GNG 1103 - Engineering Design

Group 3.4

University of Ottawa

Deliverable D : Conceptual Design

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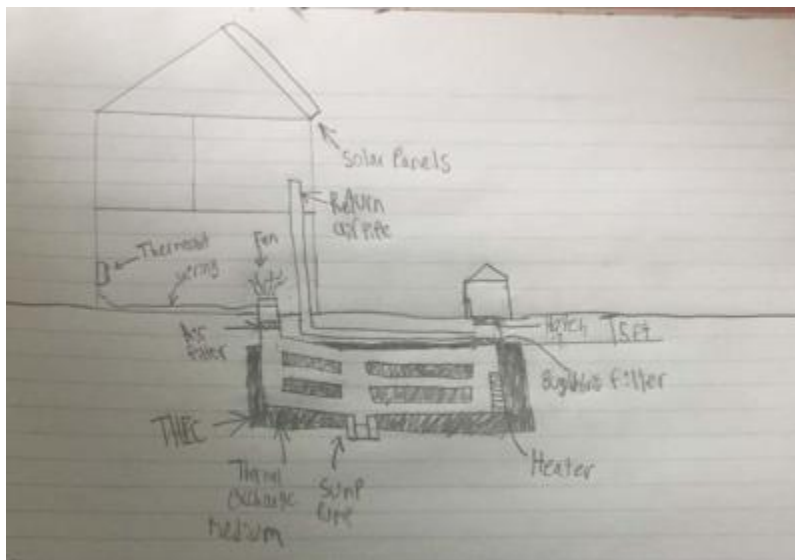
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Introduction

After reviewing our design criteria that we have for the project, we had a better understanding of our functional and nonfunctional requirements along with establishing ourselves some constraints. In this deliverable, we will be using the knowledge obtained from our benchmarking and prioritized design criteria list in order to create conceptual solutions to the given problem. After listing these solutions we are going to evaluate them and select what we believe to be the best choice and that meets as many of our established interpreted needs as possible.

Conceptual Design

Concept 1 - Stephen Palczak

Subsystems:

Electrical Subsystem:
- Solar panels
- Thermostat
- Fan
- Heater
- Sump pump

Heat exchange system:
- Heat exchange chamber
- Thermal exchange medium

Air circulation system:
- Pipes
- Hatch
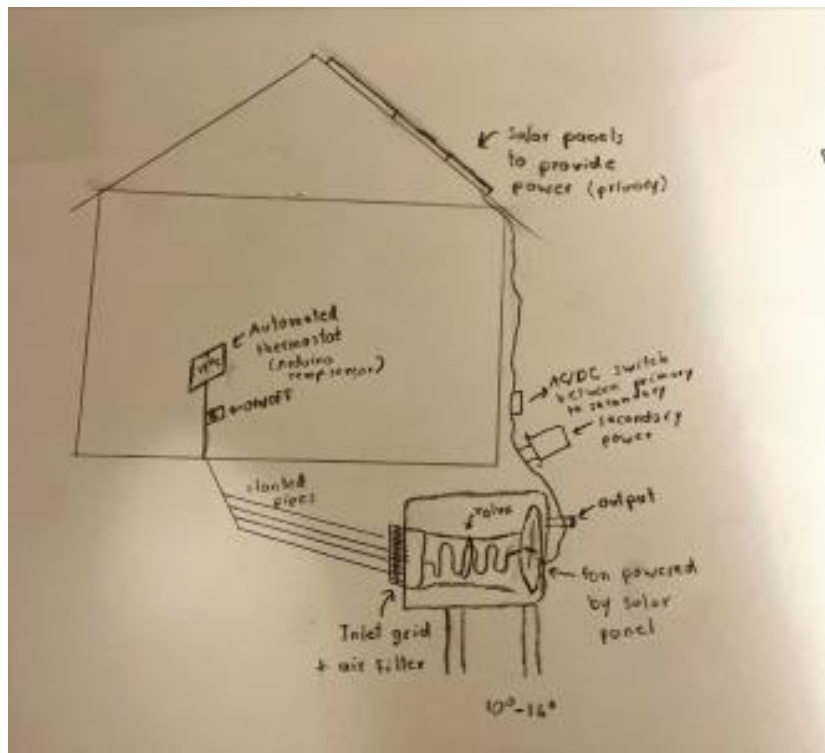- Bug/debris filter
- Return air pipe
- Air filter

Benefits
- Able to provide thermal comfort during the winter with the coupling of a heater in the heat exchange chamber
- Zero emission system
- High air quality
- Able to operate in a closed loop
- Heat exchange chamber able to be cut off during extreme weather
- Operates automatically via the thermostat
- Condensation removed from the system

Drawbacks
- Significant cost (solar panel)
- High maintenance cost (solar panel)
- Lower durability (solar panel)
- Difficult to assemble

Concept 2 - Paul Karakach

Subsystems:

Fan and thermostat interactions (electrical system):
- Fan and thermostat powered by solely solar panels with a secondary power source being a rechargeable battery.
  - AC/DC switch, programmed to determine between days of prolonged sunlight (primary power) and days of little to none (secondary power)
- Regulated Arduino Temperature Sensor to either cool or warm the interior of the building depending on a certain threshold temperature
  - Ex. 15°C or below = HIGH, 20°C or above = LOW

Ventilation system:
- Valve to direct the flow of air, inwards through THEC to warm the air or outwards from the exterior to cool.
- Inlet grid + air filter to catch any debris from the exterior and increase the quality of breathable air in the residence.
- Slanted pipes to minimize condensation + freezing in the case of excess moisture
  - CPVC pipes due to high thermal resistance, cheap cost and lifespan.

Heat system:
- THEC, cools or warms the air with respect to the thermostat signal (HIGH or LOW)
- Insulated thermal medium

Additional information:

Cost:

100 - 120$
- Pipes:
  - 3.36$/foot of CPVC pipe
    - Durable and flexible
    - Can withstand temperatures up to 200ºC and below -30ºC
    - UV and corrosion resistant
    - 50 to 70 year lifespan
  - https://www.homedepot.com/p/Charlotte-Pipe-1-in-x-2-ft-CPVC-SDR11-Pipe-CTS120100200R/203019516
- Solar panel and fan
  - https://www.amazon.ca/Powered-Outdoor-Portable-Cooling-Camping
  - 31.99$

Benefits:
- Zero emissions
- Thermal comfort during winter
- Entirely automated
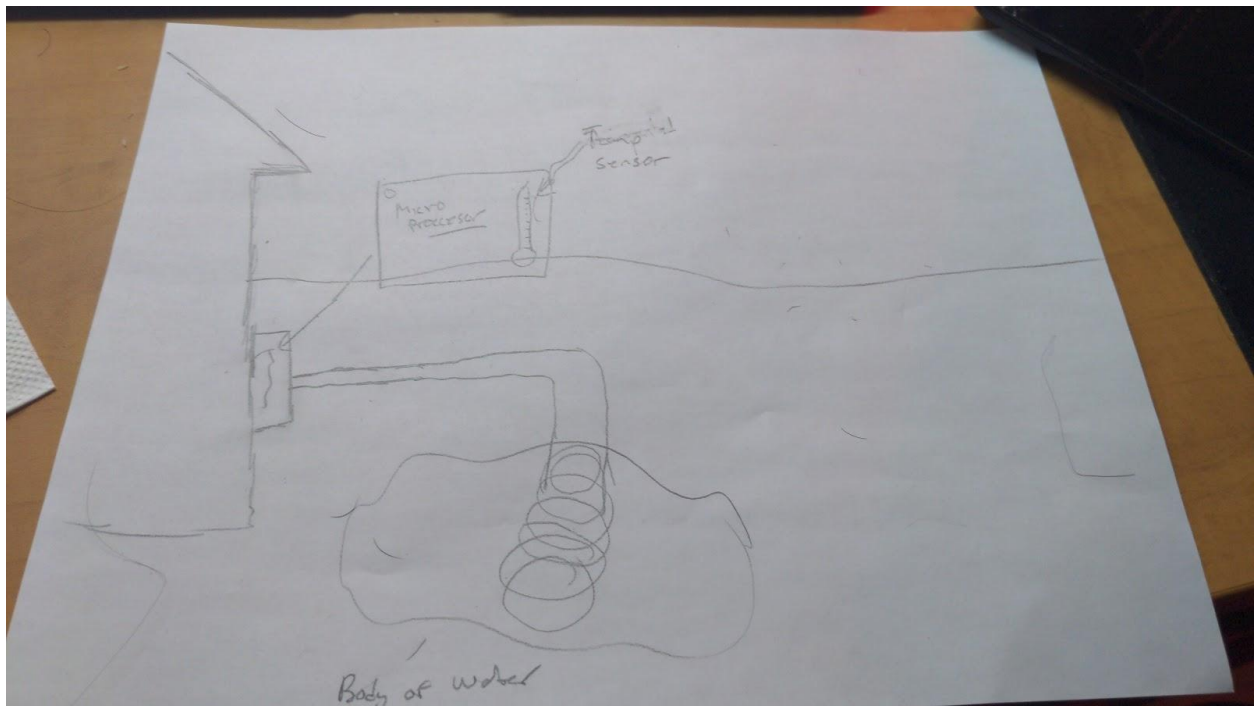- Manageable cost
- High air quality

Downsides
- Less durable
- Higher maintenance cost

Concept 3 - Luxan Jeya

Basic Loop:
Temperature sensor controller(Arduino) —> Valve —-> Process(air going through the tubes) —-----> Heat exchange chamber

This design calculates the temperature through an Arduino Temperature sensor (similar to the one we used in our lab) to then decide which way to turn the valve in order to change the direction of air flow thus cooling or heating the air in the heat exchange chamber. My design was strictly made for sites with an adequate body of water. The pvc pipe is run underground from the house to the body of water and coiled into circles at least eight feet under the surface to prevent it from freezing.

Subsystems:

Micro Controller(Arduino) :
- ON / OFF switch
- Temperature sensor
- Rechargeable battery
    - Hydropower to recharge the battery

Air Circulation system :
- Coiled PVC tubing
- Sump pump
  - Air filtration to provide high quality air

Heating and Cooling
- Micro controller will be used to control air flow.
  - To reach preferred temperature the valves will force air into a certain direction. Controlling the temperature of air released into the ventilation
- Heat exchange system

Benefits:
- Zero emissions
- Durable
- Provides quality air

Cons:
- Expensive
- Can only be used if adequate body of water is near by
  - If the water freezes, the hydro system will not work!
- Intensive construction

Cost:
Arduino UNO R3 Board = 8$
DS18B20 Digital Temperature Sensor (TO-92) = 14$
- Waterproof
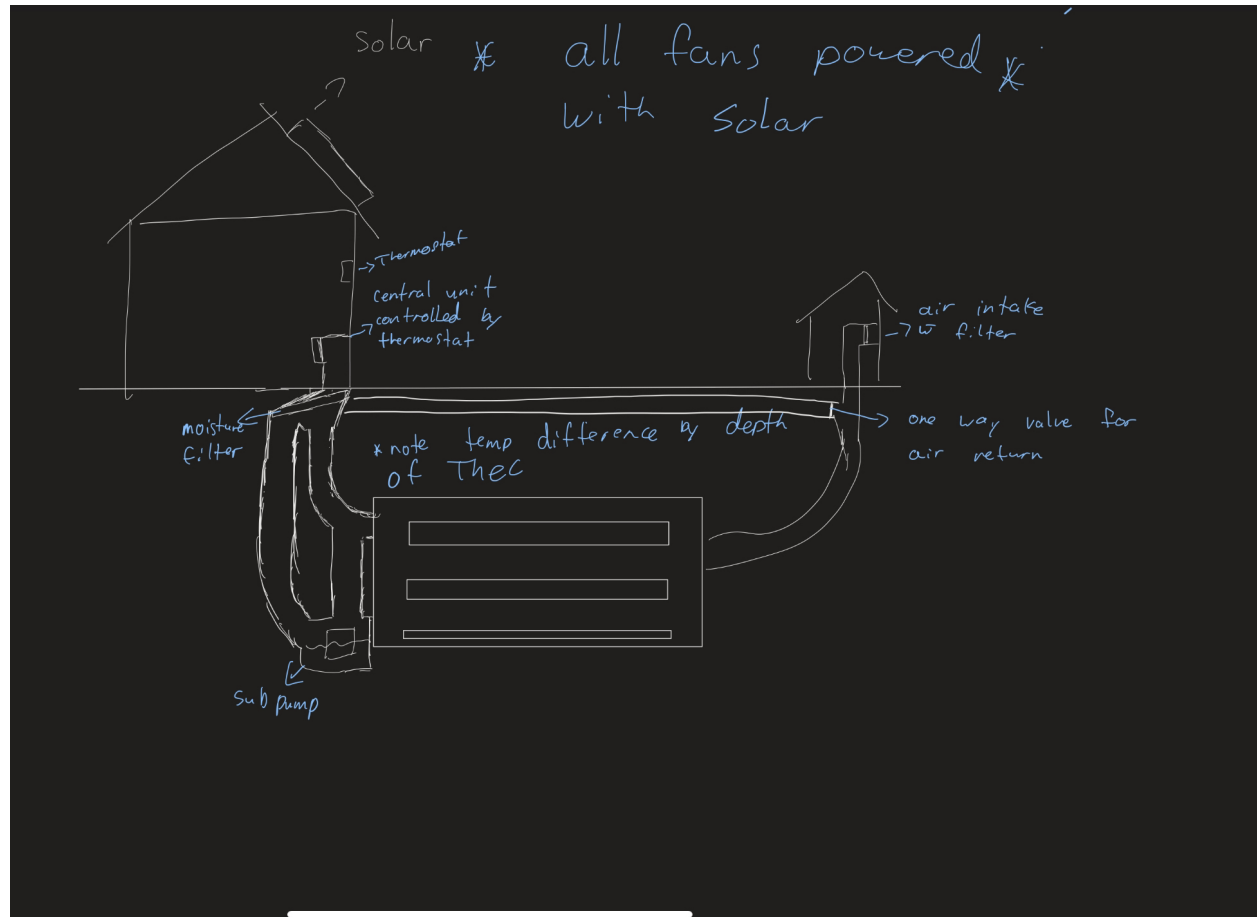
Accessories(bread board, wires and etc..) = 15$
Coiled PVC Pipe (approx less than 24 ft) - 15" by 12' - 24$ x 2 = 48$
Hydro Power kit = 50$
Estimate Cost: 136$

Concept 4 - Alex Bailey

Sub systems

Electrical
- Solar power for electrical components
- Thermostat with temperature sensor to determine when heat is needed from the central unit.
- All fans are controlled with electricity for a controlled air flow based on what is required
- Air return is also using a fan to keep system at equilibrium
- Power store would be a part of the central AC unit located in the basement of the house (climate controlled environment)

Heating/cooling
- Thermostat controls the set temperature of the house
    - If temperature increases above set temperature house will cool, if temperature is below set temperature then the house will be set to heat.
- Blower from central unit will increase or decrease speed based on how drastic the temperature difference is between set and actual.

Ventilation
- Return air vent
    - Return and recycle air at appropriate temperature to increase the net rate of heating/cooling for the house
- Air intake controlled by fan
    - The fan is only on if needed. If the outside temperature is not optimal for heating/cooling the recycled air will be used.
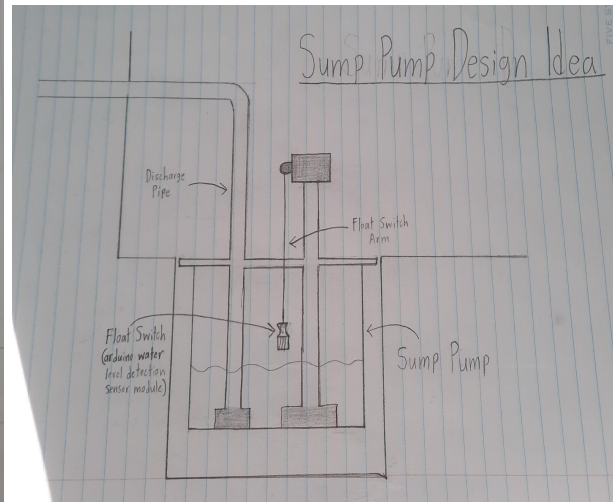
Benefits
- Heat and cooling controlled and able to be independent of outside temperature.
- Zero emission system
- Able to operate in a closed loop
- Operates automatically via the thermostat
- Two moisture filtration systems (extra cost but extra benefit)

Drawbacks
- Solar is expensive
- Why not just use an electrically powered unit for heating and cooling?
- Moisture filter is likely not needed unless there's an extreme case of moisture entering during heating

Concept 5 - Oliver Meng

Subsystems

Automated sump pump equipped with an **Arduino water level detection sensor module** attached to a float switch to simultaneously detect when the water level has reached a quarter of its capacity and activate the system. This would relay information to the rest of the system to activate (lower) the ON/OFF (float) switch that our team may decide to implement if needed. **Benefits** include cheap and ergonomic components to use for the automation of the sump pump as Arduino is openly accessible and relatively easy to use. **Drawbacks** may include finding an appropriate component to activate the switch, whether that be through physical manipulation or other detection-based methods such as light or sound based. The basin for the pump itself also has to be large enough to incorporate such a mechanism.
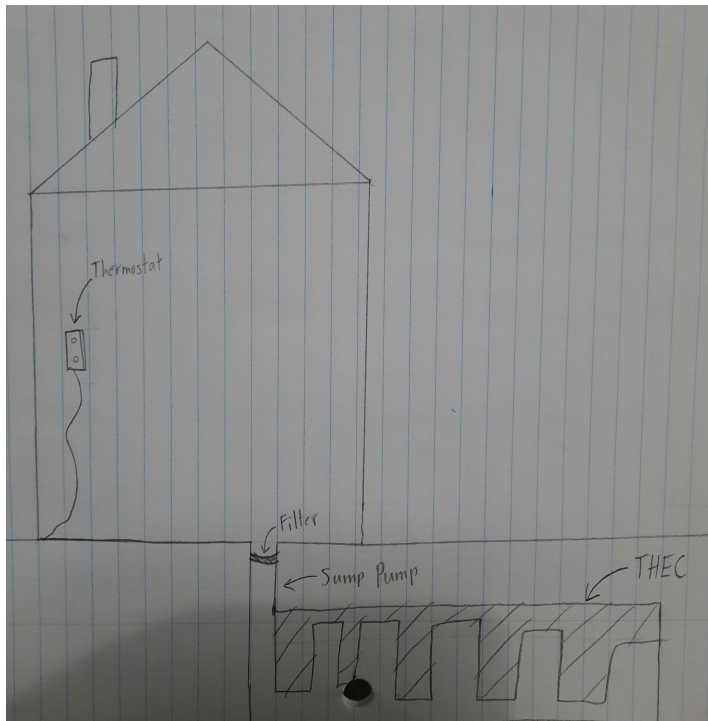
Heating:
Thermostat for temperature toggling. Drawbacks may include it not being automated requiring manual manipulation of the switch. Minor inconvenience.

Electrical:
Solar panels for power. Drawbacks may include the high cost for such materials.

Concept 6 - Dominick Bernard

Subsystems

Electrical:
- Pump
    - Down slant/vertical orientation to remove water from system
- Thermostat
    - Allows setting for heating and cooling only, no temperature control, but displays temperature on screen

Ventilation:
- Chimney to allow air out
- Proposed inlet through THEC

Thermal:
- Heat exchange chamber
- Thermal exchange medium

Benefits
- Low cost

Downsides
- Non-zero emissions
- Poor air quality
- Does not provide full thermal comfort during winter

Final Concept 1

Subsystems:

Electrical
- Fan and thermostat powered by solely solar panels with a secondary power source being a rechargeable battery.
    - AC/DC switch, programmed to determine between days of prolonged sunlight (primary power) and days of little to none (secondary power)
- Regulated Arduino Temperature Sensor to either cool or warm the interior of the building depending on a certain threshold temperature
    - Ex. 15ºC or below = HIGH, 20ºC or above = LOW
- Sump pump
    - Automated based on fill level

Heating/cooling
- Thermostat controls the set temperature of the house
    - If temperature increases above set temperature the house will cool, if temperature is below set temperature then the house will be set to heat.
- Blower from the central unit will increase or decrease speed based on how drastic the temperature difference is between set and actual.

Ventilation system:
- Valve to direct the flow of air, inwards through THEC to warm the air or outwards from the exterior to cool.
- Inlet grid + air filter to catch any debris from the exterior and increase the quality of breathable air in the residence.
- Hatch to cut off system from outside in times of extreme/cold weather
- Return air pipe to operate under closed loop
- Slanted pipes to minimize condensation + freezing in the case of excess moisture
    - CPVC pipes due to high thermal resistance, cheap cost and lifespan.

Final Concept 2

Electrical - using power grid for minimalist power use.
- Temperature sensor
    - Array of sensors throughout the house in attempt to create equal temperature throughout
- Pump
    - Down slant/vertical orientation to remove water from system
- Thermostat
    - Allows setting for heating and cooling only, no temperature control, but displays temperature on screen

Heating:
- Thermostat for temperature toggling. Drawbacks may include it not being automated requiring manual manipulation of the switch. Minor inconvenience.

Ventilation:
- Chimney to allow air out
- Inlet flows through THEC

Final Concept 3

Electrical
- ON / OFF switch
- Temperature sensor
- Rechargeable battery
    - Hydropower to recharge the battery

Heating/cooling
- Thermostat controls the set temperature of the house
    - If temperature increases above set temperature the house will cool, if temperature is below set temperature then the house will be set to heat.
- Blower from the central unit will increase or decrease speed based on how drastic the temperature difference is between set and actual.

Ventilation system :
- Coiled PVC tubing
- Sump pump
    - Air filtration to provide high quality air

Priority Matrix:

Scale from 1 to 3 (1 being poor to non-existent, 3 being excellent)

Needs	Weight	Final Concept 1	Final Concept 2	Final Concept 3
The system must be able to deliver cooled air in the summer, and heated air in the winter, controlled by a thermostat dependent on the temperature of the interior.	5	3	1	3
The system must be sturdy enough to function as intended after being buried underground and should not rust or corrode when exposed to moisture or condensation.	4	2	3	3
The system should be designed to have minimal if not zero carbon emissions.	5	3	1	3
There must be an inlet grid to prevent debris and insects from entering the system, as well as a filter at the junction with the house to ensure air quality.	3	3	2	1
The system should be inexpensive to install and operate while delivering the same thermal comfort results as larger systems on the market.	3	2	3	1
The system should be able to be cut off from the outside in times of extreme weather.	2	3	2	2
The sump pump should be automated to activate after a quarter of the water level has been reached	2	3	3	3
Total Score (w x #)	--------	65	47	58

Analysis

After further analysis the team decided to incorporate a mix of the ideas in concept 1 and in concept 4, taking the heating subsystem from the latter and the electrical and ventilation subsystem from the first concept. We believe that solar power coupled with a secondary rechargeable battery would be the most efficient power source for our system, accounting for days of prolonged sunlight and those with few. Furthermore, solar energy is emission free and earns the highest rating in our Priority Matrix.

The ventilation system is designed to be easy to install and maintain, requiring little maintenance due to the lifespan of up to 70 years of CPVC pipes and their relatively cheap cost. Unfortunately we have to work with the downside of solar energy being relatively costly to maintain our priority of "zero carbon emission". The ventilation system also offers a valve to direct air flow and control whether it should be warmed or cooled, given by the HIGH/LOW signal from the Arduino Temperature Sensor and thermostat, an inlet hatch and air filter to maximize the quality of breathable air and a hatch to cut off system from outside in times of extreme/cold weather. Finally this system offers a fully automated and programmable thermostat to adjust itself to meet the standards of thermal comfort in the residence.