Renewable Energy Powered Greenhouses

A Concept Paper, March 2011

Introduction:

Throughout 2008 and recently, countries and communities around the world suffered food and energy shortages along with subsequent and sometimes severe price hikes. In many regions of the world riots ensued and the stability of some of the world's poorest countries was completely shaken, if not broken. During this time, the Aleutian/Pribilof region of Alaska also suffered from the some effects of energy shortages. As energy prices increased rapidly, communities at the far end of the supply chain experienced significantly higher food and energy prices than the rest of Alaska; and the rest of the country. Along with higher prices came shipments delays; and sometimes no shipments at all. Though no fatalities were reported as a direct result of this experience, the people of Alaska's remote regions became reacquainted with cold and hunger or, at minimum lower quality fresh foods.

These communities are affected by global events that affect supply and demand. The United Nations' Food and Agricultural Organization recently announced, in March 2011, that the global food price index is higher than it has been in past 30 years. The USDA predicts that grain harvests will be smaller this year, with significant price increases by mid summer. These price increases must be considered with a generalized 70% increase in grain prices over last year. Political instability in Northern African and the Middle East are currently adding an extra $20/barrel to the price of oil.

As a direct result of this uncertainty and previous experiences, the Aleutian/Pribilof Island communities have sought out solutions. This process has led them to a set of food and energy security solutions that involve renewable energy and local agriculture. Considering the short growing seasons and harsh climates, these communities seek to construct small, commercial-scale agriculture, centered on a greenhouse facility, using locally available renewable energy resources. Produce from these greenhouses will augment a seasonal harvest of tubers, carrots, cabbage, lettuce, herbs, edible-pod peas and other vegetables to be sold in the local store. Revenues from these sales will go to the upkeep and maintenance of the facility including the employment of a greenhouse agriculturist.

Methods:

Though many communities in the Aleutian/Pribilof region are affected by food and energy insecurity, this discussion will use the village of Saint George as in developing an economic model for discussing the renewable energy powered greenhouse concept.

St. George receives weekly scheduled air service directly from Anchorage; and is a good representation of the average commodity values for the region. In January of 2011, the price of #2 diesel fuel for power generation cost $5.46/gal. The price of produce, flown in from Anchorage, Alaska, regularly costs 10% to 80% higher than similar items in Anchorage. This cost estimate does not include the cost of items that spoil, freeze or otherwise become unfit for human consumption between the time of purchase and time of arrival and being available on the shelf often one or two weeks later. All small communities in the region suffer from poor quality fresh food and high food costs.

The design of the greenhouse system under consideration uses a proven, “off the shelf,” commercial technology and readily available materials.

Due to the unique environmental conditions of the Aleutian/Pribilof region, the communities plan to construct geodesic dome greenhouses with a set of two to four low wattage wind turbines, including associated storage and distribution systems, in order to produce and deliver 40 kWh of power. The 51 foot diameter greenhouses are approximately 2000 square feet each and will provide year-round, commercial vegetable production. This includes a production schedule with a seasonal shift to plant starts, for outside production. Cost analyses indicate that using renewable energy resources can make this endeavor economically viable on either a community or commercial scale.

The economic analysis for the St. George Greenhouse Project (a community of 111 residents) indicates an initial investment of approximately $350,000 for a controlled environment greenhouse facility. This should conservatively produce a mixed crop harvest, with a minimum annual wholesale value, of approximately $46,500. This translates into a retail value of approximately $66,500 once the standard 30% markup is factored in for the local stores (Figure 4). These figures do not include any outside agriculture, initiated from greenhouse starts, and the community will need to provide the land and volunteer labor. Using the upper level of the greenhouse structures to initiate plant starts for the beginning of the outdoor season could yield an additional $30,000 wholesale/$43,000 retail (Figure 5). Together, these combined agricultural assets have a potential for bringing in over $76,000 (wholesale dollars) into the community. As we will see in the budget section of this document, these revenues are enough to sustain a profitable, well-maintained operation with a well-paid full-time employee, or a combination of part-time employees.

Though the economic model is feasible, we realize that this scale of agriculture is not common in the Bering Sea region and a minimum level of capacity building and training will be necessary in order to ensure success.

The manager of the greenhouse will need experience as an agriculturalist, mechanic, electrician, businessperson and volunteer coordinator. The greenhouse manager can arrange for appropriate training and assistance is available through many free and low cost venues. The University of Alaska, the State of Alaska and the USDA all have free programs available, as well as free services, that promote good agriculture products and practices. Recent discussions with university faculty and staff indicate that potential research and student assignments are possible with the UAF's School of Natural Resource Management and Agricultural Sciences, including and entire internship program. Additionally, many workshops and conferences are held throughout the year that can bring community and commercial agriculturalists together in order to share experiences, techniques and information.

Additional support for the project will come from other formal and informal institutions. The Aleutian Pribilof Islands Community Development Association has indicated that they would financially support the direct training of greenhouse participants. The Aleutian Pribilof Island Association has indicated that they would pay the community wellness nurse to participate in greenhouse activities because it fits their goal of providing for healthy foods and lifestyle. The USDA has grants and funding for the support and expansion of ongoing programs; and other programs such as EPA Recycling and EPA IGAP are just a few of the many programs available for support and success.

Expected Results:

We anticipate the planning and construction of each greenhouse to take approximately four to six months. This includes preparation of the organic, local and naturally enriched soil beds inside and the ground outside for planting and production. Formal planning of the greenhouse and wind turbine installations should take approximately 2 ~ 3 months with construction beginning as soon as possible thereafter. Construction should take approximately 3 ~ 4 weeks for each community. Internal preparation of the greenhouse is likely to take another 3 ~ 4 weeks. Planting indoors would begin immediately upon completion. Preparing the soil for the outside plots, for the next season, would be completed before September. Regardless of the community, wind turbine foundations can begin during the summer and fall and turbine installation will use tilt-up turbine towers (no cranes will be needed for these installations).

Unforeseen problems are likely to arise and due to the remoteness of the projects, patience and creative solutions will be warranted. However, the greenhouses should be able to begin making contributions to the nutritional content of each community within four to six months after completion. Within a year after construction we should begin to see the greenhouse operations running smoothly and in full production with agriculture both inside and outside of the greenhouse structure.

Budget:

Figures, graphs and tables from the budget are available in Appendix B.

The construction of the greenhouse and power system is anticipated to cost $348,000 (Figure 2).

Annual operating expenses for the commercial greenhouse systems are currently estimated at, $65,000 (Figure 3)

The estimated annual income (using St. George wholesale prices) is approximately $76,680 with approximately $46,600 (Figure 5) coming from direct green house production and $30,080 (Figure 6) coming from outdoor production. This final figure is based on approximately 2000 square feet of outdoor production and could be increased or decreased to better suit the functional or financial needs of the operations.

This economic projection, based on 2011 dollars in St. George, Alaska, anticipates the operation to fully employ one person at $40,000 with 30% benefits (~ $52,000); provide for annual operation and maintenance expenses (~ $13,000) and earn an additional $11,000 buffer for unanticipated and future needs.

Discussion:

Food security is a growing problem both nationally and internationally. The remote communities of Alaska are particularly vulnerable to supply disruptions in the food delivery system. Therefore, it becomes even more important, as food and energy prices rise, to develop a local food production and delivery system that is less dependent on outside resources and focuses on local, micro/subsistence agriculture solutions. Fortunately, many of these communities have abundant, renewable, natural resources available which enable them to build resilient food security systems. These resources include fresh water, good soils and abundant renewable energy. Together, these elements provide the foundation for year-round, community supported micro-agriculture and local food, energy and economic security.

A test case for a viable greenhouse occurs in Nikolski, Alaska, in the Aleutian Islands. The greenhouse is a small geodesic dome which as easily survived 130mph winds and is now in production. It is too small to provide for the community needs and meet the standards of the economical model presented here, but it is proof we can effectively use greenhouses in the windy Aleutian and Pribilof Islands.

Appendices

Wind Potential for the region:

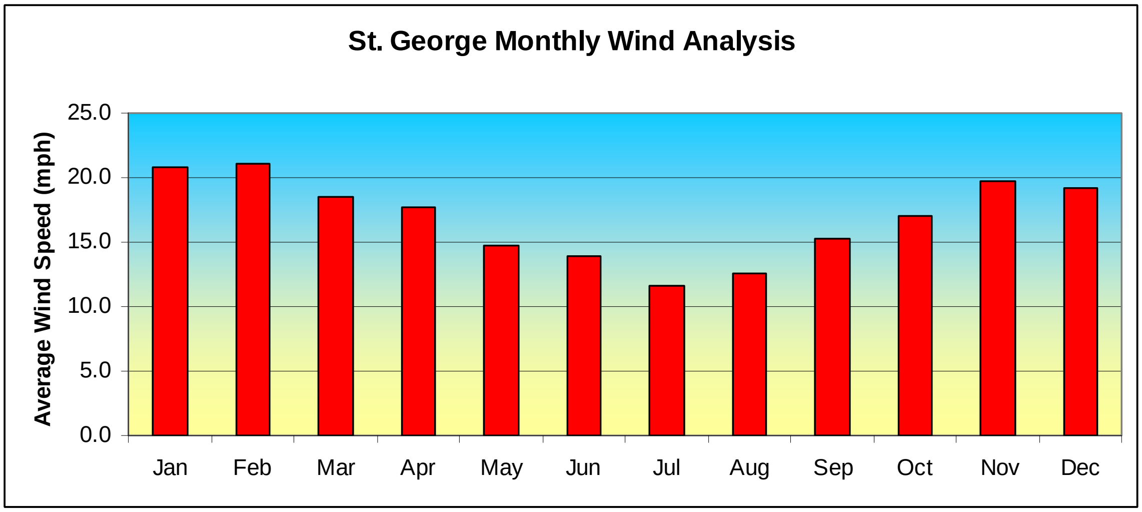

Figure 1. This wind analysis, assembled from the St. George meteorological station, illustrates the year-round wind turbine potential of the island community. This wind analysis graph is similar to other stations in the Aleutian/Pribilof Island region.

Cost Analysis Tables:

Capital Costs (as of January 2011)

Item	Individual Expense	Quantity	Item Expense
Greenhouse Dome (51' Diameter)	$ 41,900	1	$ 41,900
Wind Turbine (VAWT @ 20kWh)	$ 40,000	2	$ 80,000
Turbine Towers	$ 18,000	2	$ 36,000
Storage and Inverter	$ 60,000	1	$ 60,000
Lights	$ 400	40	$ 16,000
Electrical (Wiring, switches, etc.)	$ 10,000	1	$ 10,000
Heating	$ 2,000	1	$ 2,000
Fertilizer	$ 3,100	1	$ 3,100
Shipping	$ 15,000	1	$ 15,000
Labor	$ 36,000	1	$ 36,000
Plumbing	$ 3,800	1	$ 3,800
Admin, Setup & Supervision	$ 44,200	1	$ 44,200
Total			**$ 348,000**

Figure 2. This table is a seeks to identify the major elements in each of the Aleutian/Pribilof Island Region Greenhouse Projects. Though some items are fixed and known as of January (2011), others are estimates based on the best available knowledge at the time. Some obvious expenses are not listed, such as the cost of land for siting the greenhouse and turbines. It has been communicated that these items will be donated by each of the cities.

Operational Expenses	
Item	Costs
Electricity and Heating	$ 8,000
Labor (wages + 30%)	$ 52,000
Seeds	$ 1,000
Fertilizers	$ 2,000
General Administration	$ 1,000
Miscellaneous	$ 1,000
Total	**$ 65,000**

Figure 3. This table represents the regular expenses in operating a well-maintained, renewably energy powered, 40kW greenhouse.

Production Values based on St.George Prices					
Items	Current Value	Yield/4ft^2 in lbs (avg harvest wt x plants/GrSp x Hvst Cyc)	Annual Yield /Growing Space (GrSp)	Green House Retail Yield (2042 SqFt/4 *0.7*AnYld)	Green House Wholesale Yield (2042 SqFt/4 *0.7*AnYld)
Tomatoes, Red	$ 2.29	27	$ 61.83	$ 22,094.95	$ 15,466.47
Lettuce, Red Leaf	$ 2.80	100	$ 280.00	$ 100,058.00	$ 70,040.60
Cucumbers	$ 2.49	50	$ 124.50	$ 44,490.08	$ 31,143.05
Peppers, Not Defined	$ 2.49	45	$ 112.05	$ 40,041.07	$ 28,028.75
Zuccini	$ 1.99	16	$ 31.84	$ 11,378.02	$ 7,964.62
Celery	$ 2.19	50	$ 109.50	$ 39,129.83	$ 27,390.88
Broccoli	$ 2.99	164.5	$ 491.86	$ 175,764.38	$ 123,035.07
Onions, Not Defined	$ 2.59	94	$ 243.46	$ 87,000.43	$ 60,900.30

Figure 4. This table illustrates the current value (price) of produce at the tribal store in St. George, Alaska as of January 6, 2011. Column C (Yield/4ft^2) defines a standard growing space (plot) of four square feet and calculates the number of pounds that plot should produce in one year with the appropriate plant spacing for the plot and annual number of growing cycles for that crop type. Column D converts the produce from pounds to cash retail cash value and subtracts 30% for non-growing space within the greenhouse. Column E converts the retail price to wholesale price, recognizing that it may be better economic policy to sell to the store rather than compete.

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Potential mixed crop harvest				
Items	**Current Value**	Production Mix	Retail Value	Wholesale Value
Tomatoes, Red	$ 2.29	5%	$ 1,105	$ 773
Lettuce, Red Leaf	$ 2.80	25%	$ 25,015	$ 17,510
Cucumbers	$ 2.49	20%	$ 8,898	$ 6,229
Peppers, Not Defined	$ 2.49	10%	$ 4,004	$ 2,803
Zuccini	$ 1.99	15%	$ 1,707	$ 1,195
Celery	$ 2.19	10%	$ 3,913	$ 2,739
Broccoli	$ 2.99	10%	$ 17,576	$ 12,304
Onions, Not Defined	$ 2.59	5%	$ 4,350	$ 3,045
Total Production		**100%**	**$ 66,568**	**$ 46,597**

Figure 5. This table investigates what a mixed crop value might look like recognizing that a mono-crop production might be undesirable.

Inside Starts: Outside Production						
Item	**$/lb**	**Yeild/4ft²**	**Value/4ft²**	**Value per 2000 ft² (*0.8)**	Retail Value	Wholesale Value
Carrots	$ 3.19	3.2	$ 10.21	$ 41,689	$ 13,757.53	$ 9,630.27
Potatoes	$ 1.29	8	$ 10.32	$ 42,147	$ 13,908.47	$ 9,735.93
Turnips		8	$ -	$ -	$ -	$ -
Kale		3	$ -	$ -	$ -	$ -
Cabbage	$ 1.42	8	$ 11.36	$ 46,394	$ 15,310.10	$ 10,717.07
Total Production					**$ 42,976.10**	**$ 30,083.27**

Figure 6. This table looks at the types of crops that can be started inside and grown outside with a high degree of success. These crops may require the use of high dome tunnels, but this is not anticipated.