KATELYN K.H. LAM
APS112 TUT 0126 TEAM 137
ENGINEERING NOTEBOOK

Team 137 - APS112 ENGINEERING NOTEBOOK

Project: Reducing GHG Emissions from Homes and Buildings (072)

Client: Ms. Brototi Das, Senior Associate, Development and Planning
Emerson
66 Leek Crescent, Richmond Hill, Ontario L4B1H1

Contact information: brototi.das@emerson.com Phone: (416)-346-7397

Alternate Contact: Sebastien Lee . Email: sebastien.lee@emerson.com

Tutorial Information (Section TUT-126)

TA: Chukwum Asuzu Email: chuma.asuzu@mail.utoronto.ca
(For submitting work): chuma.espuoft@gmail.com

EM: Ron Hurtig Email: ron.hurtig@utoronto.ca (ron.hurtig@gmail.ca)

CI: Faye D'Silva Email: faye.dsilva@utoronto.ca (Google Docs)

Team Information (Primary Method of Contact: Instagram Group Chat)

(EE) Katelyn Lam (Project Manager) Email: katelyn.lam@mail.utoronto.ca
Instagram: @tfmementomori97

(EE) Bob (Yiqui) Chen (Team Leader) Email: bob.y.chen.zj@gmail.com
Instagram: @antispammingking

(CE) Keli Chen (Contact Person) Email: kelichen2684@gmail.com
Instagram: @kiwikales

(EE) Eleni Pethakas (Prototyping Lead/Draftsperson) Email: eleni.pethakas@mail.utoronto.ca
Instagram: @eleni.pethakas

(EE) Michael Silver (Editor) Email: m.silver@utoronto.ca
Instagram: steezy.ms

01/25/2023 Tutorial

Client Meeting Plan – The purpose is to develop an email to schedule an in-person meeting with the client to discuss the requirements of the project. The client is Ms. Bratati Das, Senior Associate, Development and Planning from Emerson, based in Richmond Hill.

Context for the email: We are an engineering student design team from Engineering Strategies and Practice

↳ Project: Reducing Greenhouse Gases from Homes and Buildings.

– Selection of times: Friday Feb. ~~3~~ 10, 4:00p – 5:00p
Thursday Feb. 9, 2:00p – 3:00p
Mon Feb 6 : 10:00a – 11:00a

– After Tutorial 2 on Feb. 1 (Wed)

↳ Email was approved by engineering manager and sent by Keli. When the client approves of a time Keli will email the esp office to book a campus meeting place, and we will send a confirmation email to the client.

Client Statement Impressions

- Bob researched (quick Google Search) of Emerson – it is a U.S. based company specializing in heating, ventilation and air-conditioning systems, as well as conservation and plumbing
- Scope of project seems residential "in homes" → however we are unaware of scope: What parts of the house can we modify? For example, can we add insulation? This would prevent heat loss and lower the usage of gas heaters.
- Focus on developing a better method to serve heat than heat the house → instead of circulating hot air that is heated with natural gas, we can use steam or water since it has a

higher molar heat capacity.

- City X -> is this Richmond Hill or an arbitrary city? Does the city actually matter? ← Chema recommends asking open questions to narrow down

Team Charter

Contact Person: Keli -> She is responsible and presentable -> she was dressed business casual to the meeting and keeps well-written notes

Responsibilities: - Sets up meetings (virtual and in-person)
- Communicate with clients CI, ESP office
- Take meeting minutes

Team leader: Bob - Bob is assertive and took charge of the assignment dictating how we should spend our time in tutorial.

Responsibilities: - Lead the final presentation? - Boost group morale
- Make contigency decisions - Guide people on the right track

Project Manager: Katelyn - She was project manager last term, so has some experience. Also came to the meeting prepared (with notes)

Responsibilities: - Set deadlines and allocate roles, create calendar for deadlines
- Create weekly backups of team's work
- Be a mediator in group projects - Accounting?

Editor: Michael -> Has attention to detail and edited our email ~~for with good clarity~~ and made it more clear and concise

Responsibilities: - Unifies the document - Communicate with individuals on their work
- Understand how different parts of the project fit together

Prototype Leader / Draftsperson: Eleni. Eleni is enthusiastic, technically competent with research, and learns quickly.

☆ Serene was not present

Responsibilities: - Assist with using library catalogue, finding and evaluating sources; developing basic engineering drawings
- Offer technical support, learning new software

Action items for Friday Jan 27 (Myhal 5th floor meeting)
11:00a - 12:00p: Create summary of good team charter points from ESP I and bring to the meeting.

01/27/2023 Meeting
↳ Grade Expectation: 80 - 85
- learning team dynamics, how to ~~mu~~ contribute in a team, the design process, etc.
- Creating a presentable prototype and professional rep of that can be added to an engineering portfolio for job applications
↳ Specific: ~~Complete~~ Design a solution to reduce greenhouse gas emissions for commercial environments
↳ Acquire collaboration and design skills
Time bound → 10h collectively - 15hrs, meet as a team 5h of a week
Code of Conduct
↳ Show respect and provide examples. - reinforce a positive environment, no physical methods of resolving conflict.
↳ If there's repeated negative behavior ~~[illegible]~~ ~~[illegible]~~ concerned group members should ~~send an email using the AID model~~ talk to the disobeying member.

5

Decision-making guidelines

↳ Separate minor and major changes:

Major changes: ~~meetings~~ meetings should take place, research, etc voting,

Internal submission deadlines

↳ Team decision making process:

↳ Expectation: Use voting system, pros/con list

↳ If a member does not share their opinion, it won't be taken into acct

Conflict Resolution

↳ Derive from decision making.

– Illustrate what possible conflicts are.

↳ Quality of work produced ⇒ ~~lowered~~ increased workload of other members

↳ Not pulling weight

↳ Differing opinions

↳ Personal concerns → code of conduct consequence

– Prioritize resolution ⇒ If repeated → weight are lowered and warning, considered for firing

↳ Consider what the result is.

↳ Think of core

Improvement and Change

↳ Use Google Doc ~~counts~~ comments for revision on other members' work, and mention in next meeting

← Editor should have 6h – individual sections ready for editing 36h before deadline.

Internal and External Communication

↳ Instagram Group Chat

- Zoom Meetings

- Text messages → within 4-6 hrs of 10:00a - 8:00p

- Communication etiquette

External communication - handled by contact person → ~~~~

- Must be EM approved unless ~~~~ as listed on the syllabus → can be overridden

↳ Other members can consult EM, CI, TA during tutorials, emailing handled by contact person.

Meeting Guidelines

↳ 15 minute grace period unless you notify the team in advance

- When our meetings are:

Thurs 4:00p - 5:00p Myhal 5th floor

Mon ~~10:00a - 11:00a~~ 2:00p - 3:00p

↳ Emergency online meetings on Zoom (organized by Keli)

↳ Project manager should organize meetings in IG group chat 24h in advance.

- Online meetings - if necessary, would be scheduled ~~~~ 4h-10h in advance (Sunday 1:00p - 2:00p)

Missing a meeting → 3 strike system before warning ~~~~ is issued

7

Assigning and distributing workload
  → Every group member should have a say in what they want to do
  – Create a checklist, that is checked off after each individual portion is done
  – Every member does their own references
Contingencies =
  → Emergencies: Medical, Illness, Injury, Extreme Weather, Personal
    ↳ Write sections
  – Loss/Addition of group members.
  – Loss of work → save in a hard drive
Michael – Contingencies,
Eleni – Code of Conduct, Conflict Resolution
Keli – Internal and external communications, meeting guidelines
Bob – Distributing Workload, Decision-making
Kaitlyn – Goals, Improvement and change guidelines
Everyone writes their own section in appendix.
  ↳ Wed. 2:00p – 3p to check each other

01/31/2023 (Tues) - Client Statement Preparation

Knowledge:

↳ Reference to United Nations statistic: Emissions must drop by 7.6% per year from 2020-2023 to maintain global temperature rise of 1.5°C

↳ Is this a goal/objective measure of what the client hopes to achieve? Why is it mentioned?

↳ Setting "City X" → is there a specific city? Does it matter? Are we using Richmond Hill (where the company is based?)

- Use of natural gas is space and water heating → implied that space and water heating contributes most significantly to GHG emissions

- Guidelines (can be used to form PR):

↳ Reduce energy: increasing efficiency → Must examine existing technologies, show where maximum power consumption happens. → Is it viable? How much could be saved

→ Electricity → Is this viable? What if City X produces electricity through Greenhouse Gases?

↳ Power Grid usage → ~~##~~ Is this viable for large scale?

- Zero-carbon technologies → Sounds expensive, out of scope?

- No mention of improving storage: storing heat better: insulation, using higher molar heat capacity substances, etc.

Factors considered:

Cost - What is the budget for this project? (It's not specified)

- Capture, reduce and/or eliminate

Perhaps store and eliminate?

Improve efficiency, decrease usage

Note the or.

Chemical solution perhaps? Break down GHG?

Timeline → How long is given for the project? How much of the
When is it ^ how is can be changed? Can we adopt new floorplans
needed? changes, etc. to accommodate new technologies?

Feasability → What resources does City X have & What can be controlled?

Longevity → How many years? What about maintenance & how
much is allocated for that?

02/01/2023 - Tutorial (Wednesday 16:00 - 18:00).

Microsoft Project ~~due dates~~ Milestones
- Client Meeting Plan - Client Meeting #1 - Project Requirements
- Client Meeting #2 - Conceptual Design Specification
- Design Review Greening - Client Meeting #3 - Measure of Success
- Final Presentation

-Keli confirmed email is ~~received~~ sent email Mon. Jan 30th.

Audience assessment: Boototi Das
↳ Background: Bachelor of Business Administration
- Business background: may not be familiar with technical terms
- Has worked in business development (also in Ontario Power Generation)
→ relevant experience: financial analysis and support.
→ student ~~[illegible]~~s relations
→ Expense approval, some project management

- Accomplish from the meeting:
  - ↳ Understand scope of the project
    - Main objectives and what ~~are most~~ takes priority.
    - ~~Whether~~ - Available resources ~~and~~ constraints.

Recommendations from CI:

- Start from the ER.
- Power, Transportation, Industrial ← Largest emitter of emissions
  - ↳ Are we restricted to residential?

Questions

- ↳ Geographical attributes of City X?
- Municipal government involvement
  - } – Bob?
- What are the current ~~credit~~ heating and ventilation systems of City X?
- ↳ What are the electricity generation methods of City X?
- ↳ Determining if "electrifying" according to WRI is beneficial

Action Items

Eleni – Info sheet by Friday (early), research WRI
Bob – Research Emerson.
Keli – Research GHG technologies
Katelyn – Set up the Gantt Chart
HVAC system – ~~Research WRI, efficiency.~~ ~~HVAC efficiency~~ ~~method~~
– Status report, create tentative agenda
Michael – Research technologies for GHG.

– Generate questions
Put in research folder C Drive.
~~Friday~~ Saturday 11:59p.

02/02/2023 – Independent Research (Thursday)

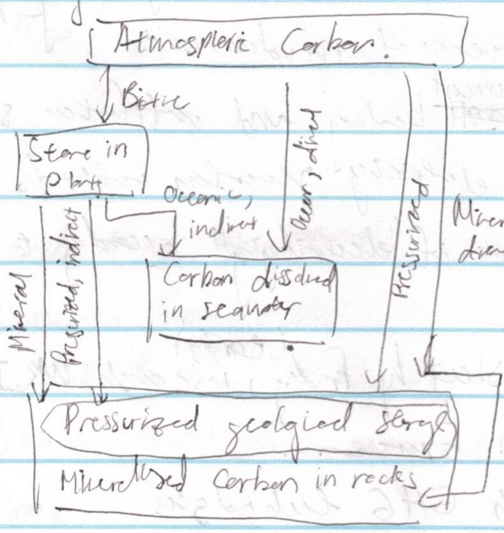
Source I: McLaren, Assessment of potential negative emissions technology

→ The source is relevant because it targets the function of capture.

→ Introduces 14 different techniques however paper was published in 2012

– Considers the following ~~~~ factors: 1) Status: should be tested, proven to work 2) Technical capacity/scalability → can use at a large scale; 3) Controllability Use of technique can be halted if needed; 4) Accountability: Takes into account side effects; 5) Side effects are known 6) Energy efficiency 7) Cost is reasonable. See research on document.

Figure 1. Summary of NET methods



– Since we are dealing with homes we might not need the Oceanic one.

↳ May eliminate some mineral solutions?

02/06/2023 - Client Meeting (Mon)

Ms. Das → Brototi (call her): Graduated from U of T, Business

- 1.5 years at Emerson, experience with ESP
- Senior associate for recruitment planning → drive growth = corporate strategy.

1. City X: Vague intentionally → to define City X as suited.
   ↳ Similar to Toronto, similar demographics, large metropolitan city
2. Type of energy ~~system~~ generation method: mostly fossil fuel with ~~[illegible]~~ natural gas, free reign.
3. Type of buildings: homes or buildings: feel free to do any define or all → whatever drives the most impact. → impact, what emits the most GHG?
4. Minimizing cost of the project → Government ~~[illegible]~~ proposal.
5. Target to government city councillors → use sustainability initiatives.

~~7~~6. How long the design will last → (e.g. ~~[illegible]~~ heat pump, ~~[illegible]~~ based on why the solution is, can't be replaced every 5 years.

8. Feasability: may not be able to change buildings, only if feasible

9. Use WRI as a loose guideline → sustainability initiatives are based on this. → aggressive enough to achieve this.
   → increasing efficiency for ← new or existing?
   ↳ lower power consumption?

Optimize - electrify?

→ Energy source more renewable, to reduce GHG

Feasability cost: Savings ~~that would result from efficiency~~ that result from efficient usage.

1. Assumption of Toronto

↳ Industries, Source of electricity, Energy consumption, etc, Population

↳ Maybe do five largest cities in ~~Toronto~~ Canada → Powered by mainly fossil fuels

2. Type of buildings → any type. city research:

3. Research cost of government projects, conservation projects

4. Government sustainability initiatives.

6. Maintenance : Should last a 'sustainable time'

8. Use existing infrastructure : focus on the cities, but include existing infrastructure

9. WRI → a list of guidelines.

Research

- WRI : Cities are large consumers of energy, make buildings more efficient, tackle buildings → Allow for buildings to consume energy better, Reduce energy requirements

- Emerson - Transport natural gas, industrial compressor. reduce efficiency and device → make greener grid

↳ Work with Hydro Quebec,

- Must consider the nature : of City X

Michael → Household energy consumption, not necessarily industrial

→ 60% for heating.

- ~~In~~ Bob - Montreal Eleni - Vancouver Keli - Calgary Katelyn - Toronto
Michael - ~~Ottawa~~ Ottawa

02/08 (Wednesday) - Tutorial Prep for Project Requirements (11:00-12:00)

The following summarizes all research completed as of Feb 08 11:00-12:00 and includes items of consideration for all categories

Introduction (Bob completed research on Emerson)

→ Project is a focus on reducing GHG emissions to meet ~~the~~ a total drop of 7.6%/yr from 2020-2030

- Emerson specializes in developing HVAC technologies, natural gas pipelines, and industrial compressors.
- Focus on reducing GHG emissions from homes and buildings

Problem Statement

★ Scope: home or just the heating system?

- Client wants to reduce GHG emissions from space and water heating ← current HVAC systems rely on natural gas ★ More research needed ★ - Wants to increase efficiency, electrify, zero-C tech.
- Users of the design: residential, ~~commercial~~, possibly scale to commercial? Client is not the end user.

↳ Focus on retrofitting, also adaptable to new builds,

This doesn't correlate to client statement

I - Method of electricity generation is primarily through fossil fuels.?

Service ~~environment~~

Use WRI electrify? If this was the case heating isn't the main emitter.

- ~~Ear~~ Solution should be generally adaptable to any city: Took five major cities for example. (~~Quebec~~ Montreal, Toronto, ~~Van~~ Ottawa, Calgary, Vancouver).
- Explain source of energy generation: electricity.

→ Temperature, ~~and~~ precipitation, wind speed.

- Living things in service environment: Perhaps may consider possible impacts of ~~fossil fuels~~ jobs ? from not doing fossil fuels, or combustion of them?

Virtual Environment → Indicate network of energy, electricity access.

★ Provide a range and indicate common characteristics ★.

Identification of Stakeholders - BE SPECIFIC.

- Energy and Waste Management Office (Municipal Government)
  - In charge of regulating utility companies, billing, etc.
- Utility Company - Provides the service, sometimes solution may be a shared commodity
- EnergyStar Company (other regulatory bodies) for ex. → Sustainability Regulators.

Functions ⇒ Functional Decomposition:

Reduce GHG emissions ~~from homes~~ to the atmosphere in homes and buildings

Conserve heat/electricity
- If less heat is lost, then this means less natural gas/electricity input.
- Prevent leakages from cold air

Maintain constant temperature
- Usually water heaters, heating systems need to maintain ~~the~~ certain temperature

Capture and store GHG?
- Prevents release from atmosphere

Generate and store electricity.
- Alternate source, not ~~fossil fuels~~ ~~fossil~~ ~~Fut~~ fuel.

Objectives

* HVAC should be main competitor, what people use now

- Research HVAC systems. Design should be able to meet these heating objectives
- ~~Capture existing em~~: Research recommended emissions. Should be that level. Constraint is existing level.
- Cost: Research existing conservation solutions?

~~Bu~~ Constraints

- Cost: Project cannot exceed (research a number); utility cost should not exceed [certain number].
- Should not emit more than current solution.
- Longevity of the design?
- Rate at which a temperature can be reached?

02/08 Tutorial

→ Gantt Chart: Submit .mpp file
 → Figure out how to incorporate subtasks.

Determine gap, need, scope: Research ~~in problem~~ heating in Problem Statement.

Scope: Focus on a ~~single~~ future new buildings (need to be constructed)
 - Commercials and Residential condominiums ~~Heating~~?
 - Purpose: Can focus on office and residential

Gap: There is no 'green' sources of heating → Conventional HVAC systems (* need research) use natural gas?

Need: To reduce GHG emissions.

Service Environment: (Loosely based of Toronto) ← Research first = building zones, height restrictions

→ Temperature ranges, seasons, Precipitation, sun, wind

- Electricity generation methods - Air quality - Utilities

- Natural features, e.g. elevation, bodies of water, etc.

* Living Things? - Houseplants, people around the building? Population density

Virtual Environment → Power grid, electricity generation?

→ How many people it serves

Stakeholders → Michael

- Housing commissioners - Residence Council - Rating Companies
- Business Bureau - Utility Companies

Functions

Focus on heating: ~~###~~

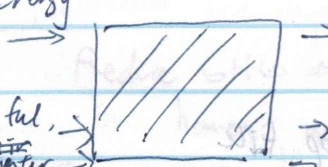
Primary Function: ~~Reducing GHG~~

~~Mass~~ Energy

Electrical Energy →

Mass: Fossil fuel, wind, ~~air~~, water (renewable sources) Natural gas

Information:
- ~~Indicate temperature~~
- How much energy is needed
- What the external weather is



Black Box

→ Energy: Thermal Energy, Electrical Energy

→ Mass: Air

→ Information: Indicate temperature

- Indicate energy output

Secondary Functions - Transport / circulate air?

- Conserving heat/electricity - Sensing temperature

- Maintaining constant temperature

Objectives

- If looking at HVAC, can research heating objectives
- Cost
- Sustainability

Constraints

- Safety concerns - Should not emit more than current levels.
- Conservation cost? - Longevity of current design

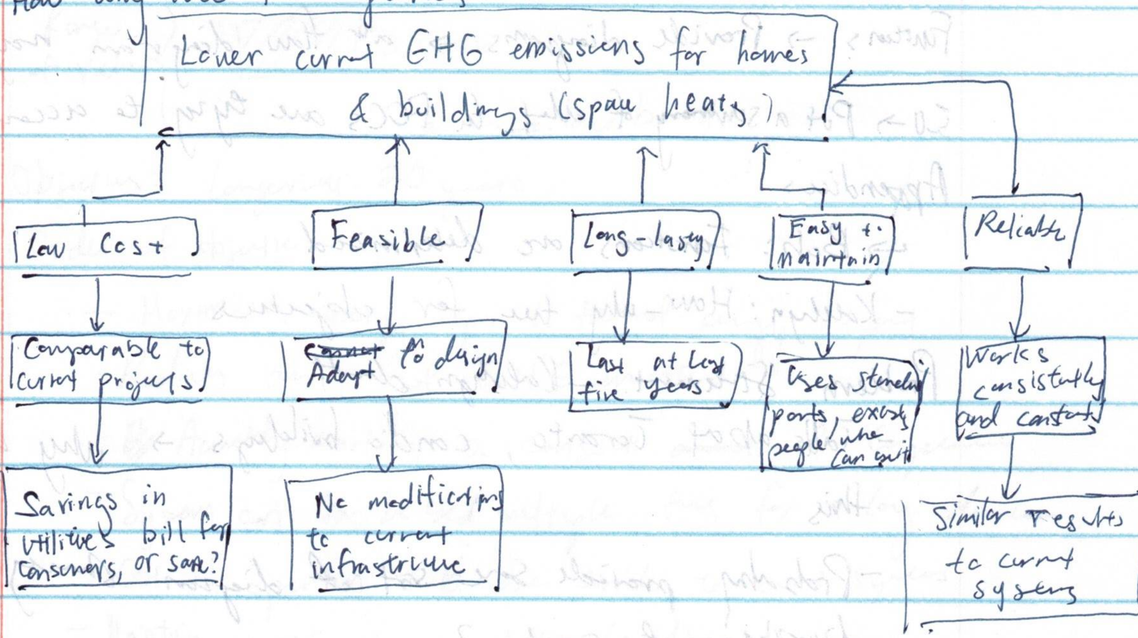
Eleni - Status Report: Day in Advance → Work on Service Environment

Meeting Tuesday 2:00p - 3:00p

~~Further~~ Bob - Functions   Michael - Stakeholders

Katelyn + Keli: Work together, but Keli (Objectives) Katelyn Constraints

How-why tree for Objectives



02/14 Meeting (Tues)

Service Environment — Plants (chase pets ! — People, may be affected by byproducts around the building

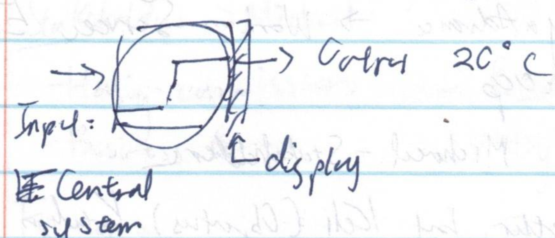
→ Provide diagrams for back up generator

— Solar, wind maps

— Map of generators, grid in Toronto.

Stakeholders — Can do Toronto, specific stakeholders for Toronto

— National Energy Board, etc.



Functions. → Provide diagrams → air flow diagram maybe?

5.0 → Put a summary of what the FCCs are trying to accomplish.

Appendices

→ Bob: Functions are determined

— Kaitlyn: How–why tree for objectives

Problem Statement. — Kaitlyn draft

— Talk about Toronto, condo buildings → why we chose this

— Probably provide some sort of diagram showing the distribution of condos?

→ Can use for multiple commercial units

02/15 Tutorial 4:00p - 6:00p (Wed)

PR Tips and Tricks

Executive Summary - Who is the audience? - Need to know info?
- How do you write concisely and clearly?

Service environment - Make sure it is a project scope -> unless it is a specific place.

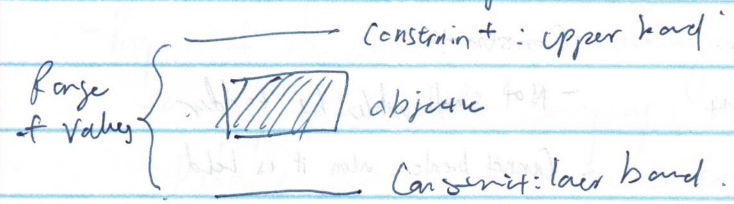
Stakeholders - Impact, involvement, affect on team. - Client and users are not.

Objectives -> Objective, metric, goal.

~~Object~~ Constraint -> Constraint, limit, Metric.

General Reminders: Cannot use screenshots of tables and captions.

Due date: 11:59p Fri, Feb. 17



Objectives: Longevity. 20 years.

Order of objectives

- Maximizes energy input to thermal energy output.
- Reduces amount of GHG emitted.
- ~~A~~ Accurately maintains a constant ~~amount of~~ temperature
- System can ~~be~~ be used multiple times for a long duration.
- Cost of operation should be similar to current systems
- Maintain current air circulation levels
- Can ~~det~~ detect temperature changes and operate automatically

- Under each category → indicate what happened → use a verb
- Gantt Chart: add more dependencies
- include a milestone → (due date)
  - ↳ including internal submissions
  - client Meeting dependent on PR

Next Status Report: Michael.

- Mar 10. → Friday 11:00am-12:00p

02/28 (Tuesday Lecture) - Reverse Engineering Activity

1. Define the Product: BIC Mechanical Pencil

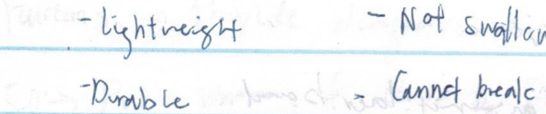
Purpose: To allow the user to write

Objectives:
- Lightweight
- Durable
- Long-lasting
- Ergonomic
- Safe to use

Constraints
- Not swallowable by toddler
- Cannot break when it is held

2. Observations: Cap has no screw, must twist and pull
- There is a spring that pushes down when ~~pencil is put on page~~ top is pushed
- There is a thin hole on the cap to put the lead
- Slider sits on top of body of pen, can open insert for lead
- Uses 0.7mm lead.

(internal ~~screw~~ spring)



03/01 Tutorial

Status Report & Gantt Chart
- Add tasks for the CDS and Design Contingency.
- Define the under control.

Client Meeting #2 - Presenting the PR.
→ What expectations are, what we are working on,
→ Get expectations from client.
- Purpose of the PR: Convince the client you can do the job.
  - Request for quote: What is the final cost?
  - Does the client change the scope?
  → Usually a contractual agreement.
- Purpose of the ORG: Convince managers of the company that the project is under company's expertise.
  - Resource management & subcontractors.
  → Team can do it, resources available, we have the money to do it.
- Purpose of the CDS: We have the solution, including ideas and priorities for what is completed.

PR Debrief

Executive Summary - Note what Emerson does, City X in executive summary, for the purposes of this project, scope to Toronto

~~SSS~~ Problem Statement - clarify heat exchangers
→ ~~[illegible]~~

Service Environment

↳ Describe unique aspects of high rise buildings

- May use a table of elements
- Temperature and humidity - use ranges
- Virtual - security systems, etc.

Stakeholders - concierges, maintenance personnel, architects, concierge

- Anyone in the building is a stakeholder
- Use Toronto, Canada

Functions - use regulate instead of output

Objectives and Constraints - explain rationale is in Appendix

↳ Do not use exact language

- Modify headers of constraint and metrics

Conclusion - Say what we did.

Michael - Stakeholders   Eleni + Bob - Service Environment

Keli - Intro, Conclusion, Objective, Constraints   Katilyn - Exec Summary and Problem

Bob - Status Report

03/08 Tutorial (Wednesday)

DRG Criteria

↳ Include a central claim: what are you trying to convince the audience?

- Use course-specific terminology

- Purpose: - Show evidence of where we are
  - What we are going to do next.
  - Assume audience has no knowledge of project.
- What does the client need? What did we determine the need to be? What did we suggest it ~~too~~ to?
- Stage of the design process: idea generation.
  - ↳ Include a tentative list of ideas.
- Follow the outline
  - ↳ Service environment matters a lot. → Provide pictures of what the service environment is.
- Name on top right corner, slide numbers on bottom.
- Assertion - evidence format for each slide
  - ↳ stated in header. Use visuals.
- Include reference list at end of presentation.

PRG Planning: Purpose - To convince the audience that we are on track.

Main Claim -> Evidence, theme of what the presentation is about.

-> About the Design Process, do not include the Gantt Chart

↳ Establish why we care about the problem

Client Meeting 2 - Notes

Problem Statement comments / Executive Summary

- Enerson does not specialize in CCS, Ms. Das will send to us.
- Scope of this project: high rises >5 floors, why new? Hard to modify central buil

Service Environment Comments: no comments

Stakeholder Comments: (8 in terms of Toronto)

- Question: In terms of City X or Toronto? We can focus on Toronto so it is specific for government regulations
  - ↳ Are residents stakeholder? No, because they are a user

Function comments: Capture and dissipate waste products → may not be relevant, focus on reducing emissions or capture energy.

Objectives and Constraints: No comments

- Prioritize objectives: 1. Sustainability → Problem Statement, why Enerson, with us, 2. Feasability, 3. Performance

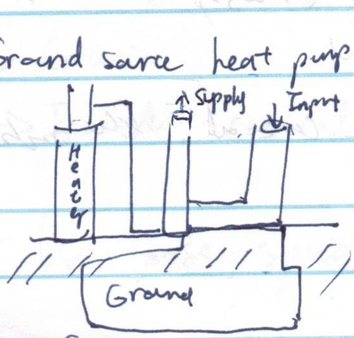
Considerations: Impact on GHG emissions?

Mar 12, 2023 - Individual Idea Generation

Measures of Success - CFD simulation (e.g. Autodesk, Ansys Fluent, Simscale) - Model HVAC System and track emissio

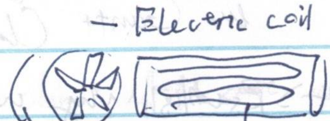
HVAC alternative benchmarks

- Ground source heat pump



Ground cools / heats air, which is supplied at ground temp

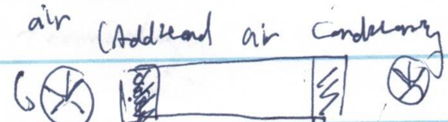
- Electric coil heater + Fan



Blows hot air

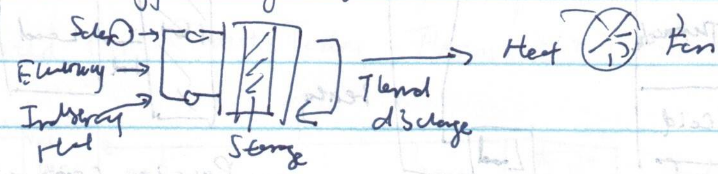
heating coils, powered by electricity

(Additional air conditioning unit



+ Carbon capture device

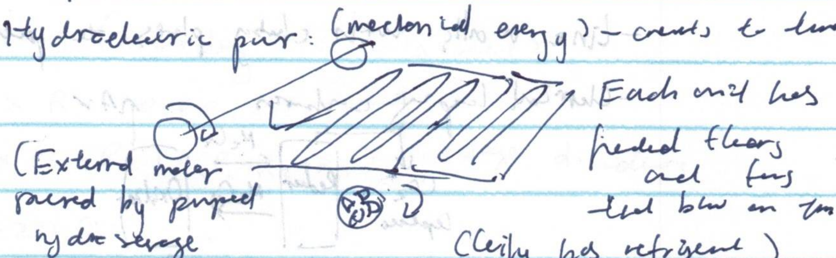
- Solar powered / Wind powered water heater
- Thermal energy storage system (Sulfur TES) (Prof. Richard E. Wirz)



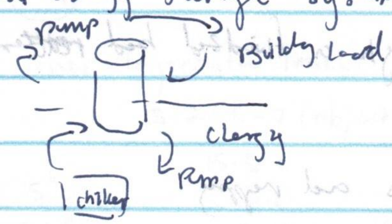
- Coils filled with water → connected to heating or cooling circuit powered by electricity, running through the walls of the room

(higher molar heat capacity than air).

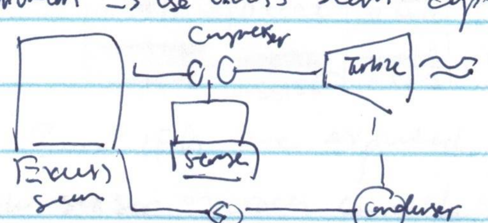
- Thermal energy storage plant (conversion from bioenergy sources
- ~~Pumped storage~~ Hydroelectric power: (mechanical energy) – converts to thermal energy



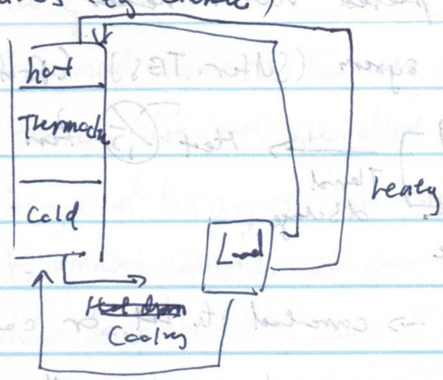
- Thermochemical energy storage system → Three types:
  - ↳ Fertilizer based
  - → Metal hydride based cooling and heating systems
  - Salt hydrates



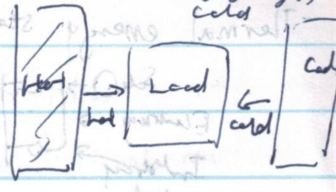
- Storing heat using large slabs of brick, concrete, etc.
  - ↳ Steam accumulators → use excess steam captured from industrial factories



Thermoclines (eg. Concrete)



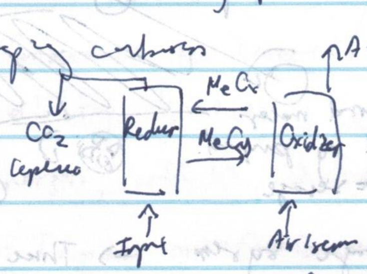
Dual-tank Storage system
↳ Passive storage, at hot, and cold



- Passive concrete

Carbon Capture Storage system

- Use a porous filter in the walls of the room, that converts CO_2 to a liquid, store in a tank
- Line walls with ~~clubg~~ climbing plants to prevent CO_2 emissions
- Chemical looping combustion



(Chemical Looping Combustion model)

- CO_2 emissions go through a fluidized bed ~~reactor~~

Temperature Sensing

↳ Using infrared sensors and ~~mapping~~ mapping

→ Using a ~~sen~~ flow sensor to measure liquid viscosity that corresponds to temperature

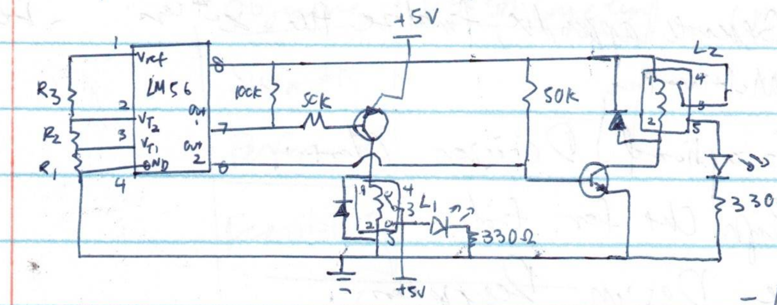
↳ RTD → Temperature causes resistance to vary. Can use Arduino to read values

↳ Thermostat IC

03/19 Individual – Measure of Success

→ LM56: Texas Instruments, Temperature Sensing Circuit

(Adapted from Circuits Today Thermostat) T_H: (Hysteresis Temp): 5°C



– L_1 is triggered when $T > V_{T1} + T_H$

→ LED will turn on

– L_2 is triggered when $T < V_{T2} - T_H$

→ Used to ~~sense~~ test efficacy of sensing circuit objective.

→ Relevant Equations (according to Datasheet):

$$V_{T1} = 1.250\,V \times R_1 / (R_1 + R_2 + R_3)$$
$$V_{T2} = 1.250\,V \times (R_1 + R_2) / (R_1 + R_2 + R_3)$$

} Voltage dividers

* $R_1 + R_2 + R_3 = 27\,k\Omega$

V_{T2} or V_{T1} $= 6.20\,mV/°C \times T + 395\,mV$

Higher temperature limit

22.5+4 = 26.5°C

22.5+2.8 = 25.3°C

lower temperature limit:

22.5−7 (objective)

15.5°C

Constraint:

22.5−5.6 = 16.9°C

→ Set point is ~~20°C~~ 22.5°C

T_2 / T_1 Temperature (°C)	V_{T2}	V_{T1}	R_1	R_2	R_3	* Note these are rounded to standard values.
26.5/15.5	~~[illegible]~~ 0.4911	~~[illegible]~~ 0.5593	~~[illegible]~~ 10.6kΩ	1.49 kΩ	14.9kΩ	
25.3/16.9	~~0.5574~~ 0.49978	~~[illegible]~~ 0.55186	~~[illegible]~~ 10.8kΩ	1.13 kΩ	15.2kΩ	

Circuit Operation: Both LEDs are expected to turn on if the sensor operates correctly. This mimics the output of the HVAC system.

03/20 - Meeting

Measures of Success → Finished

Idea Generation - Bob & Eleni: and Selection

↳ Generate appendix, finalize the section - Feasibility check

- Multivoting

- Graphical Decision Chart:

- Pugh Chart for final.

Alternative Design Descriptions

↳ Draw Design 3: Kaelyn + Kelis

Draw Designs 1 & 2 + Write Descriptions: Michael

Pugh Method - ~~Sat~~ Eleni submit by Wednesday

Section 6 - Bob

↳ Multivoting, Graphical Decision Chart

→ x-axis: GHG emissions, y-axis

y-axis: Maintaining consistent experience.

Section 7 - Start on Wednesday based on Eleni's Pugh

Chart → Bob can start working on it.

Executive Summary - Thursday after ECE.

~~Page~~ 8: Three alternative design section

↳ Create a table for each idea and we just

say how the design fits each objective.

03/22 Meeting

Alternative Design

↳ Categories for comparison: Three Primary objective

Objective	Design Category
Sustainability	
Performance	
Feasibility	

(Discussed with Michael)

DRG Feedback (Given by EM)

↳ Main Claim → Achievable.

- Claim 1: What is the outcome.

↳ Start with most relevant info.

↳ Quality over quantity of slides

- What's the cost? Consider energy cost.

↳ Energy in gas vs. energy in something else?

↳ What is the environmental impact?

Measures of Success:

Sensing may not be an important objective

↳ Test Thermal comfort (ASHRAE 55)

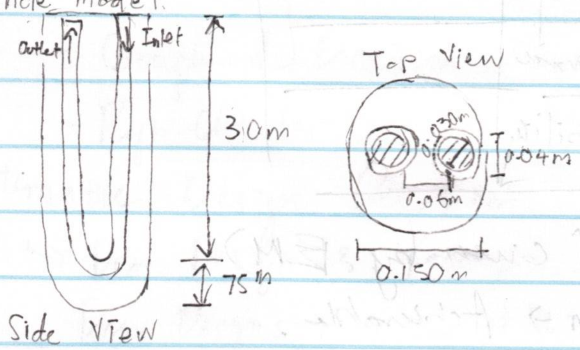
↳ Efficiency

- Model unit with Ansys? Borehole model with Ansys (CFD)

Alternative Measures of Success: Parametric Study of Vertical Ground Loop Heat Exchangers for GSHP Systems (Abdelrahman S. Ramadan), UWO

- CFD modelling procedure based on Wang and Qin's study (IEEE)

Borehole model.



(Outlet): 2

(Inlet): ~~4~~ 1

Efficiency calculations:

$COP_{heating} = \frac{Q_c + W}{W}$ ← W is amount of heat needed to power the system

$COP_{cooling} = \frac{Q_c}{W}$

- Q_c ~~is heat~~ is heat transfer

$Q_c = Q_{fluid/grout} + Q_{grout/fluid}$

$Q_{fluid/grout} = \frac{T_g - T_{f2}}{R_g + R_{p2} + R_{f2}}$

T_g - temperature of grout wall

T_f - Temperature of fluid in pipe

R_g - conductive thermal resistance of grout

R_p - conductive thermal resistance of pipe

$Q_{grout/fluid} = \frac{T_g - T_{f1}}{R_g + R_{p1} + R_{f1}}$

$R_f = \frac{1}{2\pi h r_{in}}$ $R_p = \frac{\ln(r_{out}/r_{in})}{2\pi k}$

h - heat transfer coefficient of fluid

r_{in} - inner radius of pipe (0.030m) r_{out} - outer radius (0.040m)

k - thermal conductivity of pipe material

↳ Type of pipe material and fluid will be determined later (after CDS submission)

Thermal comfort model

↳ Research apartment unit, create a model with circulation model. (Ansys Fluent)

Role Assignments:

Katelyn - Alternative Design no. 3

Keli - Alternative Design no. 2

Eleni - Alternative Design no. 1

Bob - Idea Generation ~~Writeup~~ Write-up

Michael - Alternative Design Descriptions

~~03/24~~ 03/23 - Individual Session

~~Cons~~: Three Final Alternative Designs:

1. Geothermal Heat Pump + Thermostat

↳ Pipe containing refrigerant is buried underground

- Since the ground has a smaller heat transfer coefficient than air, it remains warmer than air in winter and cooler than air in summer

- Refrigerant adjusts to pipe temperature, circulates back to the unit

- Heat is distributed throughout the unit via a radiator
  ↳ Benefits: Highly efficient, no GHG emissions
    - Already implemented in Toronto Ceg Unit 1 geothermal project
    - low cost of operation (estimated $0-75/hr)
  - Disadvantages: - Requires large changes in infrastructure
    - More expensive upfront cost than other solutions

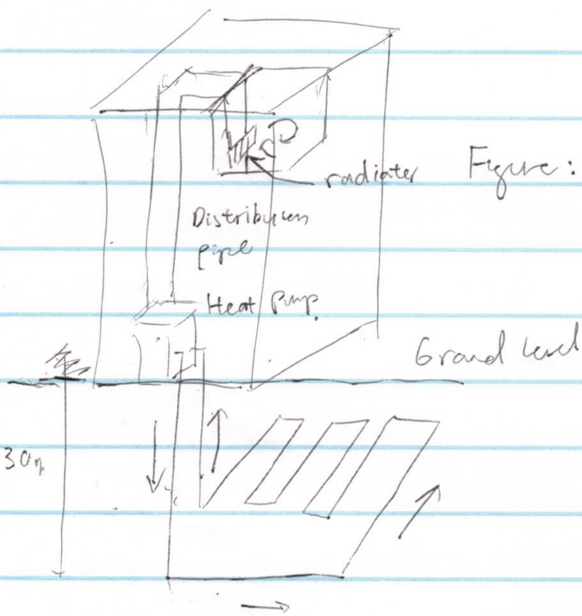
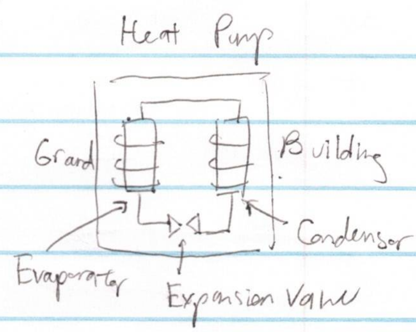


Figure: GSHP systems with radiator



2. Steam Accumulator + RTD Circuit
  ↳ Steam accumulator is a type of thermal storage system. It releases steam when needed to increase the temperature of the surroundings
  ↳ RTD circuit (resistance temperature detector) → changes resistance based on temperature sensed.

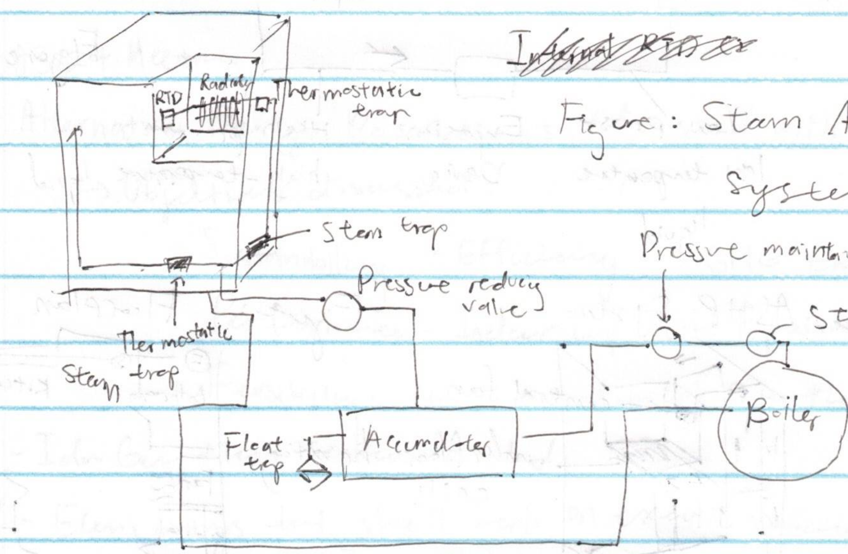
This can easily be read by the Raspberry Pi or Arduino to regulate temperature in the unit.

↳ Benefits: - Can use excess waste or steam from industrial processes, therefore reducing overall emissions
- Long lifespan (~ 40 years)

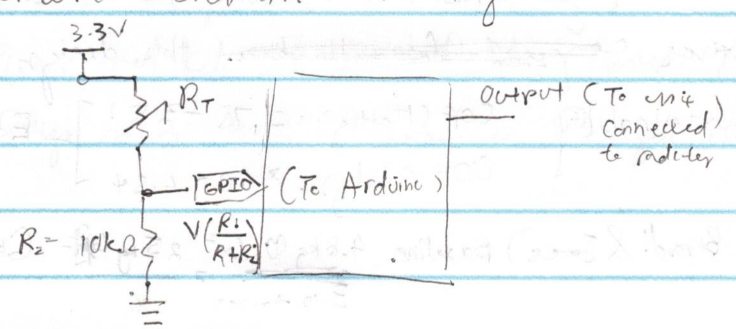
- Disadvantages: - Generally used in industrial appliances
- Cooling is difficult to implement.

~~Internal RTD~~

Figure: Steam Accumulator System



RTD Circuit Schematic (A Voltage Divider Circuit)



~~3/4.~~ 3. Air Source Heat Pump + Infrared Sensors

→ Air Source Heat Pump (ASHP) works similarly to a GSHP ~~but~~ If it is colder ~~outside~~ inside than ~~inside~~ outside, refrigerant is evaporated by outside air and transferred inside. If it is warmer inside than outside, it is possible to reverse the direction of the circuit for cooling

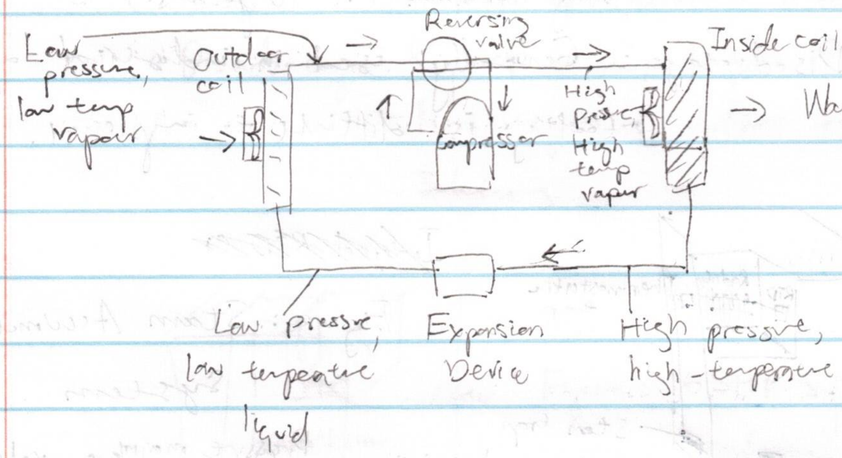


Figure: ASHP circuit

Figure: ASHP System

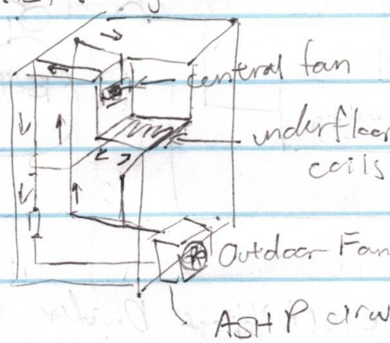
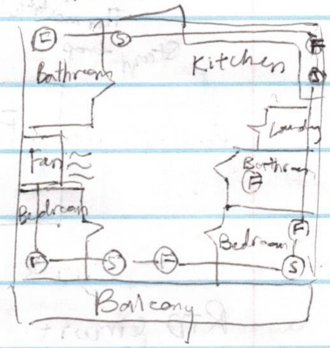


Figure: Floorplan of unit



Objectives ~~compared for all three~~ this design performs well on:

Sustainability — COP (Heating): 2.75 – 3.8; COP (Cooling): 3.60 – 4.54 — Efficiency

(From Berardi & Jones) Baseline $\frac{4.8 \text{ kg } CO_2/m^2}{3.12 \text{ tonnes}} = \frac{2.5 \text{ kg } CO_2/m^2}{x}$ — GHG Emissions

$x = 1.625$ tonnes

Performance   -40°C – 80°C effective temp range
20-25 years life expectancy
+/- 1.25% tolerance for error (sensing accuracy)

Feasibility: Cost of Operation Calculation
- 60 000 BTU system; SEER rating at 14
  - 4286W of power consumption in warm weather
  7500W in cold weather → Average: 5893 kWh

Assuming 15.1¢/hr cost of electricity, cost of operation is $0.89/hr

03/24 Meeting

Alternative Design Descriptions (discussed with Michael

↳ Objectives discussed:

Sustainability: - Efficiency - GHG Emissions

Performance: Indoor Temp, Life Expectancy, Air Circulation, Sensing

Feasibility: Maintenance, Cost of Operation

- Idea Generation section finished
- Eleni says that she'll work on executive summary on Saturday
- Submission aim for Sunday at 3:00pm (Bob will submit)

(Keli was not present at meeting)

↳ Eleni and Keli still ~~do not require~~ need to finish Alternative Design no. 3 and Alternative Design no. 2.

03/28 Tutorial – CDS Debrief

- Edit CDS until Friday, March 31 and send to Ron for approval
  - → Discuss potential client meeting times on Friday, see progress with CDS
- Comments from the ~~[illegible]~~ TA: PR-Service environment needs edits
  - Executive Summary – Tailor more to the CDS than the PR
  - Intro & Conclusion – need to go more in depth
  - Alternative Idea Descriptions
    - → Make drawing style/medium consistent for all visuals
    - – Compare same objectives for all designs. If objectives cannot be found, put qualitative values
    - – Pugh Chart should be included in this section rather than the Appendix
    - – How does sensing and HVAC system integrate together?
- Role assignments (to be completed by Friday, Mar. 31 11:00am – 12:00p meeting)
  - – Keli: fix drawings for alternative designs
  - – Eloi: fix service environment
  - – Michael: Stakeholder references, Section 6.3.1 and 7.0
  - – Kaelyn: Section 6.3.3 + Executive Summary
  - – Bob: Section 6.3.2 (least amount of data)

03/31 - Meeting

- Only Katelyn worked on the edits. Everyone else was working on APS105
- Keli wasn't present at this meeting
- Decided hard deadline on Monday, Apr. 03
    ↳ Discuss edits from 11:00a - 12:00p on 04/03, Submit to Ron by 12:00pm.
- Proposed client meeting dates (Keli get email ready for approval by Apr. 03 at 12:00pm):
    1) Thurs 04/06 11:00a - 12:00p
    2) Wed 04/05 4:00p - 5:00p
    3) Tues 04/11 12:00p - 1:00p

04/03 - Meeting

- Edits were completed on time. Submitted for approval.
- Two Measures of Success Teams:

Borehole	Apartment
- Katelyn & Eleni	- Bob, Michael, Keli

- Everyone will download Ansys and try to learn the software

04/04 - Individual Research (Borehole Parts)

(Ramadan Study)

r_{in} = 15mm (inner ~~dia~~ radius of inlet/outlet)

r_{out} = 20mm (outer radius of inlet/outlet

Borehole depth: 30m   Borehole diameter: 0.150m

Inlet/Outlet spacing: 60mm

Thermal Conductivity of pipe: 0.4 W/mK (HPDE)

Thermal conductivity of grout: 1.7 W/mK (Bentonite)

Inlet velocity: 0.591 m/s

(Refrigerant data for R410A):

Specific heat capacity: 1840 J/kg-K

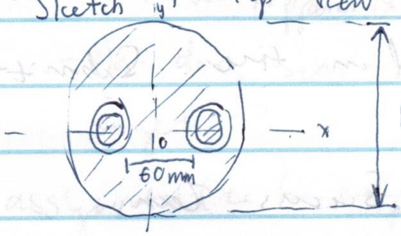
(Soil temperature from geothermal heat map): 10°C

↳ Note this is value for Ottawa, cannot find Toronto

- These are parameters for the model.
- Hard to enable downloading Ansys. May use Autodesk instead

04/03 Autodesk Fusion 360 Model

Step 1: Sketch #1 Top View



Outer diameter of pipe: 40mm

Inner diameter: 30mm

60mm → distance between centers

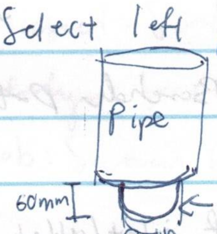
↳ Extrude: 300mm → fine mesh size

↳ If 3000 cannot generate realistic mesh (not fine enough)

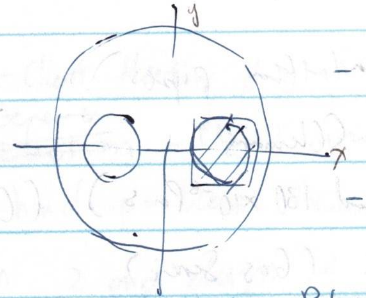
- Extrude inner pipes and ~~other~~ outer face (Shaded)

Step 2: Select left plane

- Construct plane along path

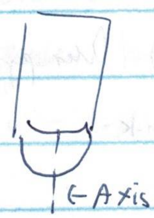


← create circular arc path and create circular cross-section to trace U-bend

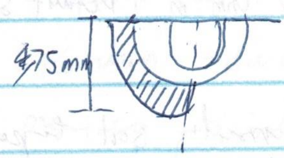


- create circular cross-section along plane.
- sweep along path to create U-tube

Step 3: Select ~~right~~ left ~~face~~ plane to create sketch (x-z plane)
- Draw centroidal axis of revolution



On same plane, draw cross-sectional arc



* Teach Eliri how to model

Step 4: Mesh generation
- Tessellate entire body
- Increase mesh density around inlet/outlet and as it goes more into the ground

04/09 CFD Model Parameters

(Materials) Bentonite (Grout) → Rings
Thermal Conductivity — Wesson Study (1.7W/mK).
Density - CARL ROTH MSDS (2.5g/m³)
Specific Heat Capacity - International Atomic Energy Agency (0.96-1.05 J/g.K set to 1.0)

R-410A Refrigerant (Inside inflow/outflow pipes)

Critical Density: 488.9 kg/m2 (Clemars)

Viscosity: 0.13 cP (estimated 130 x10^{-6} Pa.s) (Clemers)

Conductivity: 0.088 W/m.K (Gas Servei)

Specific heat: ~~1.840~~ 1840 J/g.K. (Gas Servei)

HPDE (High Density Polyethylene) Outer pipe material (Source: SubsTech)

Thermal Conductivity: 0.48 W/m.K

Density: 950 kg/m^3

M.W. Woo, Privy Specific heat capacity: 2.25 J/g.F (Melting behavior and thermal properties)

Electric resistivity: 10^3 → 10^6 Ohm.m (Default setting 1.65e+13 is OK)

~~Initia~~

Initial Conditions: Based on surrounding soil temperature, it is 10 °C.

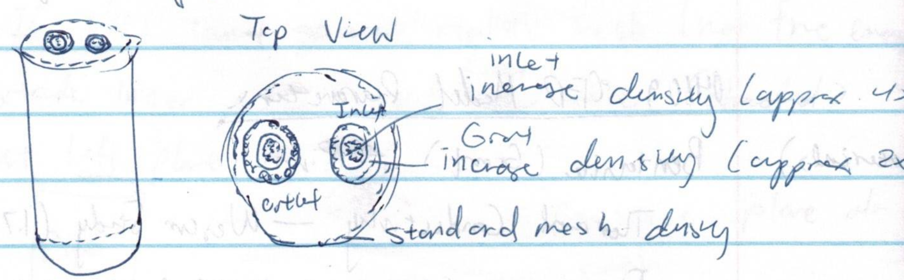
↳ Apply on whole body

Inlet velocity: 0.4 m/s and inlet temperature (50 °C) [IEEE Study]

↳ Outlet: 0 Pa Pressure

-Mesh: Automatically generate

Top View



Simulation conditions: Simulation successful

- Flow + Heat Transfer

- 150 iterations

04/11 - Client Meeting #3

Idea ~~Selection~~ Generation - No comments, elaborated on the process.

→ Eleni had problems (technical issues), so we talked abt design 2 and design 3 first.

Idea Selection - Pugh Chart

→ ideas ~~are attached~~ have no concerns

- Formatting: ~~order~~ better parallel structure: one table

Measure of Success - looking good according to chart. Likes our designs.

Internal Meeting:

Michael - done the floorplan, waiting for Bob to run simulation.

Michael & Katelyn - dwg files.

Focus of presentation → idea selection + MoS.

claim 1 ↓ claim 3 + 4 ↓

↳ Comparisons with what we have, existing geothermal projects

Individual Planning - Final Presentation

Thesis: The GSHP + thermostat design is the best solution to reduce GHG emissions for $S1 + X$ through increasing efficiency and ~~not using~~ ~~not using~~ using alternative heating sources

Claim #1: ~~Refer to idea gen~~ Reliance on heat transfer via conduction convection (not combustion of fossil fuels),

↳ Refer to idea generation process: What functions have we determined?

↳ Heat pump is the best because it is controllable (unlike storage units) and can be used in diff environments.

Claim #2: Comparison of three designs, we have determined GSHP to be the best
↳ Refer to Pugh method: ~~that~~ How does GSHP beat the other designs?
- List advantages/disadvantages of each design
- list important objectives, how it performs well

↳ Claim 1: Why GSHP meets the client's requirements (focus on meeting objectives):
→ How does it meet client requirements?
Claim 2: Why is the GSHP the best?
↳ Other PR considerations such as Service Environment, etc.
Claims 3 & 4 are M.S → These are the tests we created & presented
Claim #3: GSHP is highly efficient compared to usual systems
↳ Use Borehole model and we can see that the heating COP and cooling COP meets the Energy Star requirements.
Claim #4: GSHP system + thermostat can combine to create thermal comfort systems.
↳ Meets key requirements of ASHRAE 55
→ Cite air circulation rate objective.

Presentation Breakdown:

Intro + Context	~~2 min~~ 2.5 mins
Claim 1	1.5 mins
Claim 2	~~2 mins~~ 2.5 mins
Claim 3	2 mins
Claim 4	2 mins
Conclusion	~~1.5 mins~~ 1 mins

(0.5 mins of buffer time?)