $16,000 while a 5.6 kW system with large batteries can cost $28,000 - $30,000. Very low availability of sunlight hours in Revelstoke (particularly in the winter season) means that solar is not a viable option to create the capacity necessary to run interior space conditioning systems required by a greenhouse. The solar greenhouse described in the greenhouse structure above is also not recommended in this technical assessment.

**SOLAR THERMAL**

The sun can also be used to provide thermal energy for heating (and even cooling) a space such as a greenhouse. There are various forms of solar heat collectors applicable for different uses, but most rely directly on the sun's radiant heat to warm air or a liquid which is then circulated to heat a building. Solar cooling can be achieved by using the sun's heat to power a heat-driven absorption chiller (heat pump). Similar to photovoltaic electricity generation, solar thermal heating and cooling is heavily dependent on sunlight. Thermal storage can be accomplished using a thermal energy storage system, which usually involves insulated tanks or aquifers that can retain heat (even for use in a different season.) Solar thermal systems also have many moving parts (including pumps and valves) so are subject to increased maintenance and can be prone to freeze damage in climate with cold winters such as Revelstoke. Once the costs of installation and maintenance are considered, it is often more economically efficient in cold weather climates to heat water with electricity generated by solar panels than it is to heat water directly with a solar thermal system.

**WIND POWER**

Wind power systems use airflow to turn turbines, which convert the wind's kinetic energy into electricity. Wind turbines are prone to maintenance due to the complexity of their moving parts and generally have short-term warranties. Wind power can also be prohibitively expensive, with a small 6 kW wind turbine costing around $50,000 dollars to install. In a consistently windy place, wind power can provide a more consistent alternative to solar power and other renewable energy, but investment in storage and backup energy generation is a must. The most suitable locations for wind power are locations with an annual wind speed of close to 5 m/s (which usually occurs on the prairies, near the ocean, or proximal to the great lakes). The average wind speed in Revelstoke is only 0.8 m/s, making wind an unfavourable option for electricity generation in this area.

**RESIDUAL HEAT**

Residual heat systems capture the waste heat generated from another location or source of power generation before it escapes, unused, into the ambient environment. This heat energy can be transferred to a transfer substance via a heat exchanger, which then allows the heat to be circulated to a building providing temperature control. If a generator is used to provide the electricity required for this project (or as a backup energy source to a less reliable source like solar or wind), a residual heat system could improve the efficiency of the generator and provide heating.

# 4. MARKETING

## 4.1 MARKET ANALYSIS

Greenhouses in BC account for 11% of the total agriculture produced but only take up 0.01% of farmland in BC. To put it into perspective, the amount of vegetables that can be produced in a greenhouse is 10 to 20 times more than compared to the same area of field grown crops. The growers for the BC Greenhouse Growers Association produce 96% of BC's greenhouse vegetables. [9]

A greenhouse can create many positive outcomes to a community such as employment (seasonal and year round), contribute towards the local economy, enhance food security and increase access to local food.

The BC greenhouse industry is comprised mainly of vegetable and floriculture (flower) crops. The highest value vegetable crops are cucumbers, peppers, lettuce and tomatoes. In 2010 the combined sales of these two sectors was approximately $560 million ($276 million in vegetable and $284 million in floriculture crops) which accounted for 40% of cash receipts of BC agricultural crops. [10]

Food security like many other communities has become a top priority for the community of Revelstoke. There has been the development of the Food Charter, Food Security Strategy and the implementation of a Food Security Coordinator, which all supports the level of interest and commitment towards accessing locally grown healthy food. Revelstoke has a bi-monthly farmers market in the winter months, two farmers markets that both operate every Saturday from May to October and two local farms that offer community shared agriculture boxes (CSA).

Local businesses, restaurants and individuals were consulted through interviews and surveys to determine the level of interest in purchasing locally grown produce from a greenhouse. The businesses that were consulted about purchasing produce from a commercial greenhouse are known for their commitment to utilizing or selling local products. Local businesses were very responsive to the potential of being able to purchase local produce. Some restaurants said they would adapt their menus around the type of food that would be made available to them. Others would like to get to a point where outside suppliers become their backup as opposed to their primary source of purchasing produce. By purchasing locally there is a belief that it would cut down on the time spent placing orders, shorter delivery times and create a greater connection to the food; however there would need to be consistency and appropriate volumes of produce available. There is a preference for the food that would be available for purchase from a greenhouse to be pesticide free.

From the surveys filled out by individuals in Revelstoke, 98% said they would buy locally produced products from a greenhouse. In Revelstoke there is a conscious group of consumers who appreciate buying local, having a connection to their food, and believe local food is better

for the environment by reducing the amount of food transported into the community. The overall consensus from everyone who was surveyed was a commitment to increasing food security and that they would pay more for local produce even if it had a relatively higher cost in comparison to other points of purchase.

To expand the market potential into grocery chains locally, Canada Good Agricultural Practices (GAP) Certification would be required. GAP certification creates a food-safety plan for agricultural businesses to ensure that the production of fresh fruits and vegetables follow the national food safety standard. The A1 option of being CanadaGAP certified has an annual cost of $525 and is on a four-year audit cycle and would be the most cost effective option for a commercial greenhouse. [11]

## 4.2 MARKET ASSESSMENT

In the 2016 census, Revelstoke had a recorded permanent population base of 8,145 people; 7,547 in Revelstoke and 598 in the Columbia Shuswap Regional District (CSRD). [12]

However, during the summer and winter tourist seasons the population in town can peak at approximately 13,700 people. [13] This peak population creates a demand for food and increases the opportunity to sell local produce that is grown in the community. This also helps support the local economy and would support the sales of produce sold through a commercial greenhouse.

A community greenhouse in Revelstoke would support local residents who are interested in growing their own food. Revelstoke has a shorter growing season and the establishment of a greenhouse would allow for food to be grown year round or as an extension of the season from April to November. It would facilitate the growing of different varieties of food that are not as easily grown in outdoor gardens and in addition provide opportunities for food to be harvested for a longer duration of the season.

A commercial greenhouse could provide fresh produce to the local market in Revelstoke and surrounding CSRD area. The objective would be to grow cucumbers, peppers and tomatoes as these are higher revenue generating crops in a greenhouse environment. The demand and sales of these crops are supported by the sales recorded during the last four years.

The estimate of market demand in Revelstoke can be based upon the available data for Canadian food availability, exhibited in Table 4.

| Canadian Food availability kilograms/person/year | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|
| Cucumbers | 3.28 | 3.43 | 3.20 | 2.65 |
| Lettuce | 9.38 | 9.55 | 9.06 | 9.11 |
| Peppers | 4.37 | 4.11 | 4.37 | 4.06 |
| Tomatoes | 8.58 | 8.36 | 8.00 | 8.19 |

Table 4 CANSIM table 002-0011 [14]

Utilizing the 2016 population data of the Revelstoke area in combination with the Canadian Food availability in Table 4, an estimation of the total market demand of produce in Revelstoke can be summarized in Table 5

| Potential total market demand in kilograms | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|
| Cucumbers | 26,716 | 27,937 | 26,064 | 21,584 |
| Lettuce | 76,400 | 77,785 | 73,793 | 74, 201 |
| Peppers | 35,594 | 33,475 | 35,593 | 33,068 |
| Tomatoes | 69,884 | 68,092 | 65,160 | 66,706 |

Table 5

To determine the potential market demand in kilograms in terms of 1%, 5%, 10% and 15% of the market in Revelstoke, Table 6 indicates the potential figures.

| Potential total market demand in kilograms | 1% | 5% | 10% | 15% |
|---|---|---|---|---|
| Cucumbers | 267 | 1,397 | 2,606 | 3,238 |
| Lettuce | 764 | 3,889 | 7,379 | 11,130 |
| Peppers | 356 | 1,674 | 3,559 | 4,960 |
| Tomatoes | 675 | 3,405 | 6,516 | 10,006 |

Table 6

The demand for these products has the potential to increase substantially during the summer and winter tourist months which were not taken into account in the above calculation.

It is important to determine the yield and planting frequency in order to establish how much could be produced and the amount of profits that could be earned. In Table 7, there is an anticipated planting density, harvest yields and potential frequency of crops that could be grown per year.

| | Planting container | Planting density | Crops per year |
|---|---|---|---|
| Cucumbers | 7.5-10cm Rockwool | 1.25-1.50 plants/m2 | 2-3 |
| Lettuce | Rockwool | 16-24 plants/m2 | 12 |
| Peppers | 10cm Rockwool | 2-3 plants/m2 | 1-2 |
| Tomatoes | 10cm Rockwool | 2.1-2.5 plants/m2 | 1-2 |

Table 7

Using CANSIM table 001-0006 from Statistics Canada the average price per kilogram was calculated for Peppers and Tomatoes between 2013-2016 and for Cucumbers between 2013-2015, as no data was not available for 2016. In addition the average anticipated revenue was determined per square metres for each crop.

| **Cucumber** | **2013-2015** |
|---|---|
| Area harvested/m2 | 416,789 |
| Production/kg | 24,500,940 |
| Price/kg | $1.82 |
| Revenue/m2 | $107.00 |

| **Pepper** | **2013-2016** |
|---|---|
| Area harvested/m2 | 1,505,475 |
| Production/kg | 40,990,369 |
| Price/kg | $3.41 |
| Revenue/m2 | $92.00 |

| **Tomato** | **2013-2016** |
|---|---|
| Area harvested/m2 | 1,039,225 |
| Production/kg | 56,559,645 |
| Price/kg | $2.07 |
| Revenue/m2 | $111.78 |

Table 8

Bedding plants

In a community or commercial greenhouse, there is revenue potential in annual bedding plant production. Bedding plant production could provide revenue opportunities for repayment of capital costs or raise funds for future expansion.

Bedding plants can be considerably easier to grow than vegetables and the growing season is short. A simple greenhouse set up can accommodate the growing of bedding plants. Plants can be started from seed or purchased as plugs that have small plants already growing. The bedding plants could be sold as single plants or put into hanging baskets.

Between 2013-2016 British Columbia greenhouse flowers and plants were predominantly grown in glass or polyethylene style greenhouses. The majority of greenhouses operated 10-11 months of the year and average 5,907 square meters in size. Which can be summarized in Table 9.

**Total area and operations in British Columbia**

| Area | Estimates | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|
| Total Greenhouse operations | Number | 335 | 330 | 325 | 250 |
| Total Greenhouse area | Square meters | 2,003,085 | 1,995,010 | 1,976,030 | 1,350,627 |
| Total months of operation | Number | 3,748 | 3,705 | 3,471 | 2,502 |

Table 9 CANSIM table 001-0047 [14]

The revenue that can be made per square metre is outlined in Table 11 and will help to calculate the potential revenues from a bedding plant operation.

| **Annual Bedding plants** | 2011 |
|---|---|
| Production area/m2 | 382,843 |
| Revenue/m2 | $154.01 |

Table 11 Alberta Agriculture [15]

Table 12 summarizes the crops that have been identified to have a potential market and determines the pros, cons and considerations for each individual crop.

| Crop | Pros | Cons | Marketability | Requirements |
|---|---|---|---|---|
| **Cucumbers** | • Grow quickly<br>• harvested over many months<br>• Can be stored for 10-14 days | • Require higher temperatures to grow<br>• Could be costly in the winter to grow | • High demand for individuals and businesses | • Pollination<br>• 75-77F (23-25C) in the day and 70F (21C) at night<br>• C02 for increased yields |
| **Lettuce** | • Grows quickly growing<br>• Many harvests per year | • Variety and age (ie micro greens) will influence if it can be a viable business | • High demand for individuals and businesses | • Consistent product needs to be available<br>• Choose variety based on conditions such as light |

| | | | | |
|---|---|---|---|---|
| **Peppers** | • Demand could be increased by timing harvest when peppers are less available locally | • Labour intensive<br>• Take a long time to grow<br>• Sensitive to low temperature | • Medium demand for individuals and businesses | |
| **Tomatoes** | • Can grow multiple crops per year<br>• Demand for crop year round | • Competitive market for this crop<br>• Could take time to find best variety for Revelstoke climate and the season crop is being grown | • High demand for individuals and businesses | • Supplemental lighting in winter<br>• Choose variety based on conditions such as light<br>• Select varieties that are in demand(this could be seasonal)<br>• Cold storage |
| **Annual bedding plants** | • Short season<br>• Plants can be purchased or grown from seed<br>• Easy to grow<br>• Could be an easy cash crop | • Market is competitive<br>• Plants only sold for short time of year | • High demand for individuals and businesses | • Supplemental heat or light is dependant if starting from seed<br>• Simple polyethylene structure |

Table 12

## 5. FINANCIAL MODEL

The financial model is based upon the identified capital costs, operating costs and potential revenues from both a small community greenhouse and a commercial greenhouse to determine the return of investment.

Small (4000 sq feet or 371 sq metres), community-focused greenhouse (with 150 plots that self-funds via membership and plot rentals). Seasonal. No supplemental heating or lighting.

| **CAPITAL COSTS** | | **OPERATING COSTS** | | | | **REVENUES** | | | |
|---|---|---|---|---|---|---|---|---|---|
| Land Purchase or lease | $350.00 | Debt Repayment (2.99%) | **Monthly Cost** | | **Annual Cost** | | **#** | **$/unit** | **Annual** |
| Greenhouse Structure | $21,000.00 | *Land Lease* | | $350.00 | $4,200.00 | Membership Fees | 150 | $10.00 | $1,500.00 |
| Construction (Labour) | $3,000.00 | *Greenhouse Structure* | | $114.62 | $1,375.44 | Plot Rentals | 150 | $50.00 | $7,500.00 |
| Site Prep | $1,500.00 | Labour | **#** | **$/person** | **Total** | Programming | - | - | - |
| Development Cost Charges (Industrial) | | | | | | **TOTAL ANNUAL REVENUES** | | | $9,000.00 |
| *Central Revelstoke - Sewer* | $3,335.08 | *Volunteer* | 1.97 | - | - | | | | |
| *Septic* | $2,018.00 | *Paid ($12/hr)* | 1.97 | $24,960.00 | $49,255.06 | | | | |
| *Arrow Heights - Sewer* | $3,444.54 | Material Inputs | | | $1445.385 | | | | |
| *Septic* | $2,018.00 | Insurance | | | $608.44 | | | | |
| *Big Eddy - Septic* | $519.01 | **TOTAL ANNUAL OPERATING COSTS** | | | $8,093.89 | | | | |
| Concrete (Pathways & Sinks) | $215/ Cubic metre | | | | | | | | |
| Utility and Warehouse Space | - | | | | | | | | |
| CO2 Distribution | - | | | | | | | | |
| Metering & Control Systems | - | | | | | | | | |
| Irrigation System(4 hoses and wands) | $480.00 | | | | | | | | |
| Nutrient Recycling System | - | | | | | | | | |
| Soil | $4,875.00 | | | | | | | | |
| Rainwater (snow) collection & Storage | - | | | | | | | | |
| Supplies to make garden beds | $5,250.00 | | | | | | | | |
| Other Equipment | $24,446.00 | | | | | | | | |
| Grants | | | | | | **NET ANNUAL PROFIT:** | | | **$906.12** |
| **TOTAL CAPITAL COSTS** | $63,886.08 | | | | | **ROI:** | | | **1.42%** |

Larger (9000 sq ft or 836 sq metres), commercial greenhouse with smaller, community component. Year round. Supplemental heating and lighting.

| **CAPITAL COSTS** | | **OPERATING COSTS** | | | **REVENUES** | | | |
|---|---|---|---|---|---|---|---|---|
| Land Purchase/lease | $150,000.00 | Debt Repayment (2.99%) | **Monthly Cost** | **Annual Cost** | | **#** | **$/unit** | **Annual** |
| Greenhouse Structure | $140,000.00 | *Land Purchase* | $818.69 | $9,824.28 | Membership Fees | 50 | $10.00 | $500.00 |
| Construction (Labour) | $3,000.00 | *Greenhouse Structure* | $764.11 | $9,169.32 | Plot Rentals | 50 | $50.00 | $2,500.00 |
| Site Prep | $3,000.00 | *Infrastructure* | $149.82 | $1,797.84 | Crop Revenue | | | |
| Development Cost Charges (Industrial) | | Heating Costs | | | *Cucumbers* | 752 | $213.98 | $160,912.96 |
| *Central Revelstoke - Sewer* | $7,503.93 | *Electrical* | | $43,542.09 | *Peppers* | 752 | $92.85 | $69,823.20 |
| *Septic* | $4,540.50 | *Propane* | | $22,650.52 | *Tomatoes* | 752 | $112.66 | $84,720.32 |
| *Arrow Heights - Sewer* | $7,750.21 | Lighting (Electrical) Costs | | $8,975.78 | **TOTAL ANNUAL REVENUES** | | | **$163,912.96** |
| *Septic* | $4,540.50 | Labour | **#** | **$/person** | **Total** | | | |
| *Big Eddy - Septic* | $1,167.77 | | 4.44 | $24,960 | $110,823.88 | | | |
| Concrete (Pathways & Sinks) | $215/cubic metre | Insurance | | | $1,371.04 | | | |
| Utility and Warehouse Space | $10,000.00 | Material Inputs | | | $14,128.40 | | | |
| Heating Infrastructure | $7,500.00 | **TOTAL ANNUAL OPERATING COSTS** | | | **$180,473.68** | | | |
| Lighting Infrastructure | $19,600.00 | | | | | | | |
| Electrical Installation | $5,000.00 | | | | | | | |
| CO2 Distribution | $600.00 | | | | | | | |
| Benches | $5,567.76 | | | | | | | |
| Irrigation System | $1,477.00 | | | | | | | |
| Nutrient Recycling System | - | | | | | | | |
| Rainwater (snow) collection & Storage | - | | | | | | | |
| Other Equipment | $24,446.00 | | | | | | | |
| Grants | | | | | | **NET ANNUAL PROFIT:** | | **-$16,560.72** |
| **TOTAL CAPITAL COSTS** | **$377,694.69** | | | | | **ROI:** | | **-4.38%** |

Larger (9000 sq ft or 836 sq metres), commercial greenhouse with smaller, community component. Year round. Supplemental heating and lighting.

| **CAPITAL COSTS** | | **OPERATING COSTS** | | | | **REVENUES** | | | |
|---|---|---|---|---|---|---|---|---|---|
| Land Purchase/lease | $150,000.00 | Debt Repayment (2.99%) | **Monthly Cost** | | **Annual Cost** | | **#** | **$/unit** | **Annual** |
| Greenhouse Structure | $140,000.00 | *Land Purchase* | | $818.69 | $9,824.28 | Membership Fees | 50 | $10.00 | $500.00 |
| Construction (Labour) | $3,000.00 | *Greenhouse Structure* | | $764.11 | $9,169.32 | Plot Rentals | 50 | $50.00 | $2,500.00 |
| Site Prep | $3,000.00 | *Infrastructure* | | $149.82 | $1,797.84 | Crop Revenue | | | |
| Development Cost Charges (Industrial) | | Heating Costs | | | | *Cucumbers* | 752 | $106.99 | $80,456.48 |
| *Central Revelstoke - Sewer* | $7,503.93 | *Electrical* | | | $43,542.09 | *Peppers* | 752 | $92.85 | $69,823.20 |
| *Septic* | $4,540.50 | *Propane* | | | $22,650.52 | *Tomatoes* | 752 | $112.66 | $84,720.32 |
| *Arrow Heights - Sewer* | $7,750.21 | Lighting (Electrical) Costs | | | $8,975.78 | *Bedding Plants* | 752 | $154.00 | $115,808.00 |
| *Septic* | $4,540.50 | Labour | **#** | **$/person** | **Total** | **TOTAL ANNUAL REVENUES** | | | **$199,264.48** |
| *Big Eddy - Septic* | $1,167.77 | | 4.44 | $24,960 | $110,823.88 | | | | |
| Concrete (Pathways & Sinks) | $215/cubic metre | Insurance | | | $1,371.04 | | | | |
| Utility and Warehouse Space | $10,000.00 | Material Inputs | | | $14,128.40 | | | | |
| Heating Infrastructure | $7,500.00 | **TOTAL ANNUAL OPERATING COSTS** | | | **$180,473.68** | | | | |
| Lighting Infrastructure | $19,600.00 | | | | | | | | |
| Electrical Installation | $5,000.00 | | | | | | | | |
| CO2 Distribution | $600.00 | | | | | | | | |
| Benches | $5,567.76 | | | | | | | | |
| Irrigation System | $1,477.00 | | | | | | | | |
| Nutrient Recycling System | - | | | | | | | | |
| Rainwater (snow) collection & Storage | - | | | | | | | | |
| Other Equipment | $24,446.00 | | | | | | | | |
| Grants | | | | | | **NET ANNUAL PROFIT:** | | | **$18,790.80** |
| **TOTAL CAPITAL COSTS** | **$377,694.69** | | | | | **ROI:** | | | **4.98%** |

# 6. SOURCES OF FUNDING

Sources of funding for a greenhouse will dependent on a variety of factors; is it a community or commercial greenhouse, what is the business structure (such as non-profit, for profit), who are the partners in the greenhouse (could it be the school district or City of Revelstoke). Being able to answer some of these questions will best direct which funding sources to explore. Below in Appendix B, is a list of potential funding streams that are available.

# 7. POTENTIAL SITE LOCATIONS

**SD 19**

None of the surplus spaces could be utilized for a greenhouse such as the lots at the old Mountain View or Mount Begbie schools as they are currently in the disposition process.

Spaces that could be available are:

- 501 11th street near the district board office, the garage area behind the high school
- 1401 First Street West - the field beside Okanagan College

**CSRD**

A diagnostic study will be released on the best use of lands in the CSRD in the Fall of 2017. This will provide possible options that could be explored as sites for a greenhouse.

**CITY OF REVELSTOKE**

- Industrial Park - at the end of Powerhouse Road within the former snowmobile track (land within the floodplain) Water and electrical would need to be brought in.
- Big Eddy Park – property would require some tree-removal. Water and electrical would need to be brought in (land within the floodplain).
- 1622 Nixon Road (former Big Eddy Waterworks office) -triangle lot - 0.43 acre).

**OTHER**

- Private landowners could be approached in the CSRD or within the City of Revelstoke
- There is a 12 acre parcel of land on Westside Road that is privately owned and is exploring the options of developing a commercial or community greenhouse which would be heated with a biomass system
- A recommendation was made to consult CP Rail about the area in Southside where the old rail beds have been removed and runs parallel to Railway Street

# 8. RISKS

In any new venture there can always be a certain amount of assumed risks. Some of the identified risks in a greenhouse can be:

- Financial as a result of the substantial capital costs in a commercial greenhouse
- Leased land if the owner wants to use the land for other uses
- Insufficient leadership or volunteers to maintain and run a community greenhouse
- Lack of bed rental in a community greenhouse

Some of these risks can be mitigated through thorough planning and being proactive in the development phases. For example, should a community greenhouse not succeed, the structure could be sold and the land could return to its original state. Potential options if a commercial greenhouse was not to succeed, it could be taken over by another organization, such as the City to grow plants for the city gardens or completely sell off the structure.

# 9. RECOMMENDATIONS

## STRUCTURE RECOMMENDATIONS

The recommendations for type of structure would be contingent on what the end use of the structure is and whether the land is owned or leased. Polyethylene, polycarbonate and glass greenhouses can be moved or decommissioned if needed. The only structure that would not be able to be moved is the structure for a solar greenhouse. Vertical farming spaces are usually old warehouses that could be returned to their original state or shipping containers that could be sold or moved easily.

1. A polyethylene covered greenhouse is a good economical choice for a structure that would be utilized to extend the growing season. The greenhouse could be set up directly on the soil with raised beds to grow in. It is a simple structure that can be set up easily and requires very little maintenance. The initial capital cost is minimal and should the greenhouse need to be moved or taken down, it would be an uncomplicated process. The polyethylene cover will need to be replaced every 3-4 years which is a low cost.

2. A Polycarbonate covered greenhouse would be a good choice for a commercial greenhouse as the structure is very durable and long lasting. The initial capital investment is higher than a polyethylene covering but it will last between 22-25 years. The structure can be placed on the ground or on a cement foundation. The maintenance of this structure over time is minimal.

3. Building a solar greenhouse could be an option for a permanent structure that could be used for a year round community greenhouse. The initial capital investment is high but the cost to run the greenhouse once established will be much lower as the cost of utilities will be very low. It could have a space for growing plants, hosting workshops and the opportunity to rent it out for community functions; making it an inclusive space for everyone to spend time in. The building infrastructure could be used as a learning tool for the individuals in the community

4. Glass as a greenhouse covering can be long lasting and durable. Some of the cons of glass are the initial investment cost, it is labour intensive to install, the structure is more permanent and glass is heavy. Glass is still widely used and can be a good option but for a commercial greenhouse there could be more cost effective choices.

5. Vertical farming would be a good option if an existing structure could be developed as this would cut down on the capital costs and provide a space efficient way to grow plants year round. The cost of setting up the interior infrastructure for vertical farming can be expensive which could be a barrier. This would be a good option for commercial growing of crops as more crops could be produced in a shorter period of time than in comparison to a greenhouse.

## ENERGY RECOMMENDATION

1. Propane as a heat source was found to be the most cost-efficient and appropriate means of heating a greenhouse in Revelstoke. The disadvantage of using propane as a heating source is the long-term cost volatility, which makes budgeting for greenhouse operational costs more difficult further into the future
2. An electrical system would be comparable in cost to the District Energy system, however a disadvantage is the long-term cost volatility
3. To attain minimal heating costs with long-term price stability, depending on the location of the greenhouse, the next best option would be the District Energy System (DES). DES rates are established by recovering the installation costs (which are approximately $14,000 per trenched meter) over a designated time period
4. Proximity to residual heat sources will also decrease the installation costs and therefore limit the overall cost of retrieving residual heat
5. Proximity to rivers, waterfalls, streams and creeks will warrant verification of practicality of a micro-hydroelectric power system
6. A stand-alone biomass system would be a great option, however it would be more capital intensive but operationally the costs would be quite minimal

## SITE RECOMMENDATION

Though a location has not yet been established for the Revelstoke greenhouse, the technical report suggests bearing several factors in mind when choosing a site. Selection should favour sites that allow for optimal economic conditions. In addition, consideration should be given to land usage constraints and other regulatory factors (which may limit changes to the business model or a phased development approach).

To attain minimal heating costs with long-term price stability, priority should be given to those sites that are closest to Revelstoke Community Energy Corporation (RCEC)'s district energy system (DES). DES rates are established by recovering the installation costs (which are approximately $14,000/trenched meter) over a designated time period. Proximity to residual heat sources will also decrease the installation costs and therefore limit the overall cost of retrieving residual heat. Certainly, proximity to rivers, waterfalls, streams and creeks will warrant verification of practicality of a micro-hydroelectric power system.

The greenhouse will also need to tie into the City of Revelstoke's water, road and sewer/septic system as described by the City of Revelstoke bylaw #1781. Development Cost Charges (DCC's) are assigned for residential, commercial, industrial or institutional usage separated into 3 geographical areas (Central Revelstoke, Arrow Heights and Big Eddy). A community or commercial greenhouse would be considered for industrial use according to a varying rate schedule based on location.

Special consideration shall be given to any land or buildings that are available through donation or lease agreement. When selecting land for purchase, consideration should be given to setbacks, right-of-way, zoning, topography and other construction limitations.
Other environmental considerations include lighting, icing and snow removal concerns.
Location Recommendations

Scenario A - Community Greenhouse
A community greenhouse would be best located in a central location to limit barriers to access. Having a greenhouse located in close proximity to the School District office, which is located near one of the elementary schools and the high school, would increase opportunities for partnership and for students to utilize the space.
The CP rail area in Southside where the old rail beds have been removed would be worth investigating as the space is quite large. CP rail is a huge employer in Revelstoke and this could be an interesting initiative for the community.

Scenario B - Commercial Greenhouse
The commercial greenhouse could be located beside Okanagan College as it is a large and easily accessible space with existing irrigation located on the field and electrical at the College. The building is owned by the school district and currently utilized by Okanagan College. Having a greenhouse located in this space could create opportunities for programming from the College directly related to greenhouse production growing.
Another good space for a commercial greenhouse could be on Westside road as there would be ample space for a greenhouse as well as future expansion.

## CROP RECOMMENDATIONS

Assessing the pros and cons for each crop combined with survey results and speaking with businesses there appeared to be a demand for the following crops:

1. Lettuce
2. Tomatoes
3. Cucumbers
4. Annual Bedding Plants
5. Peppers

1. Depending on the greenhouse set up and the time of year the lettuce will be grown, will play a direct role in the profitability of the business. The individuals and businesses in Revelstoke indicated they would buy lettuce year round. The need for consistent large volumes at competitive prices would also play a key role in successfully supplying restaurants.
2. Tomatoes are a crop that could be sold year round in Revelstoke as there is a high demand indicated by both individuals and businesses. The size and scale of the

greenhouse would play a role in the success as well as selecting the most appropriate varieties for the local climate and what is in demand in the local market

3. Cucumbers are a good crop to grow that would be best suited as a crop grown between March and November to increase the profitability due to the higher levels of heat required in order to grow them
4. Annual bedding plants are something that the majority of individuals and businesses purchase each year. This would be a crop that could be grown in the off season of another crop to increase revenue potential
5. Peppers had the lowest demand locally and seem to be the most difficult of the crops that were investigated to grow.

## BUSINESS STRUCTURE RECOMMENDATION

The business structure of a community greenhouse in comparison to a commercial greenhouse would vary quite considerably.

The recommendation would be to operate a community greenhouse as a non-profit organization. The model would support the greenhouse raising money through user fees to cover the annual operating costs of the greenhouse. As a non-profit, the greenhouse would have access to grants to develop programming and accessibility to seniors, youth and individuals with intellectual disabilities and in addition, access funds to expand the greenhouse.

The recommendation for a commercial greenhouse could be two different options:

- Option one would be, for-profit so the product could be grown in order to sell to the local community.
- Option two would be a cooperative, for example a multi stakeholder cooperative, as the greenhouse would have social goals, mutually benefit the members and deliver community needs.

## FUNDING RECOMMENDATION

The funding recommendations for a greenhouse will be directly influenced by the business structure and the overall scope of the greenhouse.
A season extender or year round community greenhouse could be financed by raising the initial capital funds through grants, fundraising or in kind donations. Once established this type of structure would be capable of maintaining itself financially through user fees.

The capital costs of a commercial greenhouse can be quite high. The sales revenues are not enough to pay off the initial start-up costs in a short period of time. In order for a commercial greenhouse to be successful, significant costs would need to be raised through grants, partnerships or investors.

# 10. CONCLUSION

The findings of the feasibility study concluded that a greenhouse in Revelstoke would be supported by individuals, community organizations and businesses. A greenhouse would support organizational objectives and create a more food secure community.

The next phase for this project would be to secure land and identify partnership and funding sources. Something that might also be helpful would be consulting with Groundswell in Invermere who has successfully assisted communities implement greenhouses or another organization who has experience with implementation of community greenhouses.

It will be important to identify and secure in the land in the community at a low cost. A season extender community greenhouse could be possible for the 2018 growing season using a 40 x 100 foot double polyethylene greenhouse. Greenhouses are scalable and a smaller structure could be constructed at a lower cost until additional funds could be raised for further expansion. If this greenhouse were to be structured as a non-profit, grants could be written to finance the capital costs. Depending on the partnership opportunities and their objectives, it would be worth exploring the potential for a year round community greenhouse. Ideally the land would have room for further expansion of the greenhouse or potential for a community farm. Establishing a community greenhouse is relatively low risk due to the simple and moveable structure.

A commercial greenhouse takes time for planning and implementation as the capital costs are much higher than a community greenhouse and it is critical to determine the type of crop that will be grown. The structure is more permanent with cement foundations and the construction of the greenhouse takes longer to build. Identifying the type or types of crops is important in developing the business plan and will play a direct role in selecting the infrastructure such as the heating source, greenhouse and lighting. The cost of purchasing land in Revelstoke has become quite high, ideally land could be leased to lower capital costs.

# APPENDIX A
# COMMUNITY GREENHOUSE SURVEY RESULTS SUMMARY

1. How do you think Revelstoke would benefit from a community greenhouse?
    a. Community Learning – 85%
    b. Food Security – 89%
    c. A place to grow food – 76%
    d. Expanding the perceived notions of what can be grown – 26%
    e. Community Ventures -65%

2. How do you see a community greenhouse benefiting Revelstoke as a community?
    a. It would be nice to grow food in winter, however I fear it will be too expensive like the community gardens are.
    b. Giving everyone the opportunity to grow food would ideally reduce the overall cost of food for the community, allowing more money to be spent locally.
    c. climate change action
    d. Local food security, jobs, education and research
    e. It would reduce my need to travel outside Revelstoke for affordable produce.
    f. By providing a place to learn, a place for those not fortunate enough to have their own space to grow from seed/grow more reliably, and a space for start-up agribusinesses in town to demonstrate and prove out the concept, before they seek investment into their own spaces.
    g. Being able to start seedlings early (for the community gardens, and community members who don't have access to a greenhouse). Extending the harvestable season into early spring and late fall - especially for greens, which are so expensive out of season at the grocery store.
    h. A community of our nature should be taking every measure and opportunity to grow and utilize the fertile environment around us. A project of this sort should be on the forefront of our city council's agenda. Imagine if an area the size of the mill was utilized for food growth, in the best real estate in town. Although the mill has its significance in the growth and development of our mountain town, move industry out of town and sustainable food growth into town! Imagine taking the energy of a beautiful Saturday market in early fall and taking into a town harvest project to benefit our food security. What could be better for the moral and happiness of a community than fresh, local product at heavily reduced rates! Pay less for the best!
    i. It would be great for the local people who are unable to put in a greenhouse on their rental properties and to learn new skills on how to build, maintain and grow a thriving green house
    j. Many do not have the means or space for a greenhouse. Shorter growing season can be extended by use of greenhouse.
    k. Encourage more people to start their own seedlings and therefore grow their own stuff.

l. Increased awareness of personal food autonomy and how our food grows.
m. Food security and education; employment and green innovation
n. I think it would be a great addition to the curriculum in the elementary and secondary schools.
o. Help the food bank secure fresh foods. Have a program with people who use food bank to volunteer tending hrs as well as others who just want to. Community working together.

3. How could you see a community greenhouse being used as an inclusive space?
   a. Educational uses which then produce food that can be sold in a social enterprise or donated to those in need.
   b. A place where people come together to garden and grow
   c. Workshop venue, place to grow exotic veggies, place to grow year round
   d. Allowing all residents, both permanent and temporary to use the greenhouse
   e. Similar to the community gardens.
   f. I think it would accept anyone to partake in caring for it
   g. E corporate education classes, invite senior gardeners to contribute knowledge
   h. Free education programs, work bee days for people to get their hands dirty
   i. great for kids programs and for programs like the food bank
   j. I guess a lot of that would depend on its size. It would be nice to have access to a certain plot if you were a member?
   k. I think doing something similar to the community gardens would not maximize productivity. I would love to see it used as a teaching model for kids and community members.
   l. By providing learning opportunities for everyone in our community, including youth, new immigrants and socio-economically disadvantaged families. The space could also provide a more controlled environment for disabled or elderly citizens to learn about and experience growing for food.
   m. Run programming and intertwine school curriculum to involve the school board and involvement with the youth. To educate children on food growth is the best life skill we can give to them. Include the elderly in social days where they can get their hands dirty.
   n. Holding workshops similar to those in summer hell held by the LFI.
   o. Similar to community garden. A small fee for space used.
   p. Learning center for new to gardening folks. Great place to go to get info on the unknown questions in our gardening worlds. a community support system.
   q. Holding various workshops, volunteer opportunities, learning opportunities, employment opportunities that are inclusive by design. Making it affordable for ALL- sliding scale? Plots donated?
   r. Yes make wheelchair accessible beds....designed by people in wheelchairs.

4. How much would you utilize the greenhouse?
    a. Year round – 76%
    b. To start seedlings – 18%
    c. March – October – 10%

5. If you rented a garden plot in the greenhouse, how much would you pay for a 4' x 6' plot per year?
    a. $50 – 61%
    b. $25 – 20%
    c. $75 – 18%
    d. $120 ($10/month) – 2%

6. If you rented a plot, what would you want included?
    a. Automatic irrigation – 89%
    b. Fertilizer/compost – 69%
    c. Information on gardening – 45%

7. What type of learning support would you want included as a member of the greenhouse?
    a. Mentoring – 71%
    b. Self-directed – 69%
    c. Group learning -51%

8. If courses were offered, what would you be interested in?
    a. Greenhouse growing -89%
    b. Greenhouse growing for kids and youth – 65%
    c. Sustainable building -51%
    d. Getting started in a greenhouse 43%
    e. Microfarming -26%
    f. Pest management
    g. How to build a greenhouse
    h. Soil science

9. Do you have a suggestion of where the greenhouse could be located?
    a. At the mill
    b. Farwell
    c. Mountain view school
    d. Begbie view school
    e. Mount Begbie school
    f. Near the airport
    g. Art Gallery

10. Would you consider buying produce grown in the greenhouse if it was available?
    a. 98.1% say yes

11. Do you think being able to grow your own food is important, why or why not?
    a. Yes. For the future of food security and because it is a skill that has been lost in the last few generations.
    b. The agricultural industry is one of the main contributors to greenhouse gases. The key is to eat local. We live in a place where we would then have no fresh produce 8 months of the year. A greenhouse helps solve this problem
    c. Yes. I like knowing what pesticides have been near my food and I like the idea of being self-sustainable.
    d. Yes - so important! Fresh healthy and tasty - Gives us a connection to the land - ecologically and environmentally sound (reduces our reliance on huge monoculture farms)
    e. Self-sufficiency and resiliency are important.
    f. Yes. I think it's great to learn to be self-sufficient but also to meet nutritional goals. Nutrient Rich foods are hard to come by in the cooler months in Revelstoke
    g. It is important that the skills and knowledge of growing food for one's self continues. Affordable organic food, with a small carbon footprint.
    h. More control of how your food is grown.
    i. Being able to grow your own food is extremely important, it brings us closer to the food we eat and the ecosystem that supports us
    j. Yes I do, though supporting local farms and farmers is equally important.
    k. Absolutely. Then i know that it's healthy, that it had the last impact on the environment and the most benefit to my community.
    l. Yes! Being involved in the processes of food production is empowering and environmentally sound.
    m. Best for health as well as passing skills on from generation to generation.

12. What priorities should be considered when designing the greenhouse?
    a. Low cost
    b. Sustainable building
    c. Location
    d. Green energy
    e. Space for workshops and teaching
    f. Build the best greenhouse the budget allows so it lasts and people are excited to use it
    g. Proper aspect
    h. Central location

13. Any other information or suggestions you would like to provide?
    a. Look towards Invermere to see how their greenhouse project took shape.
    b. It would be an incredible step forward for Revelstoke. The schools would benefit highly from having facilities that teach food growing as well!
    c. We bring in 95% of our food for a reason in Revelstoke. Having a central community greenhouse answers the demand for those who are demanding food security
    d. Share this survey publically. I only heard about it through the LFI.
    e. This would be a great initiative to help people with another avenue to get involved in growing their own food. With a somewhat shorter season in Revelstoke the fact that there would be opportunity to start seedlings to get a head start in spring is great.
    f. A community greenhouse should be in a central location for easy access to minimize the use of fossil fuels.
    g. I'd encourage you to adopt a sustainable financial model, where all or part of any income the program generates is set aside for the long term to ensure that the facility is maintained and upgraded as needed -- rather than relying on grant sources to step in and cover these potentially significant future costs
    h. Think of the future and of our children. Our small community can make ripples in our province, country and world. Be the change we want to see. We have the world's best water, best mountains, and soils. Why not have the produce to match?
    i. Please keep costs at a point where we can grow more food for the dollar than it would cost to buy.
    j. I'd be thrilled at the chance to grow tropical items year round in a heated greenhouse.
    k. An adjunct bee-keeping zone :)
    l. I think it is an important skill to have. Having this space will allow for greater opportunity for students and people in the community to learn and benefit from this skill.
    m. Wheelchair accessible
    n. I think it would be nice to have a little tea house with it so it could be a social visiting place as well...benches for people who want to be in green space maybe to read in bad weather.

## APPENDIX B

## POTENTIAL FUNDING SOURCES

1. Southern Interior Development Initiative Trust
   https://sidit-bc.ca/apply-funding/

2. Columbia Basin Trust
   https://ourtrust.org/funding-support/funding-support-programs/

3. Interior Health-Food Action Initiative
   https://www.interiorhealth.ca/YourHealth/HealthyLiving/FoodSecurity/Pages/default.aspx

4. BC Hydro
   https://www.interiorhealth.ca/AboutUs/ResearchandEthics/Pages/default.aspx

5. Revelstoke Credit Union
   https://www.revcu.com/Personal/InOurCommunity/CommunityPrograms/CommunityGiving/

7. Healthy Schools
   http://healthyschoolsbc.ca/healthy-schools-bc-resources/healthy-living-grants/

8. Farm to School BC
   http://farmtoschoolbc.ca/

9. Vancouver Foundation
   https://www.vancouverfoundation.ca/

10. Rural Dividend Fund
    http://www2.gov.bc.ca/gov/content/employment-business/economic-development/developing-your-community/community-partners/rural-economic-development/rural-dividend

11. Real Estate Foundation
    http://www.refbc.com/

12. Evergreen
    https://www.evergreen.ca

13. TD Bank Friends of the Environment
https://fef.td.com/funding/

14. Fiskar's Project Orange Thumb
http://www2.fiskars.com/Community/Project-Orange-Thumb

15. Honda Canada Foundation
http://www.hondacanadafoundation.ca/

16. AF's Agriculture and Agri-food Adaptation Program Funding
http://iafbc.ca/funding-opportunities/adaptation/

17. Greenhouse Carbon Tax Relief Grant
http://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/agriculture-and-seafood/programs/greenhouse-carbon-tax/2017_greenhouse_carbon_tax_relief_grant_eligibility.pdf

18. The Agri-Food Environment Initiative (AEI)
http://iafbc.ca/funding-opportunities/aei/

19. EcoAction Community Funding Program
https://www.ec.gc.ca/ecoaction/default.asp?lang=En&n=25155A6D-1#wsF32C0F46

20. Green Municipal Fund
http://www.fcm.ca/home/programs/green-municipal-fund/about-gmf.htm

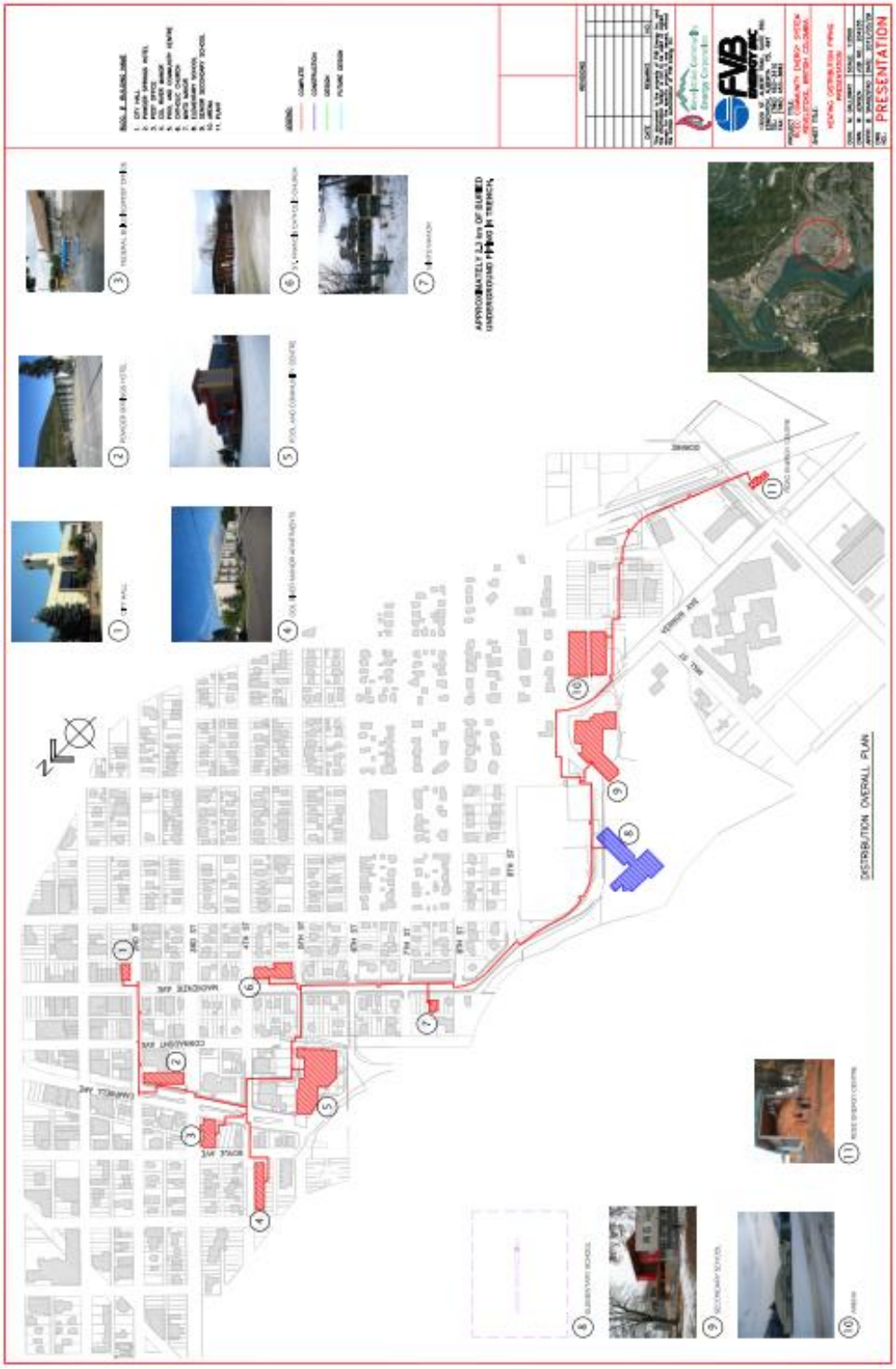
21. Youth Employment Program
http://www.nrc-cnrc.gc.ca/eng/irap/services/youth_initiatives.html

22. Small Communities Fund
http://www.infrastructure.gc.ca/plan/sc-cp-eng.html

23. College and Community Innovation Program – Applied Research & Development Grant
http://www.nserc-crsng.gc.ca/professors-professeurs/rpp-pp/ard-rda_eng.asp#procedures

24. Collaborative Research and Development Grants
http://www.nserc-crsng.gc.ca/Professors-Professeurs/RPP-PP/CRD-RDC_eng.asp

## APPENDIX C
## DISTRICT ENERGY SYSTEM MAP



# APPENDIX D
# TECHNICAL ASSESSMENT

**Description of Local Climate and Lighting Conditions**

The daily average temperature for the year is 5.1°C (13.96°C between May-September, -1.23°C between October-April). Revelstoke receives >0.2mm of rain 193 days a year with an average annual rainfall of 623.7mm. Between October and April, Revelstoke receives >0.2cm of snowfall 71 days a year with an average annual snowfall of 447.1cm. There is a 75% chance Revelstoke will remain frost-free between May 20th and September 20th (119 days) each year. [16]

Revelstoke is a humid continental climate with an average annual relative humidity of 63.5% (50.65% between April-September, 76.25% between May-August). Revelstoke does not however, receive a lot of sunlight with an annual average of 1582.7 sunlight hours. The winter months receive an average of 47 hours of sunlight each month (16% of daylight time) while the summer months receive an average of 193 hours of sunlight each month (43% of daylight time). [16]

The daily light integral (DLI) is a measure of the photosynthetically active radiation (PAR); the part of the light spectrum used in photosynthesis, that is delivered at the location on a given day. From PAR data collected at Terra Firma Farms (located 2 km South of Revelstoke city limits), the average annual DLI is 15.78 mol/m$^2$/day. This data was collected from the Adapting to Low Light Growing Conditions using High Tunnel Structures study being conducted by Terra Firma Farms and Okanagan College.

To achieve appropriate lighting and temperature conditions (minimum interior DLI of 12 mol/m$^2$/day and temperature of 18°C), a greenhouse at Revelstoke might only be operable from May until September without supplemental lighting and heating.

**Supplemental Lighting**

Photosynthetically active radiation (PAR) data was collected by researchers from Okanagan College in a single-walled greenhouse at Terra Firma Farms during February, March and April of 2016. Assuming that Revelstoke's mean monthly sunshine hours are an appropriate approximation of PAR; the remaining months were estimated by multiplying each month's % of the yearly sunshine hours by the calculated total yearly PAR (average of actual PAR data divided by % of yearly sunshine hours). The resulting daily light integral (DLI) data is found in Table 2.

Monthly lighting deficits were achieved by subtracting the calculated DLI from the desired DLI value needed to support various crops. Supplemental lighting would be needed to grow crops requiring 12 mol/m$^2$/day (such as tomatoes, cucumbers and peppers) for 5 months of the year (from October to February).

| Month | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean Monthly Sunshine Hours | 29.6 | 57.8 | 125.1 | 157.6 | 209 | 213.4 | 241.6 | 233.7 | 168.6 | 88.4 | 32.9 | 25.1 | 1582.7 |
| % Yearly | 2% | 4% | 8% | 10% | 13% | 13% | 15% | 15% | 11% | 6% | 2% | 2% | 100% |
| Actual PAR | - | 85.9395 | 164.2171 | 215.6548 | - | - | - | - | - | - | - | - | |
| **Actual DLI** | - | **7.43** | **14.19** | **18.63** | - | - | - | - | - | - | - | - | |
| Calculated PAR | 41.1233 | - | - | - | 290.364 | 296.4765 | 335.6547 | 324.6792 | 234.2359 | 122.8141 | 45.7079 | 34.8714 | 2198.8440 |
| **Calculated DLI** | **3.55** | - | - | - | **25.09** | **25.62** | **29.00** | **28.05** | **20.24** | **10.61** | **3.95** | **3.01** | |
| **Lighting Deficit (DLI)** | **8.45** | **4.57** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **1.39** | **8.05** | **8.99** | |

Table 2: Historical sunshine hours (1981-2010 @ Revelstoke Airport), Actual and Calculated PAR and DLI and Lighting Deficit data for Revelstoke, BC.

The number of light fixtures necessary is dependent on the dimensions of the greenhouse, as well as the lighting deficits calculated in Table 1. Assuming 150'x60 feet, the greenhouse would require 56 1000W High Pressure Sodium (HPS) lights [17] during December (the month requiring the greatest degree of lighting). Fixtures cost approximately $350.00 each [18] for a total of $19,600.00 in supplemental lighting costs.

The energy cost for the supplemental lighting required during the winter months is outlined in Table 3. [17] Revelstoke daily average sunlight hours are adequate during March to September to allow growth of vegetable crops and would not require supplemental lighting. The average annual electricity cost of supplemental lighting would be approximately $8975.78. [17]

| Month | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Fixtures Required** | 53 | 28 | - | - | - | - | - | - | - | 8 | 50 | 56 | |
| **KWh/Month** | 22,572 | 11,088 | - | - | - | - | - | - | - | 3,168 | 19,800 | 22,176 | |
| **$/month Electricity** | **$2570.95** | **$1262.92** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **$360.84** | **$2255.22** | **$2525.85** | **$8975.78** |

Table 3: Number of fixtures required, energy requirements and cost of supplemental lighting per month. [17] Based on a 12 hours of supplemental lighting per day.

**Supplemental Heating**

To create appropriate growing conditions, the interior of the greenhouse should remain above 18°C. As the daily average temperature in Revelstoke is less than 18°C, the greenhouse would benefit from supplemental heating (especially October-April).

A "heating degree day" (HDD) is the number of calendar days when the outdoor temperature falls below a base temperature (in this case, 18°C). The yearly heating degree days is found by subtracting the average daily temperature from the base temperature and adding up all of the days with positive numbers. Revelstoke has 4757.5 HDD at a base temperature of 18°C and

2453.4 HDD at a base temperature of 10°C. [16] Heating and cooling degree days based on various base temperatures are outlined in Table 4.

| 1981 to 2010 Canadian Climate Normals station data – Goldstream River (73km N of Revelstoke) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Degree Days | | | | | | | | | | | | | |
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Year |
| **Above 24°C** | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0 | 0 | 0 | 0 | 0 | 0.1 |
| **Above 18°C** | 0 | 0 | 0 | 0 | 0.6 | 6.4 | 24.9 | 18.5 | 0.6 | 0 | 0 | 0 | 51 |
| **Above 15°C** | 0 | 0 | 0 | 0 | 5.7 | 30.9 | 75.5 | 64.9 | 6.2 | 0 | 0 | 0 | 183.1 |
| **Above 10°C** | 0 | 0 | 0 | 1.3 | 51.1 | 140.6 | 214.7 | 198 | 60.9 | 2 | 0 | 0 | 668.6 |
| **Above 5°C** | 0 | 0 | 0.3 | 32.5 | 171.2 | 288.8 | 369.4 | 352.6 | 118.6 | 35.7 | 0.5 | 0 | 1439.5 |
| **Above 0°C** | 3.2 | 8.2 | 51.7 | 156.6 | 325.1 | 438.8 | 524.4 | 507.6 | 337.6 | 148 | 20.4 | 1.3 | 2522.7 |
| **Below 0°C** | 211.3 | 127.8 | 35.6 | 0.3 | 0 | 0 | 0 | 0 | 0 | 4.9 | 72.8 | 202.7 | 655.3 |
| **Below 5°C** | 363.1 | 260.7 | 139.1 | 26.2 | 1.1 | 0 | 0 | 0 | 1 | 47.6 | 203 | 356.4 | 1398.2 |
| **Below 10°C** | 518.1 | 401.8 | 293.9 | 145 | 36 | 1.8 | 0.3 | 0.4 | 23.3 | 168.9 | 352.5 | 511.4 | 2453.4 |
| **Below 15°C** | 673.1 | 542.9 | 448.9 | 293.7 | 145.6 | 42.1 | 16 | 22.3 | 118.6 | 321.9 | 502.5 | 666.4 | 3793.9 |
| **Below 18°C** | 766.1 | 627.5 | 541.9 | 383.7 | 233.5 | 107.7 | 58.5 | 68.9 | 203 | 414.9 | 592.5 | 759.4 | 4757.5 |

Table 4: Degree days at Goldstream River (73 km North of Revelstoke) at various base temperatures [16].

Monthly heating requirements were calculated by considering the average outside temperature, transmission heat loss (energy lost through the surface area of the greenhouse), infiltration heat loss (energy lost through ventilation systems) and U-factor (coefficient of heat transfer for a given material) of the selected greenhouse structure and are laid out in Table 5.

| Month | Outside Design Temp (average) | Monthly heating days (at 18°C) | Heat loss (KJ/hr) | Heat load (KJ/month) | Heat load (Kwh/month) | Kw/month |
|---|---|---|---|---|---|---|
| January | -6.5 | 766.1 | 643,785 | 275,476,573 | 76,521 | 102.7546 |
| February | -4.1 | 627.5 | 587,600 | 225,638,362 | 62,677 | 93.1728 |
| March | 0.6 | 541.9 | 477,571 | 194,858,053 | 54,127 | 72.6833 |
| April | 5.2 | 383.7 | 369,884 | 137,972,015 | 38,326 | 53.1783 |
| May | 10.5 | 233.5 | 245,809 | 83,962,642 | 23,323 | 31.3186 |
| June | 14.6 | 107.7 | 149,826 | 38,727,094 | 10,758 | 14.9265 |
| July | 16.9 | 58.5 | 95,982 | 21,035,608 | 5,843 | 7.8464 |
| August | 16.4 | 68.9 | 107,688 | 24,775,272 | 6,882 | 9.2413 |
| September | 11.4 | 203 | 224,739 | 72,995,359 | 20,277 | 28.1345 |
| October | 4.6 | 414.9 | 383,930 | 149,191,006 | 41,442 | 55.6492 |
| November | -1.9 | 592.5 | 536,097 | 213,052,956 | 59,181 | 82.1166 |
| December | -6.5 | 592.5 | 643,785 | 213,052,956 | 59,181 | 79.4702 |
| Annual Total | | | | 1,650,737,896 | 458,539 | 630.4924 |

Table 5: Heat load requirements by month based on Revelstoke monthly average outside temperatures and heating degree days (to 18°C).

## APPENDIX E
## ADDITIONAL BACKGROUND INFORMATION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