UNIVERSITEIT TWENTE.

SMART ENVIRONMENTS PROJECT

DOCUMENTATION REPORT

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Chapter 0: Introduction

Climate change is an important issue in the world. Because of the changing climate, many aspects of daily life will be affected. Climate change does occur naturally but in the last hundred or so years, most of the changes have come because of human activities. As such, the climate is changing at an alarming rate.

Most of the impact of climate change comes from the rising temperatures as an effect of greenhouse gases such as carbon dioxide increases in the atmosphere. As most of these greenhouse gases come from power plants that are used to generate electricity for human consumption. Therefore, it is important to look for alternative sources of energy as using fossil fuels as is currently being done, will not reduce the effects of climate change. For this reason, looking into the different sources for renewable energy other than the main ones like solar, wind, hydro, and geothermal energy.

So, it was decided to create an invention, something that no one has thought about, most of the bad ideas were too complicated to make, or just didn't work because there was a better solution for it.

Until one day in a brainstorming session the idea came, "what could harness the power of geysers". This led the team to realise that no one had thought it over, creating a system that could harness the ferocious power of a volcanic water jet coming from mother earth.

And so, at that point, trying to see how much power a geyser could have, it was found out that there is a lot of power to be harnessed from them.

The solution to produce clean and CO2-free power is this. It took a bit of time to come up with this idea. After mentioning the idea to the professors, they also think that this idea is a creative way for solving climate change.

Chapter 1: Literature Review

Find 20 meaningful publications on the general subject of climate change. Make a summary of each publication.

Due to the amount of CO2 in the atmosphere, some quantity of this CO2 ends up in the ocean. Here is a simplification of the chemical reaction on this topic. The risks are for the fauna and flora of the coral reef and in general the ocean. The acidification damages the structures of coral and shells of the ocean. If the temperatures rise 2 degrees or higher, most fauna and flora will disappear. Scaled-up management intervention and decisive action on global emissions are required if the loss of coral-dominated ecosystems is to be avoided. [1]

The Food and Agriculture Organization (FAO) has determined that approximately one-third of all food produced yearly is lost or wasted. Besides the highly immoral components that go behind such an act, the impact on the environment has been determining its damage. The association divides lost food into two categories that can be subdivided within the *lifespan* of food. These are the food lost within the production component, and food lost within the consumption component, which is considered, differently, wasted food. This paper had done this by searching for previous studies that tackle this problem, comparing them, and then drawing a conclusion from it. [2]

Receipts are a wasteful habit that is causing tons of CO2 to be released into the atmosphere, and unknown to most, it is poisoning humans due to its toxic chemicals. The two common compounds found in 93% of receipts are coated with BPA and BPS, which can be absorbed through the skin. Us humans waste a lot of money and resources while the world population already have a ton of existing solutions. Some solutions are digital receipts, card readers which send the receipt to a smart device, and integration with existing systems. Even if the customers keep on using paper receipts, they should turn to non-toxic ones… [3]

Paper receipts are an outdated recording system for both customers and businesses to record their transactions. Overall, the use of paper is highly unconventional when compared to the more modern ways of keeping data. Also, the cons of paper receipts are largely outweighed by technological solutions, as the "ink" of receipt paper is thermally activated and can easily be damaged and/or lost. Because paper receipts are white but become black when thermal energy is added, they are not made from just ordinary paper. To make the receipts turn black the chemicals BPA and BPS are used. Both of them are notorious for being responsible for long-term health problems because they disrupt certain hormone systems in the human body. [4]

The expenses following the purchase of receipt paper are capped at roughly 4 billion US dollars per year, due to the 500.000 tons of thermal paper made. In 2005 Silicon Valley companies such as Apple made the push towards electronic transaction records, but that is to this day a change that many businesses cannot afford both logistically and financially. A lot of these initiatives never saw the light of day because of the economic crisis at the time. There were almost no investors interested in thermal receipt replacements back then because it was a new and experimental technology. Companies preferred to stay safe and secure, and trying new environmentally friendly technologies was not a big priority. [5]

Every second thermal paper receipt used in Europe is made by paper company Koehler. This company offers BPA-free thermal paper but maintains it as only a choice rather than an obligation. This source analyzes in detail the different advantages and disadvantages of multiple types of thermal paper. The main categories are checkout rolls, self-adhesive labels, and tickets, and plotting. All are BPA-free and two are Bisphenol-free and the other is phenol-free. [5.1]

BPA, Bisphenol A is a chemical compound often used to manufacture resins and polycarbonate. Its most common use is in the food industry, where its purposes vary between reusable water bottles and food

containers. Overall the material has plenty of purposes, but its toxic composition often leaves traces in foods and drinks it comes in contact with. This pattern can also be seen within paper receipts, where the material can be absorbed through the skin and cause damage to the human reproductive system. [6]

What is the EU doing? Companies that distribute BPA in the European Union must label and certify the material for its dangers and hazards. Germany has also proposed that further substance control must be done to prevent additional damage to the body. [7]

Doctor Apolline Roger (ClientEarth) insisted on the EU recognizing BPA for its dangers, and that action must be taken to prevent further damage to the systems and to stop wildfires, as the substance has often been traced back as a cause of these natural disasters. It is confirmed that BPA can cause a lot of problems in the hormone systems for humans and animals. BPA is known for attacking fertility and it can be even more dangerous for young children. That is the reason that BPA was completely banned for usage in baby drinking bottles. [8]

As of January second, 2020, the EU declared a continental mandate of control for BPA. The concentration of this substance in a thermal paper distributed in the European Union cannot be higher than 0.02% of the weight of the paper. In other countries like for example, Switzerland BPA and BPS (also known for causing health issues) are already completely banned. BPS is still bad for your health, but less than BPA. That is why a lot of manufacturers who cannot produce without one of the two now use more BPS. [9]

The constant movement of tides and changes in temperature has allowed scientists to discover ways of creating environmentally friendly energy. The estimated amount of energy that could possibly be made through the harnessing of the sea ranges between 10.000 TKw/h due to thermal changes and 80.000TKw/h due to tidal changes. This can be done by letting the water flow through turbines. The water flow will make the turbines spin and this will generate electricity. These turbines can be integrated into the dam or they can be placed on the bottom of the lake. [10]

Eating fewer meat results in less CO_2 in the air because of your food consumption. Not eating beef already has a huge impact on your carbon footprint. This is because cows take the biggest amount of food and water to become old enough to be slaughtered. Pigs and chickens for example have to eat less food per kilogram of meat. Veganism makes the biggest difference. [11]

This article investigates the changing role of international law in addressing fossil fuel production to achieve climate change goals. To harness all the power that water carries, humans should not only use the seas but also the rivers. In almost every river there is a constant (may be slow) flow of water which can be harnessed to produce renewable energy. This project makes use of that and makes it possible to also convert the smallest flow into renewable energy. This article does focus on the water solutions, but also has more solutions, and thus calls for a rethinking of international law in supporting the shift away from fossil fuel production to achieve climate goals. [12]

In 1992, the national sustainable development strategy was proposed. This proposal called for countries to create a national blueprint for integrating economic, environmental, and social objectives so that through worldwide participation, sustainability could be a major part of the goals that a national policy would focus on for the countries in the UN. For the 2030 Agenda for Sustainable Development, parts of this proposal were used as a basis, so that in the national implementation of these goals, the countries would keep this strategy in mind as well. [13]

Machine Learning is a tool that can be used as a method to help in collaboration with other fields to find solutions for Climate Change. Machine Learning can be used alongside renewable energy generators as a way to make them more efficient and a better solution. It can also be used alongside existing technologies as well as developing new ones to reduce waste such as CO2 emissions or reduce the amount of energy lost while transporting it. [14]

Every year around 14 million tonnes of plastic waste pollute the ocean. Only 50% of the plastic produced around the world is made for multiple usages and the rest is only single use. Also, 14% of the total plastic is taken for recycling. There are three scenarios about how much plastic waste can be stopped from

entering the ocean based on how much plastic is reused instead of being thrown away. This also considers the plastic that is left in landfills, and so the pollution caused by plastic waste can be reduced drastically following one of these scenarios. [15]

Community composting helps in reducing the amount of wasted food and organic materials, which otherwise would have had to be disposed of in landfills and contributed to pollution. By doing it as part of a community, large or small, it can be reused effectively and gives many benefits to the community. Since organic waste is part of the community, it only makes sense to also convert it back to a usable product with the whole community. This way, the chemical energy left in the waste can be used effectively for growing new plants to generate food for the entire community to enjoy. [16]

Hydrogen is an alternative for fossil fuel, it is not only cleaner but also very common in the universe. You can use it in the following ways to create energy: fuse, split, or burn it. It does not cause acid rain and does not react with the surrounding air. It also has a very high energy density, which makes it ideal to replace fossil fuels in the future since batteries do not have very high energy densities yet. However, humans have not been able to do that yet. This article writes about possible solutions to change that. [17]

Climate change and the loss of biodiversity are related to each other. A possible idea could be to tackle these issues separately but also tackle them as 1 problem. Since the loss of biodiversity is one of the effects of climate change. It is proven that higher biodiversity can also help to stop or slow down climate change. Some trees for example can stop floods and other plants are good for the soil and water quality. [18]

This source goes further into the use of wireless communication and how to communicate with vehicle systems. This might be very handy for the project. This goes further into how power can be exchanged wirelessly. The current idea for this project involves a "car", which will need to be powered. This patent gives us an idea of how this might be achieved. [19]

This source, besides giving accurate historical information about wireless power transmission, gives extensive information on the usage of these technologies, which could be incorporated into the device(s) used to resolve the issue. Only the development of these things is going down since there are big technical difficulties such as low power density, high cost, heavyweight, etc., in the development and application. [20]

About 30% of what humans throw away can be composted. Composting at home will reduce your carbon footprint (landfills are less full), lower your need for chemical fertilizers and the energy stored in the waste will be used so nothing goes to waste. Composting at home is easy, but it is important to not compost everything biological because things like meat or grease will attract flies and such. And it was needed to reduce the amount of CO_2 that humans put into the air. [21]

Package material is responsible for an average of 5% of the greenhouse gasses generated in the food industry. There are several ways companies can produce fewer greenhouse gases during the production of packing material. An example of this is using recycled materials for packaging. Also, making the new packaging material easily recyclable is a good way to reduce greenhouse gas emissions. There is also a lot of research on biopolymers to produce plastics so that there is no longer a need for fossil fuels to produce packaging. [22]

The most energy-consuming devices in a household are mostly devices that control the climate in a building, or other devices that have to do with heat exchange. The top 2 devices on the list are devices that control the climate, such as air conditioners and water heaters. The next 3 devices on the list have something to do with heating things up or cool things down. To keep monthly bills low and to waste less energy, it is highly recommended to isolate buildings better and schedule climate control devices to work efficiently and never at the same time. Another suggestion is to use less energy on heating and cooling overall by keeping the set temperature higher or lower. [23]

Chapter 2: Identification of General Problems and Challenges

Identify 8-10 general problems & challenges from the list of publications in Chapter 1 general problems with the arguments:

- **Receipts**
  Most of the receipts are thrown away immediately after being printed in a store.
- **Packaging** is responsible for 5% of the carbon emissions in the food industry.
- **Energy consuming household devices**
  Most energy in households is used by climate-controlling devices such as AC, Fridges, and Water Heaters.
- **Waste of compostable food/materials**
  About 30% of food waste is compostable, composting properly would reduce carbon emissions (elaborate).
- **Alternative renewable energy sources**
  Fossil fuels are limited and emit a lot of greenhouse gasses, at the moment there is not enough green energy used.
- **Ocean Acidification**
  CO2 molecules lower the pH value of the ocean's water.
- **Vegetarian/Pollotarian/Pescotarian**
  Problem: Co2e/kcal of beef and lamb and arguably other meats
- **Floods**
  Climate change causes the polar ice caps to melt and so the sea level to rise.
- **Extreme temperatures**
  Greenhouse gasses warm up the earth by reflecting sunlight back onto the earth.
- **Mass migration**
  Extreme climate change causes some places on earth to be unlivable so the people who live there are forced to move to a cooler place, so these places become more crowded.
- **Food and water shortages**
  Climate change makes it harder to farm food and because the earth's population is growing there is more food and water needed in the near future.
- **Forest Fires**
  Extreme temperatures and a dry climate can cause forests to light on fire easier than ever before.
- **Hurricanes**
  Climate change causes higher temperature differences, and so hurricanes can form more easily.

Chapter 3: Identification of Relevant Problems

- **Alternative renewable energy**

  sources of energy are an important part of Climate Change. Most of the sources for climate change come from burning fossil fuels to generate electricity. As such, finding alternative sources of energy that are renewable and clean is an urgent and relevant problem to be solved. Therefore, this is something that it could be looked into to try and find solutions that are optimal and can be useful against climate change. [24] [25] [26] [27] [28]

- **Extreme temperatures**

  Extreme temperatures are one of the effects of the changing climate, which affects everyone. This is an interesting issue as it can be attempted to either find a solution that mitigates the effects of these extreme temperatures or also find a way to help the people who are affected by these changing conditions and the rising impact of climate change. [29] [30] [31] [32] [33] [34] [35]

- **Household electricity usage**

  Household appliances use a lot of energy and are one way in which normal people impact the even though most of the reasons for climate change are from businesses. By trying to change and improve the use of energy in houses. [36] [37] [38] [39]

- **Food waste**

  In every step of the production of food, a lot of it is wasted. This is an urgent and relevant as the production of food also contributes to climate change, while the wasting of food is also just as bad. As such, it was tried to find a solution to try and lessen the amount of food waste or also try and reuse the waste by composting it or finding other solutions. [40] [41] [42] [43] [44]

- **Packaging**

  Packaging that is not reusable contributes to climate change and negatively impacts the environment as well. As such, to try and make it more sustainable, a possible idea would be to create a better way to reuse and recycle packaging or try to decrease the amount of wastage created by packaging. [45] [46] [47] [48]

Chapter 4: Problem Selection and Motivation

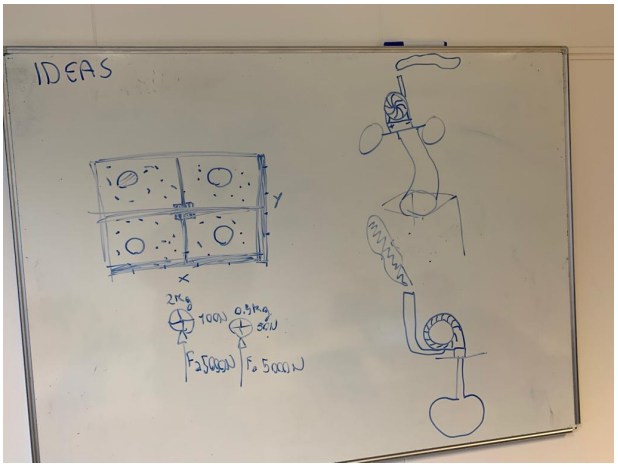
Selection: Alternative renewable energy sources

One of the biggest causes of climate change is the use of fossil fuels as sources of energy. For that reason, renewable energy and alternatives that do not release CO2 when generating electricity are the most important sources of energy to use.

The main existing sources are wind, geothermal, solar, and hydropower which are converted into electricity. These sources have and are already being continuously improved and used throughout the world. However, to make it more efficient and feasible, even more, alternative sources of energy are needed. Nuclear energy is a large and feasible source that not many countries are willing to use as another method of generating electricity. That is why, searching for alternative sources that either hasn't been considered or those that weren't thought of as useful, might be necessary to consider that governments and people might think of as safer sources, both considering nuclear and fossil-fuel power plants.

For example, 20% of the energy consumed by the state of California in the U.S. comes from geothermal energy. This shows that renewable energy can have a very positive impact and that replacing fossil fuels is viable. However, since the rest is not from renewable energy, there is still a lot of work to be done about finding new sources of energy and improving renewable energy that is already being used.

https://www.power-technology.com/projects/the-geysers-geothermal-california/
"The Geysers Geothermal Field, California," *Power Technology*, 16-Nov-2021. [Online]. Available: https://www.power-technology.com/projects/the-geysers-geothermal-california/. [Accessed: 30-Nov-2021].



Chapter 5: Potential Solutions

Find 5-8 potential solutions to your problem. Explain how these solutions could work

Solution 1: Example Stand
This solution would be a moveable stand that demonstrates different ways electricity can be generated through renewable sources. The stand would be portable so that it could be moved to many places. The table could have buttons on it and when these buttons are pressed by a user, they demonstrate different types of electricity generators. For example, there could be a small wave simulator with a small model dam at the end. When the user chooses to view “tidal energy” the wave simulator could be turned on and the user would see the dam turning the wave's energy into electricity, possibly by lighting up a light bulb.

Solution 2: River Energy
This solution would be a small turbine that when turned generates electricity. It would be made so that it could be quickly placed in a river and connected to a power grid. It would be placed in the bottom of a river and could rotate depending on the current. The solution would need to be cheap to produce and effective for many types of rivers, as a single generator would not create much energy

Solution 3: Geyser Power
This solution would involve harnessing the power of geysers as they erupt. It would be placed over the geyser, and use the kinetic energy of the eruption to push a generator and create electricity.

Solution 4: volcanic power
Extracting lava from a volcano to power a power plant to generate electricity. In addition, depending on the number of minerals in the lava, after it has cooled down the volcanic rock can be crushed and used for agricultural reasons.

Solution 5: the potential power
Before kinetic energy can be used, it has the form of potential energy. Potential energy can be transferred to create kinetic energy and vice versa. So if a power plant, or some other method of creating power, produces too much power, it can be stored in a battery or it can power a crane that will pull up a weight if the weight has reached a certain point it has a lot of potential energy. to create new energy, all is required is to have to connect the weight to a generator and lower it using gravity to create it.

Solution 6: ocean/sea power
Water currents underwater are a good source of energy, so it is possible to use them as a power supply. Wind turbines are a good example. They set the air current to generate electricity, so why not scale it down and place them on the bottom of the ocean/sea so it can spin and create energy.

Solution 7: Manpower
exercising is something everyone in their life does so why not utilize that energy. When people go to the gym they can lift weights or run on a treadmill, so instead of weights why not just pull a wire that simulates the amount of weight someone should push up, but it's connected to a wire that generates electricity.

Solution 8: Thermal
Using the steam from volcanic sites is already a reality, and it produces a lot of power very easily.

Chapter 6: Solution Selection

Selected Solution: Geyser Power

To address the issue of alternative renewable energy sources being largely underutilized, it was decided to investigate the harnessing of geysers in electricity generation.

Motivation:
There are a few reasons why this solution was chosen over the others.
Firstly it does not feel as if raising awareness would make a large enough impact on the issue, climate change awareness is already at an all-time high, meaning a contribution would be very low impact. Additionally, a sort of new renewable energy method could potentially raise awareness as a side effect of existence. Another reason it was felt that the power felt the geyser power was the best solution was that it has the potential to create massive amounts of energy, depending on the efficiency it is harvested with. Furthermore, as geysers are already used as renewable energy sources for their thermal power, there is a lot of research and other resources available that could aid in the process of creating the solution. Finally, this solution was decided for its originality. There were no other projects online that were attempting to do the same. If the group was to decide something like river energy, there would already be other people around the world that have both more experience and resources working to create a solution. In this case, the solution would be suboptimal. All of these factors led to deciding Geyser Power as the selected solution.

Modular Approach:
In order to be able to create and test this solution, there are a few necessary steps that must be taken. Firstly, a model geyser is necessary. This will be necessary to test, emulate and present the solution. This will also have to be built, this will be module 1. There will be an ESP32 that will upload data to the cloud. This will have to be presented in a nice user interface. This 2nd module will be partly programmed in a PHP database and the other part will be programmed in an HTML and CSS environment. The components in the circuit need to be able to be controlled from a central point, this will be the 3rd module. There will have to be an electrical circuit with all the components that have to be working. This will be the 4th module. For making some of the components, we need some 3D renders, this will be the fifth module. Lastly all the components together need to be tested. This will be the 6h module.

Task Division:
Module 1 (Model Geyser): Matthew, Hugo, Jules, Nico and Apurv
Module 2(Website): Hugo, Emma
Module 3(Arduino programming): Hugo, Matthew
Module 4(Electrical circuit): Hugo, Matthew
Module 5(3D models and printing): Nico
Module 6(Experimentation): Matthew, Hugo, Jules, Nico, Apurv, Emma

Chapter 7: Methodology

Equipment:

- Geyser Model:
  - Large plastic container
  - Chicken wire (grid of wires)
  - Tubing
  - Water Container (Should be strong enough to hold high pressure)
  - Pump
  - Solenoid valve
  - Water Pressure Sensor
- Generator
  - PLA plastic (for 3D printing)
  - Generator
  - Multimeter
  - Other Materials needed to control the geysers' environment (yet to be decided)

Necessary Softwares:
Fusion360 - CAD / RENDERING / SIMULATIONS
Adobe - Communication with a laser cutter
Cura - Translation from STL file to G-CODE for FDM printing
CHITUBOX - SLA printing slicer

Data Collection:

- pressure sensor
- temperature
- Ph
- Multimeter

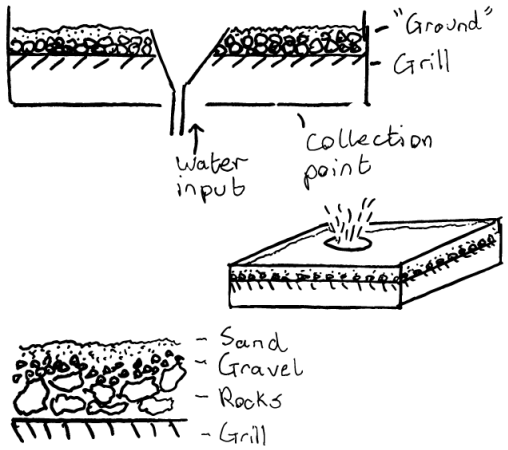
These are going to be measured in the system, but it is unknown where yet exactly.

Data Analysis and Prediction:

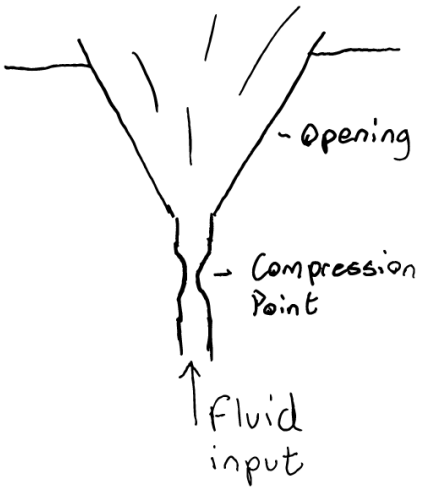
- Calculations that may be needed:
  - Pressure = Force / Area
  - Kinetic energy equation
  - Gravitational potential energy equation
  - Momentum = mass * velocity
  - Change of momentum
  - Efficiency equation
  - Bernoulli equation

Part 1: Geyser Model

Base:

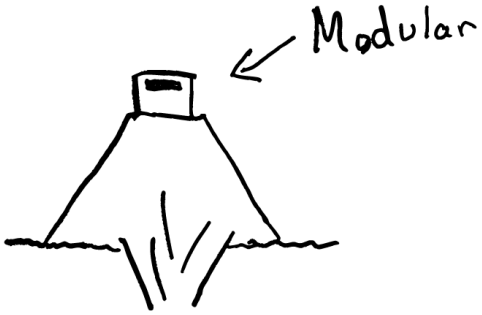


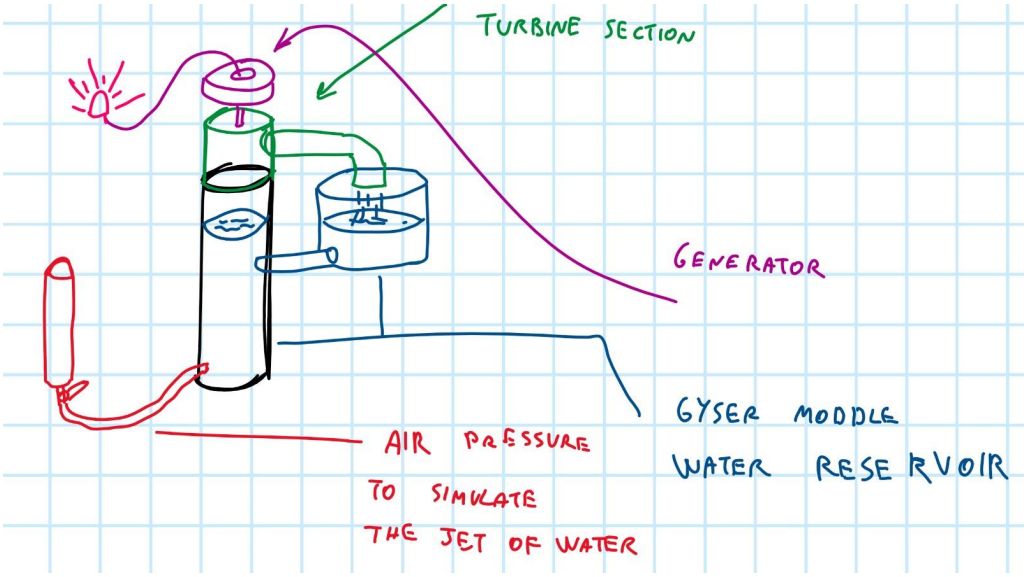
Output:

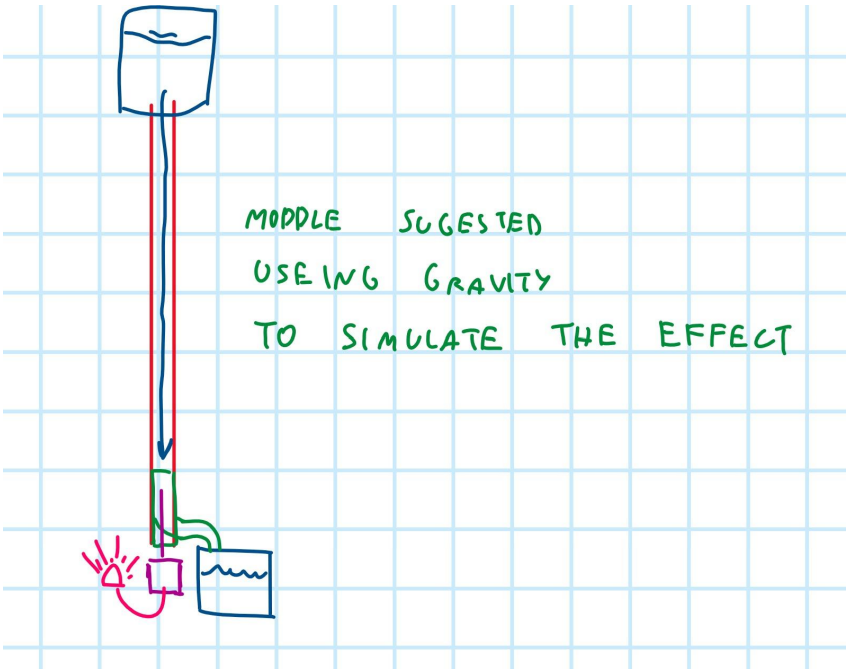


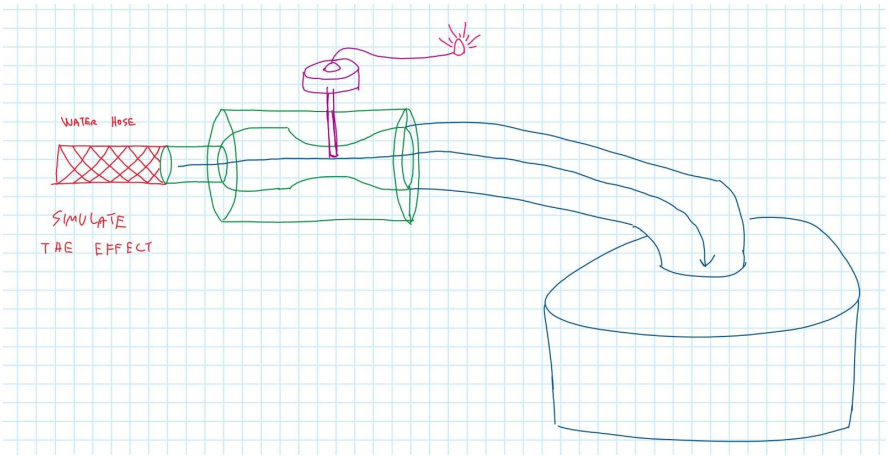
Part 2: Turbine

Funnel:



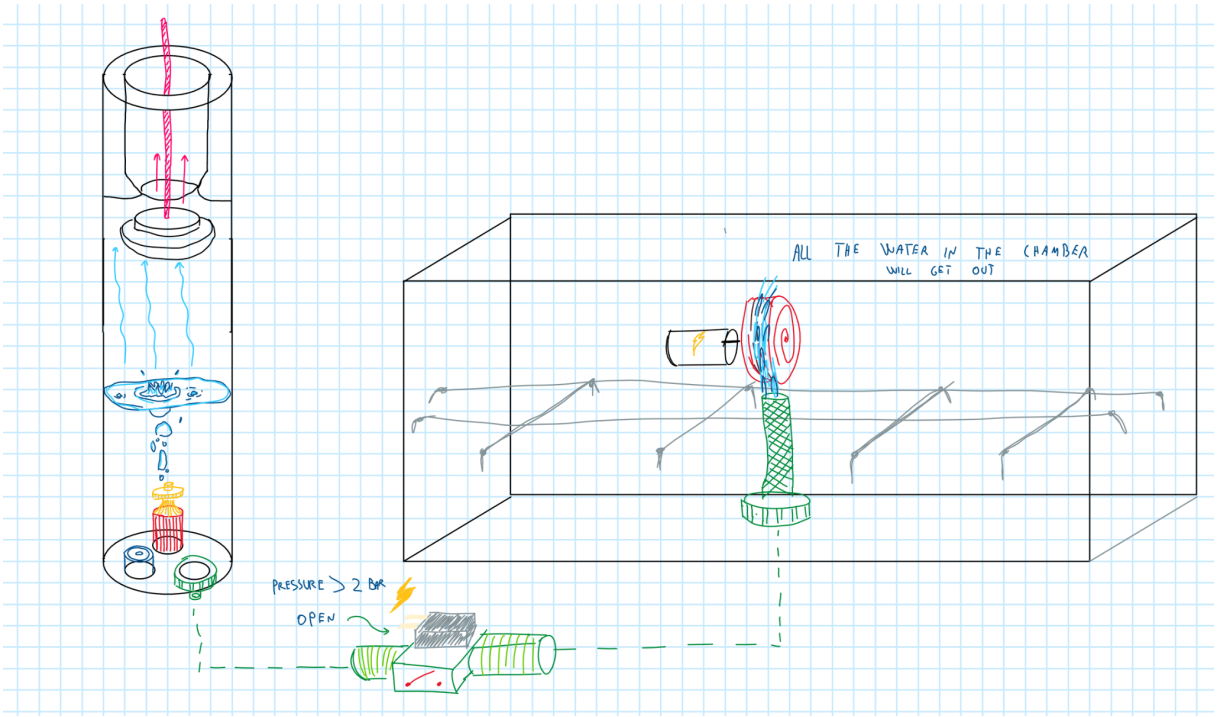

TURBINE SECTION
GENERATOR
GYSER MODDLE
WATER RESE RVOIR
AIR PRESSURE
TO SIMULATE
THE JET OF WATER

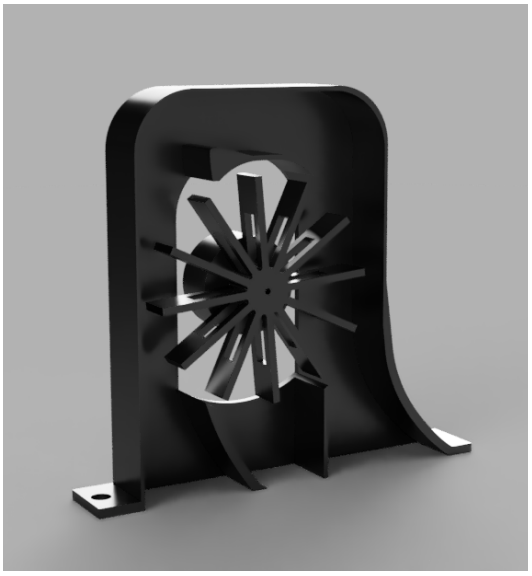

MODDLE SUGESTED
USEING GRAVITY
TO SIMULATE THE EFFECT


WATER HOSE
SIMULATE
THE EFFECT

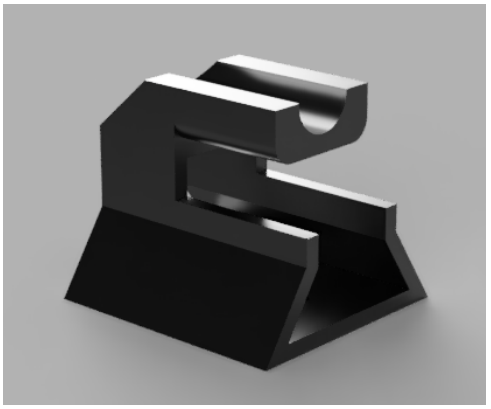
]

Final prototype



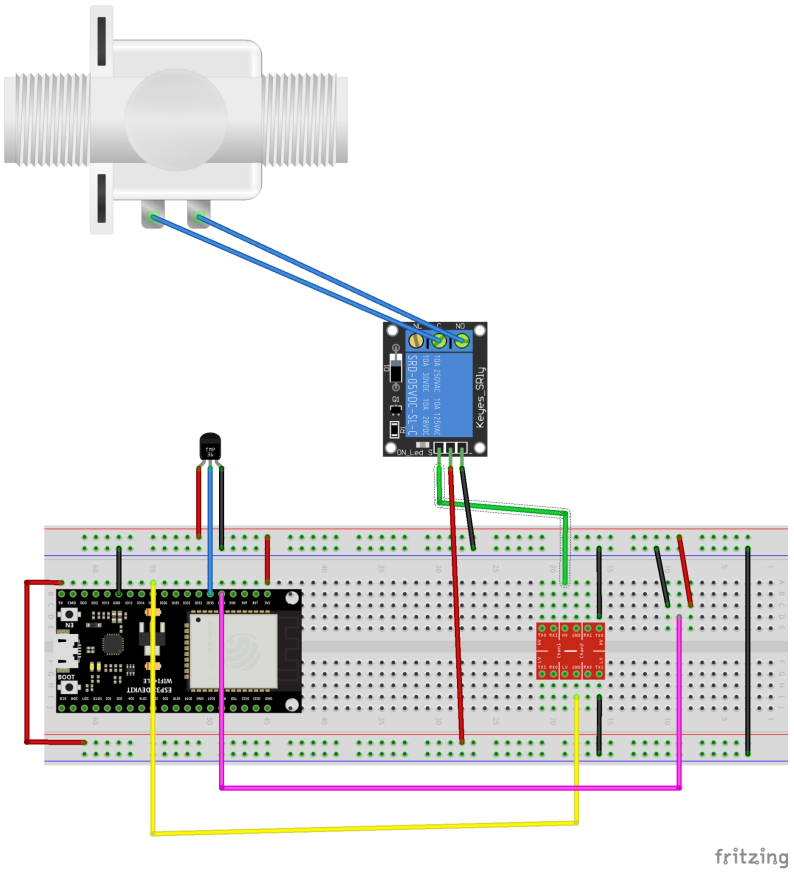


This is the model of the turbine/power harvesting component. The water follows a linear movement inside the structure.



This is the holder of the generator component of the structure. This is separated from the rest, in order to prevent the spreading of vibrations that can damage the components.

The experimental model:
Geyser Model:
The geyser will be made in a large plastic container, the goal was to have a wire grid through the container that will then hold rock, gravel, and sand. This should simulate a real ground environment and allow used water to fall to the bottom of the container. The geyser will be placed in the middle of the container. It will be connected to tubing which will supply the water. The goal was to fully decide the method that will be used to push water through the geyser exit with high enough force, but currently, the plan is to use a pump and valve. This will let the control of the pressure of the water and simulate the pressure conditions of a geyser.
Generator:
Firstly the plan was for the generator to have 2 parts: The generator and the “funnel”. The funnel channels water towards the generator and the plan were to make this in a way that the funnels were easily interchangeable. This will allow experimentation with the correct shape and hopefully, find the most energy-efficient solution.



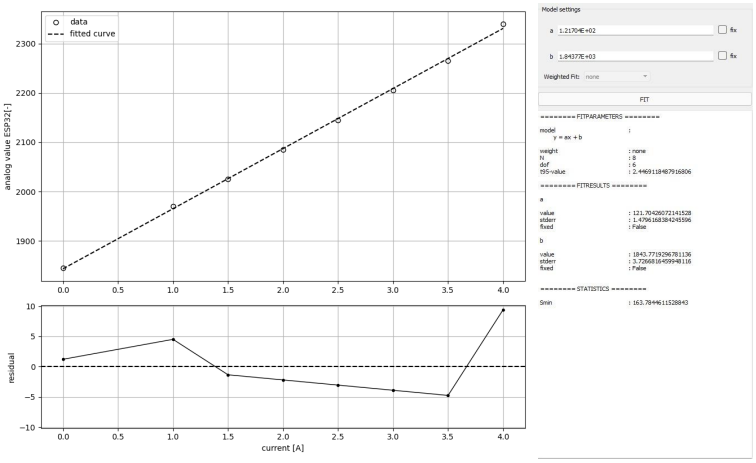
In this schematic, there is a temperature sensor instead of a pressure sensor because the pressure sensor was not found in the fritzing yet.

Chapter 8: Validation

Tests:

To test the validity of all the measuring components, they were tested to see how they behave under known circumstances. So both the current sensor and the pressure sensor were tested with 3.3 volts on the measuring devices. And further down the result will be shown.

Current Sensor



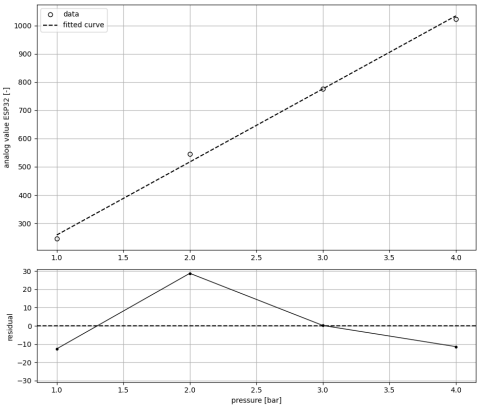
The current sensor was tested with a power supply with the ability to adjust the current and voltage supply. By adjusting the current, and also measuring it at the same time, it was possible to make a graph that shows the gradient over time. With this, a formula of the gradient of the sensor as the current build-up was established. The reason that the datasheet was not used, was because in this set-up the 5V power supply was not used. So the datasheet did not have any use for this project. After some testing, the following data were collected:

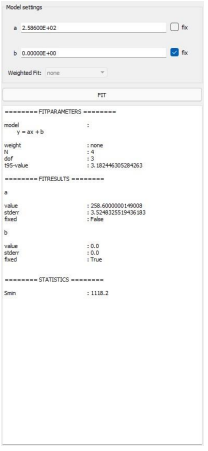
Current [A]	0	1	1.5	2	2.5	3	3.5	4
Analog value [-]	1845	1970	2025	2085	2145	2205	2265	2340

With a short python script the graph above was created. The evaluation of the data points has been done by the fplsqlib library provided by the Applied Physics department last year to one of the members of the team. This library also gives the approximate formula that stimulates progress. And tells how good or bad the relationship between the points is with a t95-value.
The values found here are actually pretty good. The StdErr is about 1.5 which is actually not that high, which means that the values are pretty accurate..

Pressure sensor

The pressure sensor was tested with the bike pump that is also used in the setup. By pumping the bike pump, the pressure was built up in the chamber. Measuring the pressure required more effort, as it required the person conducting the experiment to carry out two tasks. He had





to both pump and look at the data on the computer and the data at the bar sensor on the bike pump to read the values. This gave the following results:

Pressure [bar]	1	2	3	4
Analog value [-]	246	546	776	1023

Also here the python script that was mentioned earlier has been used to produce a graph. Here the t-95 value was higher. This is because of the reason mentioned above, where the conductor of the experiment had to do 3 things at the same time. But it is still clear that there is a linear relationship between the pressure building up and the analog output of the sensor.

The code used in the ESP32

```
//importing libraries:
#include <WiFi.h>
#include <HTTPClient.h>

//used device pins:
const int pressureSensorPin = 35;
const int currentSensorPin = 34;
const int valvePin = 22;

float pressureInput;
float pressureCalculated;
float maxPressure;

float currentInput;
float currentCalculated;
float maxCurrent;

float peakEnergyDelivery;

//wifi cridentials to make connection to the internet:
const char* ssid    = "IoTTest";
const char* password = "esp32password";

//server upload adress:
const char* serverName = "http://earthfarts.ga/post-esp-data.php";

//unique API key so not everyone can get access:
String apiKeyValue = "tPmAT5Ab3j7F9";

//custom sensor data:
String sensorName = "Geyser_001";
String sensorLocation = "Enschede";
```

```
void setup() {
  pinMode(valvePin, OUTPUT);
  Serial.begin(115200);
  WiFi.begin(ssid, password);
  Serial.println("Connecting");
  while(WiFi.status() != WL_CONNECTED) {
       delay(1000);
       Serial.println("trying to connect...");
  }
  Serial.println("");
  Serial.print("Connected to WiFi network with IP Address: ");
  Serial.println(WiFi.localIP());

}

void loop() {
  //while the pressure is too low this code runs:
  while (pressureCalculated <= 2.5) {
       pressureInput = analogRead(pressureSensorPin);
       pressureCalculated = pressureInput / 259.0;
       Serial.print("pressure: ");
       Serial.print(pressureCalculated, 2);
       Serial.print(" bar");
       delay(250);
  }

  //after the valve opening the pressure will be measured a few extra times.
  for (int i = 0; i <= 500; i++) {
       pressureInput = analogRead(pressureSensorPin);
       pressureCalculated = pressureInput / 259.0;
       if (pressureCalculated > maxPressure) {
       maxPressure = pressureCalculated;
       }
  }

  //this opens the valve:
  digitalWrite(valvePin, HIGH);

  //current will be sensed for 7.5 seconds:
  for (int i = 0; i <= 1500; i++) {
       currentInput = analogRead(currentSensorPin);
       currentCalculated = (currentInput - 1844) / 112.0;
       if (currentCalculated > maxCurrent) {
       maxCurrent = currentCalculated;
       }
       delay(5);
  }

  //valve gets closed again:
```

```
  digitalWrite(valvePin, LOW);

  //maximal power generated calculation (times 12 because of 12 volts
generator):
  peakEnergyDelivery = maxCurrent * 12;

  //upload to database code:
  if(WiFi.status()== WL_CONNECTED){
       WiFiClient client;
       HTTPClient http;

       http.begin(client, serverName);
       http.addHeader("Content-Type", "application/x-www-form-urlencoded");

       String httpRequestData = "api_key=" + apiKeyValue + "&sensor=" +
sensorName
                             + "&location=" + sensorLocation + "&value1=" +
maxPressure
                             + "&value2=" + maxCurrent + "&value3=" +
peakEnergyDelivery + "";
       Serial.print("httpRequestData: ");
       Serial.println(httpRequestData);

       int httpResponseCode = http.POST(httpRequestData);

       if (httpResponseCode>0) {
       Serial.print("HTTP Response code: ");
       Serial.println(httpResponseCode);
       }
       else {
       Serial.print("Error code: ");
       Serial.println(httpResponseCode);
       }

       http.end();
  }
  else {
       Serial.println("WiFi Disconnected");
  }
}
```

Here is the code that is being used to control and measure the valve, the pressure sensor, and the generated current. Firstly the pressure is measured using a pressure sensor being read through the analog input. The value given by the pressure sensor by default is uncalibrated, meaning it is not reading in BAR. To manage this we divide by a coefficient we found in earlier experiments. At a certain pressure, the “valvePin” connected to a relay that controls the valve is set to high output, causing the valve to open. This causes the water to be pushed through the valve at high pressure and propel into the generator. We then measure the current through another analog input. This also has to be divided by a certain

amount to be received properly in amperes. In addition to this, all the recorded information is uploaded onto a web server via a wireless connection where we can then display the information. This is accessible here.

Chapter 9: Results and Conclusion

On the last day of work, many experiments were carried out. Most of them guided the team towards the completion of the project. In the first investigations attempted, the goal was to reach a built up pressure of 1.5 Bars. Through only pumping, the decided pressure was reached and the valve released the pressure. As the withstanding of the pressure increased, so did the goals of the trials. After the effectiveness of the pressure chamber was confirmed, the team moved on to more attainable investigations. These required the use of water in the chamber. Once the tube was filled, the pumping began again. Immediately a difference was noticed in the required pumping, as with the tube filled to a quarter, the necessary pressure was reached more easily than before. The new goal became 2.00 bars and was quickly raised to 2.50. In the following number of tests, the pressure built was much higher than anticipated. When the water is poured into the chamber, there is less room for the air to build pressure, therefore it pushes down on the water with stronger pressure. For several attempts the pressure built was as expected, releasing the solenoid valve that sprayed the turbine and accumulated the water. This showed positive results, as the graphs showed that current was running through the generator, therefore the project worked. Unfortunately, carrying out the research the pressure builds higher than expected due to over-pouring of the water. The valve attachment came off due to a glue malfunction.

The main idea for creating the project is the recreation of the environment. Recreating a geyser is a difficult process, it requires 2 elements that are dangerous not only for the creators but also for the electronics: water and heat.
Because hot water is unpredictable, ideas involving it were discarded. The next best thing would be using pressure to recreate the jet of water that spouse out from the chamber of the geyser. So that is what was done, by using a bike pump and a plastic tube, a chamber where one person could pump in the air to create pressure was created and then with the release of the valve the water could spew out of the tube and into the turbine.

Constructing the pressure chamber:

- A plastic pvc pipe was used as the chamber for building up the pressure and storing the water. It needed to be sealed so two caps were 3d printed for the bottom and the top. In the bottom cap, three holes for the pressure sensor, water tube and bike pump were placed. The top cap was used as a valve that would be allowed to open to allow water to be placed in the chamber but closed for the pressure to be built up again.
- Since the 3d printed caps were somewhat hollow, when attaching them to the chamber, holes that were created around as well as in the caps did not allow to create a full seal to keep the pressure inside. This was a difficulty that needed to be solved as otherwise it would not work.

Trying to make the chamber leak proof:

- To resolve it at first, hot glue was used, as it seemed like an easy fix. However, hot glue was not an ideal material to work with as it did not solidify properly as it cooled down too quickly. This caused many holes to form within the hot glue, as such air as well as water when it was tested leaked out often. To combat this, hot glue alongside with tape was used indiscriminately. This was not the best solution and did not work for long as it had to be redone multiple times.
- Another solution other than hot glue was to use epoxy. This was a much better solution as it dried out slower and filled all the holes properly. Also it was better than hot glue. There were still small leaks, but they were negligible. When duct tape was added to this solution, it worked very well.

- Earlier the pressure only increased to 1.4-1.5 bars. However, with the newer glue, the pressure increased to 2.1-2.3 bars. This pressure allowed the water to force the turbine to move as needed to generate electricity.

One conclusion that came from these experiments to see if it worked was that too much water did not work as it created too much force at a higher pressure that caused the seals created by the glue to melt and forced the pipe away from the chamber causing the water to leak at a high speed.

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