

**PROJECT ID:**

**TITLE:**

**KEYWORDS:**

**AGE OF STUDENT(S):**

**TABLE OF CONTENTS**

**DECLARATION.....3**

**DEDICATION.....3**

**ACKNOWLEDGEMENTS .....4**

**ABSTRACT.....4**

**INTRODUCTION.....5**

**RESEARCH .....8**

**PROTOTYPE .....12**

**DISSCUSION .....16**

**CONCLUSION.....17**


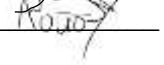
**REFERENCES .....18**

## DECLARATION

### Declaration by Candidates

This project is our original work and has not been presented by any other contestants. No part of this project may be reproduced without the prior written permission of the authors and/or the college.


Date: 10.02.2021

Candidates: Matej Milosievski – Signature   
Andreja Popovikj – Signature 

### Declaration by Supervisor

This project has been submitted for further examination with my approval as supervisor.

Date: 10.02.2021

Supervisor: Sabire Alkin – Signature   
Institution: Yahya Kemal College - Skopje

## DEDICATION

We hereby dedicate this research paper and project to our most esteemed lecturers, college staff and our beloved parents for their highly appreciated contribution during the making of this project. In recent years, frequent extreme weather such as typhoons, torrential rainfall, and large-scale forest fires has spread awareness about climate change and global warming as a matter of urgency across the world, and each country has accelerated its efforts to address climate change. Our environment is what houses and helps our ecosystem grow and thrive. Without protecting and taking care of our environment we're putting so many lives at danger such as animals, plants and crops, and even our own. All of the ecosystems that make up our environment are deeply connected. One change to an ecosystem could completely change the dynamic that has been created. One of the major reasons why we need to work towards protecting the environment is because it helps to protect humanity. If we didn't have our environment, then we wouldn't have a place to live or resources to live off of. When thinking about reasons why we should protect the environment we should know that it is our moral obligation to do so. As humans who live on earth, it is our responsibility to make sure that it is protected. Despite our age, we truly believe that students like ourselves can contribute equally to this matter as adults. We may achieve this through the increased use of renewable energy sources and lowering the total human related pollution through providing more biodegradable/ recyclable products for everyday use, hence, that is why we created this project. Hopefully, our project: "AM:PM SMART MUG: ECO-FRIENDLY, 3D PRINTED MUG W/ SOLAR POWERED WIRELESS CHARGER" is just one of the many steps that needs to be taken, in order to create an Eco-friendlier, safer and self-sustainable tomorrow both for ourselves and all future generations to come.

## ACKNOWLEDGEMENTS

We would like to thank our families for their continuous support throughout the project. Thank you, to our supervisor Ms. Sabire Alkin for her guidance and provided experience. A wholehearted thank you, to everyone who took part in the survey we conducted, both from Yahya Kemal College – Skopje and beyond. And last, but not least, we would like to thank our dear friend, Mr. Sashe, who provided us with a 3D printer for printing out the first prototype of our product. Not necessarily related, but still worth a mention are the time, effort and dedication that were given by all healthcare workers in our country and throughout the world during our fight against COVID-19. Thank you for taking care of our health and giving us young students the opportunity to work on what we love even in these challenging times.

## ABSTRACT

This project's purpose is lowering the CO<sub>2</sub> emissions and amount of plastic being produced by providing the public with a product for everyday use, which is Eco-friendly, recyclable/biodegradable and practical at the same time. We created the "AM:PM SMART MUG - ECO-FRIENDLY, 3D PRINTED MUG W/ SOLAR POWERED WIRELESS CHARGER".

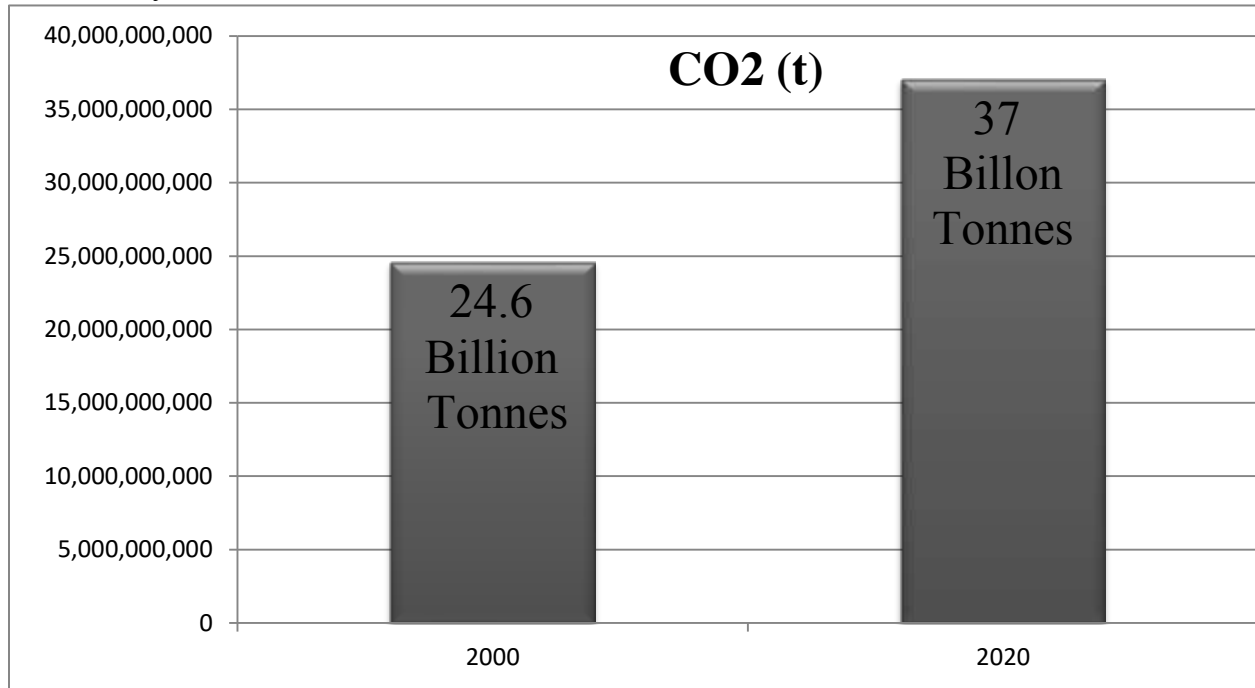
As previously mentioned, the AM:PM smart mug is product that is practical for everyday use. It can be used both in a casual manner, during physical activity and during professional occasions. We put in extra effort to supply the most Eco-friendly version of each component, while keeping the costs as low as possible.

The AM:PM smart mug is a thermal mug with a solar powered charger/s integrated in its cap. The cap basically resembles a solar power bank with a 5000 mAh lithium battery, a 5V/1A USB output and a 5V/1A, 5W wireless charger output, while still serving as a cap for the thermal mug.



## INTRODUCTION

Climate change has sadly become a part of our everyday life. There is rarely any good news. Only increasing graphs and more milestones passed each day. Almost every year breaks some new record, from the harshest heat wave, to the most rapid glacier melt. It's simply endless, and relentless. We've known for decades that rapid climate change has been caused by the release of greenhouse gases. But instead of reducing them, in 2019 the world was emitting 50% more CO<sub>2</sub> than in the year 2000.



And emissions are still rising. Why is that? Why is it so hard to just stop emitting these gases? Our collective CO<sub>2</sub> emissions can be expressed as a product of four factors and their relationship with each other. Two of them explain why worldwide CO<sub>2</sub> emissions are still rising, and two explain how we can stop that.

1. Population size:

People need food, homes and clothing. They demand luxury products, and always keep demanding for more. More people = Higher CO<sub>2</sub> emissions. It is a very simple equation. The global population is growing, and according to the UN, it will level off at about 11 billion in year 2100, which is 40% more than today. The only way to slow down this growth is investment in healthcare and education in developing countries. But even with massive investment, it will take a few decades for the effects of lower birthrates to manifest themselves, so the global population will keep growing for the foreseeable future, and, as a consequence, global CO<sub>2</sub> emissions rise over the next few decades.

2. Economic growth

The richer and more developed we are, the more emissions our lifestyle produces. The world's wealth is growing almost everywhere. And although it's far from easily distributed, economic growth has led to the highest standards of living, and the largest reduction in extreme poverty in human history. Growth has become the dominant mantra of the world's economies, no matter what kind of political system they have. It's unlikely that rich countries will give up the concept of growth any time soon. But even if they were to, developing countries want to become rich too. For billions of people, the end of growth would probably mean staying poor and so developing countries are not willing to stop growing their economies. All in all, we can agree that as guiding economic ideology is not going to go away any time soon. More countries and their citizens around the world will grow and become richer while the rich economies will continue to grow their wealth. There are some signs that growth can be decoupled from CO<sub>2</sub> emissions, but we are not close to that, yet. As a consequence of this growth, CO<sub>2</sub> emissions will rise.

3. Energy intensity

Energy intensity describes how efficiently we use energy. The more efficient something is, the less energy we need to do something. So making our technology more efficient and coming up with more efficient ways to organize our societies is one of the most important ways to reduce the modern world's CO<sub>2</sub> dependency. This can mean everything from reducing power consumption with A.I., the electrification of the transportation and industrial sectors, or sustainable production. The opportunities for improvement are almost limitless, and human ingenuity can run wild. But we know that increasing efficiency alone will not be enough, mostly for three reasons.

1. Direct rebound effects:

This means that once something becomes more efficient, it is used more, and so overall, the increased efficiency does not lead to a reduction as impressive as you would first think. Or worse, sometimes more efficiency makes humans use not \*less\* of a resource, but more of it. So making things more efficient does not automatically mean more energy use in total. It might have the opposite effect.

2. Indirect rebound effects:

Sometimes when you save money on a thing that becomes more efficient, you might spend it elsewhere.

3. Less return on investment:

The more you optimize for efficiency, the harder and more expensive it becomes to get more efficient. So, over time, the return on investment slows down. And, with many technologies, we are already pretty efficient. But, regardless of how efficient we make our economies; as long as we need at least some energy, we will have emissions. Efficiency alone won't create a zero-carbon world.

4. Emissions per energy unit produced

Humanity's global carbon footprint is the CO<sub>2</sub> released per energy unit generated. The more fossil fuels we burn, the higher our CO<sub>2</sub> output. Fossil fuels are the greatest lever humanity has right now of course, it is impossible to shut down coal and oil overnight without throwing society into chaos. But the reality is that we are not doing nearly enough to keep fossil fuels in the ground and use lower-carbon alternatives. We need to do 2 things to speed the transition away from fossil fuels. Firstly, we need to use the real leverage we have today, with today's technology. There are a lot of things we can do extremely quickly. We can cut subsidies to the fossil fuel industry, and funnel them into renewables. We can price carbon emissions harshly, and increase the price each year to create strong incentives for the world's industries to transition. We can enforce strict standards for energy efficiency, and for any type of new construction. Next we also need to invent new and better technology. Without new technologies and innovation, it will be impossible to achieve a zero CO<sub>2</sub> emission world, be it from technologies like carbon capture, or a new generation of nuclear/solar power plants, to new batteries that revolutionize the energy storage from renewables.

This is exactly why we decided to come up with a project through which the consumer will indirectly reduce CO<sub>2</sub> and plastic being produced, while being a product that can be used in multiple occasions of everyday living.



## RESEARCH

The rapid urbanization worldwide with the rising demand for electricity in developing countries is a crucial factor driving the solar energy market's market size. The increasing adoption of renewable resources that will not exhaust with time and can be used as efficiently as non-renewable sources is a contributing factor fuelling the global solar energy market's growth. Recent government initiatives to control the exhaustion of greenhouse gases and carbon emissions, which are the reasons for global warming, are propelling the demand for renewable and clean energy like solar energy harvesting. These initiatives focus on avoiding the use of fossil fuels and use solar energy. Increasing Industrialization also plays a significant part in boosting the global solar energy market as Industries are now demanding to use efficient and renewable energy. Technological advancements by the manufacturers like ultrathin wafer solar cells, dye sensitizers, and anti-reflection coating are some of the major driving factors of the solar energy industry. Solar energy is produced by converting energy from the sun into thermal and electrical energy. Solar technology can harness energy from the sun for various uses, including electricity generation, heat energy generation, etc. The global Solar Energy Market size is projected to reach USD 243.95 Billion by 2027. This is exactly why we decided to choose solar energy, as the primary source of energy in our product. But we wanted to get the opinion from the locals as well. For that reason we decided to conduct a short survey regarding their perception of the use of solar energy on a local and global scale.

### 1. Survey

The format and instructions of the survey were provided as the following:

\*The goal of this survey is to create a general idea of the public's perception on the given topic through the supplied data.

\*The responses to this survey will remain completely anonymous.

\*This survey is composed of 5 short YES/NO questions and should approximately take 1-2 minutes to be completed.

\*Feel free to answer honestly. There are no right or wrong answers.

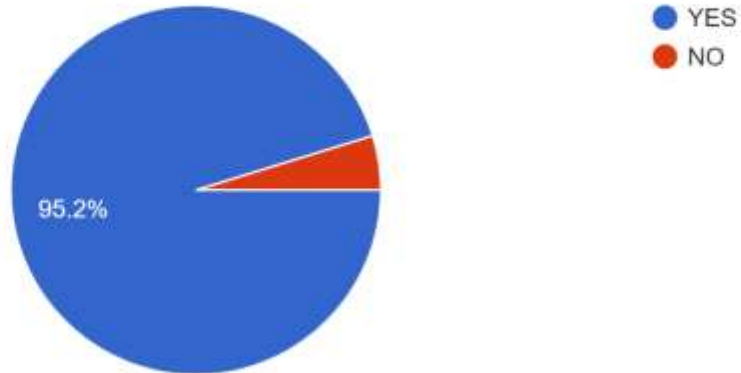
### 2. Survey Statistics:

The survey was filled in by a total of 1050 respondents ranging all the way from 10 to 40+ years old.



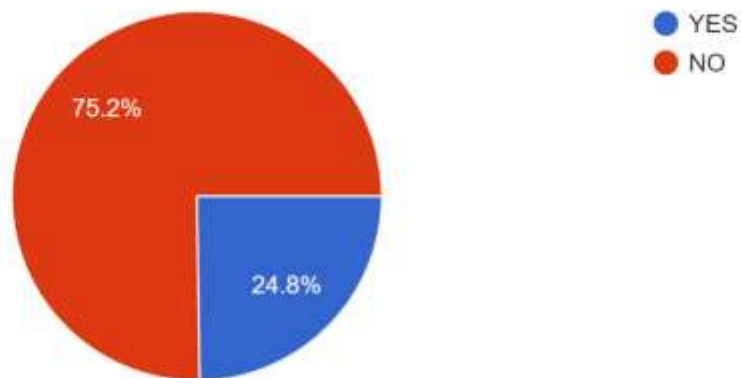
Are you familiar with the concept of solar energy?

1050 responses



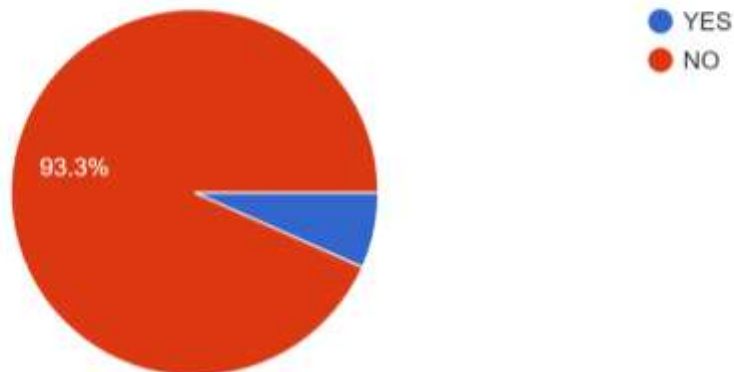
Is the concept of solar energy implemented/ utilized enough on a global scale?

1050 responses



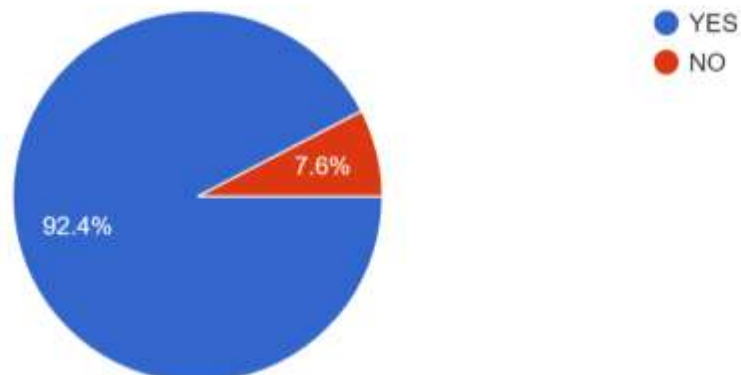
Is the concept of solar energy implemented/ utilized enough in your country?

1050 responses



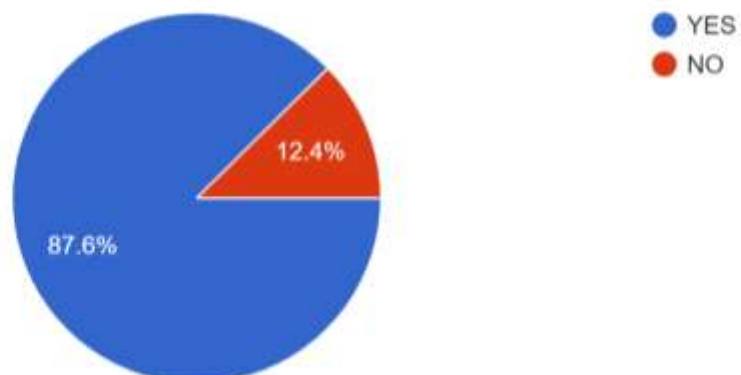
Besides the typical usages of solar energy, (residential/holiday properties; central power stations; solar water heating systems...) could the concept...emented into other segments of our everyday life?

1050 responses



Could solar energy be implemented in smaller devices, therefore giving it a portable aspect and making it easily accessible for everyday use?

1050 responses

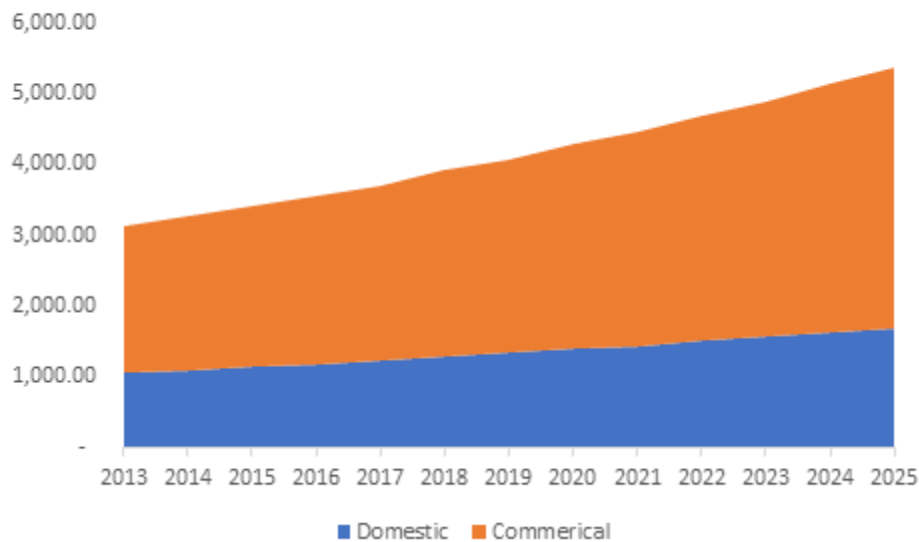


With the help of the above mentioned data, we can easily conclude that solar energy has an enormous potential for future implementation. Sadly, it isn't nearly utilized enough at the moment. But instead of implementing typical solar panels, why don't we implement solar power systems into smaller gadgets and accessories that we humans often use?

Well, that is exactly what we decided to do. We tried implementing a solar energy system into an everyday drink-ware product/ a mug.

Drink-ware market size is estimated to exhibit 29% Compound Annual Growth Rate (CAGR) by 2025 and is expected to hit USD 35 billion from \$25 billion in 2018. The surge in the demand will be fueled by consumer inclination towards convenient and easy to handle drink-ware products, which in turn will help propel the growth of the global market. Bottles and mugs are utilized for consuming beverages and water. These are manufactured from polymers, metal, glass, and ceramic. Bottles, tumblers, shakers, and infusers are majorly made from polymer owing to their lightweight and low cost. Ceramics are utilized to manufacture mugs and cups due to their great strength and durability. These products are used for storing water and beverages during travelling and camping. Bottles, tumblers, mugs, and infusers are used for travelling and professional purposes. Metal tumblers, mugs, and bottles provide insulation to the inside contents thus, are used by bikers and trekkers during adventures. Drink-ware market demand will be supported by growing travel and tourism activities owing to rising disposable incomes and favorable government initiatives. Drink-ware products including bottles, mugs, tumblers, infusers, and cups are distributed through multiple distribution channels including supermarkets, independent stores, E-Commerce channels. Consumer's inclination towards online drink-ware purchasing of products for its easy accessibility and availability will lead to upward trend in sales figures.

**U.S Market for Mugs and Cups Size By Application, 2013 to 2025, (Million Units)**



## PROTOTYPE

Before even conceptualizing a 3D model for the prototype, we gave in extra effort in research and sourcing of the most Eco-friendly yet affordable materials and components for our product. For our first prototype we decided to use the following materials:

1. Materials:

- For our choice of plastic, we decided to use PLA instead of BPA which is typically used. BPA - Plastic is a part of so many families' daily lives. We use it to package sandwiches and snacks, bring lunches to work and school, carry water, and more. While plastics have become safer in recent years, BPA plastic is still commonly used despite its many risks. BPA can affect not only your family's health, but the health of the environment as well by damaging animals and their habitats. Switching to non-plastic alternatives or using safer plastics, such as those used in bento lunch boxes, can help reduce the impact of plastics like BPA on the environment. BPA can have an impact on wildlife, particularly on aquatic life in both freshwater and saltwater areas, which become reservoirs for contaminants. BPA has been known to mimic hormones and disrupt endocrine systems, including the kidney, liver, and gallbladder. Inhaling air or ingesting something that contains BPA may cause nausea, vomiting, and other symptoms in humans, and animals may experience the same effects if they are exposed to these chemicals. This can cause the animals to die off at larger rates, disrupting the ecosystem's structure and affecting other animal and plant life nearby.

PLA - Polymers / plastics have a reputation of being environmentally friendly. They take years and in some cases centuries to decay. However, plastic bags made from Polylactide (PLA) take only five years to decompose. Containers such as drinking bottles and food containers manufactured from PLA, take slightly longer (about six to seven years) to decay, as they are manufactured from thicker material. Polylactide is referred to as a 'bio plastic' because of its environmentally friendly nature. Polylactide (PLA) is a renewable thermoplastic and a polymer. It is 'processed' from the starch of plants such as corn, sugar cane and sugar beet, making it environmentally friendly and sustainable. Fermentation of the sugars from these plants produces lactic acid and after further reactions, lactide forms. After more processing and polymerization, polylactide resin is produced. The resulting resin can be injection and blow molded, to form disposable products including those shown below. Polylactide is biodegradable, as it decays as a result of exposure to the ultra violet rays of sunlight and oxygen. It decomposes forming carbon dioxide and water, which present no danger to the environment.

- For our choice of liquid/food container, we decided to use stainless steel instead of aluminum which is typically used.

Stainless steel is made up of iron, chromium, nickel, manganese and copper. The chromium is added as an agent to provide corrosion resistance. Also, because it is non-

porous the resistance to corrosion is increased. Aluminum has a high oxidation and corrosion resistance mainly due to its passivation layer. When aluminum is oxidized, its surface will turn white and will sometimes pit. In some extreme acidic or base environments, Aluminum may corrode rapidly with catastrophic results. Aluminum has a much better thermal conductivity (conductor of heat) than stainless steel. One of the main reasons it is used for car radiators and air conditioning units. But because there is a risk factor of the aluminum conducting too much heat, hence possibly melting/deforming part of the plastic, we decided opted for stainless still a good heat conductor. Aluminum is fairly soft and easier to cut and form. Due to its resistance to wear and abrasion, Stainless can be difficult to work with. Stainless steels are harder and are especially harder to form than aluminum. This means that our product would have a better structural integrity. Stainless steel is a really poor conductor compared to most metals. Aluminum is a very good conductor of electricity. Due to its high conductance, light weight, and corrosion resistance, high-voltage overhead power lines are generally made of aluminum. Because we are using electronics in our product, stainless steel is obviously a better choice. Stainless steel is less reactive with foods. Aluminum can react to foods which may affect color and flavor. A product which is made from stainless steel such as stainless steel wire or stainless steel banding will never become useless at the end of its life and this is because stainless steel can be separated systemically and thus can enter the recycling system. Recycling is deemed viable when applied to stainless steel because within the stainless steel is iron, nickel, chromium all which are raw materials and so the process of recycling stainless steel is carried out globally all over the world. Production and recycling are not separate stages in the life of stainless steel it is important to notice that they are one and the same process. Any stainless steel object has about 60% recycled content within it. Stainless steel therefore isn't consumed but is rather sustained.

- For our choice of energy storage unit, we decided to use a lithium battery instead of a lead-acid battery which is typically used.

The single-biggest environmental issue with lead-acid batteries involves the lead component of the battery. Lead is a heavy metal with potentially dangerous health impacts. Ingestion of lead is especially dangerous for young children because their brains are still developing. The primary issue with lithium-ion recycling is that beyond smaller batteries used in consumer electronics, relatively few lithium-ion batteries (compared to lead-acid batteries) have reached the end of life stage because they haven't been in the market all that long and they last a long time. Further, because lithium isn't a toxic heavy metal like lead, there has been far less pressure to recycle these batteries. Nevertheless, the issue will have a growing profile as growing numbers of lithium-ion batteries reach the end of their usable life. The good news is that there are companies that are working on it. Li-ion batteries can be recycled at rates as high as lead-acid batteries, but the issue

has simply not yet been viewed as one of critical importance. Hence, that is the primary reason why companies such as Tesla use lithium-ion batteries.

2. Components:

- Custom PLA 3D Printed components (4 in total):

Cap (section 1)

Dimensions: 11,4cm (diameter) x 2,2cm (height)

Cap (section 2)

Dimensions: 11,4cm (diameter) x 0,2cm (height)

Cap (section 3)

Dimensions: 11,4cm (diameter) x 2cm (height)

Cup

Dimensions: 9-11,4cm (diameter/top and bottom) x 19,5cm (height)

- Battery

Dimensions: 11,2cm (diagonal)

Capacity: 5000 mAh

Material: lithium

- Power bank circuit board

Dimensions: 6cm (length) x 3cm (width)

Output: 1A – 2 USB outputs;

- Wireless Charger

Dimensions: 7cm (diameter) x 1cm (height)

Compatibility: Compatible with all wireless devices optimized for wireless charging

Charging: 5W wireless charging

Input: 5V/1,5A

Output: 5V/1A, 5W

- Circular solar panel:

Dimensions: 7cm (diameter) x 0.2cm (height)

Current: 100 mA

- Stainless steel mug

Dimensions: 7cm (diameter) x 17,5 cm (height)

3. Used tools:

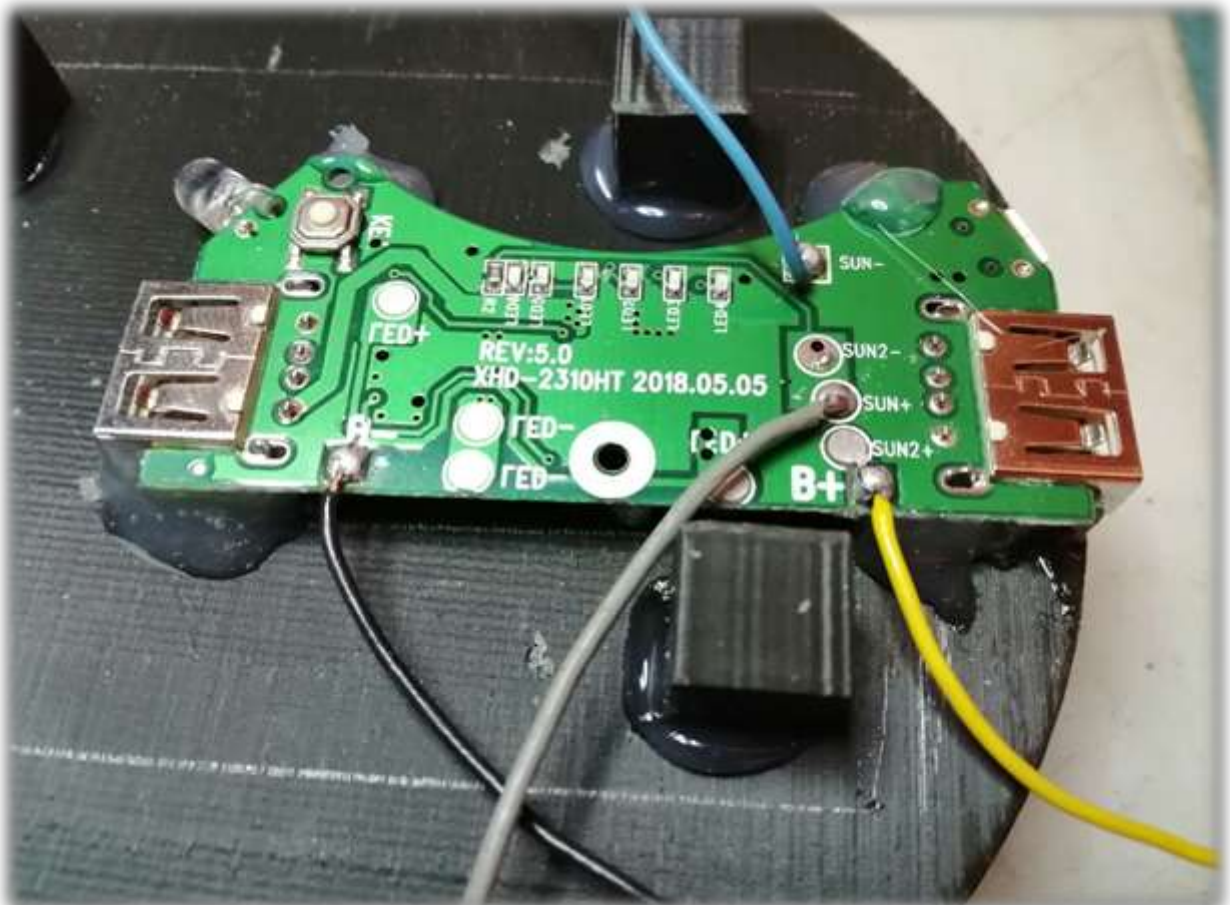
- Soldering gun
- Voltmeter
- Ammeter
- Hot melt adhesive (HMA)
- Spiral forming machine

4. 3D model:

We created 3D model using a program called Blender. The 3D model consists of multiple parts composed all together in 375 648 vertices. The model includes advanced compositing and it is adapted for 3D printing in multiple exported files.

## 5. Assembly

After testing the fit of our 3D printed parts, we inserted the stainless steel mug in the 3D printed cup which serves as a mold that holds the stainless steel mug. After that, we HMA to connect the power bank circuit board to cap (section 2). Afterwards, we placed the circular solar panel on cap (section 1) and strengthened it with HMA, whilst keeping track of the two protruding wires. We added the battery above the power bank circuit board which was previously placed on cap (section 2). Then, using a soldier gun, we connected the two wires from the circular solar panel to sections SUN- and SUN+ of the circuit board which resembled the input. Right afterwards, we soldered the two protruding wires from the battery to sections B- and B+ which resembled the power storage/supply. We connected our wireless charger to one of the USB outputs and placed in on cap (section 3). We immediately tested the circuit to make sure everything was connected the way it should be. Finally, we connected cap (section 1), cap (section 2), cap (section 3) using a hinge that was part of the 3D model and a simple screw. And so, our first prototype was complete.



## DISSCUSION

There are many aspects which make the AM:PM smart mug eco-friendlier, more useful and more practical in comparison to other products available on the market such as single use paper cups, plastic bottles or regular mugs. The obvious benefit is the solar powered charger, which resembles the cap of the AM:PM smart mug. For the first time, smartphone shipments have reached 1 billion. That probably means a lot of calling, texting, and app use. It also means a lot of phones being plugged into the grid and charging. A new study by analyst Juniper Research found that smartphone charging could soon be a massive generator of carbon dioxide, which is one of the greenhouse gases thought to cause global warming. According to the study, greenhouse gas emissions from mobile devices will more than double within five years. Currently, the world is generating more than 6.4 megatons of greenhouse gases from smartphone charging. In 2019, Juniper Research predicted, that the amount would increase to 13 megatons. Those 13 megatons are equivalent to the current annual emissions of 1.1 million cars. The cap of the AM:PM mug directly solves this problem due to its circular solar panel which serves as an input of energy. This means that the implementation of the AM:PM smart mug would lower the annual total amount of greenhouse emissions by up to 1.694 kg per person, or up to 13 megatons of greenhouse gases on a global scale. Additionally the annual total plastic production and pollution caused by plastic would be reduced as well. Quite simply, humans are addicted to this nearly indestructible material. We are producing over 380 million tons of plastic every year, and some reports indicate that up to 50% of that is for single-use purposes – utilized for just a few moments, but on the planet for at least several hundred years. Half a trillion disposable cups are manufactured annually around the world; that's over 70 disposable cups for every person on the planet. What's even worse is that these cups are rarely recyclable or disposable. This means that the implementation of the AM:PM smart mug would lower the annual total amount of plastic being produced by 5.278 kg of plastic per person, or up to 40.5 megatons of plastic on a global scale. If the single-use were to be made out of paper, this would mean that the annual total production would be lowered by up to 0.653 kg of paper per person, or 5.01 megatons of paper being produced on a global scale. This would mean that around 7.3 million trees wouldn't be cut down by the paper industry. (These calculations were done given that an average plastic cup weighs 75.4 g and an average paper cup weighs 9.34 g)

Price:

The overall price of our product is around 25 € or 30\$ USD. We believe that if our product were to be mass produced, the overall price could decrease by an additional 20%.



## CONCLUSION

We created the “AM:PM SMART MUG - ECO-FRIENDLY, 3D PRINTED MUG W/ SOLAR POWERED WIRELESS CHARGER”. Our product is practical for everyday use and can be used in multiple occasions such as casual, recreational, or professional use. One of the biggest benefits of this project would be that every single component and material can be recycled/ biodegraded in some way or another. The implementation of the AM:PM smart mug would bring many benefits to our society such as:

- Lowering the annual total amount of greenhouse emissions by up to 1.694 kg of greenhouse gasses per person, or up to 13 megatons of greenhouse gases on a global scale.
- Lowering the annual total amount of plastic being produced by up to 5.278 kg of plastic per person, or up to 40.5 megatons of plastic on a global scale.
- Lowering the annual total amount of paper being produced by up to 0.653 kg of paper per person, or 5.01 megatons of paper on a global scale, which in terms of trees transitions to 7.3 million less trees being cut down each year by the paper industry.
- Decreasing the total cases of material related food poisoning.
- Decreasing the total production of lead-ion batteries which would directly lower cases of lead poisoning.



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