Alaska Agriculture Innovation Grant

Hydroelectric-Heated Greenhouse Beds

Performance Report

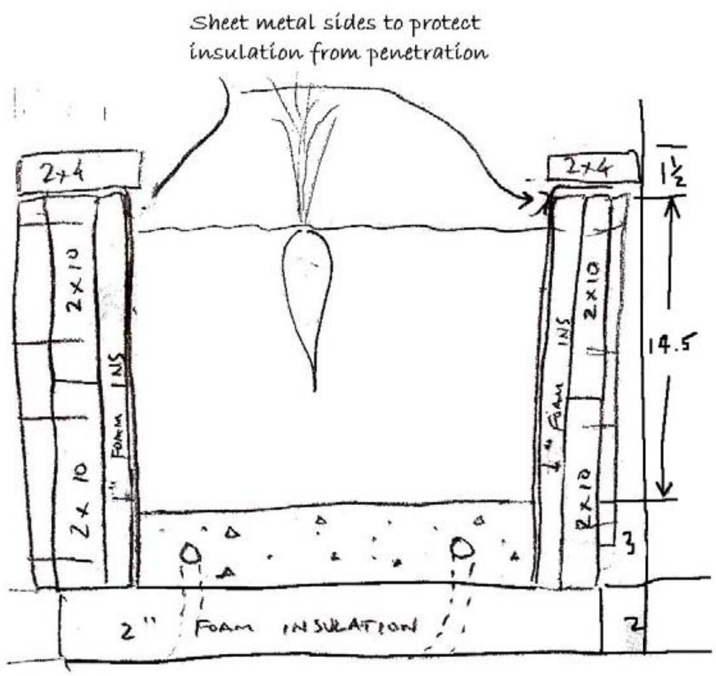
In 2010, as a part of the State of Alaska Agriculture Innovation grant program, we proposed to extend the vegetable growing season from our greenhouse using hydroelectric energy produced from a local creek.  After receiving funding we immediately embarked on a project to connect an existing 12kW hydroelectric power system to our 24'X24' greenhouse, without beds at that time.  The project involved constructing insulated, heated, raised beds, lighting for each bed, a drip watering system for each bed, and ventilation.

The following system was publicly noticed and presented to the public on May 14, 2011, at the Haines Earth Day Fair, held that day in the Haines Public School building.  An explanation and analysis was made of the integrated power system and greenhouse, and the group made a field trip, viewing both systems.

**CONSTRUCTION**

1. Five garden beds - wood sides, insulation, vapor barrier, protective metal sheets, hardware
2. Hydronic "root zone" heating system encased in a concrete floor in each bed – 1500W electric hot water heater, valves, wiring, five zone valves, pump, copper pipe, connectors, pex tubing, and associated installation hardware
3. Lighting system – light fixtures, Romex wire, switches, junction boxes, electrical service box and associated hardware
4. Automatic drip watering system – polyethylene pipe, timer, pressure reducer, filter, "soaker hose" assemblies for each bed
5. Ventilation fans

Construction began in early spring.  Preservative was applied to wood surfaces to limit decay.  Insulated raised beds were constructed in the following manner:



The raised bed design includes several features intended to increase growth potential:

1. Raised and insulated on bottom and sides to influence soil temperature. The "run of the river" hydroelectric power source ranges from 12kW in spring/fall to 2kW through the driest part of winter, so the system must operate on relatively low power.
2. Deep beds to accommodate winter root crops and easier daily maintenance.
3. Sheet metal sides and vapor barrier to minimize contact between wood structure and soil.
4. Poured concrete bed floor encasing Pex tubing (thermometer probes installed in "root zone" about six inches below the surface) in each bed. Five heat zones total.
5. Flourescent lights on individual circuits for each bed.
6. Automatic drip watering system using "soaker hoses"

In summer 2010 beds were constructed and filled with dirt and compost. Electrical and hydronics were installed in the fall. On October 15 lighting and hydronic systems were operational.

First planting was soon after system startup on October 15, 2010. Cold-weather vegetable crops (kale, broccoli, lettuce, peas, and others) germinated and began to grow. It was unknown at that point how long snow cover would allow the hydroelectric system to stay up, but it seemed worth the effort to get as much data as possible. They were about an inch high until killed by freezing after December 15 when frost forced the vacation of the hydroelectric penstock and system shutdown.

The winter of 2010-2011 ended up being long and cold. Dirtwork was delayed through April because of deep frost. Because of cold and minimal snow, several valves and a pump in the hydro/greenhouse systems froze and needed replacing. This delayed hydroelectric system startup until April 15, which is when greenhouses around here start up anyway without hydronics or lighting. However, by April 1, previously-ungerminated kale had poked up out of the beds and were growing quickly. By May system repairs had been made, and watering system components were ordered and installed.

**RESULTS**

The growing season is extended by about three months because of light and heat from the hydroelectric system. This translates into a second growing season. Automatic watering added reliability and efficiency.

Plants germinated and began growing in the heated and illuminated beds while outdoor temperatures were in the 20s and 30s. This shows that the system can sustain growth under such conditions. It suggests that an additional growing season can continue into December with the system. When used for starts in the late winter in conjunction with an outdoor garden it is possible to have an accelerated harvest from the outdoor garden plus two individual harvests between April and December from the greenhouse.

Lighting is the most crucial element of the system as sunlight wanes, and I was advised locally to keep a minimum of nine hours of light available for full plant growth. It was also recommended that lighting systems be vertically adjustable to allow bulbs to be as close as possible to plants for maximum energy absorption. This system combines standard flourescent fixtures with natural light coming through the double-wall PolyGal polycarbonate material. Electric lights will be used to either supplement natural light or operate through the night when household energy uses are low.

Additional light and elevated soil temperatures from the in-bed heat will allow continued growth despite winter's reduced solar gain in the greenhouse. Soil temperature performance observations will continue in the next years, as each of the five beds can operate at different temperatures.

**NEXT STEPS**

The plan for 2011-2012 is to plant cool-weather crops in September and harvest them in December, or as long as the hydroelectric system is operational.

Melons, corn, tomatoes, cucumbers, pole beans, beets, celery, peppers, and kale grew in the greenhouse and will be harvested at the end of August. After harvest, composted manure will be added as necessary (the beds decreased in height by several inches over the last year). I also intend to insulate the hydroelectric penstock by burying with dirt and above-ground insulation to limit freezeup.

**IMPROVEMENTS**

Lighting will be improved by making the 48" long flourescent fixtures height-adjustable, thus presenting a more consistent intense quantity of light for growth. Hopefully they can be kept just inches above the plants throughout the life cycle of the crops.

Additional fans will be added to keep air moving through the structure, minimizing insect propagation and mildew potential.

I also expect to insulate below the ground surface around the perimeter of the structure to inhibit frost penetration inside the building floor.