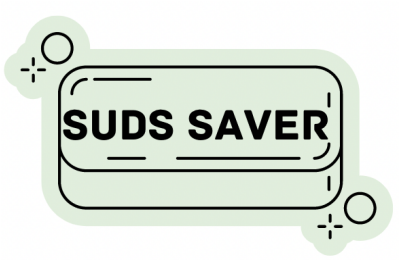
The Suds Saver



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Executive Summary

Bar soap is a commonly utilized hygiene product in households across the world. However, it can become unsanitary after prolonged use. When placed in traditional soap dishes, bar soaps that are left exposed on countertops are prone to the cultivation of airborne particles found in the environment. Additionally, a lack of proper airflow and drainage systems can result in the soap remaining in standing water. This leads to mineral residue, often referred to as 'soap scum,' accumulation on the bottom of the bar soap. This scum alters the original texture and consistency of the bar soap, causing users to remove that area or throw out the entire bar prematurely. Due to these common problems, consumers are more inclined to select liquid soaps as an alternative. Liquid soap leaves a larger carbon footprint because it requires high water usage, large transportation, and an inefficient disposal process. Overall, liquid soap results in a more negative environmental impact due to its inadequate plastic packaging.

The Suds Saver is a product designed to eliminate bacterial contamination and disintegration often found in other bar soap holders. Our product creates a sanitary and durable container that optimizes bar soap's use by utilizing a partially closed container. It uses internal ridges and a tilted mount to drain the water off of the soap bar using gravity and keep it protected from potential spills or aerial transmitted contamination. A magnetic front lid design creates an effortless user experience while being robust enough to hold heavy soap bars. There is also a rotatable stand on the bottom with a suction cup for versatile attachment. Overall, the Suds Saver provides additional protection to soap bars compared to traditional soap dishes while providing improved user experience and comparable efficiency.

We have designed our product to be made out of recyclable polypropylene (PP) with injection molding and overmolding technologies. Polypropylene is characterized by its high melting point, high tensile strength, chemical resistance, and semi-crystalline nature. These properties are suitable for living hinge design, injection molding process, and a durable product structure.

Our manufacturing process requires the recycling of plastic polypropylene products, turning them into pellets, and the transportation of these pellets and the suction cups and magnets to our facility. The pellets will be put in an injection molding machine where overmolding will encase the magnets in plastic. Then the plastic will be cleaned, the suction cups will be attached, and the product will be packaged and sent to distributors.

The soap dish market is primarily composed of long-term bar soap users, the majority being the middle-aged and the elderly. To attract these customers, our product sales will be mainly through physical retail outlets such as Walmart and Target. Since the soap dish market in the United States is fully competitive, our product will be priced competitively to highlight the additional values our design provides the customers with. Among the 2.3 billion people globally expected to gain personal hygiene access in the next ten years by the World Health Organization, we expect to capture 3% - 5% of this market with our soap-saving design. We estimated that the annual sales volume in the United States will be between 336,000 and 725,000 units, and in the international market, between 1 and 2.5 million units a year. We estimate an average net annual revenue of $1.49 million combined from these markets.

This report will include the Suds Savers design concept, manufacturing proposal, economical analysis, and lifecycle study to show the best approach to reducing plastic waste pollution while simultaneously maximizing the use of bar soap. This report also presents a literature review on approaches and standards applicable to the engineering and marketing processes associated with the making and sales of the Suds Saver.

Introduction

Existing soap holders do not consider how bacteria grows on soap and the lack of sanitation in the environment in which the soap resides. Our solution to this common problem in soap usage is the Suds Saver, a bar soap holder that creates a safe and bacteria-free environment for sanitary soap usage. It consists of a plastic container that holds bar soap, allows excess water to drain, and prevents bacteria from getting on the soap and bacteria from growing on the soap.

Existing Products, Patents, and Publications

Existing Products

Soap Case. Existing bar soap containers fail to address many issues with bar soap use. For instance, the Soap Case is a plastic box holding bar soap, as indicated in Figure 1 [1]. Although this box is good at preventing bacteria from attaching to the soap, the box does not drain water to prevent bacteria growth. Microorganisms can grow in a closed environment that does not drain water because they can attach to the hydrophobic tail of soap molecules and take advantage of the water in the surrounding [2], [3]. In addition, if soap is in water for a prolonged time, it will start to disintegrate. The Soap Case failed to address these issues by not being able to drain excess water [4]. Finally, the Soap Case has a small size and rounded shape, making it less friendly to different types of soap shapes.

Figure 1. Soap Case [1]

Figure 2. Soap Box Drain Holder [5]

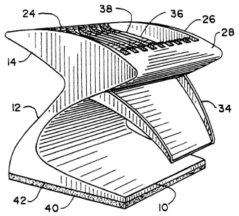
Soap Box Drain Holder. The Soap Box Drain Holder, as indicated in Figure 2 above, is also similar to the Suds Saver [5]. This product is a tilted soap holder that drains out water with a duct. However, the large opening means that small pieces of soap cannot stay within the container securely, thus unable to maximize the value of a bar soap. In addition, it does not provide a cover for the soap, exposing the soap to a potentially unsanitary environment. Lastly, this product is unable to be mounted on slanted or vertical surfaces due to its support structure.

Soap Dish. Perhaps the most common shape of bar soap container is the Soap Dish, as indicated in Figure 3 [6]. The Soap Dish is an open soap holder with grids on the bottom to drain the water. Although this concept is efficient at storing soap, the dish's open environment risks bacteria exposure to the soap, rendering it unsanitary. This design is also different from ours since it is not tilted and cannot attach to a wall. This product's drainage system differs from the Suds Saver's because it consists of water draining out of the bottom of the dish. This drainage system would not be practical for a sink environment, considering that the counter will likely be spilled with drained water.

Figure. 3. Soap Dish [6]

Patents & Publications

Soap Dish. A patent that reports similar existing products is the Soap Dish, as indicated in Figure 4. The soap dish (US 5181606A) is a dish made out of plastic rivets that are shaped to allow consumers to hold a bar of soap without lifting the bar out of its container [7]. The ribs on the dish allow adequate friction to keep the soap in place and the position of the dish allows excess water drainage.



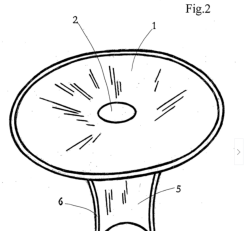
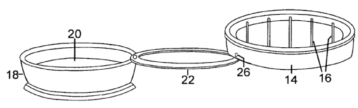


Figure 4. Soap Dish [7] Figure 5. Self Drain Soap Dish [8]

Self Draining Soap Dish. Another publication is the self-draining soap dish (US 2011/0297562 A1) as indicated in Figure 5 [8]. This is a soap dish that stands up vertically and consists of two conjoined parts: an oval bowl on top and a curved base with an arch that projects first upwards and then downwards. This base acts like an open channel, with no covering on top. This product was made as an improvement of the traditional soap dish with a smooth and efficient drainage feature. The dimensions of this publication are as follows: the oval bowl attachment on the top is 5.5 by 3.5 inches, with a 0.75 diameter. It has an inclination of 25 degrees. The channel tilts down 40 degrees and extends two inches from the bowl.

Soap Dish System. The publication of the soap dish system (US 8037999 B1), as indicated in Figure 6 below, can also represent a similar idea to the Suds Saver [9]. This soap dish system relates to the facilitation of the support and movement of the bar soap between an optimal orientation and an ideal storing orientation in order to create a clean, safe, convenient and economical experience for the consumer. This soap dish system consists of a circular soap dish with standing sidewalls to support the bar soap. This dish has an open top, and its base and walls are designed with openings in them so that the water can be effectively drained. The tray in this system has a circular base with an open top and standing side walls for the soap to stay moisturized. The base and walls of the tray are perforated so that the excess water can drain out.



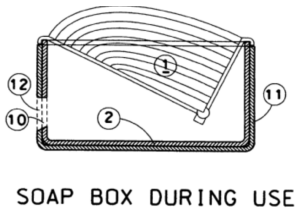


Figure 6. Soap Dish System [9] Figure 7. Soap Box [10]

SoapBox. The soapbox (US 2009/0173644), indicated in Figure 7, is designed to drain water from wet bar soaps efficiently [10]. This box is made up of three parts, the bottom dish, the soap rack, and the top cover. The rack is made out of semicircular bars to support the wet bar soaps, with the flat surface of the bars facing the soap and the curved surface away from the soap. The surface tension draws the film of soap water away from the bar soap and onto the box. The bottom dish and top cover are designed to ensure that the water in the bottom dish does not touch the bar soap and contaminate it.

Product Design

Design Requirements

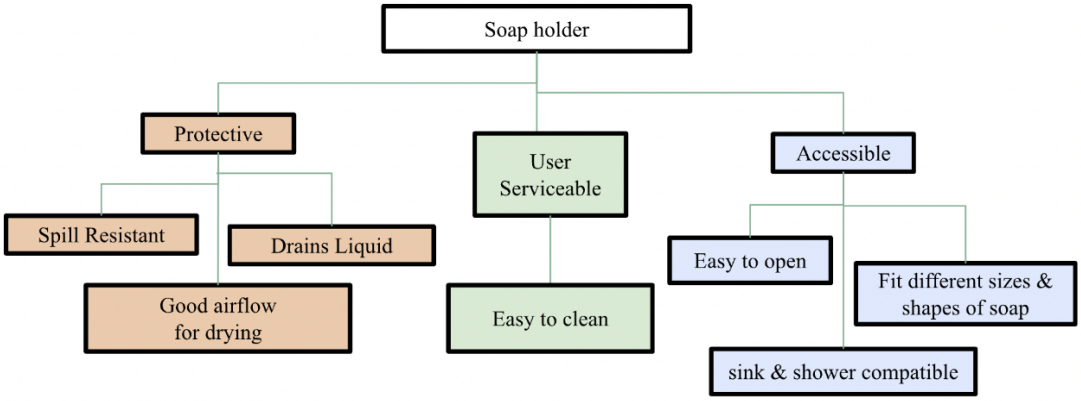


Figure 8. Objective Tree

When prototyping the Suds Saver, there are three important factors to focus on: the product must be protective, both against damage and contamination of the soap, accessible to all potential users and bar soap sizes, and user-serviceable to a common consumer without the need for complex tools. We developed an objective tree (Figure 8) and a morphological chart (Table 1) to highlight various ways to address our initial problem and the objectives listed below. The boxes in green were determined as the best designs for our goal.

CATEGORY	OBJECTIVE	DESIGN 1	DESIGN 2	DESIGN 3
Protective	Good Airflow	Side Grill	Open Rear End	Open Lid
	Drains Liquid	Bottom Grill	Front Opening	Bottom Duct
	Spill Resistant	Closed Box	Openable Lid	Drain Property
Accessible	Easy to Open	Living Hinge	Removable Top	Insertability
	Adaptability	Suction	Straight Stand	Tilted Stand
	Fits Different Soap	Malleable Plastic	Oval Box	Rectangular Box
User Serviceable	Easy to Clean	Use Flat Surfaces	Multi-Part Compartment	Provide Cleaning Tool

Table 1. Morphological Chart for Suds Saver

Final Design and Technical Drawing

The final design of Suds Saver includes a rectangular main body and a detachable tilt-stand. The stand has a diameter of 40 mm and has a silicone suction cup at the bottom. The main body is attached to the tilted stand, as indicated in Figure 9, at a 22-degree angle, allowing the soap bar to be inserted at the back and slide down the slope. It has an open rear and a front lid connected with a living hinge. The user can effortlessly open the lid, and the soap bar will be gently delivered into their hands by gravity. Since the lid is closed by magnets, the user can effortlessly flip up the lid after retrieving the soap. The soapbox is 100mm x 75mm x 42mm on the inside, which is versatile to fit most soap bars on the market. On the bottom corners of the front lid, there are two fan-shaped openings, where any liquid inside the container will flow out following the ridges on the inside bottom surface.

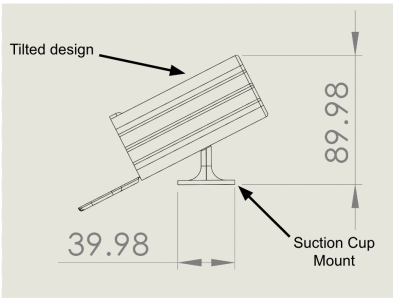


Figure 9. Side View of Suds Saver

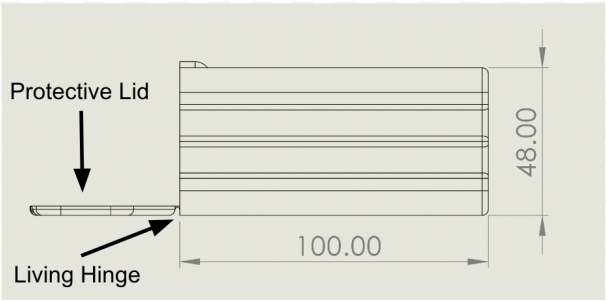


Figure 10. Side View of Lid and Living Hinge

The round N42 grade magnets, as indicated in Figures 11 and 12, have a diameter of 5.4mm and a thickness of 3mm. The distance between the two pieces of magnets will be 0.7 mm when closed, so this pair is able to exert 2.72N of maximum pull force. Assuming that the soap bar hits the center of the front lid when it slides down the slope, the maximum force the soap can exert is 5.44N without pushing the lid open. Assuming an initial velocity of $0.1m/s$ when the user puts back the soap bar, the theoretical final velocity of the soap sliding down the slope will be $0.266m/s$ in 0.05 seconds. In the real world, this value will be much smaller due to friction. Assuming that the sliding soap is stopped in 0.01s, the maximum mass of the soap bar this magnet design can withstand is $204g$. Since regular soap bars on the market average around 100g, our design is robust enough for heavier soap bars and for users who put soap bars back in a more aggressive manner (higher initial speed). This ensures a consistent experience regardless of the type of soap.

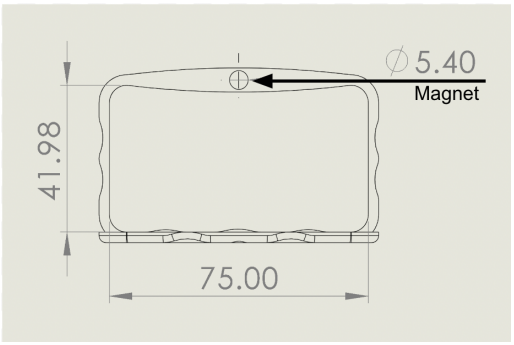


Figure 11. Front View of the Suds Saver

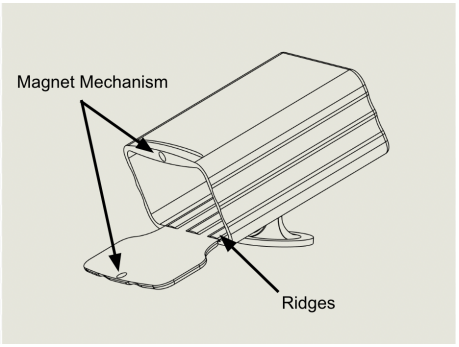


Figure 12. View of Ridges and Magnets

Required Properties of the Polymer

The plastic of choice for the Suds Saver is dependent on various factors. Our aims for the product, outlined in the Objectives Tree, are ease of use, durability, and protectiveness. These aspects are contingent upon the exact plastic that is suitable for use.

Suds Saver Material Requirements

The Suds Saver's main purpose includes adequate storage of soap. Therefore, we would expect the product to be free of any toxic chemicals that could transmit onto the soap, and eventually the skin. We would want the polymer to be Bisphenol A (BPA) free. BPA is an industrially produced chemical in plastics that, when absorbed or ingested, has been linked to adverse effects in multiple areas of health, such as endocrine disruption and memory impairment [11]. Additionally, our product is meant to withstand continuous exposure to moisture. To reduce the risk of standing water harvesting bacteria, this polymer should have hydrophobic and nonpermeable properties in order for the water and suds to drain and evaporate accordingly, leaving as little residue as possible. The environment in which the product is used includes anywhere with a shower or sink. In these high-activity areas, the product is prone to high impact from falls. It may also experience high surrounding temperatures produced by water streams up to 120 degrees Fahrenheit [12].These scenarios require polymers with high melting points and tensile strength to minimize the probability of product damage or weathering.

Types of Plastic and their Properties

We evaluated our options for three common types of plastic: Polyethylene terephthalate (PET), polyethylene (PE), and polypropylene (PP). All of these polymers are made of recyclable materials, but each of them has different benefits. PET is characterized by high transparency, impact resistance, and lightweight qualities. PE is also known for its transparent appearance. It has strong resistance to lower temperatures and low absorption of water. Conversely, PE is not durable against environmental stress and can age very quickly under hotter conditions. PP is produced at the lowest cost. Paired with its high-temperature resistance and high strength, the properties of polypropylene make it the most economical material [13]. The only disadvantage is its general opaque appearance. We address this through our Suds Saver marketing plan to produce solid-colored products.

Polypropylene (PP)

For the production of the Suds Saver, we decided to use PP plastic, whose polymer structure is illustrated in Figure 13. Its durability, ability to be recycled, and low cost makes it the most economically feasible material for maximum profit. PP is composed of propylene monomers. These monomers contain carbon and hydrogen molecules to create the product C_3H_6.

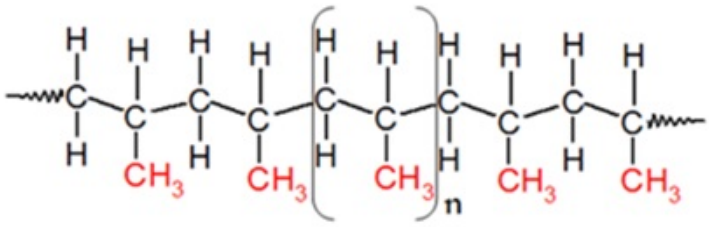


Figure 13. Molecular Structure of Polypropylene (PP) [14].

PP is a thermoplastic polymer, meaning that it is able to be melted and remolded into a variety of shapes. This is relevant because it means that we are able to use PP in the injection molding process when manufacturing the Suds Saver. The "crystallinity, molecular weight distribution, length of the chain, and the isotacticity of the macromolecule" define the properties of this plastic. Polypropylene exudes chemical resistance to water, alkalis, and acids. The polymer is also stress-resistant to typical wear and tear and has a high flexural strength that allows it to withstand pressure when bent [15]. This makes it the most suitable for living hinge designs. Polypropylene has a high melting point of 130°C (266°F). This contributes to its ability to be reused, as well as its durability. Therefore, it would be able to withstand any temperature in the sink or shower [16].

Manufacturing Process

Material Acquisition

The first stage of the manufacturing process of the Suds Saver will be acquiring the necessary materials and bringing them to a manufacturing plant. The polypropylene (PP) plastic we use will first be collected, sorted, cleaned, and melted [17]. It will then be turned into pellets by grinding down the melted PP [18]. The PP pellets will be brought to a manufacturing facility using trucks. We will also acquire silicone suction cups and neodymium magnets from nearby sources and transport them to our production plant.

Manufacturing

We will be using injection molding to manufacture the Suds Saver. First, we will need to acquire a custom mold for our product design. Once we have the mold, we will place it onto the clamping unit of our injection molding machine. The first stage of the injection molding process will be feeding our PP plastic pellets into the injection molding machine's feed hopper. Then, a screw will move the pellets forward while applying friction to produce heat. When the pellets have melted, they will be injected into our mold through a cavity. After some time, the plastic will cool and take the form of our product. In order to remove the product, the clamping unit will be retracted and ejection rods will push the finished plastic product out of the mold [19]. For our purposes, an electric injection molding machine works best. Electric injection molding machines are reliable, have low maintenance and operation costs, and are easy to reconfigure. Compared to hydraulic injection molding machines, electric machines are more reliable in terms of accuracy. Accuracy will be important because our product will utilize a small living hinge, which will need to be molded correctly to function properly [20].

We plan on utilizing the technique of overmolding to embed magnets in our product. In overmolding, the plastic part produced from the first mold will have two cavities for the two magnets. Magnets will be inserted into the cavities, then the plastic part will be placed into a second mold. This plastic injected into this mold will cover the magnets and fuse the two plastic parts together [21].

After our product has been molded, finishing processes will be applied. These include degating and deflashing, which removes excess plastics from the injection molding process. Considering the small size of our product, both of these processes can be done manually. Then, the product will need to be cleaned to ensure that it is spotless, which can also be done manually using stain-removing cleaning products [22].

Finally, we need to attach the suction cup to the bottom of the plastic. The Suds Saver has a built-in slot into which the suction cup can be clipped. Attaching the suction cup into the slot will be done manually.

Packaging

We will be using fine-printed cardboard as the packaging for our product. We chose this material because it is protective, cost-effective, sustainable, and easy to store [23]. Additionally, the majority of cardboard is recycled, minimizing the environmental footprint of Suds Saver [24]. We will order printed cardboard in bulk and bring it to our manufacturing facility, and machines will package the product and seal the packaging. Additionally, we will use Shredded paper cushioning within the packaging to protect our product during transportation.

Materials and Manufacturing Cost

The price of producing the Suds Saver is an accumulation of raw materials, manufacturing, labor, shipping, packaging, and tariff expenses. The specifics of these costs will be highlighted and discussed in this section.

Bill of Materials

Material and Manufacturing Cost		Capital Expenditure	
Polypropylene	$0.165	Packaging	$0.0377
Magnets (2x)	$0.028	Shipping	$0.13 - $3.53
Suction Cup (1x)	$0.04	Tariff	3% of Imported Value
Machine and Labor	$0.44 - $0.54	Retail Commission	5% - 15% of Sales Price
Total Unit Cost: $1.011 - $5.714			

Table 2. Bill of Materials

Material Cost Breakdown

Polypropylene. The primary material for the Suds Saver is recycled plastic Polypropylene. Polypropylene costs $1,189 per metric ton [25], and this cost encompasses the expense of the collecting, sorting, and sterilization of the raw materials and the extrusion and pelletization of the newly created polypropylene. Since the dimensions of the Suds Saver, a hollow box-shaped product, are 2’’ x 3’’ x 4’’, the total cost of the polypropylene per unit will be $0.165.

Neodymium Magnets. For this product, neodymium magnets were selected specifically for their strength, due to their high resistance to demagnetization (coercivity) and their high levels of magnetic saturation, allowing them to generate large magnetic fields [26]. The most cost-efficient neodymium magnets were found to be $0.028 [27]. Neodymium prices in the global market have risen significantly over the past year, and we are actively monitoring the cost of implementing such magnets in our products. We believe our per-unit margin can comfortably cover a potential increase in magnet price [28].

Silicone Suction Cups. We decided to use the VC-144F silicone cup with a height of 0.76 in, a diameter of 2.46 in, and a mounting stem of 0.37 in. Furthermore, the silica of this suction cup was rated “excellent” for wear resistance and “good” for oil resistance. It also has reported working temperature values between -50 and +400 F, which displays efficient endurance capabilities in bathroom environments. After requesting a quote, the per-unit cost is reported to be $0.04 [29].

Additional Costs

Labor. The process of injection molding will cover the majority of the work needed to create the product, and a majority of the labor will be used to attach silicone cups to the plastic support of the Suds Saver. We estimate the per-hour worker wage of factory labor to be around $5 an hour (above the $3.88 average factory worker hourly wage in China), so the cost will be $0.042 of labor per unit manufactured at a production rate of 120 parts per hour [30].

Packaging. The criteria for the packaging of the Suds Saver were durability, affordability, sustainability, and security. With this in mind, we decided to choose recycled paper for the packaging and shredded paper as the internal protection material. The actual box will be a color-printed paper box, with an estimated per-unit cost of $0.0187 [31]. We are able to acquire ten kilograms of shredded paper for $37.19 [32], so the per-unit cost will be $0.019 if we use 5 grams of shredded paper per package. The total cost of packaging per Suds Saver averages $0.0377.

Machinery. As stated previously, the selected choice for machinery is an injection molding machine. The Suds Saver is a relatively uncomplicated product to produce, as it is made up of a single body, with a simple side that has to be allowed to move whilst being used. Accounting for overmolding machinery costs, the total cost of the appropriate tooling/machinery is estimated to be $30,000 for 100,000 units [33].

Shipping. Since the Suds Saver will be manufactured in Southeast Asia or China, we will primarily ship our product to the American continent by container ships. The dimensions of the package are 2.2 in x 3.4 in x 4 in, and each standard 40 feet container will be able to hold 136,998 units of the Suds Saver [34]. Shipping one container of our product from Guangdong, China to Los Angeles, California will cost approximately $3200 [34]. Combined with a $150 to $250 monthly container rental cost, the total cost of shipping internationally is $3450, or a per-unit cost of $0.0251 [35]. As for shipping domestically within the United States, the cost varies by distance. The estimated maximum domestic shipping cost, when shipping from California to Maine, is $0.5 per unit [36]. For online sales through either direct sales or partner services like “Fulfilled By Amazon”, the fulfillment (delivery and storage) costs for each unit is estimated to be $3.28 [37]. Thus, the total shipping cost in the US will range from $0.1 to $3.5.

Tariff. The tariff on the Suds Saver imported from China or Southeast Asia is 3% of the customs import value, meaning that the per-unit tariff cost will be $0.03 [38]. However, with a fluid global market, this value could change over time and economic conditions. Noticeably, the US punitive tariff on some Chinese goods may result in a 25% tariff, although the Suds Saver is currently not on the Section 301 list of items subject to the 25% additional tariff [39].

Retail Commissions. In the United States, major retail partners such as Walmart take an 8% commission on the Suds Saver when priced below $10 [40]. When sold on Amazon.com, the retail commission will be 15% of the retail value, in addition to any storage, and delivery fees [37].

Potential Customers, Competition, and Other Stakeholders

Potential Customers

As reported by [41], bar soap is more widely accepted among elderly groups in the United States, with more than 60% of the aged 65 and older interviewees willing to use bar soap to wash their faces. These existing bar soap container customers will be the primary customers of the Suds Saver. For younger consumers who are less attracted to bar soap, we aim to attract them by penetrating the market through social media and advertising the convenience and sanity of our product. Because bar soaps are perceived

as “unhealthy” to be shared in public places, public institutions or public service restrooms are not part of our main target customers.

Globally, we aim at developing markets whose people expect to get access to personal hygiene services in their households by 2030 [42]. These households often have a large number of members, and our product can help them keep the bar soap clean and save bar soap bits, which saves them the cost of personal hygiene in the long term. Besides hand-washing, bar soap is also used globally for body washing, and our product has compatibility for shower environments to offer protection to the soap. Therefore, households in these areas with large needs for bar soap will be our international customers.

Competition within the Market

The Bar Soap Holder Market is a fully competitive market with many existing competitive products. Because of the low technological requirements for this industry and the relatively simple structure of the products, the pricing of soap dishes in the United States market is homogeneous. Since we are using similar materials and providing improved user convenience and protection, we expect the customers to be attracted to the additional capabilities of our product at a competitive price. Figure 15 shows a normal distribution of the best-selling soap dish prices, upon which we determined the pricing of Suds Saver.

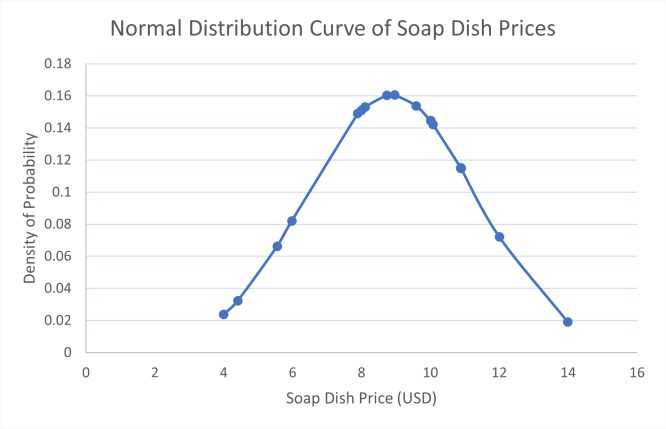


Figure 14. Prices of Top-Selling Bar Soap Dishes on Popular Online Retail Platforms

While our design will be patented when our product reaches the average consumer, it is no surprise that products with similar designs will compete with our design in regions with poor intellectual property protection, often with poorer quality but lower prices. This means that our product could potentially become less competitive among cost-priority markets, but will remain competitive in more mature and high-profit markets like North America and Europe. This is why the design and pricing choices of our product target consumers with average or above-average financial capabilities.

Competition from Alternative Products

In recent years, the bar soap industry has faced competition from other personal hygiene products, such as liquid soap and hand sanitizer industries. According to [43], the average price of bar soap (whether deodorant or non-deodorant) per unit in the United States is anywhere from 27% to 117% more expensive than the average price of liquid hand soap or hand sanitizer. Besides price, convenience is another major reason Americans transfer from using bar soap to liquid soap alternatives. According to [41], more than half of consumers say bar soap is inconvenient and unclean because they leave residue and are often covered in germs. Since our product greatly improves both the convenience and cleanliness of bar soap

use, we expect more people to take advantage of bar soap's benefits to personal health and return to the use of bar soap.

As a result of the competition between liquid soap and bar soap, the main competitor of the plastic soap dish market is the market for plastic liquid soap dispensers. These two products support users who prefer bar soap or liquid soap, and the average costs of bar soap and liquid soap containers overlap each other to a great extent. In this competition, our product makes up for the shortcomings of soap bars compared to liquid soap by ensuring its cleanliness and improving its convenience. We are confident that we will outcompete liquid soap dispensers in most households by helping our customers to take advantage of healthy natural bar soap. Lastly, liquid soap pumps manufactured in China are currently subjected to a 25% tariff [39], while our product, a soap holder, does not have such tariff restraint, which allows us to provide a competitive product with competitive pricing compared to plastic hand pumps.

Other Stakeholders

Additional stakeholders include our materials suppliers. They have a direct interest in our product as our continued success will provide them with greater profits. Government agencies also have a stake in our product. Considering our product's usage of recycled plastics, the Environmental Protection Agency (EPA) will be an important partner to consider. We will have to ensure that our manufacturing facility meets the EPA's guidelines regarding plastic molding and that we have the required permits [44]. Additionally, we must be prepared for on-site inspections by the EPA [45]. We will also have to ensure that we obey local environmental regulations. Additionally, the government may have incentives for plastics recycling that we can take advantage of to increase our revenue.

Market Analysis and the Economics of Suds Saver

The Bar Soap Market

The bar soap holder market in which our product competes, as its name suggests, is heavily dependent upon the consumer market for bar soap. The bar soap industry is not only fully competitive, but it is also experiencing healthy and steady growth in recent years. According to [46], the bar soap market is expected to grow at a compound annual growth rate of 8.1% from 2022 to 2030, reaching a market size of $778 billion. Globally, the market value for bar soap reached $1.94 billion in 2020 and is expected to reach $3.64 billion by 2030 [46]. Since the outbreak of the COVID-19 pandemic, the bar soap industry has experienced a boost in sales across the globe, and we expect this trend to continue in the foreseeable future.

Expected Market Size

As one of the most widely used personal hygiene products in the United States, bar soap is used by 276 million Americans (or 83.8% of the United States population) in their households [47]. At this rate, 103 million US households have used bar soap at home in 2020 [48]. By providing bar soap containers with a far more friendly environment to stay in, we aim at these households as our main customer market. Since each American household, on average, has two restrooms with one sink in each, we expect 172.6 million sinks with soap use in American households in 2020 [49]. Assuming American households change the soap dish of each sink every 36 to 84 months (when they become unsanitary and extremely hard to clean), the annual sales of soap dishes in the United States are expected to be between 24.6 and 57.5 million units. We plan to capture this soap dish market at an average penetration rate of 1%, accounting for 246,000 to 575,000 units of sales in the United States each year. The number of American households is also growing at an annual rate of 1.5%, or 1.5 million households per year [50]. As the new households

are likely to be composed of young members of society with more open minds to try new things, we plan to capture between 6% and 10% of this portion of the growing market and sell 90,000 to 150,000 units annually. This brings the annual sales volume in the United States to between 336,000 and 725,000 units.

According to the World Health Organization (WHO), there are still 2.3 billion not having access to such services, as indicated in Figure 15 [42]. Under the United Nations' goal of "achieving access to adequate and equitable sanitation and hygiene for all by 2030" [42], we expect another two billion people globally to start using soap in hand-washing in the next eight years. It is estimated that they make up between 333 and 500 million households globally [51]. Among these households, we plan to collaborate with local distributors or retailers to distribute our product at high volumes and achieve a 3%~5% penetration rate. Assuming that households in this market have one personal hygiene facility per household, our product's sales volume will be between 0.99 and 2.5 million units per year in these growing markets.

Figure 15. Percentage of the global population with limited or no personal hygiene access [42]

Sales Revenue

Based on the above considerations, we decide to price our product at $8.99. As mentioned in *Potential Market Size,* we aim to sell 339,000 and 723,000 units each year in the United States. Our pricing is 0.054 standard deviations away from the average price of the top-selling soap dishes available in major retailers like Walmart and Target, as indicated in Figure 14. Since shipping to large retail centers around the United States is cheaper compared to shipping directly to a customer's residence, we expect an additional $2 to $3 in revenue from sales in retail centers compared to online sales. Since the personal hygiene and soap dish market in the United States is very mature, offering aggressive pricing is unlikely to bring any significant sales volume increase, so we think that balancing between per-piece margin and sales volume will bring the most revenue for our shareholders. At an average per unit revenue of $4, our US sales yield an estimated $1.4 million to $2.9 million of gross annual revenue.

In the emerging global markets of personal hygiene products, we plan to keep a consistent $0.5 per-piece gross margin through collaboration with local retailers. Because many of these customers are purchasing a personal hygiene product for the first time, we plan to take 5% of the market share with aggressive pricing. We will be able to make up the revenue by selling in a higher volume. As a result, an estimated 0.99 to 2.5 million units of sales per year yields $500,000 to $1.25 million gross annual revenue.

From the gross margin, a 26% combined state and federal taxation is deducted, and a 20% business expense is anticipated [52]. After these expenses are subtracted from gross revenue, the average net revenue of this business is estimated to be $1.49 million annually, with an expected high of $2.26 million and a low of $1 million.

Lifecycle Analysis

Material Procurement

The primary raw material we will need for the Suds Saver is recycled plastics, specifically recycled polypropylene. Polypropylene is used in many products, from banknotes to stationary [17]. We will need polypropylene from a plastics recycling facility or a distributor of recycled plastics. Our suction cups will be made from silicone, sourced from silica, a nonrenewable substance available in large amounts. The process of extracting silicone from silica uses carbons and hydrocarbons, which are extracted from natural gas and petroleum [53]. An alternative material for suction cups is polyvinyl chloride (PVC) [54]. It is a type of synthetic plastic that is cheaper than silicone, though it has many environmental disadvantages [55],[56]. The production of PVC requires the usage of toxic pollutant chlorine and dioxins, therefore unsuitable for the production of Suds Saver [55]. The neodymium magnets in our product are renewable but the mining of these materials can result in significant damage to the ecosystems in which they are located [56].

During the process of recycling plastics, the plastics must be collected and distributed, sorted and categorized, washed and shredded, then extruded and categorized for usage by manufacturers [57]. Large trucks are a potential choice to bring these recycled plastics to a manufacturing plant. According to the EPA, a heavy-duty Class 8 truck can go 5.29 miles per gallon, which is not as fuel efficient as light trucks and vans traveling at 17.50 miles per gallon [58]. Compounding this problem is the fact that 97% of Class 8 trucks run on diesel [59]. A single gallon of diesel can produce 22.45 pounds of carbon dioxide. Regular motor gasoline, meanwhile, can produce 19.37 gallons per gallon [60]. To reduce this impact, we can source our raw materials from suppliers and distributors close to our manufacturing plant to reduce total emissions.

Manufacturing

The most environmentally impactful factor during the manufacturing process is electricity consumption from injection molding machinery, which varies heavily depending on the type of machinery [61]. Following the cooling of our plastic product, it will undergo finishing processes such as polishing, dying, or removing excess plastic, which could be done manually or with machines [62]. Our product is not very large, so our emissions generated will be lower compared to larger plastic products.

Packaging

We will be using printed cardboard as packaging in the form of boxes. According to the New York Department of Environmental Conservation, 70% of all cardboard is recycled [63]. In this regard, the environmental impact of our packaging from waste will be lessened because most of our packaging will be recycled. The manufacturing of new cardboard will result in excessive sulfur dioxide pollution, so we can lessen our packaging's environmental impact by using recycled cardboard [63]. To keep our product in place during transportation, we will use shredded paper for its comparable performance in protection and significantly smaller environmental impact compared to packing peanuts or bubble sheets. While styrofoam is useful at insulating and absorbing shock, it is made from raw materials that originate in petroleum and natural gas, degrades very slowly over time, and when it disassembles into small pieces it can be consumed by wildlife [64]. Although paper material has environmental costs in terms of deforestation and water usage, it is a recyclable product, thus lessening our overall impact [65]. We will not be providing a physical instruction manual for product assembly, but a digital manual will be provided via a QR code printed on the packaging.

Distribution

To bring our product to market or package distributors, we will use a variety of vehicles, including trucks, vans, trains, and container ships. General distributors like Amazon use delivery trucks, which have an average fuel efficiency of 6.50 miles per gallon [58]. For global shipping, maritime and rail freight produce 7 and 24 grams of carbon dioxide per tonne-kilometer respectively [66]. Since we expect the majority of sales to be achieved within retail stores, greenhouse gas emissions from individual delivery will account for a smaller percentage of the overall environmental impact of the Suds Saver.

Usage

The Suds Saver will not have a particularly high environmental impact in terms of its usage by consumers. A major source of environmental impact is that it will need to be cleaned occasionally. The Suds Saver can be washed with water and soap or cleaned with disinfecting wipes. How often our product gets cleaned will vary, but we estimate that cleaning once per month would be sufficient.

Final Disposal

Because our product is mostly made of recycled polypropylene, it will be partially recyclable [17]. The silicon suction cup is also recyclable, but through specialized recycling facilities [53]. The magnets are recyclable but may be difficult to retrieve from the polypropylene casing [56]. If the user does not recycle the product, it may end up in a landfill or an incinerator. Since both polypropylene and silicon are non-biodegradable, our product would contribute to environmental damage should it be taken to a landfill [53], [67].

Conclusion

The Suds Saver is a product designed to address all major problems with existing bar soap dishes. It creates a sanitary and durable container that optimizes bar soap's use, keeps the soap bar dry, and protects it from potential spills or aerial transmitted contamination. Its modular suction stand also provides the versatility to be used almost anywhere the user prefers. The Suds Saver delivers all of these unique advantages at competitive pricing while offering a compatible, robust, and effortless experience for all of our users.

We have designed our product to be made out of recyclable polypropylene (PP) with injection molding and overmolding technologies, which characterize high melting points, high tensile strength, and strong chemical resistance suitable for any personal hygiene environment. The overall recyclable selection of materials and manufacturing/transportation methods with minimal environmental footprint renders the Suds Saver friendly to our users as well as the environment. Among millions of American customers and 2.3 billion people globally expected to gain personal hygiene access, we estimated net annual revenue of $1.49 million combined.

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