UNIVERSITEIT TWENTE.

SMART ENVIRONMENTS PROJECT

DOCUMENTATION REPORT

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Chapter 0: Introduction

Global warming is up until today unfortunately a big issue that is only going to grow more and more relevant as time continues. However, this is, of course, a problem that is way too broad to be taken care of in a small scale project. Therefore we chose to direct our focus on power waste. Power waste is a problem that for most people would not come to mind immediately but actually does contribute to global warming with a sizable amount. Take for example the fact that in the United States only about 17% of the energy that is produced actually is renewable energy, the rest is newly generated energy with most of that generated energy not being so climate-friendly. Of course, this means every bit of power that is wasted contributes (even if just a small amount) to global warming in the end. It is, however as stated before, difficult to attack on a large scale. A big part of the wasted energy is for example caused by transportation via our electricity network, this is something that we could not tackle in a smaller project, and also would not initiate the tools that we have at our disposal as much.
What we chose to do, however, still has an impact, because it could be implemented in lots of houses and therefore the expression “every little bit counts” would stand. Due to the fact that a lot of small amounts of energy would still count up to quite a reasonable sum.
The project we settled on is a relatively small hydro-powered generator. This, because in our current homes we have a water flow that is just there to be disposed of for our needs, washing hands, drinking, or taking a shower. Still, it could be used for more, and we, as the residents, don’t have to do anything for it. The idea is that the system will be located in drainage pipes where you would just interchange a part of the pipe with our system. In the drainage pipe, there will be two small water wheels that generate power via the use of a dynamo. An Arduino will be connected to measure and visualize the amount of power you are actually generating. We don’t expect the amount to be very big, because it will merely be a prototype and we currently do not have the resources or time to make it more efficient. We do believe, however, that the idea has a lot of potentials if you could scale it up and implement it in, for example, high buildings, where the water has quite a substantial path to flow through, meaning a larger version of the system could be visualized and more power could be generated.

Chapter 1: Literature Review

1. **Power outage** - https://www.ready.gov/power-outage
   Power outages nowadays affect all of us. It is usually not a ground-breaking death-causing problem. But no power also means no internet and no internet is a very big problem.

2. **Internet outage** - https://medium.com/datadriveninvestor/effects-of-internet-downtime-to-your-organization-1d9fc673a01e
   No internet is one of the biggest regular disasters. When the internet is out, banking, streaming, healthcare, and market services don't work anymore. which costs a lot of people a lot of money.

3. **Wildfires** - https://www.theguardian.com/australia-news/bushfires
   Wildfires are a big issue because they burn thousands of acres of land, destroy wildlife and harm the environment. The damage caused by wildfire is almost always irreversible because trees don't grow quickly and therefore the wildlife doesn't easily return.

4. **Traffic jams** - https://www.volkskrant.nl/nieuws-achtergrond/nederland-stond-weer-vaker-in-de-file-in-2018~b57147be/
   Over the years traffic jams have become more and more common in our society, the term rush hour is used to indicate the time of day when most traffic jams occur, usually at the start and end of a typical workday. There are of course multiple causes for this but a big one is a movement from urban areas to suburban areas. as a result, people need to get up earlier, essentially meaning more working hours.

5. **Economic crisis** - https://www.tpedigitaal.nl/sites/default/files/bestand/de_kredietcrisis_-_oorzaken_gevolgen_en_beleid.pdf
   If the stock market crashes a lot of bad things happen.
   how to prevent: have a good economic structure and make a buffer for when such events happen, so you can easily start the economy up again. (AKA don't be Greece, or Spain, or Portugal, or Italy, or any country in South-America or Africa)

6. **Heatwaves** - https://www.researchgate.net/publication/267340687_Magnitude_of_extreme_heat_waves_in_present_climate_and_their_projection_in_a_warming_world
   In 2010, an extreme heatwave occurred in Russia. It was the biggest global heatwave in decades and was larger than the hottest European summer of 2003. The paper introduces a new index for the measurement of heat waves which is necessary. All the other indexes were not robust enough, in their opinion, which would suggest that the heat waves are getting worse than imagined.

7. **Floods** - https://www.who.int/health-topics/floods#tab=tab_1
   The amount of floods has been increasing over the past years and between 1998 and 2017 more than 2 billion people have been affected. In the Netherlands, most people will remember the disaster of 1953.

8. **Droughts** - https://www.c2es.org/content/drought-and-climate-change/
   Extreme droughts have a long-lasting effect on the soil. Mainly plant life is affected by these great droughts, but this also relates back to fauna. Great droughts create a lot of long-lasting damage, they also increase the chances of wildfires

9. **Pandemics** - https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7147210/
   The year 2020 has been a prime example of a pandemic gone wrong, it has had a bad impact on healthcare, economy, and social interaction. Any of these issues are disasters on themselves already. There has been a shortage of staff in Intensive Care and any smart assistance would help.

10. **Yellowstone eruption** - https://www.youtube.com/watch?v=WFaFfdOzPP8
    If a huge magma chamber that is very close to the surface like in Yellowstone erupts (a supervolcano), a large part of the world, if not all of it, would be affected. Lava and volcanic stone in a 100 km radius, ash raining a few continents and oceans wide which also causes blockage of the sunlight.

11. **Earthquakes** -
    http://sitn.hms.harvard.edu/flash/2019/predicting-next-big-earthquake/
    Over the past half-century, earthquakes have been the leading cause of death from natural disasters. Earthquakes appear when the earth's plates pull apart-, slide against- or collide against each other. Predicting the when and where of earthquakes is hard. The where correlates to the so-called 'faults' in the earth's crust. These faults are cracks in the earth's surface that can cause earthquakes. The when is the hardest. The two most used theories about how to predict the timing of earthquakes are likely to be flawed since they're sometimes off by a decade.
    Today, prediction methods are primarily focused on probability. The probability of an earthquake might occur in a certain timeframe. This allows areas to make sure they're prepared for the possible disaster. Besides this, there is an earthquake early warning system, which is a sensor that detects that an earthquake is going to happen in the next minutes, allowing people to prepare themselves.
    It is important to develop new ways of predicting earthquakes. Falsely predicting one disrupts an area both financially as well as mentally. Artificial intelligence is now being researched, as it could see correlation humans could never be able to.

12. **Volcano eruptions**
    -https://www.who.int/health-topics/volcanic-eruptions#tab=tab_2
    Volcanic eruptions can cause severe problems both for the environment and the people. This does not only affect people nearby, but it can affect people hundreds of kilometers away because of the ash being carried by the wind. In addition, volcanic eruptions generate various kinds of health problems such as suffocation, conjunctivitis, acute chronic respiratory diseases from breathing fumes, ash and fumes, eye and skin irritation from acid rain, and much more.

13. **Raw material shortage (oil, wood, etc) fossil fuel ran out** -
    https://mahb.stanford.edu/library-item/fossil-fuels-run/
    It is no surprise to anyone that we as a world will run out of fossil fuels. Especially with the rising earth population. Our oil will run out in about 30 years, gas will last us around 40 years and coal will last us another 70 years. Fortunately, we're not too late yet. By changing our use of fossil fuels to renewable forms of energy, we can keep living the way we do now. Nuclear energy is also a way of energy production that keeps becoming more and more prominent. It is carbon-free, vital to our clean energy future and its safety features have improved dramatically since its invention. Of course, nuclear waste is a problem. However, the coming of thorium-based nuclear reactors might change this.

14. **Food shortage** -
    https://www.un.org/en/sections/issues-depth/food/index.html#:~:text=The%20latest%20available%20estimates%20indicate,AIDS%2C%20malaria%20and%20tuberculosis%20combined.
    It is estimated that over 821 million people in 2018 were malnourished. 1 in 9 people does not get sufficient nutrients in order to live an active and healthy lifestyle. Hunger and malnutrition are one of the world's biggest risks, even bigger than malaria, AIDS and tuberculosis combined. If all the people in the world affected by various degrees of food insecurity were added up, it would come to an estimated 2 billion people worldwide that do not have access to a safe and steady source of nutrition, including 8% for the North American and European population.
    challenge: food waste.

15. **Soil nitrogen levels** - https://www.greenfish.eu/the-dutch-nitrogen-crisis/
    When nitrogen levels in the soil are too high, biodiversity can be affected as some plants do not grow that well with high nitrogen levels and other plants do grow better. The Netherlands has put limits on output on housing companies and farmers, which has put some strain on those sectors.

16. **Sea pollution** - https://www.bbc.com/news/world-europe-54420508
    On the East coast of Russia, there has been a pollution disaster, as people living there have seen a wide range of symptoms. Except for affecting people, a lot of the sea creatures in that area have died. Specialists have been using drones to collect data and samples.

17. **Dying coral reefs** - https://telanganatoday.com/what-will-happen-if-all-coral-reefs-die#:~:text=Coral%20reefs%20provide%20protection%20against,to%20perceive%20at%20this%20moment, https://www.iucn.org/resources/issues-briefs/coral-reefs-and-climate-change
The coral reef is dying because of several reasons. Firstly by the pollution of the oceans: unclear water makes the reef more vulnerable to diseases, unclear water also makes it easier for algae to grow and pollute the water. But the pollution is not the only thing that is damaging the reefs. Global warming also plays a big part, it causes certain algae to grow and bleaches the coral reefs. If this happens too often or for too long the coral dies of the bleaching. If eventually a large amount of coral dies multiple things would happen: a lot of animal species would die out or get endangered (for example sea horses would be more exposed to predators because there is nowhere to hide), food shortages because regions near the sea will have a lot less fish available to eat which could be a huge problem, also certain drugs could not be produced anymore because ingredients are gathered from reefs. This list goes on, so in short, it would be a big problem if we do not start doing something/more about it soon because if the temperature rises 2 degrees more globally, up to 99% of the reefs could disappear.

18. **Extinction of animals** - https://www.theguardian.com/commentisfree/2014/dec/16/five-ways-to-stop-mass-extinction
Globally, 41% of amphibian species are facing extinction; 13% of all birds are at risk; as are 22% of flowering plants. The reasons for these problems differ, however they are all the consequence of the human activity. Since the beginning of humanity, we have spread from Africa to all of the worlds. Humans survive solely on nature, therefore we need to save it. Here are 5 things that need to be changed immediately. We need to give back places to nature and nature alone. Next to that, we shouldn't look at nature as something we own. We shouldn't pretend like we can choose what happens to certain nature reservations. Also, we should change the way our economic system works with nature. Right now, it is seen as a "market failure" when the external costs to the nature of human activities are given no monetary value. The fourth thing we need to change is to end public subsidies that damage nature, such as the agriculture and fishing industries. The last thing we need to change is human inequality. Saving nature is just one of the many reasons humans should be treated more equally. The top 1% richest people in the world are the ones that influence nature the most. Having the ability to buy poached products, such as ivory, is devastating for world nature.

19. **Deforestation** - https://www.pachamama.org/effects-of-deforestation#:~:text=The%20loss%20of%20trees%20and,of%20problems%20for%20indigenous%20people Deforestation is caused by several things, the biggest reason being the cutting down of forests for several branches of agriculture, but also cattle ranching causes deforestation because they cut down trees to provide land for the cattle. If this continues a lot of animal species could die out and CO2 emissions would go up immensely because if you cut down trees CO2 gets released and CO2 also does not get absorbed anymore by those trees.

20. **Global warming** - https://www.nationalgeographic.com/environment/global-warming/global-warming-effects/ Global warming is caused by a lot of reasons, a lot of them are already mentioned above. Deforestation, traffic jams, wildfires, but also the emissions caused by airplanes and animal farms. There is also a wide variety of effects (direct and indirect) that are caused by global warming. A lot of which are again mentioned above: heat waves, floods, droughts, extinction of animals, and dying coral reefs. The list is endless because it simply affects all of the worlds.

21. **School shooting** - https://www.youtube.com/watch?v=Ox1dJDs451o&ab_channel=TEDxTalks In the past 20 years, about 50 school shootings have occurred (in the USA). Schools are rehearsing protocols, exercises, increasing security, and so on. But this only increases the danger of triggering or inspiring students because most of the shooters are either current or past students of the school. Also, most of the shooters are suicidal. Most of the shooters also threaten in advance, these are currently met with penalties and punishments, but this only makes matters worse. We should actually view these as a cry for help and talk/give help to the potential shooters.

Traffic Jams, Pandemic, Global Warming, Volcano Eruptions, Floods

Chapter 2: Identification of General Problems and Challenges

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

1. **Pandemic**
   Because of how easy it is to travel to the other side of the world in our modern time, it is also incredibly easy for a virus to spread globally. As happened with the most recent Coronavirus which we all know way too well by now. The challenges that come with this are the following. We as humans are social creatures, we meet with other people a lot. This on its own wouldn't be a problem if we always kept 1.5m distance, but of course, we don't. How do we keep our distance from each other? Besides that, people need to be tested for the virus. Preferably as quickly as possible. How do we make sure people are being tested as efficiently as possible?

   A possible solution is perhaps smart germ protection/prevention.

2. **Traffic Jams**
   Traffic jams are becoming more and more common and there is no sign of this trend stopping anytime soon. How can we improve the efficiency of highways?

   Every modern vehicle these days has GPS, using all this data it should be very achievable to have a responsive traffic system, adjusting navigation routes according to the newest GPS data.

3. **Global Warming**
   It is no surprise to anyone that global warming is a big problem. Mass extinction, rising water levels, extreme weather, costs for society and the economy are all consequences of global warming. Global warming is caused by many big and small human activities. Agriculture, deforestation, and energy generation through fossil fuels are all causes of global warming. How can we make these more efficient? Or can we come up with a new way of generating energy?

4. **Volcanic eruptions**
   There are long lists and reasons why volcanic eruptions can cause severe problems both for the environment and the people. This begins with the hundreds of kilos of ash that volcanic eruptions spew into the atmosphere, being carried thousand of kilometers over borders and oceans, falling in the air neighboring countries, and having people breathe in ash and toxic fumes, causing eye and skin irritations from acid rain, ash, and the overall toxicity in the air. Furthermore, the resulting lava that drips down the side of the volcano, can cause severe damage to crops, housing, cities, etc.

5. **Floods**
   The floods can flood the streets, disabling almost all of the infrastructure. These floods can also cause mud floods, dragging a lot of things with them. Even though the severity of damage from a flood is correlated with its size, its severity is also very much dependent on how well an area is prepared. How can we improve flood preparation? Or how can we decrease its damage?

   Something to prevent the streets flooding, even if there is heavy rainfall.
   A beach is placed on large hydraulic plates. When a tsunami is detected the whole beach rotates 90 degrees clockwise and forms a wall to stop the water.

6. **Food shortage** -
   It is estimated that over 821 million people in 2018 were malnourished. 1 in 9 people does not get sufficient nutrients in order to live an active and healthy lifestyle. Hunger and malnutrition are one of the world's biggest risks, even bigger than malaria, AIDS and tuberculosis combined. If all the people in the world affected by various degrees of food insecurity were added up, it would come to an estimated 2 billion people worldwide that do not have access to a safe and steady source of nutrition, including 8% for the North American and European population.
   Some challenges are inefficient ways of farming, no clean water, mass production of food, droughts, food waste.

7. **Deforestation**
   Deforestation is caused by several things, the biggest reason being the cutting down of forests for several branches of agriculture, but also cattle ranching causes deforestation because they cut down trees to provide land for the cattle. If this continues a lot of animal species could die out and CO2 emissions would go up immensely because if you cut down trees CO2 gets released and CO2 also does not get absorbed anymore by those trees.
   Some challenges are forest fires, non-environment friendly farming, mass food production.

8. **Power waste.**
   Power waste is very big currently, about 75% of energy gets wasted yearly. Generating power actually produces a lot of greenhouse gases, a lot of those could therefore be spared if we use our power more efficiently.
   Some challenges are: forgetting to turn off devices, unused power when a device is idle/standby and still plugged in, the transport of electricity also wastes a significant amount of energy (5% a year).
   A lot of people leave the light and other devices turned on even when they're not in the room. Sensors could notice it when you leave your room and slowly start turning off devices.
   https://www.edf.org/card/6-ways-cut-big-waste-our-energy-system?card=2

Chapter 3: Identification of Relevant Problems

Identify 5 new problems you find relevant, urgent, and interesting, not yet been addressed effectively

Pandemic
Pandemic is of course very relevant at the moment. It is already being addressed, but not yet effective because otherwise, the second wave would not have happened. Definitely, if the vaccine is not going to work (good enough), we are going to need a different solution or approach. For example, a facial scanner at the entrance of shops that checks if you have a mask on and then, like a speed checking board, gives you a happy or a sad smiley to motivate more people to wear a mask, even if it is not mandatory.

Floods
can flood the streets, disabling almost all of the infrastructure. These floods can also cause mud floods, dragging a lot of things with them. Even though the severity of damage from a flood is correlated with its size, its severity is also very much dependent on how well an area is prepared. How can we improve flood preparation? Or how can we decrease its damage?

A problem that we could perhaps help solve is that of tsunami's, by building an interactable retractable wall that can be raised on short notice when a tsunami is sensed by the sensors of the Arduino.

The sensors would be placed all along the coastline and in the **bluewater**. They would be the first to notice a disturbance in the water. That information could be sent back to the main system where the information could be compared to existing data. The location could be charted on a fault line map to see if there is a possibility that it might result in a tsunami. Or the data could be compared to previous sensor inputs to have a reference as to what happens when that kind of data is received.
In the event of an actual tsunami, big or large, the necessary precautions could be accurately taken, since the sensors keep tracking the tsunami, we would know the exact speed and heading. If the tsunami would be actually large enough to cause significant harm on the mainland, a last-resort emergency wall could be activated. This being a large metal wall normally concealed under the beach, in the case of an emergency this wall could be raised, now acting as a wave breaker to try and slow down the tsunami to limit the speed and therefore also the damage.
Best case scenario; the wall would hold off the tsunami entirely.

Global Warming

→ Power waste

Power waste is very big currently, about 75% of energy gets wasted yearly. Generating power actually produces a lot of greenhouse gases, a lot of those could therefore be spared if we use our power more efficiently.

Some challenges are: forgetting to turn off devices, unused power when a device is idle/standby and still plugged in, the transport of electricity also wastes a significant amount of energy (5% a year).

A lot of people leave the light and other devices turned on even when they're not in the room. Sensors could notice it when you leave your room and slowly start turning off devices.

https://www.edf.org/card/6-ways-cut-big-waste-our-energy-system?card=2

→ Food waste

Food waste also plays its part in global warming. Seventy percent of the world's fresh water is used in agriculture. A bag of apples for example consists of 81% water. Throwing away some of these apples because you bought too many leads to a big amount of water wasted. Which could have been used in places where clean water is desperately needed. Besides the waste of water, food waste also contributes to the release of methane into the atmosphere. When food is thrown out, it eventually makes its way to landfills, where it can start to decompose and rot. The production of these foods already released methane gas and now because the food is wasted, even more, methane gas is released because of it. This is especially bad since methane gas is 25 times more effective than CO2 in keeping the heat in the atmosphere.

The winning of oil from the earth is a big global warming cause. Now, think about the added fact that when this oil is used for the production or transportation of food, and this food is then wasted; this has great consequences for the environment.

Because of people wasting food, the food production business thinks more food is demanded than is actually needed, resulting in more chunks of food wasted daily. For this seemingly big demand, huge pieces of world forests are turned into farming land each year. The loss of millions of trees, who are responsible for the CO2-to-oxygen conversion in our atmosphere.

https://www.newfoodmagazine.com/article/43551/five-ways-food-waste-environment/

Traffic Jams

Traffic jams are becoming more and more common and there is no sign of this trend stopping anytime soon. How can we improve the efficiency of highways?
Every modern vehicle these days have GPS, using all this data it should be very achievable to have a responsive traffic system, adjusting navigation routes according to the newest GPS data A possible solution could be adding more roundabouts in intersections, which would decrease the number of cars waiting at lights pumping CO2 into the atmosphere, as well as making traffic flow much better. The usage of GPS has become very widely spread across the globe, which could become a benefit for drivers around the world, because by using GPS location, traffic updating apps such as Google Maps, Ways and such, could give more and better traffic information, meaning people would be able to avoid congestion and take less time driving their cars. In addition, this could also help, by predicting where traffic is most likely to happen, and therefore anticipating where to direct people in order to avoid creating traffic jams and similar things. In addition, making cars obsolete inside cities is also a very effective and cheap way of helping remove traffic jams. A type of system similar to this is already being used inside big cities in Germany, where a color code system was implemented. Green means this car is the least pollutant and therefore can go anywhere in the city. Yellow is in between and can only go in certain areas where the green cars can, as well as its own areas. Red stickered cars are forbidden from entering the city center in major German cities (as well as being obsolete and forbidden in the country as they are deemed to the pollutant (with exceptions made for historic cars)) but can park in some spots for yellow stickered cars in the outskirts of the cities. If a system like this was implemented in every city, major traffic jams would be avoided, as well as cleaning up the air quality inside the city and saving money because of not having to build parking infrastructure. Maybe another idea is to keep track of Bluetooth the same as with the corona
https://retro.nrc.nl/W2/Lab/Profiel/Files/bestrijding.html

Food shortage

Food shortage is still a very urgent issue sadly. Which has apparently not been addressed effectively yet. One in nine people is actually malnourished. This is due to numerous reasons.
For example, inefficient ways of farming, no clean water, mass production of food, droughts, food waste, or infrastructure problems (or the infrastructure is just non-existent in some places). Unfortunately, this problem is most prominent in third world countries, so any solution you come up with should be pretty bare and simple technology-wise. Drones these days are getting increasingly cheap, this could be used as a solution to the infrastructure problem. Or a smart way to automatically drain water from a dirty river and filter it, without having to replace too many parts, it has to be low maintenance.

Chapter 4: Problem Selection and Motivation

Select one problem you would like to work on for your project of the list of 5 problems identified in step 1. Motivate your choice

Global Warming

We chose global warming because we think that it is a very relevant problem that is/ is going to affect our everyday lives more and more. Global warming is a broad problem, and that is why we're going to focus on a sub-part of the problem.
Global warming is caused by numerous factors. The factor we are going to focus on with our project is energy waste.

Energy waste
Every year about 75% of energy gets wasted and sadly a lot of that energy is still being produced with fossil fuels. Some problems that are relevant include: energy wasted transporting energy, 66% of fossil energy getting wasted to access heat, leaving devices on, using old lightbulbs, keeping your fridge open whilst browsing, ignorance of energy waste because it is cheap anyways, not turning off the thermostat and keeping devices idle because they are still plugged in. A lot of these are just a small percentage, but when you try to attack a few of these problems it could make a real difference. To eliminate a small percentage of this waste we could come up with various systems that could contribute to reducing energy waste. It probably will not be a very big
influence, but every little bit counts.
Besides that, a problem with energy waste is that people primarily think about the cost of electricity. For the number of things you can do with electricity, it is relatively cheap. Therefore, when thinking of energy waste, we first think about the costs we could spare and not about the consequences it has to the environment. This could be something to solve. A device could be thought of which changes the way we think about energy waste. What has shown to work in the past is the visualization of energy usage. For example, a screen that shows how much energy your household has used that day.

Chapter 5: Potential Solutions

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

What we would focus on is the energy usage within a household.
Home Energy Magazine
1 Automatic lighting system
A system that manages the devices and lights in your house. Turning them off when they are not being used, saving a lot of energy. The lamps would go off,

2 Fridge and freezer browsing
According to Home Energy Magazine, about 7% of a household's used energy yearly is due to browsing your fridge or freezer. This is a habit that could easily be combatted or could be adapted to. The lights could for example turn off after a certain amount of time. Once you open a freezer or fridge a button for example would be released, turning on the lights. Then, using the Arduino, a timer could start and after a set time (for example 5 seconds) cut off the electricity for the lights and turn them off. This could affect the behavior of the user and teach them to be quick and decide what to take before opening the door.
Another thing that could help even more with this behavior would be the ability to see and know what is inside your fridge or freezer beforehand. This could be achieved by having a window in your fridge or freezer, of course, it would have to be very well-insulated glass. Otherwise, all this energy saving would be for nothing. You could also achieve the ability by having a camera inside the fridge or freezer or having an inventory app on your phone where you put in your grocery list and it would automatically recognize the products you will put in a refrigerator. This way you can take inventory easily and decide what you are going to take before opening the door.

3 Smart plugs
One of the biggest problems in households nowadays is the number of utilities and appliances we have in our houses on standby consuming power because we do not want to close what we are doing, or we leave things on while we go to the store, such as leaving the washing machine on or the dishwasher. Not only does this consume power while you're out of the house but it could also be potentially dangerous if it were to break while you are out which could cause damage to your house as well as consuming a lot of electricity. Smart plugs could be a good solution for this because it forces you to either stay home when you are doing these things, like washing dishes or clothes or turn everything off when you leave the house and nothing is working while you stay out. These plugs work by turning on and off based on your position in the house, when outside all are off, and when inside depending on where your phone is located through Bluetooth chip it will turn on and off those plugs. In addition, you can also customize for specific things to always be on or always off, as well as customize in order for certain appliances, like coffee machines, etc, to learn your usage patterns and automatically turn off and on whenever you go to use them.

4 Small scaled-down hydropower generators
To help households not only save money as well as produce electricity, but small scaled-down hydropower generators could also be implemented in the drainage systems where the water movement from when people shower, when the dishwasher and washing machine are on when sinks and toilets are used, to turn the hydropower generators and therefore produce small amounts of electric energy in order to replenish the energy these appliances consume. This should be enough power to at least power up some LED bulbs inside the house, therefore the household would consume less power.

5 Energy usage visualization
Elaborating more on the visualization of energy usage briefly mentioned in the previous chapter. This idea got its inspiration from a previous CreaTe project, namely, the Smart Bin. The Smart Bin is a trash can that visualizes how much trash is being thrown into the bin on a big screen. This visualization makes it fun for people to throw away their trash, motivating them to actually do this in the trash can instead of perhaps somewhere in the bushes.

Implementing this same way of thinking into our project would be the following. A smart meter that calculates how much energy is being used and for what. This allows people to have more insight into their energy usage and where they could save energy.
The screen could show averages of how long people showered that day, or how often the dishwasher is being used, and how much energy these activities have used. Especially these big energy consumers are important to focus on, as they make the biggest difference.

This idea in itself would already be a motivator for people to start thinking about how they could save energy. What would work even better is when a local (or perhaps national) competition is set up. There would be a leaderboard that shows how your energy usage compares to that of other households with the same amount of people living there. Not only will you then be motivated through confrontation, an extra motivation of “I want to be better than my neighbor” would also come into play. Perhaps adding small bonuses to this competition would increase the effect even more.

6 Smart solar system:
The whole energy-saving house wouldn't be complete without solar panels, making all the used energy green and relieving the national power grid. However solar panels only make peak power during 1 hour of the day. If we could stretch this hour so that more power would be generated, this would greatly help with energy efficiency.
The solar panels would be placed on a rotating disc, this disc is controlled by the Arduino. The sun path could be mapped and the disc could rotate accordingly. The angle of the solar panels could be easily controlled as well to maximize power output. With this system placed on the roof of the house, the panels would always deliver the most output.

This power could either be directly used within the house, for all the other applications for example or the power could be used to charge a built-in battery in the garage. This power could then be used when necessary, like at night.

The idea of adding solar panels itself is rather boring, but they are just too good to not use them.

7 Using natural light, a window following the sun
Instead of using electricity for lighting during the day, you could use the light of the sun to light up a room, simultaneously using it to heat up the room. to get the most sun possible in a day however, just a static window will not be enough, instead, we could make a moving window that would follow the sun throughout the day, for example by using a light sensor and processing the weather forecast, you can make the optimal setup depending on the day.

8 a smart laundry hanging system instead of a dryer.
the dryer is still one of the biggest energy wasters in our current household and just hanging the laundry out to dry can make a pretty big difference in your power usage, a problem, however, is that hanging your clothing is a lot of work and can take a lot of time, so making that smarter or automated could be a good way to encourage people to not use the dryer. having a moving washing line for example.

9 General garbage bin
Using a network of different sensors, we could make a general garbage bin that sorts out the garbage automatically. At first, we could filter out all the liquids. When those are removed, an electromagnet could be used to sort out metals. We could detect organic materials with near-infrared organic photodetectors[1] . When all the liquids, metals and organic materials are sorted, a capacitive sensor can detect plastics, wood and other raw materials. In an average household, we can expect no wood would be disposed of inside the garbage bin. When all the plastics are removed the only litter left should be residual waste. This machine makes sure the companies which recycle the waste have a more sorted supply. They already do their sorting themselves, but this way the process is more efficient and more reliable. This system however is a lot more difficult than the rest of the solutions and would not result in a big difference in terms of global warming.

[1] https://pubs.acs.org/doi/10.1021/acs.chemmater.9b00966

Chapter 6: Solution Selection

Select 1 solution. Motivate your choice. Explain why you selected this solution over the other candidate solutions you found

Our solution

Our first idea was to make an energy efficient house, this would include a few different solutions. However, this would be a little too ambitious for the time we have. Therefore, our main focus will be the hydro power generator. We envision the generator to be installed in multiple drainage pipes. Starting with the drainage pipes that get the most water. So that would be the one for the shower, the one from the washing machine and dishwasher or even in the central heating system. These could be connected to an Arduino that registers how much energy has been produced, the Arduino would send data to our energy visualization system (ambitious plan) and show how much energy you have generated using this system. It could show a graph of the energy produced set off to the time. Also how much energy you have produced that day and so far.
We would like to go with the most realistic, but also the most fitting solution we came up with. We would at least like to make a proto type of the hydro power generator, but we also want to try and implement the energy visualisation, because it would be really nice to combine these. The generator could send information about how much that certain water fan/wheel has generated and it would be visualized in one website/app or with an LED system.
We choose this solution, because it is more realistic than for example the general garbage bin, which would take a lot of different and advanced sensors, a smart solar system, which is quite intricate with all the calculations and precision that would be needed. But also more fitting than for example the laundry hanging system, which seems a little inefficient because it is not a real alternative for a dryer. Especially in colder climates like in the Netherlands the laundry would not dry nearly as fast as desired.

Roles:

- Build prototype -- Wessel, Jasper
- Documentation -- Daymen, Liam
- Presentation -- Daymen, Wessel
- Research -- Rafael, Froukje
- Safety -- Rafael, Froukje
- Programming -- Liam
- Idea sketching -- Jasper, Wessel

Realistic planning:

Week	Date	Deadlines during this week	Plan	Done
1.	**13-11**	Team formation		8-10 problems identified
2.	**20-11**	Theoretical work		Chapter 1 & 2
3.	**27-11**	Theoretical work		Chapter 3 & 4 Presentation
4.	**4-12**	Theoretical work and ordering of hardware		Chapter 5
5.	**11-12**	Research & development		Chapter 6 & 7
6.	**18-12**	Research & development	Hardware ordering Physics calculation	Chapter 0
7.	**25-12**	*Vacation*	*Vacation*	*Vacation*
8.	**1-1**	*Vacation*	*Vacation*	*Vacation*
9. (7)	**8-1**	Research & development Re-define documentation	Prototype building Making the presentation Programming Arduino	
10. (8)	**15-1**	Research & development **5-minute presentation of first prototype**	pre-made hydro-generator; connecting lamp; Fine tuning the presentation Chapter 8	
11. (9)	**22-1**		Fine tuning the final demo presentation and proto type	
12. (10)	**29-1**	**Final presentation**		

Ambitious planning:

Week	Date	Deadlines during this week	Plan	Done
1.	**13-11**	Team formation		8-10 problems identified
2.	**20-11**	Theoretical work		Chapter 1 & 2
3.	**27-11**	Theoretical work		Chapter 3 & 4 Presentation
4.	**4-12**	Theoretical work and ordering of hardware		Chapter 5
5.	**11-12**	Research & development		Chapter 6 & 7
6.	**18-12**	Research & development	Hardware ordering Physics	Chapter 0
7.	**25-12**	*Vacation*	*Vacation*	*Vacation*
8.	**1-1**	*Vacation*	*Vacation*	*Vacation*
9. (7)	**8-1**	Research & development Re-define documentation	Prototype building (own hydrogenerator) connecting a plug	
10. (8)	**15-1**	Research & development **5-minute presentation of first prototype**	Chapter 8 documentation; Prototype building (own hydrogenerator) connecting a plug	
11. (9)	**22-1**		Visualisation programming (LCD)	
12. (10)	**29-1**	**Final presentation**		

Chapter 7: Methodology

Think of your methodology* to follow: Which equipment you need, data collection, data use/analysis

* Methodology would be re-defined based on your experience. Do not worry if it is not concrete. It is not binding to what you will do eventually, but more like a guide for you.

Hydro power generator

- Dynamo, either from a bike and then modified or made ourselves
- water wheel connected to the dynamo
- arduino that registers how much power is generated

Energy visualization

- voltmeter/LCD screen
- A way to visualize the data: processing
- LED's to connect and visualize that energy is being produced (realistic plan)
- A power plug you can plug your phone charger into (ambitious plan)

We also should do some research into if it has already been done before, how much energy could be produced with the flow of how much water under what pressure, how to isolate the electric components as well as possible and how the rotors are made the most efficiently.

Where to use

What we have made is of course just a prototype. The small scale proof of concept we have made is just to show how one element of the system would work.
When the system would be implemented into the real world, it would be seen multiple times per household in the most active water drainages. For a good amount of energy production it is logical to place the generator inside the following drainages:

- Shower
- Central heating
- Dishwasher

And other active drainages can be tested as well. Because, the more places a generator is placed, the better.

We shouldn't only think about just placing one generator per drainage pipe. More generators can be placed within the same pipe as long as they're placed efficiently. Meaning, placing two of them on the same side of the pipe directly above each other doesn't work.

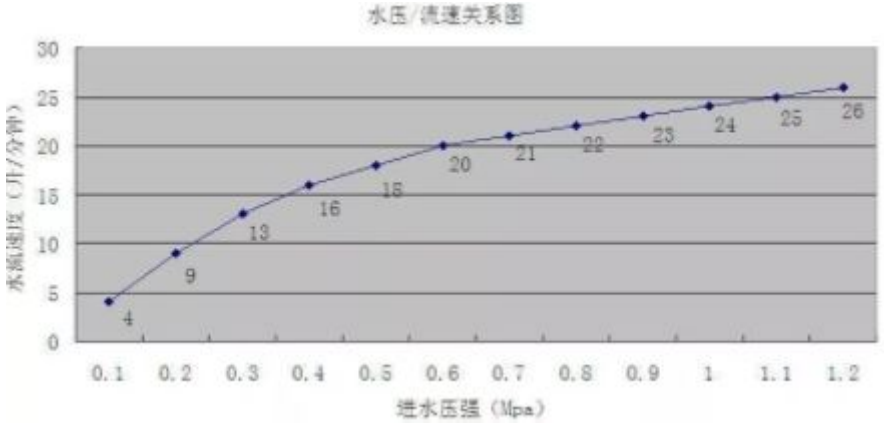
How to use

Cloggage
One problem that would occur when implementing the generators in a household would be clogged drainages. When placed inside drainage pipes that have more than just water flowing through them, for example hair in your shower drain or leftover food in your kitchen sink.
Solutions to this problem would need more thinking through then what we can manage to do in this project. However we did come up with a solution that also already brings another problem with it. The use of a filter that only lets through filtered water would prevent the generators from clogging up. However, you would have to clean the filters every once in a while, which is not optimal.
Maybe something could be done with how the generator is placed so that only clean water hits the rotor. Or perhaps the rotors itself could be made in a way that they don't clog.

Safety
When engineering a product that uses water and electricity, safety is extra important. We all know water and electricity aren't a good match.
Intelligently placing the dynamo to which the rotor is attached can already make it a lot safer, now only splashes of water can reach the electric. Combining this with the use of waterproof material and precise work can guarantee a safe environment.
To isolate the hole in the pipe where the arm comes in

Electricity availability
There of course should also be looked into how the produced electricity can be stored and then used.
The first thing that comes to mind is to direct the produced electricity directly to the main electricity network of the household. However, this might not be possible due to the high voltage this network has. We would have to look into converters that convert our low voltage electricity into high voltage electricity. It is also not sure if the needed voltage is even doable with the generators.
Another idea is to work with batteries, which then can be used for small electricity usages such as your phone charger. The big upside of this one is that the electricity can be stored for later use. Besides, it is easier to use with the low voltage.
Our final idea is to do it the same way it is done now with solar panels. The electricity produced by solar panels is redirected to the energy supplier. They measure how much electricity they got from your household and subtract that from your electricity consumption.

Expected Power output.



This is the graph that was supplied with our dynamo. It can produce 30 Volts at 1 Amp at 1.2 MPa, which is 12 bar. A regular water tap has around 50 to 60 PSI of water pressure which is somewhere around 3.5 to 4 bars or pressure. But since we're using the pressure from waste water coming from the sink we're counting at around 1 to 1.5 bars of pressure.
The quantities of water will however help because we choke this water flow to increase the pressure and to the flow fit our generator piping. We expect to end up at around 2 bars of pressure at the generator level.

This means that we can expect 0.1 to 0.2 Mpa giving us around 4 to 9 Volts at 1 Amp. Enabling us to charge at 4 to 9 watts of power. Which is quite impressive.

Visualisation

We are going to visualise the produced energy in multiple ways. The first one is to use a simple voltmeter to see the most direct result possible.
Using Arduino we can connect it to a simple LCD screen (figure 1) to show how much voltage is produced.

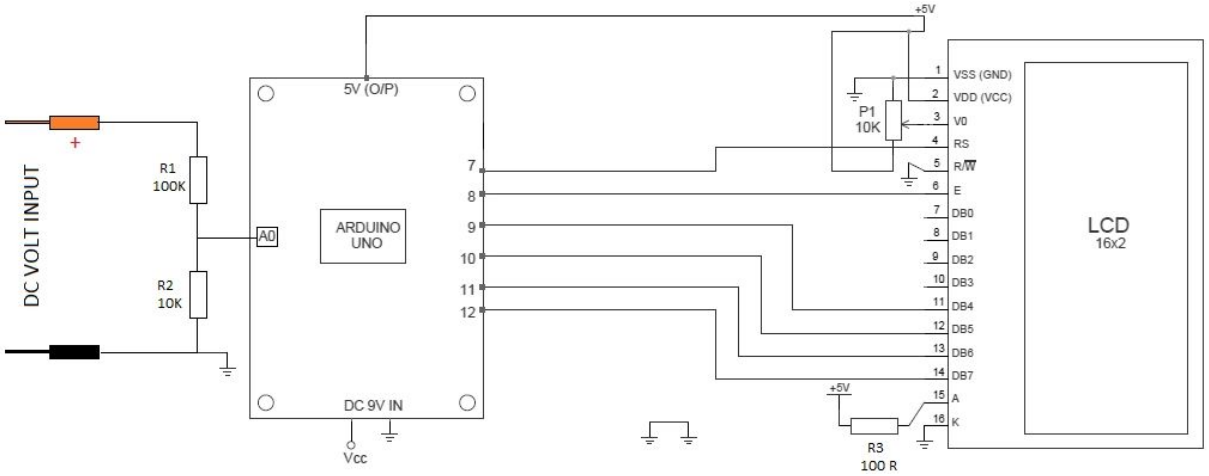


Figure 1: schematics to connect the Arduino to an LCD screen

We can also then connect this to a laptop and let Processing draw a graph to visualize the produced voltage.

To make it even more user friendly, we can translate the hard numbers into numbers everybody understands. For example, the amount of times the average phone battery can be fully charged or the amount of time you can now watch television.
Apart from these screen wise visualisations we are also going to connect either a lightbulb or a plug with which you can for example charge your phone (albeit for around 3 percent). This would be for a more physical type of visualisation.

The prototype

We ordered multiple systems that we could use, so we always have a backup system. We ordered a ready made system that already has a built in dynamo and waterwheel in a pipe (figure 2).

Figure 2: ready made hydro generator

This is of course a big part of our project already in one system. However, it is very small and we do not know what it looks like on the inside. Therefore, this is our last resort backup system. If we do it on our own we have more control and better results. We are making the prototype with a dynamo(figure 3) and a rotor we are going to 3D print (figure 4). For our prototype we will put the rotor inside a 70 mm PVC pipe as seen in figure 5.

Figure 3: 5-24V DC dynamo

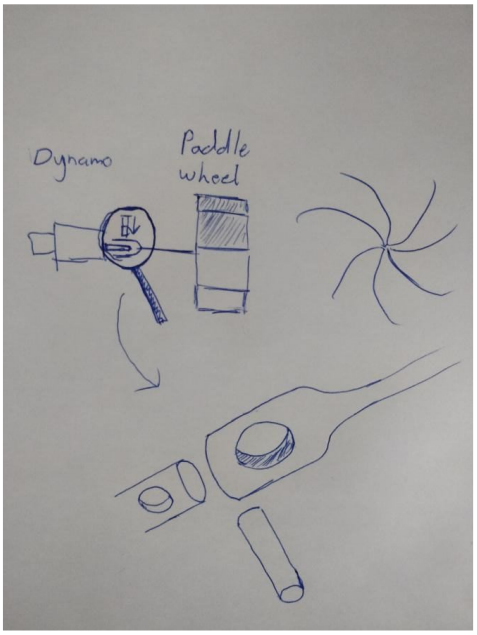


Figure 4: design for the rotor

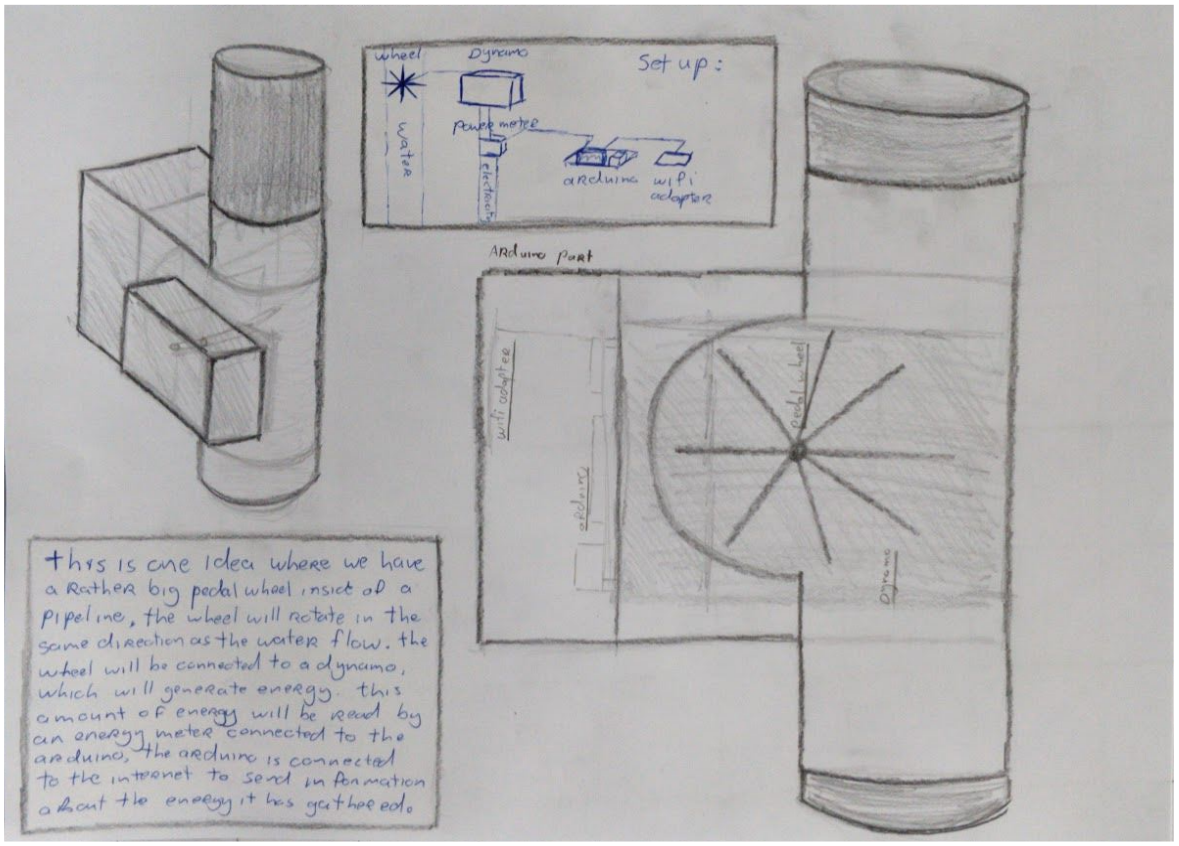


Figure 5: rotor inside the pipe

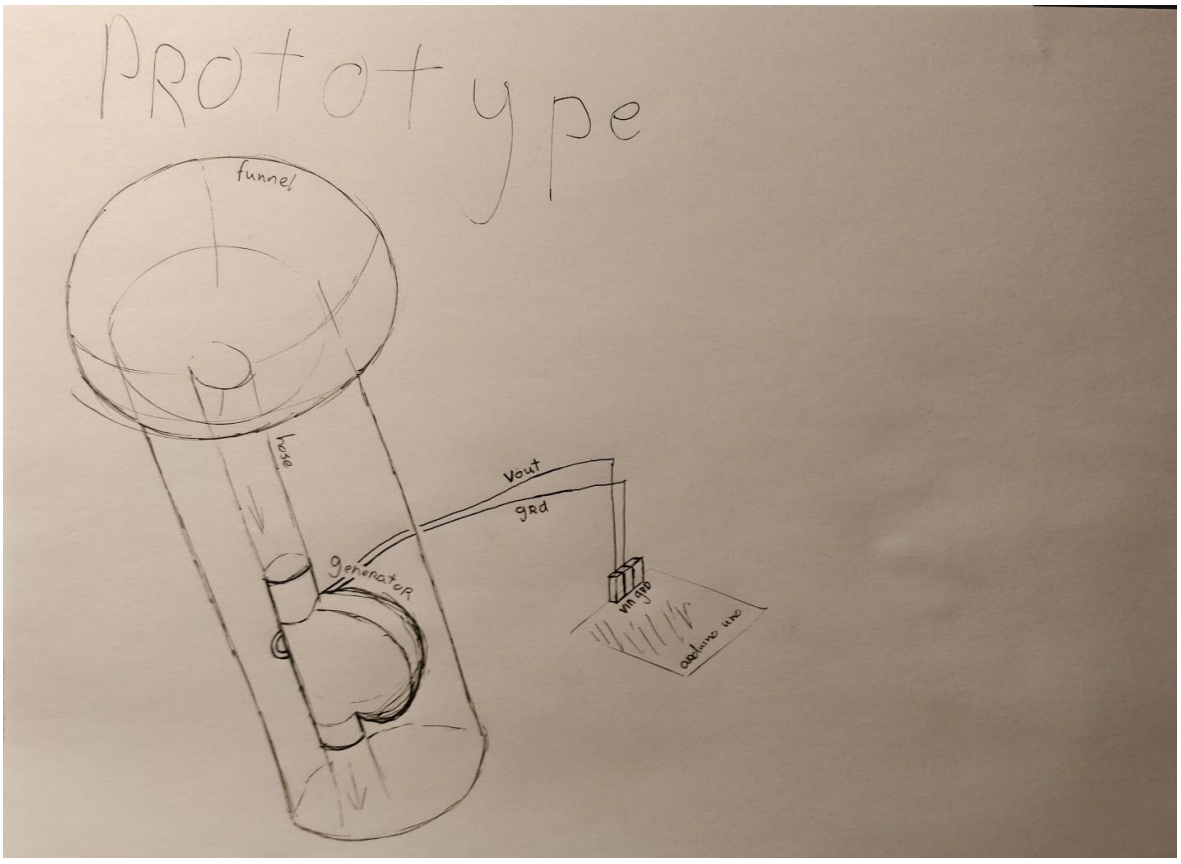


Figure 6: How our simple setup will look like

Cost saving estimations

1 kWh = €0,22

$$E_{(\mathrm{kWh})} = P_{(\mathrm{W})} \times t_{(\mathrm{hr})} / 1000$$

Normal household (4 people): **total: 0.0033*365.25+0.0024*365.25+0.0019*365.25 = €2,78 a year**

- shower/bath/sinks: 4*15min = 1 h of showering (9W/s); 4 baths a week: 4*5 min = 20 min of high pressure water flow(10W/s); 4*10 min = 40 min of low pressure water flow sink usage(4W/s).
  This all corresponds to: 9*1/1000+10*0.333/1000+4*0.6667/1000 = 0.015 kWh a day which is equal to 0.015*0.22 = €0,0033 a day
- dishwasher/kitchen sink: 1 h of dishwasher a day (9W/s); sink 30 min a day (4W/s) which corresponds to 9*1/1000+4*0.5/1000 = 0.011 kWh a day wich is equal to 0.011*0.22 = €0,0024 a day
- washing machine/dryer: 4*1.5h = 6h a week so 6/7 = 0.857 h per day at average pressure (8W/s); dryer 2*1.5 = 3h a week so 3/7 = 0.429 h per day at low pressure (4W/s) this corresponds to 8*0.857/1000+4*0.429/1000 = 0.008571 kWh a day so 0.008571*0.22 = €0,0019

Student housing (10 people): **total: €10,92 a year**

- Shower:
  - 10 * 15min * showering two times a day = 5 h of showering a day
  - Showers have moderate water pressure: this gives 8 Watts.
  - 8 Watts/1000 = 0,008 kWh an hour
  - 0,008 kWh * 5 hours a day = 0,04 kWh a day
  - 0,04 kWh * €0,22 = €0,0088 a day
  - €0,0088 a day * 365 = €3,21 a year
- Dishwasher/kitchen sink:
  - Dishwasher is high pressure, kitchen sink is low pressure
  - Dishwasher:
    - Two times a day for 2 hours is 4 hours a day of high pressure (big student house has a lot of dishwashing to do)
    - 10 Watts/1000 = 0,010 kWh an hour
    - 0,010 kWh * 4 hours a day = 0,040 kWh a day
    - 0,040 kWh a day * €0,22 = €0,0088 a day
    - €0,0088 a day * 365 = €3,21 a year
  - Kitchen sink:
    - Average of 1,5 hours of kitchen sink runtime a day
    - 4 Watts/1000 = 0,004 kWh an hour
    - 0,004 kWh * 1,5 hours a day = 0,006 kWh a day
    - 0,006 kWh a day * €0,22 = €0,00132 a day
    - €0,00132 a day * 365 days in a year = €0,48
- Washing machine:
  - Washing machine in high pressure
  - 5 hours of runtime a day
  - 10 Watts/1000 = 0,010 kWh an hour
  - 0,010 kWh * 5 hours a day = 0,050 kWh a day
  - 0,050 kWh a day * €0,22 = €0,011 a day
  - €0,011 a day * 365 = €4,02 a year
- **Total:**
  - €3,21 + €3,21 + €0,48 + €4,02 = **€10,92 a year would be saved**

High building (hotel with 500 rooms): **total: €278,42**

- Height difference:
  - Helps build pressure, device can run at 12 Watts.
- Estimation per room:
  - 500 rooms * 1 shower a day*15min = 125 hours of showers per day
    Shower generates 10 Watts at average (different height differences)
    125*10/1000 = 1.25kWh a day
    1.25*0.22*365.25= €100,44
  - 500 rooms * 30 min sink = 250 hours of sink water per day
    Shower generates 8 Watts at average (different height differences)
    250*8/1000 = 2kWh a day
    2kWh a day *0,22=0,44 cents a day.
    0,44 a day +356,25= €160,71 a year.

- Kitchens:
    - dishwashers: 3 meals*3 dishwashers*2 times per meal*2min = 36 min a day at very high pressure (12W)
      0.6*12/1000 = 0.0072 kWh a day
      0.0072*0,22*365,25= €0,57 a year.
    - sinks: 3 meals*4 sinks*30 min per meal = 6 hours a day
      at an average pressure (8W)
      6*8/1000 = 0.048 kWh a day
      0.048*0,22*365,22=€3,85 a year.
- Washing machines for the hotel:
    - 80 liters a day for 2 cycles *4 = 320 liters a day for 4 washing machines
    - Washing machine is high pressure
    - 4 machines with 2 cycles a day with a 2 hour duration per cycle = 16 hours
    - 10 Watts/1000 = 0,010 kWh an hour
    - 0,010 kWh * 16 hours a day = 0,16 kWh a day
    - 0,16 kWh a day * €0,22 = €0,0352 a day
    - €0,0352 a day * 365 = €12,85 a year
- **Total:**
    - €100,44 + €160,71 + €0,57 + €3,85 + €12,85 = **€278,42 a year would be saved**

Practical use:

The devices generate power that could be used in any circumstance, however in some applications different scenarios would apply.
For instance in a 4 person household, using the device to charge your phone wouldn't be really practical since you would first need to connect your phone and then use the sink. Therefore we think that in smaller applications it would be best to use our device in combinations with a smart sink including a small battery. The system would then be able to power itself.

For larger applications like student housing or hotels the generated power could instantly be used again, since it would be an almost constant power flow, which could be used for a much wider range of applications.

Chapter 8: Results and Conclusion

Results:

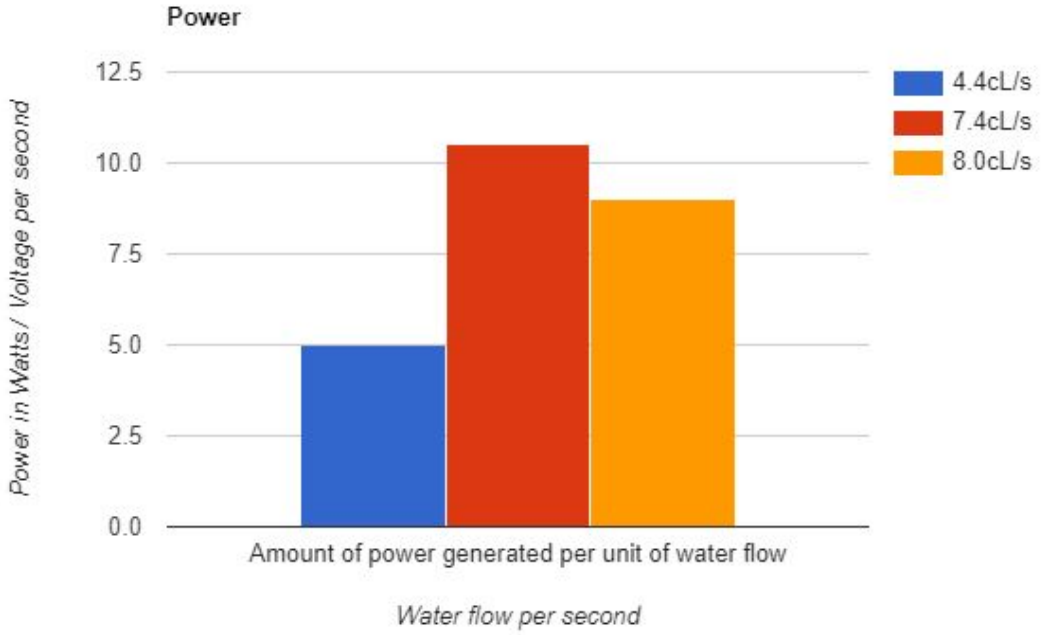
During the later stages of the project we came to the conclusion of not being able to make our ambitious plan come true. We had too many problems and with a tight deadline, we as a group decided on sticking to the basic plan of the project. Therefore we used the pre-made hydro generator.

When we were nearing the demo day and our prototype was built, we unfortunately found out that the components we used for the generator were not suitable for what we wanted to accomplish. The reason for this is that the generator requires 1-10 bars of pressure. This amount of pressure cannot be produced by water that is flowing slowly without any pressure. Therefore, to achieve some form of validation and results, we connected our prototype to a water tap. This solution provided us with around 1-3 bars of pressure which we could use to get some measurements.

Measurements:

Water flow (cl/s)	Voltage (V)	Current (I)	Power (W)
4.4cl/s	**4.85**	**1**	**5**
8.0cl/s	**9.32**	**1**	**9**
7.4cl/s	**10.2**	**1**	**10.5**

Since the current is constant, the power and voltage are the same in the graph below.



These measurements do not represent our product for day to day use. The general idea was to check if our prototype is still viable. If you want our product to be used in real households, you would have to build in a hydro generator that needs a lot less pressure than the one in our prototype, because of the pressure restrictions. The drainage pipe underneath a shower, for example, will only give around 0.1 bar while the shower is being used.

Conclusion:

To sum up, our prototype right now is not yet usable for the market. However, we think it has a lot of potential if you were to fix the pressure problem, because of numerous reasons. To start, it is quite cheap. This has always been and always will be a big factor to determine if a product is feasible. If you would want to have the product with the Arduino and the LCD screen to visualize the amount of energy produced, the total price would be: 10 euros for the Arduino, 5 euros for the hydro generator, 3.50 euros for the LCD screen and around 5 euros for casing/wiring. All this together leads to a price of €23.50, this is of course without any profit margins and when the product is not being mass produced, so excluding any discounts on the parts. We estimate that users would be willing to pay €50 if it were to be a "package deal". Such a package would include three of our systems around the house: one in the kitchen (dishwasher/sink), one in the bathroom (toilet, shower, bath, sink) and one near the washing machine/dryer.
Next to our product being cheap, it also saves people money, since "free energy" is being produced. The user would pay less for their electrical bill.
Finally, people would feel good about the fact that they are doing something for the environment. Since they are saving energy that has been produced by fossil fuels and using green energy produced by an otherwise unused force.

If you would want to use our idea and product to its full potential. You might want to think bigger and look at high buildings or flats. The residents would collectively invest in a bigger version of our system. The system will then be built into the bottom of the main drainage system of the building. Here our system would produce bigger amounts of energy due to the very large height difference and therefore big force working on the hydro generator. This type of system has big potential for project developers who are looking for ways to make their new buildings greener and more environmental-friendly.

First Prototype:

New Prototype: