By Shayarna Cohen

Hydro Generator

Aim:

The aim of this project is to produce reliable energy from a renewable energy source without relying on natural or non-renewable energy sources. This project will do this with hydropower which uses head pressure and gravitational forces.

Introduction:

Renewable energy is an important way of producing energy as it produces no greenhouse gases, reducing the impact of climate change and increases economic growth and development. By investing in renewable energy, industry can create jobs in manufacturing, installation and maintenance. Although hydroelectricity is very beneficial for the environment, the source of energy is unreliable as it relies on rainfall, which is limited or completely unavailable to people in certain parts of the world.

Hydroelectricity that is currently used relies on natural flowing water such as rivers, tidal and wave energy. This is limited as the hydropower can only be generated at places that have flowing water, and places far from these locations miss out. The hydro powered generator ideally would only need a small amount of water, which is recycled through the generation process so there is no need to continuously supply the water and it doesn't rely on natural flowing water such as a river or ocean. A set up such as this could be useful in remote tropical island communities that receive regular tropical rainfall and are less likely to have access to power.

Design Brief:

The first prototype was a basic ram pump which had minimal output and a large amount of wastewater. The next models were refinements aiming to increase the amount of pressure and output whilst keeping the same amount of waste water. Refinements made throughout the project included longer PVC pipe, an increased input hole, and adjustments in the angle and height of the water reservoir.

The following images and diagrams will help to explain how the ram pump works.

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Figure 1: The final prototype below shows the key elements of the design.

Figure 2: Final prototype image of ram pump:

Figure 3: Final prototype image of reservoir and saved water

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Figure 4: Final image of up-close ram pump

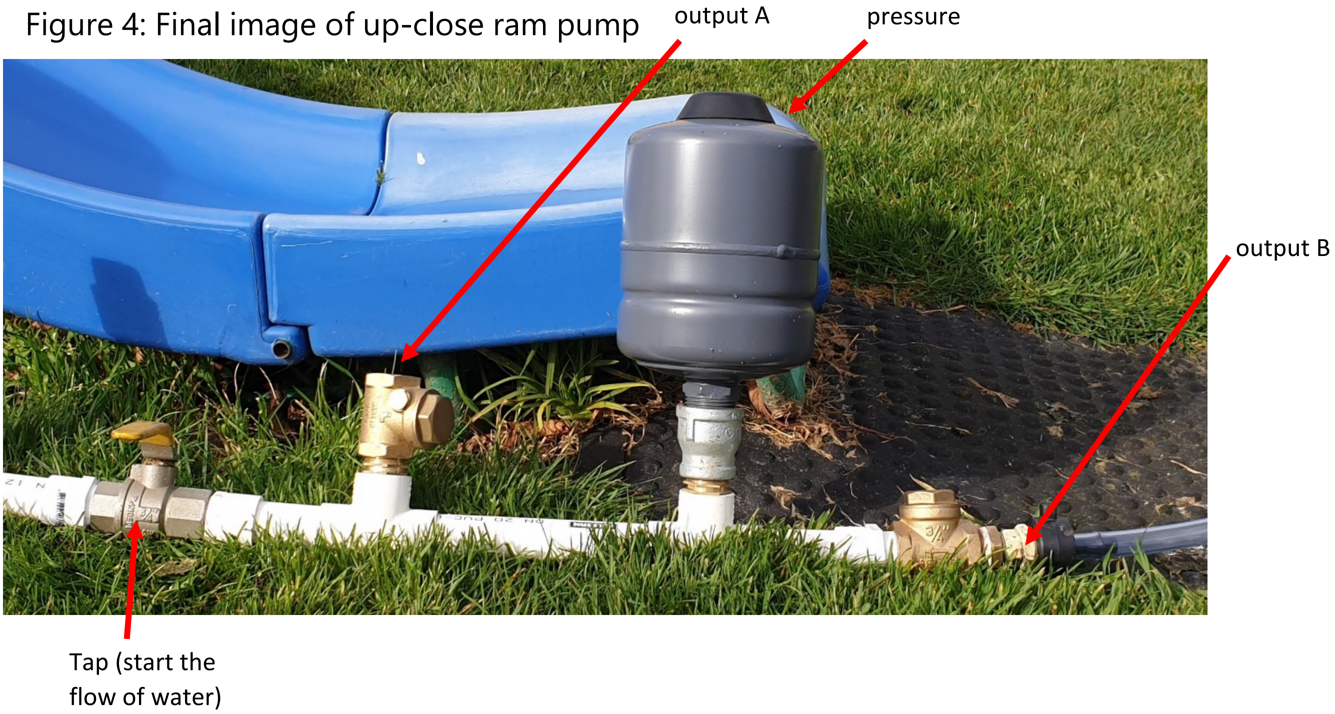


Figure 5: Below is the final ram pump prototype design with key elements labelled

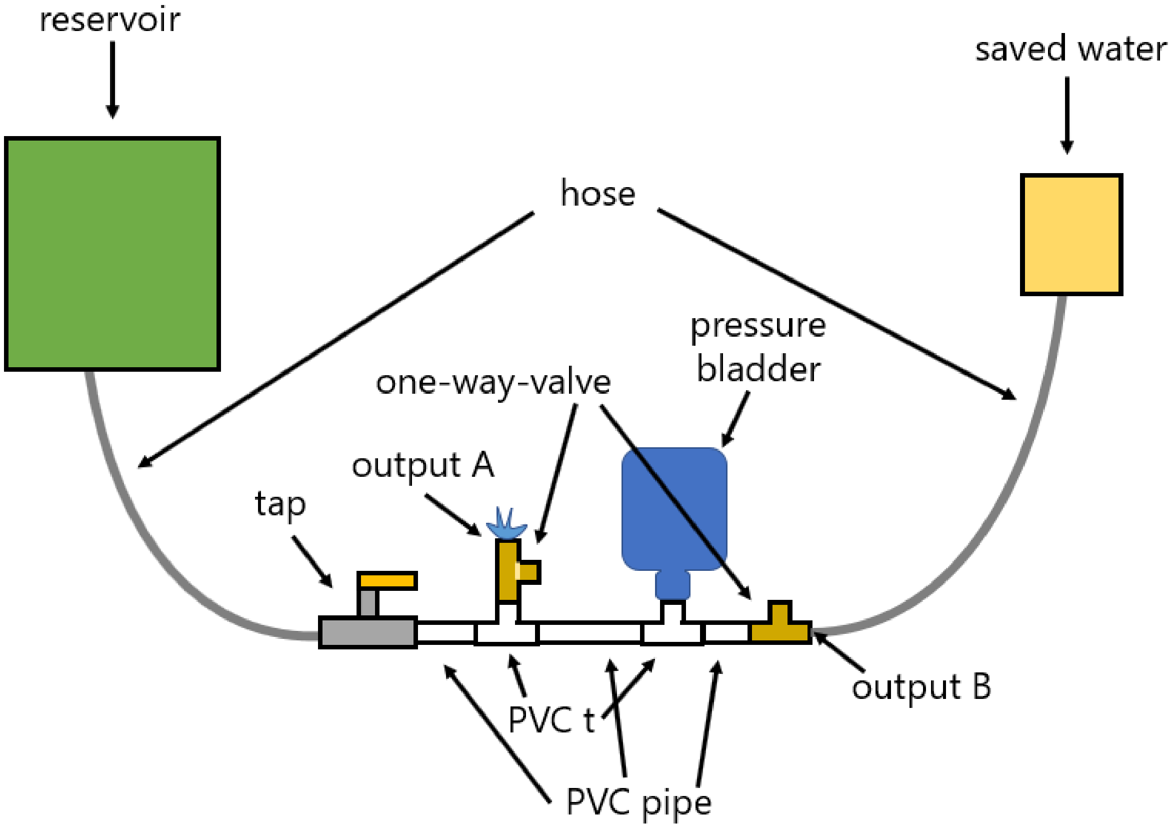


Figure 6: ram pump design not pressurised (blue arrows = movement of water)

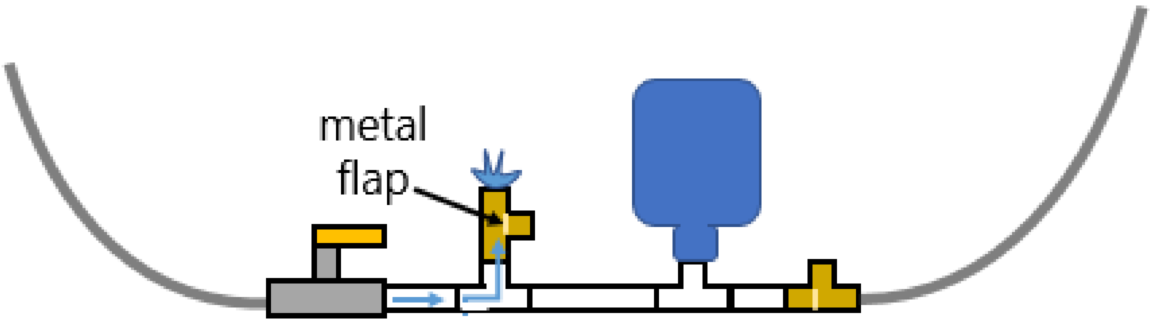


Figure 7: ram pump design pressurised (blue arrows = movement of water)

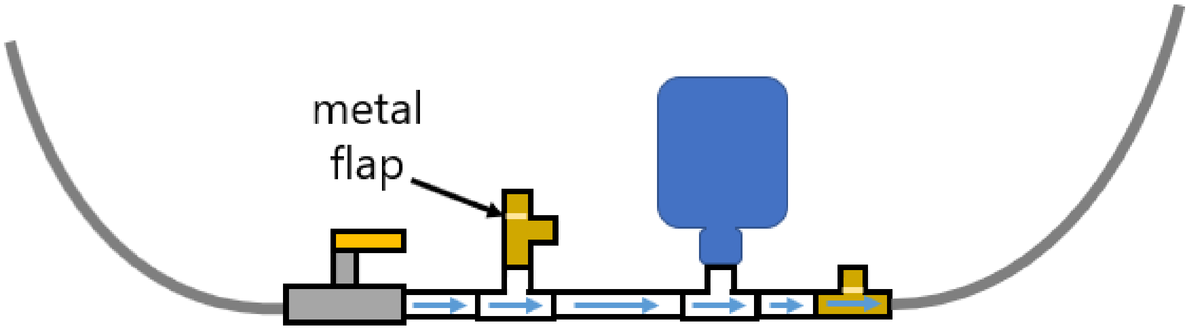
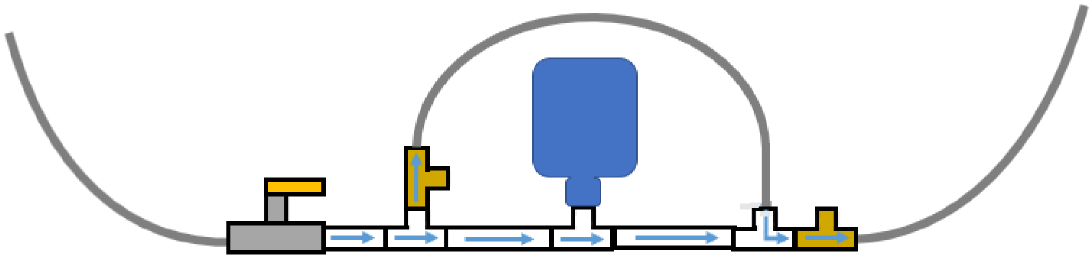


Figure 8: improved ram pump design (blue arrows = movement of water)



Results:

	Water Saved (ml)
Test 1	485ml
Test 2	500ml
Test 3	600ml
	Average: 528

The final prototype had a water saving total average of 528 ml per 10 litres which is equivalent to a saved percentage of 5% ((528 ÷ 10,000) * 100). This amount of saved water makes it insignificant to calculate the flow rate as it is such a small percentage of water.

Discussion:

Ram pumps are a reliable way to transport water as they require no electricity to run. They are particularly common in rivers to transport water to houses located uphill as there is a natural flow and the wastewater produced will not be overly wasted. The technology of the pump involves gravity, and pressure. The gravity takes place in the fall between the bucket and the ram pump which creates head pressure. The water from the input first reaches a tap which initially controls the pressure going into the ram pump. The water then goes from the tap to a one-way-valve (one-way-valve A). The one-way-valve is placed vertically on a tee and lets water flow through, out of two openings: one vertical and one at a 90° angle pointing upright (Figure 5). The water then flows through PVC pipe to a pressure bladder which adds additional head pressure resulting in an increased flow of water (Figure 5). The water then flows through a second one-way-valve, one-way-valve B, and to the output.

The water has two outputs; output A, and output B (Figure 5). Output A is located at the top of the first one-way-valve and is considered wastewater as it leaves the ram pump. Output B is located at the end of the second one-way-valve and is considered saved water as the water goes through a hose and to a house or, in theory, through a water turbine to generate electricity. When the ram pump is first set up, the pressure closes the first one-way-valve, but the water doesn't pass the height of the starting water flow (Figure 7). After manually pushing on the metal flap of first one-way valve the pump should begin working and simultaneously push water through both output A and B. When the ram pump is under no head pressure, one-way-valve A will be open and one-way valve B will be shut (Figure 6). When the head pressure from gravity is produced, one-way-valve A will be forced shut and the water will flow through to one-way-valve B and force the flap open to push the water upwards (Figure 7). Once the pressure is released, one-way-valve B will be forced shut, releasing one-way-valve A to open to return to the non-pressurised condition (Figure 6). This process then repeats to push water continuously higher than the initial reservoir. After starting once, the pump can reach a point called 'primed' meaning the pump will work without needing the manual start, even if the pump runs out of water.

As stated in the results, there was negligible flow rate produced by the ramp pump. A fault that made the ram pump less efficient were the air bubbles created in the hose. This made the hose unable to fill completely up and made the flow of water less efficient. To resolve this, one could add a bleed-nipple which releases air whilst keeping head pressure and increases the input water flow.

An attempt was made to address the low flow rate. The first modification was to change the length of the PVC pipe between the two PVC tees. This increased length added additional head pressure which improved the flow rate by a small margin. The

diameter of the reservoir vessel increased the initial flow rate to the pump and decreased the start-up time for the ram pump and overall made the pump more efficient marginally.

The biggest fault was the wastewater produced from output A. The design would be useful in areas where there is natural flowing water or constant heavy rainfall but makes the system much more limited and less efficient. This could be improved if the prototype could be readjusted to put the water back into the ram pump (Figure 8).

Conclusion:

The ram pump was overall unsuccessful as it didn't produce enough water to generate electricity and had a large amount of wastewater even after some modifications. With only 5% of the initial water saved, the flow rate was too low to be of any real use in a real-life context.

References & Bibliography:

Aditya, A., Aditya, S. and Hasha, Y., 2015. Hydroelectricity Generation by the Recycling of Water. 2(3), pp.1-5.

US EPA. 2020. *Local Renewable Energy Benefits And Resources | US EPA*. [online] Available at: <https://www.epa.gov/statelocalenergy/local-renewable-energy-benefits-and-resources> [Accessed 4 September 2020].

Acknowledgements:

Ms Prior - teacher: Help with knowing the requirements of the TSTS competition. Help with writing.
Jenny - teacher: Advice on equipment and help with initial prototype design
David Cohen - Dad: Help with the pipes and fittings, engineering the design
Scott Cohen - brother: Advice on engineering design

Appendix:

Logbook:

Week 1 | 27th of July - 2nd August:

31st July: drew first design sketch (Jenny, Ms Prior)

Week 2 | 3rd - 9th of August:

3rd of August: got some supplies from dad for the ram pump (1x pressure bladder, 2x 1-way valves, 2x tees)

7th of August: began writing and understanding how a ram pump works, found more supplies (in shed) (ram pump: 2x tee, got more supplies with dad (ram pump: ¾ inch PVC pipe)

Week 3 | 10th - 16th of August:

15th of August: dad found and bought rest of supplies (),
16th of August: built first and second prototypes

Prototype 1:

initial problems: one-way valve was wrong way, bucket needed adjustment
result: successful prototype but low output flow

Prototype 2:

changes made: added longer PVC pipe between first one-way valve and pressure bladder
problems: no problems
result: only slightly increased flow but still not enough water to generate electricity

Week 4 | 17th - 23rd of August:

19th of August: background research of renewable energy (general websites for all renewable energy)

Week 5 | 24th - 30th of August:

26th of August: background research of renewable energy (solar background)
28th of August: renewable energy research, wrote about how I began my investigation

Prototype 3:

changes made: increased hole size
problems: NA
result: increased water but still not enough

Prototype 4:

changes made: angled bucket and lowered hose
problems: NA
result: much better water flow from output and input. still too much water loss

Week 6 | 31st of August - 6th of September:

4th of September: wrote introduction, design brief and discussion

test 1:

aim: to measure how much water saved and how much is lost if the saved reservoir is level with the output reservoir
problems:
result: with a total of 10 litres of water
saved: 750 ml
lost: 9,250ml

Prototype 5:

aim: to measure how much water is saved and how much is lost when the saved water reservoir is 400mm higher than the output reservoir

changes made increased height of saved water reservoir
problems: NA
result:
test 1:
saved: 485ml
lost: 9,515ml

test 2:
saved: 500ml
lost: 9,500ml

test 3:
saved: 600 ml
lost: 9,400ml

average water saved: 528.3

Week 7 | 7th - 13th of September:
9th of September: wrote discussion

Week 8 | 14th - 20th of September:
18th of September: wrote risk assessment
20th of September: wrote results, discussion

Week 9 | 21st - 25th of September:
21st of September made prototype designs
22nd of September: took ram pump video
25th of September: proofread and edited submission

Risk Assessment:

SCIENCE AND ENGINEERING INVESTIGATION AWARDS

RISK ASSESSMENT

This form is required for all Science and Engineering Investigation Awards projects. **This form should be completed before you start your investigation or design project.**

Student's Name/s:	Shayarna Cohen
Year Level:	Grade 10
Teacher/Mentor:	Mrs Prior
Title of Project:	Hydro Generator

You will need to answer Questions 1 and 4 for all projects. You will only need to answer Questions 2 and 3 if you are using hazardous materials, equipment or potentially hazardous biological agents.

You must include a copy of this form with your investigation or design project report.

1. **Investigation/Design project risks**

a. List the risks involved in your project. - Possible foot injury from dropping heavy pressure bladder when testing - Hack saw could cause injury when cutting pvc pipe. - Slipping due to water spillage on slippery surface
b. Describe the safety precautions and procedures that you will use to reduce these risks. - When testing, wear appropriate footwear in case of dropping pressure bladder - Quickly dry any spills that could be hazardous

2. **Specific hazards (if applicable)**

a. List all hazardous chemicals, activities, and/or equipment that you will use.

Hack Saw

b. List any potentially hazardous biological agents that you will use.

n/a

c. Describe the safety precautions and procedures that you will use to reduce the risks associated with hazardous chemicals, activities, equipment, and/or any potentially hazardous biological agents as listed above.

- Use a clamp to secure pvc and have adult supervision when using the saw, if needed

3. **Disposable of hazardous materials (if applicable)**

Describe the disposal procedures of any hazardous chemicals or potentially hazardous biological agents that you will use.

n/a

4. **References**

List the source(s) of safety information you used, including websites, books or laboratory safety guidelines. Jenny Brazier - Lab Technician at Smithton High school David Cohen - Father

☑ I/We have talked with my/our teacher/mentor about the **risks** associated with this project and how I/we will manage these.

☑ I/We have discussed with my/our teacher/mentor about any **specific hazards** associated with this project and how I/we will manage these, including the safe disposable of any hazardous materials.

Signed: Sarah Prior (Teacher)

Date 20/9/20

Shayarna Cohen:

Shay

Video:

https://drive.google.com/file/d/1WTfv1BinYPgzVlBHvdLYkKmpR9Tt2V1F/view?usp=drivesdk