Northeast SARE
Farmer/Grower Initiated Grants

FNE01-361: Alternative Energy Greenhouse

Final Report
June 2005

Background & Objectives:

In order to effectively operate a greenhouse in the northeast portion of the United States year round, many structures need supplemental heating – especially in the winter months.

Traditional heating fuels include hydrocarbon liquids (propane, gas, oil, etc.), wood, and coal. In addition, electric heaters could also be used, although these tend to be cost-prohibitive unless powered by a hydro-electric source.

Heating a greenhouse by "burning" fuels also presents a risk to the interior environment – smoke and residue can be harmful to the plants.

Therefore, products that provide alternative and non-polluting heat/power sources would be attractive to farmers and growers in cold-climate areas of the country like the Northeast.

Experimental Concept – Modified Greenhouse with Non-Conventional Heat Sink:

Central to the concept of a self-sustaining or minimal-power-use greenhouse is use of a "heat sink". A heat sink is usually a mass of solid concrete or stone masonry that can absorb excess heat. The heat sink may form part of a wall exposed to the sun, or it may be built into the floor. Once warmed up, the heat sink can radiate heat for many hours into the night, reducing the need for additional heat from an external source.

The greenhouse for this study (a 15' X 50' bow-styled structure with 4-layers of plastic media) uses a 4,000-gallon tank of water as a heat sink. The water tank also doubles as a fish hatchery, thereby providing dual-utility.

Fish Hatchery:

The 4,000-gallon water tank was created by cutting a tanker trailer in half. The original tank infrastructure provides for seven ready-made, naturally-segmented sections – this is useful for separating different species fish or fingerlings from the adult fish population.

Water is circulated through a primary biofilter which removes harmful ammonia compounds and solids. The water stream is then passed-through hydroponic trays to provide moisture for the plants.

There are several species of fish that have been raised in the hatchery – primarily rainbow trout and tilapia. Fish are reared to stocking size and then released into man-made ponds or used in the owner's "smoked fish" business.

Plants:
There are salad greens growing in the hydroponic media and various hanging plants throughout the greenhouse. The grower has been experimenting with the optimal configuration to allow the greatest amount of sunlight to hit the heat sink while growing plants throughout the greenhouse.

Supplemental & Alternative Energy Sources for Greenhouse:

Renewable energy refers to energy resources that occur naturally and repeatedly in the environment and can be harnessed for human benefit. Interest in alternative energy sources is growing, accompanying a need for less dependence on "traditional" nonrenewable sources with their accompanying environmental issues.

In addition, "non-polluting" energy is highly desirable, especially within the closed-confines of a greenhouse. Examples of non-polluting renewable energy systems include solar, wind, and hydrogen-powered generators.

Solar Energy:
Besides the aforementioned process of heating the greenhouse with the heat sink, solar energy is also utilized during the summer months when the opposite goal – namely "cooling" – is paramount. For this activity, photovoltaics is employed. Photovoltaic power sources convert sunlight directly into electricity. Photovoltaic cells (a.k.a. solar panels) provide power for 4 circulating fans that are used for cooling the greenhouse during the summer months. In addition, a pump running on energy from the solar panels provides water from a shallow well to replenish evaporated moisture and the water used to spray on the hydroponic media.

Wind Energy:
Wind energy projects provide cost-effective and reliable energy. The onsite Jacobsen windmill is a horizontal-axis variety, like the traditional farm windmills used for pumping water.

Modern wind technology takes advantage of advances in materials, engineering, electronics and aerodynamics. Electricity from the Jacobsen windmill is fed into the local utility grid and offsets the power supplied by the local utility via "net metering".

Net metering is simply a method of measuring the energy consumed and produced at a site that is connected to the local utility electric grid. And that site has its own independent electrical generation capability. Under net metering, the excess electricity produced at the site spins the meter backwards. Net metering is particularly important in the selection of an intermittent source of power such as wind energy. Since the site may generate power at a time separate from its own needs for electricity, the net metering concept allows the service to 'bank' its electricity needs.

Hydrogen Generator:
During those times when there is a long absence of sun & wind, a hydrogen generator was purchased to provide fuel for heating the greenhouse. This was the only unsuccessful technology that was tested and may be the result of a low-quality unit (see Exhibit C).

Currently, the technology for efficient standalone hydrogen-generator units does not appear to be available for small commercial or personal use. Our tests yielded approximately 5 minutes worth of gas-burning fuel after 7-8 hours of running the hydrogen generator. In theory, excess electricity created from windpower could be stored in a bank of industrial size batteries which provide the energy needed start the hydrogen gas producing process; however, we were unable to prove this theory in our field experiments as the generator only created enough hydrogen for a few minutes of fuel.

Conclusions:

- **Clean, renewable energy sources can significantly reduce the expense in running a greenhouse** in the northeast portion of the U.S. where harsh winter seasons exist. Two technologies, solar energy & windpower, are successful alternatives to traditional energy sources.

- **Solar energy**: Addition of a heat sink significantly decreases the energy required for heating the greenhouse. Prior to the installation of the 4,000-gallon fish tank, a 6-month heating system required nearly 200 gallons of propane gas to heat the structure throughout a winter season.

  During the following year with the installation of the water tank/heat sink, the same structure was heated with about half of the fuel needed during the previous season[1]. (see Exhibit A).

  Also, photovoltaic cells provided energy needed to power cooling fans and a water pump within the greenhouse.

- **Windpower**: The addition of the windmill yielded substantial savings for the entire property where the greenhouse is located. Although unable to accurately measure the electricity needed for the greenhouse itself, one can assume that the savings are linear in scope; meaning, that property-wide energy savings could be proportioned relative to the building structures' needs compared to the entire property. In other words, whatever electricity was needed specific to the greenhouse prior to the installation of the windmill, the greenhouse realized the same degree of energy savings as the entire property[2]. In terms of savings, the electric bill was approximately 45% lowers during the second winter season with the windmill (see Exhibit B).

[1] Other variables – average temperature, snowfall totals, fuel costs per unit, etc. – were not accounted for when deriving comparison data

[2] The comparison data assumes that the number of wind-filled days and/or the aggregate intensity of the wind in terms of energy provided is equal in the months measured

Conclusions (cont.):

- **Hydrogen gas generation is currently an unproven technology for individuals and/or small scale operations**. The investment in starting materials and the energy needed to run a small-size hydrogen generator does not yield monetary savings for a greenhouse owner at this time – especially in the northeast section of the United States where additional measures (creation of an insulated, storage structure) need to occur in order to operate a unit during the winter months.

- **ROI and Economic Findings:** Because the owner of the greenhouse is a craftsman and inventor, he was able to fashion many unique tools/apparatus, build several items from kits, and/or utilize used parts & scrap materials for many projects. In addition, a few items were "donated" to the experimental greenhouse project.

  As such, it is beyond the scope of this research project and unknown to the author as to when a precise return-on-investment for start-up materials would occur. However, based on some rough estimates on purchasing newer, used items (windmill, solar panels, etc.), it appears that upfront monies can be recouped in approximately 7-10 years from *monthly energy savings only*.

  In addition and more importantly, the profits from the products grown in the greenhouse yield tremendous margins.

  Rainbow trout: after accounting for initial purchase of fingerlings and the food needed to grow the fish into reasonable sizes for harvesting within 6 months, preliminary estimates show that 2 crops of fish annually can garner approximately $18,000 in profit.

  Salad greens: growing on 50 sq. ft. hydroponic media, approximately $1,500 in sales with virtually no cost-of-goods expenses.

  Based on market conditions, personal preferences, and other factors, owners obviously have a variety of crops they can produce which affect the overall profitability of an alternative energy greenhouse.

Exhibit A

Number of Gallons of Propane Used in Greenhouse Season #1 with<u>out</u> Heat Sink Season #2 <u>with</u> Heat Sink

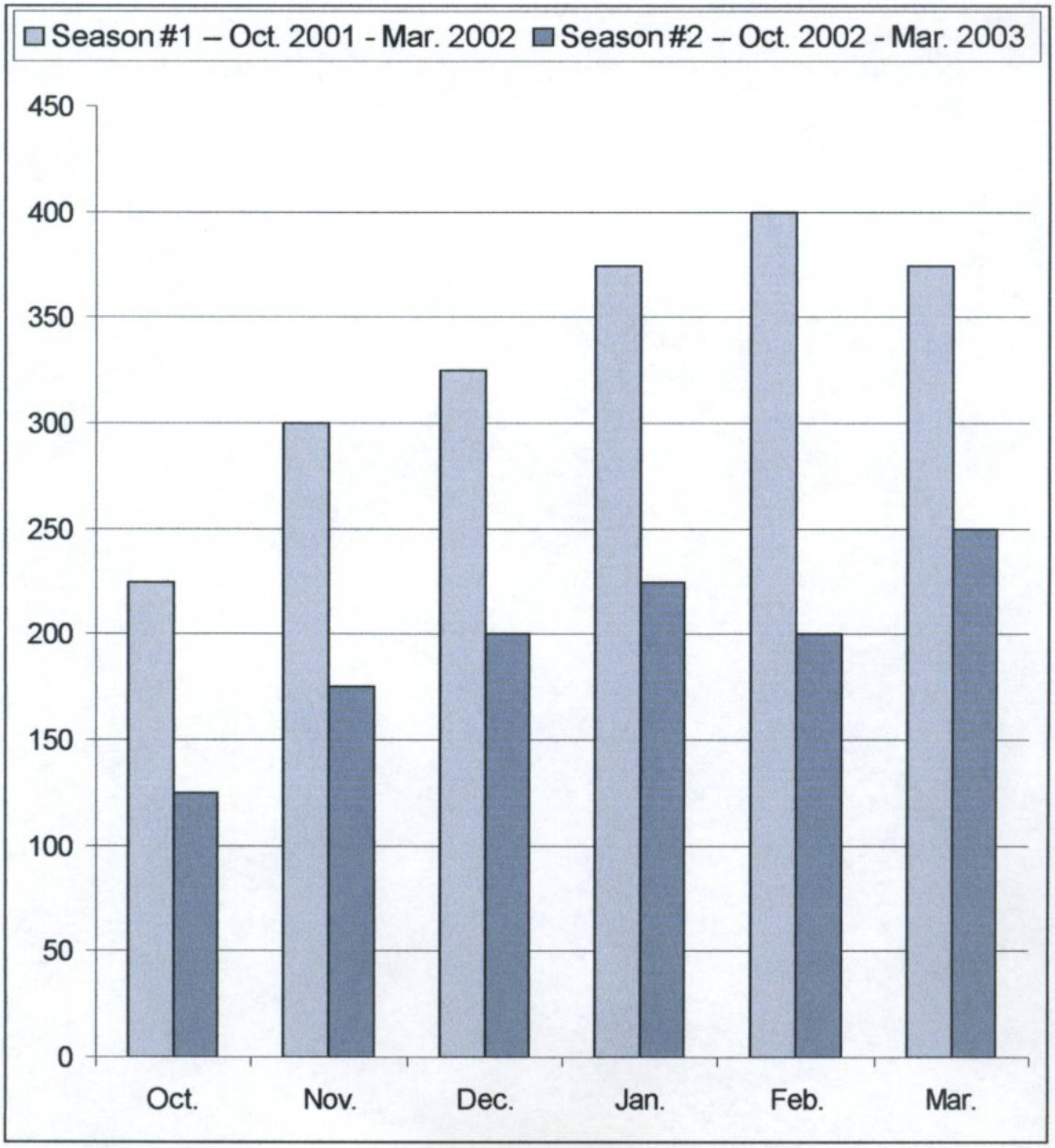

Exhibit B

Electric Bill for Entire Homestead (in Dollars)
Season #1 without Windmill
Season #2 with Windmill

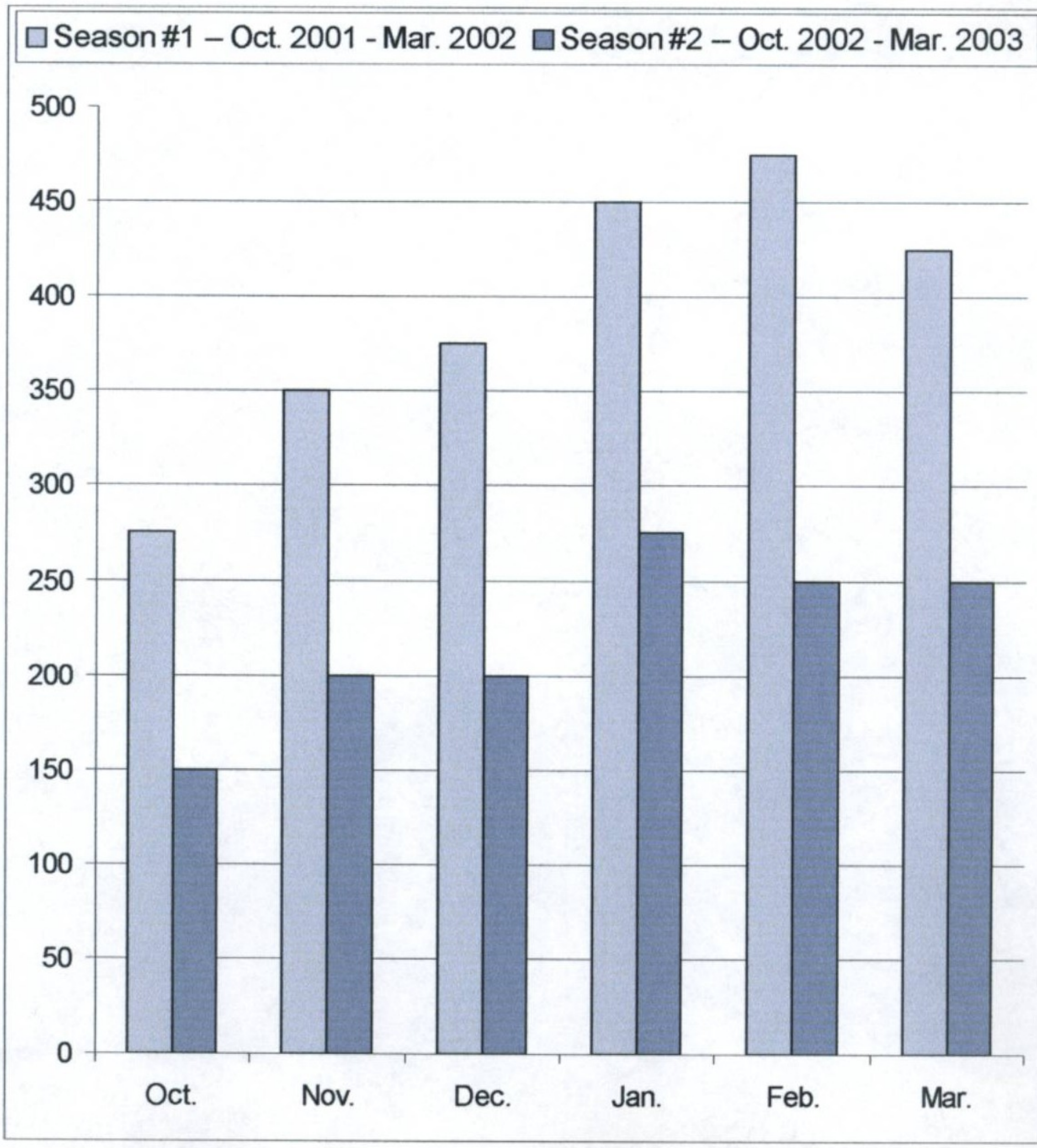

Exhibit C

Letter to Hydrogen Generator Manufacturer Explaining Trials/Tribulations with Unit

September 1, 2004

Mr. Bob Green
Thermodyne Systems
44447 Valley Central Way #222
Lancaster, CA 93536

Dear Bob –

RE: Damaged Hydrogen Generator and Repair Price Quote for $2,800

I received your letter stating that the hydrogen generator I sent back to your business is a complete loss and that the repair bill is $2,800 to fix the unit. I am hoping that as a good faith gesture, you will repair the unit and charge me only for shipping & handling.

As you may recall, I have been very patient and accommodating throughout our business relationship for the past 3 years. I would like to refresh your memory on several items:

- After explaining the exact application & parameters for a hydrogen generator (including the type of structure – greenhouse/biosphere with flexible plastic sheeting; location & climate – central New York State with harsh winters; and reason for purchase – to fulfill a SARE Farmer Grant requirement ... FNEO1-361 Alternative Energy Greenhouse), you initially sent a unit that you, yourself admitted, would not operate under these conditions.

- You replaced the original unit with another model and issued a seemingly-nonchalant instruction that a suitable structure would be needed to protect the hydrogen generator. Unlike a "shed" which may suffice in warmer surroundings such as southern California, I needed to build a structure that could withstand the elements associated with a harsh winter. Specifically, the storage structure required an insulated cement floor, insulated walls, and other special materials. I spent a great deal of time, effort, and money to construct a "storage unit" for your generator, which I stored in my main residence during construction. Labor & material costs for the storage structure was approximately $6,000.

- Despite storage in a climate-controlled environment during construction of the storage shed, the hydrogen generator's holding tank became rusty, which in turn, resulted in rust particles in the water. I called you about this and your instruction was that the ionized, filtered must NOT have rust particles in it. Noting a design flaw, I replaced the steel on the holding tank with STAINLESS steel – again, using my own time, effort, and expense. In addition and based on your directions, I "flushed" the system with warm, soapy water.

- The hydrogen generator worked for approximately three days before it started leaking/dripping water from the bottom of the unit. Noting a backlog of repairs at your shop and stating that fixing my generator would take "weeks", you suggested that I could repair the generator myself, using glue. After gluing the bottom of the unit, the top started leaking too. Again, I glued the leaks but also needed to design and implement a bulkhead for venting excess gas to prevent the leaks from reoccurring.

- Continued problems with the generator prompted me to send it back to your office – I paid for the shipping costs.

- Despite following your explicit instructions for storing, cleaning ("flushing"), and repairing the unit, it appears that you want to cite customer-neglect as a reason you are unable to fix the hydrogen generator without charging nearly three thousand dollars. Your literature/marketing materials suggest that the unit should last 25-50 years, yet it appears as if the hydrogen generator can easily become damaged/non-working almost immediately and be disqualified for warranty repair.

Exhibit C (cont.)

Letter to Hydrogen Generator Manufacturer Explaining Trials/Tribulations with Unit (page #2)

Letter to Mr. Bob Green
RE: Damaged Hydrogen Generator and Repair Price Quote for $2,800

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Notwithstanding the extra time, effort, and money I have spent trying to rectify design flaws and/or performing D-I-Y repairs (because your staff was too busy), I still believe in this alternative energy source. In fact, I recently purchased several 1,000 gallon tanks based on information you provided about the equipment used by successful clients of your units.

I would like to fulfill the requirements of my grant by demonstrating a working hydrogen generator. There is significant pressure to demonstrate the unit in a timely manner – further delays may result in forfeiture of the grant fund balance.

I would prefer to avoid letting the SARE executives know that I am having trouble with the supplier of the hydrogen generator (which is causing a delay in my final demonstration); however, I'm sure you can appreciate how I must release this information if I cannot perform the required demonstration in a timely manner. Therefore, I ask that you send a fully-functioning unit as soon as possible (again, I will pay for shipping costs).

Again, I am a "true believer" in this technology and desperately want to report favorable results. In addition, I have stated to you on numerous occasions that with my network and connections within the East Coast farming community, as well as being able to demonstrate "working examples" on my farm, I know that I could be a successful distributor of your products. As such, I implore you to return a working hydrogen generator to me ASAP.

Sincerely,

Leonardo Busciglio/sjt
President
Lenny Bee Productions

Exhibit D
Technical Data / Specifications

Greenhouse: 15' X 50' Bow Style. Aluminum frame with 4 layers of plastic.

Heat Sink: 4,000 gallon water tank doubling as an indoor fish farm

Windmill: Three-bladed Jacobsen windmill with maximum output of 10 Kilowatts

Solar Panels: 75 watts / 4.5 amps (providing energy to two 12 volt cooling fans and a sure-flow water pump (pumping 3.5 gallons per minute from a shallow well)

Hydrogen Generator: Unsuccessful experiment. Unable to verify energy savings.

In Addition: I have another hydrogen generator from "Hydrogen Wind Inc.", Rt.2, Box 262, Lineville, IA, 50147 – 515-876-5665 to continue testing.