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Project Title:
Solar Direct Drive Cold Storage System For Off-Grid Preservation of Fish and Perishable Goods

University:
Independent University, Bangladesh || City, University of London

Theme(s): Refrigeration/ Space cooling

Supervisor: Dr. Khosru M Salim

Industry Mentor: Julian Kruger

Efficiency for Access Design Challenge:

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It has truly been an incredible experience.

Executive Summary

This report showcases the prototype for Team 2021-31, which is based on Solar Direct Drive Space cooling and Refrigeration System and its benefits and uses in off-grid rural locations all across the globe.

The project focuses on the social and environmental impact that it can remify as well as makes an attempt at solving a few real life issues that have become imminent to be solved.

The report also provides a sound business and revenue model for it to become a viable active product to ensure its use in the real world with statistical data.

Abstract

Table of content: gives an outline of all the topics discussed in this paper.

Chapter 1: talks about the product innovation and gives a brief about the product description and the user interface

Chapter 2: paints a picture of the social impact that our product wishes to have on our user end along with a justification for our product to be a viable solution to the proposed issues.

Chapter 3: refers to the environmental impact our project wishes to have and also justifies the SDG we wish to sustain through the use of our project.

Chapter 4: includes the scalability of our final product and our business plan and expansion plans to growing or emerging alternative markets.

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Chapter 01 Product Innovation

1.1 Introduction

Food is one of the most essential necessities for human survival. The main reasons for impoverishment in Bangladesh are insufficient food production and a lack of an effective food preservation system. Bangladesh is experiencing a food scarcity due to a lack of preservation systems, which results in around 68 percent food losses in total Municipal Solid Waste[1]. The current state of food waste in Bangladesh, as well as the existing storage technologies, have been thoroughly researched in this paper. According to the findings of this inquiry, the biggest impediment to a suitable storage system in Bangladesh is a lack of energy. As a result, incorporating renewable energy sources such as solar energy into existing food preservation systems can provide beneficial solutions. As a result, incorporating solar energy into Bangladesh's existing food storage system will mitigate the risks of the food crisis and provide a zero-energy food storage system.

keywords: *renewable energy, food preservation, cold storage, Bangladesh*

1.2 Problem Statement

The process of producing, processing, distributing, consuming, and disposing of food is referred to as the food supply chain. Food insecurity affects about 2 billion people as a result of massive food losses. This disruption in the supply chain has a direct impact on poor growers and consumers, affecting availability, price, and nutritional content[2]. The main causes of food loss are inexperienced handling, poor packaging, inefficient storage systems, limited market access, and inadequate post-harvest on-farm storage technology[3].

Mohammad et al. states that production losses account for around 29 percent of total losses (2018). Adverse Post-harvest waste accounts for 15% of total waste, with the top causes being incorrect

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[1] Joardder, M. U. H., Mandal, S., & Masud, M. H. (2018). Proposal of a solar storage system for plant-based food materials in Bangladesh. *International Journal of Ambient Energy*, *41*(14), 1664–1680. https://doi.org/10.1080/01430750.2018.1507932

[2] Mandal, S., Yasmin, H., Sarker, M. R. I., & Beg, M. R. A. (2017). Prospect of solar-PV/biogas/diesel generator hybrid energy system of an off-grid area in Bangladesh. *AIP Conference Proceedings*. https://doi.org/10.1063/1.5018538

Adeyeba Olunike, A. (2014). Utilization of Legumes in the Tropics. *Journal of Biology, Agriculture, and Healthcare IISTE*, *4*(12), 77–84.

Puma, M. J., Bose, S., Chon, S. Y., & Cook, B. I. (2015). Assessing the evolving fragility of the global food system. *Environmental Research Letters*, *10*(2), 024007. https://doi.org/10.1088/1748-9326/10/2/024007

[3] McClements, D. J. (2004). Food Emulsions. CRC Press. https://doi.org/10.1201/9781420039436

Wills, R. B. H., & Golding, J. B. (2016). *Postharvest : an introduction to the physiology and handling of fruit and vegetables.* Unsw Press.

Beddington, J. R., Asaduzzaman, M., Fernández, A., Clark, M. E., Guillou, M., Jahn, M. M., Erda, L., Mamo, T., Van, B. N., Nobre, C. A., Scholes, R. J., Sharma, R., & Wakhungu, J. W. (2011). Achieving food security in the face of climate change: Summary for policy makers from the Commission on Sustainable Agriculture and Climate Change. *Cgiar.org*. https://doi.org/https://hdl.handle.net/10568/10701 packaging, humid weather, and a lack of cold storage. On the other hand, around 35% is lost due to an inefficient processing system[4]. Furthermore, the distribution and consumption stages account for around 12% and 6% of the total. In Bangladesh, the percentage of food and vegetable waste is roughly 68 percent, making it the largest contributor to total municipal solid trash generated[5].

1.3 Brief Prototype Concept Description

The proposed design concept of Solar Direct Drive Cold Storage System for Preservation of Fish and Perishables harnesses the power of solar energy through two photovoltaic solar panels with rated power of 320W placed in parallel in order to operate two 24V DC compressors which uses vapour compression refrigeration (VCR) systems to cool down the chambers within the container. The system uses the highly efficient R600a refrigerant which is much more environmentally friendly than traditional R134a coolants.

The proposed design as seen in the 3D model below, uses readily available materials which can be locally sourced and manufactured. In the concept we have used an old discarded shipping container as the ideal shell for the cold storage since it will not only make the product affordable, but also the shape of the container will make it easy to transport. This is an added advantage especially in flood prone areas and areas which have frequent cyclones such as the coastal off-grid areas of Bangladesh.

Fig.1 shows the front view of the 3D model of the prototype.

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[4] Beddington, J. R., Asaduzzaman, M., Fernández, A., Clark, M. E., Guillou, M., Jahn, M. M., Erda, L., Mamo, T., Van, B. N., Nobre, C. A., Scholes, R. J., Sharma, R., & Wakhungu, J. W. (2011). Achieving food security in the face of climate change: Summary for policy makers from the Commission on Sustainable Agriculture and Climate Change. *Cgiar.org*. https://doi.org/https://hdl.handle.net/10568/10701

[5] Beddington, J. (2010). Food security: contributions from science to a new and greener revolution. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *365*(1537), 61–71. https://doi.org/10.1098/rstb.2009.0201

The shipping container is separated into three different chambers, a large refrigeration chamber in the middle of the container for keeping vegetables such as potatoes fresh under (2 °C to 8 °C) which is accompanied by two heavily insulated freezer chambers that contain large ice banks that not only act as a storage for thermal energy during night time but also doubles down as a chamber for storing fishes and perishables such as milk, that needs to be kept under 0 °C temperatures. These two chambers can be as cool as -20 °C and they are heavily insulated to avoid heat loss to the surroundings. Two temperature controlled cooling fans on either side of the middle chamber ensure that all chambers operate at optimum temperatures. The fans are operated at night using small solar charged batteries which are small and cost a fraction of the large bulky lead acid batteries which our system avoided. The entirety of the container is heavily insulated using styrofoam padding and the inner linings are covered with aluminium foil to ensure minimum heat loss to the surroundings. The system will additionally have IOT features which will allow the manufacturers real time feedback on the products in use and it will help us make better iterations in and add more useful features to it whereas also allow the customers who have access to the internet to get vital information about their goods via the internet. This will also provide great customer feedback and we can help them fix minor issues regarding the refrigeration system remotely without having to send over a repairman.

Fig.2 shows the rear view of the 3D model of the prototype.

Due to the system operating without an external power source other than the solar panels it has no energy cost compared to absorption refrigerators that require kerosene or other crude oil based energy sources as the primary source of power which makes them not only costly but also terrible for the environment. In addition, our design also eliminates the additional cost to buying and maintaining and replacing bulky batteries that need to be replaced every 4-5 years. Hence, this project has almost zero additional energy costs and overhead cost. The container also has options to add wheels in the end which might make it more mobile if need be. This is a crucial feature in flood & cyclone prone areas where the end user might need to relocate abruptly due to unforeseen circumstances.

1.4 User Interface Design

The user interface designed for the project is meant to be user-feedback centric. We've added an LCD display on the body of the 'container' to help the end user monitor vital information such as temperatures in the three different chambers, the overall weight of the entire unit, the amount of ice banks available (in litres) and the humidity and ambient temperature. The doors of the different compartments can all be accessed separately and an RFID is attached to each door to mitigate theft and allow the product to be shared within the community safely. The doors provide single-handed use to allow people with disabilities to operate it and we can provide a small sound alarm system along with LDR sensors to inform the users who are impartial to hearing and sight. More features can be added in the future to help the end-user have the best possible experience using our product. We designed our product to give us feedback in two ways:

a) The user adapts its behaviour to the (not perfect) user interface; or
b) The user interface will be redesigned according to the input from the usability tests, and we restart the evaluation.

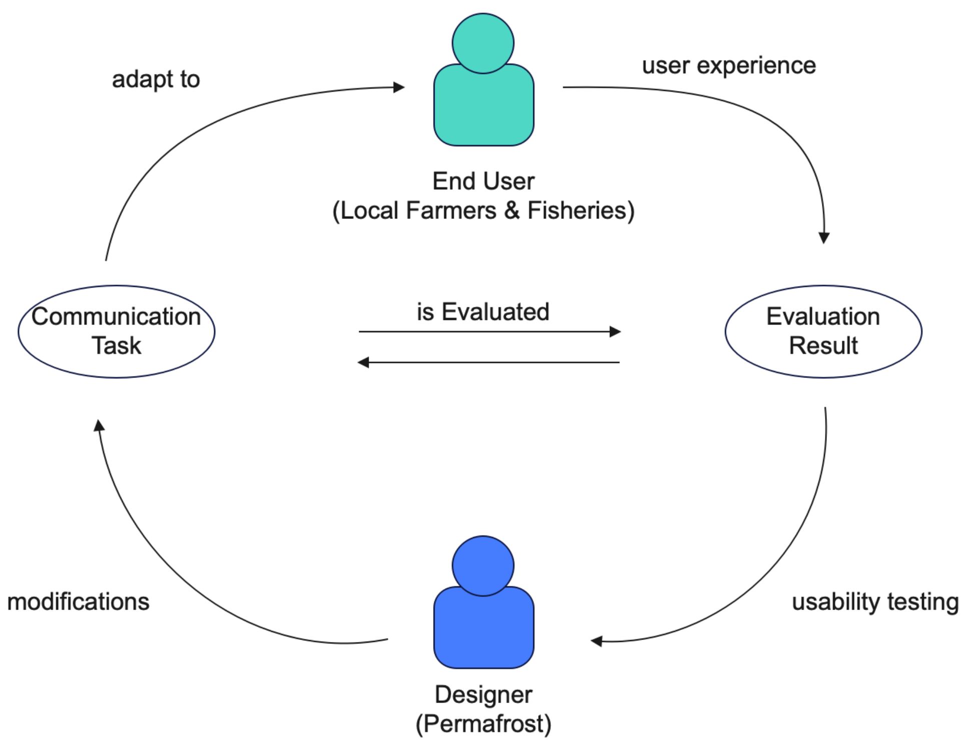

Fig.3 shows the user interface design

Chapter 02 Social Impact

2.1 Introduction

The cold storage unit offers numerous economical and sociological benefits for the local and global community. One important aspect for this project is the social impact that it will make in its areas of use. As defined by the Center for Social Impact, the former is the net effect of an occurring activity on the well-being of the members of the community to address a pressing social issue[6]. Our outlook on the social impact of the cold storage unit revolves around empowering the minority groups and adding value to rural regions that suffer economically while preserving a sustainable way of life.

In Bangladesh, farmers have to battle the issue of low storage facilities availability to store their fish and perishable products. The current cold storage facilities are held by large corporations that are located at far distances from the rural areas, and that operate on gasoline. The farmers must pay rent to use the facilities which drives their operational costs up and profit margin down. As a result, local farmers gain low income and lose a substantial portion of it in the supply chain of intermediaries. The cold storage unit will offer these marginalized individuals an outlet to store their goods locally and sell it through the area for a higher price, especially when the products are off season (such as potatoes). The propagation of the product will also allow for a means to tackle poverty in those regions with food scarcity. The six benefits of social impact for businesses that we have centered our mission around are as follows:

1. Build trust with a community
2. Keeps employees engaged
3. Attract local customers
4. Creates meaningful change
5. Ensures sustainability
6. Tells a story people care about

The 6 benefits above are embedded within our team and the Cool Storage System. Creating a storage system that is built for people living within suburban areas will provide them with the opportunity to be able to increase their profit while maintaining the quality of their food but most importantly reducing waste.

2.2 Social Dilemma caused by food shortages

An estimated one third of all food produced ends up going to waste on a yearly basis. With prominent world crises such as malnourishment and hunger, it is vital to take a global initiative to reduce these statistics. Large quantities of food are produced daily and not consumed by anyone is unethical and morally unacceptable. In addition, this poses a negative economic and environmental social impact.

The cold storage system plans to tackle these issues by providing a means to store fish, perishable products (such as milk, fruits, and vegetables), at an optimum temperature to lengthen their durability. The climate in Bangladesh is commonly hot, typically varying between 69°F to 85°F. These temperatures make food more likely to rot and perish unless preserved properly early on. The cold storage unit will be composed of three separate chambers, two freezer sections and one fridge section. One of the freezer sections will be for the storage of fish, which need to be isolated for sanitary purposes since raw fish needs to be treated with caution. The other two will be for vegetables and other perishable products as per the user's needs.

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[6] *About Social Impact | CSI*. (n.d.). Www.csi.edu.au. https://www.csi.edu.au/about-social/

2.3 Proposed solution

The distribution of the cold storage unit will present solutions that will assist the local rural communities in Bangladesh with the following points:

1. Affordability
2. Food security
3. Multi-purpose usage
4. Portability

2.4 Justification of proposed solution

Within the key components that have been taken into consideration for the social impact of the product, we have included economic stability, sustainability, and agility. The cold storage unit will be fairly priced based on the manufacturing cost. The aim is to lower operational costs for the local farmers and assist them at increasing their profits by removing extra fees, such as rent. For these reasons, the retail price of the product will be lower than competitors on the market and there will potentially be an option to lease the unit with monthly payments.

The sustainability and agility of the product are two key factors that have been additionally taken into consideration. The Cold storage unit will be easily portable to facilitate relocation. In certain coastal areas, there are risks of natural disasters, such as tornadoes, which will require relocation under short notice. In order to ensure that this is feasible, the unit will not be composed of large batteries, only small ones to run the fan at night (during hours of no sunlight), which will make it significantly lighter. In addition, the unit can be easily equipped with two to four wheels. Portability can also be useful if the unit is to be operated as a communal facility. If numerous individuals decide to use the same cold storage unit (to economize or for other reasons), they can easily do so by transporting it from one location to the next. The unit is also composed of three separate sections, as mentioned previously, to allow for multi-purpose usage. It is large to withhold large quantities of goods while the quality of operation does not deter. This leads on to the final goal which is food security. The minority groups that suffer from poverty and hunger will be able to help themselves by running improved storage operations.

Chapter 03 Environmental Impact

3.1 SDGs Aimed for the Project

The following table shows all the sustainable development goals the project wishes to achieve and the targets associated with it. The contributions have also been briefly justified in the table with more emphasis being placed on goals 7 (Affordable and Clean Energy), goal 8 (Decent Work & Economic Growth), goal 10 (Reduced Inequality), goal 12 (Responsible Consumption & Production), and goal 13(Climate Action).

Table.1 shows the SDG goals and Targets addressed by the Project.

Number	Goal	Target	Brief justification for how your design contributes to this SDG
1	7	1	Our product does not use a battery so it is a lot more sustainable and clean than its competitors.
2	8	2	Our product will achieve higher levels of economic productivity through diversification, technological upgrading and innovation, including through a focus on high-value added and labor intensive sectors by allowing the population to lead better lifestyles.
3	10	1	Due to reduced food wastage and better storage facilities, farmers and fishermen will be able to sell products at a higher profit. There will be a sustained income growth for the bottom 40% of the population.
4	12	3	Due to our project, food waste at the retail and consumer levels will be reduced which will result in fewer losses and shortages and it will also give enough time for sellers to find the right buyers.
5	13	B	No use of batteries allows for a better means of waste disposal which would help us stay in line with better management of resources.

3.2 Impact of Project on Environment & Sustainability

The core principle of our design concept is to ensure a sustainable and environmentally friendly product that can have a positive impact on the society and its people. The following table points out some of the technical challenges that might be faced while implementing this product in the field and also talks about the myriad economic, social and environmental benefits that can be reaped off of this project by the people.

Table.2 shows the impact of the project outcome

Attributes	Impact of the project outcome
Technical	The project requires an intermediate level understanding of photovoltaics, electrical engineering and knowledge about power electronics, which can be a technical hurdle in rural areas.
Economic	The project can help create businesses in rural off-grid areas in the form of both cold storage facilities and also secondary repair and maintenance services to maintain these units. It can also help preserve perishables longer which would help farmers get a better price throughout the year which previously would have not been possible without the device and hence increase economic output.
Social	This project can be used in off-grid locations where the communities suffer greatly through food shortages during the drought season and also lose a lot of value to their crop yields due to lack of storage spaces. Having a product such as this at their disposal would boost morale and increase prosperity in the region.
Environmental	The use of solar panels as a source of generating power reduces the carbon footprint of the project whereas the choice of not using batteries as a primary storage unit also reduces the impact the project will have on the environment and the ecosystem, since batteries degrade quickly and are very difficult to dispose of.
SDG Goals 2030	The SDG goals 7 (Affordable and Clean Energy), 8 (Decent Work & Economic Growth), 10 (Reduced Inequality), 12 (Responsible Consumption & Production), 13(Climate Action), and 15 (Life on Land) can all be directly or indirectly achieved by this project.

Chapter 04 Scalability

The scalability of the product is critical for long term value creation for the ecosystem in Bangladesh where the Cold Storage units will be sold. The aim is to ensure a production process with sustainable production and consumption patterns that has high scalability. It is important to determine the technical and economical feasibility of the model, particularly in off-grid areas where no there are no grid connections in Bangladesh. A key factor to take into consideration is the load scalability of the system, encompasses its ability to function properly without unproductive resource consumption, its ability to function with a range of varying load sizes, and the extent of possible counterfeit systems[7].

4.1 Sales & marketing

Asia leads the world in aquaculture production and according to Ghose, fish is the second largest contributor to agricultural crop in Bangladesh, and it provides millions of people employment opportunities (2014). The local fish industry has a significant impact on national income and food security[8]. However, intensive farming has led to an array of environmental challenges that could ultimately pose a risk to human health and the marine ecosystem. The cold storage system incorporates a system that reduces the risk of deteriorating human heath as it maintains an optimal cold temperature where the fish can be stored. The portability of the product facilitates travel, reduces maintenance cost, and improves longevity of safe storage. Additionally, due to its solar powered roof, the product introduces a more sustainable and eco-friendly approach to fish maintenance that helps to protect the environment, therefore contributing to the reduction of fossil fuel consumption.

With the demand in the fish industry on an exponential rise for years and the world's fish stocks gradually diminishing, almost half of the seafood is now produced in aquaculture, with Asia at its lead. The region is responsible for 52% of global fish consumption and dominates production with an 88% share as reported by the Asian Development Bank.

The primary target for the cold storage unit are farmers, however, its expansion potential stretches to smaller businesses, private consumers, and more. Although the system is mainly directed to fish, it also has the capabilities to store other food as well such as vegetables, for example potatoes which also require a cool storage system as they rot fast from too much sunlight.

To ensure the product receives recognition it would initially require some advertising, with only 12.5% Bangladesh in rural areas listening to radio it did not seem like a viable option although we would expect the majority to be able to drive to transport the products. The best option is to contact a marketing and advertisement agency to help with introducing the product.

Selling to local businesses for a certain price to which they can sell for a higher margin and make profit. Also, with regards to branding we're happy for local businesses to re-brand the product to make it their own product.
The product can also be purchased on monthly deposits and rented out.

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[7] Bondi, A. B. (2000). Characteristics of scalability and their impact on performance. *Proceedings of the Second International Workshop on Software and Performance - WOSP '00*. https://doi.org/10.1145/350391.350432

[8] Ghose, B. (n.d.). Fisheries and Aquaculture in Bangladesh: Challenges and Opportunities. *Annals of Aquaculture and Research*. Retrieved April 15, 2022, from https://www.jscimedcentral.com/Aquaculture/aquaculture-1-1001.php

4.2 Manufacturing

One of the aims of this research is to explore the economic and technical feasibility of the cold storage unit. Through the use of renewable energy sources, the aim is to prevent loss of fish and other perishables, mainly potatoes at the farm level, due to the lack of proper storage facilities.

The design process will primarily be based locally to serve the target market correctly and benefit from reduced transportation and operational costs. The vision is supported by the concept of a manufacturing process based in Bangladesh, rather than one of its neighboring countries for example, and selling locally is supportive of a circular economy (CE). A model of production and consumption that makes use of local existing materials and products to the furthest extent while making, using, reusing, and recycling over time is one of the goals of CE. Through this process, pollution is reduced and the use of sustainability is encouraged. The cold storage system being sold is designed to help people through improved transportation of food, but will also provide long lasting food, more jobs for local people, as well as boosting the economy through the advantages of local manufacture[9].

Additionally, the cold storage unit may benefit from imported supplies that present cheaper manufacturing costs. The materials needed will be manufactured from different suppliers and then assembled from by a supplier within Bangladesh, thus the assembly and final product creation process will take place locally. As the product uses a variety of materials, it will be **important to get great materials and equipment from different suppliers, possibly from nearby countries as needed**. Training can be carried out via the members of the team on how to assemble the system, with the possibility of having further training carried out via an online platform as required.

4.3 Affordability

Cost is an important factor to consider with a product that is mainly directed to farmers with low income, therefore minimizing the capital cost of the product is critical for the success of distribution. In addition, it is important to create a portable storage system that can transport food from point A to point B and still maintain its freshness, there must also be a cost benefit. Some components of the system will require a larger investment outlay, however, there are substantial cost reduction opportunities in the long term especially if the system is commercialized. We’ve limited the use of batteries which drastically reduces the initial cost and the maintenance cost of the product making it more affordable and portable. We’ve also used only locally sourced materials to create the project so it can be easily mass produced in the native country and the containers used to shell the cold storage unit are reclaimed so it's being recycled at the end of its life cycle.

4.4 Lifecycle and waste

For the product, it would be best to analyze the components separately as well as a complete analysis of the final system. The reason for this being certain elements within the system can be easily replaced once the user understands its components and its functionality without having to replace the system in its entirety.

[9] Selim, S. A., Saha, S. K., Sultana, R., & Roberts, C. (Eds.). (2018). *The Environmental Sustainable Development Goals in Bangladesh*. Routledge. https://doi.org/10.4324/9780429463365

The life expectancy varies depending on the size of the storage system the customer gets. According to the 23rd annual portrait of the U.S. appliance industry, a standard cold storage system usually lasts anywhere between 10 to 18 years with an average life expectancy of 14 years. However, a smaller fridge (which can be transported on a car) has a shorter life expectancy ranging from 4-12 years with an average life expectancy of 8 years[1].

According to Greenmatch, a sustainability website, the life expectancy of solar panels is about 30 years before decommissioning. During the life of PV panels, a 20% decrease in power capacity might occur. Between the first 10 to 12 years, the maximum decrease in efficiency is 10%, and 20% when it reaches 25 years. Although, experience shows that the efficiency drops by merely 6% to 8% after 25 years. The lifespan of solar panels may thus be much longer than officially stated[10].

The process of the recycling in Bangladesh has not yet been developed in detail to perform an analysis. The process of recycling solar panels can differ on the type of solar panel used which is either silicon based or thin film.

Having the knowledge to be able to assemble the product in Bangladesh provides the country with the knowledge to be able to disassemble and recycle it.

4.5 Growth and Expansion Potential

On a global scale, there is 1.6 billion tons of food that go to waste each year, which accounts for $1 trillion worth, due to problems such as improper storage or spillage [11]. The cold storage unit could benefit numerous countries that have heavy fishing activities but lack the resources to properly store it, or that are suffering from harmful repercussions that are affecting the environment. Additionally, as previously mentioned, the cold storage unit is also beneficial for preserving farm produce, thus making it a useful resource globally.

The cold storage unit could expand to neighboring countries first, to facilitate its distribution. For example, India, Pakistan, Myanmar have a large fishing industry, and in some regions have encountered the same issues as the market in Bangladesh; most prominently in off-grid areas. As discussed by Indrani, lack of storage facility with the appropriate temperature and poor infrastructure on fishermen's boats in India affect the quality and health of the fish being transported[12]. Presenting an off grid system in these areas could bring lots of benefits to the local communities and subsequently on a larger scale to the regions.

The product can also be distributed later on to other countries in Africa. African countries on the coast have some of the largest fisheries in the world and yet lots of areas still struggle with lack of electricity

[10] *The Lifespan of Solar Panels | GreenMatch*. (2015). Greenmatch.co.uk. https://www.greenmatch.co.uk/blog/2015/01/the-lifespan-of-solar-panels

[11] Strubenhoff, B. K. and H. (2019, October 16). *How off-grid cold storage systems can help farmers reduce post-harvest losses*. Brookings. https://www.brookings.edu/blog/future-development/2019/10/16/how-off-grid-cold-storage-systems-can-help-farmers-reduce-post-harvest-losses/

[12] B. Indrani , Dr. B. Kanagaraj, 2019, A Descriptive Study on Challenges & Opportunities Faced by Fishery Sector in India, INTERNATIONAL JOURNAL OF ENGINEERING RESEARCH & TECHNOLOGY (IJERT) Volume 08, Issue 09 (September 2019),

access. In recent years, the use of renewable energy has been more prominent in African countries, such as in Kenya and Ethiopia. As reported by the UN, these initiatives have greatly improved this problem and the locals have adopted a new culture around renewable energy[13]. In the county of Lamu in Kenya, the largest fish harvest is produced yearly nationally. This area could benefit from the cold storage unit due to its accessibility, affordability, and governance dynamics[14].

4.5 Consumer Value Proposition

The consumer value proposition model depicts the relationship between the customer's emotional wants, their rational needs and their fears and the product's benefits and features to tackle these issues.

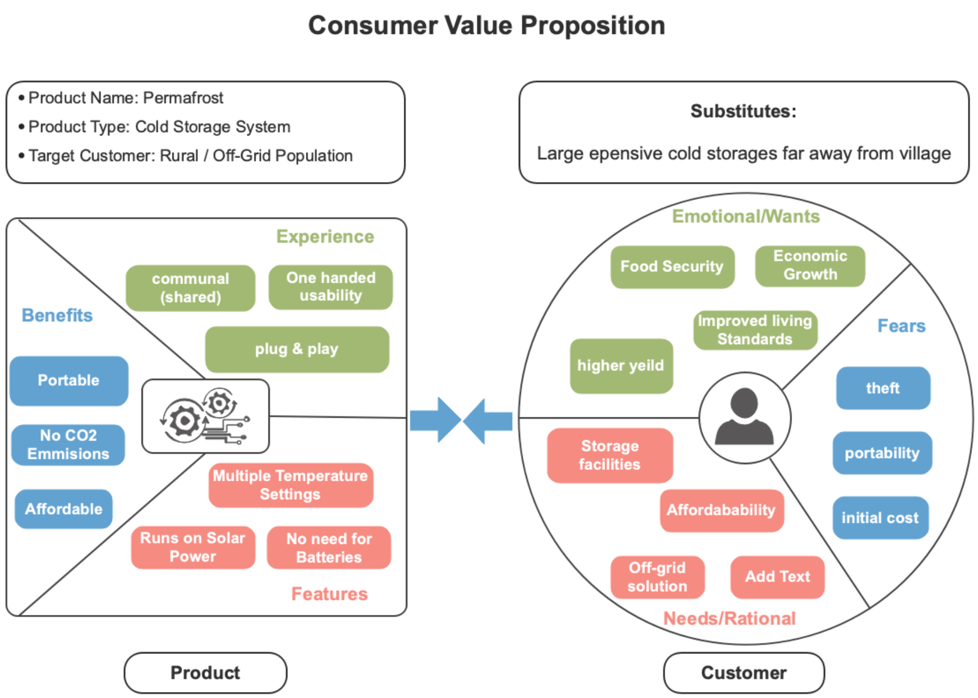

Fig.4 shows the the consumer Value Proposition

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[13] Obonyo, R. (2021, January 6). *Push for renewables: How Africa is building a different energy pathway*. Africa Renewal. https://www.un.org/africarenewal/magazine/january-2021/push-renewables-how-africa-building-different-energy-pathway

[14] Kabibi, S. T., Okeyo, B., & Timamy, M. H. K. (2022). STATUS, CHALLENGES AND OPPORTUNITIES OF THE COLD CHAIN SYSTEM IN KENYA: THE CASE OF THE FISHERIES SECTOR IN LAMU AND MOMBASA COUNTIES. *Journal of Environment*, *1*(2), 28–46. https://doi.org/10.47941/je.753

4.5 Revenue Model

For our revenue model we plan on developing a sales team that would advertise our product using social media platforms, and newsletters and newspapers. There will be a dedicated website to reach out to us to order the product directly, cutting out all middlemen in the process.

In the initial stages, we wish to grant the customer the ability to customize their product according to their preference, which will build a stronger customer, client relationship.

We also wish to approach NGOs and Non-profit organizations who actively look for viable solutions for cold storage systems and we plan to work with them hand-in-hand to ensure our clients are getting the best and most affordable solution for their problem. The stakeholders involved in our project are featured below:

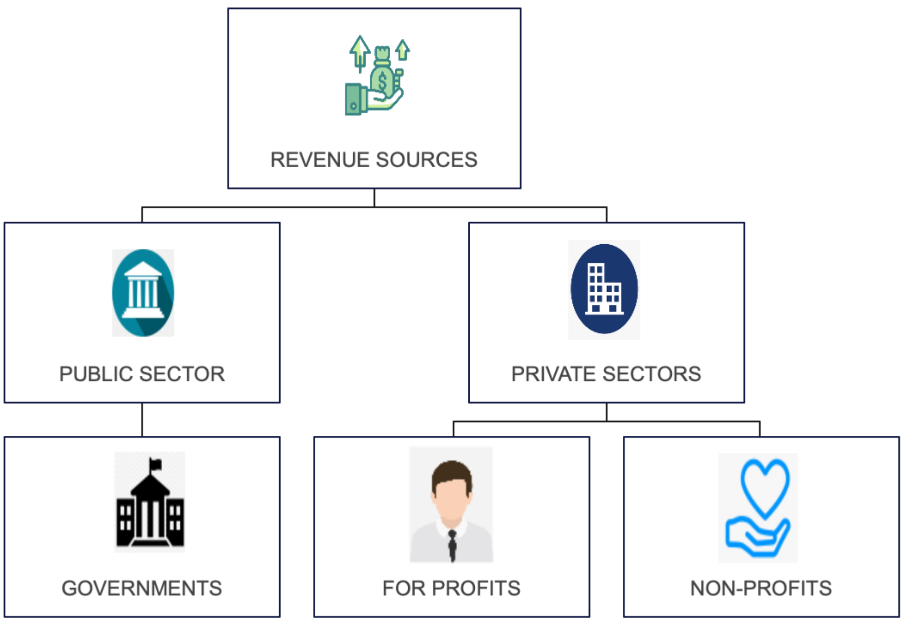

Fig.5 shows the revenue model diagram

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Appendix:

Efficiency for Access Design Challenge

Prototyping Application - Budget

Team Number: 2021-31

University: Independent University, Bangladesh - City, University of London

Project: Solar Direct Drive Cold Storage System for Off-Grid Preservation of Fish and Perishable goods.

Item number	Item Description	Link to item/quote where appropriate	Quantity	Unit Cost	Cost
1	Solar Panel 150W		2	$ 200.00	$ 400.00
2	Dc compressor 24V		1	$ 125.00	$ 125.00
3	Fridge Framework		1	$ 150.00	$ 150.00
4	1/4 Copper pipe		15	$ 2.00	$ 30.00
5	DC Cooling Fan		2	$ 12.50	$ 25.00
6	Heater		1	$ 15.00	$ 15.00
7	Defroster		1	$ 15.00	$ 15.00
8	Temperature Sensor		4	$ 1.50	$ 6.00
9	PCB Board & Micro-controller		1	$ 30.00	$ 30.00
10	R600 Gas (1kg)		2	$ 17.00	$ 34.00
11	LCD display		1	$ 5.00	$ 5.00
12	Transportation Cost (Logistics)		1	$ 25.00	$ 25.00
13	On Field Survey (For Visitation & Consultation with NGO)		1	$ 100.00	$ 100.00
14	10 Layer Condenser		1	$ 25.00	$ 25.00
15	Gas charging Gauge		1	$ 15.00	$ 15.00
				Total	$ 1,000.00