Powering a city through a fleet of robots; tiding over our electrical crisis

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1 Abstract

In Singapore, most Singaporeans are not worried about Singapore's energy security at all, since we have all been blessed with electricity, it is all around us and easily accessible. However, the fact is that our electricity is scarce and we have minimal land, and that constrains us from building certain large scale energy efficient plants. We use a lot of fuels to refuel ships that come to our country to trade. Therefore, we rely more heavily on imported fuels which mainly comes from burning fossil fuels than other countries. Before we try to reduce the impact of burning these fossil fuels, we must first recognise the fact that we cannot live without energy when we are already so reliant on it, we will have to be diverse and source our energy from other more renewable energy sources.In an attempt to reduce Singapore's reliance on fossil fuels for electricity, our team has decided to create an autonomous boat that can maximise the capture of solar energy.

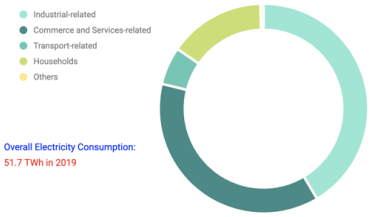


Figure 1: *electricity consumption from different sectors*[5]

In practice, we plan to have a large fleet of these robots, capable of moving to locations of maximum sunlight in order to help maximise the impact of our project. Even when docked and discharging gained electricity, our robots become part of another energy source, wave energy. Waves, which grow stronger at night due to the gravitational pull of the moon, will allow electricity to be generated at all times, maximising efficiency. Only recently have we tried to move to solar energy. However, that did not make that much of an impact on the environment, as shown in the graph. As such, we aim to come up with a robot that defies the restriction of Singapore's limited land, providing a constant supply of renewable energy for Singapore.

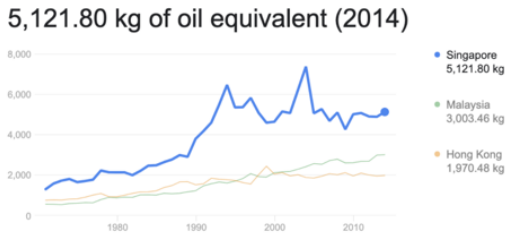


Figure 2: *Singapore/Energy use per capita*[12]

2 Introduction

Before we begin, we must first understand how energy came about and its initial use for us, humans. For that, we will go back to 1752 when Benjamin Franklin discovered electricity. He ran his famous kite experiment that sparked the discovery of electricity. As a prominent American scientist and one of America's founding fathers, Franklin tied a key to a kite string during a thunderstorm and proved that static electricity and lightning were one and the same thing. Following this historic result, people were eager to try harnessing the power of electricity for the primary goal of lighting their homes in a cheap and safe way instead of oil and gas lamps which were flammable and dangerous. [1] However, as time went by and humans started to see the convenience in electricity, the effect of electricity has pivoted to bring more bad than convenience. People started using electricity in massive amounts in e-commerce sections and industrial sectors as shown in this graph.

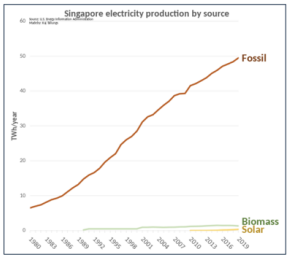


Figure 3: *Energy source consumption*[6]

Singapore's limited land use affects our ability to use renewable sources of energy, yet it is nonetheless important for us to be energy sustainable. The purpose of this project is to come up with a robot that can consistently bring in energy from renewable sources whilst defying Singapore's land constraints. We are planning to source our energy from the ocean, to build a miniature solar boat that can withstand Singapore's choppy maritime waters. These small robot can do the job of larger floating solar panel platforms.

Figure 4: *UNSGD #7 Affordable and clean energy*[10]

The boat will take in energy in the morning and dock at the port at night, discharging the energy it collected in the morning. This robot aims to collect energy by using both Solar and tidal energy collected from the sea. Solar remains the most promising renewable energy source for Singapore, while energy storage systems allow us to counter the indeterminacy of renewable energy sources such as solar[8]. Tidal turbines operate in a similar way to wind turbines, except that tidal turbines use the flow of the tide to generate predictable and efficient renewable energy, unaffected by weather and the time of day[10]. Both of these energy are not only useful for reducing Singapore's footprint but can also solve UNSGD #7 Affordable and clean energy.

3 Description

We will not be helping people more efficiently use their energy, nor will we be encouraging people to reduce energy consumption. We will need to be able to build a resilient robot that can withstand the waves or any obstruction that comes. And we also need to effectively predict and move the robot to positions with the most sunlight on an hourly basis. If all goes well, we can turn this into a nationwide project (since Singapore is surrounded by water) and this may very well become another source of energy for us, building an energy resilient Singapore. This may be a new solution to Solar energy in Singapore. As of now, other than putting solar panels on HDB blocks and on large solar panel farm[13], this new method can introduce a new ground-breaking way to collect solar energy despite our land limitations.

Figure 5: *Sembcorp to build Singapore's largest floating solar farm*[13]

Moreover, the problem with large stationary solar panel farm is many. For example, it has to be located at calm waters and whenever a cloud goes over the farm, for the entire day, the solar panel farm cannot generate energy. "Aided by advancements in miniaturisation of electronics and an increase in companies offering space launch services, small satellites promise more comprehensive coverage and flexible usage at a lower cost," said Mr Iswaran [2] [7]. The same can also be said for the small boats we are making.

4 Objectives

The first goal of the project is to of course make a boat that can move around without sinking. This requires us to make the boat airtight, buoyant and strong. Then we will need to add in the solar panel and battery and come up with an algorithm that makes use of the weather API to search for areas with sunlight. We can also make use of gyroscopes to make sure that the main component in the shell remains upright at all times.

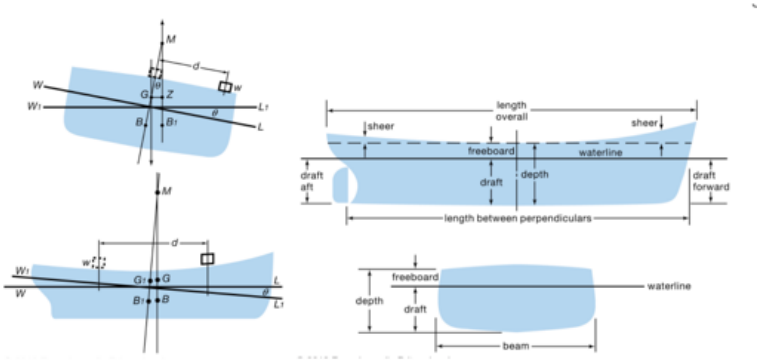


Figure 6: *structural integrity of boats*[11]

4.1 Problem statement

"How might we effectively and efficiently bring in renewable sources of energy to sustain Singapore's energy usage whilst battling the problem of limited land with the help of innovation and technology?"

4.2 Purpose

We aim to solve the problem of Energy at your home or your community. We plan to take full advantage of the time when renewable energy is abundant in Singapore. To do this, we aim to create a new product that knows where and when to take advantage of the abundance of energy in Singapore. We can store the extra power in the boat, and make sure that we use the power when there is lots available. Our robots and its robotics systems can help make sure we have an optimal amount of renewable energy available. And that we use renewable energy in a smart way in our homes or in our communities.

4.3 Practical Application

This can be another of Singapore's sources of energy, making us more energy resilient. Since Singapore is near the equator, the length of its day is relatively constant throughout the year, and thus so is the amount of sunshine it receives. Daily sunshine hours are mainly influenced by the presence or absence of cloud cover. They average from four to five hours during the wettest months to eight to nine hours during the drier periods.

Furthermore, as we are trying to move the robot, we will create motion, so if we can fit another propeller under the robot, we can then change this kinetic energy into a battery, allowing us to create energy even at night when the robot is docked at the bay. We can use the following circuit.

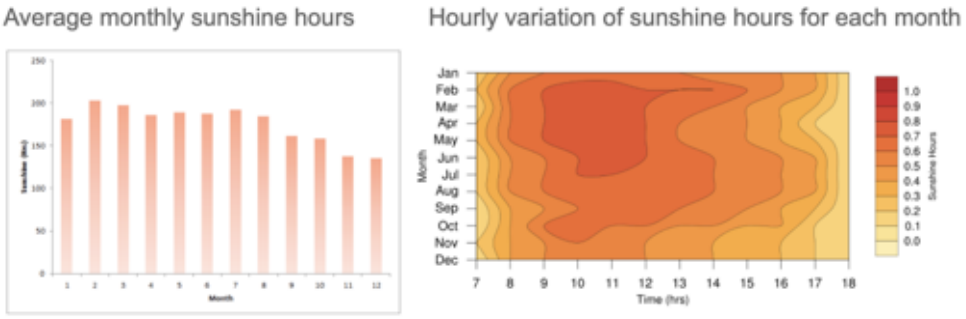


Figure 7: *Sunlight Statistics in Singapore*[4]

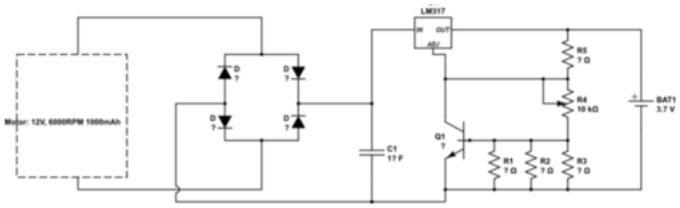
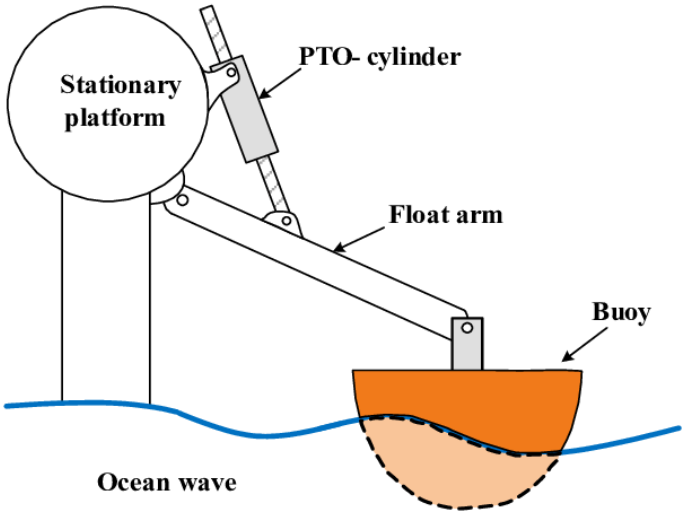


Figure 8: *Circuit to charge battery using Dc motor*[3]

We also had an idea to utilise the boat docked at the port as an Point-absorber type wave energy converter (WEC). The boat acts as an bouy when docked at bay during night time where the wave can move the arm up and down, and this movement will will be kinetic energy that will be converted into electricity via a dc motor. [14]



4.4 Methods

We plan to build a boat that:

1. Goes out in the morning to collect sunlight
2. Returns at night (after the darkness reaches a certain value) to discharge whatever energy it collected.
3. Can follow where the sunlight goes to get maximum exposure to the sun.
4. Does not obstruct maritime trade
5. Can stay upright

4.5 Equipment List

1. A waterproof container
2. Solar panel
3. Battery
4. Motors x3 medium
5. Motors x1 large
6. Ev3 brick
7. Solar power manager
8. ldr/ photoresistor
9. Propeller
10. String
11. Gyroscope
12. Dc motor

5 Diagrams of Possible Prototypes

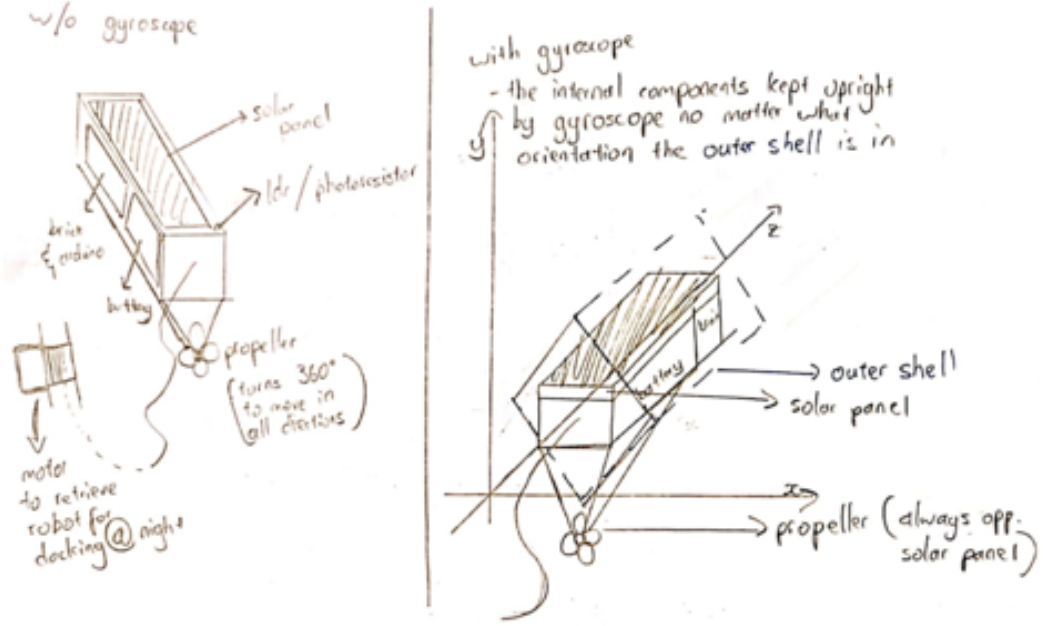


Figure 9: *brainstorming prototypes (click for more)*

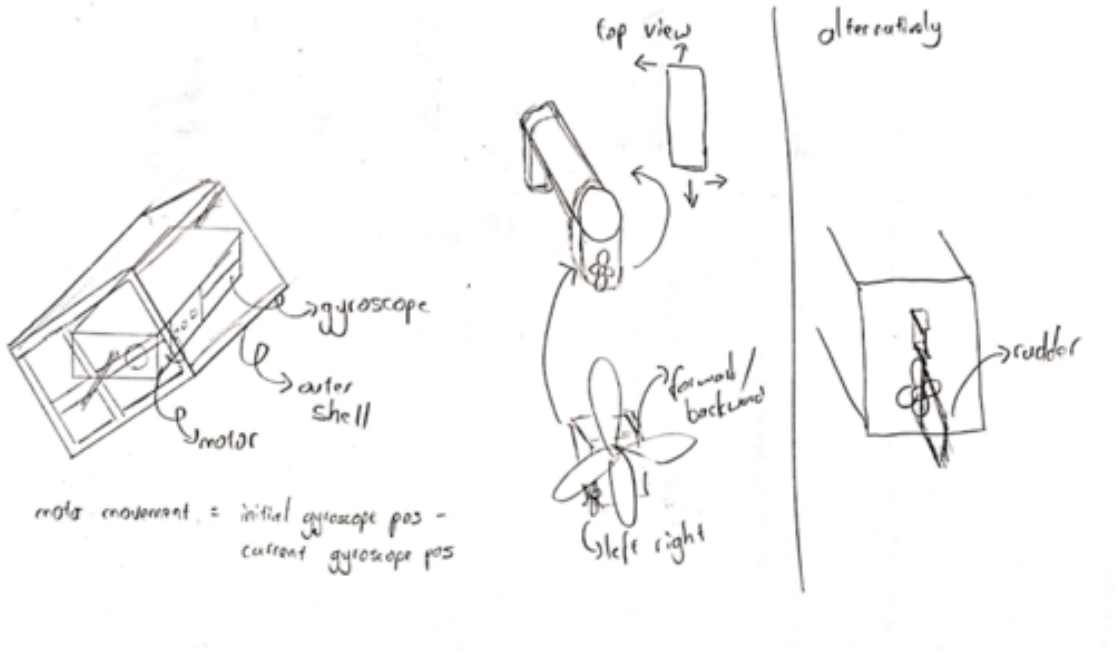


Figure 10: *brainstorming ways to move the robot (click for more)*

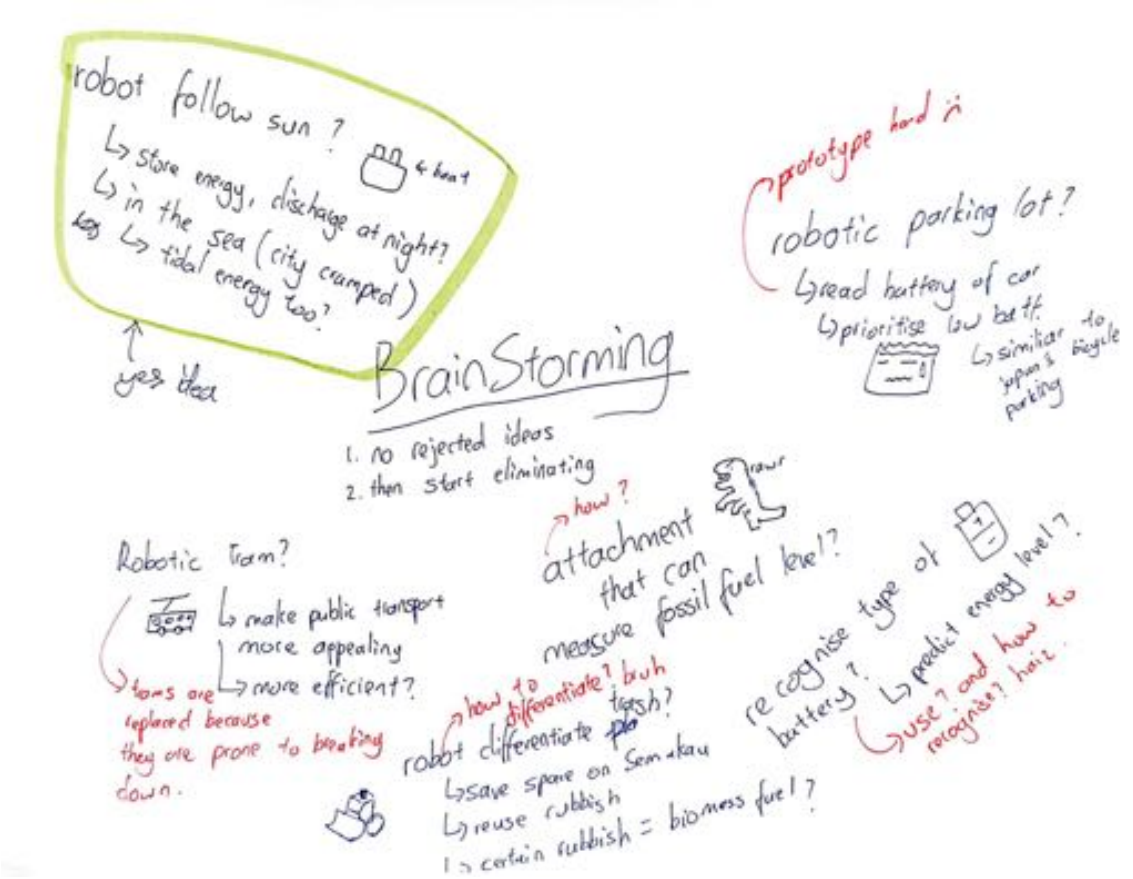


Figure 11: *brainstorming ideas (click for more)*

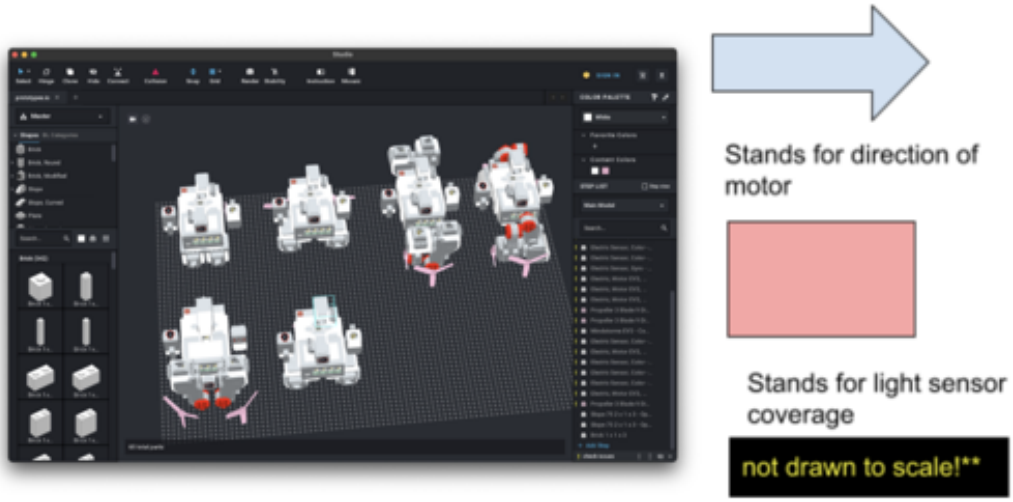
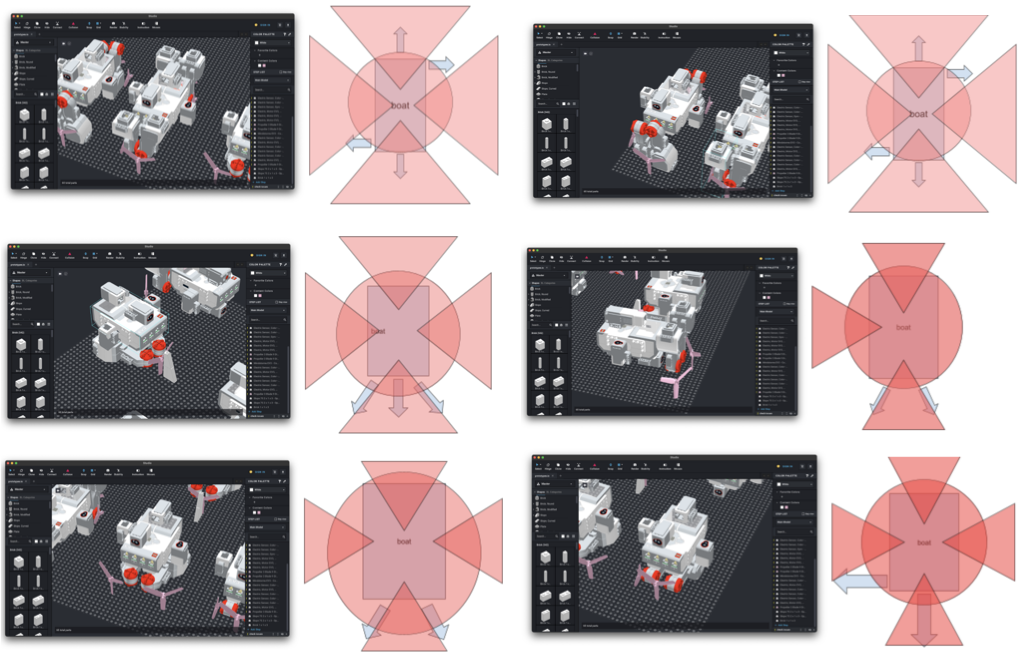


Figure 12: *All 6 prototypes (click for more)*



6 Prototyping

6.1 Collecting Solar Energy

To collect solar energy, we will be using 4 Mini Solar Panel (3V 0.36W) and a Sunflower Solar Power Manager 5V. We choose this specific solar panel for its price and energy efficiency. This small power and high-efficiency solar power management module designed for 5V solar panel. It features as MPPT (Maximum Power Point Tracking) function, maximizing the efficiency of the solar panel. The module can provide up to 900mA charging current to 3.7V Li battery with USB charger or solar panel. The ON/OFF controllable DC-DC converters with 5V 1A output satisfies the needs of our project. Moreover, it also features a Battery (BAT IN) overcurrent and overdischarge protection is added to improve battery safety, ensuring our safety in case something

happens while the prototype is in water.

The specifications of this particular solar panel manager is that it needs to have at least a 5-6 volts in order to charge the battery. Despite the solar panel saying that it is able to provide 5 volts, in actual fact, when we did the experiment, it could only provide 3v, so we will need to double the number of solar panels in order to get it to charge the battery.The solar panel will also need to have a diode to prevent the current from backflowing, so we also had to solder that onto the wire, then the wie onto the solar panel.[9]

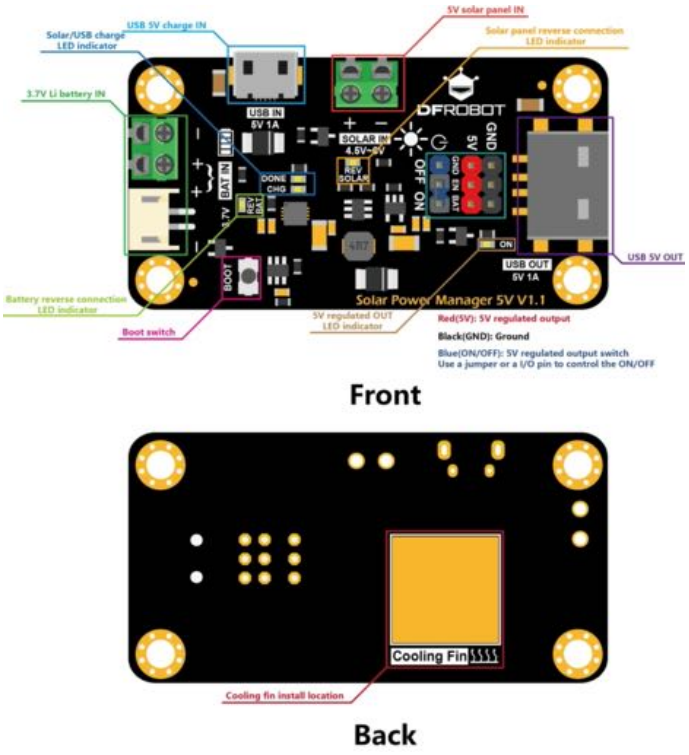
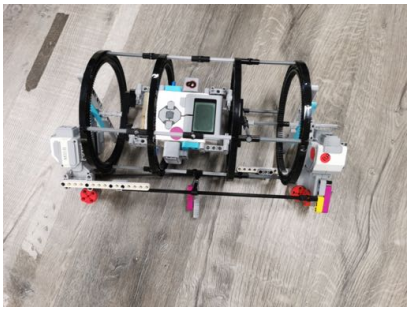


Figure 13: *Sunflower Solar Power Manager 5V*[9]

6.2 Prototype 1 - Gyrobot

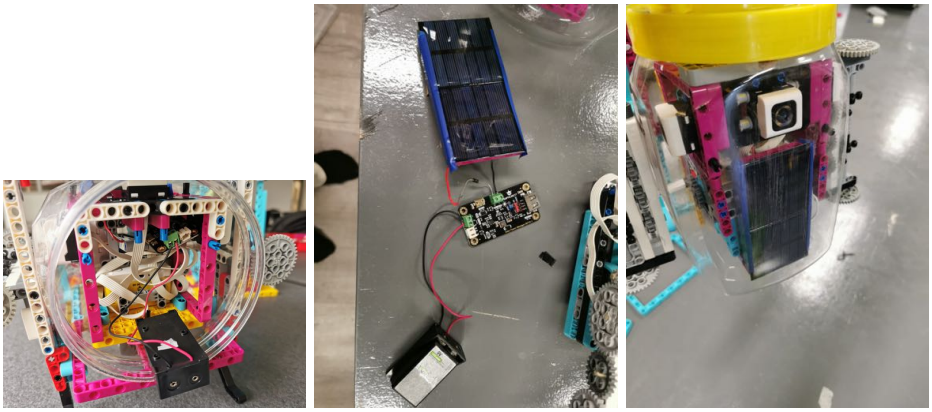
GyroBot uses a variation of prototype 2 where it will rely on its own body weight to keep the body upright despite other inferences. This prototype is not made to work but rather as a proof of concept that our idea of using gravity or gyroscope to keep the robot upright is correct. We had two variation of this the first being the first prototype and the second being the one we will be using for proof of concept. More media can be found here.



6.3 Prototype 2 - The robot

6.3.1 Introduction to The robot

The robotis the working prototype for this project. it makes use of a modified version of prototype 5. We used a box that we found at home and the spike robot. Some might think that we used Spike instead of Mindstorm is because of their light structure of the brain and also the small space it takes up. Well, yes we did chose them for these defining features of scratch that will make building the prototype a lot easier, however, we chose spike largely because of reason of the notch that allows the wire of spike to only take a 1 by 1 hole space, allowing us to squeeze the motors and sensors into small spaces unimaginable when using EV3.



6.3.2 Structural Integrity

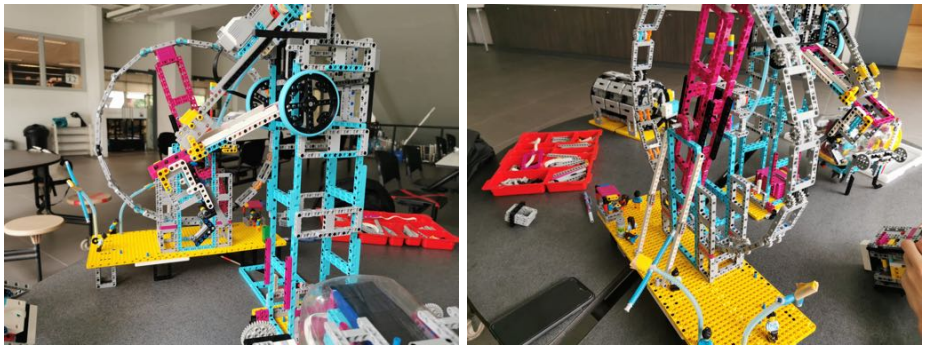
When building the spike robot, you might be surprised to hear that we actually constructed the robot from inside out. This is to ensure the structural stability of the robot to make sure that in no instances should the items inside slip out. However, with bad planning, this will result in taking a long time to take out the components inside, as shown below. (39369 PANEL 11X19 is blocking the top, where the solar panels are supposed to be.)

6.3.3 Ensuring Stability

Before we put in all the sensors and Lego components such as the brick and motors, we first had to make a plan on how to build it. We had to allocate space for the robot based on the importance of the item. This resulted in us having to remove a single light sensors. We had to allocate space in the robot based on the weight of the items. This is to ensure that the robot has a low centre of gravity. Accompanied with a keel, this is prevent the robot from flipping over.

6.4 Harnessing Wave Energy

Using the diagram on 4.3 Practical Application, we made the structure that can harness wave energy at night and also made it possible to connect it to our robot. We attached a gear to the gear rack on the PTO cylinder, then connecting it to another motor that will move when the first motor that is connected to the gear moves. this motor will move a wheel which represents a Ferris wheel' which is an representation and pun to how our product will be able to generate electricity to for the public, keeping the earth "turning".



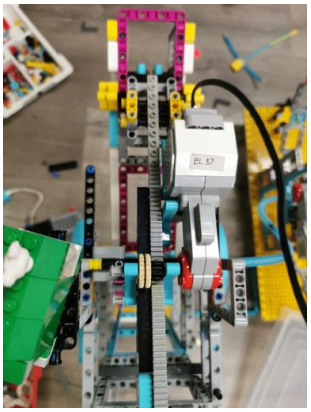
6.4.1 The stationary platform

The stationary platform is essentially just a elevated platform to store the PTO cylinder and the DC motor which will convert it to electricity. The most important part of building this structure is definitely how it should have a low centre of gravity and stable structure. We made this happen by adding heavy objects at the bottom of the structure and also connecting another structure which houses the Ferris wheel to the structure, increasing the base area and preventing it to tip over.

Structural Integrity The float arm of this certain build exerts a very high strain on the sides and the arm of the stationary structure. Therefore, we needed to have extremely reliable and firm structures that are prevented to come out on at least two sides. For example, the sides are secured and prevented from being disconnected from the top and from the side, where the strain of using the float arm will most likely occur, As for the arm, we will have to exert large force to the arm to move the large motor so we had to secure the arm from all directions possible.

6.4.2 PTO-cylinder

The PTO cylinder consists of the dc motor (which is the large motor) and the gear racks and gear which will convert the arm's up and down motion into moving the gear. This gear is the connected to the dc motor which is the large motor. then we can connect it to another large motor and allow it to turn, showing that this structure is indeed able to generate electricity.



6.4.3 The Ferris wheel

Leaving the second motor to turn is actually extremely boring, so we decided what else is there better to do other than to attach a Ferris wheel to give this project a punch! We attached a freewheel and 2 to 1 rotation converter to it so that the Ferris wheel can have a constant rotation such that the jerky up and down motion of the arm will not affect the rotation of the Ferris wheel, which is an representation to how we intend to intend to provide clean and constant energy to the public to enjoy, Ferris wheel are meant to be enjoyed :)

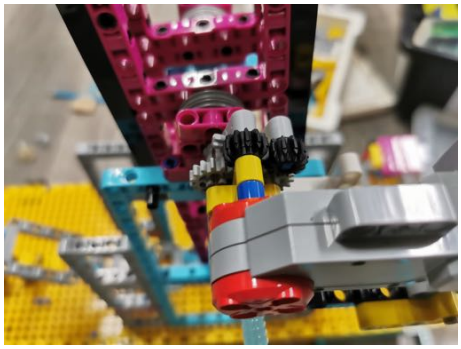
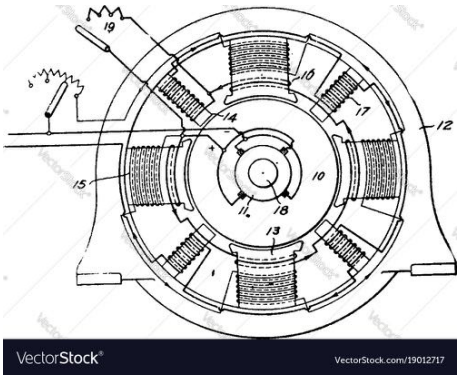


Figure 14: *2 to 1 rotation converter*

6.5 Generating energy through magnetic fields

Aside from simply generating energy from the motor by itself (which is boring), we were also planning to harness more energy through the use to magnetic fields. By looping copper wire around the inside of the Ferris Wheel and placing magnets to the side of the Wheel, electrical energy can be generated when the wheel spins, giving us a third method of harnessing energy through our project. Moving a magnet around a coil of wire, or moving a coil of wire around a magnet, pushes the electrons in the wire and creates an electrical current. The current can then be harnessed and used as electrical power. However due to time and material constraints we are unable to carry out this plan for this competition

So as a result, we started building a up-scaled dynamo in an attempt to show how the Wave energy converter would generate electricity, if we line the plates on the outside container with fixed magnets and fill the 6 middle fins with coils of wire, we will most probably get electricity from it. And because of this, we left the Ferris wheel alone so our project now has two attachments that can possible be connected to our wave energy converter.



7 Coding

Coding was only for the The robot. It was the simplest part in the entire project. We only needed to sense whether the current ambient light found recorded was too low, if it is it will take one of the 3 actions:

- turn left to the left side which has more light
- turn right to the right side which had more light
- move forward when both light sensor had similar light values

In order to make this more reliable, we added a threshold value so that the robot will not waste unnecessary energy but adjusting itself too much. It only needs to move in the general direction and when it senses that there is enough light it will stop in order to decrease the amount of energy expanded to move the robot.

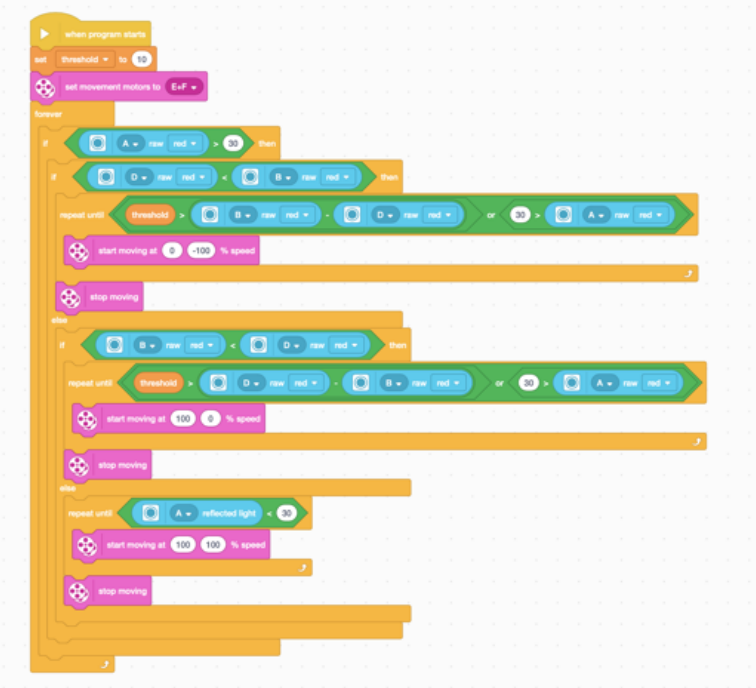


Figure 15: *the code (click for more)*

8 Conclusion

In conclusion, I feel that our idea to build an robot that collect energy from the sun and convert wave energy at night is a good idea. It is entirely feasible and can be easily implemented to our current society. We are confident that this idea of ours is able to to a certain extend help to lessen the load of global warming by making full use of any available resources we have.

More perspective of the robot can be seen in the 2 minute demonstration video we included in the same drive. Thank you for taking the time to read this report.

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