

**Motivation, Goal, Impact**

**Motivation:** At Asawana Farms, small farmers need an affordable way to start seeds earlier, while avoiding fossil fuels use.

**Goal:** A geothermal heating system capable of maintaining greenhouse germination temperatures in the winter.

**Impact:** Higher yield, increased profitability, environmental sustainability. Allows seed germination 4-6 weeks earlier in winter

**Requirements**

- Heat greenhouse air to 65°F - 80°F for seed germination
- Utilize geothermal heating
- Implement autonomous temperature control system
- Within construction budget of \$15,000

**Geothermal Loop**

- 76 ft x 18 ft trench
- 3 ft diameter loops
- 5-ton heat pump

**Fancoil Unit**

- Installed inside germination room
- Transfers geothermal heat to air
- Circulates warm air through chamber

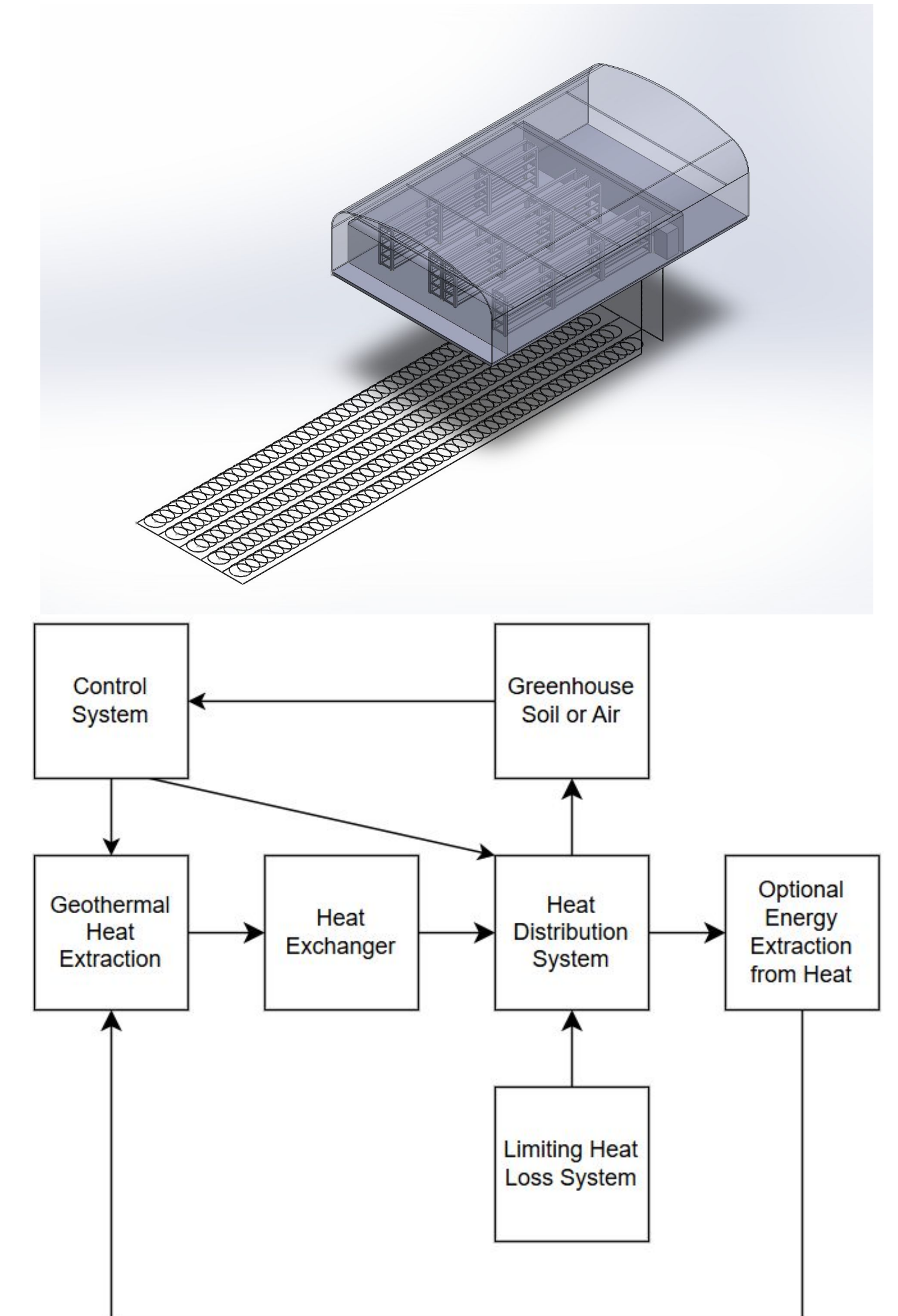
**Final Design**

**Germination Room**

- 30 ft x 33 ft Room
- Single layer 6 mil LLDPE plastic
- Magnetic access door for opening and resealing

**Control System**

- PID Style control
- Microcontroller based sensing and control
- SHT41 temperature sensing

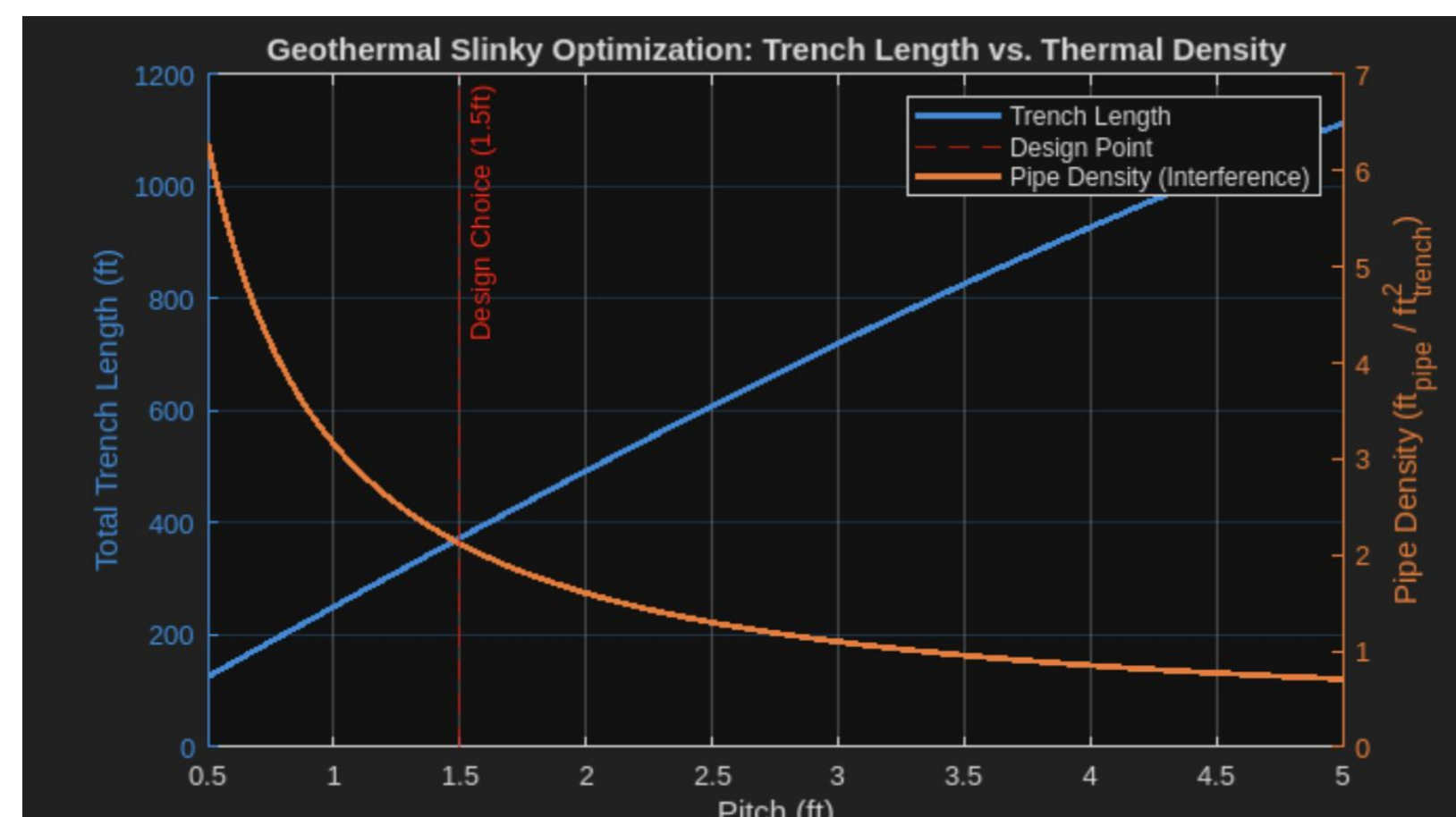


**Design Calculations & Decisions**

**I: Heat Pump Sizing**

- $Q = U * SA * \Delta T$
- 47.50 kBTU/hr = 3.958 tons
- 5-ton Heat Pump

**II: Ground Heat Exchanger Piping Optimization**



**III: Controls Systems Strategy**

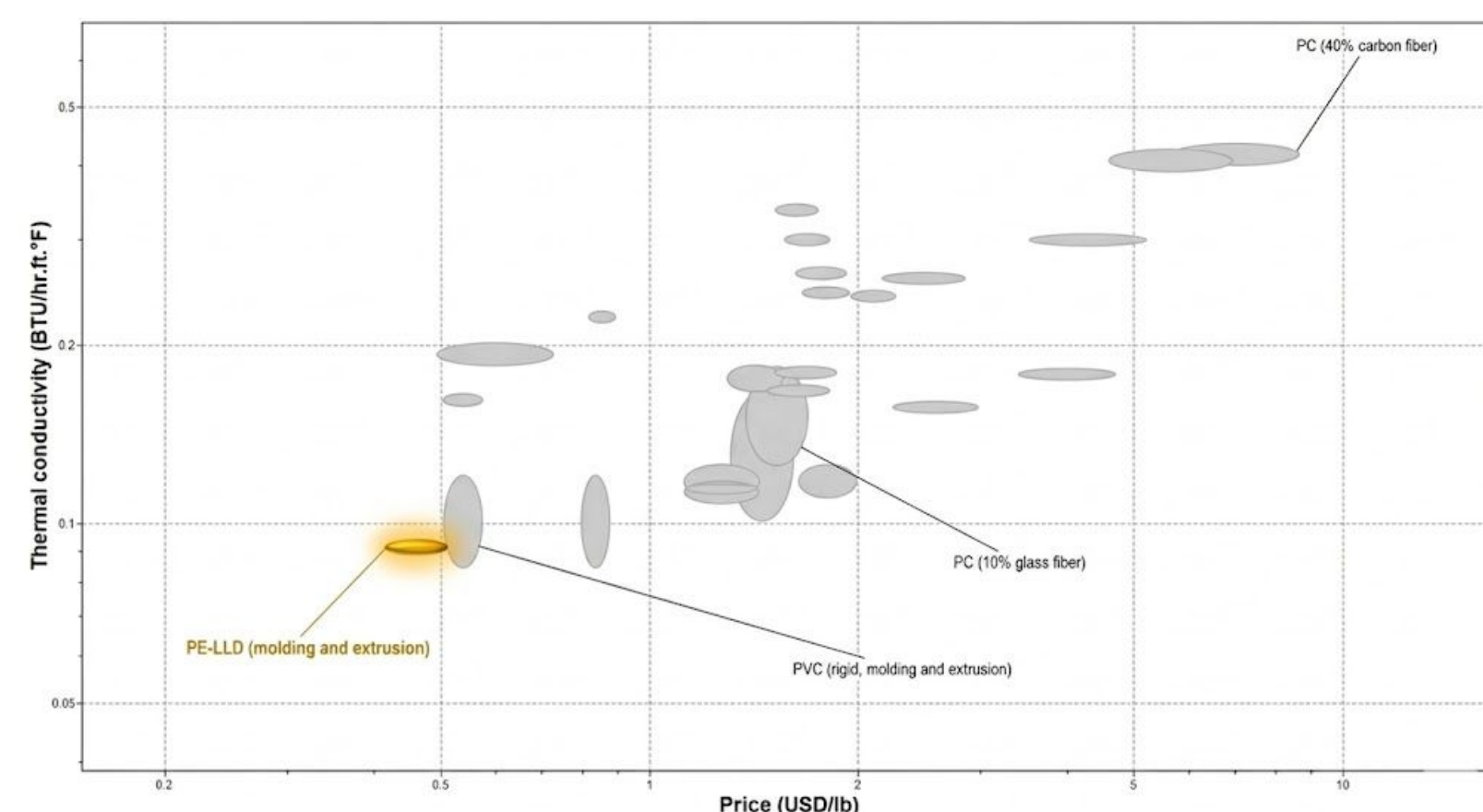
Matlab simulation demonstrated 7.5% energy savings with PID

**IV: Fan Coil Unit Sizing**

- $CFM = Q / [1.08 * (T_{supply} - T_{return})]$
- CFM ~1100 CFM output required

**V: Germination Chamber Plastic**

- LLDPE (Linear Low-Density Polyethylene)



**VI: Tarp Fastening Method**

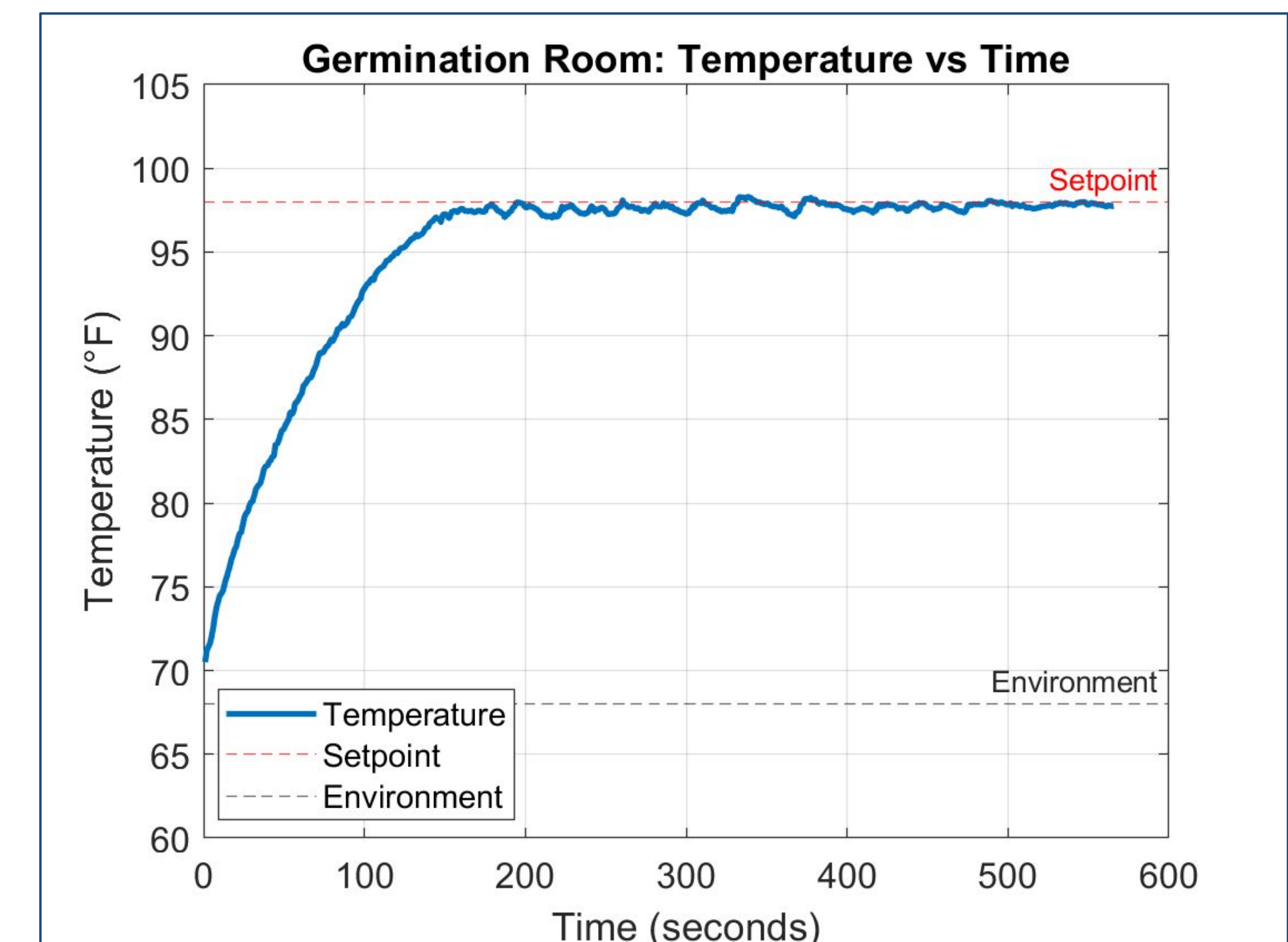
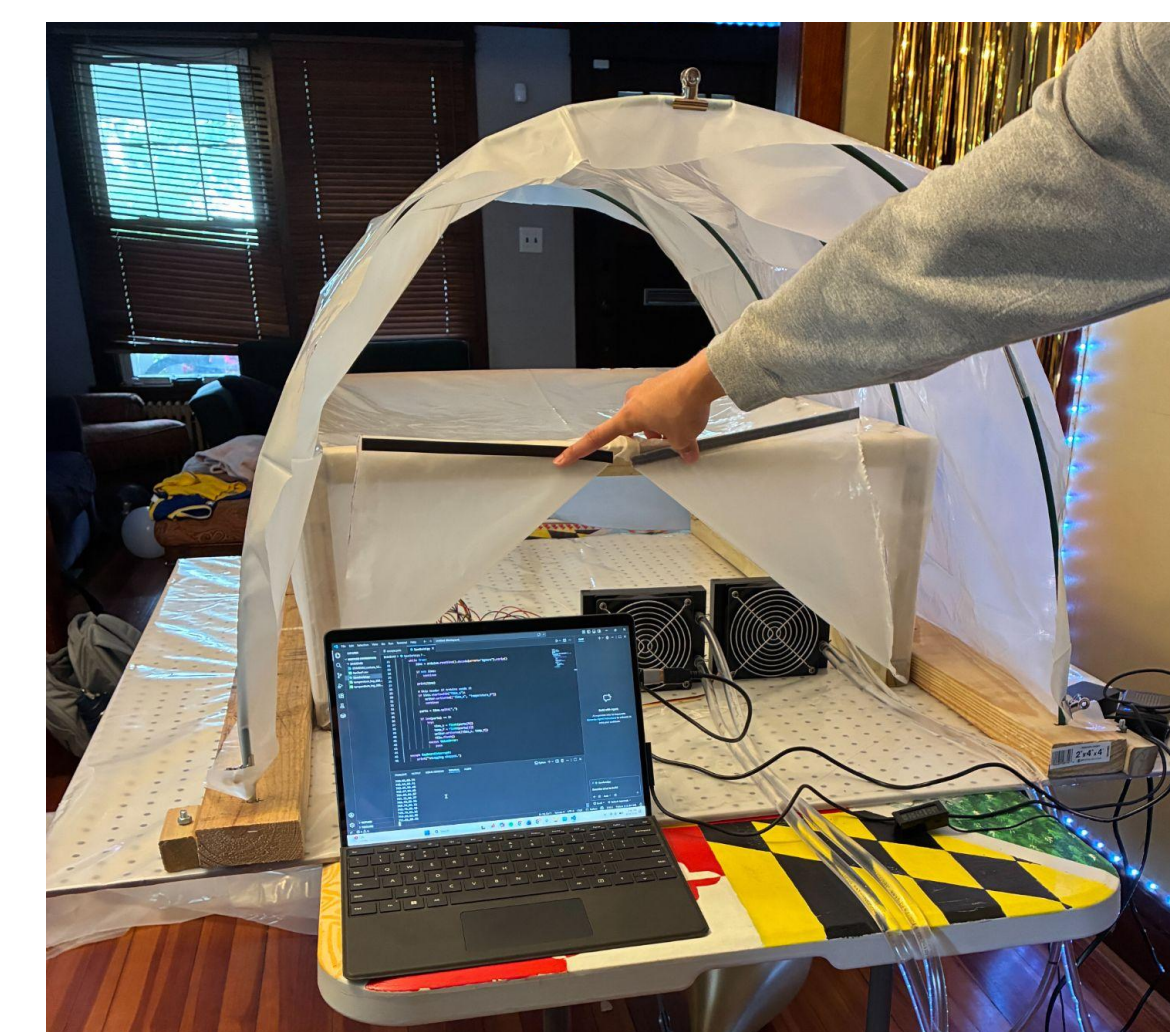
- Plastic clip load capacity of 1110 N is well under design load of 13.5 N

**Prototype & Test Results**

Temperature Differential Achieved: 30°F in 2½ minutes

**Components:**

- Immersion Water Heater
- Water pumps
- Fan Coil Units
- LLDPE outer chamber layer
- Thermistors
- Arduino + Computer for actuation



- Internal temperature was consistently held at a 30°F differential (98°F), utilized PWM control of motors to implement PID control capabilities.