Project Deliverable D: Conceptual Design
GNG 1103 – Engineering Design
Faculty of Engineering – University of Ottawa

Objective:
Develop a set of conceptual designs for your problem statement, based on benchmarking and the list of prioritized design criteria you have developed. Analyze and evaluate these concepts and choose those that you will continue to develop. Justify your reasoning as you go.

Instructions:
Based on your team's problem statement, benchmarking and the list of prioritized design criteria, each team member will generate at least three concepts for each subsystem required (identify who created what in the deliverable). Team members will then reconvene as a team and discuss these concepts in order to categorize/condense/combine/refine/reconsider them. As a team, the goal is to produce completely new or modified concepts for each subsystem, which can then be combined into three fully functional solutions. These global concepts will then be analyzed and evaluated against your design criteria using a selection matrix similar to the one used in class for comparing the solutions which resulted from the benchmarking process. From this analysis and evaluation, one global concept will be chosen and identified for further development. Each concept should be well documented using sketches and descriptions. Ensure that you justify your reasoning at each stage of the process.
Your chosen concept will continue to be used in future project deliverables including your project plan and cost estimates, as well as prototyping. It is possible that you realize along the way that your chosen concept is not ideal or requires modification. Therefore, it is critical at this stage of the process that you properly document your ideas in case you need to change or modify your design later.

Submission:
Each team (only one person from each team) must submit a PDF copy of this deliverable by uploading the file as an attachment into BrightSpace.

Due Date: See BrightSpace.

The automation team have multiple areas to cover when designing the house. The areas have been split into three different sections, lights, heating, and water. With the lighting team, there job is too implement an efficient and automated lighting system throughout the inside and outside of the house. The heating team is required to provide an efficient and automated heating system throughout the house to make the house a livable and comfortable environment

for humans. The water team is responsible for providing an efficient and automated water source delivery system. All three teams will provide multiple solutions to get to the final product of an efficient and automated house. These solutions will then get reviewed by the other team members and by the client as well to dictate which one is the best and should be pursued into development phase. This will occur for all of the three teams and they will further discuss why the option chosen in the end is the reason why it is the best solution to get to the final product.The teams will accomplish this by demonstrating a chart showing the priorities of each need and want as well as showing which solution will provide the best outcome for that certain area. The total will then be calculated proving that the solution chosen in the end is indeed the best design out of all of them.

Lighting: Tristan/Veronique

Upon a second meeting with the client, the list of wants and needs has been further developed and finalized. The following table summarizes these wants and needs for the lighting components.

Needs	Wants
Automatic system for efficiency	Dimmable light
Manual component to the automatic system	Neutral, space efficient light fixture (beige or something)
Interchangeable lights	Light colour you can stand for a long time
Light switch location by door	

To begin, a type of lightbulb had to be chosen. The options are either incandescent, fluorescent, or LED. The table below summarizes the differences for each type of lightbulb. The incandescent light bulb has a very low cost, however it is only 10% efficient. Furthermore, it gives off a yellow colour, which can be unpleasant after long periods of time. The client has expressed the want for a colour that would be pleasant for extended periods of time. For this reason, along with the low efficiency, we have decided to not choose the incandescent light bulb. The LED light bulb has a high cost with a high efficiency (90%). It gives off a white colour which is very pleasant. However, it is not interchangeable with other type of lightbulbs, which the client expressed they wanted. We have chosen to not use the LED light bulb due to its high cost and lack of interchangeability. The fluorescent light bulb has an average cost and an efficiency of 85%. It gives off a white colour which is pleasant over long periods of time. We have decided to spend a little bit more on fluorescent light bulbs rather than incandescent since it is more efficient and pleasing. Also, it is interchangeable with the incandescent, therefore the client can replace the light bulb with either one in the future.

Type of lightbulb	Incandescent	Fluorescent	LED
Cost	Low	Medium	High
Efficiency	Low	Medium	High
Colour	Yellow	White	White
Interchangeability	Compatible with fluorescent	Compatible with incandescent	Not compatible with other types of lightbulbs

The client has also requested a neutral light fixture that occupies the least amount of space possible. We were able to meet this want by choosing the following light fixture: Bowl.

The client has requested a convenient location for the light switches. Thus, they will be placed by the door. This way, the client can control the light immediately when they enter or leave the home, if a manual mode is included. They can also turn off the outside light right away if a manual mode is included, to save power and improve efficiency. Unfortunately, the dimmable light bulbs have a very high cost which does not meet the available budget. We have decided to not include dimmable lights in our design. Excluding the automatic/manual feature of the lights, which will be mentioned next, every need and want of the client was met, other than the dimmable lights.

Automatic/manual feature:

Having the lights turn on where the where the proper voltage and current is met to each load in order for them to operate properly is a priority. The lighting system also needs to be as efficient as possible since there is a limited supply of electricity. In order to make the system efficient, the lights need to be automated as to be off when there is no one present in the home. However, the client requested to be able to override the system and control it manually when they choose to do so. With these main points taken into consideration, three conceptual designs were discussed during one of our group meetings about how the lighting system would be implemented. The first conceptual design is to have a fully automated system. The second design concept is to have a switch between fully automated or fully user dependent. The third design is a fully manual lighting system.

<u>Design concept #1: the fully automatic system</u>

The first design concept to have the fully automated system turn on and off the lights is to first have working circuits to give the proper amount of voltage and current to each load. In order to deliver the appropriate electricity to the lights in an automated fashion, sensors would be used. These sensors would be set up around the house and cover all the surface area of the house so that no matter where the user is in the house the sensors will always know somebody is in the house. With the information of the sensors knowing that somebody is in the house, then the lights will turn on when they detect a human and stay on until the person leaves the house.

This will be efficient because whenever the person is not home, the lights are not needed; therefore, the lights will turn off no matter what, which will save energy. This will eliminate the users error where if they leave the house and forget to turn off the lights a lot of energy will be wasted, which is why this solution solves that problem. At the same time during the night, the person would like to sleep without the lights turning on everytime they move. To solve this problem, the automated system will turn off the lights during the night at a specific time everyday when the average time a person usually goes to bed and turn back on when the average person wakes up. The data gathered to determine when the lights should turn on and off for when the person goes to bed was gathered from a health online news source called *withings*. This article that was posted by them was a study about when and how long the average person sleeps for in different countries such as France, Germany, the United Kingdom, and finally the United States of America. With this house being used in Canada which did not appear in this article, the closest and resembling country was the United States of America, therefore the data used was generated from the US. The time the lights will turn off and on will be at 11:40 pm and turn back on at 7:05 am. This system is not the best as it is a rough estimate of when the person goes to bed and if the person would like the lights off or on midday, it is impossible for that function to happen which is a main reason why this solution was not further progressed when brought back to the group to finalize the concept that would be used. Source used: https://blog.withings.com/2014/11/04/study-of-the-sleep-patterns/

Design concept #2: the fully manual system

The second design concept that was brought to the group was to have a fully manual system. This fully manual system would have no automation whatsoever and would be fully dependent on the user. This solution has benefits because whatever the user wants the lights on or off at any given time is very easy to achieve. This system would operate with a switch that has two possible positions, either being off or on. This switch would only change positions if the user manually changed it. With the position of the switch being in the on position, the lights will turn on. If the switch is in the off position then the lights output will be off. With the problem of the fully automatic system where the user could not dictate when they wanted the lights to turn off for bed was the main reason why that option was not chosen as the final result. This manual system completely solves this solution as the user can simply flick a switch to turn off or on the lights when they need them to be on or off. With this reliable system thought it is also not very efficient. With a house that only has a certain amount of electricity to use per day, it must be very efficient. With the manual system, it is not very efficient because if the user forgets to turn off the lights when they leave the house, then a lot of energy and electricity will be wasted while the user is out of the house. With only so much electricity in the battery it is vital that no electricity is wasted to operate the house. With this huge flaw in the design of this solution, it is the main reason why this solution was not further explored by the team; however the idea was still brought up to the client meeting and even the client agreed that this is reliable and effective but not necessarily efficient which is one of the main priorities in the house.

Design concept #3: the automatic/manual system

The third design concept was to mix the two previous concepts together to get the best of both solutions as well as eliminating the problems with each solution. The solution brought to the group was to have a three way switch that would alternate from on to off to automatic. This three way switch could be changed by the user to whether they would like the lights to be on or off by placing the switch in the correct position. The third switch would be labelled automatic where if placed in this position the lights would transition to the automated system. Using this design, we get the best of both designs where the user can still decide if they would like the lights off for when they go to bed by flicking the switch to the off position. Then as the user gets up in the morning they can flick the switch to the automatic position where the system then turns to a fully automatic system. Therefore, the user can no longer worry about the lights anymore as they will be automated from now on. This solution works because the automatic system bypasses the night where it would not work at all but then turns back on during the day where it is optimal to use. This design also saves on efficiency because when placed on the automatic mode it becomes very efficient. When bringing this design to the client, she agreed with us thinking this was a good option. The client also talked about implementing a porch light so that the house would look more inviting when entering the home. We graciously accepted this want and figured out a way to put this idea to practice. To implement the porch light we decided to come up with a fully automated system where when the user walks up to the house there should be a sensor that will turn on the lights when a person is standing outside the house. Therefore, this solution has little flaws in its design while also maximizing the benefits of this outcome which is the reason why this design was chosen as our solution to use for the house.

In conclusion, All three of these designs will operate with a central control unit. What central control unit to use has been decided unanimously by the group that an arduino will supply this need. The arduino will take in the inputs of the sensors inside and outside of the house to determine if a person is present or not. Once the inputs are taken into the arduino, it will then run a code developed by ourselves. This code will say that when the arduino is getting readings from the sensors that somebody is there, the lights will turn on accordingly. Similarly If the arduino is getting inputs from the sensor that say that nobody is present, then the code will tell the arduino not to turn on the lights. For the third design concept that has a three way switch the arduino will work slightly differently. It will still have everything the same as before except there will be more inputs being the three way switch. Whenever the switch is set to automatic, everything will work the same as before, but when placed to on the arduino will use this input and make sure that the lights are on at all times. Same goes for when the switch is set to the off position, the arduino will use the input to run the code that says that the lights should be off at all times. Therefore, the arduino will do most of the work by determining when and where the lights should be on or off at any given time.

Benchmarking table:

	Importance	Automatic	Automatic/manual	Manual
Cost	1	2	2	3
Power efficiency	3	3	2	1
User controllability	2	1	3	1

Water: Adeeb/Nathan Lee

Benchmarking Table

	Concept 1	Concept 2	Concept 3
Cost ($)	Motion sensor: https://tinyurl.com/y68e3qy7 ($4) Sink: https://tinyurl.com/y4tcq989 ($11.50) Faucet: https://tinyurl.com/y2yw2j54 ($10) hose: https://tinyurl.com/y3f829df ($12) Wood: Total: ~$40	Sink: https://tinyurl.com/y4tcq989 ($11.50) Faucet: https://tinyurl.com/y2yw2j54 ($10) hose: https://tinyurl.com/y3f829df ($12) Wood: Total: ~$36	Motion sensor and Faucet: https://tinyurl.com/yya8dt8s ($54) Sink: https://tinyurl.com/y4tcq989 ($11.50) hose: https://tinyurl.com/y3f829df ($12) wood: Total: $77.50
Efficiency	Very efficient because of the motion sensor and the hose.	Not very efficient compared to the others since there is no motion sensor. Manually run therefore it could be left on wasting water.	Would be the most efficient out of the three, but is not cost effective.

Above were the possible designs we came up with for the how water will be available to the consumer while they are in the house. Deciding which idea went with was based on two categories. Cost and Efficiency. During the client meeting, the client stated that she wanted a

tap which would have a sensor installed on it which would determine the flow of water. Below is a brief description of each concept.

Concept 1 includes a sensor, a sink, a faucet, a hose and some wood. The wood will be used to act as a base for the sink. A price has not been listed for wood because it all depends on if the brunsfield center has it available or not. If not available we will have to buy some or borrow some from the construction team. This concept will cost around $40 and is very efficient because of the motion sensor and the hose. It also meets the needs of the client.

Concept 2 does not include the motion sensor. However it does include, a sink, a faucet, a hose and some wood. The wood will serve the same purpose as concept 1 and the same problem regarding the price of it is also present in this concept. This concept will cost around $36 and is not very efficient because the motion sensor is not present. With the motion sensor not being present the tap will have to run manually, meaning at times there could be a certain amount of water being wasted if it is left on. It does not meet the needs of the client.

Concept 3 includes a sensor, a sink, a faucet, a hose and some wood. The same purpose and issues for wood a in the previous concepts are also present in this concept too. This concept will cost around $77.50 and is by far the most efficient because of the very expensive motion sensor and faucet. It also meets the needs of the client but is not a viable option because it is way too expensive.

In conclusion, we decided that the best concept was the first one, although it is more expensive than concept 2 it is a lot more efficient because of the sensor. It meet's our client's needs and will als help, whoever stays in the house, to save some water.

Heating - Rob/Nathan Liu

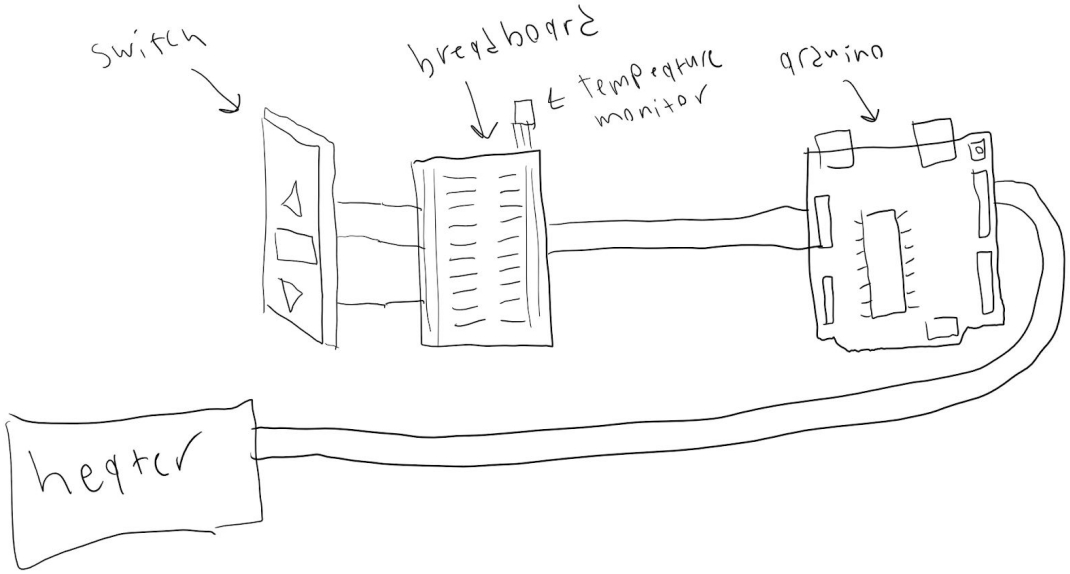
Heating Benchmarking

When designing each system, there were four main benchmarks used to consider each design. The first of these benchmarks which also hold the most weight is heat optimization. With a weight of three, heat optimization is how efficient the system is at generating heat. In other words, it is how well each system supplies heat without any interaction from the user while also managing to conserve as much energy as possible. Ideally, a system with good heat optimization will keep the house warm whenever the user is in the house, and will turn off/lower when the user leaves the home or goes to bed in order to conserve as much energy as possible. The next benchmark is UI simplicity with another weight of three. This parameter is an indication of how simple it is to use a given UI for the heating system. The better the system UI, the more potential for expansion it has whilst also remaining simple enough for the user so that it doesn't confuse them. After that, the next parameter with a weight of two used is electrical need. When the heating system is in use, the less electricity required to keep the system up and running, the better the electrical need for the systems. The final benchmark used to decide the best system is cost, with another weight of 2. Being the most self-explained concept; the lower the total cost in order to build the system, the higher the system scores.

Design concept 1: 7 segment interface

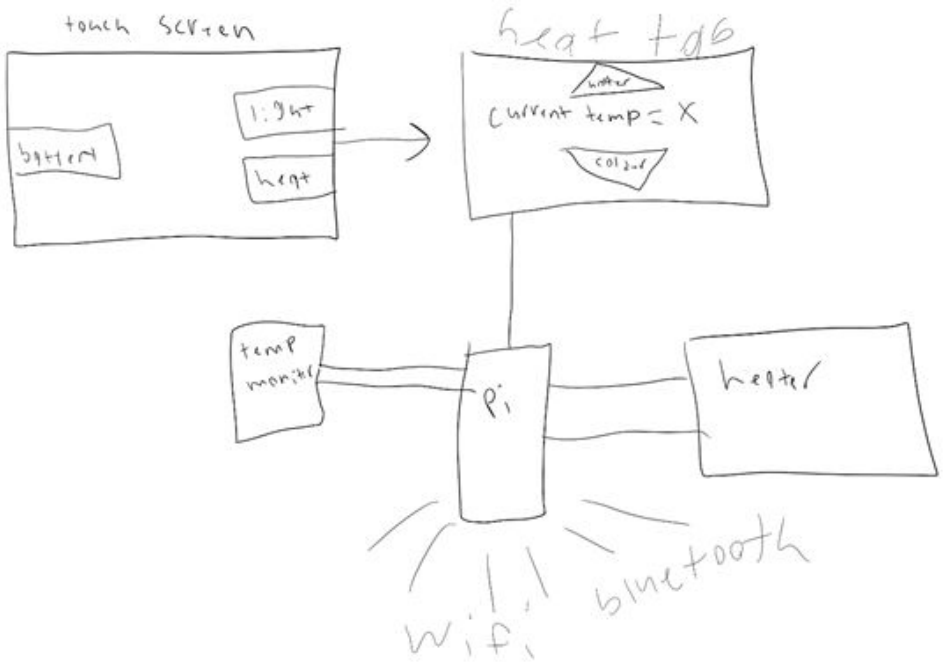
The heating system will work by using an Arduino, two buttons, a two digits 7 segment display, a temperature monitor, and of course the heater itself. The main control for this system will integrate the two buttons and the lcd. The two buttons will be responsible for increasing and decreasing the room's temperature. The display will show the room's current temperature. When the client wants to change the temperature, the display will switch to showing the projected temperature for a short period, then switch back to displaying current room temperature. While the system is increasing the room's temperature the display will present an icon to communicate that the temperature change is in progress. In order to encase the display and the buttons together a cover will be required. This cover will be designed using solidworks, then it will be 3d printed. An internal mounting box will also be created using the same method. Inside this mounting box will live a breadboard and the temperature sensor. The breadboard will be responsible for organizing all the signals then sending them to the Arduino.

The controller for everything will be an Arduino uno. The temperature up and down buttons will both be connected separately to the board. As well as the display, heater, and temperature sensor. To achieve the set temperature the Arduino will turn on the heater until the temperature is reached then turn it off, if the temperature then proceeds to dip below the set temperature the Arduino will recognize this and turn the heater back on. For this system to work a maximum temperature for the thermoset will be required. To optimize the system multiple software solution can be implemented. One such solution is to use the lighting systems software to determine if the client is home. Using this knowledge, the Arduino can automatically turn down the temperature to save power, then when the client returns the temperature will then increase back to the set temperature.



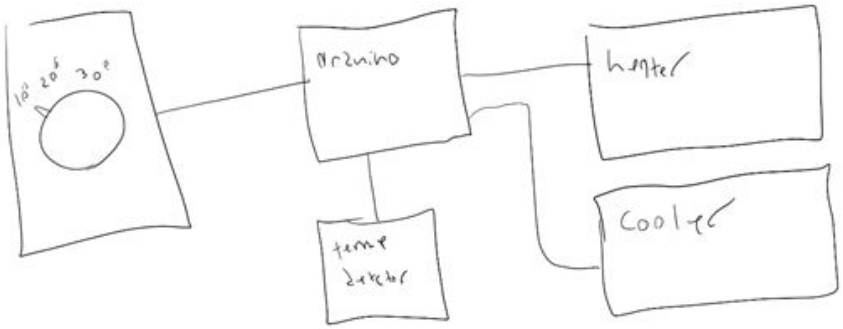
Design concept 2: touch screen interface

This concept will either require a raspberry pi computer or an arduino as well as, a touch screen display, a temperature monitor, a heater, and a temperature monitor. The touch screen display will be on standby mode when not in use. When it is running there can be many features displayed such as the time, the current battery levels, a light controller, and the heat controller. When the heat controller is selected is will display the current temperature as well as a button to decrease it or increase it. This will work similarly to concept 1. Once the raspberry pi computer receives the information from the temperature monitor and the user's input it will then turn on the heater until it reaches the projected temperature. This can also be accomplished using an arduino. This method can use all the power saving techniques detailed in concept 1. The two controllers both have pros and cons. With the pi being a computer, it can run multiple task at the same time, and it can potentially connect to a smartphone or to the internet to make it possible to control everything remotely. Where a arduino can only run one process at a time and has no internet connectivity. But the pi will also introduce many complexities that would not be an issue for the arduino.



Design Concept 3: dial interface

This concept will work similarly to concept 1 except it will cut back the features of the LCD, in its place is a simple dial will be used to change the temperature.



	Concept 1	Concept 2	Concept 3
Cost (2)	2	1	3
UI Simplicity (3)	2	3	1
Electrical Need (2)	2	1	3
Heat optimizations (3)	3	2	1
Total:	23	19	18

After weighing the pro and cons of each of the design concepts the conclusion was that concept 1 will be the best design. All three concepts share similar internal systems as a result the main method to differentiate the three would be by using the input methods. The input methods for all three would have worked but due to the high costs of a touchscreen, it would have been unlikely to maintain the budget. the dial on the hand is much cheaper but it would not be able to communicate when power saving measures are in effect which could cause confusion if when the client returns to the house to find it colder then the set temperature. With the segment display it will be possible to keep costs down as well as keeping the client informed the heater is working. In conclusion using concept 1 will be the best to keep costs low and keeping the client informed on whether the heater is working or not.

Conclusion:

In conclusion, all the teams have decided what the final design is to get the best outcome for the house. The lighting team have decided that there will be a fully automated light outside the house to be a porch light inviting guest into the home as well as a three way switch inside the house going from manual on off switch to a fully automated mode which will make the client happy and the house very efficient being automated. The heating team have decided that having a 7 segment display with an automated arduino is the best option depending on the client needs as well as keeping the cost low. The water team has decided that the best solution is to get a motion sensor to make an automated sink when your hands are placed under the tap for an efficient water source delivery system. Therefore, these design have been declared the final solution for now and these designs will be pursued in the future to accomplish the goal of making an efficient and automated home.