Solar Room Air Heater

Heating Solution for Schools in Ladakh

Master of Design

by

Kulkarni Vedang Uday

22M2229

Project Guide

Prof. B.K. Chakravarthy

IDC School of Design

INDIAN INSTITUTE OF TECHNOLOGY BOMBAY

(2024)

Approval

This is to certify that Industrial Design Project III (P3) entitled "Solar Room Air Heater for Ladakh School" by Kulkarni Vedang Uday is approved in partial fulfillment of the Master's Degree of Industrial Design at IDC, Indian Institute of Technology, Bombay.

Signature of the Project Guide: Prof Chakrabarti B.K Mukherjee

Signature of the Chairperson:

Signature of the Internal Examiner:

Signature of the External Examiner:

Date:

Declaration

The written submission is a part of my report, "Solar Room Air Heater for Ladakh School" is done as a Project - 3 for post-graduation program at IDC, IIT Bombay, under the guidance of Prof. B. K. Chakravarthy

Thereby declare that the thoughts, ideas, and words in this document are original, and appropriate references are cited wherever due. I understand that the violation of the above can cause disciplinary action by the institute.

Kulkarni Vedang Uday
22m2229
IDC - IIT Bombay

Acknowledgement

It is my pleasure to thank people who made this project possible.

I want to express my sincerest gratitude to my guide Prof. B. K. Chakravarthy who allowed me to work on this project under his guidance. His interest in this project, enthusiasm, great efforts to explain things, and giving clear directions have helped me keep myself motivated towards my project and fulfill its requirement.

I will like to thanks all other faculty members who gave me feedback about the project at each stage, without which it would have been difficult for me to get the right direction.

Special thanks to Prof. Rane, Prof. Prabhu, and Sakshi Mandlecha, Shri. Mahendra Mandlecha, Turtuk Valley School students who helped to understand the problems faced by the school students in the school due to cold climate

I would also like to thank all my friends at IDC, who kept supporting me throughout the project.

Abstract

This project aims to address the heating needs of the Turtuk Valley School in Ladakh by designing a solar room air heater to provide a comfortable learning environment for students during the harsh winter months. Collaborating with the mechanical department, a solar air heater panel developed by Prof. Rane was incorporated into the design. This panel harnesses solar energy to generate heat, which is then circulated within the classroom using a suction fan and air diffusing unit, both designed specifically for this purpose. Extensive field visits to Ladakh were conducted to understand the local conditions, including the unique atmospheric challenges, temperature fluctuations, cultural aspects, and architectural nuances of the school building. These insights informed every aspect of the design process, ensuring that the solution is tailored to the specific needs of the school and its students.

In the design and development phase, numerous tests were conducted on the solar air heater panel to optimize its performance and efficiency. Prof. Prabhu provided invaluable expertise in engineering and thermodynamics, guiding the team through the technical challenges and ensuring the feasibility and reliability of the system. Throughout the project, Prof. Chakravarthy served as a mentor, offering continuous support and direction, ultimately playing a pivotal role in the successful completion of the project.

The resulting product is a working prototype that offers a sustainable and cost-effective heating solution for the Turtuk Valley School. By harnessing renewable energy sources, the solar room air heater not only provides warmth but also promotes environmental consciousness and reduces the school's carbon footprint. This project demonstrates the power of interdisciplinary collaboration and the importance of understanding local context in design solutions. It also serves as a model for addressing similar challenges in remote and cold regions, offering a scalable solution that prioritizes comfort, education, and sustainability.

Keywords

Solar room air heater, Turtuk Valley School, Ladakh, heating solution, winter comfort, solar energy, mechanical engineering, interdisciplinary collaboration, sustainable design, renewable energy, field research, prototype development, thermodynamics, environmental consciousness, education, cultural sensitivity.

Content

Introduction

The Turtuk Valley School, situated amidst the breathtaking landscapes of Ladakh, faces a pressing issue every winter: keeping its classrooms warm for its students. In the biting cold of this high-altitude region, ensuring a comfortable learning environment becomes crucial for the well-being and academic performance of the students.

To tackle this challenge, we've collaborated with the mechanical department to develop a solar room air heater specifically tailored for the school's needs. This heater relies on the abundant sunlight in Ladakh to provide heating throughout the day, ensuring that students can focus on their studies without the discomfort of the cold.

At the heart of our design is a solar air heater panel, expertly crafted by Prof. Rane, which captures sunlight and converts it into heat energy. This heated air is then circulated within the classroom using a suction fan and air diffusing unit, ensuring uniform warmth across the space. To understand the school's requirements and the unique environmental conditions of Ladakh, we spent significant time conducting field visits to the region. We studied the school's architecture, observed temperature fluctuations, and immersed ourselves in the local culture. This firsthand knowledge informed every aspect of our design process, ensuring that our solution is both effective and culturally sensitive.

Guided by the expertise of Prof. Prabhu and Prof. Chakravarthy, we meticulously engineered and tested our solar room air heater prototype. Their insights in engineering and design were invaluable in overcoming technical challenges and ensuring the reliability and efficiency of our system.

Beyond just providing warmth, our project emphasizes sustainability. By harnessing renewable energy sources, our solar heater reduces the school's reliance on fossil fuels and contributes to environmental conservation efforts. This aspect is particularly significant in Ladakh, where access to conventional heating fuels can be limited and costly.
In this report, we will delve into the details of our design process, from concept development to prototype testing. We will also explore the potential impact of our project on education, sustainability, and community development in cold regions like Ladakh. Through our work, we aim to not only improve the learning environment for the students of Turtuk Valley School but also inspire others to seek innovative and sustainable solutions to similar challenges around the world.

Design Process

Cause >>>> **Context** >>>> **Comprehension** >>>> **Check** >>>> **Conception** >>>> **Crafting** >>>> **Connection**

The resolve to solve a problem	Understanding the problem space and the environment	Arriving at design insights	Creating a product brief	Generating ideas and concepts	Building Mock-ups and prototype	Delighting the user

Problem Statement

In the northern and northeastern regions of India, situated at high altitudes, the winter season brings extremely cold temperatures, often reaching -10 to -15 degrees Celsius. The residents in these areas constantly require heating solutions to cope with the **cold harsh climate**. Prolonged exposure to such low temperatures can pose health risks, particularly for vulnerable groups like the **Children**, **elderly**, and **individuals** with certain medical conditions, leading to conditions like **hypothermia** and **frostbite**.

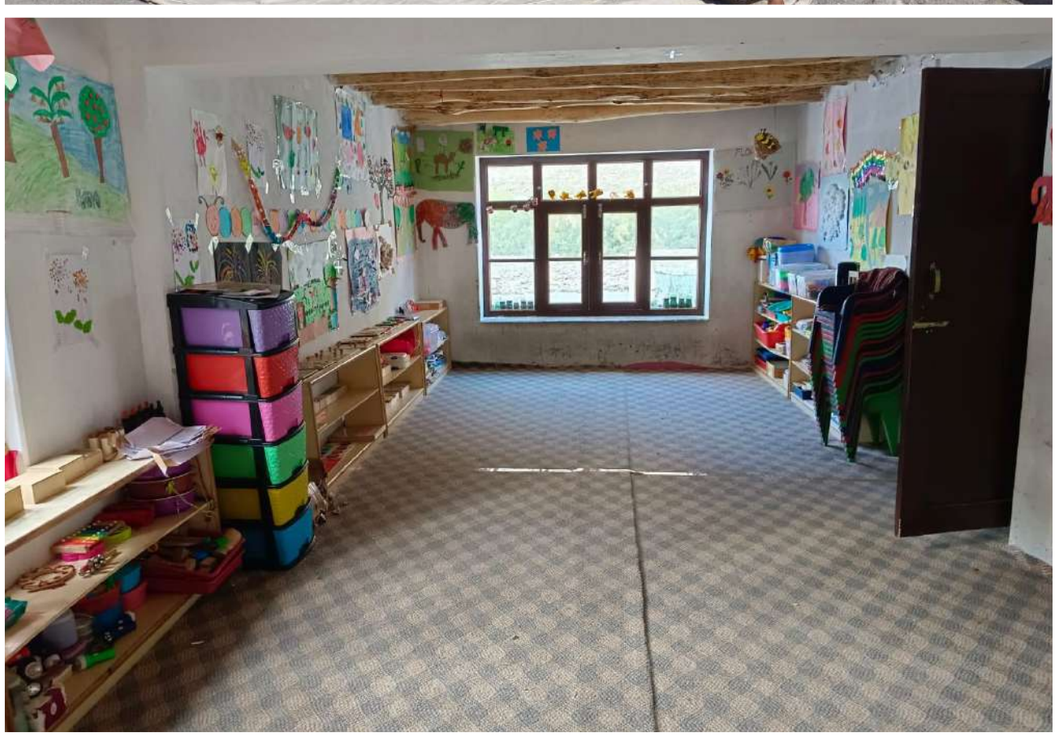
Turtuk Valley school visit to Shenoy Innovation Studio

Students and teachers of Turtuk valley school along with Prof. Chakravarthy. Every year the students of Turtuk Valley school visit Mumbai in the winter holidays. Due to harsh winter most of the people from Ladakh region relocate in Indian to avoid the winter.

About
Turtuk Valley School

Turtuk Valley School is nestled in the villages of the Karakoram Range, a remote village of Ladakh – Turtuk. It is not just a " School " it is a DREAM of many parents and kids of this region who cannot afford to go to the Bigger Towns/Cities for better Quality of Education. This school has given Wings to the children and they now dream of a Bright Future ! Started in 2020 with 25 kids the school is currently catering to over 100 + children from grade Pre – Nursery to Grade 6th. With Natural Growth we aim to Go upto Grade 12th.

An Active Volunteer programs runs through the year where we have people from different walks of life coming and living in the village and volunteering with the school to teach subjects and co-curricular activities along with training our local teachers.
The Local Teachers are also trained in Mumbai, through "KOTAK EDUCATION FOUNDATION"



Photos of Turtuk valley school

About
Turtuk Village

Turtuk is a village in the Indian Union Territory – Ladakh. Turtuk is one of the northernmost villages of India, second only to Murgo Village, the northernmost village of India. It is situated in the Leh District of the Nubra Valley. It is 205 km away from Leh, it is 2.5 km from the Line Of Control between India and Pakistan.

Turtuk is located on the banks of the Shyok River. These villages form the only region in India populated by Balti People. Turtuk is known for its varieties of fruits, especially Apricots.

Turtuk was under Pakistani control until the War of 1971 when the Indian Army captured this village. It’s the last outpost of India's Ladakh Region. It is also one of the gateways to the Siachen Glacier.

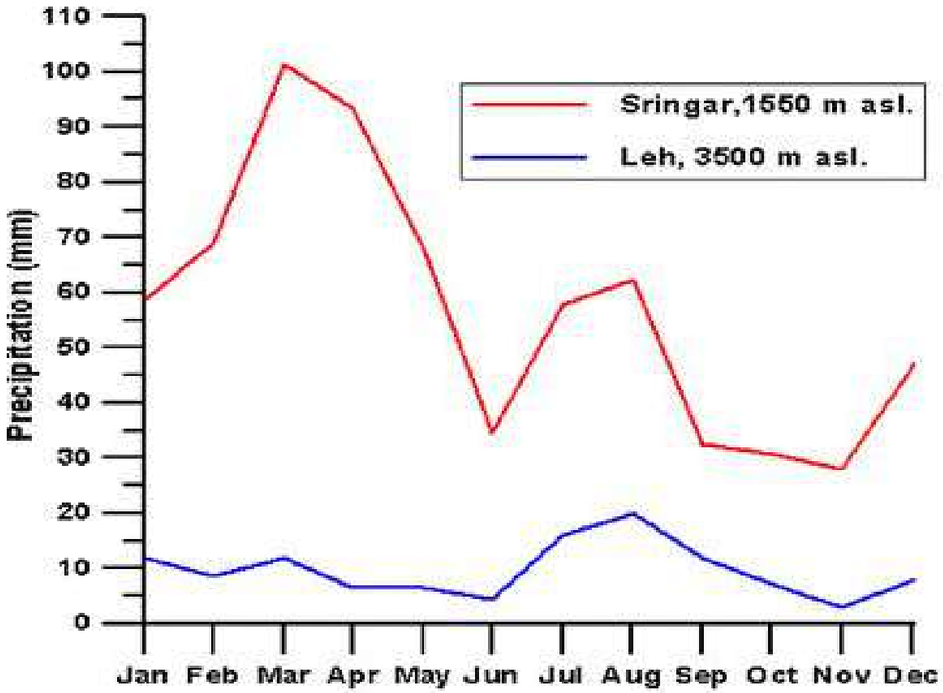
Turtuk Village

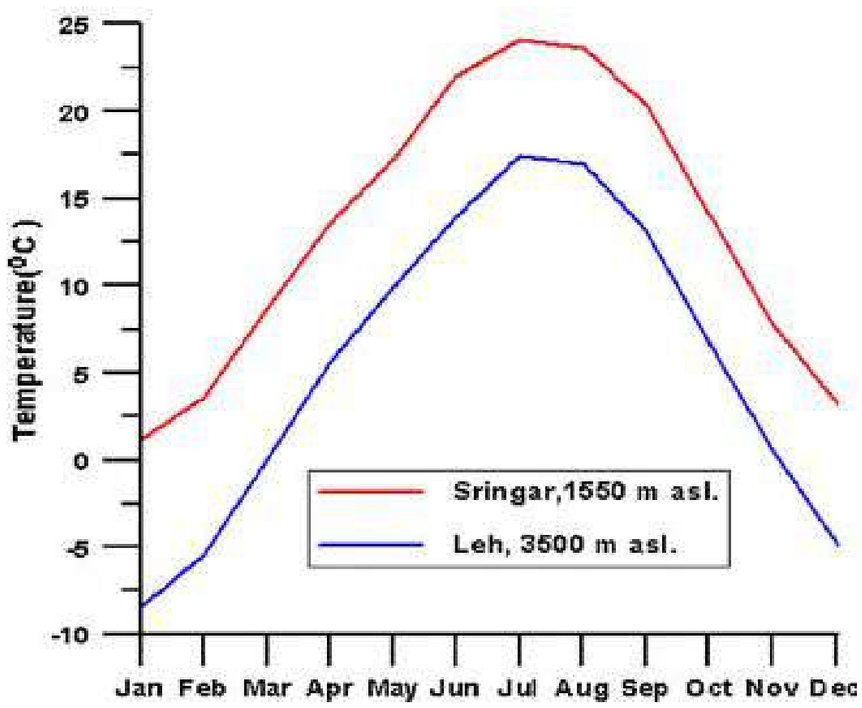
Climate of Ladakh

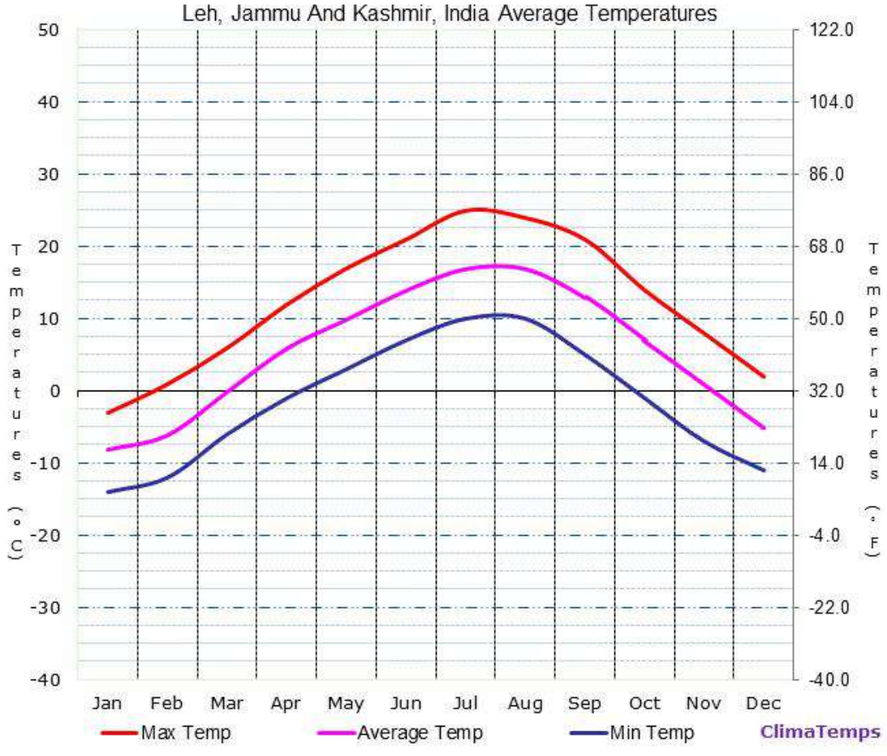
Ladakh is a cold, dry desert with drastic temperature changes due to its high altitude. Winters are extremely cold, with temperatures often below -40°C (-40°F). In the summer, daytime highs are 20–30°C (68–86°F), but night temperatures are below -30°C (-22°F). Ladakh receives little rainfall, averaging up to 90 mm annually, and it's rare in the winter. Glaciers take the entire season to melt, and temperatures remain below freezing for almost three months from December to February.

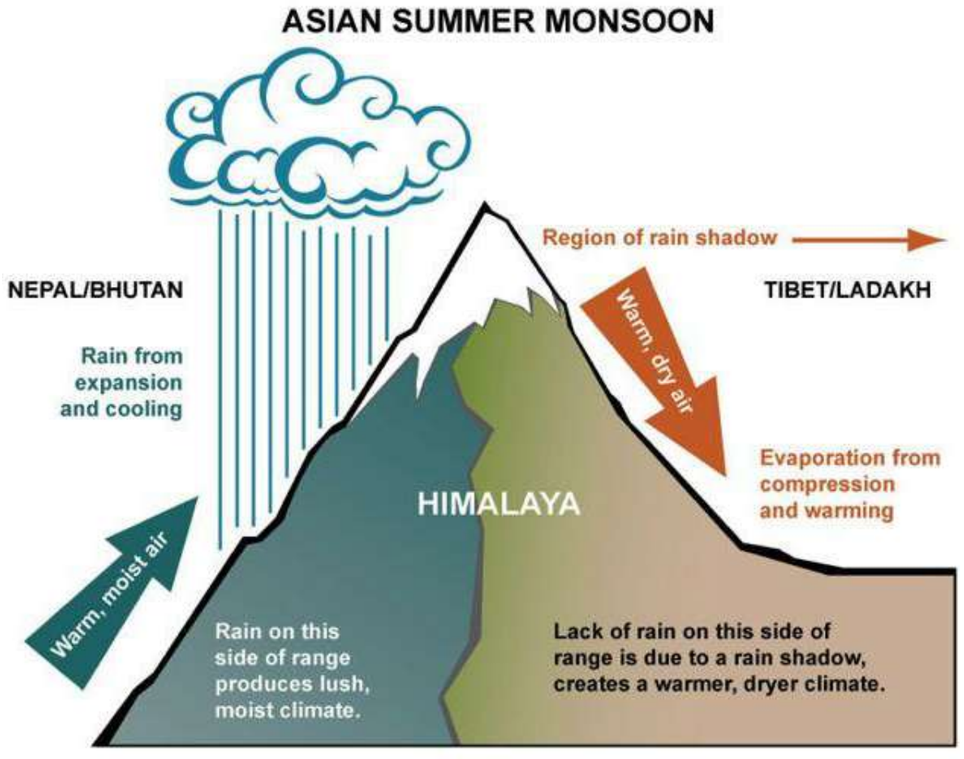
The climate of Ladakh is hostile by any measure. The temperature goes to extremes at times. Most of the areas of the region remain cut off from the rest of the world in winter due to heavy snowfall. Most of the areas are inaccessible.It is the highest, driest and the coldest region of India. It is a cold desert and most of the areas are devoid of any vegetation. Winter lasts almost one-third of the year. The temperature often goes to extremes. While in winter you may have frost bites due to a low temperature, in summers sunburns are caused due to extra heat and lack of moisture in the air. The rainfall is very low as the region lies in the rain shadow area, where monsoons reach without any moisture at all.

Ladakh is situated at a very high altitude. It is the world’s highest elevated and inhabited land. It is situated in the Karakorum Range of the Himalayas. These factors combine together to determine the climate of Ladakh.Having such climatic conditions, the trip to Ladakh is never going to be easy. Being at high altitude can be hazardous for health if necessary precautions are not taken. So, it is always advisable to spend a day or two at places with a comparatively lower altitude, so as to acclimatize with the local conditions. This acclimatization becomes important if you are planning a trek into the mountains of the region. This being said, area still remains one of the most visited paces on the earth. Things that are hard to achieve are always too delightful. The thing that makes Ladakh a delightful place is its serenity and its calmness. The atmosphere is quiet and calm. The sky is usually clear and dazzles with stars during the night.









Data of precipitation and Temperature of Ladakh and Srinagar

Sunlight Data

Here are some key points regarding sunlight in Ladakh:
High Altitude: Ladakh is situated at a high altitude, with most of its areas lying above 3000 meters (9800 feet) above sea level. This elevation allows for greater exposure to sunlight.
Clear Skies: Ladakh is characterized by clear skies for most of the year. The region experiences very little rainfall and cloud cover, especially during the summer months, leading to more direct sunlight reaching the surface.
Sunlight Intensity: Due to its high altitude and clear skies, the sunlight in Ladakh can be intense, especially during the summer months. This intense sunlight is often utilized for various purposes, including solar energy generation and agriculture.
Seasonal Variation: Like any other region, Ladakh experiences seasonal variations in sunlight. Winters may have shorter daylight hours and less intense sunlight compared to the longer and brighter days of summer.
Solar Potential: Ladakh has been identified as having significant solar energy potential due to its high solar insolation levels. Several solar power projects have been planned or are already operational in the region to harness this potential.

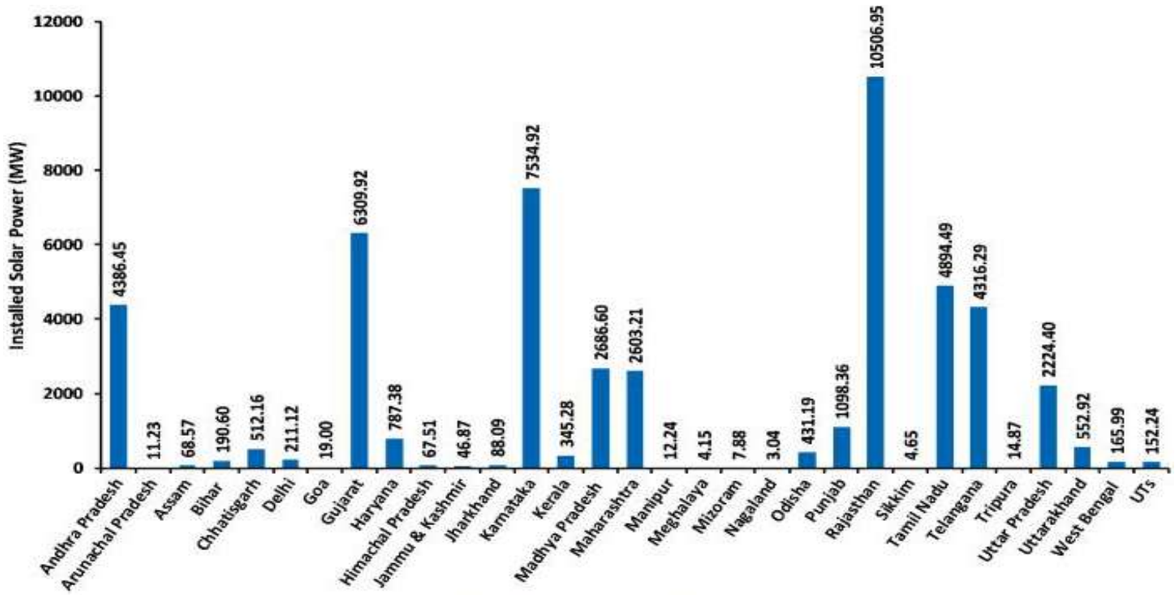
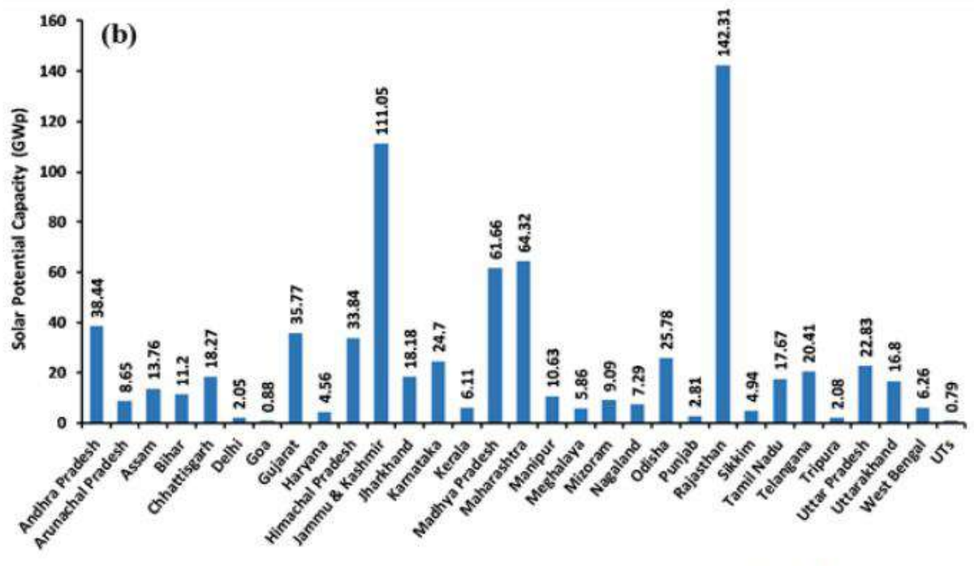


Figure 3. State wise installed solar power capacity by 31st January, 2022.



1. (a) Time series plot for net electricity generation growth from solar energy in India and (b) state-wise estimated solar potential capacity according to MNRE annual report 2020-21.

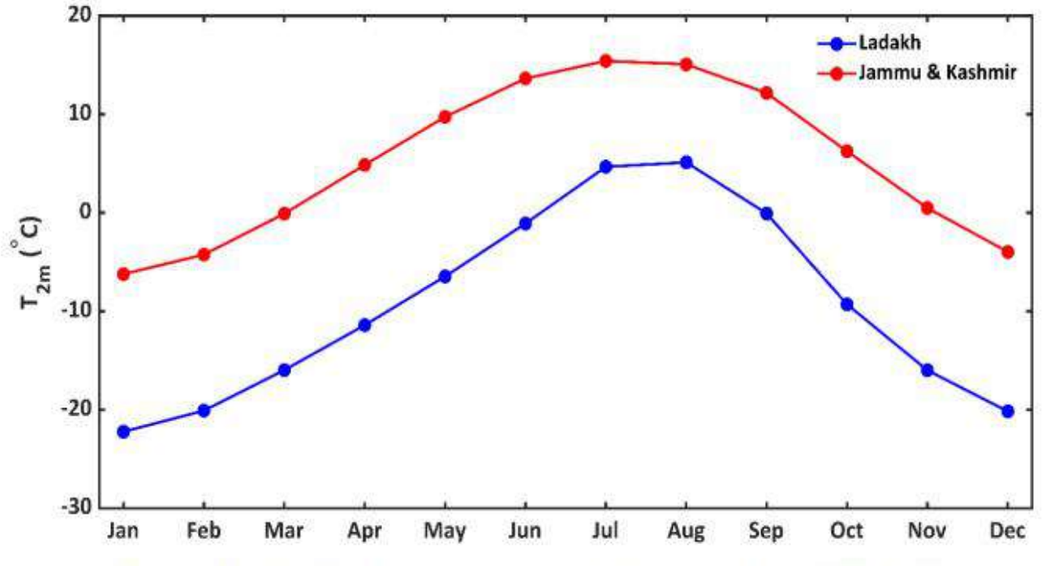


Figure 4. Monthly distribution of averaged 2m-temperature from 1981 to 2020.

Education system in Ladakh

The Moravian Mission opened a school in Leh in October 1889, and the Wazir-i Wazarat of Baltistan and Ladakh prepared that every family with more than one child should send one of them to school. The school taught Tibetan, Urdu, English, and Geography, Sciences, Nature study, Arithmetic, Geometry and Bible study. It is still in existence today. The first local school to provide western education was opened by a local Society called "Lamdon Social Welfare Society" in 1973. Later, with support from HH Dalai Lama and some international organizations, the school has developed to accommodate approximately two thousand pupils in several branches. It prides itself on preserving Ladakhi tradition and culture.

Schools of Ladakh

Schools are well distributed throughout Ladakh but 75% of them provide only primary education. 65% of children attend school, but absenteeism of both students and teachers remains high. In both districts the failure rate at school-leaving level (class X) has for many years been around 50%. Before 1993, students were taught in Urdu until they were 14, after which the medium of instruction shifted to English.

In 1994 the Students' Educational and Cultural Movement of Ladakh (SECMOL) began Operation New Hope (ONH), a movement to offer "ethnically suitable and locally appropriate education" and make government schools more functional and useful. Eliezer Joldan Memorial College is a government degree college of Ladakh, which makes possible students to pursue higher education in Ladakh. According to the Year 2001 poll, the in general literacy rate in Leh District of Ladakh is 62% (72% for males and 50% for females), and in Kargil District of Ladakh 58% (74% for males and 41% for females). Conventionally there was little or nothing by way of official education except in the monasteries. Usually, one son from every family was appreciative to master the Tibetan script in order to read the divine books.

- The language used in books and exams was one non-Ladakhi language, Urdu, up to class 8, and then another, English, for classes 9 and 10.

- All the textbooks, even in early primary classes, came from Delhi. The examples were of unfamiliar cultures and environments like ships, oceans, coconut trees and monsoon rains. These alien examples in alien languages only confused Ladakhi children.

- Most of the teachers had no training at all and should not be blamed for the problems. They had succeeded in education from similar schools and were then thrown into teaching without any training. They mainly taught through rote memorisation without comprehension.

- All teachers were rotated to different areas every two years, away from their homes. Irregularities in the transfer system left many teachers disturbed and demoralized.

- Community participation was minimal. Villagers didn't know how schools were supposed to run, so if the school stayed closed for days or weeks, they didn't know who to complain to or how, or even whether they had the right. At the same time, villagers gave no support to teachers, who often had genuine problems in remote villages.

Temperature in Classrooms

Did you know that the room temperature in your home or office affects much more than your body's physical comfort? Room temperature also affects our brain in many different ways.

The Science Behind Temperatures

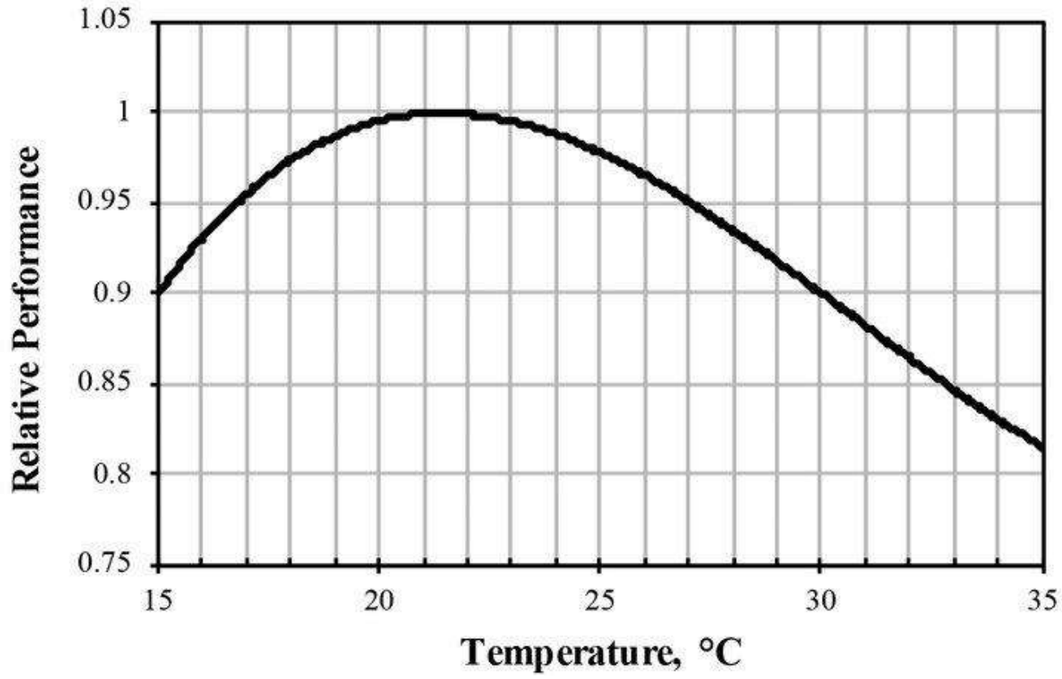
Before we can look at any of the benefits that can be received from having the right room temperature, we must understand how room temperature affects our brain physically. Most of us probably remember learning in science class that the average body temperature for a human is 98.6 degrees Fahrenheit, and our brain works really hard to make sure that our bodies maintain this temperature. In order to do this, our bodies use glucose, but heating up and cooling down the body do not require equal amounts of energy or glucose.

Our brains expend greater energy in order to cool our bodies down than it does to warm our bodies up. The more glucose that our bodies are using to regulate our body temperature, the less glucose is available for our brains to use for our higher order cognitive functioning. So, keeping the room temperature at an optimal temperature that will help our bodies naturally maintain our 98.6-degree body temperature, will also improve our brain's overall ability to function.

Just as with the work environment and productivity, there has been a lot of research dedicated to determining whether room temperature affects our ability to learn and the effectiveness of studying, and how.

The Environmental Protection Agency's Special Achievement Award winners set out to answer the question "does the temperature you set for your air conditioner or heating system impact student performance?" They conducted several experiments that included testing students in different climate-controlled rooms.

At 61 degrees Fahrenheit, 72 degrees Fahrenheit, and 81 degrees Fahrenheit, and concluded that temperature does have an effect on a student's attention span, with students in both the warmer and cooler rooms testing more poorly than the students in the control room which was maintained right around 72 degrees Fahrenheit.
Students that were in the warmest room (81 degrees Fahrenheit) did the poorest on the test with an average score of 72%, those in the coolest room (61 degrees Fahrenheit) performed only slightly better than the students in the warmest room with an average score of 78%, but students in the control room (72 degrees Fahrenheit) scored the highest with an average score of 90%! Another study done by an undergrad student at Loyola University came to the same conclusion that in environments with warmer and cooler room temperatures memory was impacted negatively, and that test scores were significantly higher in a classroom environment that maintained a room temperature around 72 degrees Fahrenheit.



Experiment to find best temperature to study

Background: This study aimed to investigate the effect size (ES) of air temperature on the executive functions of human brain and body physiological responses.

Methods: In this empirical study, the participants included 35 male students who were exposed to 4 air temperature conditions of 18°C, 22°C, 26°C and 30°C in 4 separate sessions in an air conditioning chamber. The participants were simultaneously asked to take part in the N-back test. The accuracy, electrocardiogram (ECG) signals and the respiration rate were recorded to determine the effect of air temperature.

Results: Compared to moderate air temperatures (22°C), high (30°C) and low (18°C) air temperatures had a much more profound effect on changes in heart beat rate, the accuracy of brain executive functions and the response time to stimuli. There were statistically significant differences in the accuracy by different workload levels and various air temperature conditions($P<0.05$). Although the heart beat rate index, the ratio between low frequency and high frequency (LF/HF), and the respiratory rate were more profoundly affected by the higher and lower air temperatures than moderate air temperatures ($P<0.05$), this effect was not statistically significant, which may be due to significant reduction in the standard deviation of normal-to normal intervals (SNND) and the root of mean squared difference between adjacent normal heart beat (N-N) intervals (RMSSD) ($P>0.05$).

Conclusion: The results confirmed that the unfavorable air temperatures may considerably affect the physiological responses and the cognitive functions among indoor employees.Therefore, providing them with thermal comfort may improve their performance within indoor environments.

Keywords: Air temperature, Executive functions of brain, Electrocardiogram, Respiratory rate, N-back test

SECMOL

The Students' Educational and Cultural Movement of Ladakh

The Students’ Educational and Cultural Movement of Ladakh (SECMOL) was founded in 1988 by a group of Ladakhi college students who felt that the education system needed great change. For many years, SECMOL worked on reforming the government school system. At the same time, SECMOL Campus grew into a eco-village where students, staff and volunteers live, work and learn together. It’s not a conventional school, but a place to pursue practical, environmental, social and traditional knowledge, values and skills. The Campus is solar powered and solar heated; students learn ancient Ladakhi songs, dance and history alongside modern academic knowledge; and the students mainly manage, run and maintain the campus.

Ladakh is a high desert region in the Indian Himalayas, with a culture and history drawing from Tibet, India, Kashmir and Central Asia. No road connected it to the outside world until the 1960s, but recent decades have brought a flood of development and tourism. SECMOL strives to equip young Ladakhis and others growing up in Ladakh, especially those from rural or disadvantaged backgrounds, with the knowledge, skills, perspective, and confidence to choose and build a sustainable future.

EDUCATION REFORMS AND ONH

From the founding of SECMOL in 1988 one of our main objectives was to improve the educational system of Ladakh. In 1998, 95% of Ladakhi students failed the state 10th class exams every year, so we concluded that it was necessary to change the educational system. In 1994 SECMOL launched the Operation New Hope movement to improve education in Leh District, in collaboration with the Education Department, the local government and the village community members. In 2007, SECMOL had to pull out of school reform, and stopped working with the local government on it. Substantial improvements are visible, although more should still be done.

All teachers are now trained, primary level children have locally relevant textbooks, the language confusion has been reduced, teachers and administrators are more accountable, and village committees oversee and improve their schools. The number of student passing the matriculation exam increased, so that from 2003 to 2006 about 50% of government school students passed their matriculation exam in Leh District every year, and after a drop in 2008 to 28%, it has risen to over 2/3 of students passing.

SECMOL launched Operation New Hope (ONH), in 1994 to overhaul the primary education system in the Government schools in Ladakh. This tried to tackle the roots of the problem and to reform the education system, especially in remote villages. The ONH movement had three arms working together: the Government, the Non-Governmental Organizations (NGOs), and the village communities.

ONH's aims and objectives:

- To organize the village communities for constructive participation in the running of schools by forming Village Education Committees (VECs).
- To train teachers in creative, child-centered, and activity-based teaching methods in order to make schooling less painful and more joyful for children.
- To produce Ladakh-relevant versions of primary textbooks and teaching materials.
- To use the above factors to revive the interest, strengthen the confidence, and enhance the dedication of Government school teachers.

SECMOL
PASSIVE SOLAR HEATING

SECMOL buildings are heated without emitting CO2 or burning anything fuel such as firewood or gas, nor electric heaters. Passive solar design absorbs heat from the sun and then stores it as long as possible. It does not use circulating water pipes, air blowers, or moving parts. With only passive solar heating, the SECMOL buildings have let us run residential programmes every winter for the last 15 years — even when the minimum outside temperatures falls to -25°C.

The temperature in the main building at SECMOL Campus has been:
Normal evening temperature in coldest part of winter: +14°C
Minimum in a normal winter: +10°C
Minimum observed in 19 years: +7°C

In the main building at Phey Campus, the stairwells have houseplants flourishing even in January.

The main features that keep the buildings warm are:

- South facing windows, as the sun moves low in the southern sky in winter.
- Greenhouses are attached the south side for winter.
- Greenhouses are removed in springtime to prevent overheating.
- Skylights are covered with glass or clear plastic to keep warm air indoors.
- Thick earthen walls and floors to store collected heat (thermal mass).
- Insulation in the roof, outer walls, and in some places under the floor.
- Natural lighting so electricity is not needed for light in the daytime.

In winter, we roll huge plastic sheets down to make a big greenhouse which works as a solar collector for each building. In summer, the plastic is rolled up to prevent overheating. This UV-stabilised plastic is commonly used for agricultural greenhouses in Ladakh.

THERMAL MASS IN WALLS AND FLOORS

Most of our buildings are at least three feet (1 m) below ground on the north side. The earth's temperature at that depth is relatively warm in winter and cool in summer. It also helps us get the building material — earth — on site. The earth we dig out becomes the walls of the building.

All of our buildings are made of earth, so the building material comes right from the site and is not transported hundreds of miles. When construction is finished, there is no debris to be thrown away: no addition, no subtraction. Earth buildings stay warm in winter and cool in summer, and also moderate the humidity of the building.
The walls of the big building at Phey campus and the Leh office are rammed earth. This means the earthen walls are cast in place, in a simple wooden frame. Sand and clay are mixed in the right amounts to get a very strong constitution. It is then packed in the frames and rammed with pounders.

Some buildings here are made of straw clay bricks for insulation. Our earliest buildings were made of the common local style earth bricks.
The thick earth walls are not just structural (to take load) but also have an essential function as the heat bank (thermal mass). They absorb the excess solar heat during the day and release it to the rooms at night. The same property also keeps rammed earth buildings cool in summer.

Rammed earth is an ancient technique used in monasteries, castles and forts around Ladakh. These structures have survived, unprotected and exposed to the elements, for hundreds of years.
While we resurrected this method in Ladakh, we were pleasantly surprised to learn that there is a resurgence of this technique in Europe, North America, and Australia.

NATURAL LIGHTING: THE SUN

Windows and skylights ensure that no place in the building needs electric lights in the day.

INSULATION IN CEILINGS, OUTER WALLS AND FLOOR

Insulation protects the heat of the day, but need not be expensive modern materials. The wood waste generated during the construction is stuffed in the ceiling to stop heat loss through the roof. Insulation below the floor also helps. Layers of various sizes of rocks create insulating air-pockets between the rocks. A top layer of gravel and cement acts as a heat bank. Sometimes the top layer of the floor is slates from nearby mountains. This reduces the use of cement, and the slates also become a thermal mass or heat bank as they are now cut off thermally from the cold ground.

This kind of floor absorbs the excess heat during the day and releases it during the night. Otherwise floors can be an area of big heat loss.The outer walls are insulated by a jacket wall outside the main structural wall. The six inch gap between the two walls is filled with low cost insulation: saw dust, wood shavings or sometimes paper and plastic garbage like bottles and bags. Sometimes we have also used cow dung as an insulating plaster. Mixed with the right amount of earth and clay, it makes a strong and thermally effective plaster.

If comparing 'thermal conductivity' (insulation property) of common Ladakhi building materials, you find that mud is the best:
1 ft mud wall = 2 ft concrete = 4 ft stone = 1.5 inch of saw dust. = 1 inch of Thermocol, rockwool etc.

The Cause

To create solar room air heating system for students of Turtuk valley school

The Context

- Turtuk Valley school
- Schools at High altitude cold areas
- Tuition classes during winter
- Government Offices

Room Heating Solution

What is a Room Heater

Room heaters are regarded as one of the most useful and efficient household appliances to have ever existed. They are easy to use, readily available and do not have large maintenance expenses. With the level of technological advancement today, room heaters are economical and take up minimal space. Weather conditions in parts of northern India can make it necessary to own a room heater to combat the chilly winter nights. It is crucial to understand how different types of room heaters function and understand the various price ranges that they are available in. Our aim through this report is to clearly understand which type of heater you should purchase without getting confused.

These room heaters available in the market can be segregated based on their principle of heating. There are conventional heaters which use a coil to generate heat. conduction heaters which use a metallic panel which is electrically charged and finally, Radiant heaters, which use infrared radiation for heating purposes.

Types of Room Heater

1

FAN HEATER (also known as Ceramic / Convection / Blower room heaters)

2

INFRARED HEATER (also known as Halogen / Quartz / Radiant room heater)

3

OIL FILLED ROOM HEATER / oil heater

FAN HEATER

A fan heater is an electric heater that uses a fan to circulate warm air. It works by heating air with a heating element and then using a fan to blow the warm air into the room. Fan heaters are often used to quickly heat up a room in a short period of time. They are a popular choice for those looking for a fast and efficient way to heat their home.

OIL FILLED ROOM HEATER

An oil heater is a type of space heater that uses oil as its fuel source. It is typically composed of an electric heating element, a reservoir of oil, and a fan to disperse the heated air. Oil heaters are often used in residential homes and commercial buildings to heat large areas or provide additional warmth during cold weather. They are usually more efficient than electric space heaters, as the oil can retain its heat for a longer period of time.

INFRARED HEATER :

An infrared heater is a type of electric heater that uses the invisible infrared light spectrum to directly heat objects and people in the room without having to heat the air in between. It is often used to supplement traditional home heating systems, or in areas where a conventional space heater might not be practical, such as a garage or workshop. It works by emitting infrared radiation, which is absorbed by any solid object in its path, such as furniture and people. This radiation is then converted into heat, which is released into the surrounding environment.

Why is a heater necessary?

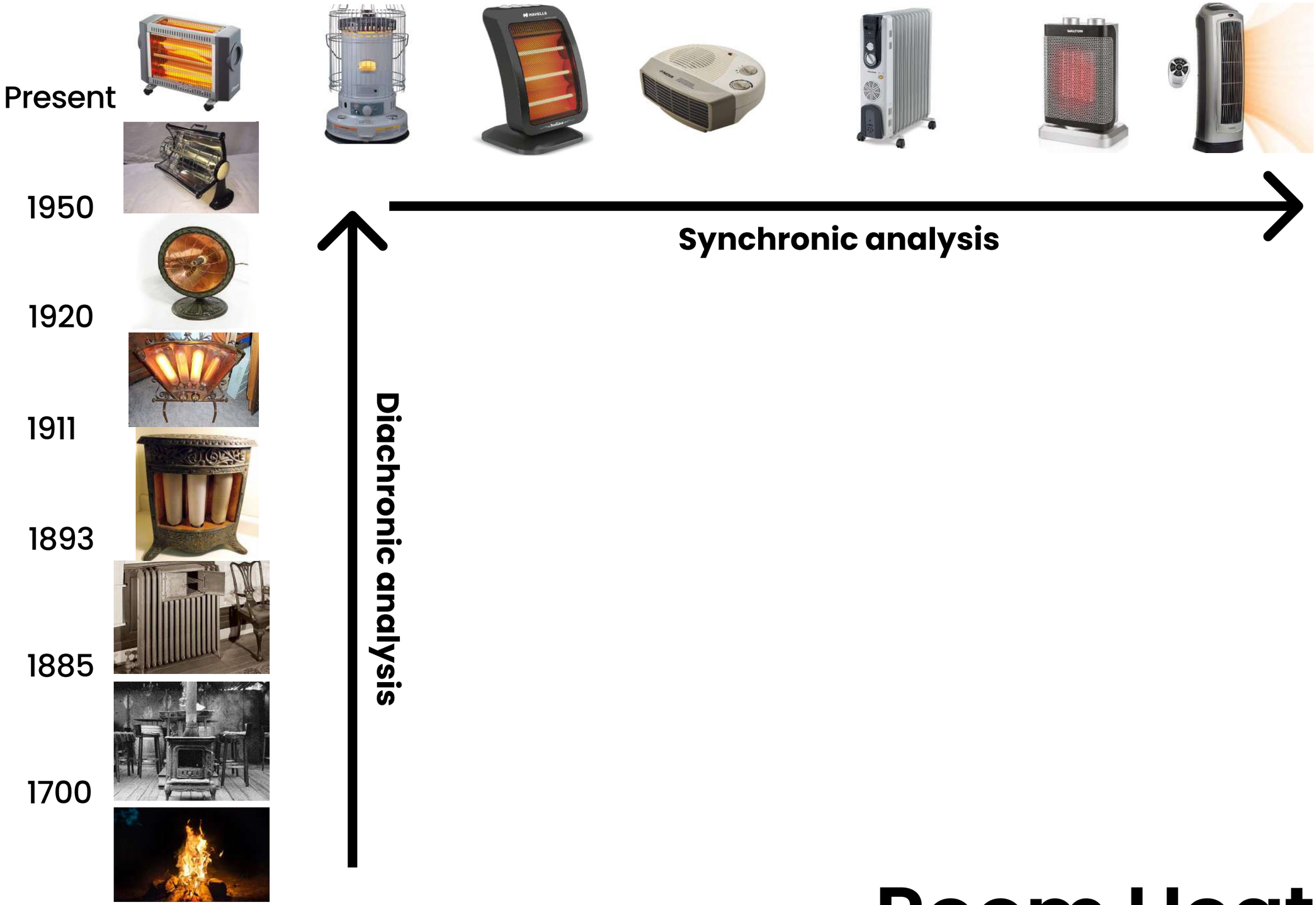
A heater is necessary for several reasons, primarily related to providing comfort, maintaining health and enabling various industrial processes. Here are some of the key reasons why heaters are essential:

- Temperature Regulation: Heaters are used to increase the temperature in indoor spaces during cold weather. They help maintain a comfortable environment by preventing excessively low temperatures that could lead to discomfort and even health issues

- Health and Well-being: In cold climates, exposure to low temperatures for extended periods can be harmful to human health. Heaters help prevent conditions like hypothermia and frostbite, especially for vulnerable groups such as the elderly, children and individuals with certain medical conditions

- Preventing Freezing: In colder regions, heaters are used to prevent freezing of water pipes and other essential infrastructure, ensuring that water supply and various system remains operational

- Comfort and Productivity: Comfortable working conditions are essential for productivity in workplaces. Heaters contribute to a conducive environment, allowing people to focus better and perform their tasks efficiently.


Present
1950
1920
1911
1893
1885
1700
Synchronic analysis
Diachronic analysis

Room Heater

Existing heating products

Bukhari

The "**Bukhari**" is a traditional heating appliance commonly used in the Ladakh region, particularly in households and establishments located in high-altitude areas with cold climates. It is a type of wood-burning stove or heater that serves as a primary source of warmth during the harsh winter months.

The Bukhari typically consists of a metal or clay structure with a cylindrical shape, equipped with a chimney for smoke ventilation. It is designed to burn wood, coal, or dried animal dung as fuel, providing radiant heat to the surrounding space. The heat emitted by the Bukhari helps to warm up rooms, making indoor environments more comfortable for occupants, especially in extreme cold conditions.

In Ladakh, where modern heating solutions may not always be available or feasible due to geographic and climatic challenges, the Bukhari remains a popular and practical heating solution due to its simplicity, effectiveness, and affordability. It is an integral part of traditional Ladakhi architecture and culture, providing essential warmth and comfort to households and communities in the region.

Existing heating products

Solar Hamam

- **The Solar Hamam** provides an anti-freezing outlet. It provides for 15-18 litres of boiling hot water, within first solar illumination of 30-35 minutes, at maximum temperature of 90°C in the morning.
- Successive batches of hot water are available 15-20 minutes apart.

Primary Research

Round 1.
Conducted interview with the Sakshi Mandlecha , the member of the Turtuk Valley School

Questionare

Introduction:
Can you tell me a bit about your experience living and working in Ladakh?
How would you describe the climate and weather conditions in Ladakh, particularly in terms of cold temperatures?

Indoor Heating Needs:
What are the primary methods currently used for heating indoor spaces in Ladakh?
In your opinion, what are the main challenges or limitations with the existing heating methods?

Solar Heating Awareness:
Are you familiar with solar heating solutions for indoor spaces?
Have you or others in the community used any solar heating systems before?

Specific Challenges in Ladakh:
How do extreme cold temperatures in Ladakh affect indoor comfort, especially in schools?
Are there specific times of the day or year when heating is particularly challenging?

Energy Availability:
How reliable is the current energy supply for heating purposes in Ladakh?
Are there frequent power outages or limitations that impact indoor heating?

Space Considerations:
What are the typical sizes of indoor spaces in schools that require heating?
Are there any specific challenges related to the layout or structure of school buildings?

User Preferences:
What features would be most important to you in a solar heating solution?
Are there any preferences regarding the aesthetics or placement of heating systems in indoor spaces?

Community Involvement:
How open do you think the community would be to adopting new, sustainable heating solutions?
Are there any community-based initiatives or preferences that should be considered in the design?

Maintenance and Durability:
How important is the ease of maintenance and durability of heating systems in Ladakh?
Are there any specific challenges related to maintenance in the high-altitude environment?

Environmental Impact:
To what extent is the community concerned about the environmental impact of heating solutions?
Would a solar heating solution be well-received in terms of its environmental benefits?

Cost Considerations:
How sensitive is the community to the initial cost and operating expenses of heating systems?
Are there any potential funding sources or support for adopting new heating technologies?

Feedback and Suggestions:
Based on your experience, do you have any specific suggestions or feedback for designing effective solar heating solutions for Ladakh?

Interview Insights

- The Turtuk valley school runs in the month from March to November. After November there are winter holidays because of extreme cold winters
- Currently there is no use of any heating solution in the school for students.
- The awareness about solar energy is very less in this area. Very few people use solar products.
- The is daily power cuts in the village for long duration.
- Till last year there was no continous internet service in the village. As its very difficult to deploy connection in the high altitude. Last year Airtel internet service was made available for the villagers
- At present 150 students are studying in the school from nursery to 8 th standard.
- The school timing of Turtuk Valley School is 9.00 am to 3.00 pm
- The school fees is not compulsory fo the students who cannot affort to pay. Thats why anyone can take education and study

Round 2.

Conducted interview with the students and teachers of the Turtuk Valley School

Questionare

Introduction:
- Hi! My name is [Your Name], and I'm working on a project to make your classrooms warmer using solar heaters. Can you tell me your name and which grade you are in?

Experience with Cold Weather:
- How would you describe the weather in Turtuk Valley, especially during the winter months?
- Can you share a bit about your experiences with the cold weather in your classroom?

Current Heating Methods:
- What methods are currently used to keep your classrooms warm during the cold days?
- Do you think these methods are effective in keeping the classrooms comfortable?

Classroom Comfort:
- On really cold days, how does it feel to be in the classroom? Is it too cold, just right, or too hot?
- Are there specific times during the day when the classroom feels colder?

Solar Energy Awareness:
- Have you heard about solar energy before? Do you know how it works?
- What do you think about using the power of the sun to make your classrooms warmer?

Your Ideal Classroom Temperature:
- If you could choose, how warm would you like your classroom to be on a cold day?
- Are there any activities or subjects where having a warmer classroom would be especially helpful?

Concerns or Challenges:
- Are there any challenges you face due to the cold weather in the classroom?
- What do you think would make your classroom experience better during the winter?

Solar Heater Design Preferences:
- What features do you think would be cool to have in a solar heater for your classroom?
- Are there any colors or designs that you would like for the solar heater?

Learning and Studying:
- How does the cold weather affect your ability to focus and learn in the classroom?
- Are there specific subjects that become more challenging when it's cold?

Environmental Awareness:
- Do you think using solar heaters in your classrooms is a good idea for the environment?
- Are you interested in learning more about how solar energy works?

Fun Questions:
- If you had the power to control the weather in your classroom, what would it be like?
- What creative ideas do you have to make your classroom warmer and more comfortable?

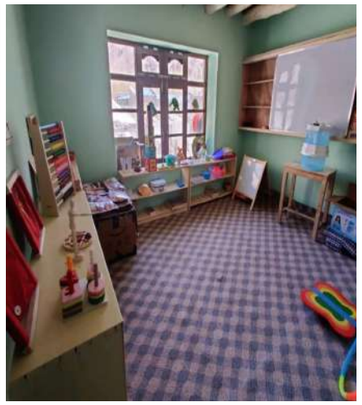
Interview Insights

- There is abundant sunlight in the region , as people suffer sunburn in the non winter months.
- All students go to tutions in the winter months when there are holidays in school.
- In homes everyone use Bukhari as a heating solution in winter months. Bukhari is a traditional heating solution in the ladakh region.
- School building receives complete sunlight through the year. There is no shadow of any mountain on the school building
- When the school reopens in March, the month March and April are little cold and also October and November.
- Few people use Solar items such as Solar water heater, Solar cooker, Solar panel, etc
- The village receives very less rainfall throughout year.
- Everyday there are power cut issue in day and night time.
- During winters some people sleep with warm water bottle or closed container, bag with hot stones to avoid chilling cold.

Primary Research

Round 2 : Conducted interview with the students and teachers of the Turtuk Valley School. These students visited Mumbai in Winter months

School Photos







Round 3.

Conducted an interview with Mipham Jigmet, he is a Masters student of IIT Bombay who is from Ladakh region. He shared some important insights about the schools and heating solution.

Interview Insights

- During winter months the schools are having holidays, but during the school working months ,the heating solution is definitly needed in October , November ,March and April.
- We can use this product in tutions also during the winter months.
- Generally building in Ladakh are South facing and are having Big windows for sunlight.
- In remote village there is electricity shortage on higher altitude, so there is no lighting in classroom, thats why the windows of classroom are big for natural lighting.
- Ladakh Renewable Energy Development agency helps in providing solar items to maximize the use pf solar energy in the region.
- As we are providing heat inside the classroom but the insulation is more important in this context. Heat should not escape the classroom.
- We can use heavy curtains to block the cold entering the room.
- Maximum 20 kids are there in one classroom.
- Try out ansys simulation for the project.

Round 4.

Conducted an interview with a friend named Rabgais who lives in Leh. He was intern in IIT Bombay and worked on heating solutions.

Interview Insights

- Though we are providing heat inside the room, but the heat can easily escape from the gaps so the insulation is very necessary in the project.
- Air heater panel should be at an angle of 16-25 degree celcius such that the sunlight should be perpendicular to the panel.
- The room heater should be placed on the floor or 1 feet above floor, because hot air is light weight and it goes up and cold air is heavy so it comes down.
- So heater should be at bottom for maximum use.

Priority Matrix

Must have

Solar operated
Floor mounted
Insulation

Should have

low maintenance
Culturally sensitive
Simple use

Could have

Horizontal structure
Heat sink plate

Would have

Children interface
Heat storage unit

Objective

The motive is to provide **a comfortable atmosphere** for the students of Turtuk Valley school during the day working hours to tackle the harsh cold climate.

Design Brief

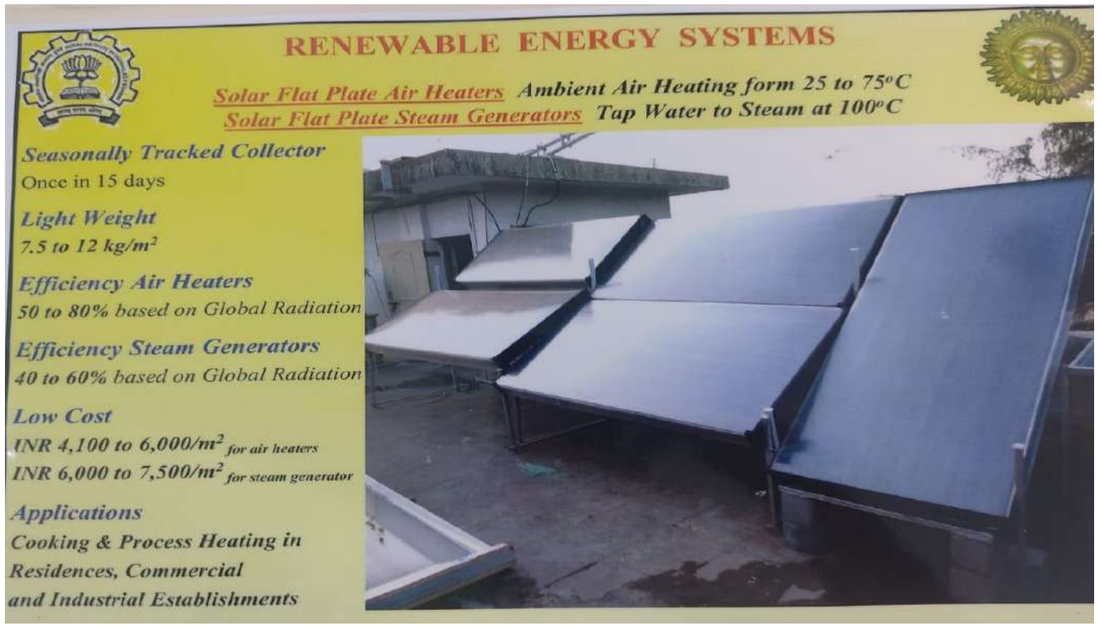
To design an **indoor solar room air heating system** for the **school classrooms, tuitions** during the **day school hours**

- **Temperature difference of 5-10° C**
- **Comfortable atmosphere**
- **Mounted neat floor**
- **Culturally sensitive**
- **School Product**
- **Proper insulation**
- **Low Maintenance**
- **Solar powered**

Solar technology exploration

Solar air heater by Prof M.V. Rane

Prof. M. V. Rane is a professor of mechanical engineering at the Industrial Research and Consultancy Centre, IIT Bombay His areas of expertise include solar plastic air heating systems and solar air heaters.



Title of Scientific/Technological Lead	Subcategory (under Clean Energy)	Technology Readiness Level (TRL)
	Cross Cutting	TRL 9 - Commercial operation in relevant environment

Technology Outline (Process Description)

SOLAR AIR HEATERS, SAH

for Enabling Once Through Solar Air Heating for a Wider Range of Applications

Light-Weight Low-Cost, Efficient Solar Air Heating for Grid Independent Operation
Deployable as ***Roof of the Facility***

Designed using novel light weight corrugated extruded sections to enable high temperature rise on the air side while keeping the air side pressure drops very low

Multi-Wall PC Top Covers glass-less UV stable multi-wall polycarbonate top cover reduces top loss and ensures high efficiency while delivering high hot air delivery temperatures along with increased durability while reducing weight and cost

Multi-Wall Extruded Absorber enhances heat transfer while maintaining very low air side pressure drop

Multi-Layer Composite Insulation reduces heat loss from the bottom while serving as a durable back cover and internal duct along with stiffening the collector panel without use of metal frames

Salient Features/Advantages		Key Outcomes	
Novel Design Enhances Efficiency by Reducing Losses *Comprises of Multi-Wall Plastic Top Cover, Corrugated Aluminium Absorber and Multi-Layer Composite Insulation*		***Hot Air Temperatures***	***50°C*** with -30°C Inlet ***120°C*** with 30°C Inlet
Air Side Pressure Drop	***1.6 to 5 mm H_2O***	***Light Weight***	***7.5 to 12 kg/m²***
Efficiency Air Heaters	***60 to 80%*** based on Global Radiation	***Size*** (L x W x D all in m)	***1.2 to 5 x 1.22 x 0.087***
Applications *Space Heating for Rural, Residential, Commercial and Industrial Applications Agro Produce Drying, Industrial Drying, Organic Waste Drying Cloth Drying Residential as well as in Laundromats Industrial Air Heating or Pre-heating like Paint Shops Air Heating, Milk Drying in Diary, Waste Water Vaporisation, etc.*		***Grid Independent Operation***	***20 m² SAH*** using ***1 m² PV Powered Fan*** for Once-Through Air H eating
		Cost Effective	***INR 7,500 to 9,500/m²***
		Early Payback	***75 to 240 days*** typical Drying: Naga-Chillies 75 days; Ginger 240 days

IP PROTECTION details (Related to above Technology Lead)	
Patent filed (Title, national/International)	
Patents Granted	Solar Flat Plate Fluid Heating Device IP 234778 986MUM2004 Solar Air Heater IP 456622 4209MUM2014
Copyrights obtained /progress on commercialisation /PL specify connect with industry	Licensed Solar Air Heater for Organic Waste Composting Machine to Lahs Eco Engineering, Thane
Contact details (for more information)	
Nodal Person name	***Milind V Rane, PhD,*** *Professor, ASHRAE Fellow and Energy Technology Consultant*

Solar technology exploration



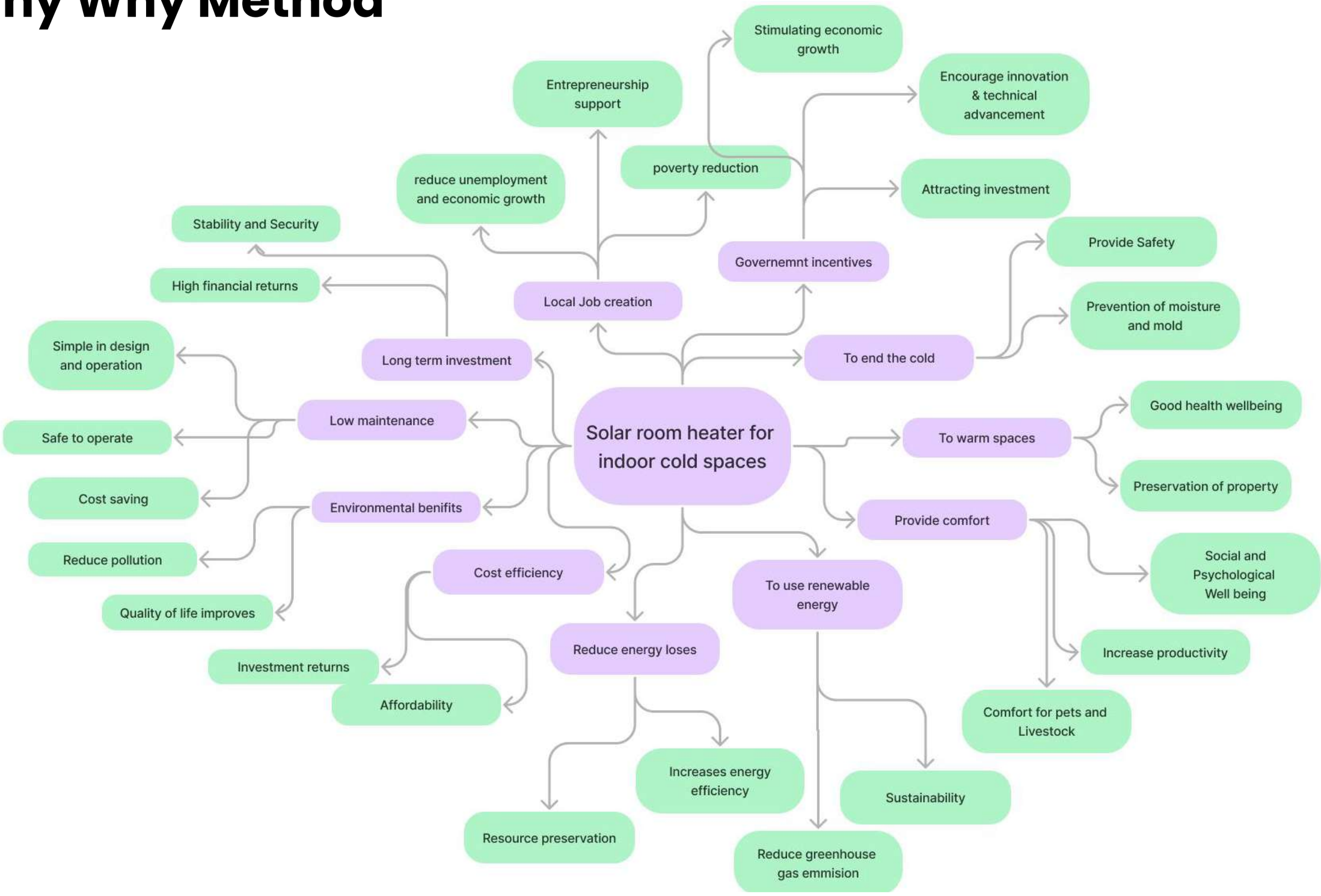



Tested the Solar Air heater on the terrace at temperature of around 32 degree celsius .Collected heat in a container.

Ideation

- Why Why method
- Six thinking Hats
- Ideation sketches

Why Why Method



Ask Why for each and every sentence till you get the core answer

6 Thinking Hats

In this methods I asked the question in What, Why, When, Where, Who, How format in positive and negative way to get a clear idea of what my product will do and not do.

- What does your product do?
- What does your product don’t do?

- What will happen when there will be heater in classroom?
- What will happen when there will be no heater in the classroom?

- Why the solar heater is needed in Ladakh ?
- Why the non solar heater is not needed in Ladakh ?

- When is the appropriate time for solar heater to work ?
- When is the non appropriate time for solar heater ?

- Where will the product be installed ?
- Where will the product be not installed ?

- Where will these solar heaters be manufactured ?
- Where will these solar heaters will not be manufactured ?

- Where there is need of product ?
- Where there is not need of product ?

- Who is the user of the product ?
- Who is not the user of the product ?

- Who is responsible for the development and distribution of solar room heaters in Ladakh ?
- Who is not involved in the development and distribution of these solar room heaters in Ladakh ?

- How do these solar room heaters function to provide warmth in Ladakh's classrooms ?
- How do these solar room heaters not function to provide warmth in Ladakh's classrooms ?

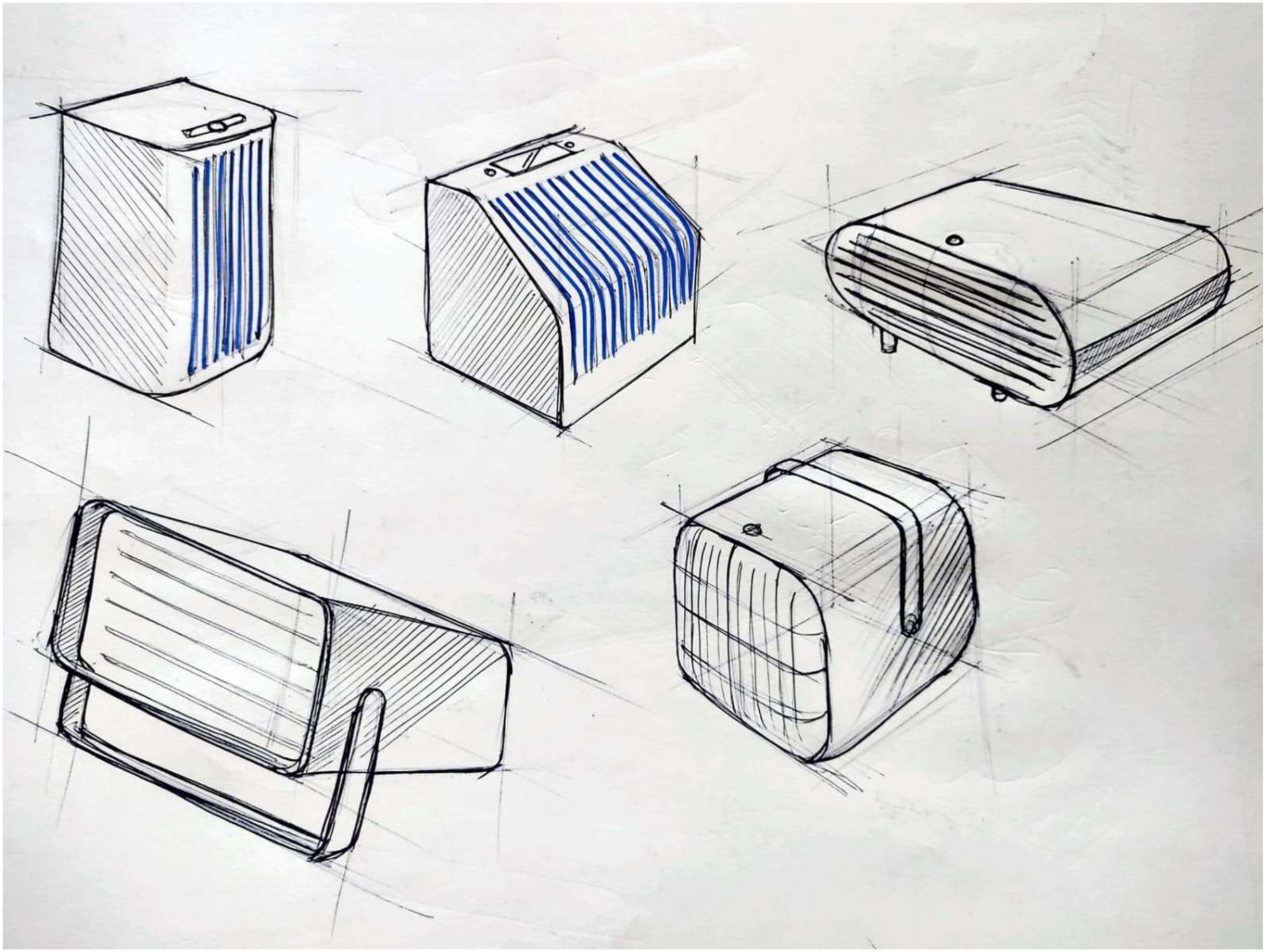
- How users should use the product ?
- How users should not use the product ?

Important insights

Gathered insights from both the ideation methods: ‘Why Why method’ and 6 ‘Thinking hats’ and summarized the insights to be considered while designing the Heater.

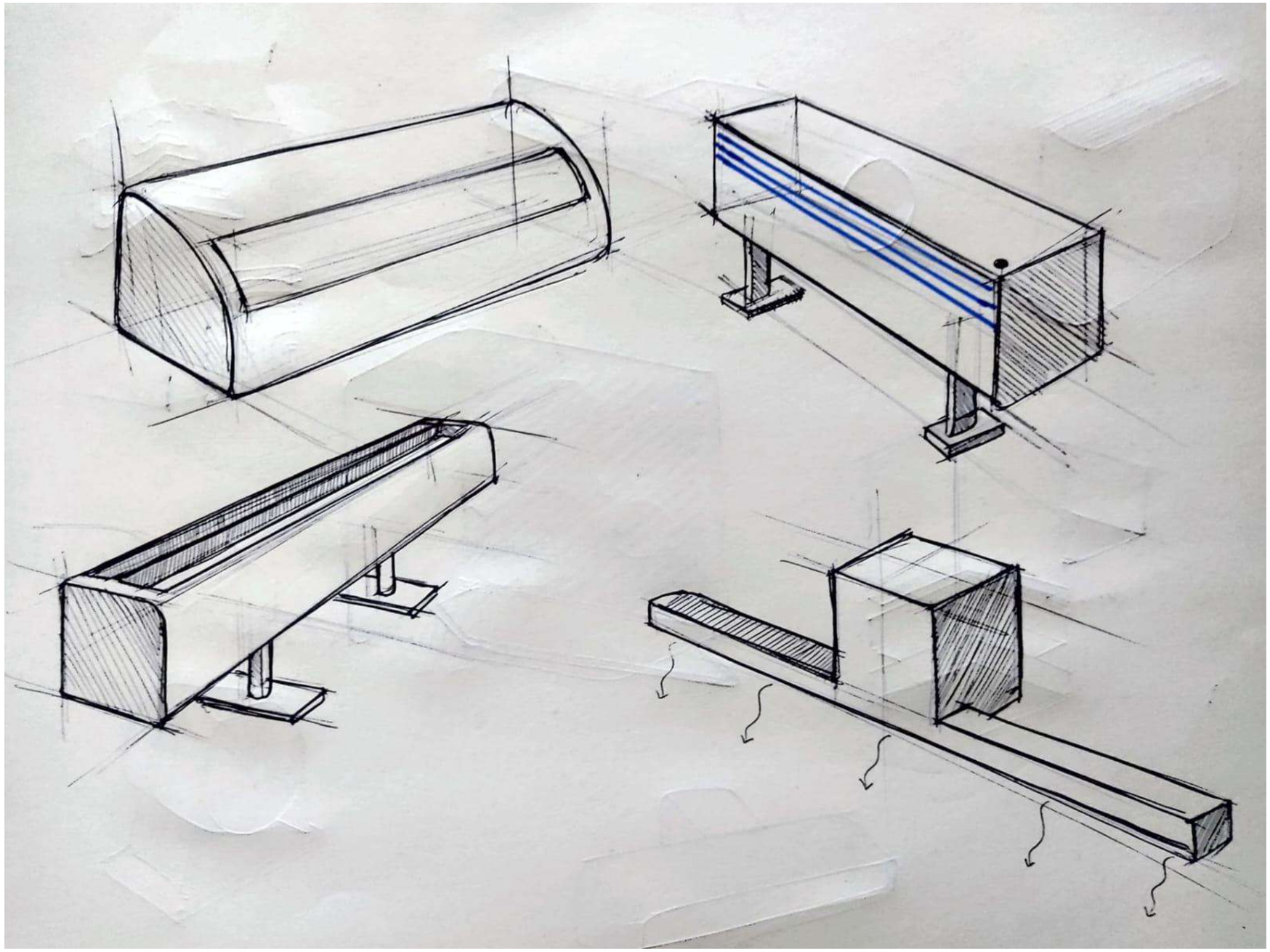
- Provide comfort
- Use renewable energy
- Environmental benifits
- Long term investment
- Reduce energy loses
- Increase productivity
- Reduce greenhouse gas emission
- Low maintainance

Ideation sketches



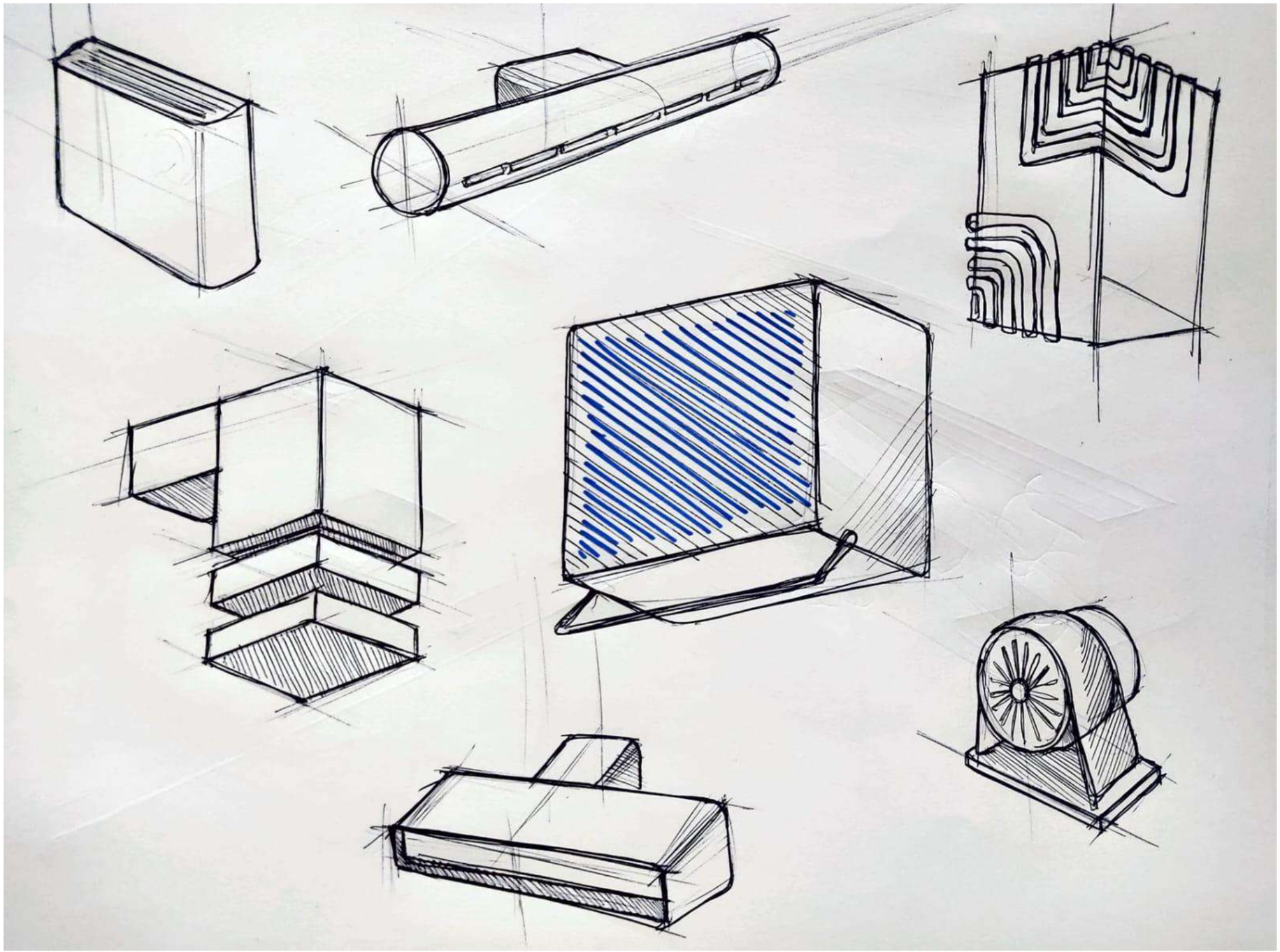
Rough Exploration sketches

Ideation sketches



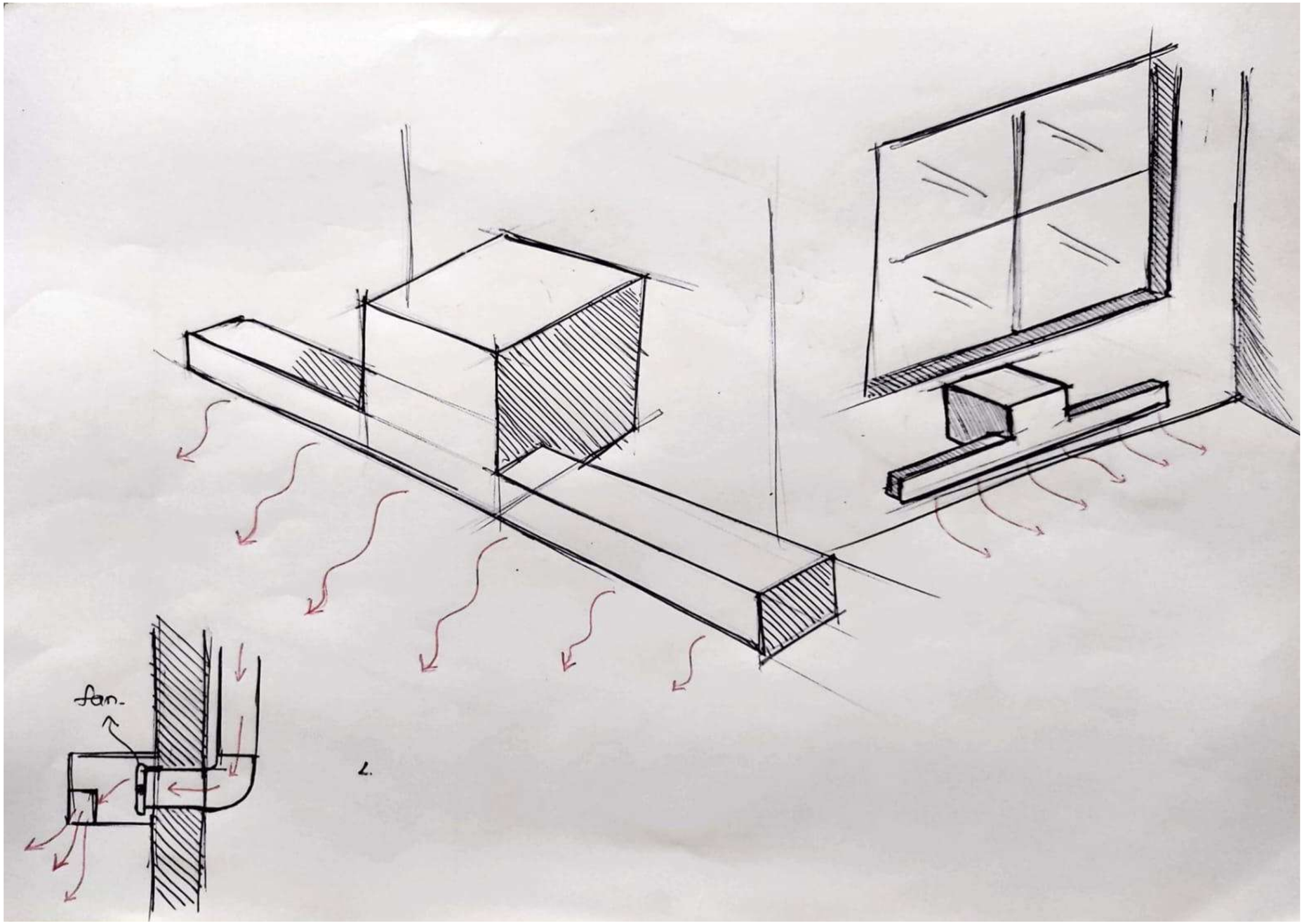
Rough Exploration sketches

Ideation sketches



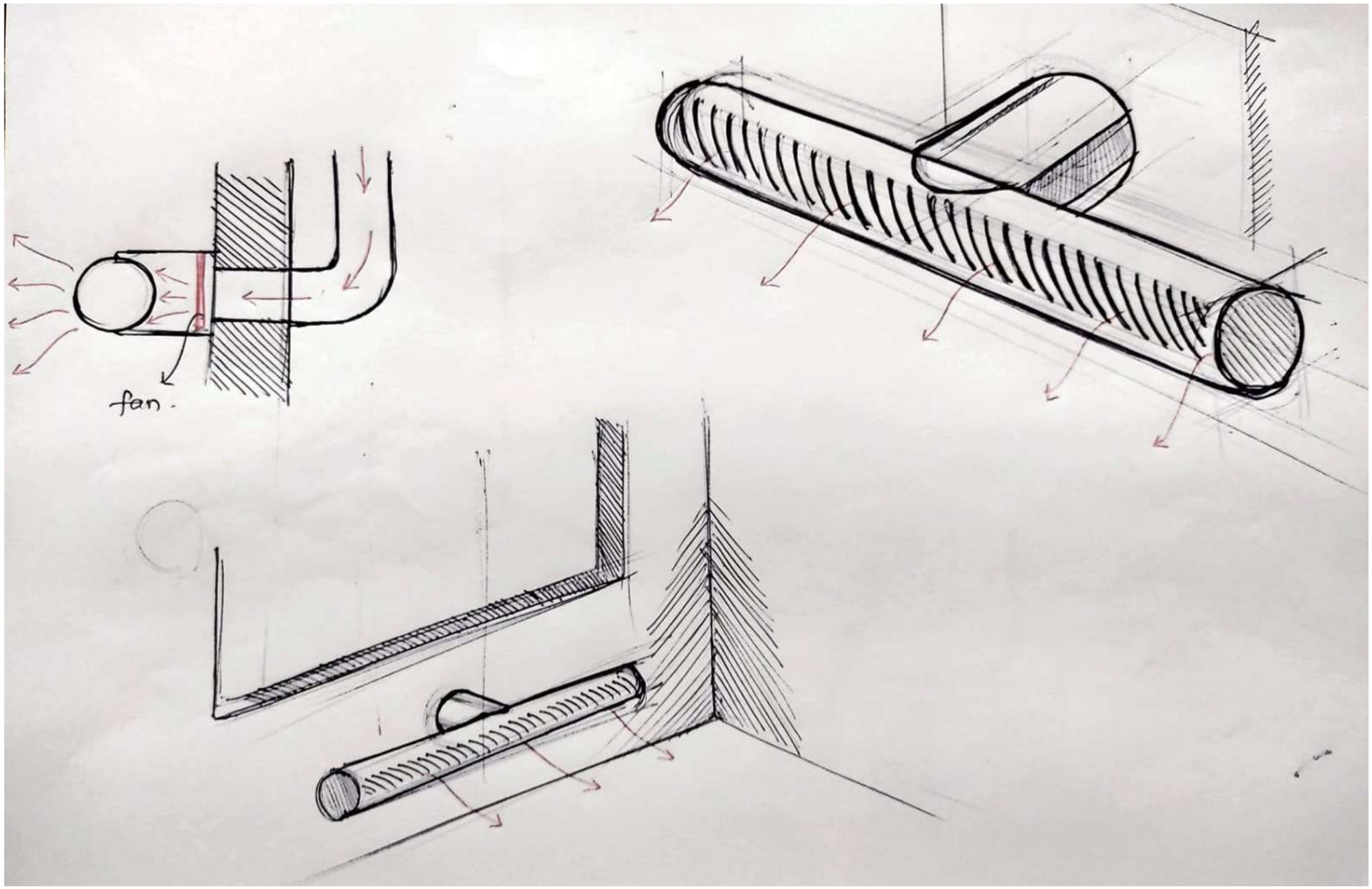
Rough Exploration sketches

Ideation sketches



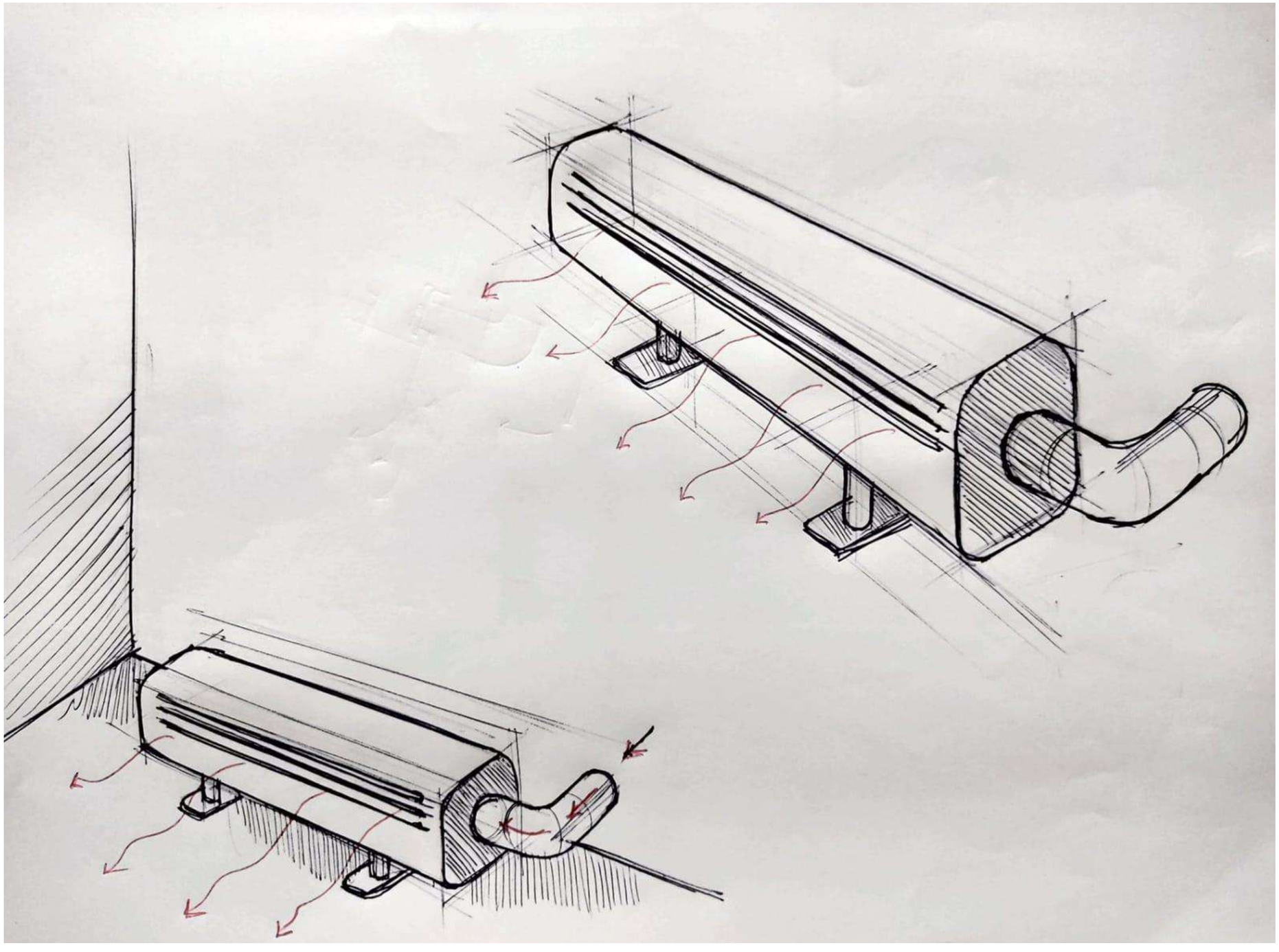
Wall mounted heater

Ideation sketches



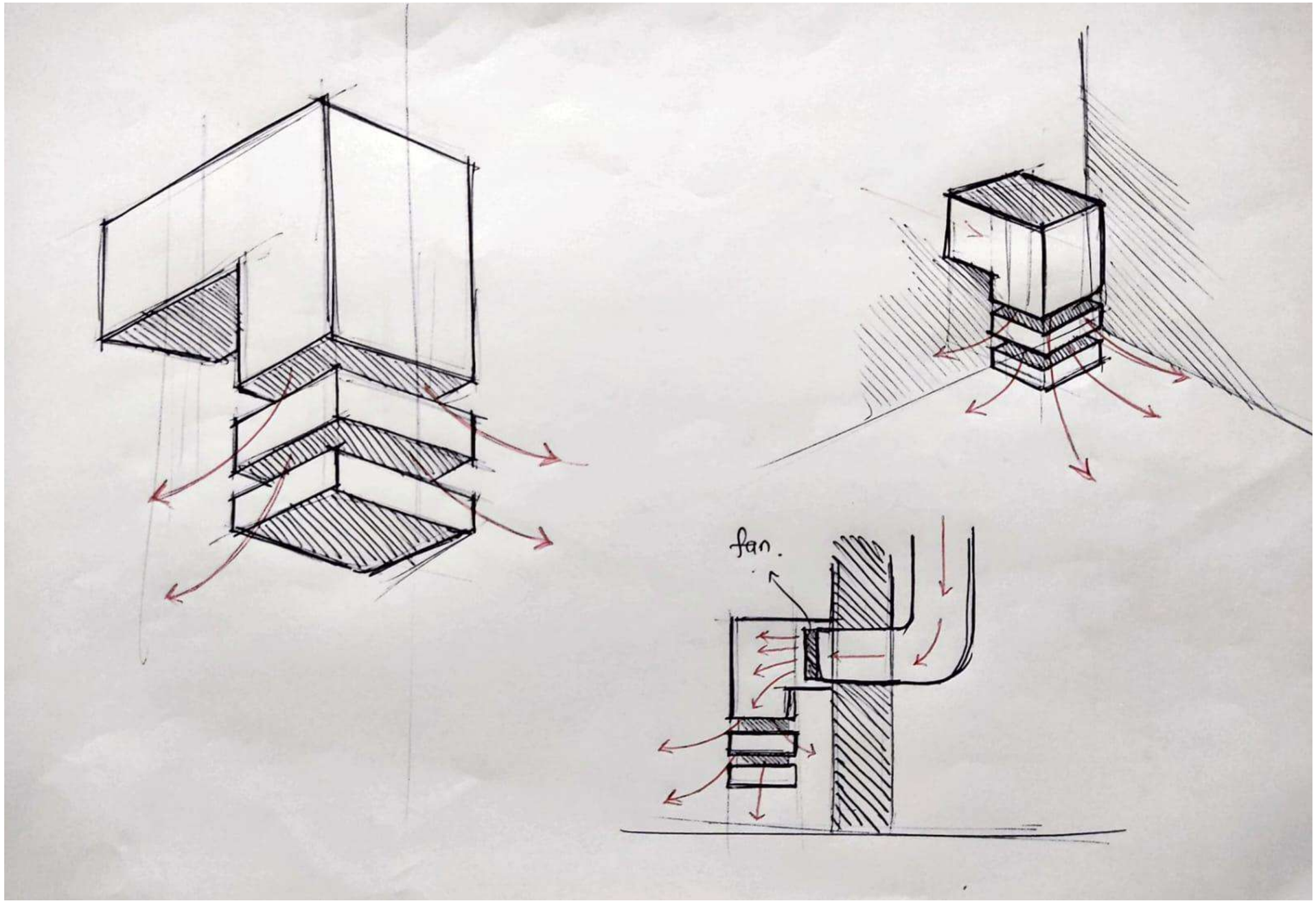
Wall mounted round heater

Ideation sketches



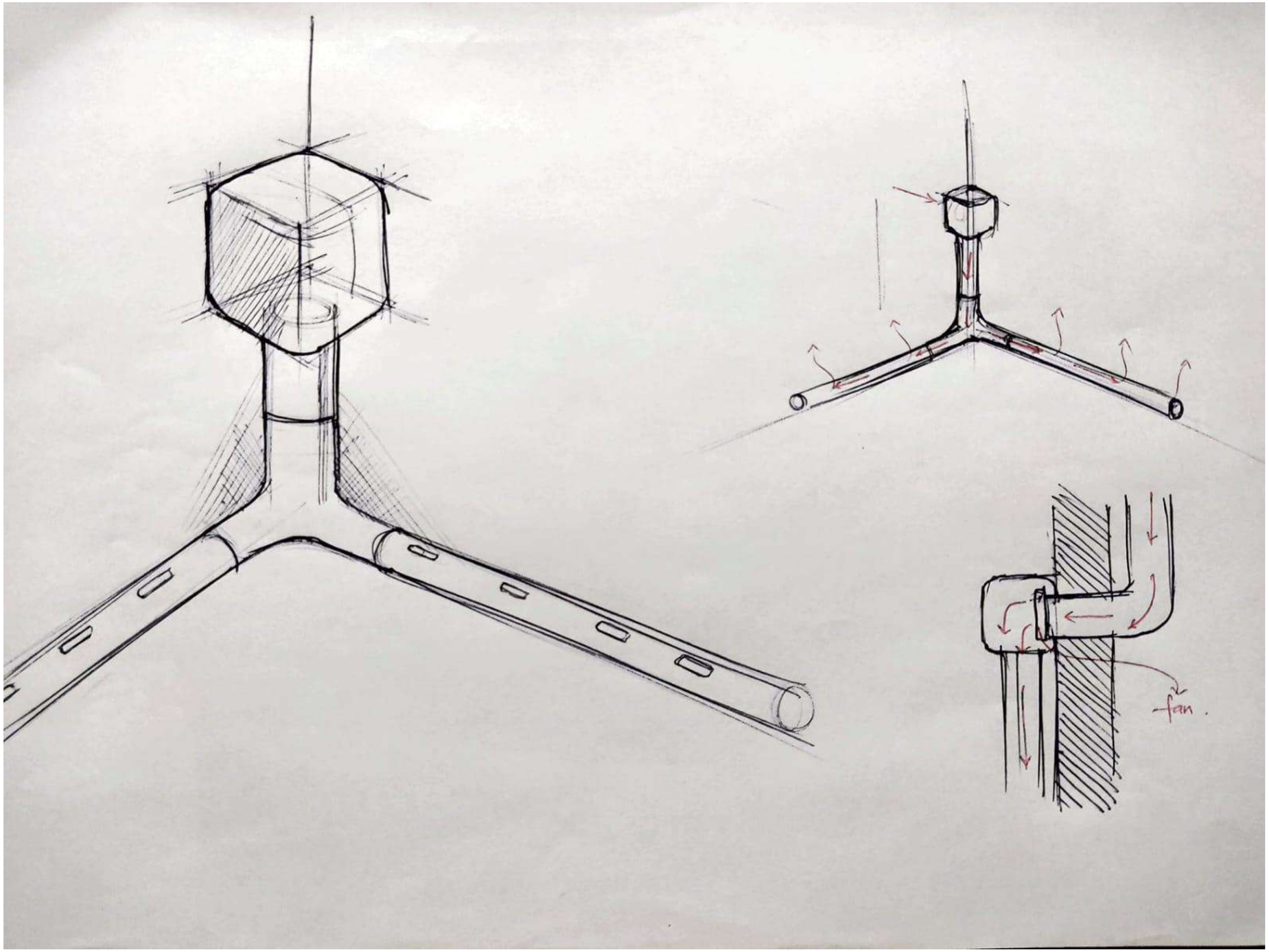
Floor mounted heater

Ideation sketches



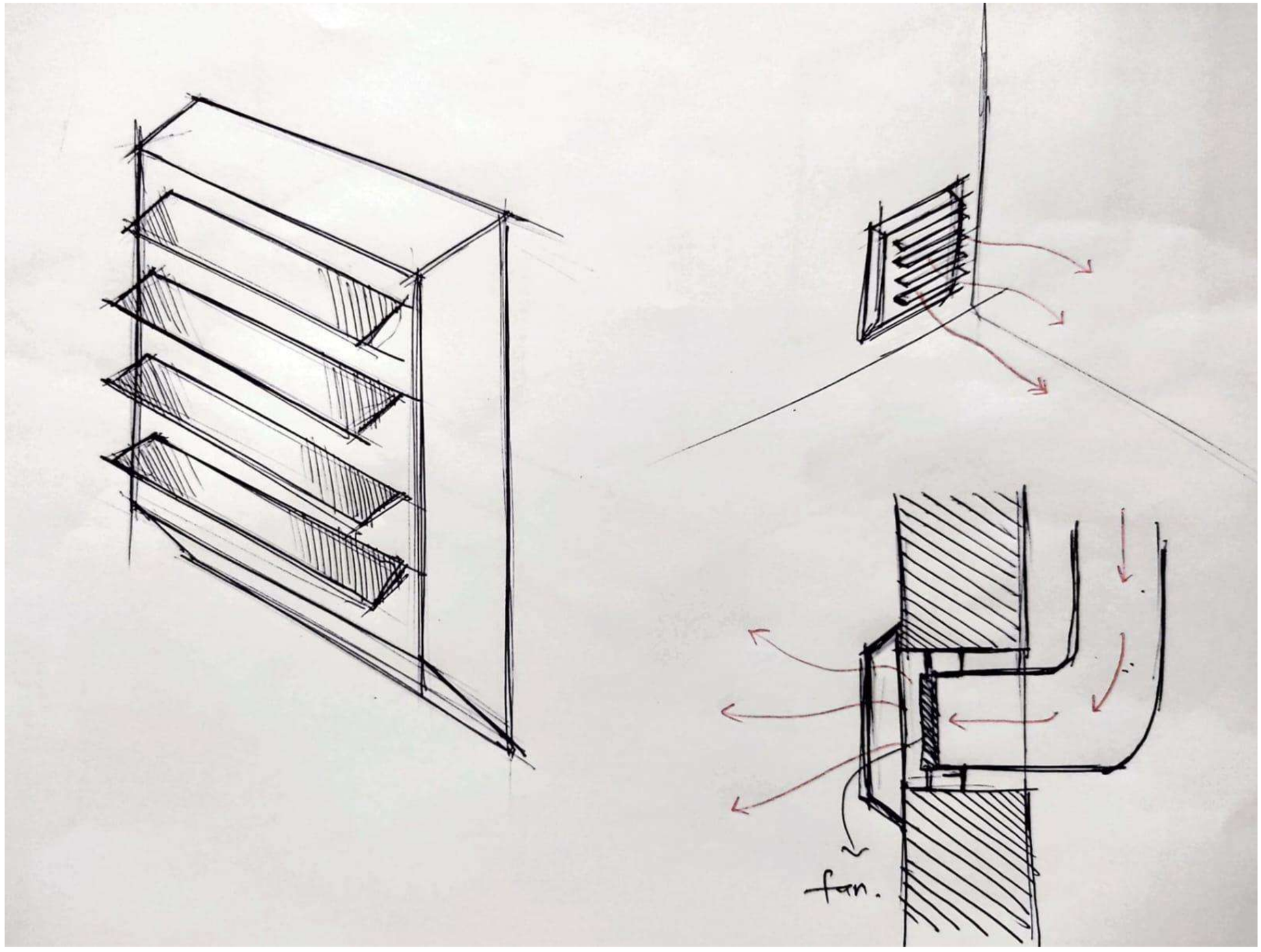
Wall mounted heater

Ideation sketches



Corner mounted heater

Ideation sketches



Wall mounted heater

Mockup 1

Corner mounter heater mockup. Heat can be spread in all direction

Mockup 2

Floor mounted heater mockup

Mockup 3

Corner mounted heater mockup

Mockup 4

Wall mounted heater mockup

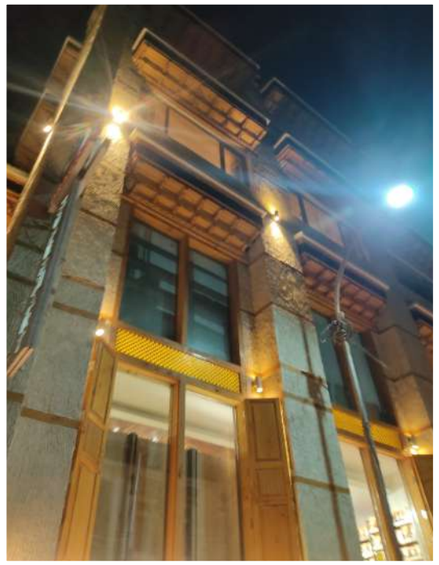
Mockup 5

Rough Exploration sketches

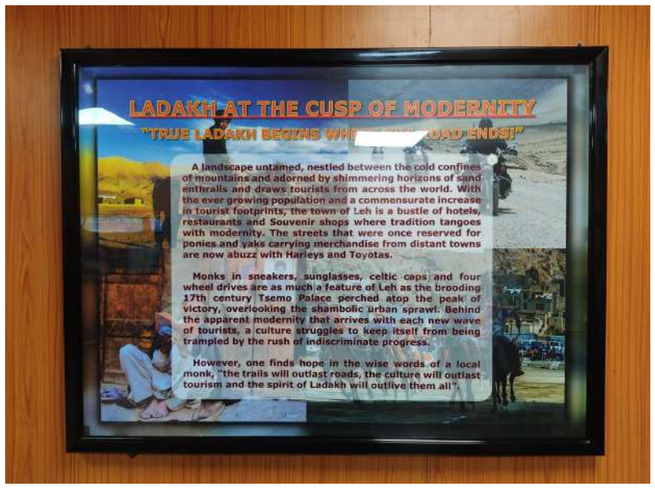
Field Visit to Ladakh

- We had a the field visit to Turtuk Valley School in Ladakh.
- Places covered during field visit are Leh city, Hall of fame museum , SECMOL, Leh Market, Shanti Stupa, Monastery, Diskit, Turtuk village.
- We studied about the Ladakh Culture, Ladakh Architecture, Floura , Fauna. We saw the project site where our project will be installed.
- Studied the turtuk valley school in detail.
- Got different insight which will be really helpful in further project.

Architecture style



Ladakh culture



SECMOL school visit







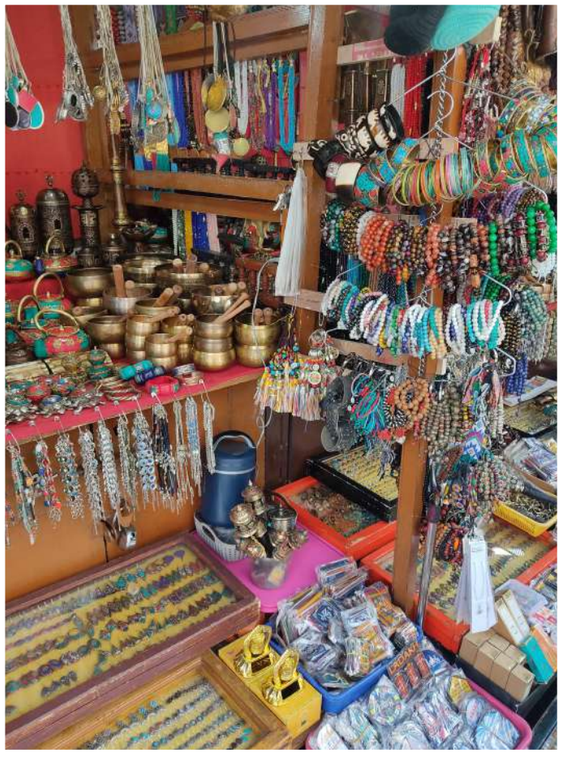





Ladakh Market study

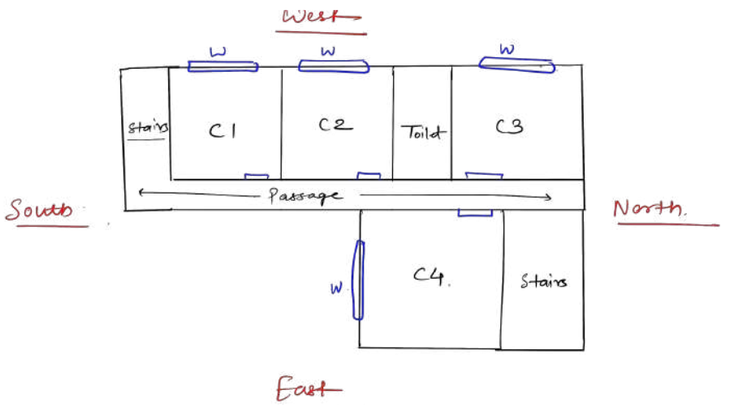







Turtuk valley school visit - Old building

Turtuk valley school visit - New building



Insights of Field visit

Insights of Field visit at New building of Turtuk valley school:

- Visited the New building of the the turtuk valley school.
- The building is going to have 3 floors
- Currently only one floor is been constructed
- Mostly the classroom are face towards West wards. Due to uneven they not able to make a south facing building.
- They are having corridors on the south side of the buildings
- During winter after 2 o'clock there is a shadow of mountain on the school because the new school is close to the mountain.
- The dimentions of the classroom is 17 * 18 * 10 ft .
- Only space to install air heater is the terrace.
- The 2nd floor will be in maximum benifit from the Air heater because of less pressure drop due to less distance between air heater and room
- For ground and 1 st floor we have to connect air heater from the terrace through aluminium ducts.

Insights of Field visit at old building of Turtuk Valley School

- Visit to the old building
- Interacting with the students.
- Roleplaying about the use of room heater.
- Checked about the insulation they use to avoid cold air inside classroom
- Checked the walls to install the solar air heater.
- Old building is facing east side
- We get the sunlight in the classroom till 2 pm

Insights of Field visit in the village:

- Electricity schedule of turtuk village is
- Power cut - 6 am - 7 pm
- electricity - 4am - 6 am, 7pm - 11 pm
- During school hours there is no electricity in the village.
- They get 24hrs electricity during the summer, but we don't need room heater during summer
- Room heater is needed in only 4 months, i.e. Oct, Nov, March, April
- Therefore the important insights we got is we have to install PV powered DC fan to operate the Room heater.

Technical considerations to design a Solar Air heater

Heating load is a function of many parameters:

1. Size: 17×18×10 ft for the Classroom of Turtuk Valley School in Ladakh
   a. Area 28.4 m2 (306 ft2) & Volume 284.6 m3 (3,060 ft3)
2. **Outdoor Temperature:**
   a. Typically taken as the lowest temperature with 99% reliability from Weather Data
   b. Check if it is to be taken as -30oC or -20oC, depending on the time of use, day/night or both
3. **Indoor Temperature:**
   a. Typically taken as the lowest acceptable temperature
   b. Check if it is to be taken as 10oC to 20oC, depending on the depending on occupant's age, activity and clothing
4. **Construction features of the room/space to be heated.**
   a. Wall thickness (thermal mass), type of windows, type of glazing (single, double, triple), air tightness of the space
   b. Area of the external wall, insulation effectiveness, areas of windows, etc
   c. Are the adjoining rooms/spaces also maintained at similar temperature conditions
5. **Desired Indoor Relative Humidity?**
   a. Typical values should be 30 to 40% rh during the heating season
   b. Would recommend ~33% rh to keep the heating requirement low and still provide comfort

Note the SAHs will be operating only some part of the day, and the intensity of heat collected and delivered will vary throughout the day as the sun moves through the sky.

Two to four panels of 2.1 m2 will be required based on the above site conditions/the above-listed information.

Title of Scientific/Technological Lead	Subcategory (under Clean Energy)	Technology Readiness Level (TRL)
	Cross Cutting	TRL 9 - Commercial operation in relevant environment

Technology Outline (Process Description)

SOLAR AIR HEATERS, SAH

for Enabling Once Through Solar Air Heating for a Wider Range of Applications

Light-Weight Low-Cost, Efficient Solar Air Heating for Grid Independent Operation
Deployable as ***Roof of the Facility***

Designed using novel light weight corrugated extruded sections to enable high temperature rise on the air side while keeping the air side pressure drops very low

Multi-Wall PC Top Covers glass-less UV stable multi-wall polycarbonate top cover reduces top loss and ensures high efficiency while delivering high hot air delivery temperatures along with increased durability while reducing weight and cost

Multi-Wall Extruded Absorber enhances heat transfer while maintaining very low air side pressure drop

Multi-Layer Composite Insulation reduces heat loss from the bottom while serving as a durable back cover and internal duct along with stiffening the collector panel without use of metal frames

Salient Features/Advantages	Key Outcomes
Novel Design Enhances Efficiency by Reducing Losses *Comprises of Multi-Wall Plastic Top Cover, Corrugated Aluminium Absorber and Multi-Layer Composite Insulation*	
Air Side Pressure Drop ***1.6 to 5 mm H_2O***	***Hot Air Temperatures*** ***50°C*** with -30°C Inlet ***120°C*** with 30°C Inlet
Efficiency Air Heaters ***60 to 80%*** *based on Global Radiation*	***Light Weight*** ***7.5 to 12 kg/m²***
Applications *Space Heating for Rural, Residential, Commercial and Industrial Applications* *Agro Produce Drying, Industrial Drying, Organic Waste Drying* *Cloth Drying Residential as well as in Laundromats* *Industrial Air Heating or Pre-heating like* *Paint Shops Air Heating, Milk Drying in Diary, Waste Water Vaporisation, etc.*	***Size*** *(L x W x D all in m)* ***1.2 to 5 x 1.22 x 0.087***
	Grid Independent Operation ***20 m² SAH*** *using* ***1 m² PV Powered Fan*** *for Once-Through Air H eating*
	Cost Effective ***INR 7,500 to 9,500/m²***
	Early Payback ***75 to 240 days*** *typical* *Drying: Naga-Chillies 75 days; Ginger 240 days*

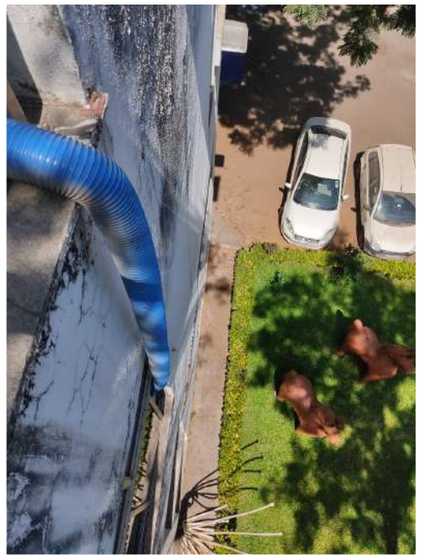
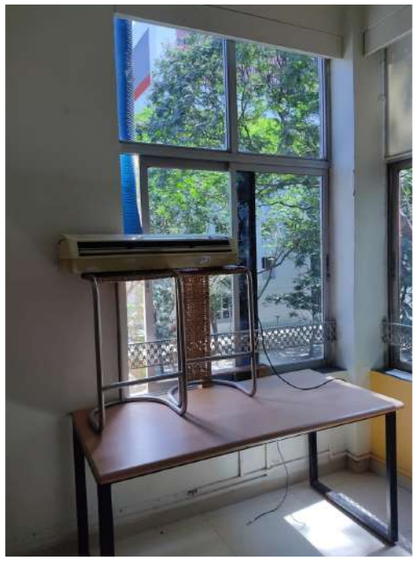
IP PROTECTION details (Related to above Technology Lead)	
Patent filed (Title, national/International)	
Patents Granted	Solar Flat Plate Fluid Heating Device IP 234778 986MUM2004 Solar Air Heater IP 456622 4209MUM2014
Copyrights obtained /progress on commercialisation /PL specify connect with industry	Licensed Solar Air Heater for Organic Waste Composting Machine to Lahs Eco Engineering, Thane

Prototype installation - Stage 1







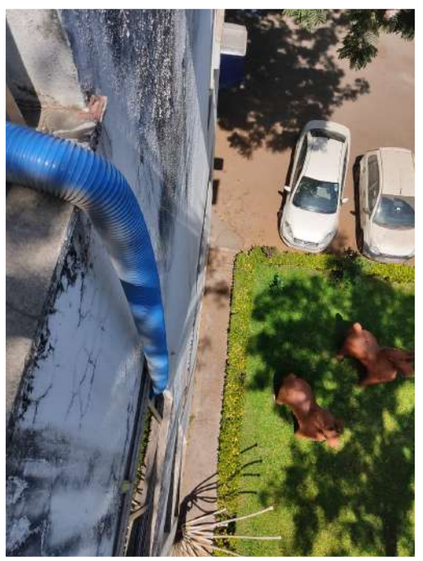
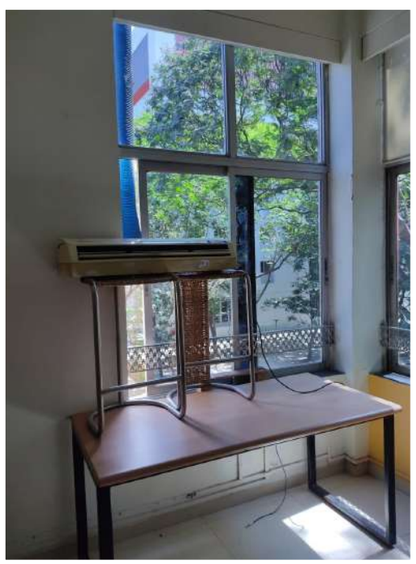



Insights

- In the first prototype we tried connecting AC box along with the impellar fan to the solar air heater and installed this setup in the room.
- During the testing, the impelar fan was too big and difficult to create suction in the 4 inch duct pipe.

Prototype installation – Stage 2




Insights

- In the second prototype we tried connecting air tight box along with axial fan to the solar air heater and installed this setup in the room.
- During the testing, the axial fan sucks the hot air from Solar air heater through duct. Varying the fan speed can vary the hot air extraction.

Outside room

Near outlet

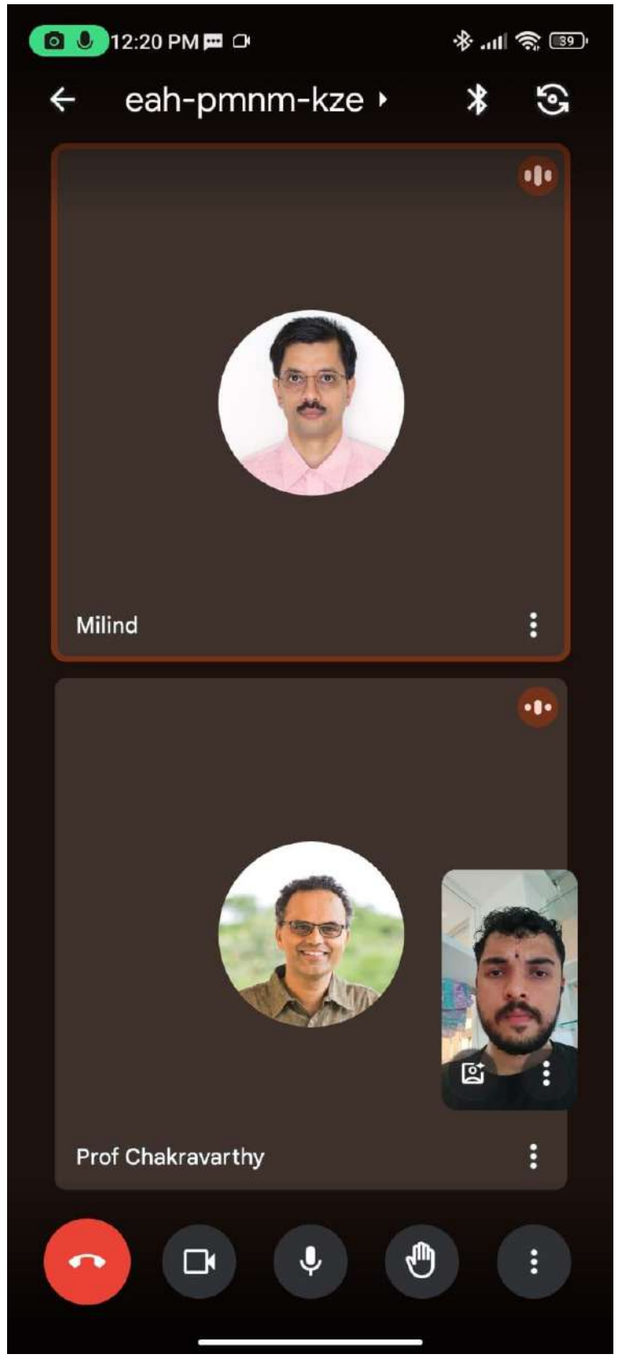
Inside room

Average difference of 2-3 degree Celcius

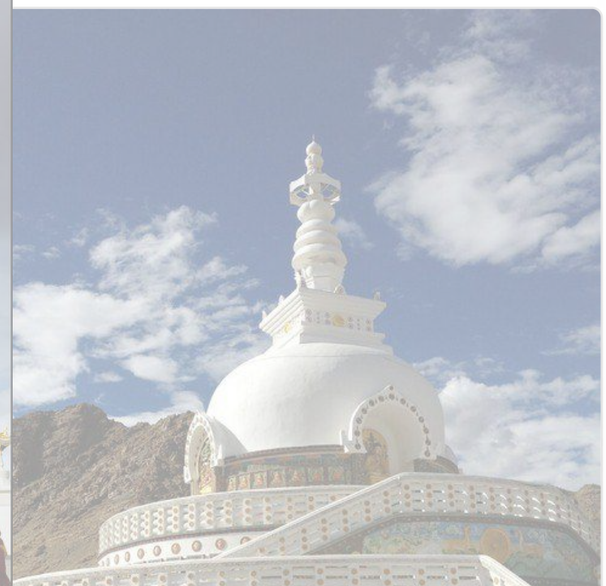
Surface Temperature testing during prototypes testing

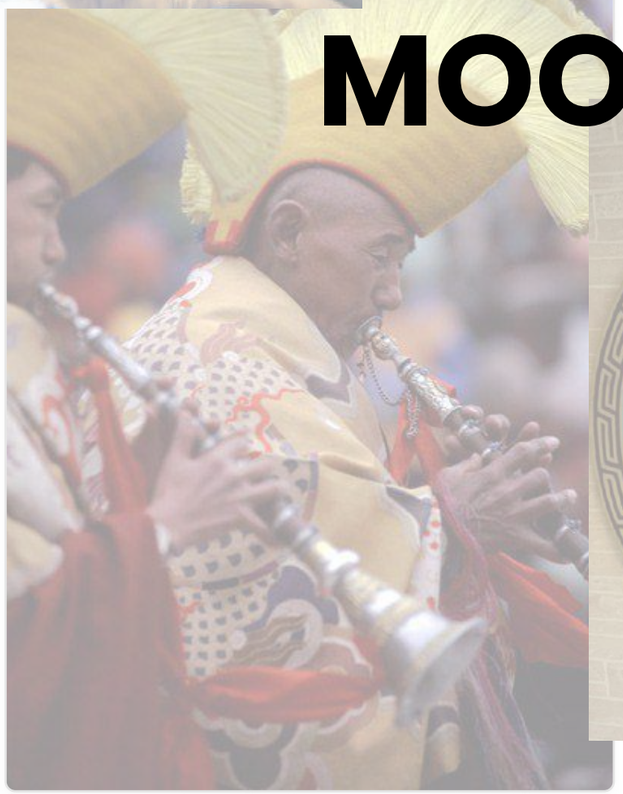
Technical inputs on SAH by Prof. Rane

- Solar air heater angle should be more than 30° in Ladakh. Check sunrays angle in Ladakh and decide SAH angle. Sunrays should be perpendicular to panel.
- In current setup, SAH is far away from the room, the long duct is making the air cool. SAH should be very close to the Room which is to be heated. SAH can attached to the wall facing south.
- Connect fan direct to the end of the duct for better results. Fan can have variable speed to control output hot air temperature, so that overheating of fan can be prevented.
- As there is no electric socket in the classroom, we have to connect DC fan to the PV panel , which will be near SAH. So in this case we can install fan outside the room, near the opening of the duct near SAH opening. And just release the other end of the duct inside the room.
- Use polypropylene Duct pipes.
- Keep hot air diffuser close to the floor.
- To control the heat, we can also use motorised damper to avoid overheating of Fan.



Mockup of the suggested changes by Prof. Rane sir. Major change was to install SAH near the window to reduce the pressure drop

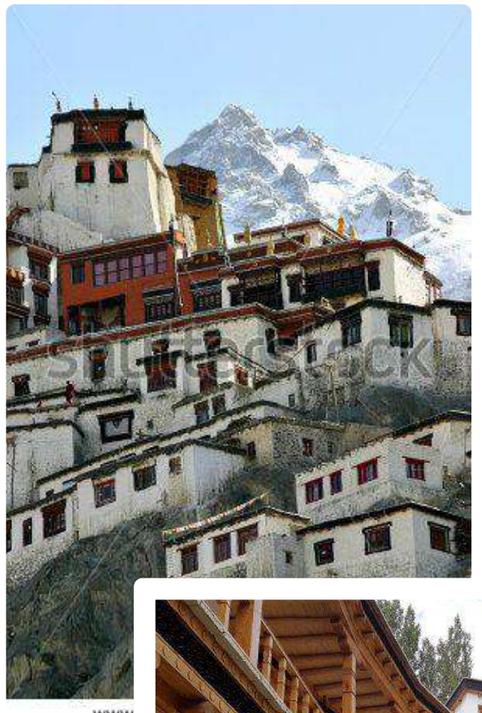


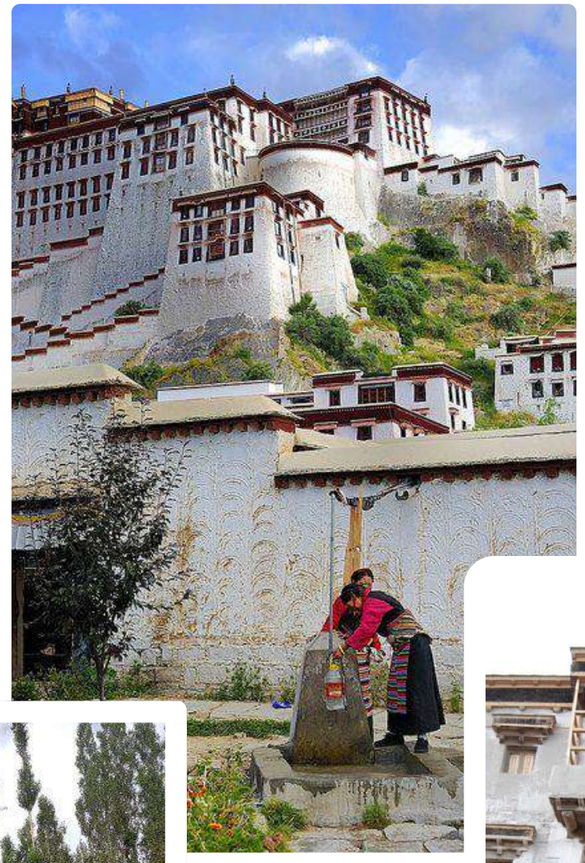


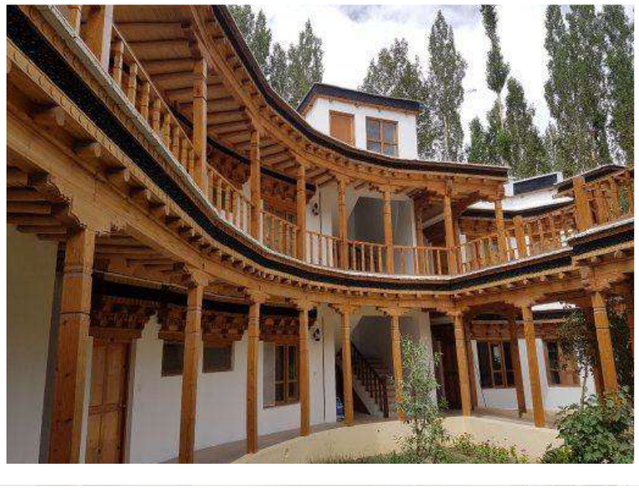
MOODBOARD

Architecture

The Ladakhi traditional construction uses earth extensively. The vernacular architecture of ladakh is a beauty of its own.





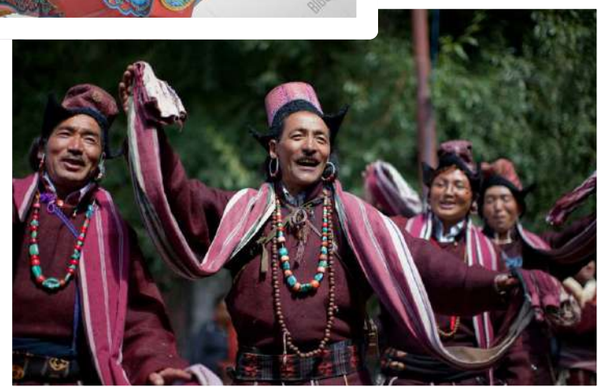


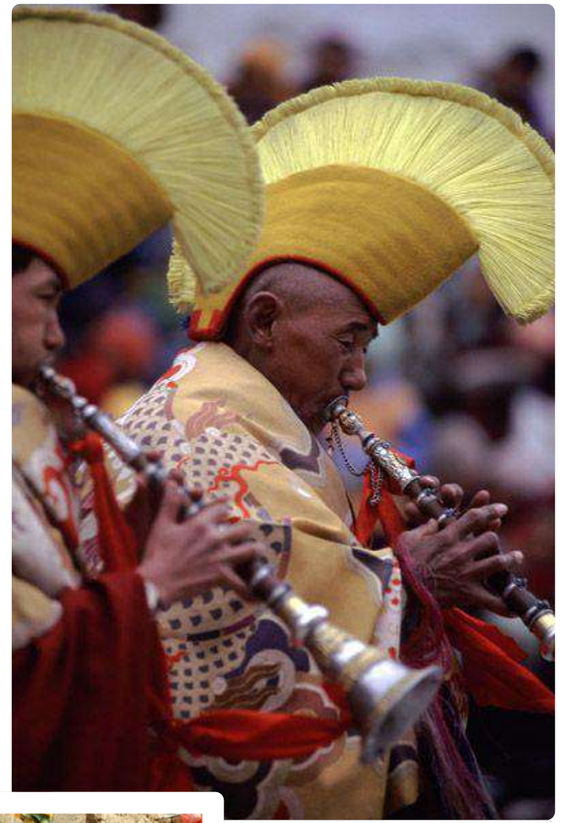
Patterns

These patterns hold the story of a thousand years, stories and beliefs passed down from generation to generations.

Culture

The ladakhi culture is rich and colorful, with monastic festivals and celebrations



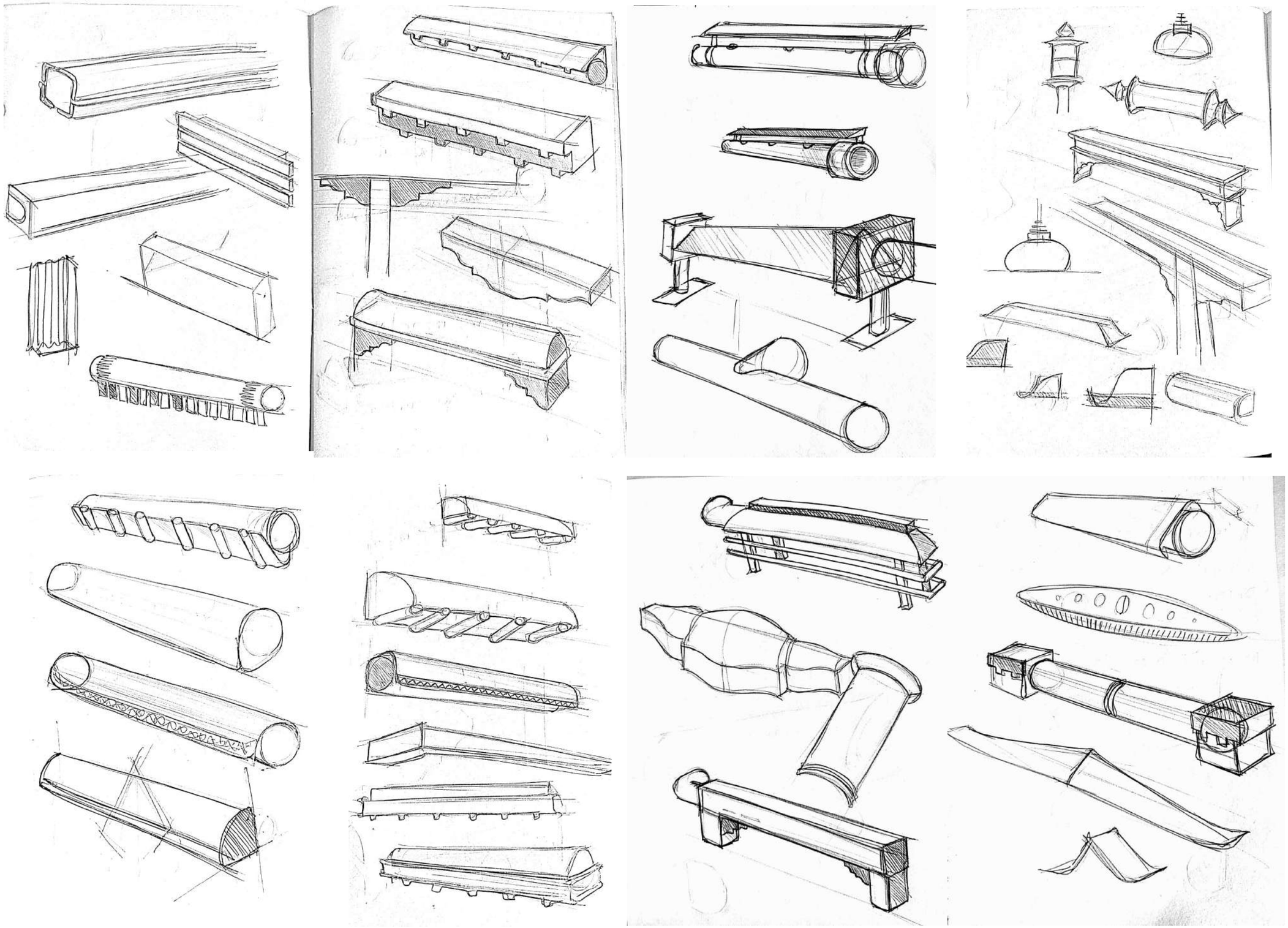


Keywords

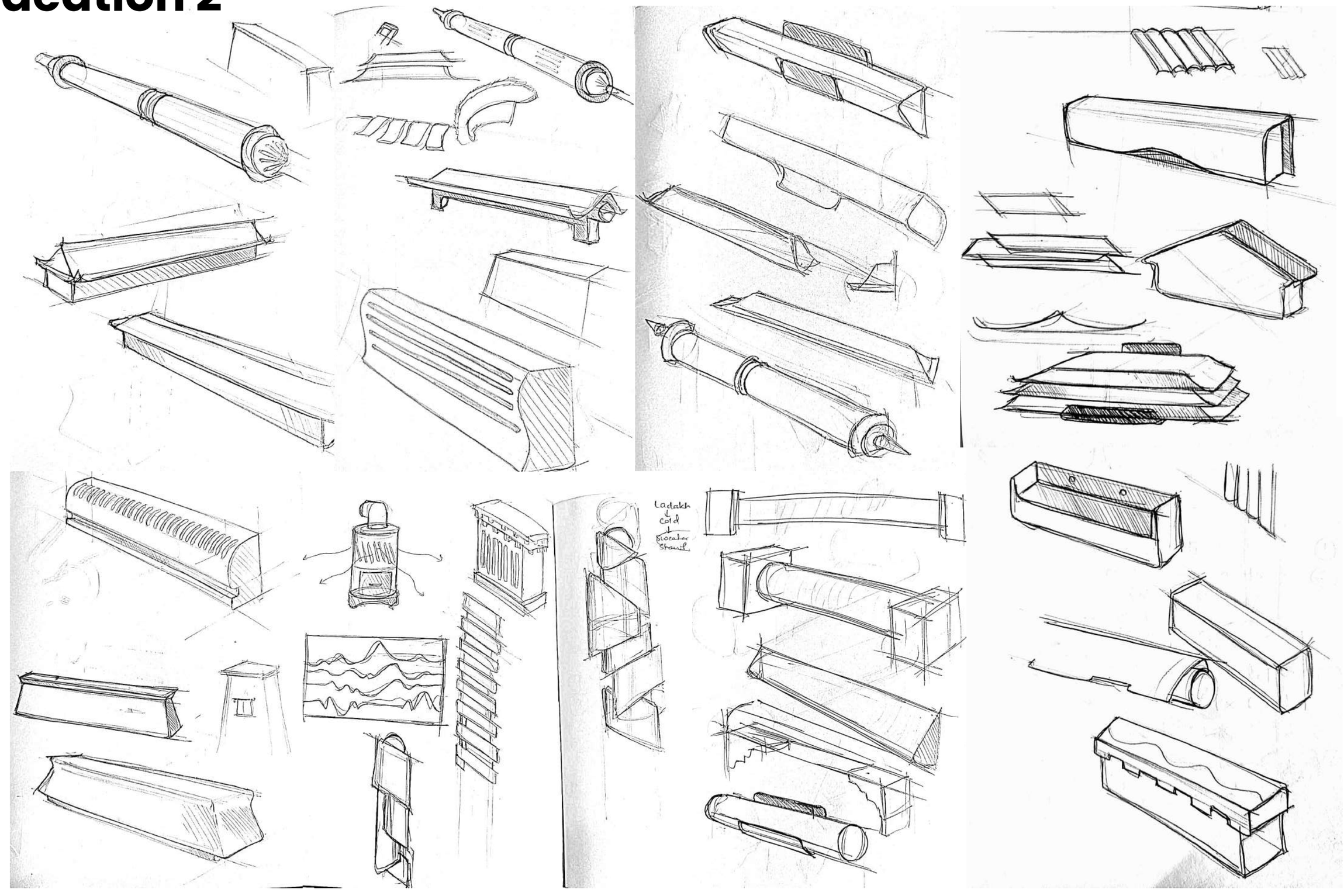
Architecture	Patterns	Culture
Rustic	Geometric	Buddhist
Traditional	Intricate	Nomadic
Minimalist	Symmetrical	Festive
Earthen	Floral	Spiritual
Intricate	Ethnic	Vibrant

Ideation 2

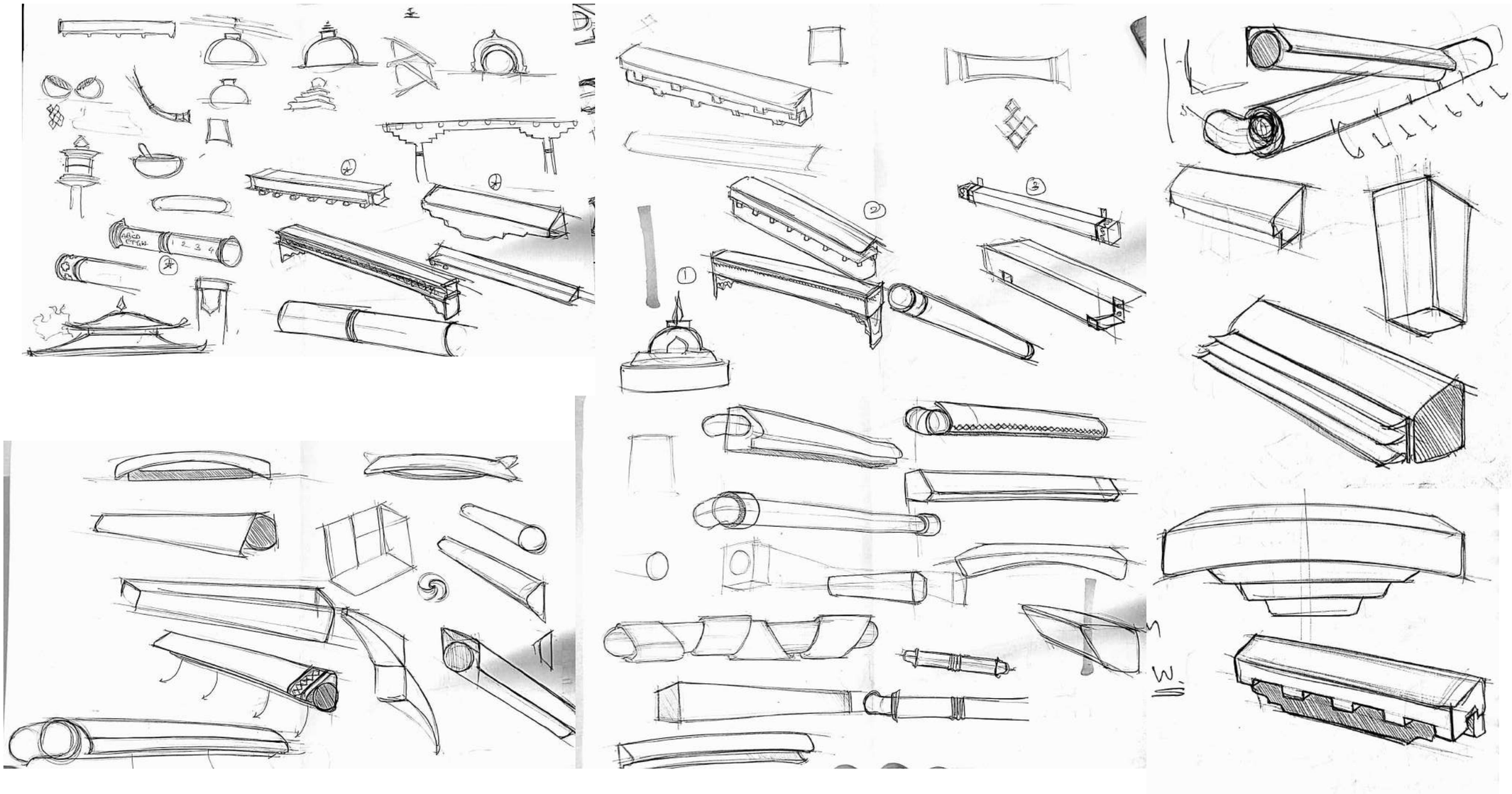
Ideation inspired from the mood board



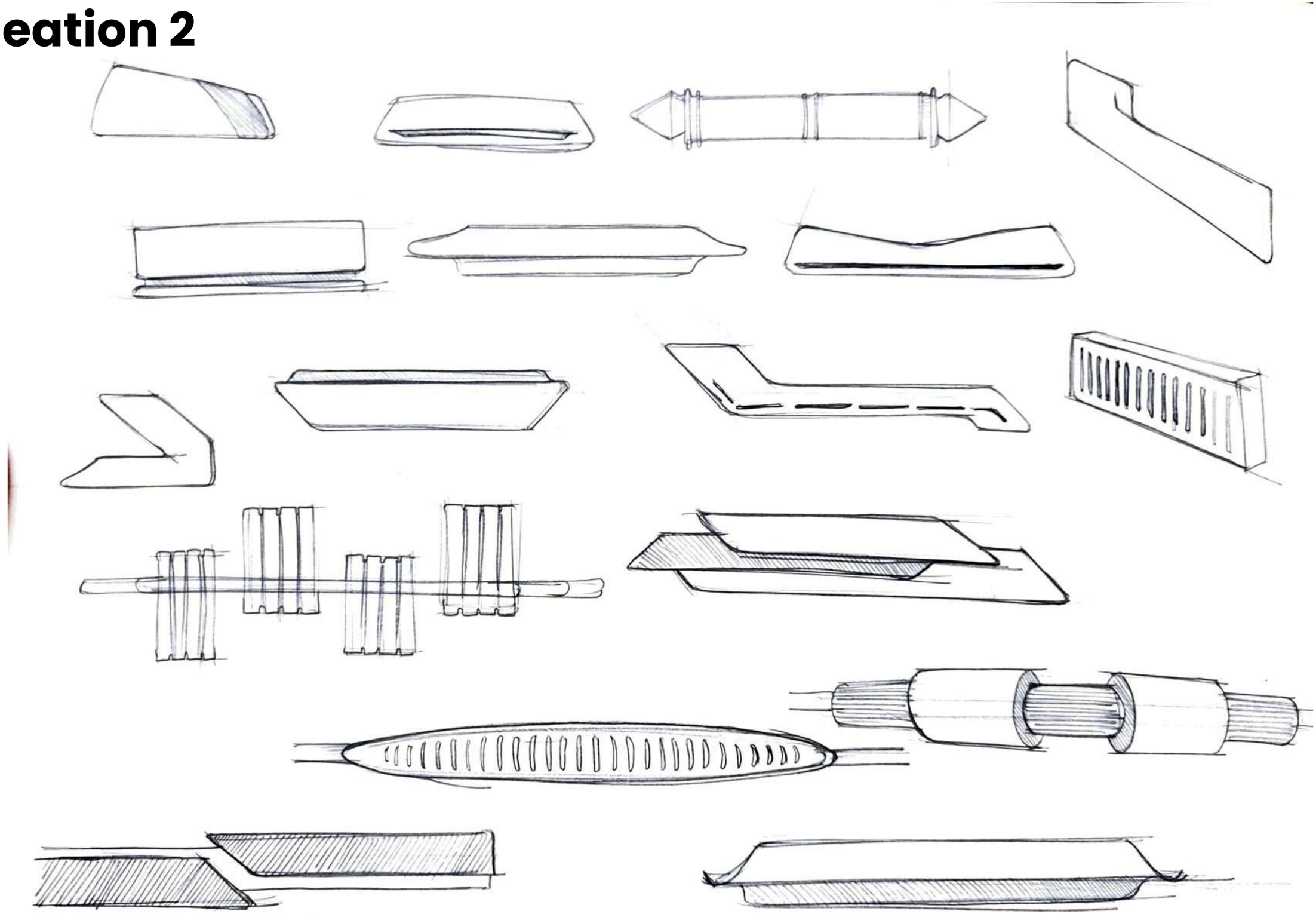
Ideation 2



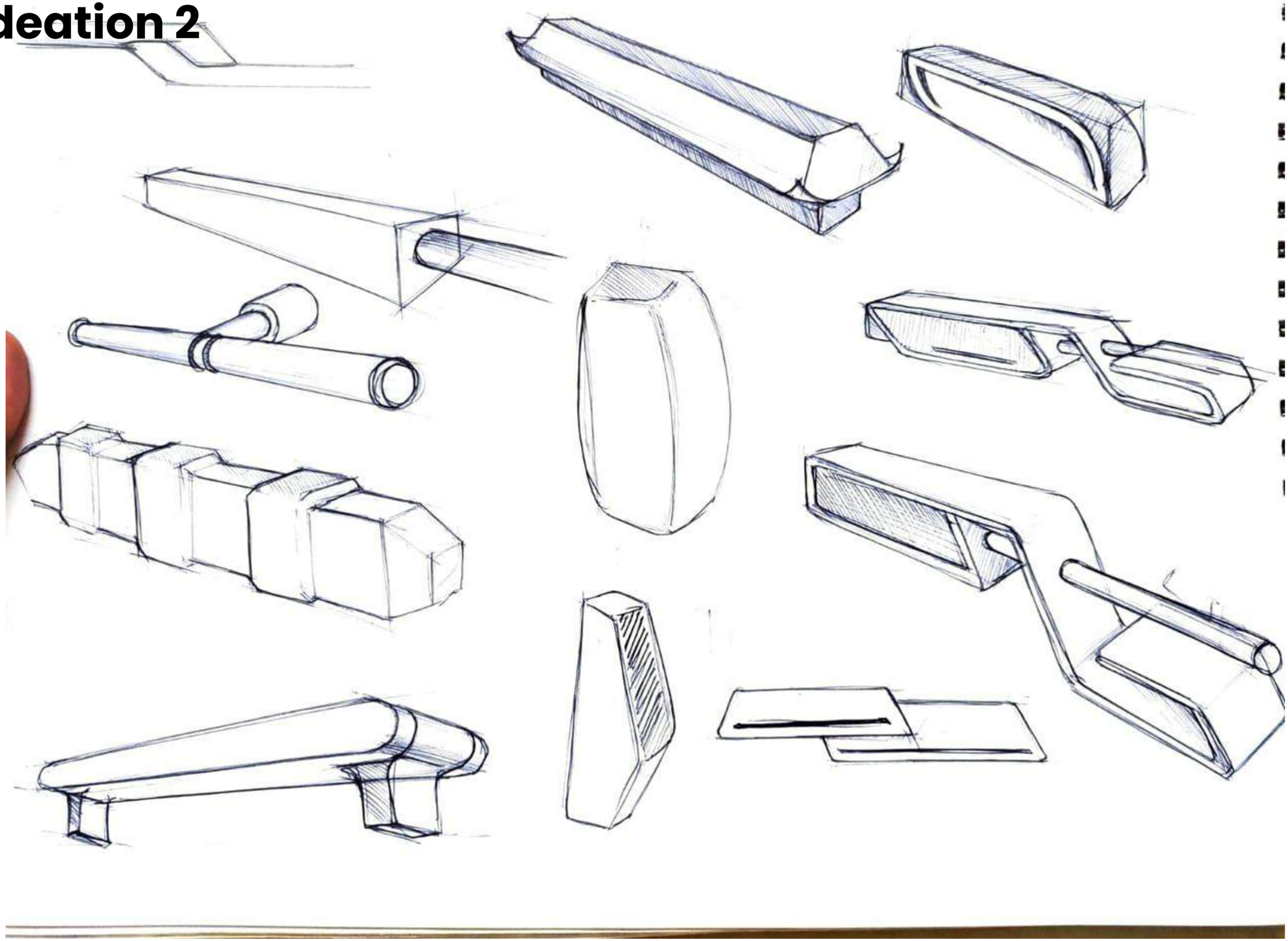
Ideation 2



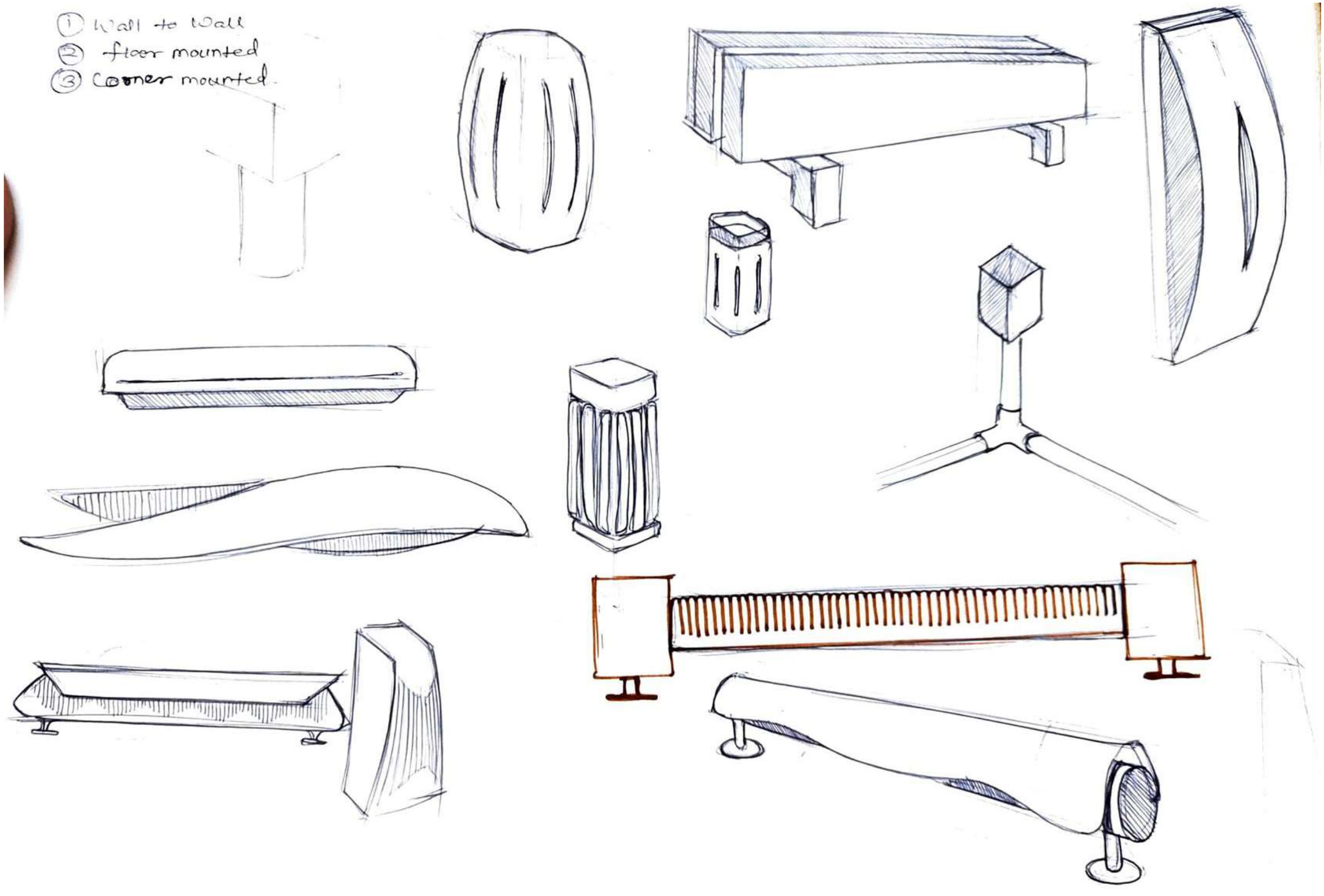
Ideation 2



Ideation 2



Ideation 2



Ideas segregation

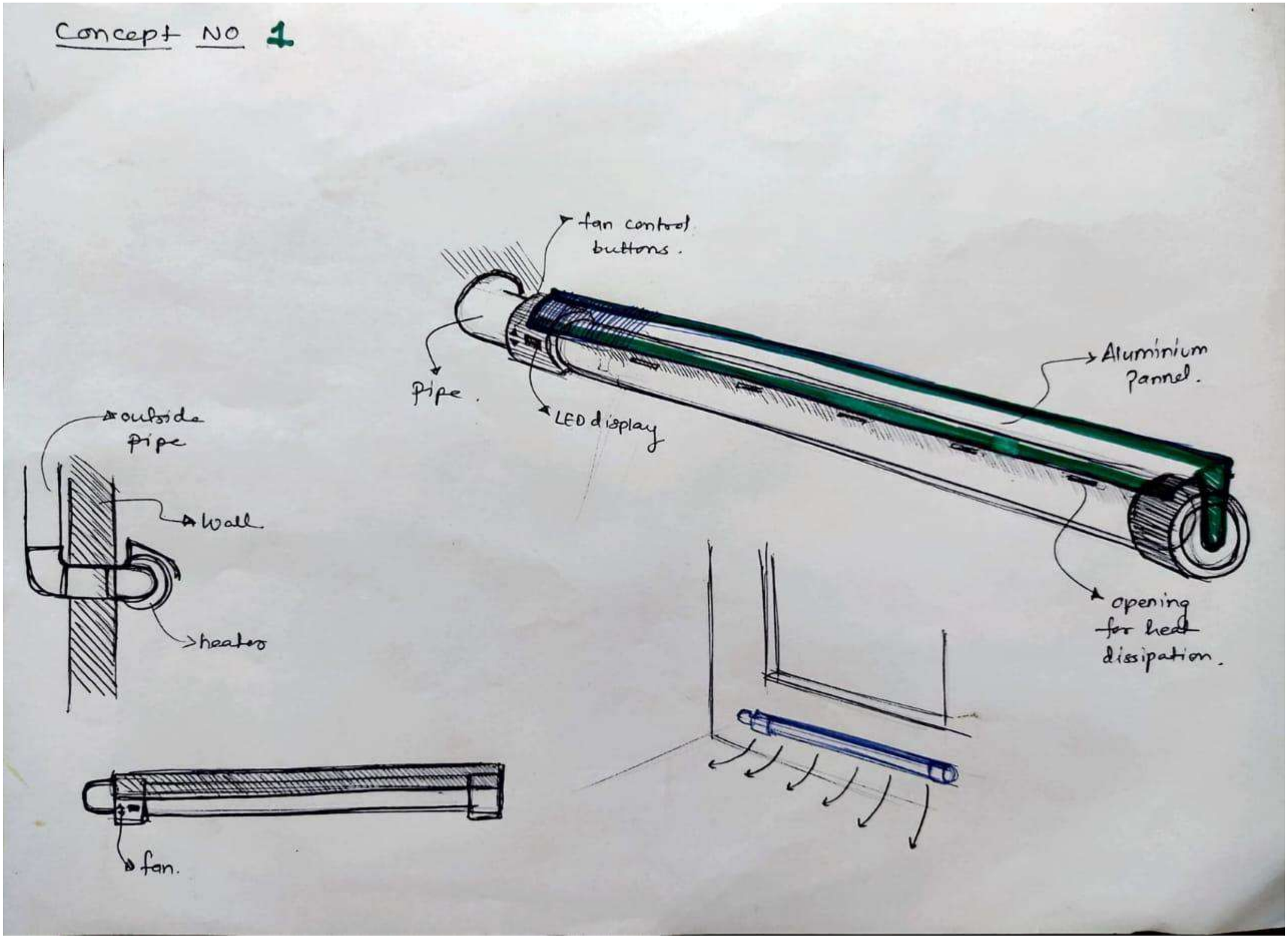
From the ideations, 3 concepts are formed according to the Size, Shape ,orientation. By considering the pros and cons of the concepts weightage segregation of the properties will be done to select the final idea.

Concept 1:
Horizontally oriented

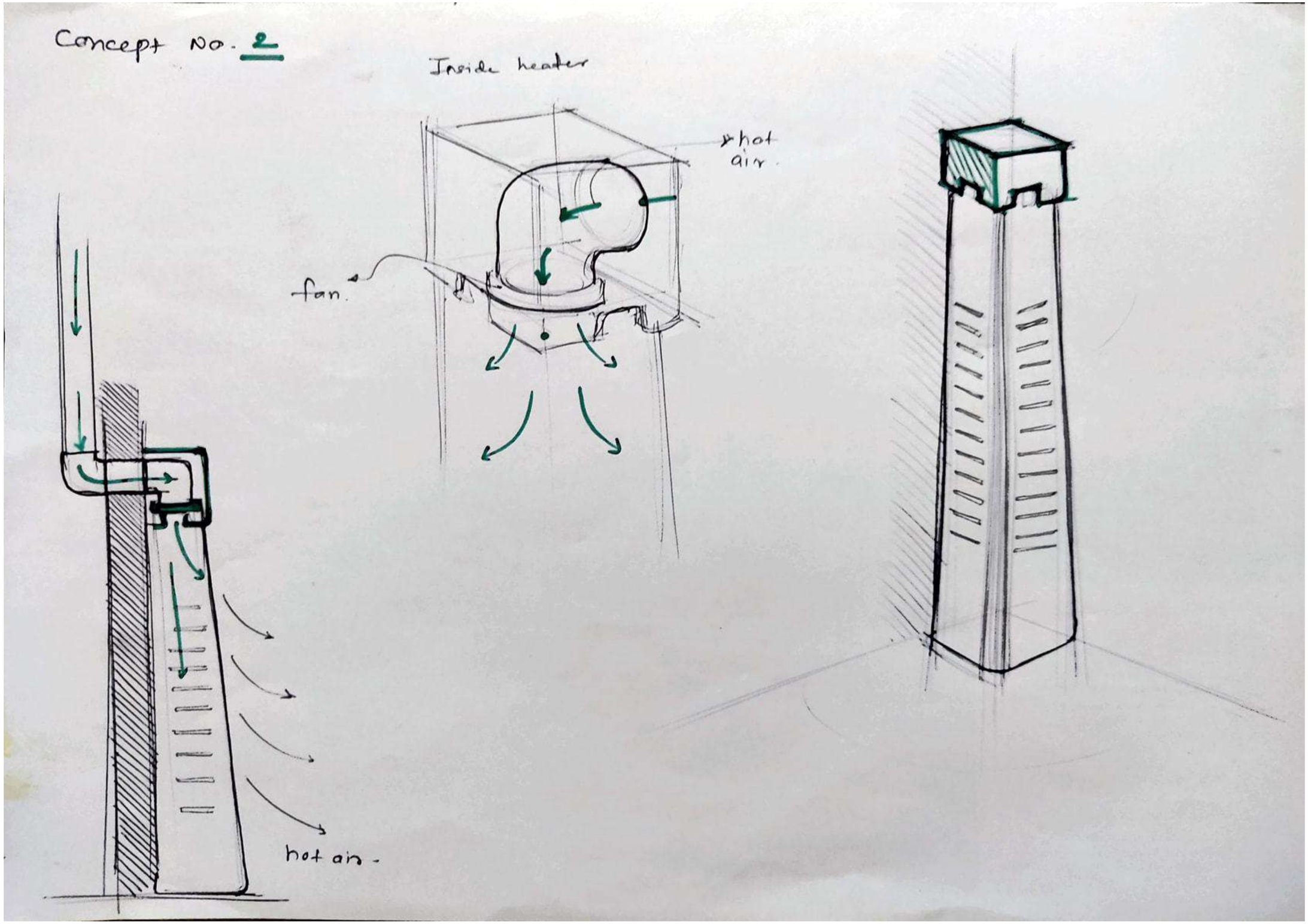
Concept 2:
Vertically corner oriented

Concept 3:
Wall mounted single outlet

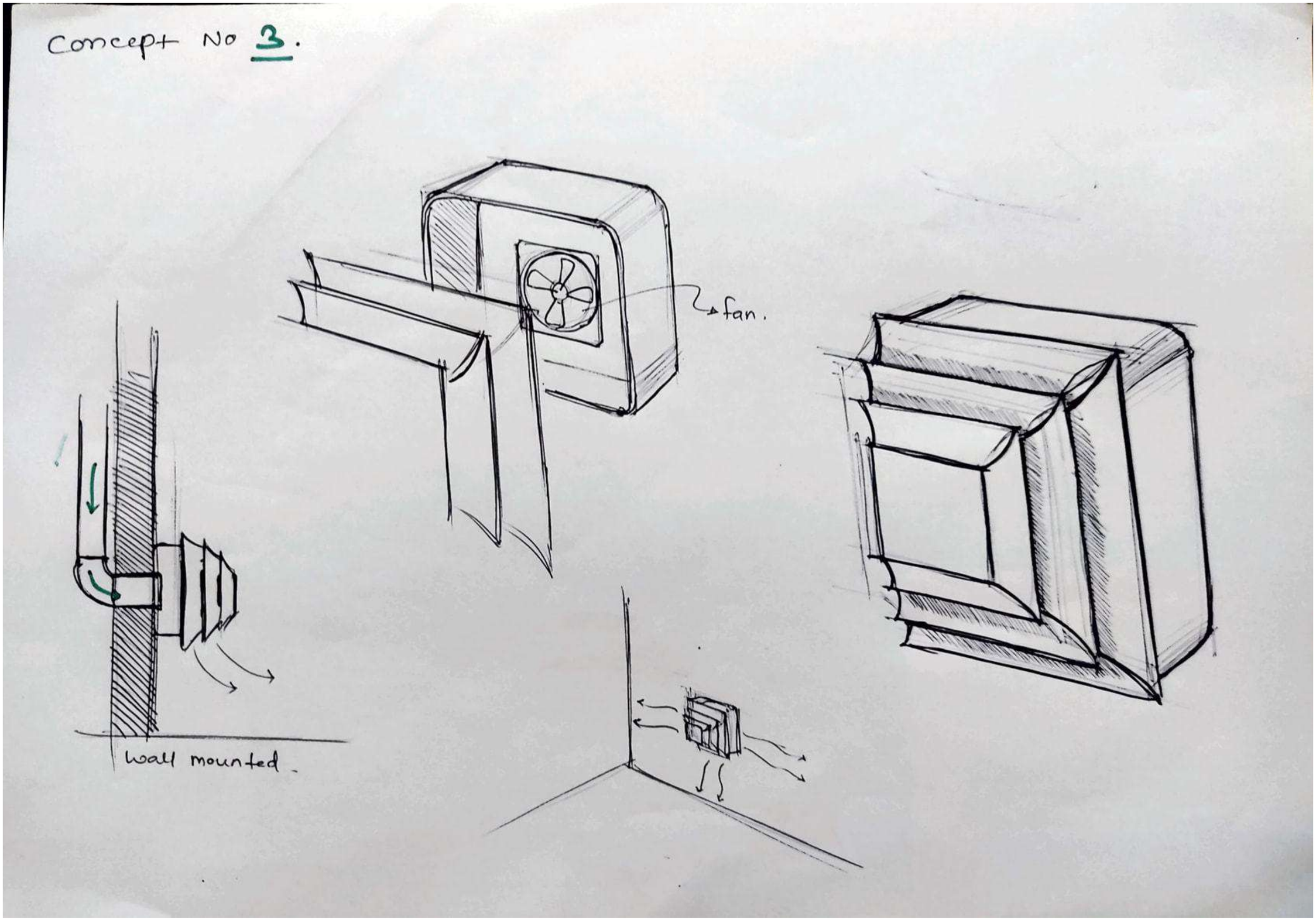
Concept NO 1



Horizontal longitudinal wall mounted concept



Vertical corner mounted concept



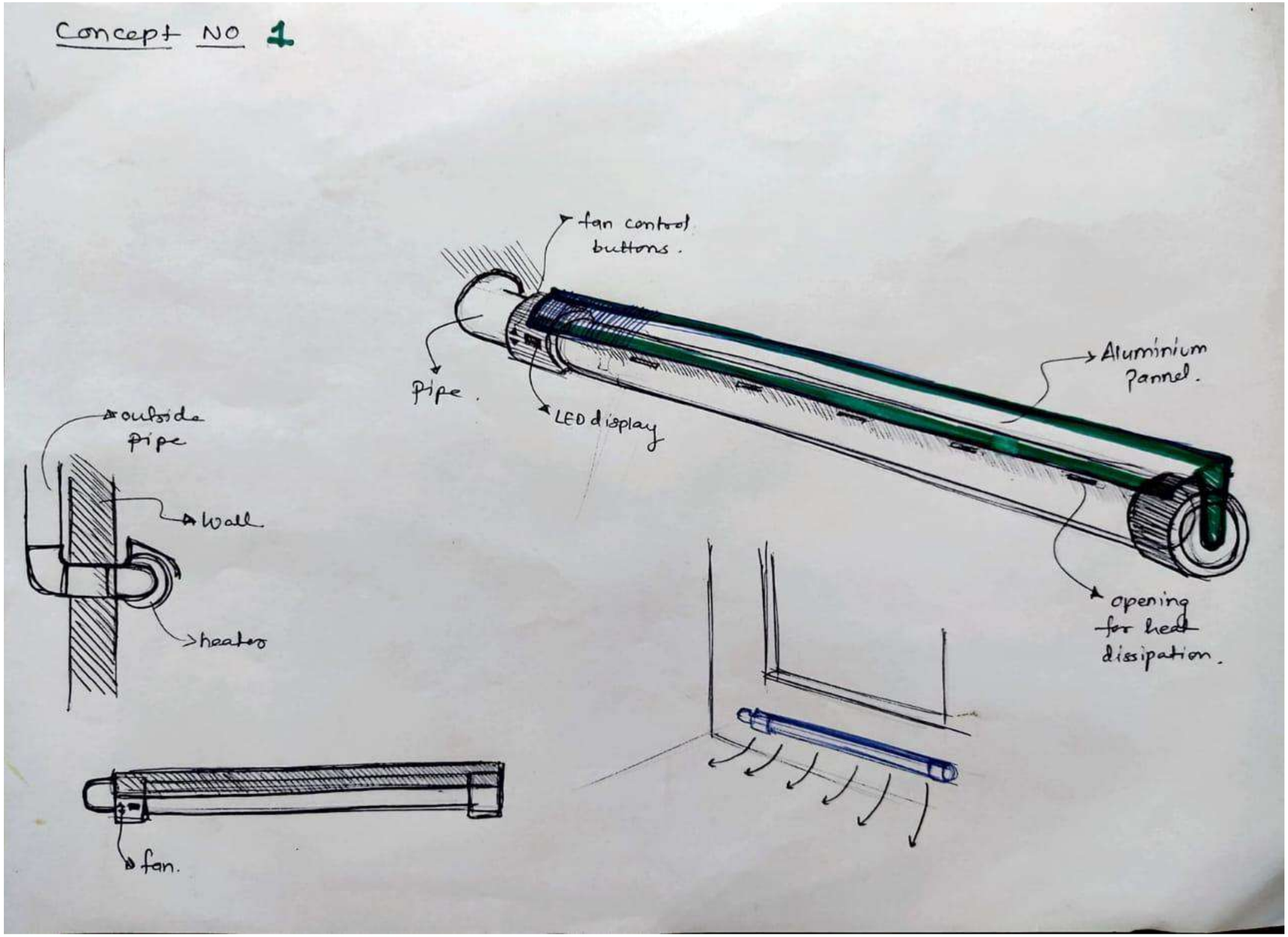
simple Wall mounted concept

Weightage segregation

(Marks out of 1,2,3)

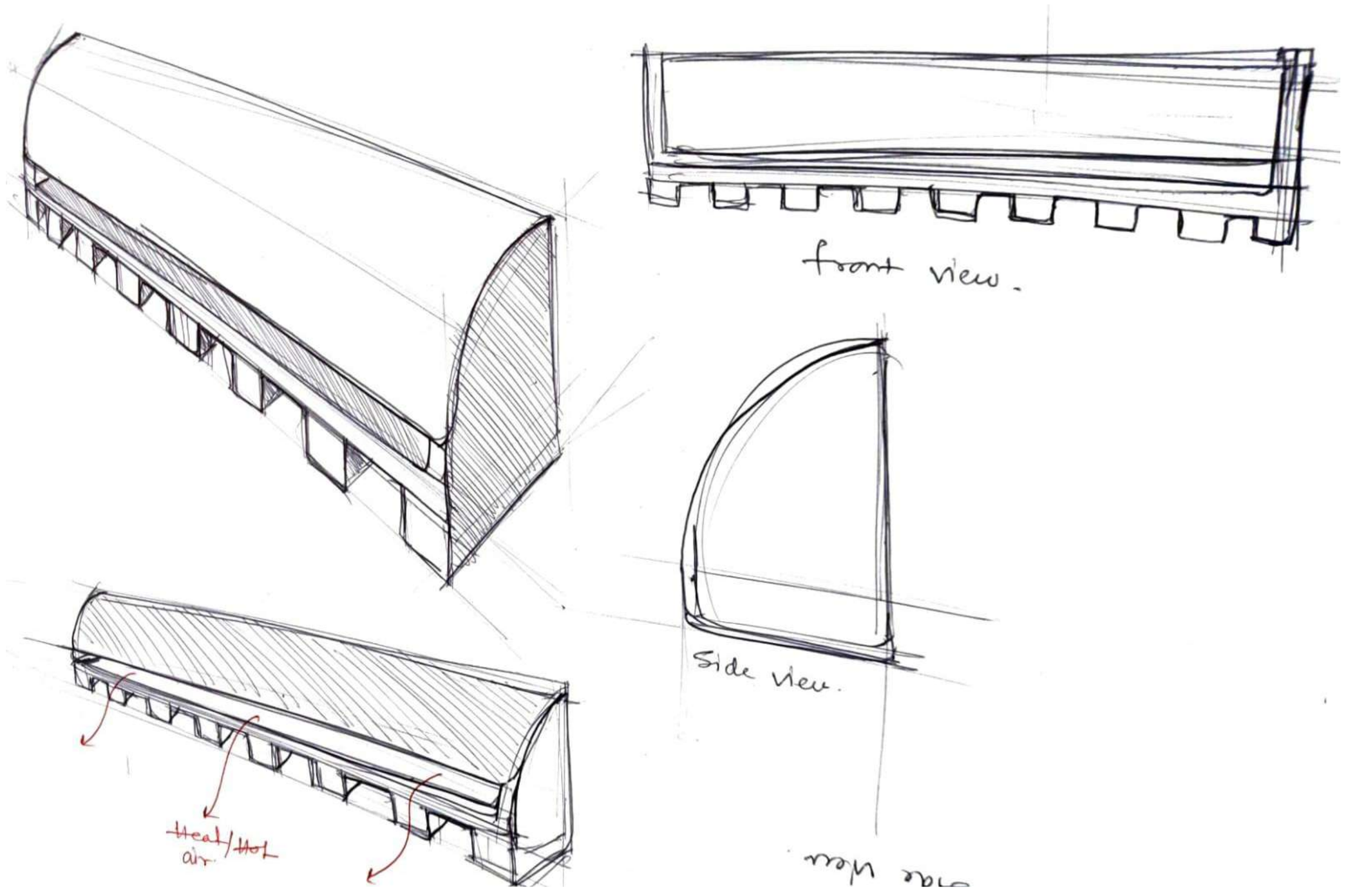
Key Properties	CONCEPT 01	CONCEPT 02	CONCEPT 03
Best distribution of Hot air * 3	3	2	1
Closest to the people * 2	3	1	2
Space utilisation in the classroom * 1	1	2	3
Constrain of Piping * 1	1	2	3
Easy to install*1	1	2	3
Total	**18**	**14**	**16**

Selected Idea

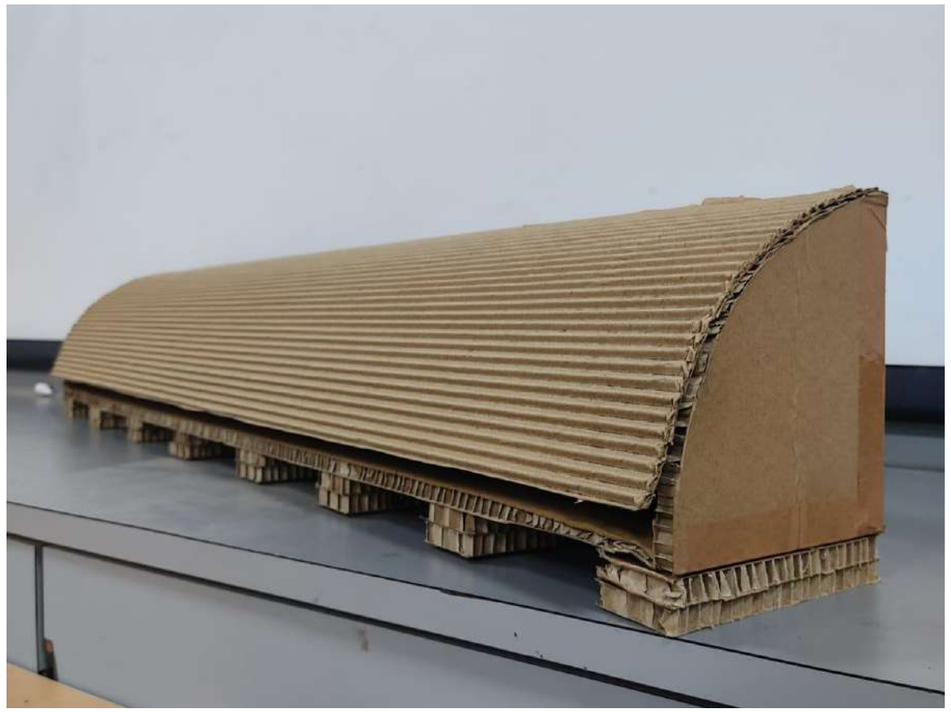


Horizontal longitudinal shaped design is selected by the weightage segregation method

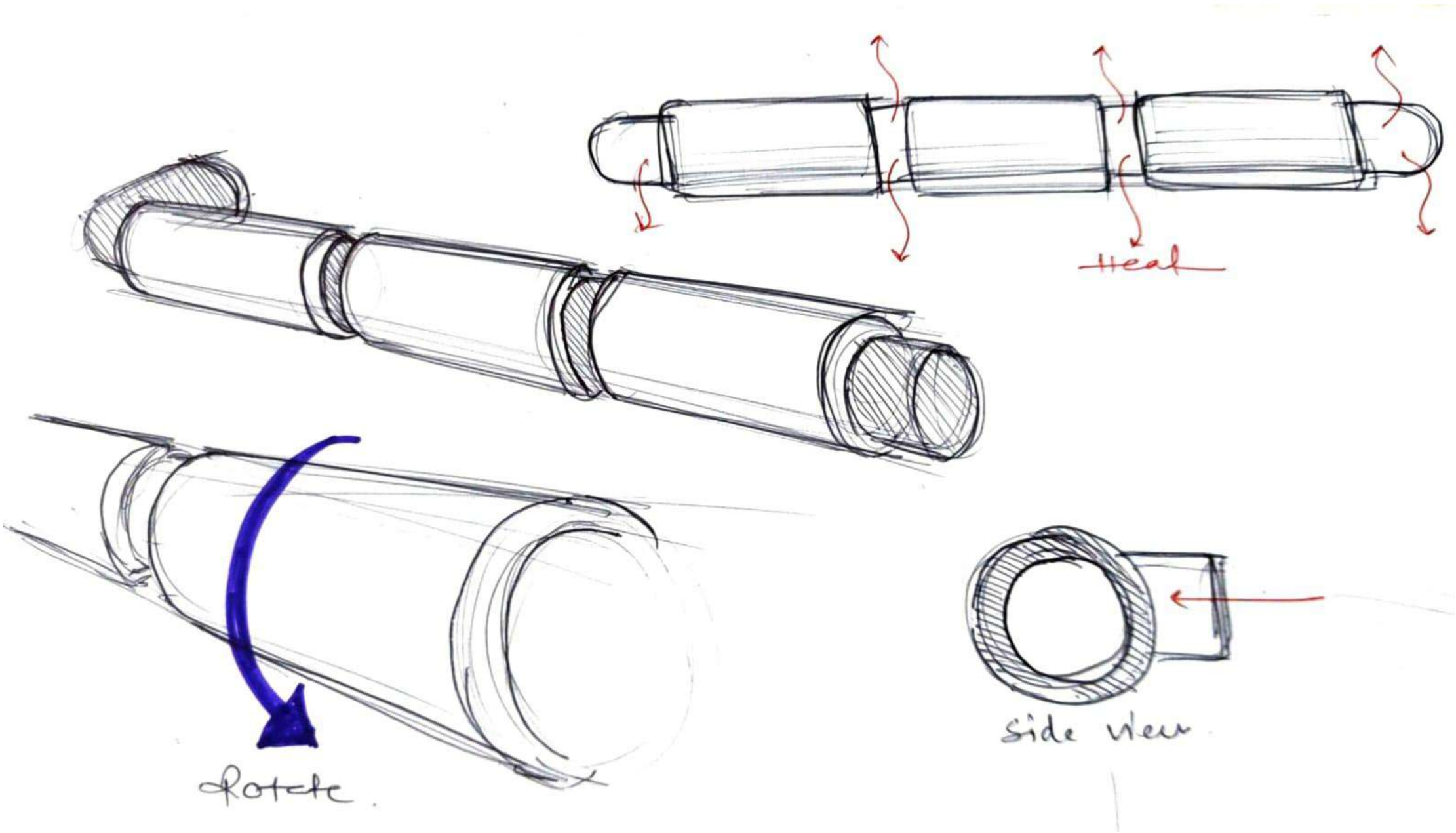
Ideation 3 - a)



Mockup a)

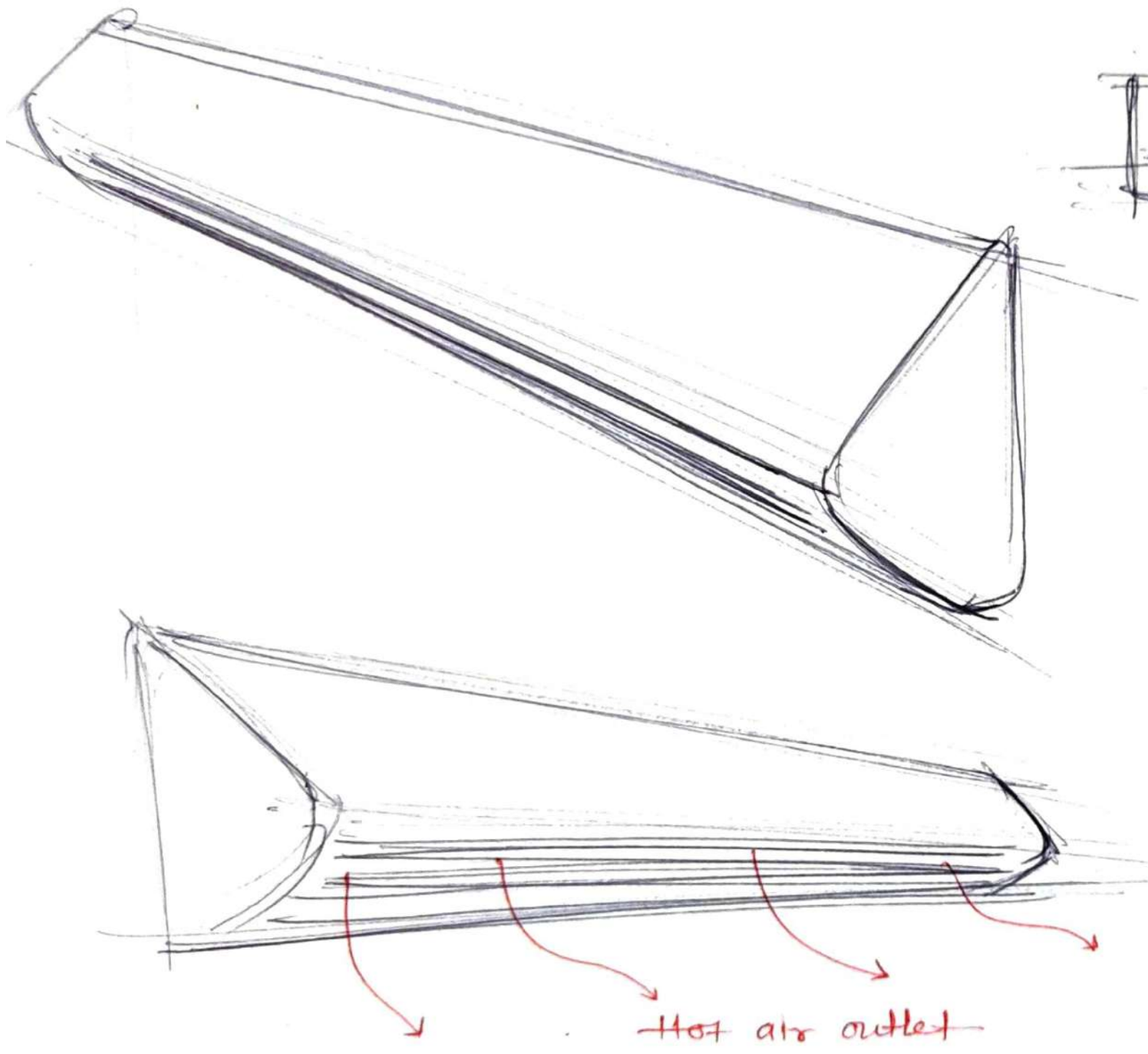


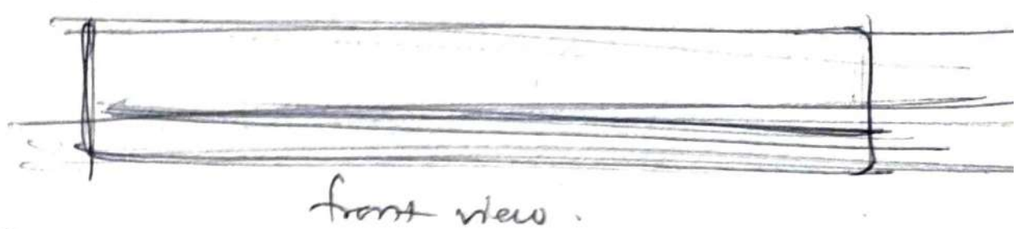
Ideation 3 - b)

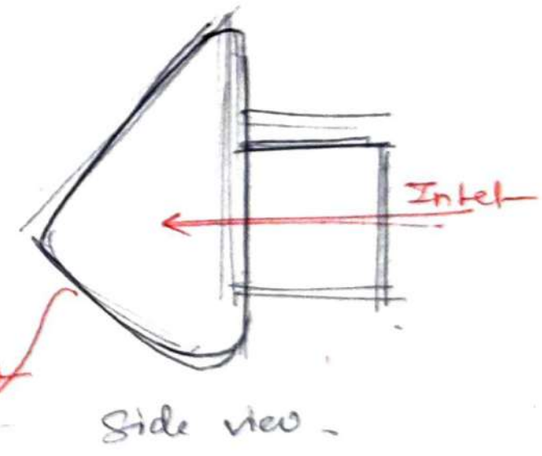


Mockup b)

Ideation 3 - c)

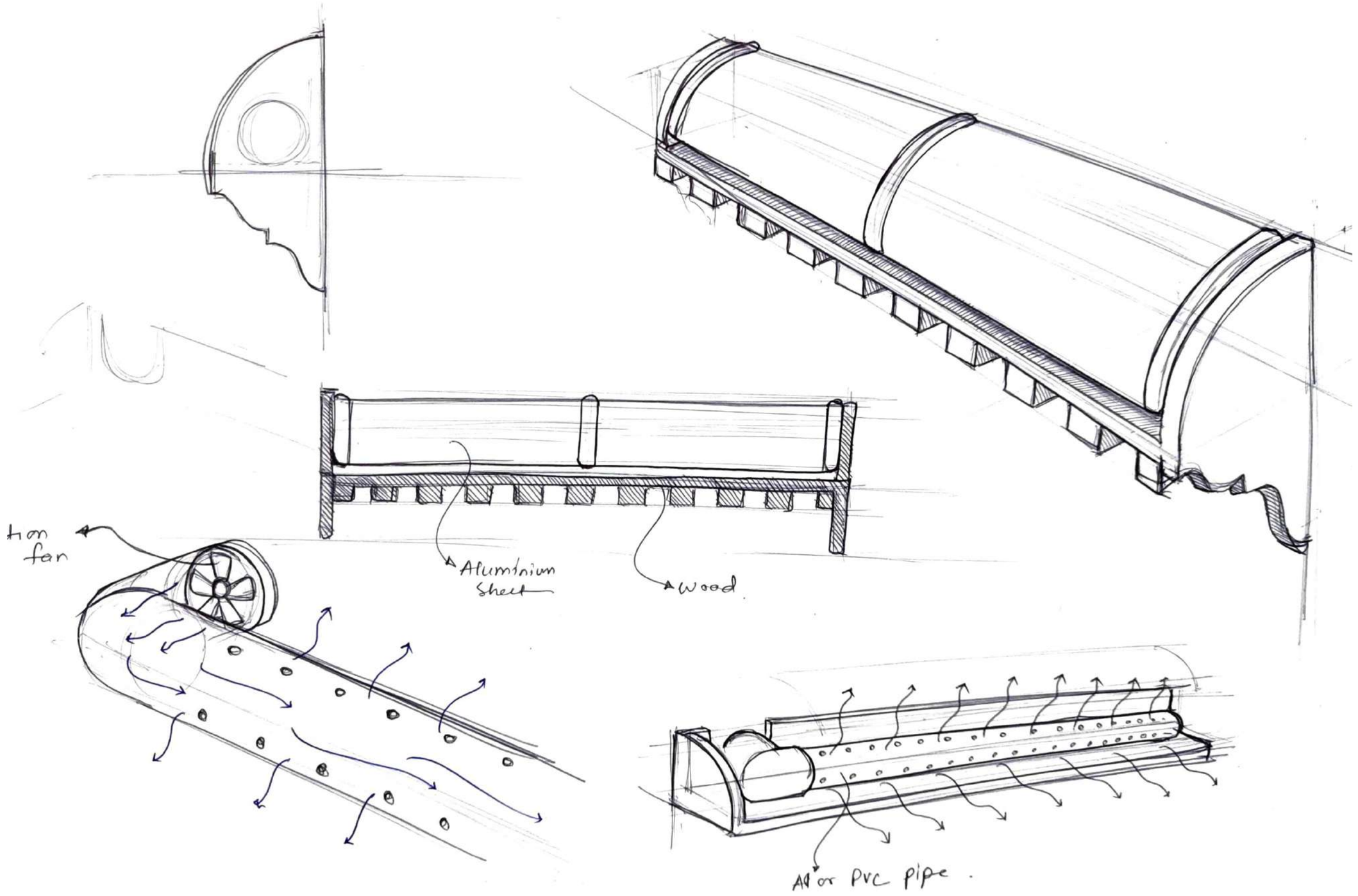




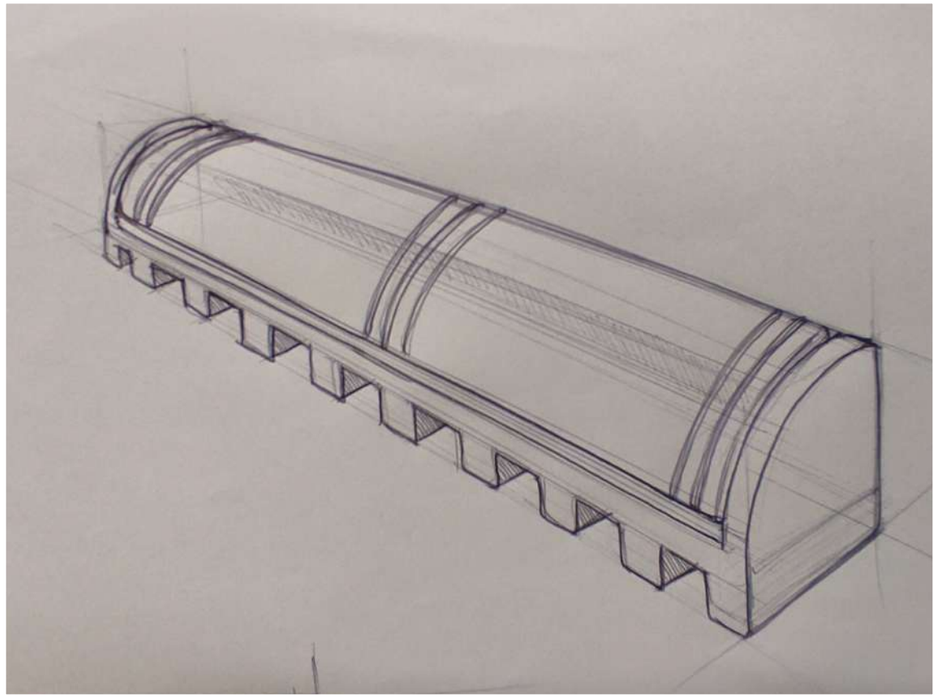


Mockup c)

Refined sketch of Idea 1



Prototype making of Idea 1

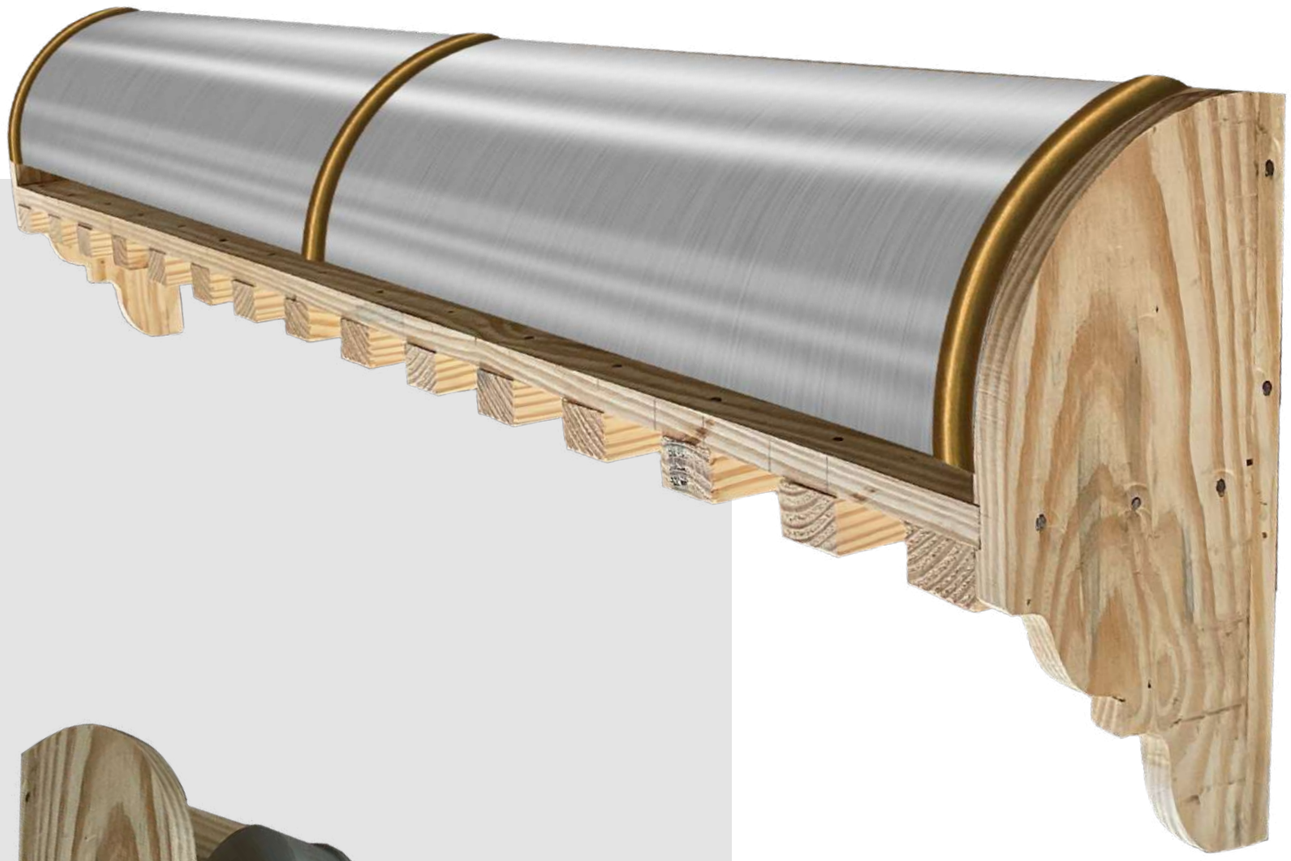


The form of the product is inspired from the ladakh architecture resembling the traditional Shinchik style. This long pipe will distribute the hot air uniformly inside the classroom.

Stand for Solar air Heater

Final Design

Design inspired from Ladakh Archirecture



Electric components used

About this item

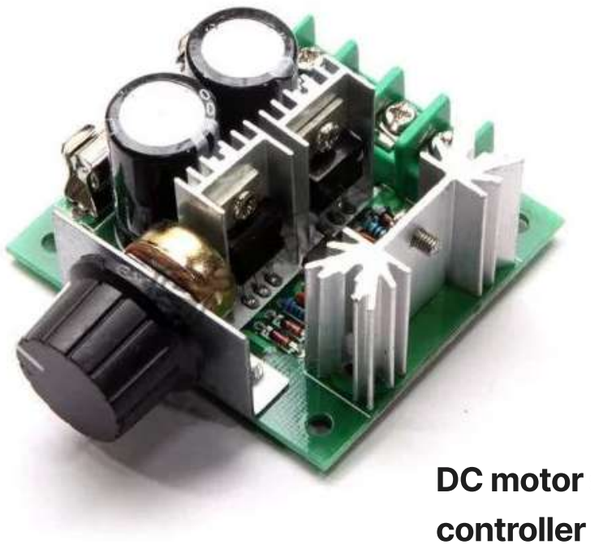
- PGSA2Z CPU Cooler Fan For Server PC PFC1212DE DC 12V 3.24A 12CM 120*120*38MM Cooling PWM 5600RPM
- Features: MODEL:PFC1212DE Size: 120 x 120 x 38MM Voltage: DC12V Current: nominal 3.24A Speed: 5600
- Air volume: 252.85CFM (7.16m3/min) Wind pressure: 1.412 in H2O (351.7 Pa) Weight: 0.351kg Noise: 66.5 dB (A) Power: 57.6W

Flow rate

252.85 CFM , 429.594885837 (m^3/h)

MPS (5 AMP)

12 volt



DC motor speed controller

60 W Solar panel

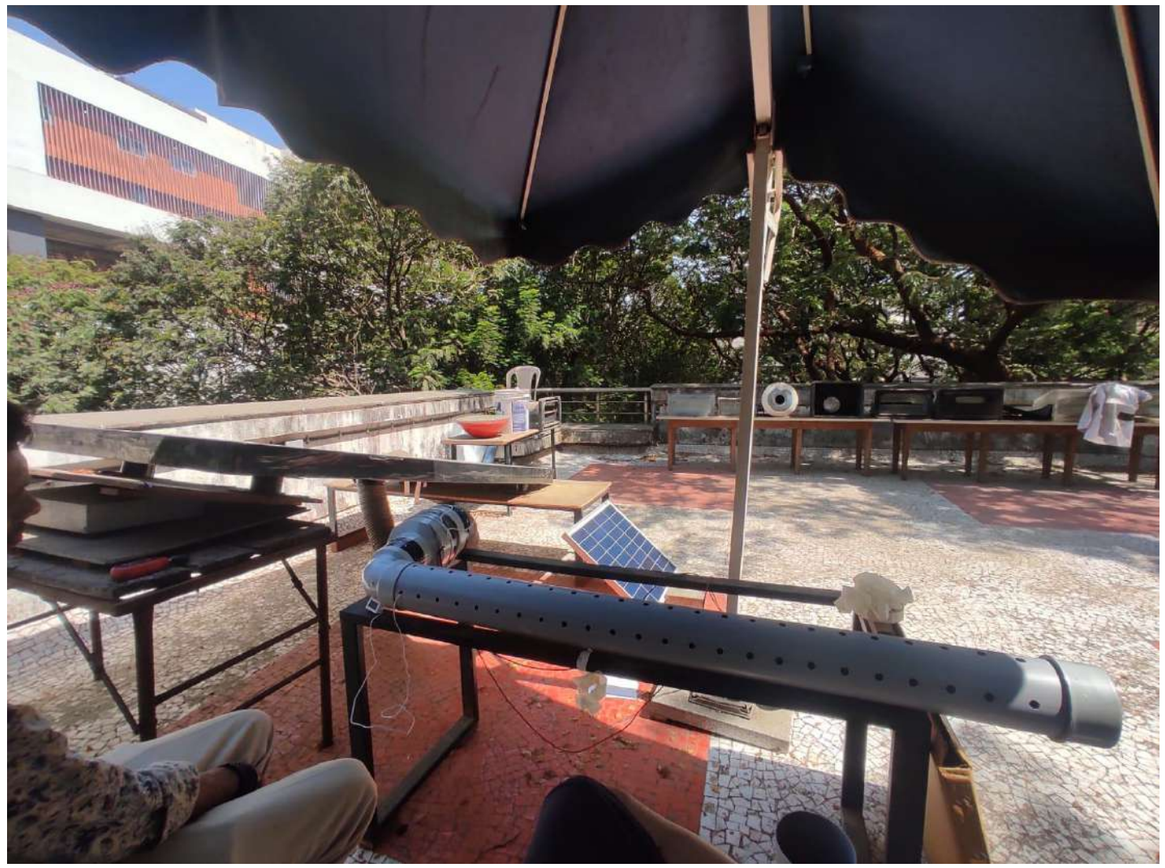
Thermodynamic analysis

Guided by Prof. S. V. Prabhu

Gathering insights from Prof. S. V. Prabhu and Prof. Chakravarthy during thermodynamic analysis

Final prototype testing setup

Preformed the testing of Solar air heater panel and the heater prototype. Done various test by changing different parameters to extract maximum heat from the heater



Final Prototype testing

Test no 1. (Time - 12.30 pm Ambient Temperature- 33 degree celcius)
Connected the fan with DC voltage with the help of PV panel of 10W.
Calculated the velocity and temperature at each diameter hole respectively.
Hole Dia 5mm : Temperature- 71 degree , Velocity- 0
Hole Dia 7.5mm : Temperature- 66.9 degree ,Velocity- 0
Hole Dia 10mm : temperature- 55.9 degree , Velocity- 1.1m/s (temp-40.7 degree)







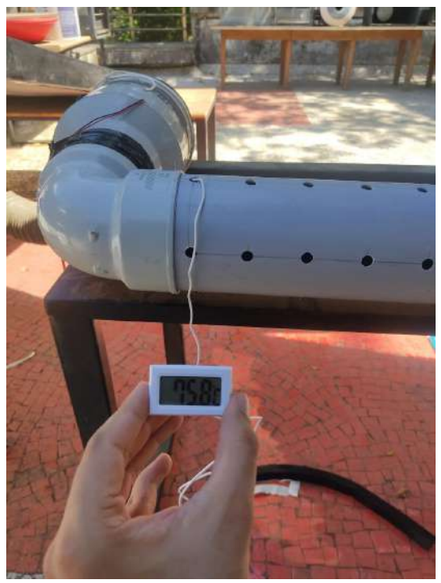

Test no 2. (Time - 12.30 pm Ambient Temperature- 33 degree celcius)
Connected the fan with AC voltage with the help of 12Volt and 2A adaptor.
Calculated the velocity and temperature at each diameter hole respectively
Hole Dia 5mm : Temp - 77.1 degree , Velocity - 0 m/s
Hole Dia 7.5mm : Temp - 73.5 degree , Velocity - 1.3 m/s (temp - 43.3 degree)
Hole Dia 10mm : Temp - 72.5 degree , Velocity - 1.6 m/s (temp- 46.7 degree)



Final Prototype testing

Test no 3. (Time - 12.30 pm Ambient Temperature- 33 degree celcius)
Connected fan with same AC voltage but now increased the size of Diameter of Holes . The respective diameters are 7.5mm, 10mm and 13 mm.
Hole Dia 7.5mm : Temp- 75.8 degree , Velocity - 0m/s
Hole Dia 10mm : Temp- 74.3 degree , Velocity - 1.0 m/s (temp- 40.5 degree)
Hole Dia 13mm : Temp- 63.3 degree , Velocity - 1.2 m/s (temp- 37.9 degree)



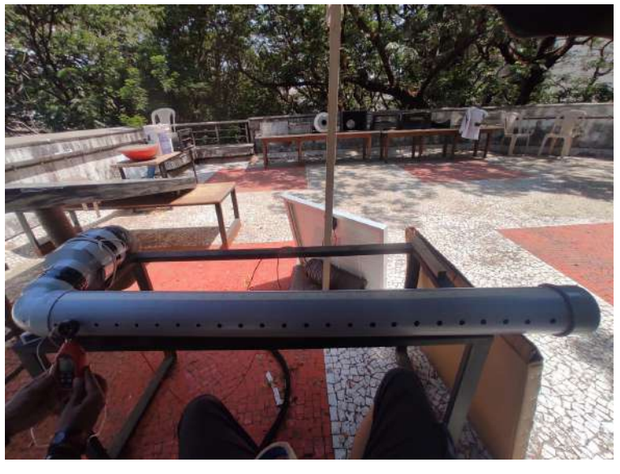


Test no 4. Time - 12.30 pm Ambient Temperature- 33 degree celcius
Connected the fan with DC voltage with the help of PV panel of 60W.
Calculated the velocity and temperature at each diameter hole respectively.
Initial Temp- 75.8 degree
Final Temp- 69.2 degree


Final Prototype testing

Test no 5.
Connected the fan with DC voltage with the help of PV panel of 60W.
Calculated the velocity and temperature at each diameter hole respectively.
Hole Dia 7.5mm : Temp- 68.1 degree , Velocity - 0m/s
Hole Dia 10mm : Temp- 65.5 degree , Velocity - 0.8 m/s (temp- 43 degree)
Hole Dia 13mm : Temp- 60 degree , Velocity - 1.3 m/s (temp- 41.9 degree)

Test no 6.
Connected the fan with DC voltage with the help of PV panel of 60W.
Calculated the velocity and temperature at each diameter hole respectively.
Hole Dia 7.5mm : Temp- 70 degree , Velocity - 1.3 m/s (temp- 38.0 degree)
Hole Dia 10mm : Temp- 65 degree , Velocity - 1.6 m/s (temp- 38.8 degree)
Hole Dia 13mm : Temp- 60 degree , Velocity - 2.0 m/s (temp- 38.9 degree)



Final Prototype testing

Test no 7.
Connected the fan with DC voltage with the help of PV panel of 60W.
Calculated the velocity and temperature at each diameter hole respectively.
Hole Dia 7.5mm : Temp- 70 degree , Velocity - 2.1 m/s (temp- 45.1 degree)
Hole Dia 10mm : Temp- 65 degree , Velocity - 2.7 m/s (temp- 40.7 degree)
Hole Dia 13mm : Temp- 60 degree , Velocity - 3.1 m/s (temp- 41.0 degree)

Test no 8.
Connected the fan with DC voltage with the help of PV panel of 60W.
Calculated the velocity and temperature at each diameter hole respectively.
Temp- 69,2 degree , Velocity - 2.5 m/s

Calculations after testing

Gathered insights from the prototype testing and with the help of technical data calculated the efficiency of the heater at different parameters.

Diameter of pipe = 4inch = 100mm.
Velocity of air. (V_{exit}) = 2.5 m/s
T_{in} = 69.2°C.
$T_{ambient}$ = 33.
ΔT = 69.2 − 33.0 = 36.2°C [for ladakh]

Volume of Room = $(3.03)^3$ = 27.82 m^3

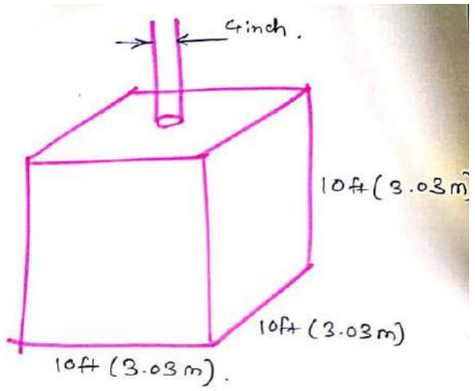
∴ mass flow rate $\dot{m} = \rho AV = \rho \frac{\pi d^2}{4} V$.

$= 1.125 \times \frac{\pi}{4} \times (100 \times 10^{-3})^2 \times 2.5$

$\dot{m}$ = 22.09 gm/s. OR 0.022089 Kg/s

$Q = \dot{m} C_p \Delta T$

$= 22.09 \times 10^{-3} \times 1005 \times [69.2 - 33] = 803.65$ W



$\dot{E}_{out} = \dot{Q}_{conv.} + \dot{Q}_{rad.}$

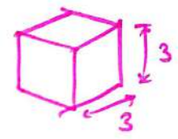
$= h A_s (T_{air} - T_{wall}) + \sigma E_w A_s [T_{air}^4 - T_{wall}^4]$

(A_s. h = 10. $A_s = 4 \times 3 \times 3 = 36 m^2$)

$= 10 \times 36 (36 - 0) + 5.67 \times 10^{-8} \times 1.0 \times 36 [309^4 - 273^4]$

$= 1296 + 7270$

E_{out} = 8566 W.



— : Comparison :—

E_{in} = 803 W. E_{out} = 8566 W.

★ According to Rane sir data :—

15 gm/s. ⟶ 750W.
80 gm/s ⟶ 1500 W.

☆ According to Our data:—

22 gm/s ⟶ 800 W.

Key insights after testing

Increase Solar air heater Panel

False ceiling to reduce area

AirFlow restriction leds pressure drop

Human Body heat emission

Less and bigger diameter holes

No bends in pipe or bigger radius bends

Product development

Don’t obstruct the air flow

Big diameter holes

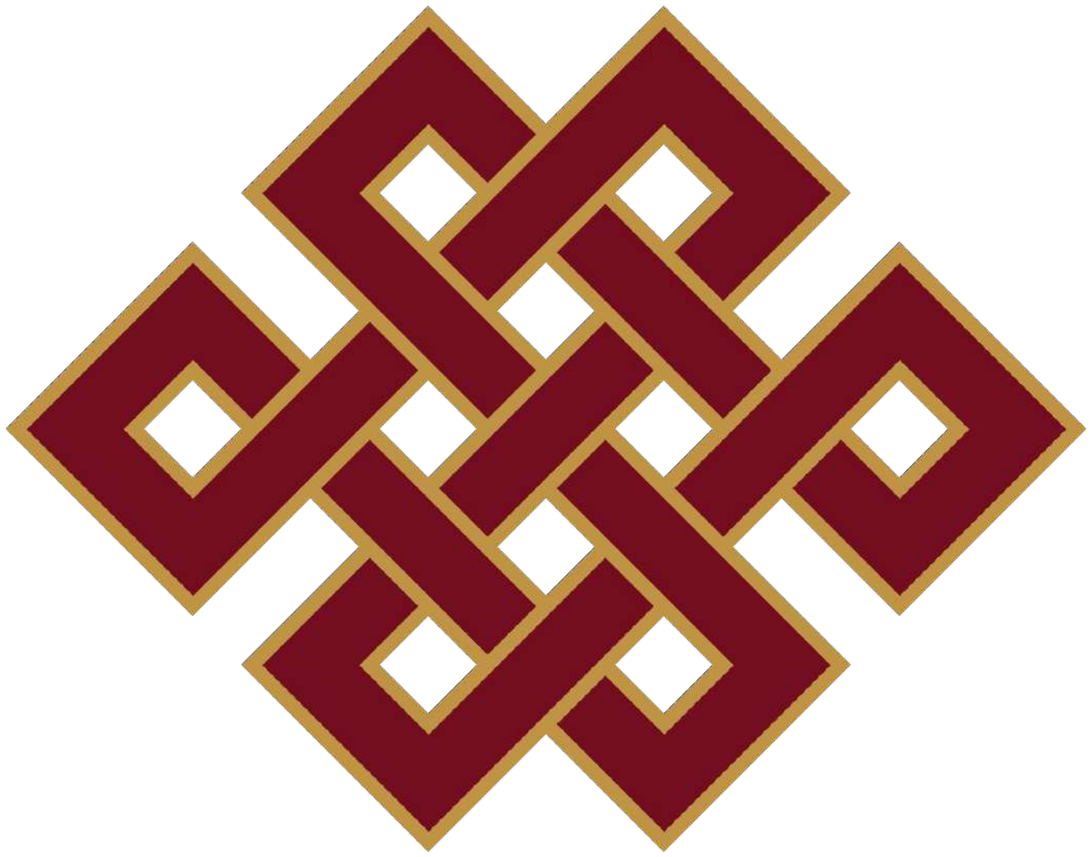
Create space for air passage

Orientation of Holes direction

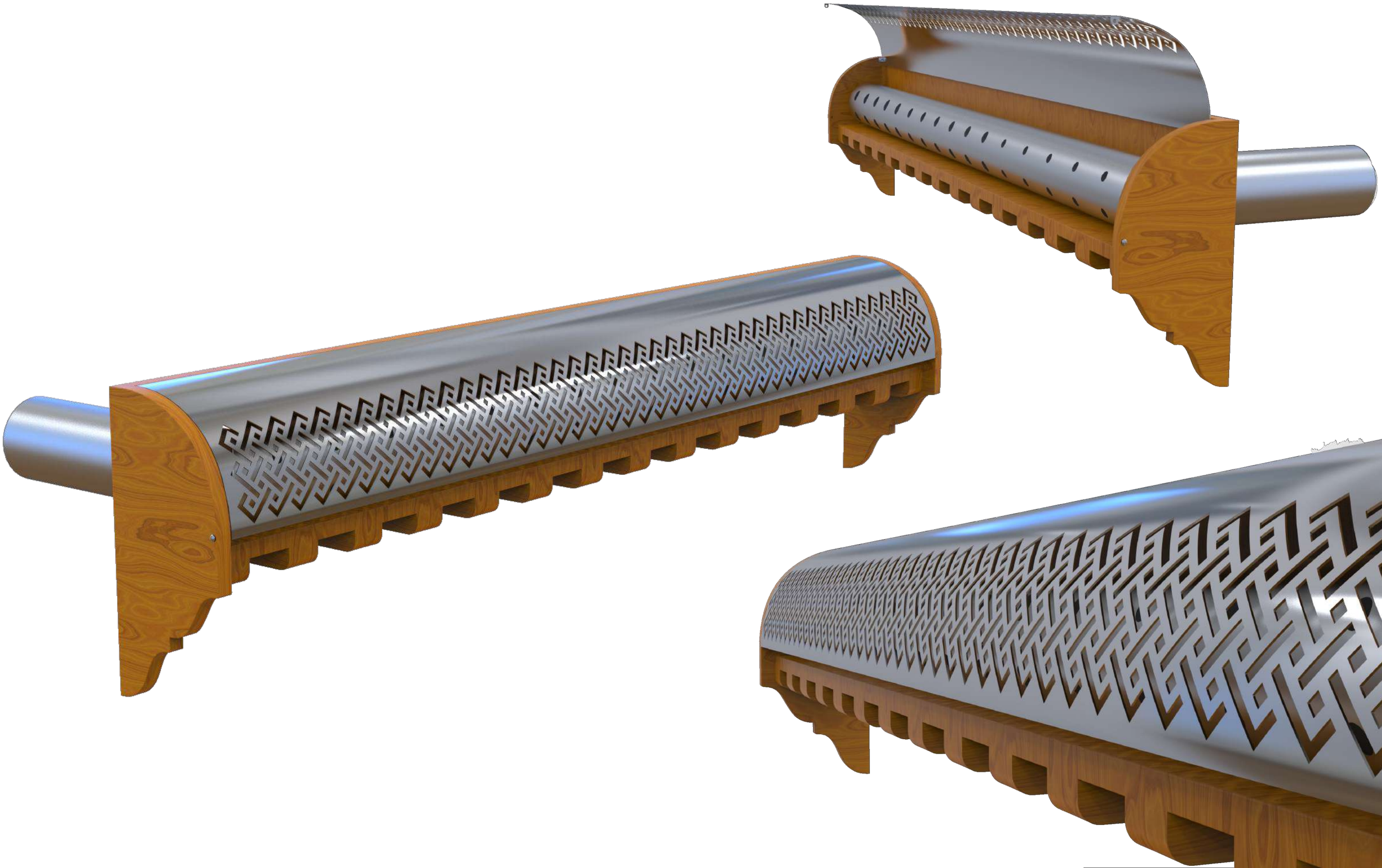
Inspiration: Endless Knot

Design inspired from Ladakh Archirecture

The endless knot is a symbol found in various cultures, notably in **Tibetan Buddhism, Hinduism,** and **Celtic art.** It represents the interconnectedness of all things, eternal continuity, and the harmony of wisdom and compassion. This intricate design with no beginning or end signifies the infinite cycle of life and the perpetual nature of existence.



Final Model Renders



Final Model Making








Final Model

About Final Design

- The final design of Solar Room Air Heater is inspired from Ladakh Architecture. Specially inspired from the “Shinchik” which is a traditional design installed on the top of Door and Windows of the building.

- The Room heater is installed at the bottom of South/ East/ West wall. As the hot air is light weight ,it goes in the atmosphere. To avoid that Heater is placed in the bottom, so that maximum heat will be in the classroom.

- It is recommended to Install the Solar air heater panel facing south. So that it will trap maximum heat.

- Solar Air heater panel is installed just outside the classroom so that there should be less pressure drop and less heat loss.

- There are two possibilities to install heater inside classroom such as

1. South Wall
2. East or West wall

If heater installed on South wall, there will be one bend in the pipe, resulting a bit pressure drop

If heater is installed on the East/West wall, there will be no bend in the pipe resulting no pressure drop (Recommended to keep pipe as straight as possible, if not there should large radius bends in the pipe.)

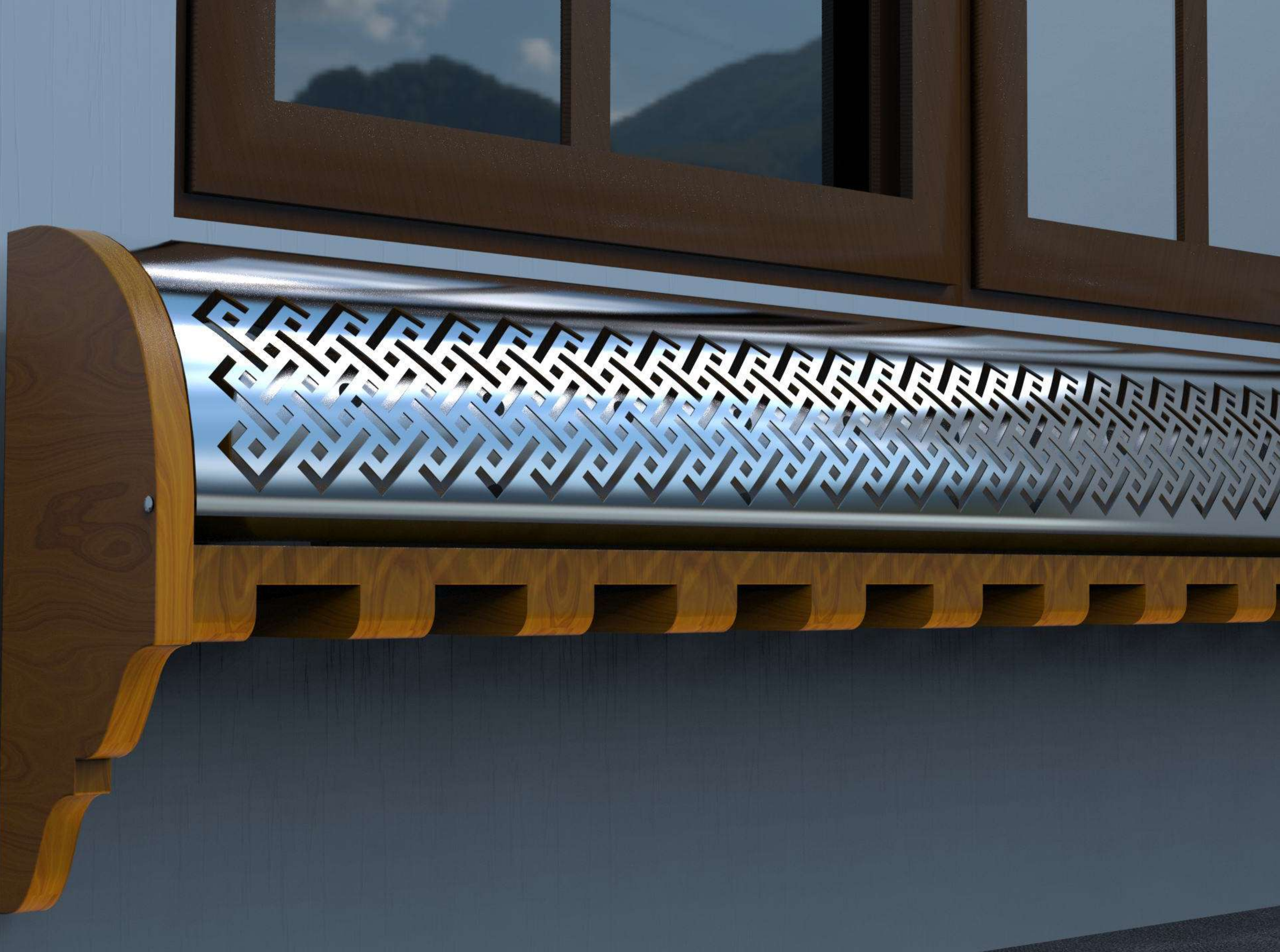
- Aesthetics of the heater is designed considering the local and cultural references and frame made from Wood material to retain the cultural aspect. Upper aluminium panel is used to warm the hands

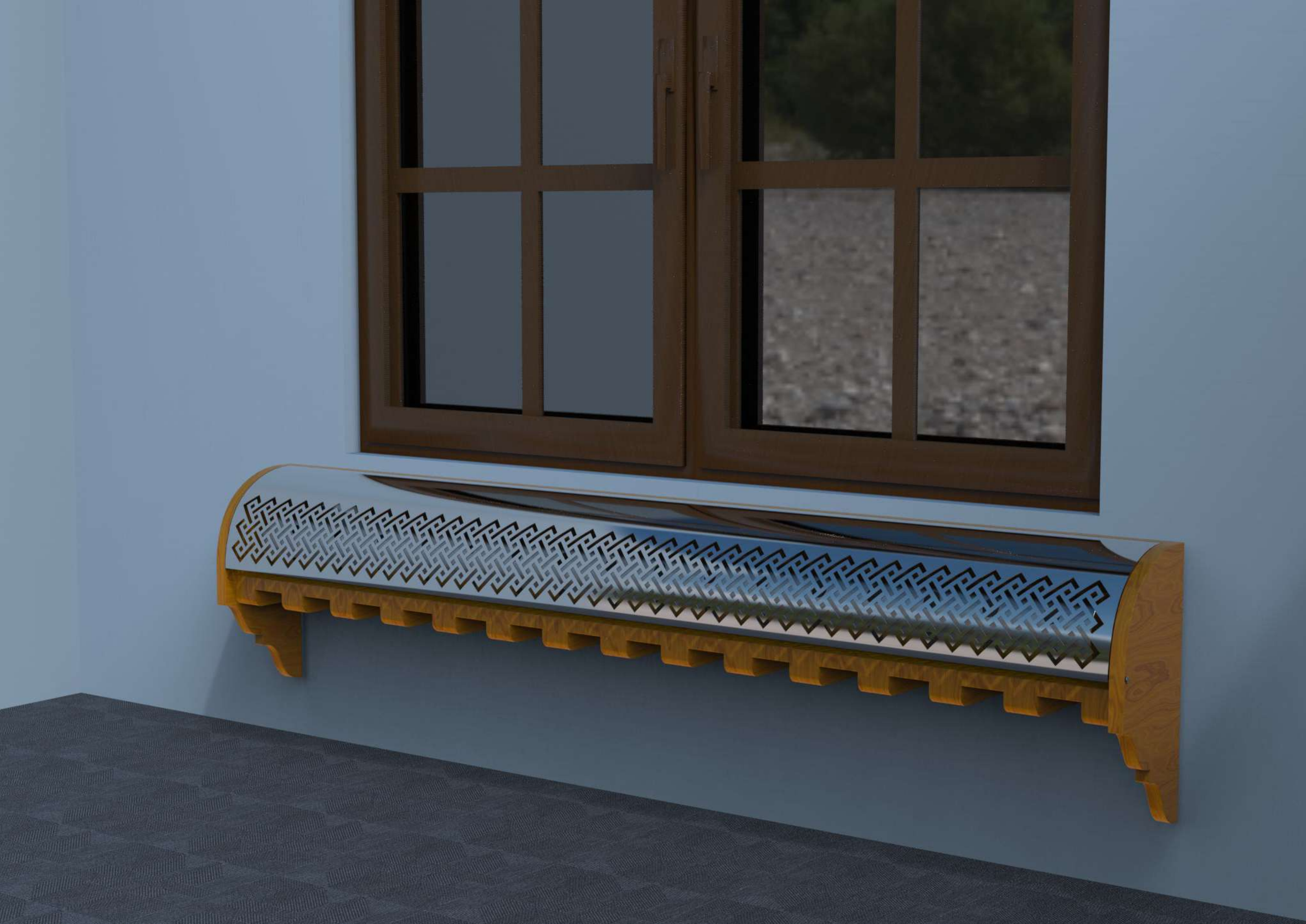
- The pipe inside the room heater can be of Aluminium or PVC , as these materials are readily available in the market. The pipe material which connected from the Air heater to blower can be PU rubber duct hose or Aluminium duct.

- The blower fan inside the heater will run on 60 watt solar panel because there is not electricity in the village during day hours.

- For the future scope of the project the Solar air heater panel, Solar panel and blower parts will be supplied through the manufacturer and rest parts will be available in the Ladakh Market.

- The main work of heater is to provide comfortable environment in the classroom to the student . It will not heat the room but provide just comfortable environment



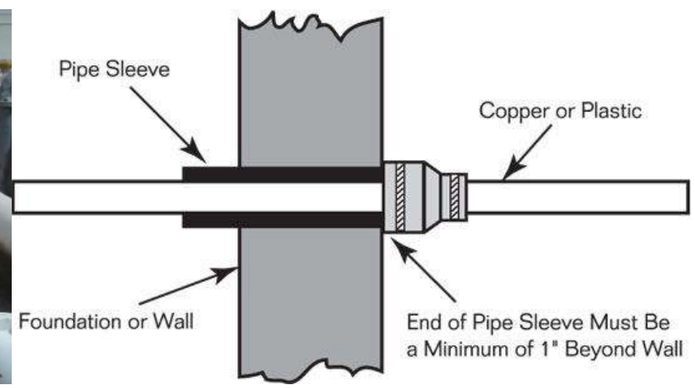


Final Model

Roleplay as a student in a classroom, enjoying warmth of the product

Installation tools

Core cutting machine



Machine required to make proper holes in the wall to install the heater

Round Ducting System

Stainless steel air duct

90° elbow

Reducer

Items needed for the ducting system of the heater

Installation tools

UPVC pipe fittings

Polypropyl

PVC paste-adhesive

Installation tools needed during the heater installations

Solar Air heater stand

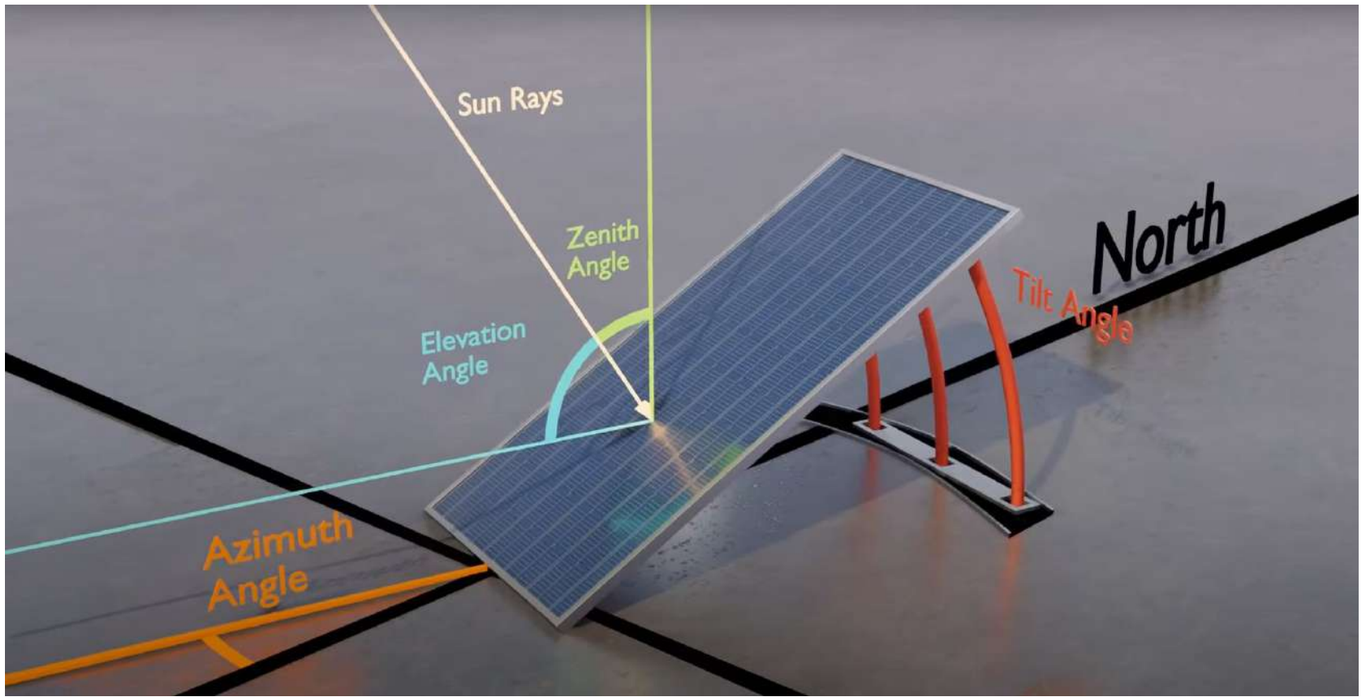
References

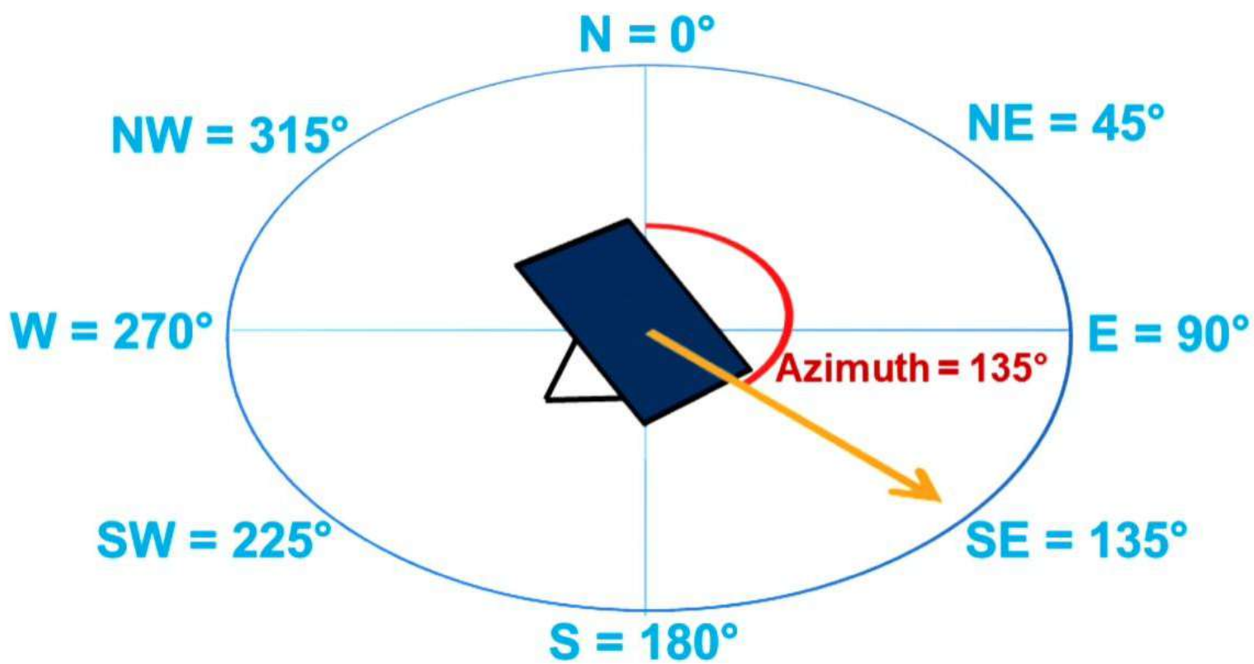
Angle changing stand designed for the solar air heater panel.
Angle changing feature is necessary to change the angle of panel according to the sun position

Stand model

Solar Air heater Angle

Solar air heater panel and solar PV panel is installed at a specific angle to extract maximum solar energy from the sun.

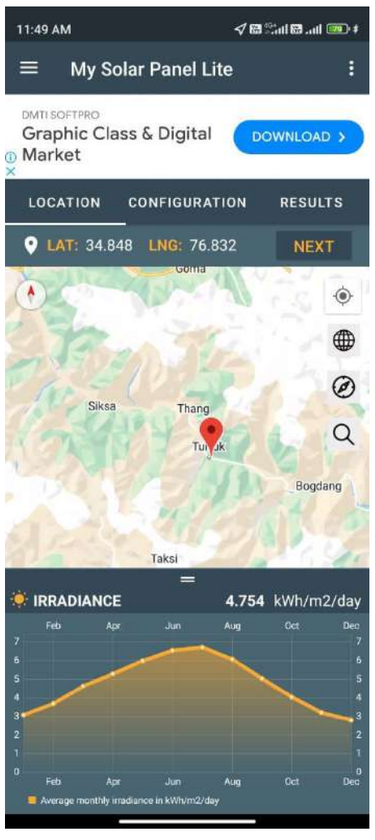




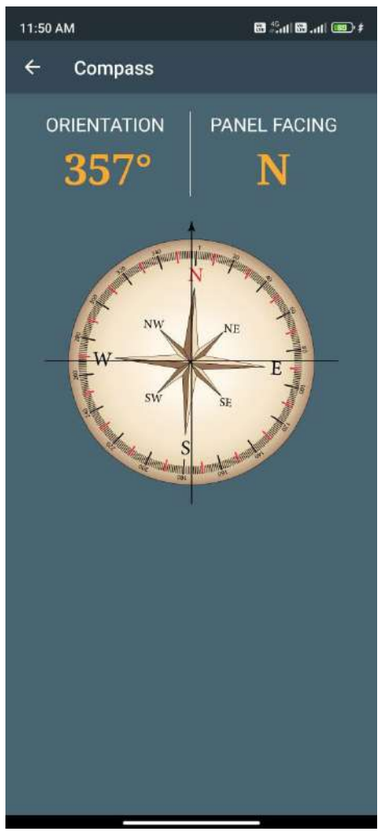
Solar Air heater Angle

My Solar Panel App

This app provides the angle for the solar panel according to the sun position in the specific area. As we need the angle in the Ladakh region, we get the optimal angle for the panel for maximum output of the heater.

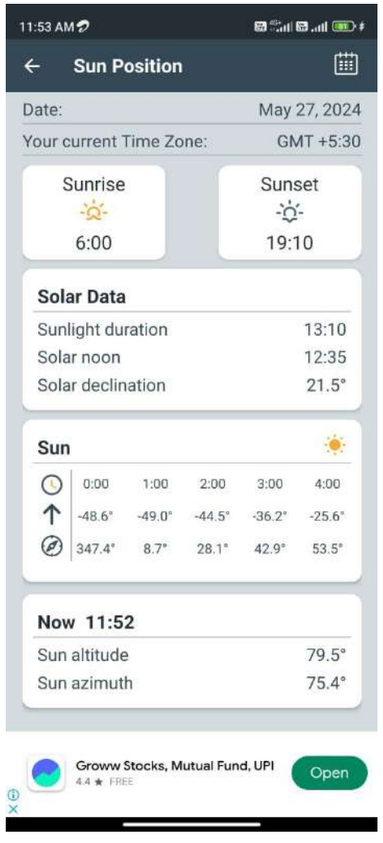


Set the location

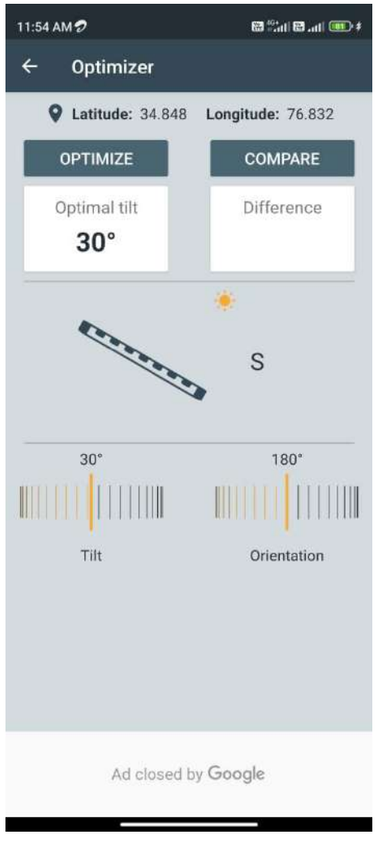


Check the angle of panel facing

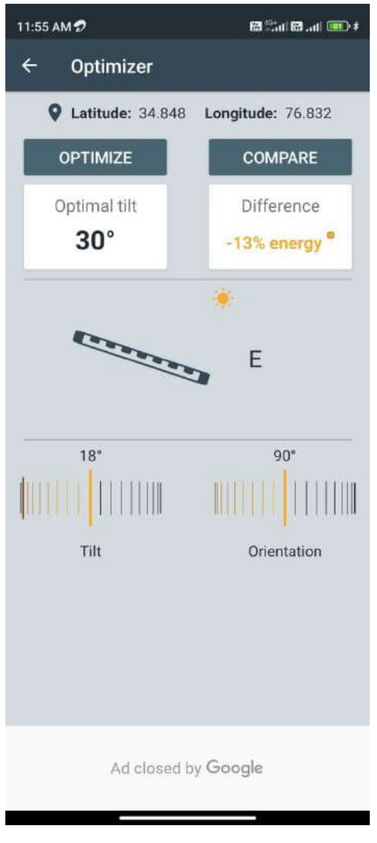
Check the optimal tilt angle



Sunlight data

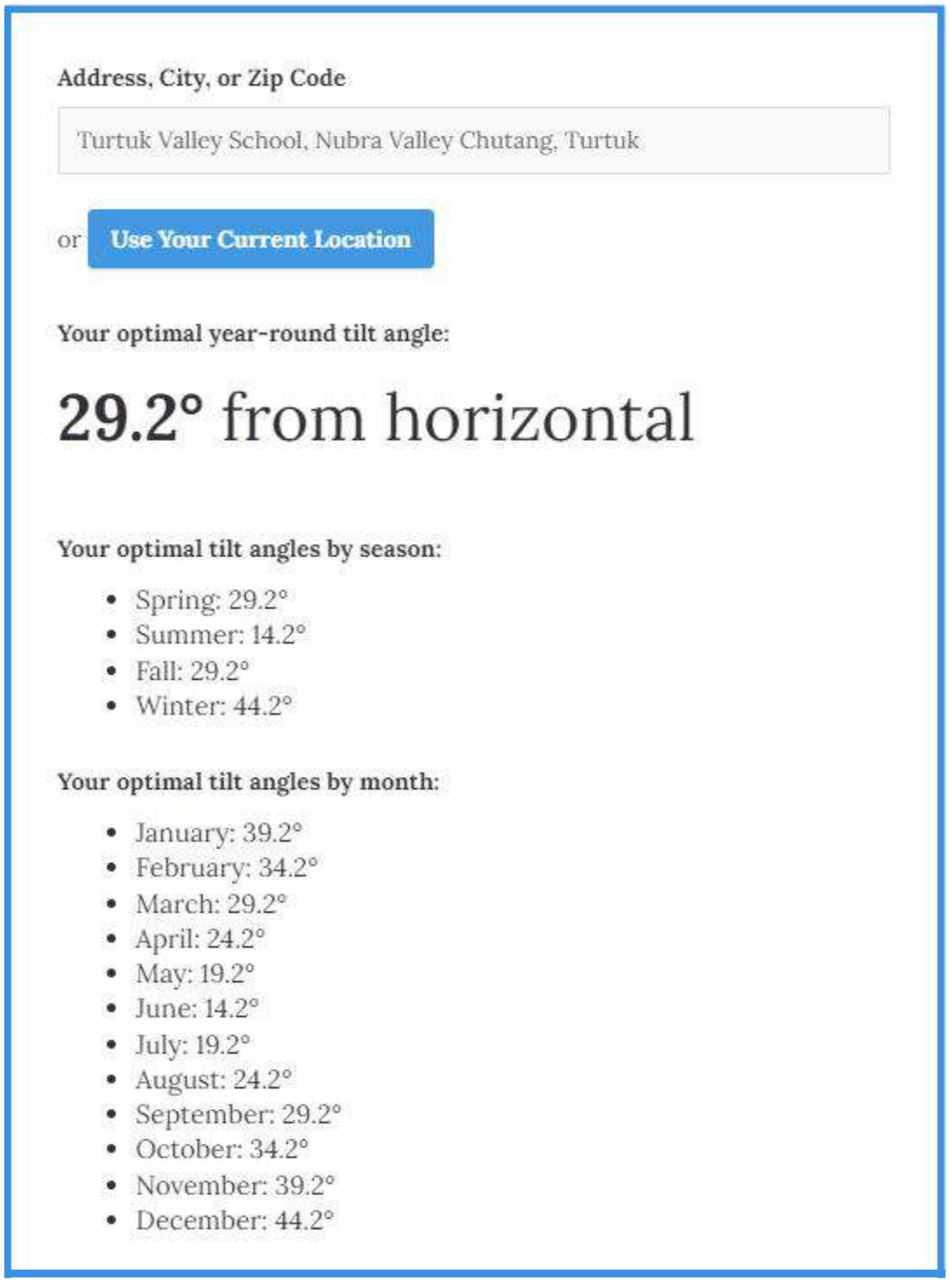


Check the optimal parameters



Check energy loss at different orientations

SAH and solar panel angle throughout year



Address, City, or Zip Code

Turtuk Valley School, Nubra Valley Chutang, Turtuk

or **Use Your Current Location**

Your optimal year-round tilt angle:

29.2° from horizontal

Your optimal tilt angles by season:

- Spring: 29.2°
- Summer: 14.2°
- Fall: 29.2°
- Winter: 44.2°

Your optimal tilt angles by month:

- January: 39.2°
- February: 34.2°
- March: 29.2°
- April: 24.2°
- May: 19.2°
- June: 14.2°
- July: 19.2°
- August: 24.2°
- September: 29.2°
- October: 34.2°
- November: 39.2°
- December: 44.2°

SAH panel installation

Previous orientation of SAH panel was facing East, but after prototype testing ,for maximum output the SAH orientation changed towards South in the optimal angle.

Previous orientation of SAH outside school.

Revised orientation of SAH outside room ,facing South

Room Insulation Prducts

Products that will stop the heat loss and incoming of chilling cold wind

Thermal curtains

Door Draft stopper

Wall insulation by foam

Future Scope

My project is close integration of engineering ,research and design. At the same time I am not undermining the requirements of the product which are from the point of view from the user convenience, product installation, transportation, manufacturing, perfection and styling. And considering all this factors I am expecting a startup connecting with the small NGO's from Ladakh who will take responsibility to take it forward. I am going to find out small factories who will help in making pipes ,wooden products, and whole will fabricate the product. Technology will come from city i.e. the Panel. Small factories can purchase the panel and fabricate further product in the ladakh.

Special Thanks

Prof. Milind Rane, Prof. S. V. Prabhu, Kailash sir, Gopal sir, Saroj, Samarth sir, Deepak sir, Abhijeet sir, Suraj Sir, Jay, Jitendra Mandlecha sir, Khaliq sir, Sami, Sakshi, Sukhadev and all Turtuk valley school students and staff.

References

- https://indianarmy.nic.in/content2/adb/introduction-adb
- https://paisleyandsparrow.com/best-space-heaters-for-living-room/
- https://economictimes.indiatimes.com/top-trending-products/buying-guide/heater-buying-guide/articleshow/102392463.cms?from=mdr
- https://www.cse.org.uk/advice/room-heaters/
- https://www.moglix.com/articles/about-room-heater-types-features-tips-and-how-to-choose
- https://timesofindia.indiatimes.com/most-searched-products/electronics/buying-guide/all-about-room-heaters-in-india-types-features-precautions-more/articleshow/70467752.cms
- https://www.google.com/search?q=fan%20heaters&tbm=isch&hl=en&tbs=isz:l&rlz=1C1CHBF_enIN979IN979&sa=X&ved=0CAIQpwVqFwoTCKijsMuBhYQDFQAAAAAdAAAAABAH&biw=1903&bih=911#imgrc=gjmsVlSBdyQMyM
- https://www.turtukvalleyschool.in/about.php
- https://www.qssupplies.co.uk/history-of-heating-timeline.html

Thank You