July 10th, 2017

Addressing Food Insecurity with year-round Geothermally Run Greenhouse in Canada

Author: Amanda Appasamy

Masters of Development Practice Program student (Indigenous Development)

Tel: 204-396-4009

University of Winnipeg

515 Portage Avenue

Winnipeg, MB

R3B 2E9 Canada.

Contents

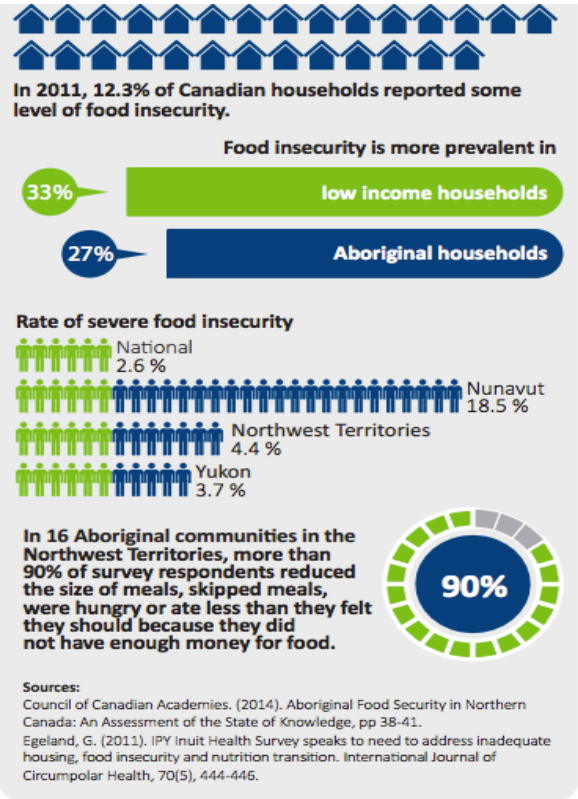
1 Introduction 1
2 Recommendation 2
3 Benefits 2
3.1 Social and Cultural Benefits 2
3.2 Economic and Fiscal Benefits 3
3.3 Environmental Benefits 3
4 Case Studies of Geothermally-Run Greenhouse 4
4.1 Case Study: Geothermal Greenhouse Project in Altura, Minnesota 4
4.2 Case Study: Low-grade geothermal heating and cooling for greenhouses in Nebraska and Denver, Colorado 4
4.3 Case Study: Geothermal provides heat and power for greenhouse at Chena Hot Springs, Alaska 5
4.4 Case Study: Geothermal greenhouses in Iceland 6
4.5 Case Study: Geothermal Greenhouse in Hearst, Ontario, Canada 7
5 Solution 7
6 Potential Characteristics and Operation of a greenhouse in Canada. 8
6.1 Structure 8
6.2 Heating and Electricity 8
6.3 Watering system 9
6.4 Supplementary Lighting 9
7 Conclusion 9
8 Bibliography 11

1 Introduction

Food insecurity occurs "whenever the availability of nutritionally adequate and safe foods or the ability to acquire acceptable foods in socially acceptable ways is limited or uncertain"[1]. Food security is crucial to broader health as malnutrition and hunger can contribute to permanent mental, physical and social issues such as poor learning outcomes, developmental delays, low birth weights, depression, anxiety and suicide which create barriers to economic security as well as educational and employment opportunities.

Food insecurity is not only a phenomenon in developing nations, in Canada hunger and malnutrition are concerning issues as well. As shown in figure 1, in 2011, it was estimated that 4 million Canadians, including 1.15 million children experience food insecurity due to low income[2]. In 2012, the rates of food insecurity in Canada was found to be alarming according to the United Nations Special Rapporteur on the Right to Food[3]. Low income, lack of access to transportation, geographic isolation and low literacy rates have been found to be some of the key barriers to food security nationally [4].

Fig 1: Rate of Food Insecurity in Canada and in Northern Indigenous communities



Source: Toward Food Security in Canada's North. Canada's public policy Forum. Nov 2015.

Studies by Che & Chen in 2001 and Ledrou & Gervais in 2005, have found that remote northern communities in Canada are more vulnerable to food insecurity; in particular, Indigenous peoples face one and a half to two times higher risk of food insecurity than non-indigenous peoples [5]. Colonization along with the forceful shift from subsistence living to wage labour, has contributed to the denial and loss of access to traditional food and traditional language through the residential school systems and the seizure of Indigenous lands. Moreover, Industrial development has caused a decline in animal populations such as moose and caribou[6].

[1] Rawnda Abraham, Lori Chambers, Teri Fiddler, Teresa Socha, Mehdi Zahaf, "Food Security in a Northern First Nations Community: An Exploratory Study on Food Availability and Accessibility" *Journal of Aboriginal Health* (2012):6. Accessed on June 21st, 2017 from: http://www.naho.ca/jah/english/jah08_02/08_02_food-security.pdf
[2] Isabelle Couture and Darren Gilmour, "Toward Food Security in Canada's North" *Canada's public policy Forum* (2015): 1. Accessed on June 21st, 2017 from: https://www.ppforum.ca/sites/default/files/Food_Security_november_04_sept_2015.pdf
[3] Couture and Gilmour, "Toward Food Security in Canada's North", 1.
[4] "The view from here 2015: Manitobans Call for a Renewed Poverty Reduction Plan- Food Security" *Canadian Community Economic Development Network/Canadian Centre for Policy Alternatives–MM* (2015):57. Accessed on June 21st, 2017 from: https://www.policyalternatives.ca/sites/default/files/uploads/publications/Manitoba%20Office/2015/01/View%20from%20here-5%20Food%20security.pdf
[5] "Couture and Gilmour, "Toward Food Security in Canada's North", 1.
[6] National Aboriginal Health Organization. "Resource Extraction and Aboriginal Communities in Northern Canada: Cultural Considerations." 2008:7. Accessed on July 7th, 2017 from: http://www.naho.ca/documents/naho/english/resourceExtraction/Cultural_EN.pdf

Some communities have reported that hunting, fishing and trapping have become more difficult leading to dependency on non-traditional market foods that are often expensive and of lower nutritional value[7].

These phenomena have contributed to factors such as low income, poverty and lack of transportation making market foods not only unaffordable, but they are often not culturally adapted to Indigenous peoples' diet. Similarly, many Indigenous communities face multiple social problems that stem from the legacy of colonization and intergenerational trauma of the residential school system.

Food insecurity is not unique to Canadian Indigenous peoples but is also rampant in other countries, specifically in remote Indigenous communities in northern Australia[8]. For Indigenous communities, political sovereignty and traditional knowledge are key to redressing the legacy of colonization which can help in achieving food sovereignty and the increase access to traditional and healthy food.

2 Recommendation

In order to enhance community independence and increase access to locally determined food systems, one potential solution would be a year-round access to greenhouse grown food with the use of geothermal energy. One challenge of running a greenhouse year round in cold climate countries is the high heating and electricity cost. However, with the use of geothermal energy as a source of heat and electricity, the cost of running a greenhouse year round is significantly lower than other renewables alternatives, including fossil fuels[9]. Not only is geothermal energy a secure and sustainable source, it is known to be the cleanest source of electricity and heat, using less land, and producing fewer emissions than any other energy source[10].

Greenhouses can be run as vegetable production facilities in the form of a social enterprise in support of local economies. Vegetables grown can be adapted to each community's needs and cultural context. Not only can greenhouse grown vegetables provide for stronger food security through nutritious, healthy, local and pesticide free fresh vegetables, the vegetables can also be sold to gain profits that can be invested back in the development and wellbeing of the communities.

3 Benefits

3.1 Social and Cultural Benefits

In Canada, the weather does not allow for fresh local food all year round. Communities are heavily dependent on imported food that often travels thousands of kilometres from the farm to consumers, contributing to a considerable amount of greenhouse gas emissions. In addition, in remote northern communities, the cost of fresh food is often high and of poor quality.

---

[7] National Aboriginal Health Organization "Resource Extraction and Aboriginal Communities in Northern Canada: Cultural Considerations." 7

[8] Abraham, Chambers, Fiddler, Socha, Zahaf "Food Security in a Northern First Nations Community: An Exploratory Study on Food Availability and Accessibility", 6.

[9] "About Geothermal Energy." Canadian Geothermal Energy Association. 2016. Accessed on Nov, 12th, 2016 from: http://www.cangea.ca/about-geothermal.html

[10] Ibid

As a result, people tend to resort to cheap packaged food contributing to poor health. Hence a greenhouse can provide affordable, healthy, local, fresh, organic, culturally appropriate, non-genetically modified vegetables to communities and displace the dependency on food imports. Healthy food is key to addressing health care concerns.

In addition, having a greenhouse in communities can encourage and train community members in horticulture and garden building; contributing to community wellbeing as well as providing communities with autonomy over their food sources. Greenhouses can also be used for school programs as it can act as a living biology lab providing for chemistry and biology lessons. This can also encourage children to be more willing to eat vegetables if they understand and are involved in the growing process.

3.2 Economic and Fiscal Benefits

In Canada, the gaps in employment and participation rates and reliance on government transfers have increased for Indigenous population living on reserves as compared to the non-Aboriginal population[11]. A year-round greenhouse production facility has the ability to address food security and provide local economic opportunities including employment and training opportunities. In 2011, the unemployment rate of Indigenous people was 15% as compared to non-Indigenous people at 7.5% nationally[12]. Hence, greenhouses can provide full time and part time employments for community members.

Furthermore, the shift from income support to employment can contribute to potential savings for the Government through lower transfer payments. A greenhouse can also provide synergetic local economic opportunities such as community gardens, chicken farms, composting and plant nursery. Finally, profits made from running a greenhouse as a social enterprise can help increase social capital, build adaptive capacity to increase community resilience and foster social innovation, entrepreneurship, and economic diversification.

3.3 Environmental Benefits

A sustainable greenhouse operation and production system with the use of geothermal energy and of a water recycling system as proposed, will have very minimal impact on the environment. Further, a greenhouse in the community can promote community composting program, encourage community participation and allow for reduction in landfill wastes.

With the use of non-genetically modified seeds, the need for pesticides and harmful chemicals that pollute lakes and rivers will be eliminated. In addition, a greenhouse is a great avenue to educate communities about seed saving and the preservation of endangered local varieties of seed. Finally, the greenhouse will provide sustainable greenhouse vegetables in terms of ethical workers' treatment, fair trade and nutritious food.

[11] The National Aboriginal Economic Development Board. "The Aboriginal Economic Progress Report 2015", *The National Aboriginal Economic Development Board* 2015:2, Accessed on June 22nd, 2017 from: http://www.naedb-cndea.com/reports/NAEDB-progress-report-june-2015.pdf

[12] The National Aboriginal Economic Development Board. "The Aboriginal Economic Progress Report 2015", 4.

4 Case Studies of Geothermally-Run Greenhouse

4.1 Case Study: Geothermal Greenhouse Project in Altura, Minnesota

Photo source: Clean Energy Resource Teams.

After researching the best possible combination of renewable energies for heating the soil in a greenhouse amongst ground source heat pumps, wood boiler systems, wind turbines, and photovoltaic cells by a couple in Minnesota, it was found that geothermal energy was the most feasible not only for heating in the winter but also for keeping cold storage areas cool. Ground source heat pumps are used to heat or cool the greenhouse depending on the time of the year.
The couple has been operating the greenhouse since 2011, which has helped them maintain a reliable income throughout the year. They have been successful at growing beans, cucumbers and tomatoes which are the most profitable crops in the winter[13].

4.2 Case Study: Low-grade geothermal heating and cooling for greenhouses in Nebraska and Denver, Colorado

Photo source: citrus in the snow: the report

Low grade geothermal heating ranges between 10 to 18 °C and is available everywhere in the world in any climate. Low grade geothermal energy uses air to circulate, collect and store geothermal energy. The initial cost of this concept costs 50% less and the maintenance cost is 90% less in a 35 year test period.

Russ Fin has researched and tested this technology in his home for 35 years and for the past two decades have been producing tropical flowers, citrus fruits and vegetables in sub-zero weather in the Nebraska plains with no heating or cooling cost[14].

[13] Jenna Lewein , Ashley Stucky. "No Winter at Whitewater Gardens Farm: Geothermal Greenhouse Project in Altura, MN. Case Study: Geothermal - Southeast Region" *Clean Energy Resource Team* (2011): 1-2. Accessed on June 22nd, 2017 from: http://www.cleanenergyresourceteams.org/sites/default/files/publication_files/CERTsCaseStudy_SE_Whitewater.pdf

[14] "Citrus in the Snow: The Report" *GreenCube Publishing, div ISBU Association, Inc. Copyright © 2012-2017* Russ Finch. Accessed on June 23rd, 2017 from: http://www.citrusinthesnow.com/geothermal-book.htm

The low grade geothermal heating system:

- uses geothermal heating with air circulation and not liquid
- requires no geothermal heat pumps
- requires no heat exchangers
- requires no other heating sources
- has low water consumption
- has very low maintenance cost
- has no mold or fungus
- can produce premium citrus fruits, floral and vegetables
- has lower installation cost than present geothermal exchange systems[15]

Similarly, in Denver Colorado, low grade geothermal heating has been successful in heating and cooling hydroponic and aquaponics greenhouses year round[16].

4.3 Case Study: Geothermal provides heat and power for greenhouse at Chena Hot Springs, Alaska

A year-round supply of greenhouse fresh vegetables are produced with the use of geothermal energy since 2004 in Chena Hot Springs Alaska, a place that has some of the world's coldest temperatures[17]. The greenhouse provides fresh produce to local restaurants and one market year round[18]. Chena Hot Springs has been a leader in the use of efficient local resources, i.e. geothermal energy to help communities move towards self-sufficiency and independence in food production.

Photo source: Greenhouse Canada

The Hot Springs resort has a 400 KWe geothermal generating facility that not only heats and cools the resort buildings and greenhouses but also produces electric power replacing diesel generators which were used to power the facility in the past.
In addition, geothermal energy is also used to cool an ice museum in order to maintain the temperature at -4°C throughout the year, which is especially useful in the summer when the temperature goes up to + 32°C[19].

[15] "Citrus in the Snow-The Report"
[16] "Low Grade Geothermal Heating and Cooling for Greenhouses*", 2017 Bright Agrotech*. Accessed on June 22nd, 2017 from: https://blog.brightagrotech.com/low-grade-geothermal-heating-cooling-greenhouses/
[17] Meriam Karlsson, Jeff Werner. "Growing fresh vegetables: Midnight sunlight & the Earth's warmth". *University of Alaska Fairbanks – Alaska's Land Grant Institution.* (2010). Accessed on June 27th, 2017 from: https://www.uaf.edu/files/snre/MP_09_10.pdf
[18] Treena Hein. "100 per cent renewably-powered Alaskan greenhouse" *Greenhouse Canada is an Annex Business Media publication. | Copyright © 2017*. (2012). Accessed on June 27th, 2017 from: https://www.greenhousecanada.com/energy-edge/renewables/100-per-cent-renewably-powered-geothermal-alaskan-greenhouse-again-showcased-at-energy-fair
[19] Bernie Karl; Connie Karl, Mike Leland. "An Example of Small Scale Geothermal Energy Sustainability: *Chena Hot Springs, Alaska" Proceedings World Geothermal Congress 2015*. (2015): 1, 2, 5. Accessed on June 27th, 2017 from: https://pangea.stanford.edu/ERE/db/WGC/papers/WGC/2015/38003.pdf

The greenhouse is 656 square metre in size. The geothermal power plant supplies 62 kilowatts of energy needed for the High-Intensity Discharge lights used in the greenhouse as well as other electrically powered equipment for about 16 hours a day[20]. In addition, a temperature of +24°C is maintained throughout the year with the geothermal resource that generates 500,000 BTUs per hour throughout the winter when the temperature drops to -46°C. According to the University of Alaska fair banks, this technology saves about 284 litres of fuel oil daily and can help communities save on the high cost of power[21]

The technology used is a binary plant that uses low temperature geothermal fluids whereby geothermal fluid at 74°C is converted to gas to produce electricity. The gas is cooled to produce geothermal water which is then routed through the buildings and injected back into a thermal reservoir to be finally reheated by the earth. The system is a closed loop that has zero greenhouse gas emission and is known to be the lowest geothermal producing power in the world[22]. This example of low temperature geothermal resources could be a solution to achieving self-sustainability in remote places of the world.

4.4 Case Study: Geothermal greenhouses in Iceland

Iceland has been using geothermal energy to heat greenhouses since 1924 thanks to its Mid-Atlantic Ridge location, providing for abundant hydropower resources through precipitation from mountains and volcanoes[23]. Geothermal resources in the country are used for both electricity generation and direct uses[24].

Photo Source: Orkustofnun. National Energy Security

50% of the greenhouse production is used for growing vegetables and the rest for potted plants, forest plants and nurseries for bedding[25].The majority of greenhouses are enclosed in glass and steel pipes are installed on the walls and hung over plants for heating[26]. The temperature in the greenhouses have automatic indoor climate control where temperatures can be adjusted from 10°C to 25°C depending on the crops grown.

Outdoor growing is also common where geothermal water is used for soil heating in early spring. Similarly, geothermal steam is used to boil and disinfect the soil [27]. One greenhouse in Iceland has been converted into a café and bar that sells produce from the greenhouse providing employment opportunities and year round food production.

---

[20] University of Alaska Fairbanks "Case Study: Chena Hot Springs" *Alaska Center for Energy and Power — 2010* (2010) Accessed on June 27th, 2017 from: http://www.uaf.edu/files/acep/greenhouseenergy.pdf
[21] "100 per cent renewably-powered Alaskan greenhouse"
[22] "Low Grade Geothermal Heating and Cooling for Greenhouses"
[23] Orkustofnun. National Energy Security. "Greenhouses". *Orkustofnun*. Accessed on June 27th, 2017 from: http://www.nea.is/geothermal/direct-utilization/greenhouses/
[24] Árni Ragnarsson. "Geothermal Dev;5elopment in Iceland 2010-2014". *Proceedings World Geothermal Congress 2015*. (2015):5. Accessed on June 27th, 2017 from: https://www.geothermal-energy.org/pdf/IGAstandard/WGC/2015/01077.pdf
[25] Orkustofnun. National Energy Security. "Greenhouses". *Orkustofnun*.
[26] Árni Ragnarsson. "Geothermal Dev;5elopment in Iceland 2010-2014", 5.
[27] Orkustofnun. National Energy Security. "Greenhouses". *Orkustofnun*.

The owners of the greenhouse also provide tours to educate the public about greenhouse agriculture and gardening. Most importantly, the greenhouse use hives of bees to pollinate plants throughout the growing season[28].

4.5 Case Study: Geothermal Greenhouse in Hearst, Ontario, Canada

A $230,000 geothermal healing pump was installed by a greenhouse grower in Ontario after testing a small scale geothermal system that produced successful results. The biggest challenge in operating a greenhouse in Northern Canada is the heating cost. With the geothermal system, the grower is expecting a 70% reduction in heating cost. According to the grower, geothermal system is the best option in eliminating humidity in a greenhouse that contributes to molded vegetables that go to waste[29].

5 Solution

As seen in these case studies, Canada has a huge potential for addressing food insecurity across the nation with geothermal technology. In Canada, high energy and electricity requirements and costs can affect the economics of greenhouses. However, geothermal energy has the ability to address these challenges allowing for year-round access to fresh food, sustaining the local economy and providing for employment opportunities.

In fact, a 2012 report on Canadian greenhouses found that the greenhouse vegetable industry is succeeding as innovative greenhouse technologies are improving operations whilst increasing water and energy conservation. In addition, integrated pest management and traceability safety systems have improved to ensure high quality and the safety of greenhouse produce[30]. The size of the greenhouse industry in some parts of Canada, in terms of area, has grown steadily during the last few decades. A survey done in Alberta Canada indicated that in the next three to five years “the buy local movement, non-traditional products, organic or green products and export markets would serve as opportunities for expansion”[31].

[28] *Katherine Hysmit.* “Hidden greenhouses in the Icelandic countryside grow and serve tomatoes”. *© 2017 Boston Globe Media Partners, LLC.* (2015). Accessed on June 27th, 2017 from: https://www.bostonglobe.com/lifestyle/food-dining/2015/09/08/hidden-greenhouses-icelandic-countryside-grow-and-serve-tomatoes/H9ELr0WPS0PzsmznHyzlYI/story.html

[29] Callam Rodya.” Hearst greenhouse grower installs geothermal heating system”. *Northern Ontario Business* (2012).Accessed on June 27th, 2017 from: https://www.northernontariobusiness.com/industry-news/green/hearst-greenhouse-grower-installs-geothermal-heating-system-368218

[30] Farm Credit Canada. “Advancing the business of Agriculture Update on the North American Greenhouse Vegetable Industry”, *Farm Credit Canada* (2012): 2,6. Accessed on June 29th, 2017 from: https://www.fcc-fac.ca/fcc/agKnowledge/publications/ag-sector-guides/pdfs/north-american-greenhouse-vegetable-industry.pdf

[31] Emmanuel Anum Laate. “Profile of the Greenhouse Industry in Alberta. Industry Profile 2014” *Economics and Competitiveness Division*. (2015):1. Retrieved on June 29th, 2017 from: https://agga.ca/pdf/2014-industry-profile.pdf

6 Potential Characteristics and Operation of a greenhouse in Canada.

Based on existing greenhouses in Canada and across the world, below are some recommendations of the characteristics and operation of a geothermally run greenhouse.

6.1 Structure

Most new Greenhouses in Canada are constructed of wood, steel or masonry covered with either glass, fiberglass, double plastic or single layer of plastic.
Hence, the proposed greenhouse could be constructed of wood with the masonry covered in diffuse glass or solar glass greenhouses allowing for natural sunlight to be more evenly distributed and further reducing energy cost[32].

6.2 Heating and Electricity

Geothermal resources can be found across Canada and are more prominent in Western and Northern parts of the country[33]. As seen in the case studies, low grade geothermal energy, referred to as "geoair" can be effective in Canadian climates for heating and cooling; a concept that uses air to collect, circulate and store geothermal energy [34].

In Canada, natural gas is the fuel of choice for heating greenhouses and the average heating cost in 2014 was estimated at $12.54 per square metres[35]. The average natural gas requirement for a 10,000 square metres vegetable greenhouse is about 10% of the production cost[36]. As a result, "the majority of growers are anticipating business threats such as higher energy costs, markets/prices, import competition, and taxes and regulation"[37]. Hence, geothermal energy can address these challenges.

Levelized Cost of Energy ($/MWh)

LCOE SCENARIO ANALYSIS	HIGH CASE	BASE CASE	LOW CASE	MIN.	DIFF.
Solar PV (Crystalline)	$201	$153	$119	$119	$82
Solar PV (Thin Film)	$180	$140	$110	$110	$71
Fuel Cell DG	$117	$90	$72	$72	$46
Solar Thermal	$126	$90	$69	$69	$57
Coal	$66	$55	$46	$46	$19
Natural Gas (CCGT)	$64	$52	$40	$40	$25
Nuclear	$64	$62	$35	$35	$29
Wind	$61	$43	$29	$29	$32
Geothermal	$59	$36	$22	$22	$38
Efficiency	$30	$15	$0	$0	$30

Source: Credit Suisse

Geothermal power is price competitive, and lower than other renewables alternatives, including fossil fuels. In addition, "geothermal power plants provide long term cost certainty which helps stabilize electricity rates, providing an important protection for consumers"[38].

Fig 2: Source: Canadian geothermal energy association 2016

[32] "Profile of the Greenhouse Industry in Alberta", 90.
[33] Support Geothermal in Canada". Canadian Geothermal Energy Association (2016). Retrieved on June 29th, 2017 from: http://www.cangea.ca/
[34] "Citrus in the Snow-The Report"
[35] "Profile of the Greenhouse Industry in Alberta", 1.
[36] Ibid
[37] Ibid
[38] "Support Geothermal in Canada".

Geothermal is known to be the cleanest source of electricity & heat, using less land and producing fewer emissions than any other energy source[39]. It uses large scale direct use of the hot water derived from the earth hence providing energy security and economic growth. Finally, useful by-product heat produced by geothermal power facilities can be integrated with greenhouses[40].

6.3 Watering system

The watering of ground beds can be done with soaker hoses, which run parallel to each side of the bed. The source of water can be from greenhouse roof water collection, well and from community rivers to minimize water cost. A sand filtration system can be used for water treatment[41]. In addition, greenhouse water can be recycled eliminating the need for the disposal of waste water.

6.4 Supplementary Lighting

Supplementary lighting may be required in the winter whereby LED lighting can be used. LED lighting is energy efficient and help maintains low operating costs[42].

7 Conclusion

This report recommends the use of geothermal energy to operate sustainable year-round greenhouses across Canada in order to address food insecurity and displace dependency on food imports. Imported food travel thousands of kilometres from the farmers to consumers and are often expensive in remote northern communities. In addition, the cost of running regular greenhouses are often heat and power intensive which makes growing food year-round difficult. Hence, geothermal energy can be used to replace high heat and power cost providing for the ability to grow quality, locally sourced, non-genetically modified, organic and culturally appropriate fresh vegetables for communities.

A greenhouse can also provide synergetic local economic opportunities such as community gardens, chicken farms, composting and plant nurseries. A greenhouse can create employment opportunities, train communities in horticulture and be used for school programs. Profits made from running greenhouses as a social enterprise can help increase social capital, build adaptive capacity to increase community resilience and foster social innovation, entrepreneurship, and economic diversification.

[39] "Support Geothermal in Canada".
[40] Ibid
[41] "Profile of the Greenhouse Industry in Alberta", 34.
[42] Heather Exner-Pirot. "Guideline for establishing a northern greenhouse project" *International Centre for Northern Governance and Development. University of Saskatchewan.*(2012): 7. Retrieved from on November 26th, 2016: https://www.usask.ca/icngd/publications/reports/Reports-Files/Northern%20Greenhouse%20Guidelines_FINAL.pdf

The sustainability of this project will be reflected in the use of geothermal energy, with minimal waste production and environmental impacts through the collection and recycling of rain water and the multipurpose use of the greenhouse as a live laboratory for students.

The challenges of the project are the intensive operational and capital cost. However, the net social benefits of this project outweigh the capital costs. Hence this project can qualify for government subsidies. Finally, the profit gained from the operation of the greenhouse can be used for further economic development in the communities.

8 Bibliography

Abraham, Rawnda, Chambers, Lori, Fiddler, Teri, Socha, Teresa and Zahaf Mehdi. 2012 "Food Security in a Northern First Nations Community: An Exploratory Study on Food Availability and Accessibility" *Journal of Aboriginal Health*. 1-11. Accessed on June 21st, 2017 from: http://www.naho.ca/jah/english/jah08_02/08_02_food-security.pdf

Árni, Ragnarsson. 2015 "Geothermal Development in Iceland 2010-2014". *Proceedings World Geothermal Congress 2015.* 1-15. Accessed on June 27th, 2017 from: https://www.geothermal-energy.org/pdf/IGAstandard/WGC/2015/01077.pdf

Canadian Geothermal Energy Association. 2016. "About Geothermal Energy." Accessed on Nov, 12th, 2016 from: http://www.cangea.ca/about-geothermal.html

"Citrus in the Snow: The Report". 2017. *GreenCube Publishing, div ISBU Association, Inc. Copyright © 2012-2017 Russ Finch*. Accessed on June 23rd, 2017 from: http://www.citrusinthesnow.com/geothermal-book.htm

Couture, Isabelle and Gilmour Darren. 2015. "Toward Food Security in Canada's North" *Canada's public policy Forum*. 1-18. Accessed on June 21st, 2017 from: https://www.ppforum.ca/sites/default/files/Food_Security_november_04_sept_2015.pdf

Emmanuel Anum Laate. 2015 "Profile of the Greenhouse Industry in Alberta. Industry Profile 2014" *Economics and Competitiveness Division*.1-112. Retrieved on June 29th, 2017 from: https://agga.ca/pdf/2014-industry-profile.pdf

Farm Credit Canada. 2012. "Advancing the business of Agriculture Update on the North American Greenhouse Vegetable Industry", *Farm Credit Canada*.1-12. Accessed on June 22nd, 2017 from: https://www.fcc-fac.ca/fcc/agKnowledge/publications/ag-sector-guides/pdfs/north-american-greenhouse-vegetable-industry.pdf

Hein, Treena. 2012. "100 per cent renewably-powered Alaskan greenhouse" *Greenhouse Canada is an Annex Business Media publication. | Copyright © 2017.* Accessed on June 27th, 2017 from: https://www.greenhousecanada.com/energy-edge/renewables/100-per-cent-renewably-powered-geothermal-alaskan-greenhouse-again-showcased-at-energy-fair

Hysmit, Katherine. 2015 "Hidden greenhouses in the Icelandic countryside grow and serve tomatoes". © 2017 Boston Globe Media Partners, LLC. Accessed on June 27th, 2017 from: https://www.bostonglobe.com/lifestyle/food-dining/2015/09/08/hidden-greenhouses-icelandic-countryside-grow-and-serve-tomatoes/H9ELr0WPS0PzsmznHyzlYI/story.html

Karl, Bernie, Karl Connie and Leland Mike. 2015 "An Example of Small Scale Geothermal Energy Sustainability: *Chena Hot Springs, Alaska" Proceedings World Geothermal Congress 2015*. 1-6. Accessed on June 27th, 2017 from: https://pangea.stanford.edu/ERE/db/WGC/papers/WGC/2015/38003.pdf

Karlsson, Meriam and Werner Jeff. 2010. "Growing fresh vegetables: Midnight sunlight & the Earth's warmth". *University of Alaska Fairbanks – Alaska's Land Grant Institution*. Accessed on June 27th, 2017 from: https://www.uaf.edu/files/snre/MP_09_10.pdf

Lewein, Jenna and Stucky Ashley. 2011. “No Winter at Whitewater Gardens Farm: Geothermal Greenhouse Project in Altura, MN. Case Study: Geothermal - Southeast Region” *Clean Energy Resource Team.*1-2. Accessed on June 22nd, 2017 from: http://www.cleanenergyresourceteams.org/sites/default/files/publication_files/CERTsCaseStudy_SE_Whitewater.pdf

“Low Grade Geothermal Heating and Cooling for Greenhouses”. 2017 *Bright Agrotech.* Accessed on June 22nd, 2017 from: https://blog.brightagrotech.com/low-grade-geothermal-heating-cooling-greenhouses/

National Aboriginal Health Organization. (2008). “Resource Extraction and Aboriginal Communities in Northern Canada: Cultural Considerations.” *Ottawa, ON.* 1-8. Accessed on July 7th, 2017 from: http://www.naho.ca/documents/naho/english/resourceExtraction/Cultural_EN.pdf

Orkustofnun. National Energy Security. “Greenhouses”. Orkustofnun. Accessed on June 27th, 2017 from: http://www.nea.is/geothermal/direct-utilization/greenhouses/

Rodya, Callam. 2012 “Hearst greenhouse grower installs geothermal heating system”. *Northern Ontario Business* Accessed on June 27th, 2017 from: https://www.northernontariobusiness.com/industry-news/green/hearst-greenhouse-grower-installs-geothermal-heating-system-368218

The National Aboriginal Economic Development Board. 2015. “The Aboriginal Economic Progress Report 2015”, *The National Aboriginal Economic Development Board.* 1-92, Accessed on June 22nd, 2017 from: http://www.naedb-cndea.com/reports/NAEDB-progress-report-june-2015.pdf

[1]The view from here 2015: Manitobans Call for a Renewed Poverty Reduction Plan- Food Security” 2015. *Canadian Community Economic Development Network/Canadian Centre for Policy Alternatives–MM.*57-59. Accessed on June 21st, 2017 from: https://www.policyalternatives.ca/sites/default/files/uploads/publications/Manitoba%20Office/2015/01/View%20from%20here-5%20Food%20security.pdf

University of Alaska Fairbanks 2010. “Case Study: Chena Hot Springs” *Alaska Center for Energy and Power — 2010”*. Accessed on June 27th, 2017 from: http://www.uaf.edu/files/acep/greenhouseenergy.pdf