Final Proposal

ThermoPonics

Grand Challenges

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Problem

Alaska is the largest state in the United States but produces very little of their own food. At any given time local grocery stores do not have enough stock to sustain their customers for a week (AK Farm Bureau, 2016). Consequently, consumers in Alaska pay significantly more per meal than a family anywhere else in the country because the most reliable food source is a state away.

The average annual temperature of alaska is 37°F, making outdoor agriculture production difficult (U.S. Climate Data, 2016). Only 4% of Alaska's 365 million acres is remotely farmable with only 0.24% actually being utilized for agriculture (Cioni-Haywood, 2013). These and other climate related issues contribute to the need for the state to import 95% of their food (Renewable Energy Alaska Project).

The government of Alaska has demonstrated their investment in this problem space. The Department of Agriculture (DOA) is constantly looking at ways to increase Alaska grown food and finding ways to reduce their dependence on outside states. Alaska's 2016 Specialty Crop Block Grant Program is proof that the government is actively invested in making Alaska a better place for year round agriculture (Alaska Department of Natural Resources). It also shows that they do not have the answers to their problems but they are looking for innovation and are willing to support what comes their way.

In the future, fishermen have the greatest potential to be negatively affected by our project. If we are successful in our implementation and Alaska adopts the system, there is an increased chance of competition within the local markets. However, seeing as Alaska is in such a critical state in their food dependency, there remains ample time for policymakers and farmers to come together and decide on guidelines that will be most beneficial for the state.

The Alaskan farmer is the largest stakeholder in our project. They are in the position to receive the most direct benefits from our system. Our attempt to make their business more viable and profitable will provide them with a less variable and better standard of living. We are also doing this project with the expectation that it will create more jobs for farmers and increase the role of agriculture in the alaskan economy.

The people of Alaska stand to benefit in multiple ways. They could take part in a new part of the economy by becoming a farmer. Alaska as a whole is a food desert; year round there is only 3-4 days worth of food to sustain the alaskan people. If Alaska can double their domestically grown food from 5% to 10% of their total supply, they can circulate another 125 million dollars through their economy (AK Farm Bureau, 2014).

Aquaponics is a new field that shows promise for the elimination of food miles. While there are many areas both in the United States and around the world that are using aquaponics to supplement food imports and large scale agriculture, most practices are located in areas with warmer climates (Love, 2014). Currently there are two aquaponic farms in Alaska and they are located in the same city. A company called Alaska Aquaponics provides a box of locally grown vegetables to customers for a fee of $60 per month. The other company, Blood, Sweat, and Food raises and sells their produce to two local restaurants. Both companies are located near Homer, Alaska and heat their greenhouses year round using natural gas (Armstrong, 2015). This attempt to extend Alaska's growing season and reduce food imports has served as a proof of concept: aquaponics can work in Alaska using traditional energy sources. However, the successes of these companies are limited to the population of Homer and rely on unsustainable energy sources. Our team wants to use this new agricultural approach for Alaska and make it more energy efficient and more widespread.

Many different farms have seen success with geothermal energy systems. For example, Whitewater Farms in Altura, Minnesota uses geothermal energy to heat their greenhouse which allows them to grow fresh vegetables year round. The geothermal energy retrieved from a ground source pump is used to heat the soil in the greenhouse as well as for cooling the storage area. The Dietz's received a grant for $4,000 from Clean Energy Resource Team (CERTs) to experiment with geothermal energy and have had considerable success (Lewein, 2011). Their work shows promise in advancing the use of geothermal energy for extending the growing season but still leaves room for improvement. Our team would like to use the technology the Dietz's are using and instead of heating soil which can become expensive and scarce, use it to heat the water in aquaponic systems.

Plant farms are not the only ones to mesh well with geothermal energy. According to a study done by Klaipėda Science and Technology Park in 2012, countries across the world are using geothermal energy to heat the water used in their aquaculture systems: "[t]here are geothermal eel farms in Slovakia. China has over 200 hectares of geothermal fish farms, while Japanese fish farms grow eels and alligators. There are also fish farms in France, Greece, Israel, Korea, and New Zealand." Geothermal energy is successfully being used to heat water in aquaculture systems but no attempt has been made to use the same science in aquaponics, a very similar system. Geothermal is frequently and easily implemented in Alaska and would be an ideal place to pair geothermal energy for aquaculture heating and hydroponic produce.

The Alaskan government has made moves to promote local farmers, however when out of state producers are more reliable, grocers choose to go buy from them instead of local farmers. It is difficult for local farmers to earn enough money to make agriculture worth the effort. Many of the current grants and programs for agricultural improvement are focused on the needs of farmers in the contiguous 48 which are much different than the needs of farmers in Alaska (Stevenson, 2014). Nothing seems to be adding up in Alaska's favor.

There are individuals attempting to start up sustainable agriculture practices, but it is difficult for them to get off the ground when they lack the infrastructure necessary for larger scale energy usage. Smaller villages throughout the state lack the infrastructure to utilize geothermal resources to provide heat or energy for their greenhouses (Stevenson, 2014). Converting any home or building that uses fossil fuels (oil or gas) to heat water is a difficult process which just ends up with starting from scratch in order to implement geothermal heating (Smart-Energy). While geothermal energy is not a new field, it remains distant to the small business owner that cannot afford the initial setup expenses, perpetuating the use of other non sustainable energy sources.

Goal

Our goal is to combine geothermal heat pumps with aquaponic technology to grow food year round in Alaska. The overall effect of implementing this combination of technologies would be the growth of the agricultural industry in Alaska thereby decreasing the amount of food imports necessary in order to sustain their population. While beneficial, geothermal "hotspots" are not necessary for our project to work. While there are some areas that are hotter underground, the majority of the earth underneath the permafrost stays around 50°F year round, which is the source of the temperature differential (Meyer). With this in mind, we plan to locate our system in a populated area that has the potential to significantly benefit from local farming.

Objectives

Alaska needs a new idea for addressing their high levels of food insecurity. Living in the contiguous United States, we cannot relate to the uncertainty of whether or not the grocery store will have enough food for our family's dinner. The people of Alaska need a local food source. Fuel prices are currently low but their tendency to fluctuate makes the Alaskan food supply highly unstable. Along with the benefit of cutting cost, carbon emissions from food transport will be diminished by local production.

By implementing a geothermally heated aquaponic system in Alaska, we would be utilizing a common energy source in a way they addresses the problem of food miles. When we started this project we focused on urban environments but we found that most of the work in the area of aquaponics is being done in the same urban environments that we were looking at. We saw that no one is focusing on Alaska because it *appears* that there is no problem. The people of Alaska have developed a false sense of security and the rest of the country sees this as enough reason to focus on issues closer to home.

The first step necessary in achieving our objective is building a proof of concept near campus. Aforementioned, geothermal aquaponics has never been done before and it is our job to prove that it can not only be done, but be done effectively. We must show that a geothermal aquaponics system can supplement an establishment's overall energy use before we expect to receive grant money from the state of Alaska. Once construction and installation are complete, we will use the system's first few growth periods to measure energy use, geothermal energy output, energy efficiency, plant growth, and fish wellbeing in order to ensure that the system is functioning properly in Atlanta's temperate climate.

Upon further analysis, the data collected from the Atlanta system will be compiled and used to apply for the 2017 Specialty Crop Block Grant Program. This will provide part of the funding needed to build a functioning system in Alaska, to prove that the system can function outside of the state of Georgia. The geothermal set up in Alaska will vary slightly from the Georgia system in order to access the geothermal that is trapped far below the permafrost but this should not pose problems for the system. The main goal for our model is for it to be accessible to the people of Alaska, providing farmers with a tangible model that can be used as a model for their own farms.

With such a high percentage of food being imported into Alaska, we cannot consider the possibility of completely cutting reliance on outside sources in the next decade. However, as a team we would hope to decrease that percentage of food imports. Any decrease in food imports caused by the combination of geothermal technology and aquaponics will be considered a success. If our system ends up being more expensive than importing the food it replaces, our project only fails in part. The main goal is to decrease the distance food has to travel to get to the consumers of Alaska. Keeping the price of the aquaponic crops to equal or less than that of imported food is our secondary objective, but we do recognize that cost is a large factor in the success of future farms in Alaska.

We have four problems in our way, the first being distance and geographic mobility. Alaska is both distant and unknown to us, which makes most on-site interaction unattainable, which we must work around in Georgia. With this constraint in mind, we have made our goal to create a functioning system on campus with similar conditions to a system in Alaska, creating a proof of concept model for future systems to be modeled after in Alaska.

Funding also poses challenges to our group. We currently have limited funding from Grand Challenges, and while it is enough to begin the project, it is not enough to run this project to completion. We are looking to use money from Grand Challenges to run our proof of concept, and then get a grant from Alaska to make the final farm a reality. A project similar to ours has been done in Minnesota where Whitewater Gardens Farm was founded after being awarded a four thousand dollar CERT (Clean Energy Resource Team) Grant for running a feasibility study on clean energy for a greenhouse farm. They now have a functioning geothermal greenhouse, and while it is not aquaponics, they have been successful in their endeavors (Lewein, 2011). We will be reaching out to them in order to inquire about successfully getting grant money, the profitability of their farm, and the longevity of their project.

Grant money in itself is another hurdle, with paperwork, advising, research, and proposals, getting the funding we need is going to be one of the hardest parts of our project. We have identified Alaska's 2017 Specialty Crop Block Grant Program as both fitting our project and having the potential to provide fifteen hundred dollars in funding. We need our proof of concept functioning before we can apply for the grant. If our team can put together this document and take on the challenge, the funding issue is resolved.

The first challenge our team will face concerns the location for our project's first stage. The most feasible location for our project involves a partnership with Dr. Van Ginkel and working alongside his aquaponics project that is being implemented at an Atlanta public school. He wants to first build an aquaponics system as a STEM education tool for the students and then implement more components for his own research in net zero aquaponics systems (Stephen Van Ginkel Ph.D., personal communication, January 28, 2016). We are going to recommend geothermal energy and hope he sees the promising innovation in our design. We believe this arrangement will prove to be the most cost effective approach to the problem. He already spoke to us and said he believed our greatest impact would be finding ways to make aquaponics net zero, and that is what our design addresses.

Project Team

Team Thermoponics will consist of six student members and one advisor. The project manager serves as the first point of contact for the team, sets deadlines and monitors the team's functionality. The treasurer keeps budgets, maintains financial solvency, and applies for funding both from Tech and other sources with the help of the legal manager. The legal manager will attempt to maneuver the agricultural policy for Alaska, apply for grants with the treasurer, and handle any patents that may arise. Two experts will serve as the advisors for the complexities of these systems. Though not responsible for the entire design process, they will be responsible for understanding the system more proficiently than the rest of the group members. Public Relations, with the support of the legal team, will be the face of Thermoponics, representing the team to the institute, local businesses, and the any other groups. The Team Administrator will set deadlines, monitor the team dynamic and assign workload. Much like a startup company, all members will fill in as needed, the roles are simply there to provide guidance and build areas of expertise.

In addition to the members of the team Thermoponics will also leverage many community contacts. Dr. Jason Danaher is a leading aquaponics expert at Pentair Aquatic Ecosystems. He was the main speaker at the North Carolina Aquaculture Development Conference and has provided us with insight and understanding of the inner workings of standard aquaponics systems. He also has a working relationship with Urban Organics, a large aquaponics company located in Saint Paul, Minnesota; they are currently designing a cold water aquaponics system in at an old grain mill. Dr. Danaher will be providing us with their insights when the project is completed in December of this year. We will also utilize our connections with Dr. Van Ginkel to implement a proof of concept in his local school project. Finally, we will seek a partnership with an Alaskan contact who will provide us with the information and contacts that we will need when we begin construction on site.

Timeline

Fall 2016	Spring 2017	Summer 2017
Collect data from Urban Organics about cold water farm	Finish Atlanta-Based proof of concept and Atlanta farm	Begin construction of first Alaskan geothermal aquaponic farm
Continue to identify possible partners and funding	Apply for 2017 Specialty Crop Block Grant Program, and any other chosen grants	

Budget

Category	Description	Cost
Equipment	Geothermal heat system	12,000
Services	Contractor for Geothermal system	12000
Total		24,000

*Figures waiting on estimates from a geothermal contractor
**Denotes unplanned trip expenses

Expected Outcomes and Future Directions

By the end of next year we expect to have a completed the construction on our proof of concept. The research that we have done so far shows that what we are trying to do is technologically possible and we are in a good position to implement a design. However, due to the cold climate of Alaska, a true warm water aquaponics systems will be inefficient., we will need to modify our design after we receive the results from Urban Organics' pioneer cold water aquaponics system. They should have results by the end of December, and we will have more detailed information through Dr. Donaher, our contact to Urban Organics.

One we have adapted our system, we will pursue a partnership with Dr. Van Ginkel. Assuming a partnership with him, the geothermal system will take 2-3 grow cycles to prove the concept (roughly 120 days). Our timetable, however, is dependent upon the construction of the lab's aquaponic system and our ability to attain the funds necessary for the geothermal installation. Once the system is set up we will have real data rather than cursory research to test our assumptions.

We plan to cooperate with the Alaska Departments of Agriculture and Natural Resources in order to implement a system. The first system, likely to be built in Fairbanks,the largest inland city, will serve as a long term experiment, with the design and system parameters being modified as necessary. This is where team Thermoponics sees our contribution ending and letting the farmers and people of Alaska utilize the system to create more geothermal aquaponics farms to secure their food supply.

Works Cited

AK Farm Bureau. “Take Action in the Community.” *Renewable Energy Alaska Project.* REAP, 2014. Web. 10 Apr. 2016.

Alaska Department of Natural Resources. 2016. *Alaska’s 2016 Speciality Crop Block Grant Program*. Retrieved from DNR.Alaska website: http://dnr.alaska.gov/ag/Grants/Final_16_SCBG_RFP.pdf

Armstrong, M. (2015, January 28). Aquaponics: A blast of green in midwinter.*Homer News*. Retrieved March 17, 2016, from http://homernews.com/homer-news/local-news/2015-01-28/aquaponics-a-blast-of-green-in-midwinter

Cioni-Haywood, B. (2013). *Alaska Department of Commerce, Community, and Economic Development* (United States, Alaska Department of Commerce, Community, and Economic Development, Division of Economic Development). Retrieved April 24, 2016, from https://www.commerce.alaska.gov/web/Portals/6/pub/2013_Alaska_Economic_Performance_Report.pdf

"Community." *Renewable Energy Alaska Project*. Web. 24 Apr. 2016. http://alaskarenewableenergy.org/take-action/eat-local/

Klaipēda Science and Technology Park. 2012. *Supply chain for geothermal aquaculture: Feasibility study.* Klaipeda University. Retrieved from KMPT website: http://www.kmtp.lt/uploads/Tyrimai/Supply%20chain%20for%20geothermal%20aquaculture_KSTP%20(3).pdf

Lewein, J. (2011, August). No Winter at Whitewater Gardens Farm: Geothermal Greenhouse Project in Altura, MN. Retrieved March 17, 2016, from http://www.cleanenergyresourceteams.org/sites/default/files/publication_files/CERTsCaseStudy_SE_Whitewater.pdf

Love, D. C., Fry, J. P., Genello, L., Hill, E. S., Frederick, J. A., Li, X., & Semmens, K. (2014). An International Survey of Aquaponics Practitioners. *PLoS ONE, 9*(7). Retrieved March 25, 2016.

Meyer, J., Pride, D., O'Toole, J., Craven, C., & Spencer, V. (2011, March 31).*Ground-Source Heat Pumps in Cold Climates* (Rep.). Retrieved April 25, 2016, from Denali Commission website: http://www.uaf.edu/files/acep/Ground-Source-Heat-Pumps-in-Cold-Climates.pdf

Smart-Energy. (n.d.). Geothermal FAQ. Retrieved March 24, 2016, from http://smart-nrg.com/geofaq.php

Stevenson, K. T., Alessa, L., Kliskey, A. D., Rader, H. B., Pantoja, A., & Clark, M. (2014). Sustainable agriculture for alaska and the circumpolar north: Part I. development and status of northern agriculture and food security. *Arctic,67*(3), 271-295. Retrieved from http://prx.library.gatech.edu/login?url=http://search.proquest.com/docview/1670216515?accountid=11107

U.S. Climate Data. (n.d.). Retrieved March 20, 2016, from http://www.usclimatedata.com/climate/alaska/united-states/31714

Utermohle, C. (2016). *Food Insecurity in Alaska*. *Alaska Department of Health and Social Services*. Retrieved 2 April 2016, from http://dhss.alaska.gov/dph/Chronic/Documents/brfss/pubs/Food-Insecurity.pdf