Geothermal Climate Battery High Tunnel Powered Primarily by Alternative Energy

West Virginia Small Farm Conference
Via Zoom
TL Fruits and Vegetables, LLC

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February 26, 2021

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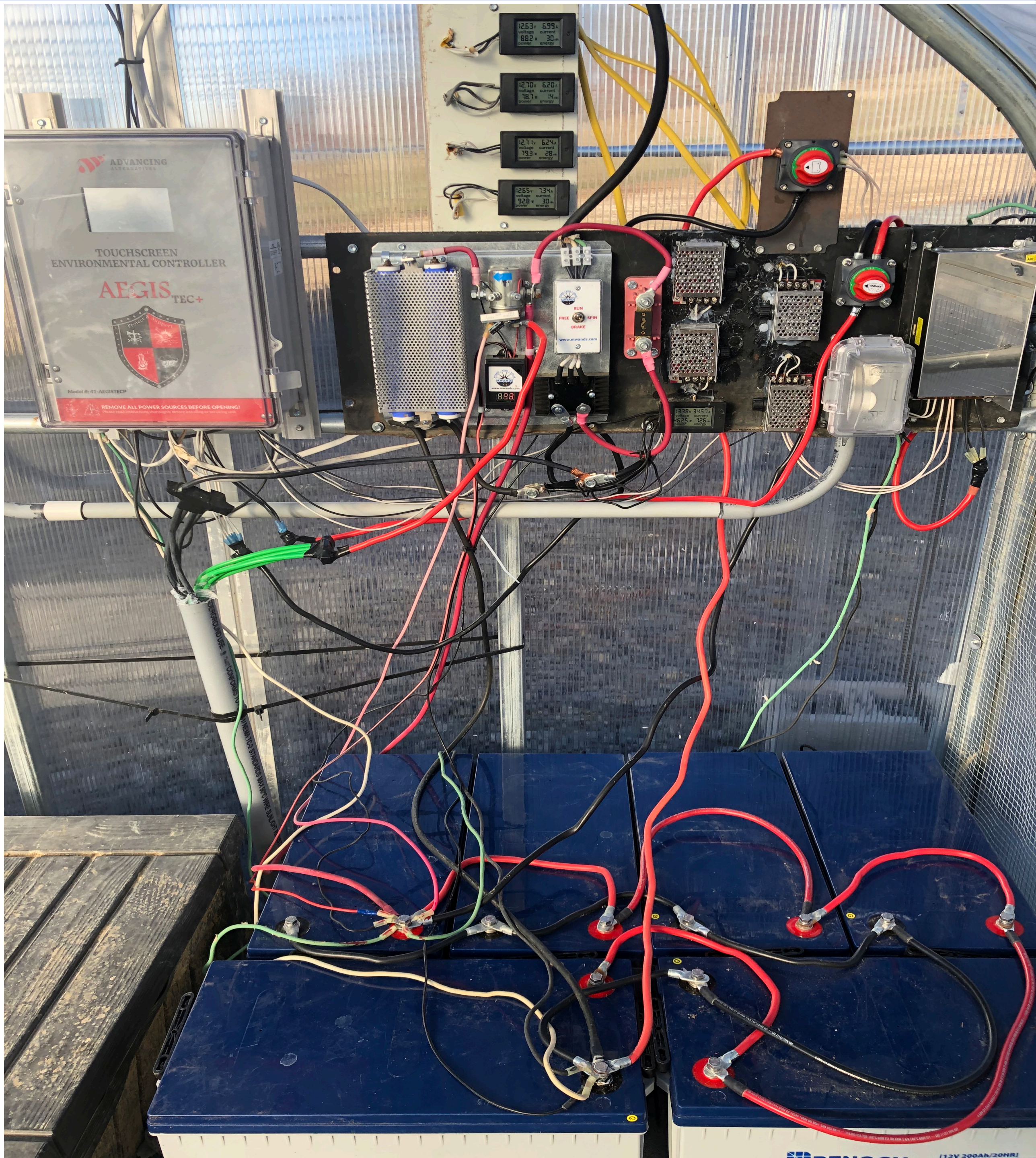
Don’t Panic!

You Don’t Need All This Equipment



Initial Notes and Disclaimers

- **Research funded by Sustainable Agriculture Research and Education Grant (SARE) FNE 20 962-34268 and USDA Rural Energy for America Program (REAP) grant**
- **We are not geothermal, solar, wind, battery or electrical engineers**
- **Information is derived from our research and experimentation - Others may have different results**
- **We learn something new about this project almost everyday!**

Project Goal:

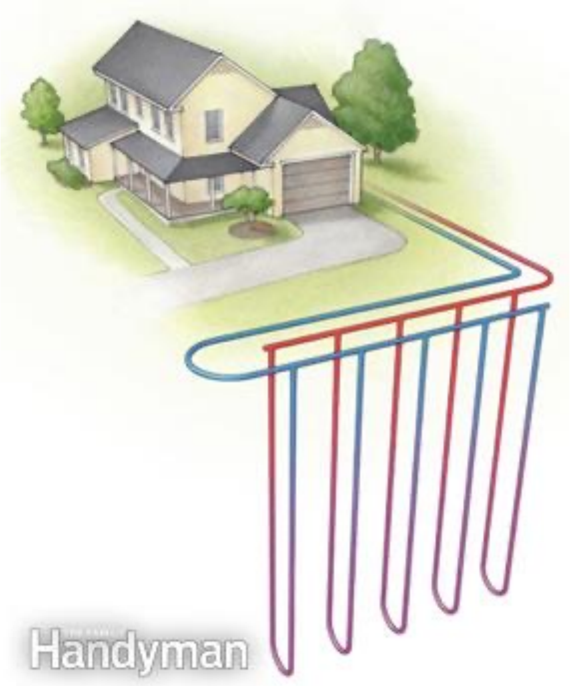
Minimize the Effects of Extreme Weather in a Large (30 x 96 ft) High Tunnel utilizing primarily Alternative Renewable Energy Sources

- **Geothermal**
- **Solar**
- **Wind**

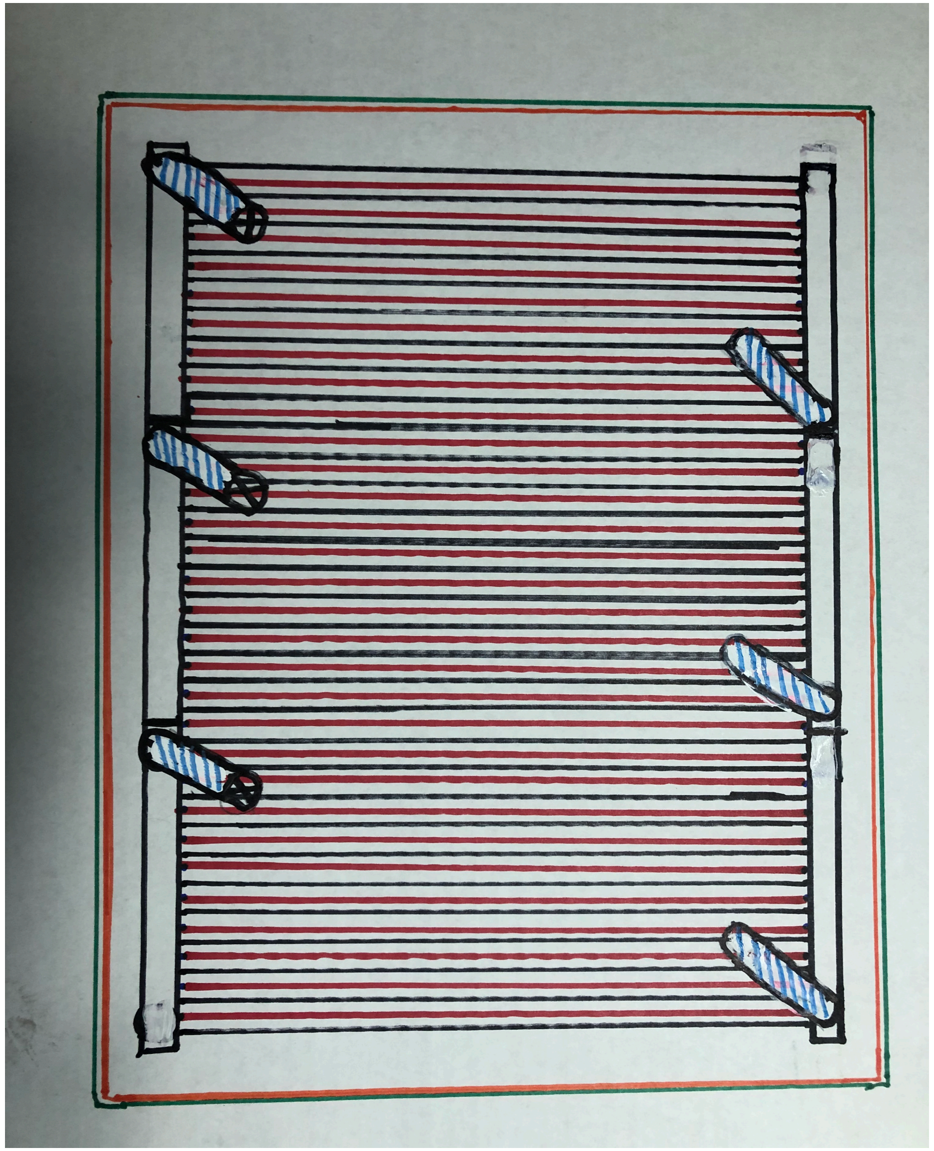
Two Types of Geothermal

Traditional Geothermal

- **Horizonal or vertical**
- **Liquid in 1”-1.25” pipes circulates**
- **6-8 ft deep horizonal**
- **250 -300 ft deep vertical**
- **2000 sq ft house 1500-1800 ft of pipe**
- **Temp is fairly constant at 30 ft deep – 50-57 degrees in WV**
- **Requires heat pump to increase or decrease temperature in house beyond underground temperature**



Geothermal Climate Battery



- 4” sleeved perforated pipes 5 ft deep 27 ft long
- 4” sleeved perforated pipe 3 ft deep - 27 ft long
- Three separated Horizontal 18” manifold pipes per side
- Three vertical 18” manifold pipes per side
- 4 x 8 ft /2” thick foam boards
- 3 fans
- Perimeter of 30 x 96 ft high tunnel

Steps to Installing Geothermal

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90 perforated 27 foot corrugated sleeved 4” pipes

Steps to Installing Geothermal

- Three vertical pipes attached with “L” connectors to horizontal manifold on each side
- Pipes covered with soil or gravel

The Greatest Challenge: Determining Optimum Fan Velocity

- Three 16” radiator fans blow air through pipes
- Experts recommend air should exchange at least 5 times the high tunnel volume (26000 cubic ft) per hour (2166 CFM) for heating and at least 8 times ((3466 CFM) for cooling.
- Initial testing suggests for this size high tunnel about 8000 CFM is optimum for heating. Cooling still to be tested
- If air velocity is too fast, air in pipes will not have time to heat or cool
- If air velocity is too slow, air will not maximize the heating and cooling

Geothermal: Lessons Learned During Cold Season Testing

- Climate battery works
- Deeper pipes (8 feet) had little effect - 3 and 5 feet deep is acceptable
- Minimize clay content in soil
- Determining optimum fan velocity is critical in a large high tunnel
- Unlike traditional, underground temperature fluctuates daily based on pipe temperature air intake
- The colder the outside temperature, the greater the temperature variance between the outside and the high tunnel
- No expected additional cost after installation
- Drainage pipe not required but useful
- Estimated geo materials costs: sleeved pipes $2400, fans $150, manifolds $2665, wiring $168, pipe connectors $615, insulation boards $1100

  Total $7098

High Tunnel Geothermal Requires Energy to Power Fans

There are lots of options:

- **Electricity**
- **Solar with batteries**
- **Wind with batteries**
- **Solar/ wind combination with batteries**
- **Solar/wind/electricity with or without batteries**

Electricity to Power Fans

Benefits:

- Easy to install
- Can use AC fans or with converter DC fans
- Fans with high CFM output readily available
- Minimal upfront costs: converter $40 plus cost of electrical connection to the grid

Negatives

- Ongoing estimated electricity costs for 300 watts at 24 hours a day for a year is $316
- Must have access to power grid
- Cost of connecting to power grid

Solar

Benefits

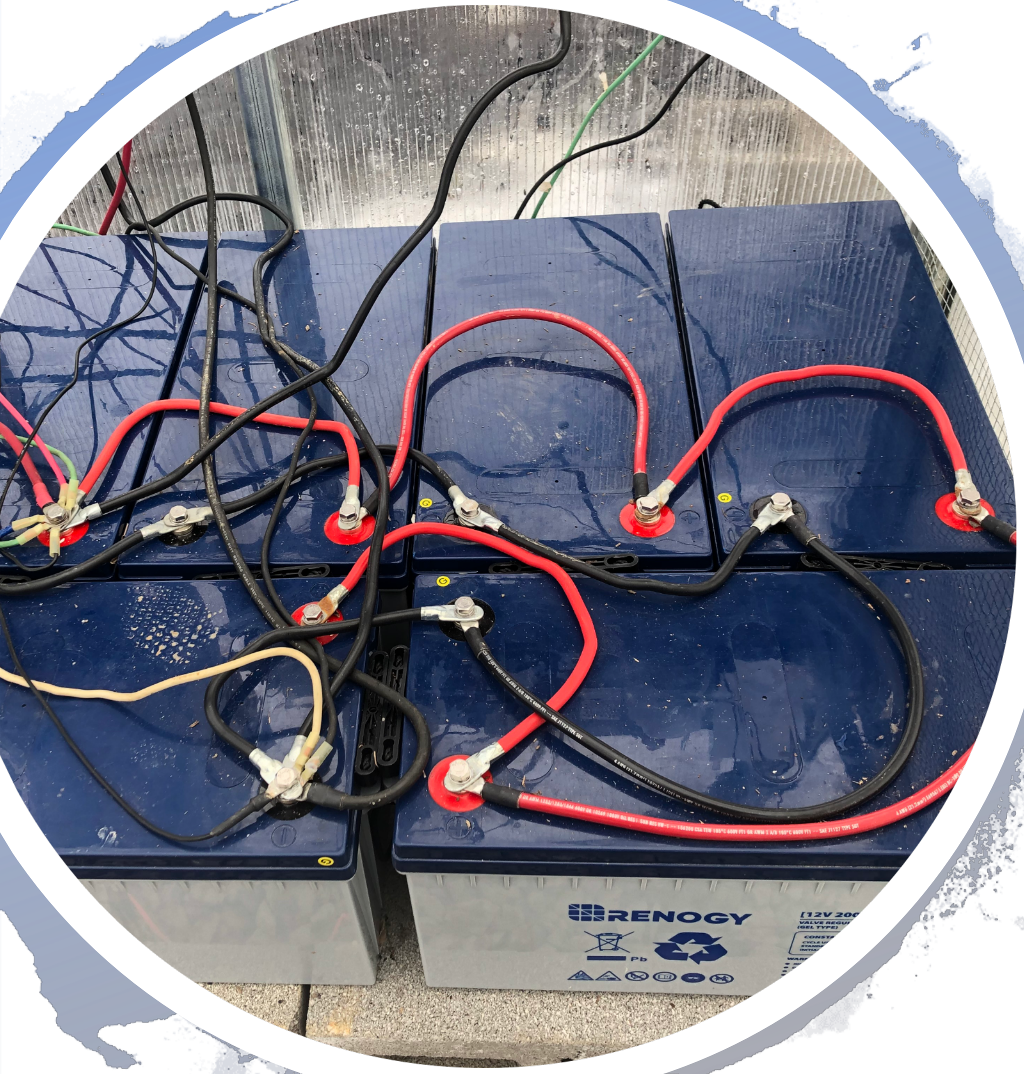
- **Solar produces free energy for many years**
- **Solar will produce enough energy in full or partial sun to run fans and charge batteries**
- **Solar has few components: panels, charger, solar wire and stand**
- **Easy to install**
- **Estimated material costs: 10 solar panels $1000, controller $100, wiring $100 and DIY metal stand $215, 6 bags of concrete $60. Total $1475**

Negatives

- **Requires batteries to run at night and in overcast weather**
- **May require electrical backup or additional batteries in dead of winter**

Solar Lessons Learned

- **Produces significant amount of energy**
- **Angle of solar panels your latitude plus 15 degrees in winter and minus 15 degrees in summer.**
- **Recommend adjustable solar stand or winter angle since less daylight.**
- **Snow sheds off panels easier at steeper angle**
- **Point panels due South**
- **Locate solar panels close to controller and batteries to avoid current (amperage) loss**
- **Use heavy gage wire to connect panels to controller**



Batteries

Benefits

- Keeps fans running at night and in overcast weather when no wind
- Rechargeable and Renogy designed to last 12 years allowing for with 750 discharges at 50%

Negatives

- Batteries are expensive: each Renogy 200 Ah hybrid gel battery was $395 or more. AGM batteries are less expensive but not rated to last as long. Each battery should produce enough power for 4 hours at 300 watts before recharging.
- Electrical backup can reduce need for additional batteries

Batteries Lessons Learned

watts = volts x amps
300 watts = 12 volts x 25 amps
200Ah battery lasts 4 hours before reaches 50% threshold

- **Charge batteries when they arrive**
- **Four types of deep cell batteries – flooded, AGM, hybrid gel and lithium – Lithium is best but very expensive**
- **The higher the Ah (amp hours), the longer the battery will produce energy**
- **Wire batteries in parallel to retain 12 volts and increase amps.**
- **Batteries should not be drained more than 50% during use**
- **Keep batteries insulated from cold**
- **Full battery voltage is about 12.8. Never drain more than 50% (about 12.2 volts)**
- **Do not mix old and new or different types of batteries**
- **Get sealed batteries. No adding of water.**

Wind Energy

Benefits

- **Exceptionally entertaining**
- **Produces free energy for many years**
- **Estimated low materials cost – kit at Missouri Wind and Solar includes 1600 watt wind turbine and all in one controller with wire for $960. Add $120 or more for mounting pole**

Negatives

- **Must live in a windy area**
- **Wind turbine must mounted high enough and far away from buildings, trees and other obstructions to avoid wind turbulence**

Lessons Learned

- No wind/no energy
- With no wind turbulence – no buildings or trees around
- Energy produced in ideal conditions:
  - 12 mph – 100 watts
  - 20 mph– 300 watts
  - 30 mph – 600 watts
  - 55 mph – 1600 watts

Some Very Preliminary Results

- We compare outside temperatures, a control high tunnel temps without geothermal and the temps within geothermal high tunnel.
- Geothermal in winter can raise high tunnel temperatures at least 10 degrees over outside temperatures when temps are 20 and below and CFM is about 8000 (300 watts).
- The colder the outside air, the greater the temperature difference
- Geothermal helps circulate air year round
- Solar works great. Wind turbine requires strong winds to generate sufficient watts (12 mph winds maybe 100 watts)
- Electrical backup if available can greatly reduce the need for additional batteries when there is no wind or partial sunshine for several days

What about conventional heating of high tunnel using natural gas or propane?

- **Heating only**
- **Estimated retail cost of two 175,000 BTU Renzor gas furnaces with stainless steel heat exchangers is $5200. Installation estimated at least $1000.**
- **Estimated <u>annual</u> natural gas cost for 90 days, 12 hours a day is $5,560 and for propane $12,867.**

Special Thanks

- **Sustainable Agriculture Research and Education (SARE) – Candice Huber**
- **USDA Rural Energy For America Program – Jessee Gandee**
- **Joshua Peplowski at West Virginia Extension Service**
- **Advancing Alternatives –Rich Hite**
- **Missouri Wind and Solar**
- **Windy Nation**
- **Solar Holler**
- **RBS Inc**
- **Online articles and videos**