Solar Solution For Domestic Use In Rural Scenario

PROJECT III

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SOLAR SOLUTION FOR DOMESTIC USE IN RURAL SCENARIO

INDUSTRIAL DESIGN
PROJECT III

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APPROVAL SHEET

Industrial Design Project – III

Solar Solution for domestic use in Rural scenario

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Is approved by partial fulfilment of requirements of a post graduate degree in Industrial Design at IDC School of Design, IIT-Bombay.

External Examiner

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Project Guide

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DECLARATION

I declare that this written submission represents my own ideas and where other's ideas or words have been used, I have adequately cited and referenced the original sources. I also declare that I have adhered to all the principles of academic honesty and integrity and have not is represented or fabricated or falsified any ideas/source/fact in my submission. I understand any violation of the above will be the cause for a disciplinary action by the institute and can also issue penal action from the sources which has been thus not been properly cited or from whom proper permission has not been taken where required.

Signature : 

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Roll No : 156130009

Date : 17/4/17

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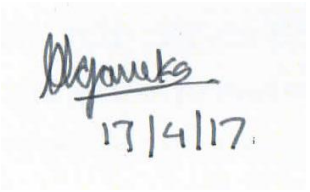
I would like to thank Prof. Chetan Solanki ,the head of the million SoUL project for giving me the opportunity and aid to work on this project. I would also like to thank Harshad, Pawan and Nikita of million SoUL who helped me in understand the system. Thank you Prof. Bapat for his valuable guidance, around the clock availability, and extreme patience. I also thanks Nishith and all my classmates for their help and support.



ABSTRACT

Even after electrification of 96% of villages in India, almost 30% of households still lack electrification due to which villagers use kerosene as their main source of lighting. SoUL, IIT Bombay started an initiative to provide power in rural parts of India with solar energy to electrify the regular households helping rural people with day to day domestic activities and reduce their dependence on kerosene.

This project is an attempt to develop the solar solution to serve to domestic needs in rural houses by providing them with a kit containing set of lamps and add-ons like fan, mobile charger and radio, hence improve their livelihood and enhance usability. The kit is so designed that, assembly, distribution, installation and servicing will be done by the local villagers to create job opportunity

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PROJECT BRIEF

“To design solar solution to serve as efficient power source for domestic needs in rural scenario.”

Detailed Brief:

Scenario:
- Rural Indian villages where there is no electricity
- Population currently uses only conventional source of power such as kerosene lamps, paraffin, wax to illuminate there houses
- Region of India where solar energy is found in abundance

System:
- The system should be economic and easy to use
- It should be familiar to the user
- Provision to accommodate the devices upto a power limit
- Easy cable management

Lamps:
- Set of 3 lamps
- Provide sufficient lighting in the house
- Serve to most of the domestic works in a house
- Interchangeability to generalise the lighting system and use according to power requirement

Fan:
- A fan is an add-on in the system
- For domestic use
- Fan should serve to the activities of a general rural household
- It should provide air throw to most members of the family

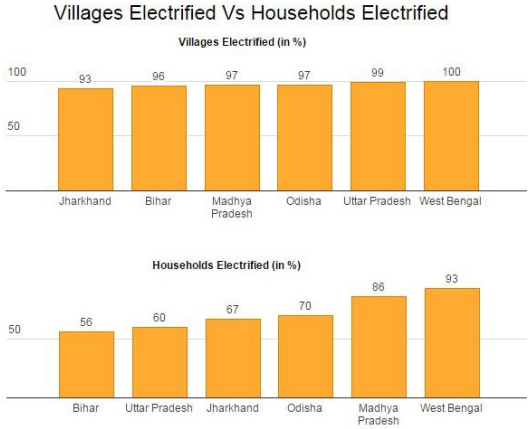
Radio:
- Radio is an Add-on in the system
- Radio should work on AM waves
- Should serve to the domestic needs in portable and fixed activity

Manufacturing and servicing:
- The products are open-sourced to be manufactured by company
- The assembly of manufactured parts to be done by rural population
- Installation and maintenance to be done by rural group of trained people creating employment in the village

1. INTRODUCTION

Rural power system in India:

Rural sector is a major part of Indian land. And unfortunately most of the rural India is under developed due to lack of and poverty. Basic amenities such as food, shelter, water, electricity should be integral part of our life and one should not be kept away from these. Electricity is one of the major sector which is developing in rural area. According to the statistics as shown in fig 1.1, nearly 96% villages in India are electrified but only 69% of homes have electricity connections. Large part of India's electrification and energy access is on paper. The only source of power that is used by these electricity deprived community is using kerosene for lighting their house. Almost 40% of our population uses kerosene as their main source of lighting.



http://ceew.in/pdf/CEEW-ACCESS-Report-29Sep15.pdf

Fig: 1.1 Household electrification in India

Kerosene lamps are harmful in many ways

1. Trap families in poverty: kerosene as a consumable fuel takes a toll on the economic conditions of the family. As the lamp needs to be refilled regularly, it becomes very expensive for the users (who are mostly below the poverty line) to keep their homes lit.

2. Prevent children from learning **:** kerosene lamps are also one of the causes of illiteracy. Children find it difficult to read under the kerosene lamps. Moreover, since kerosene lamps are expensive to maintain, the children do not enjoy the liberty of studying for long hours after sunset.

3. Toxic fumes cause respiratory diseases **:** being a combustible fuel, kerosene fumes are toxic. Since these lamps are generally used indoors and the users have to sit close to them, (for reading, studying etc.) They are bound to experience long term health issues.

4. Considerable impact on climate change **:** fumes consist of black carbon and carbon dioxide gas.

Need for Solar Solution:

Solar Power is a better solution for a country like India as seen from fig.1.2, which has favourable geographical location for harnessing solar energy. Low demand in remote places, independence from large scale infrastructures, makes it perfect to use. It is faster to install and cost of power is very less. It also prevents the accidents and fire hazards which were caused due to use of kerosene. Hence improve safety and allow activities to occur after daylight hrs.

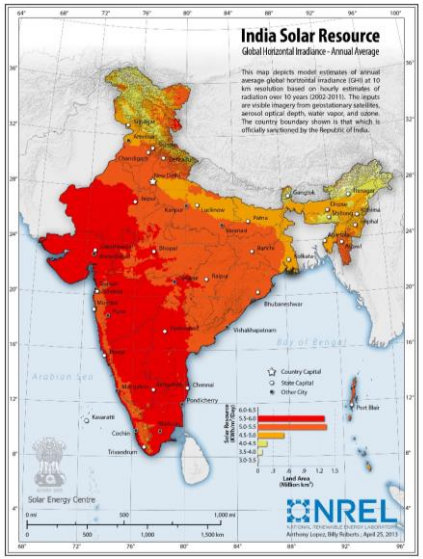


Fig:1.2: India solar resource

Source:
https://en.wikipedia.org/wiki/Solar_power_in_India

About SoUL, IIT Bombay:

Solar lamps that are of low cost are typically required in remote, rural areas; they should be locally available along with access to timely and low-cost aftersales service. At present the lamps are produced in large urban cities, which results in high cost of lamp (due to higher overheads), minimal availability at local level (due to lack of distribution channels), and after-sales service is time consuming and expensive due to distance the end user has to cover to reach out the repair shop. Hence, to directly and completely address this problem, any SoUL solar lamp programme involves local people in all aspects of assembly, distribution, and after-sales service ensuring the lamps are of low cost, sufficiently available in local market and thereby, promote market penetration of solar products into remote areas. This kind of mechanism also ensure timely and low-cost after-sales service as locally available trained manpower will be repairing the lamps. A countrywide largescale solar lamp programme must address, simultaneously, the issues of Scale, Speed, and Skill. IIT Bombay has developed one such model, the Million Solar Urja Lamp (SoUL) Programme that focusses on the localization of solar energy. In this model, the assembly, distribution, and maintenance of the solar lamps are done by the locals. In order to achieve scale, the model is designed such that it can be replicated in parallel in multiple blocks, across districts and states. To achieve speed, the assembly and distribution for any block is designed to be completed in specific time. In order to target skill development, rural residents are trained in the assembling, distribution, and repair of these lamps in their local areas. *The same business model will be used in the solar solution for domestic needs in rural scenario project which will include manufacturing and distribution of Solar solution including solar panel, battery, set of lamps, dc fan , mobile charger and radio.*

2. WORKING OF OFF-GRID SOLAR POWER SYSTEM

These systems allow you to store your solar power in batteries for use when the power grid goes down or if you are not on the grid. Fig2.1 shows the working of off grid solar power system.

- Sun shines on the solar panels, generating DC electricity
- The DC electricity is fed into a regulator(Charge controller) which controls the amount of charge
- Deep cycle batteries are charged with this charge
- 12 volt appliances can be run directly off the batteries or the current routed through an inverter which converts it to 240V 50Hz AC electricity; suitable for running standard home appliances..

Benefits: Provides power for the critical loads when the grid power is unavailable.

Downside: Cannot be expected to provide power for all the loads since the cost and volume of batteries would be prohibitive.

Off-Grid systems require a lot more specialized equipment to function specifically they require a central/string inverter, a charge controller as well as a batteries.

In this project we are using off grid system of solar power due to remote location of villages and unavailability of any kind of grid electric supply. Only DC appliances can be connected to the system to efficiently use the power generated from the solar panel.

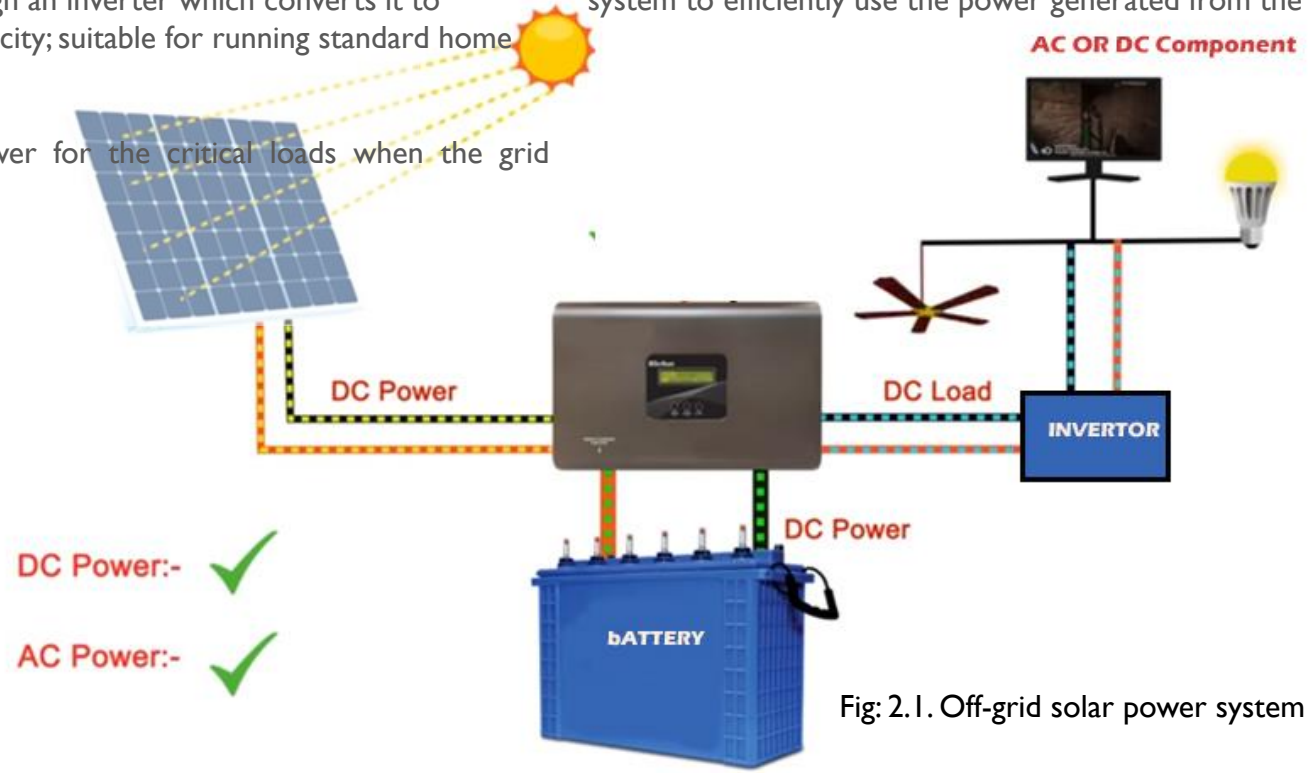


Fig: 2.1. Off-grid solar power system

3. TYPE OF LIGHTINGS

The ambient or general lighting layer: It is generally the relatively uniform lighting of the space and often tends to establish mood. It includes uniform downlighting, indirect lighting (uplighting and all washing), and some special techniques, but can also be the decorative lighting. It is called "general lighting" if at task levels (30-50 fc or more) and "ambient lighting" if lower than task levels.

The Ambient Layer

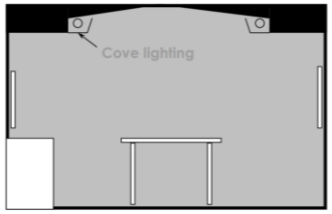


Fig: 3.1 Ambient lighting

The task layer: It is generally limited to "task lighting" of the horizontal work surface at work locations and tends to help create drama. It usually produces 50 fc or more within a small area. Refer fig 3.2 for understanding the position of task lights

Ambient and Task Lighting

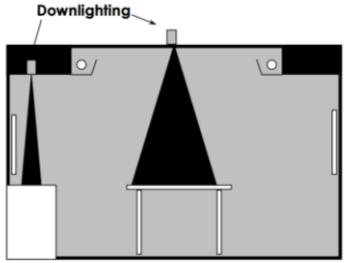


Fig: 3.2 Task lighting

Here we are talking about the General/ambient lighting intended for general illumination of an indoor area in the form of basic lamp on a table or floor, or a fixture on the ceiling.

Downlighting is most common, with fixtures on or recessed in the ceiling casting light downward. This tends to be the most used method, used in both offices and homes. Although it is easy to design it has dramatic problems with glare and excess energy consumption due to large number of fittings. The introduction of LED lighting has greatly improved this by approx. 90% when compared to a halogen downlight or spotlight. LED lamps or bulbs are now available to retro fit in place of high energy consumption lamps.

Uplighting is less common, often used to bounce indirect light off the ceiling and back down. It is commonly used in lighting applications that require minimal glare and uniform general illuminance levels. Uplighting (indirect) uses a diffuse surface to reflect light in a space and can minimize disabling glare on computer displays and other dark glossy surfaces. It gives a more uniform presentation of the light output in operation. However indirect lighting is completely reliant upon the reflectance value of the surface. While indirect lighting can create a diffused and shadow free light effect it can be regarded as an uneconomical lighting principle.

Front lighting is also quite common, but tends to make the subject look flat as its casts almost no visible shadows. Lighting from the side is the less common, as it tends to produce glare near eye level. Backlighting either around or through an object is mainly for accent.

A wax candle produces on the close order of 13 lumens, a 60 watt incandescent lamp makes around 700 lumens, and a 15-watt compact fluorescent lamp produces about 800 lumens.

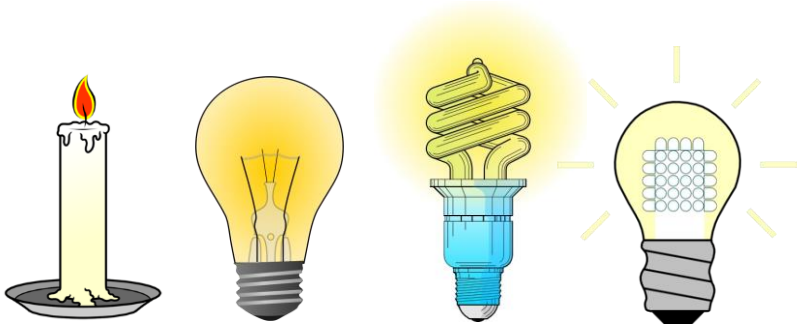


Fig: 3.3

Illumination levels

The table below is a guide for recommended light level in different workspaces:

Activity	Illumination (*lux, lumen/m²*)
Public areas with dark surroundings	20 - 50
Simple orientation for short visits	50 - 100
Working areas where visual tasks are only occasionally performed	100 - 150
Warehouses, Homes, Theaters, Archives	150
Easy Office Work, Classes	250
Normal Office Work, PC Work, Study Library, Groceries, Show Rooms, Laboratories	500
Supermarkets, Mechanical Workshops, Office Landscapes	750
Normal Drawing Work, Detailed Mechanical Workshops, Operation Theatres	1,000
Detailed Drawing Work, Very Detailed Mechanical Works	1500 - 2000
Performance of visual tasks of low contrast and very small size for prolonged periods of time	2000 - 5000
Performance of very prolonged and exacting visual tasks	5000 - 10000
Performance of very special visual tasks of extremely low contrast and small size	10000 - 20000

Source:https://www.noao.edu/education/QLTkit/ACTIVITY_Documents/Safety/LightLevels_outdoor+indoor.pdf

Fig: 3.4

Additional Recommended Light Levels Indoors

HOMES	
Living rooms general	50
Casual reading	150
Sewing darningsrudies desk and protuged	300
Bedroom general	50
Bedlead kitchen	150
Kitchen working areas	
Bathrooms	100
Halls and landings	150
Stairs	100
Workshops	300
Garages	50

Fig: 3.5

4. MARKET STUDY

To understand the types of products which are already in use, study of various products which are available in market was done.

1. Su-Kam Solar lighting: Su-kam is a reputed brand for electronic devices. This solar lighting solution kit consisted of solar panels of required capacity of 4-5W which is customizable by the buyer. Charge controller controls the output and input and has converters, transformer and rectifiers. This product as shown in fig 4.1 provides the attachments which can be connected to DC fan, TVs and radio.

Fig: 4.1 http://www.su-kam.com/Upload/UploadProduct/Solar-Home-Lighting-Systems.jpg

2. Befilal company: A made in India product, has 25W 12 V solar panel with controller, 2 led bulbs, mobile charger and a 12V DC fan. Battery is around 9Ah and the kit costs around ₹8000.

http://ecx.images-amazon.com/images/I/71N85DTqcmL._SX355_.jpg

Fig: 4.2 Befilal solar power

3. TATA power solar: Tata solar power kit has set of 4 led lamps, a 10-70W solar panel, batteries ranging from 7.5Ah to 70Ah. It also provides a set of mounting brackets/structures and cables.

Fig: 4.3 Tata power solar
https://n1.sdlcdn.com/imgs/a/h/e/Tata-Venus-1-Solar-Home-SDL017301073-1-dc82c.jpg

4. Selco home lighting:
Selco provides kits with solar panel capacity ranging from 10W to 60W for home lighting system. The kit also has led/cfl lamps, battery (10Ah-80Ah). And an optional dc fan.

Fig:4.4

This study provided us with the rough info in fixing up the specifications of the components needed in out Solar solution kit.

5.COMPONENTS

Major components in existing Solar Solution kit are:

1. Solar Panel, 2. Charge controller 3.Battery 4.Set of lamps 5. Add-ons like DC Fan, Mobile charger,

1. Solar Panel: A panel consisting of modules of photovoltaic solar cells designed to absorb the sun's rays as a source of energy for generating electricity or heating. Each panel is rated by its DC output power in wattage.
2. Charge controller: it controls the charge going into the battery so as to prevent any damage to battery due to overheating.
3. Battery: Battery absorbs the charge from controller and it in the form of electric energy. It supplies the dc power to the loads
4. Set of LEDs/ bulbs
5. Inverter: Inverter converts the dc power received from battery into ac power. AC power is mostly required for our standard electric equipment.
6. Add-ons: DC Fan, Mobile charger, USB cables, Radio

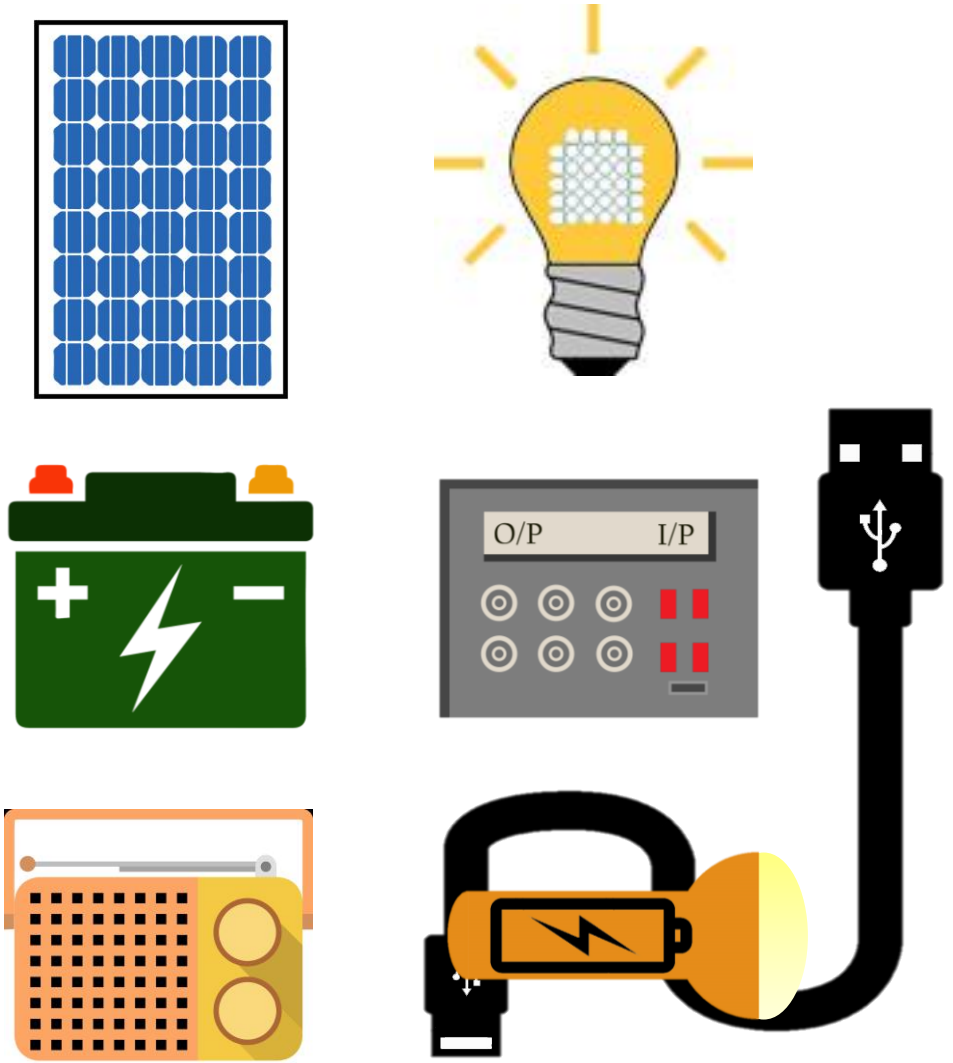


Fig: 5.1 Courtesy: Author

6. ACTIVITIES

Understanding the rural scenario and the household activities done by rural people on daily basis was important. The daily schedule was observed by visiting a rural house after sunset to understand the light requirement in the house at that time. Following activities were observed during the task: Cleaning and washing of clothes and utensils, Using the toilets which is far away from the house, children playing just outside the house, cooking and eating inside the kitchen where there is minimal light is used, milking the cattle in the evening, children studying in the house, People chatting and talking in the veranda,, farmers going to the farm in the night. All these activities were carried out in a very less to no lighting which was hindering their day to day activities.

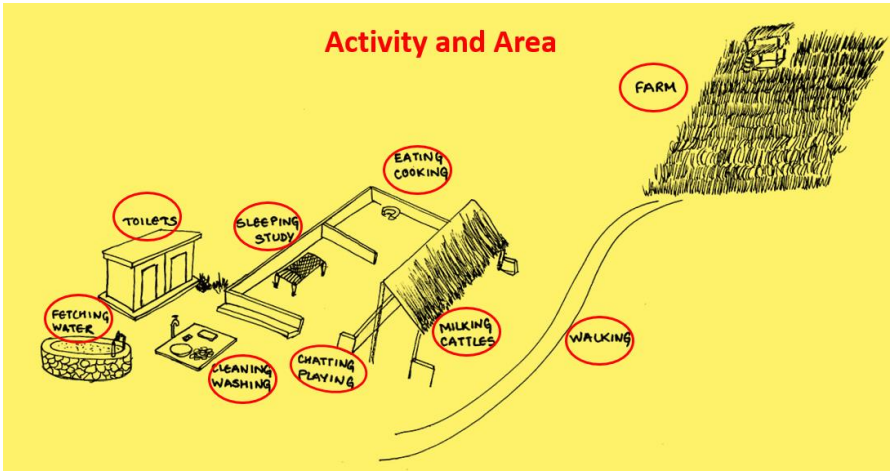


Fig: 6.1 Courtesy: Author

Courtesy: Author

Fig:6.2

Courtesy: Author

Cooking: Cooking being the very major activity in household, the light requirement and position of lights were ideated by sketching various scenarios in the following 3 cases. So, there are mainly 3 kinds of kitchen in rural India: cooking on chulha (refer fig 6.3), cooking on elevated base(refer fig 6.4) and cooking on stove on the floor(refer fig 6.5). The position of light can be of 2 types namely light on the floor/at some elevation or light mounted on the wall. The light should illuminate the area including stove, cooking utensils, vegetable cutting area.

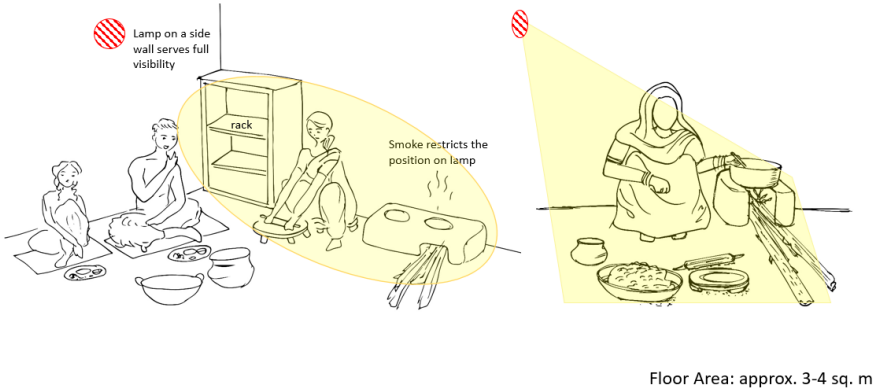


Fig: 6.3

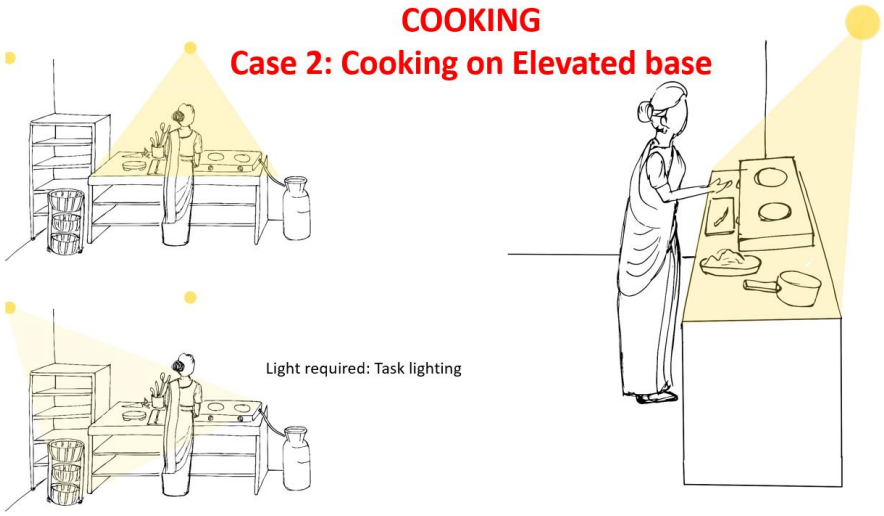


Fig: 6.4

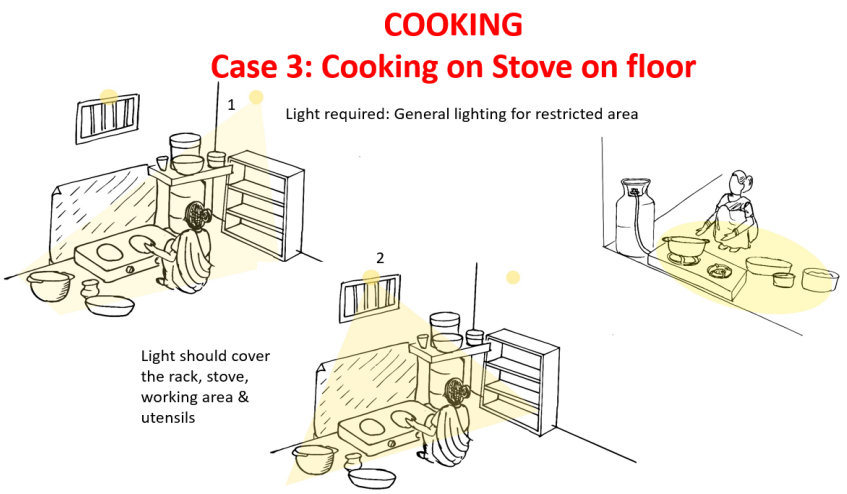


Fig: 6.5

Courtesy: Author

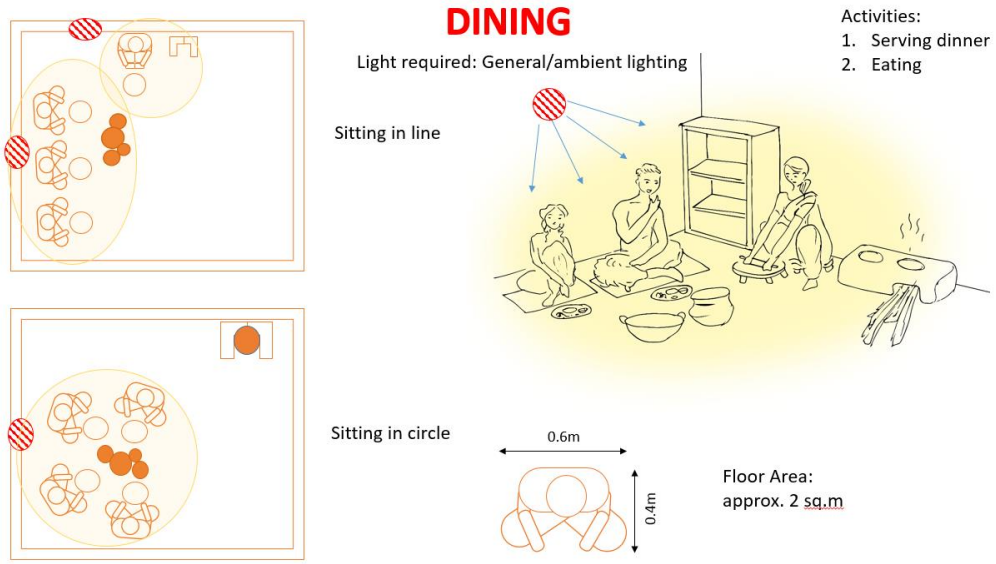


Fig: 6.6

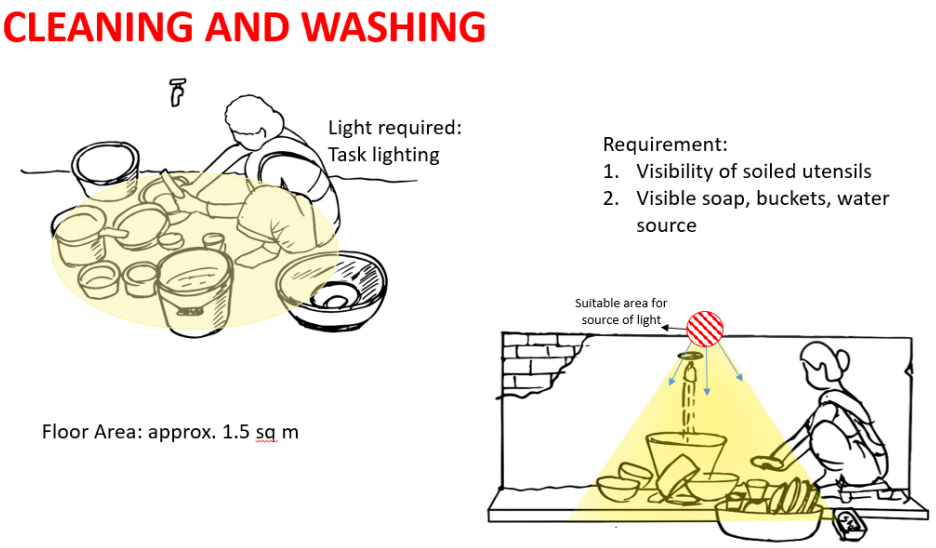


Fig: 6.7

Dining:

As observed from the survey, dining is also carried out in kitchen itself. So it is also necessary for the lamp to illuminate the dining floor area. The way in which people sit down on floor for dinner was studied and two ways of sitting for dinner were discovered as shown in fig 6.6, which are 1) sitting in a line where the lady serves other family members and 2) whole family sit together forming a circle.

Cleaning and Washing:

Cleaning and washing requires light to check whether the utensils are fully cleaned or not. In rural India, utensils are cleaned outside the house with either tap water or water from bucket. The lamp should be made and placed in such a way that it would avoid contact with as much as possible.

Use of Toilets: In rural India, many a times the toilets are built outside the house due to insufficient space inside the house and due to some socio cultural problems. The main problem being unavailability of light inside the toilet or even on the way to toilet in the night time which may result into dangerous accidents due to encounter with any insect, animal or even rocks in the path. It is important to illuminate the path to the washroom as well as the inside of the washroom. The lamp should be such that it is easily to carry to the toilet, easily mountable at an attainable distance by children as well as adults. Most important is that it should serve the required illumination inside the toilet. Figure 6.8 shows the various requirements of light for using toilet.

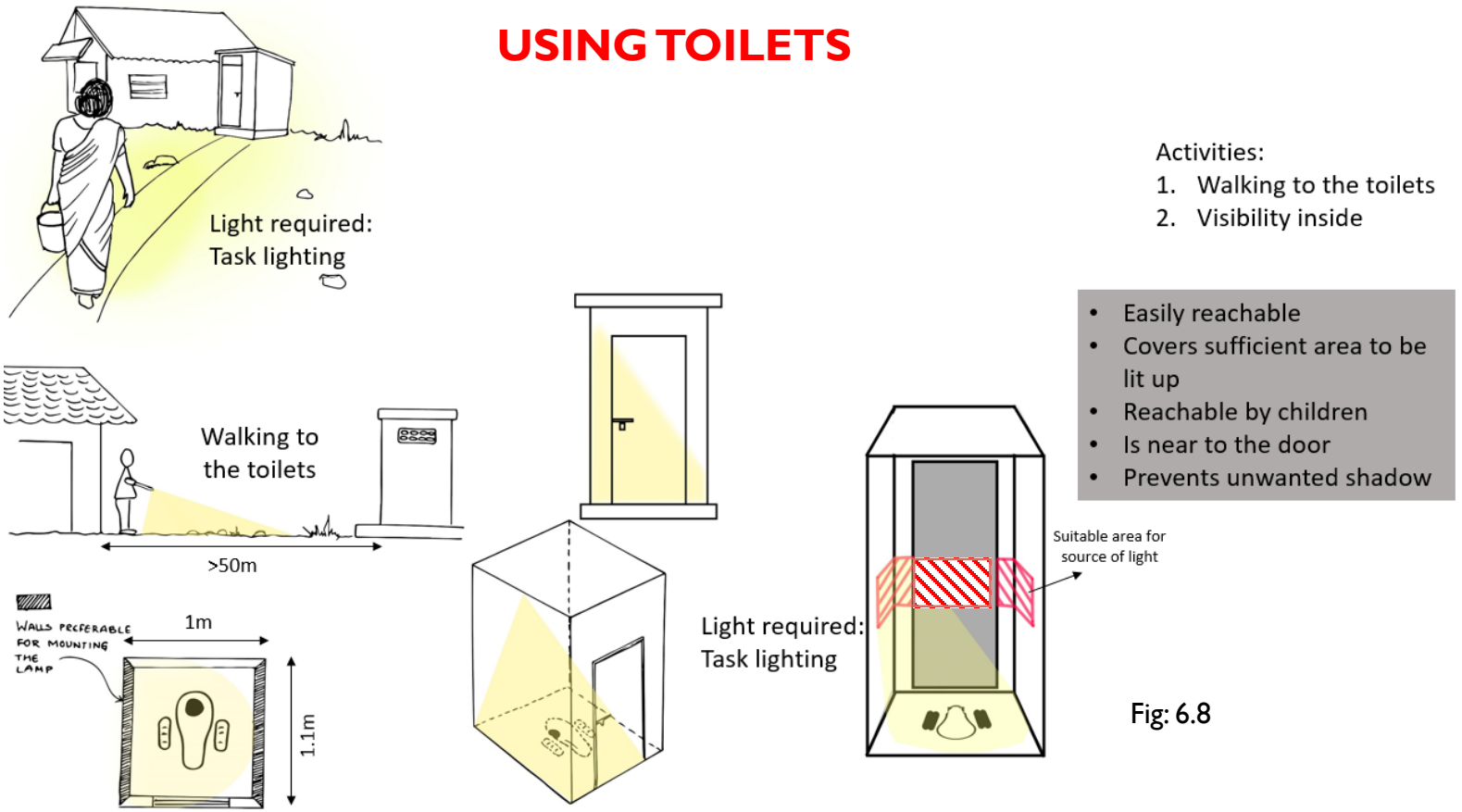
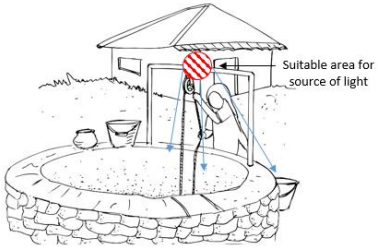


Fig: 6.8



Light required:
Task lighting

Activities:
1. Fetching water from well (fix)
2. Carrying it back to home (portable)

Requirement:
1. Visibility of well and container
2. Visible buckets and pulley

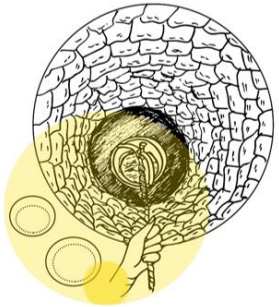


Fig:6.9

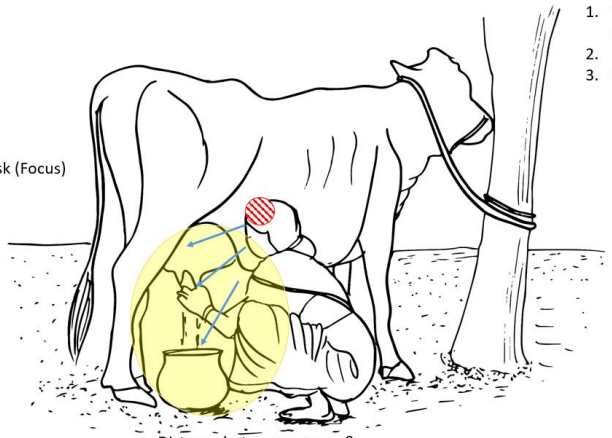
Floor Area: approx. 4sq m

Drawing water from well: Drawing water from well is the activity that is done by rural women early in the morning. It may be dark outside, so there is a need of lamp to illuminate the path to the well as well as to assist the water drawing task. The water containers and its going into the well should be visible to the user. The probable location of the lamp can be either on the pulley of the well or it can be a wearable lamp as shown in figure 6.9

MILKING THE CATTLE

Activities:
1. Walking to the cattle shed/ stable
2. Milking the cattle
3. Get the container back to house

Light required: Task (Focus) lighting



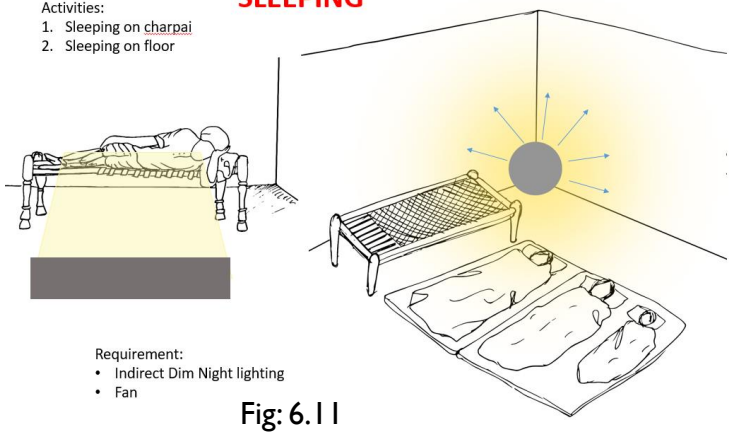
Distance between person & cattle: 30-40cm

Fig:6.10

Milking the cattle: It is an activity which is mostly repeated twice a day namely early in the morning or in the evening, probability being that it is dark outside. Cattle barns are mostly outdoor and the need of illumination could not be fulfilled by the lighting inside the house. There is a need for a separate light for this activity. Fig 6.10 shows the light requirement while milking the cattle.

SLEEPING

Activities:
1. Sleeping on charpai
2. Sleeping on floor



Requirement:
- Indirect Dim Night lighting
- Fan

Fig: 6.11

Sleeping: Sleeping time is from around 10pm to 5am when there is dark outside. There often occurs a situation when one has to wake up and go to use toilet. And due to null visibility, accidents may occur. A need of night lamp was noticed so as to provide a low visibility in night time. The lamp should be dim and indirectly lit. Refer figure 6.11.

Fig:6.12

Walking: There are activities where the person has to go out in darkness such as going to a shop, visiting a temple in the evening, walking on road. Often farmers have to go to there farmland in the night to keep up the security. They either sleep there in the farm house or there may be activities such as watering the plants that they do. So, a need of portable light which they can carry from their home to the farm and use in the farm. Refer figure 6.12 to understand the need and possible location of lamps.

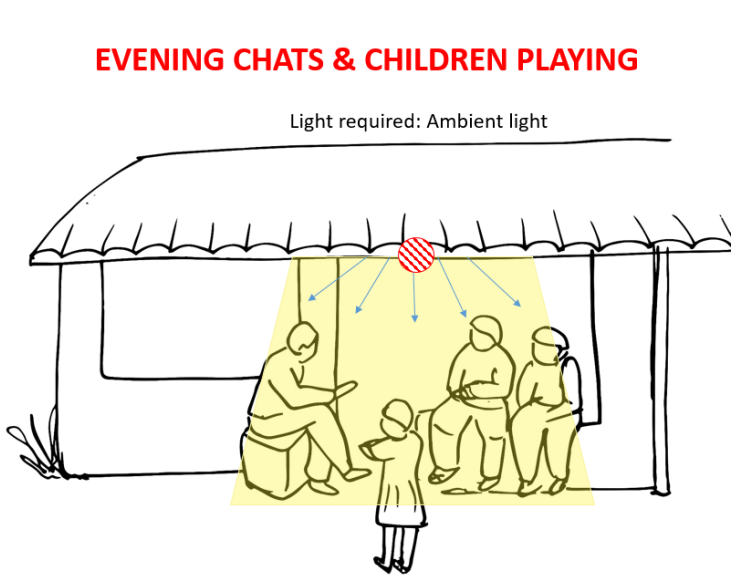


Fig:6.13

Gatherings: Activities such as evening gatherings of neighbours and children playing in the veranda is often observed. A type of light where max area outside the home is covered will be useful in this case. Figure 6.13 shows the probable location of source of illumination and area that should be illuminated.

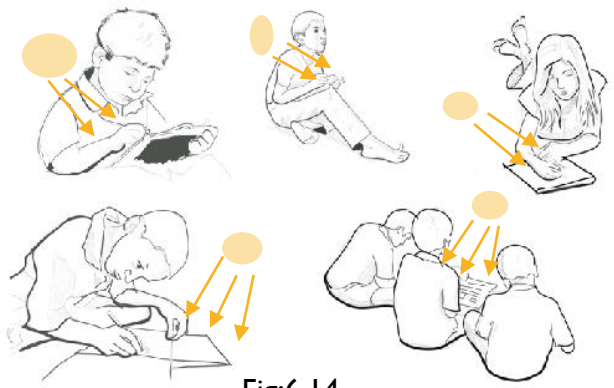


Fig:6.14

Studying: Studying in the evening is a major activity done in every house. In absence of efficient lighting for studying, many problems such as pain in eyes, less concentration while studying may develop resulting in child's academic process depreciation. A light which should not produce glare on the child's aye and also focus on the books is required in this scenario. Various postures of children studying and the probable light locations are ideated in this case has been shown in fig 6.14

Following is the table with various activities, there timings with total working hrs, light requirement and floor area to illuminate:

Activity	Time span	Total Working hrs	Light requirement	Area to illuminate (m^2)
1. Kitchen: Cooking : Chulha, Elevated, Ground stove	7-8pm	1 hr	High (Task light)	4
2. Eating: Circle, In line	8-9pm	1 hr	High (Task light)	4
3. Sleeping: Floor, Charpai	10pm-5am	7 hrs	Low (Indirect)	10
4. Cleaning Utensils	6-7pm or 9-9.30pm	½ or 1hr	High (Task light)	2
5. Toilet	In between night	2 hrs	Medium (Task light)	1
6. Water from well: with pulley, without pulley	5-6am or 6-7pm	2 hrs	High (Task light)	5
7. Evening talks in verandah	6-8pm	2 hrs	Medium (Ambient/general)	6 (Max)
8. Farmer going to farm at night	10pm-5am	7 hrs	High (Task+general) long span	Depends
9. Studying children	7-10pm	3 hrs	High (Task light)	1
10. Milking the cattle	4-5am or 5-6am	1 hrs	High (Task light)	1-2

Fig: 7.15

7.CONCEPT GENERATION

Concept generation started with fixing on how many lamps are needed in the regular rural house. The no. of lamps required can be found by categorising the activities into different work timing and conditions. Example, it can be categorised into indoor activities and outdoor activities. Similarly according to availability of time and schedule each lamp can be allotted with specific set of activities.

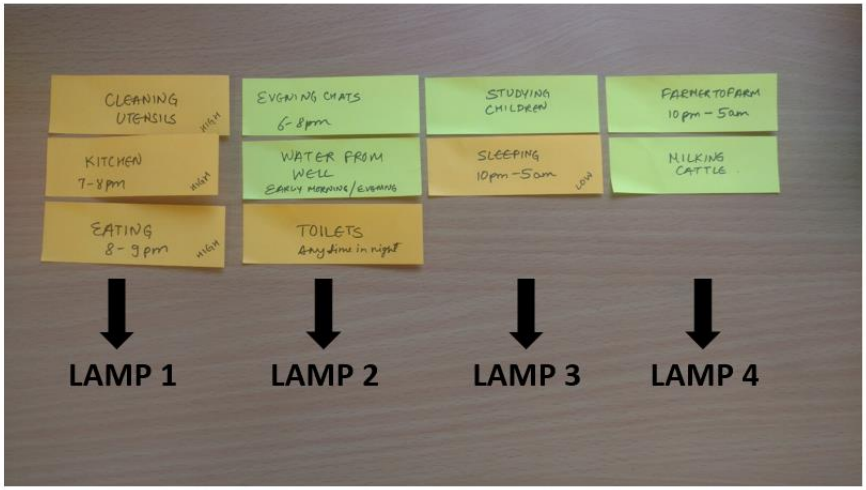


Fig: 7.1

Lamp 1 : Portable: Kitchen(Cooking, Eating), Cleaning utensils, washing

Lamp 2 : Fixed: Living Room (Studying, sleeping)

Lamp 3 : Portable: House door (Security, Playing, chatting, toilet, washing, fetching water)

Lamp 4: Portable: (Farm, Walking, Milking)

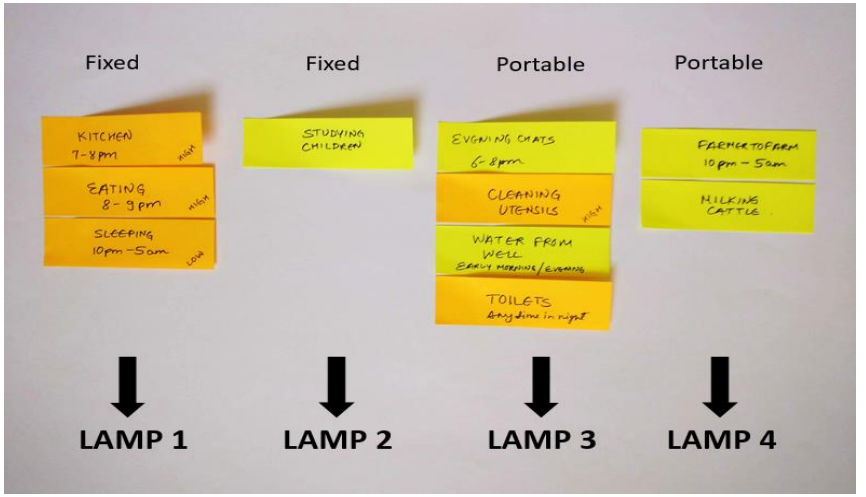


Fig: 7.2

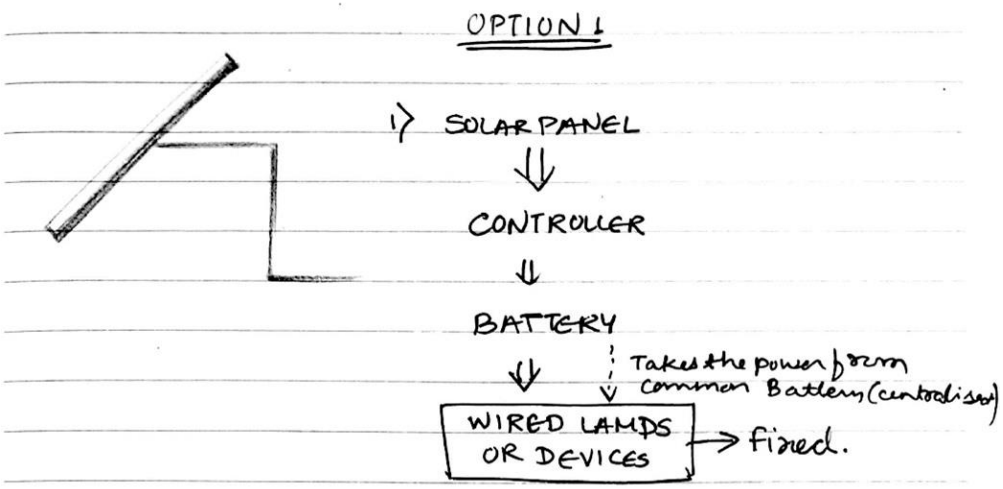
Lamp 1 : Fixed: Kitchen(Cooking, Eating)

Lamp 2 : Fixed: Living Room (Studying, sleeping)

Lamp 3 : Portable: House door (Security, Playing, chatting, toilet, washing, fetching water)

Lamp 4: Portable: (Farm, Walking, Milking)

7.1 SYSTEM DESIGN



One of the method in which the lamps can be put up is by directly connecting it to the battery via cables. These electric devices will work only when they are connected to the centralised battery through cable.

In this case, the lamps can be fixed in each room just like regular grid home lighting. It is observed that using wired system is a much cheaper way to connect the lamps with centralised battery. A portable lamp in the form of separate lamp can be provided along with it. Figure 7.1.1 shows the system where lamps and portable lamps are connected to the centralised battery for illumination and charging respectively.

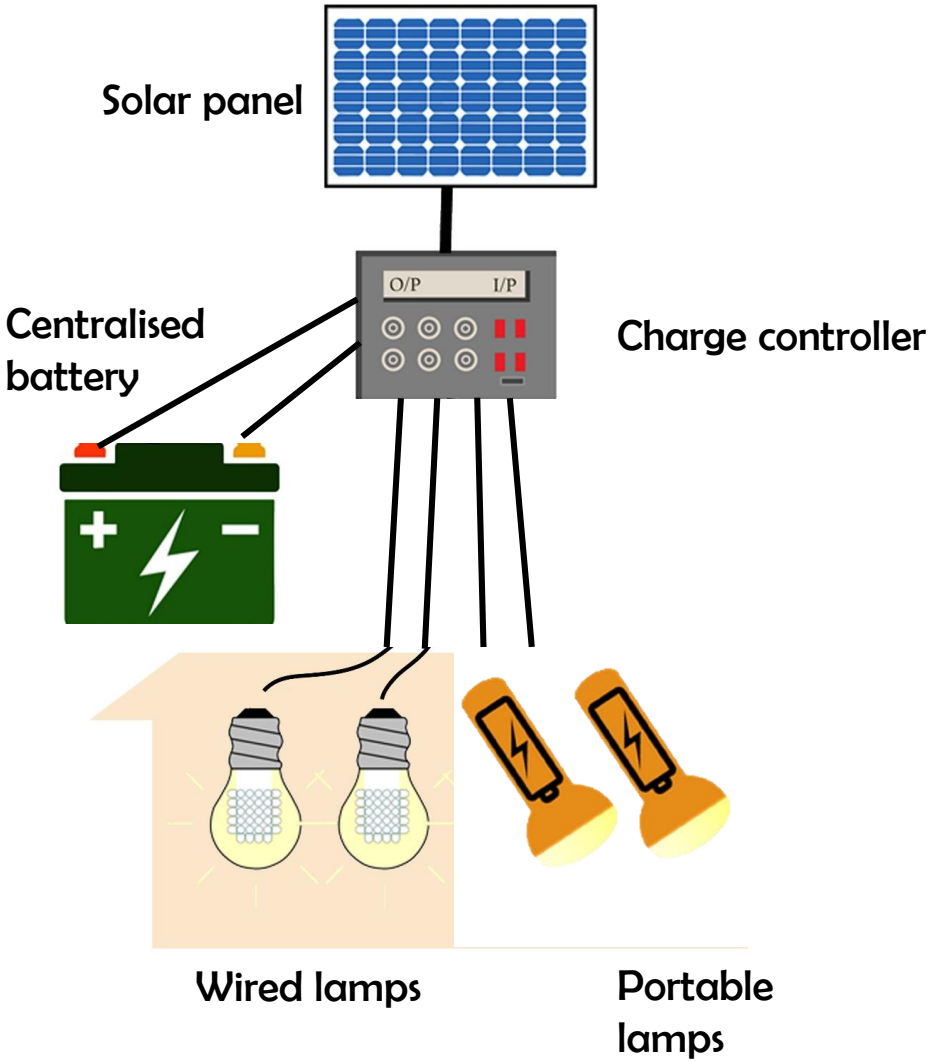


Fig:7.1.1 Schematic of system

The connection and system has to be designed in such a manner that it covers maximum area in the house, consumes less power, less power losses and has sufficient wiring to reach maximum mounting points. Let us see the comparison between the system.

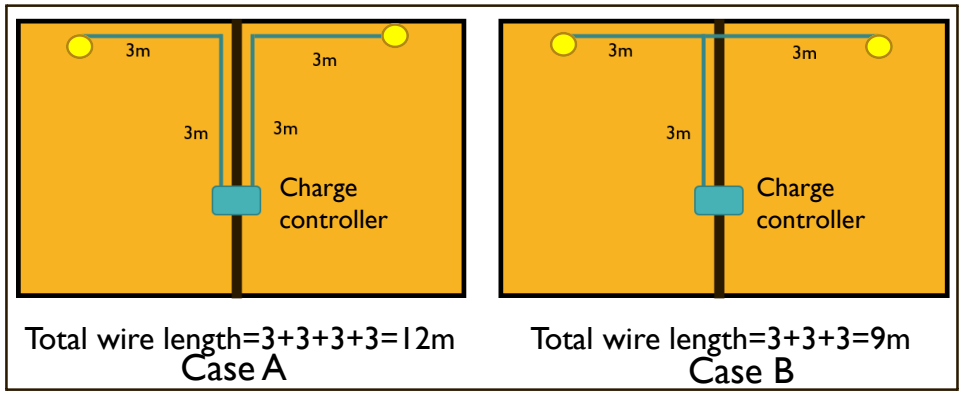


Fig7.1.2: Comparison between 2 cases

As seen from above comparison in fig 7.1.2, it can be seen that case B uses less wire hence less electrical losses as compared to case A. Hence Case B was taken further into the concept design. This case also reduces the number of plug points in the charge controller and reduces the wire cost.

System Concept

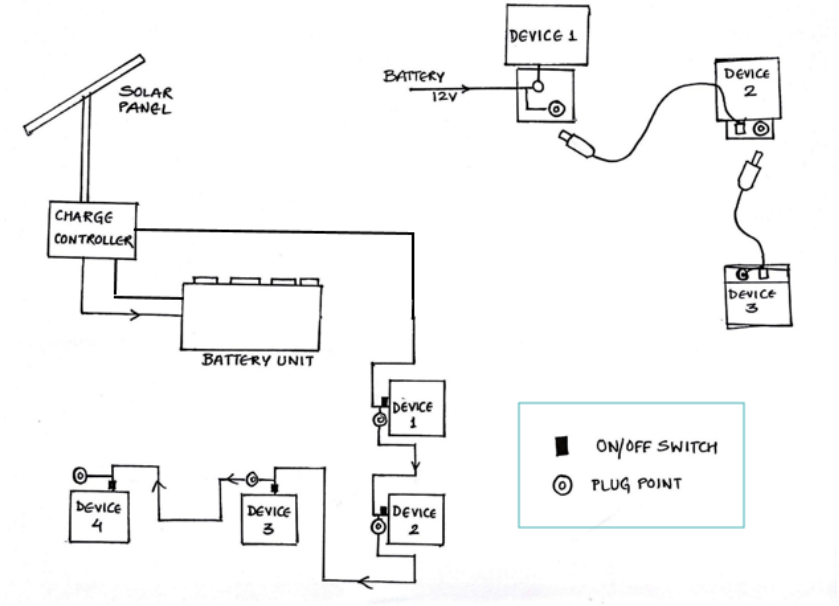


Fig:7.1.3 Line diagram of system

Above is the rough schematic of the system concept.

This system concept has a charge controller with in-built battery. A connector from one device is plugged in the plug point on the controller. A parallel connection is formed where one connection goes to 1st device and the other is given to a plug point, where connector from other device can be plugged in. In this way, other devices can be powered by plugging into the connection of previous device.

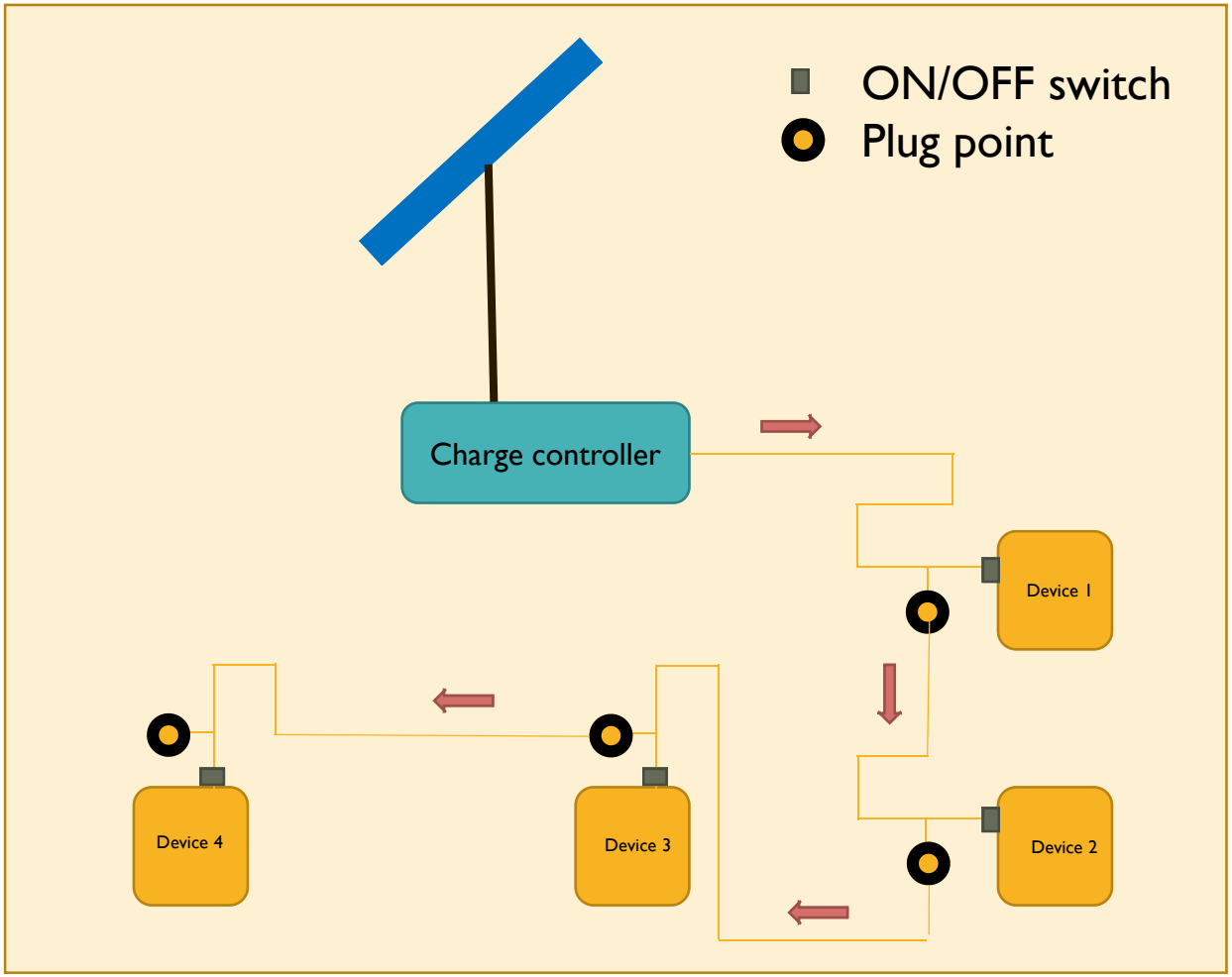


Fig:7.1.4 Final system concept

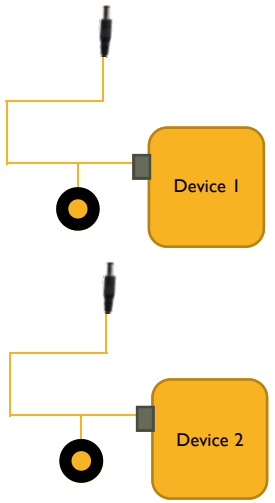


Fig:7.1.5 way of connection in the system

Instead of fixing the system and devices at one place, extra wire has been provided with each device to facilitate the system where the devices can have portability inside the house.

Cable management

As we are providing extra length of wire in our final concept, there was need seen of possible requirements for wire management of extra wire kit. The following solutions were brainstormed (fig 7.1.6) and then ideated for fulfilling the requirement(fig 7.1.7).

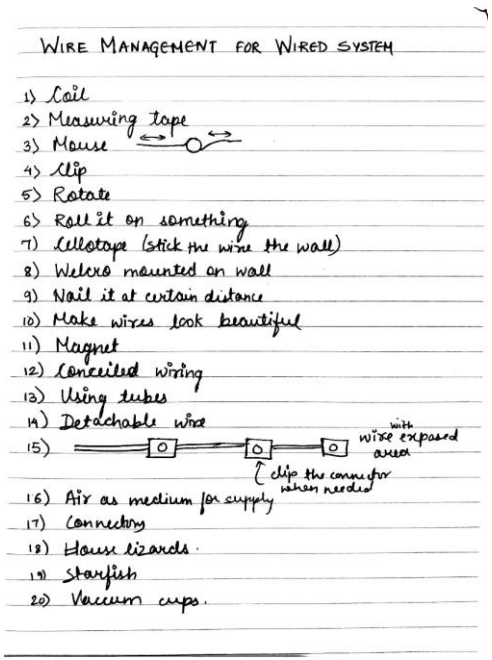


Fig: 7.1.6 Cable management ideas

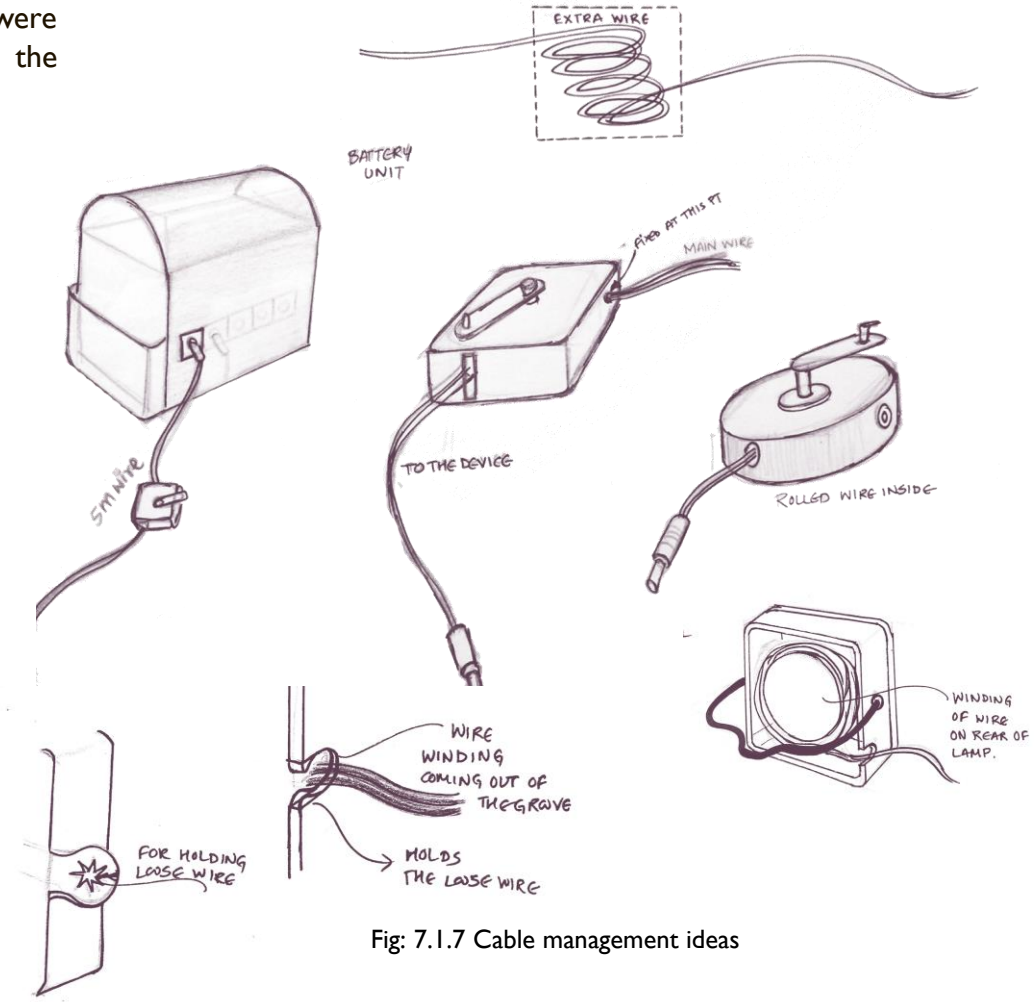


Fig: 7.1.7 Cable management ideas

Different types of connectors

Connectors are part of a cable that plugs into a port or interface to connect one device to another. Most c**onnectors** are either male (containing one or more exposed pins) or female (containing holes in which the male **connector** can be inserted). Here, in this system we need to use the DC connectors which are easy to connect, safe to use, are of good quality and yet less expensive.

- These connectors are easy to use and less expensive
- In this system we are using these connectors to connect the devices

These connectors are mostly used for high voltage dc applications and are very efficient but also very expensive

Fig: 7.1.8 Type of dc connectors available in market

7.2 LIGHTING SYSTEM: LAMPS

Requirements in Lamps

- Portable and wired connections
- Easy to handle and use
- Should serve while doing domestic tasks of a typical rural house which are cooking, eating, studying, cleaning, milking, fetching water to be done during off-day time.
- Affordable design

Brain Storming

Brainstorming is a process in which we note down the number of possible options in any criteria of the product. The ideas that come to mind may be logical or totally absurd. It is important to note down each of this idea so as to arrive at a wide variety of alternative solutions. Once all the possibilities are listed out, we choose about 5-6 of them that seem to be feasible, innovative, different or interesting. These ideas are then taken forward by working on them and making them possible.

Brainstorming to see various possibilities that can be found while to design the lamp according to the requirement. This included brainstorming various ways to mount the lamp & various ways to arrange the lamps. As the project brief defines the need of 3 portable and one flash light. The ideations were done according to this requirements.

Ways to mount the lamp

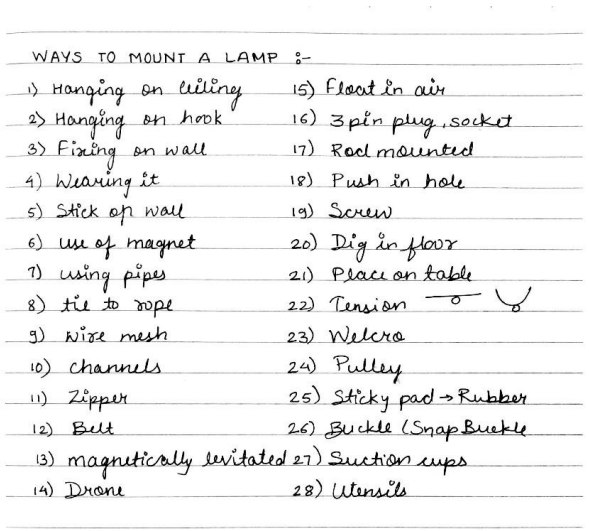


Fig:7.2.1 Brainstorming I Ways to mount the lamp

Ways to arrange the lamps

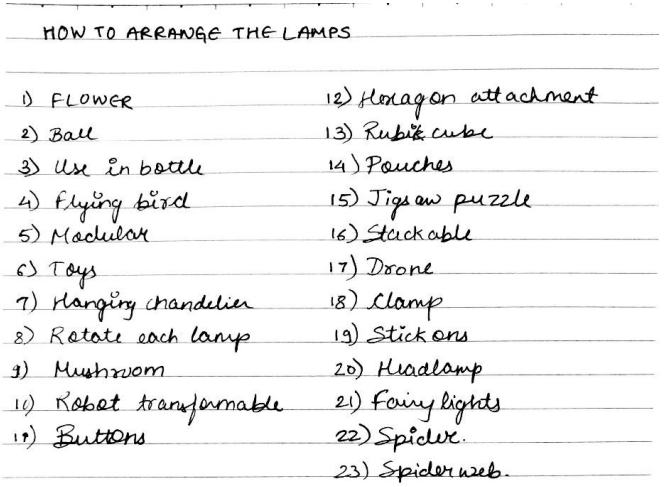


Fig: 7.2.2 Brainstorming Ways to arrange the lamp

STUDY OF PORTABLE LAMPS

A study of lamps available in the market was conducted to better understand the preferences of the user. The fact that these products were already being used was testimony to the fact that users liked these products. Most of these products have been in use in rural parts of the world. The aim of this study was also to understand different features in the products. All aspects of these products like features, price, availability, materials used, distribution process etc have been studied. Some of the more successful products are shown and described in more detail below. These products are portable in nature which has inbuilt batteries in them and needs regular recharging. Refer figure 7.2.3 showing portable lamps available in market.

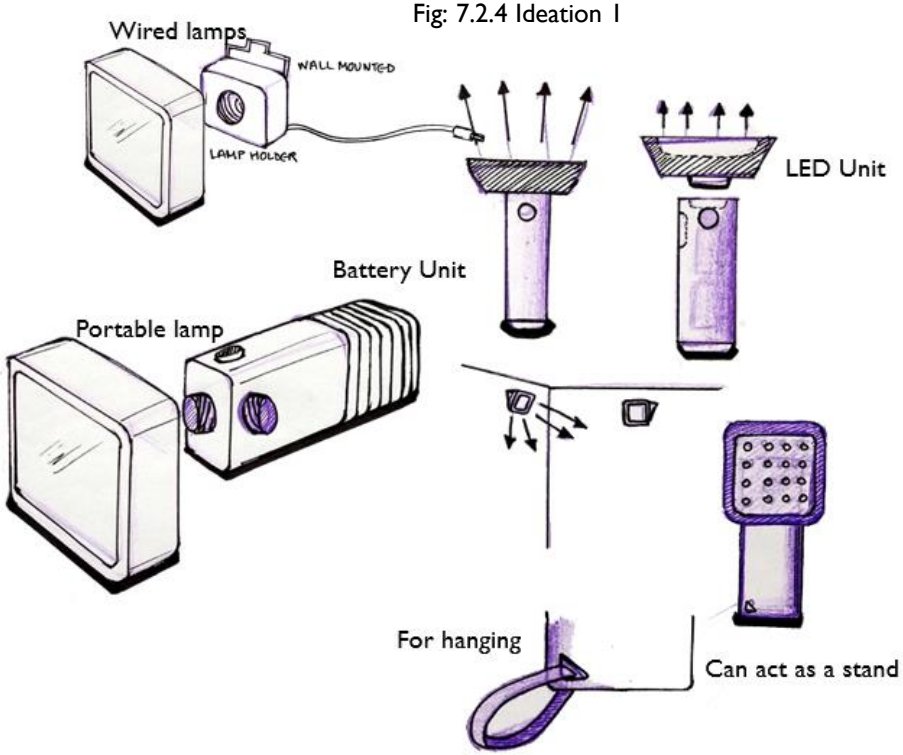
Fig: 7.2.3 Portable lamps available in market

Courtesy: Author

IDEATION 1

- 1 led unit
- 1 battery unit
- Lamp holding unit
- 2 positions of attaching LED unit to battery unit

Fig: 7.2.4 Ideation 1



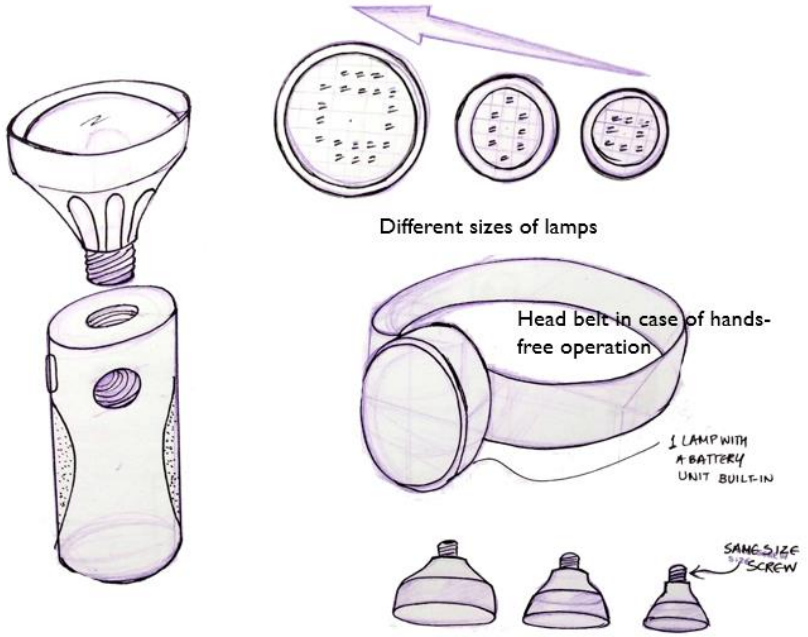


Fig: 7.2.5: Ideation 2

IDEATION 2

- 1 led unit
- 1 battery unit
- Lamp holding unit
- 2 positions of attaching LED unit to battery unit
- 1 LED with inbuilt battery
- Different sizes of LED units
- Head band for hands-free operation

IDEATION 3

- 1 led unit
- 1 battery unit with holder
- Wired Lamp holding unit
- Various heights of LED units

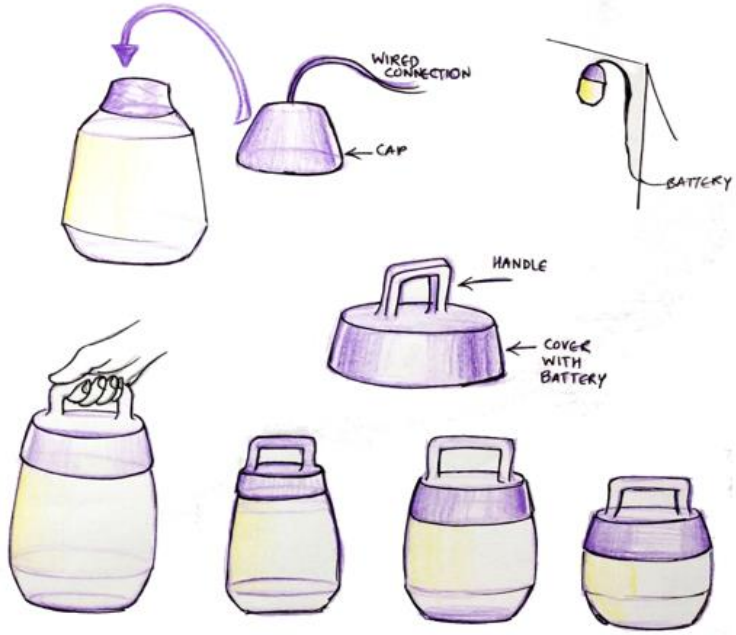


Fig: 7.2.6: Ideation 3

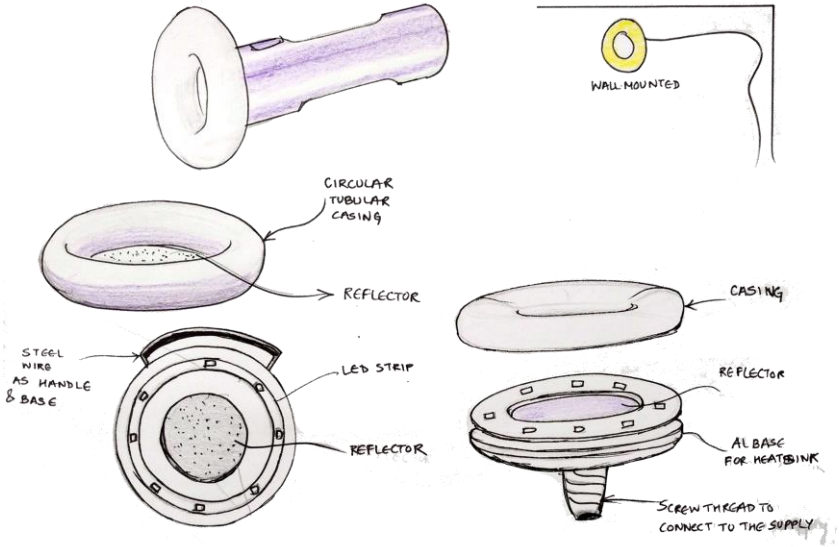


Fig 7.2.7: Ideation 4

IDEATION 4

- Led unit with circular tubular casing and reflector at the centre
- 1 battery unit
- Lamp holding unit

IDEATION 5

- 1 led unit with a hinge for light direction adjustment
- Inbuilt battery unit
- Unwired/Wired connection
- Easy portability
- Also Stands vertically

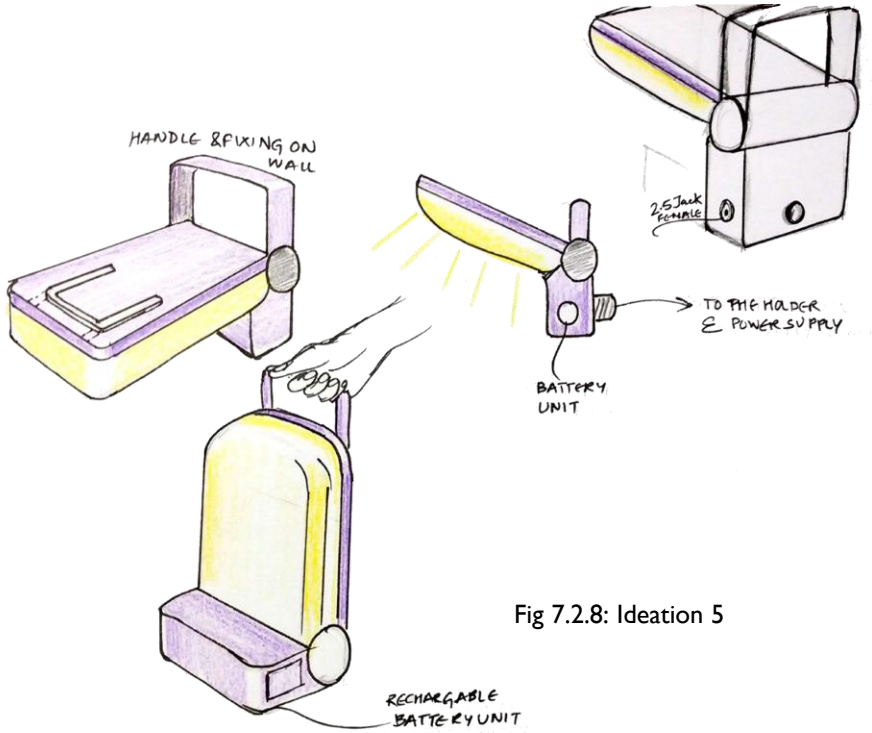


Fig 7.2.8: Ideation 5

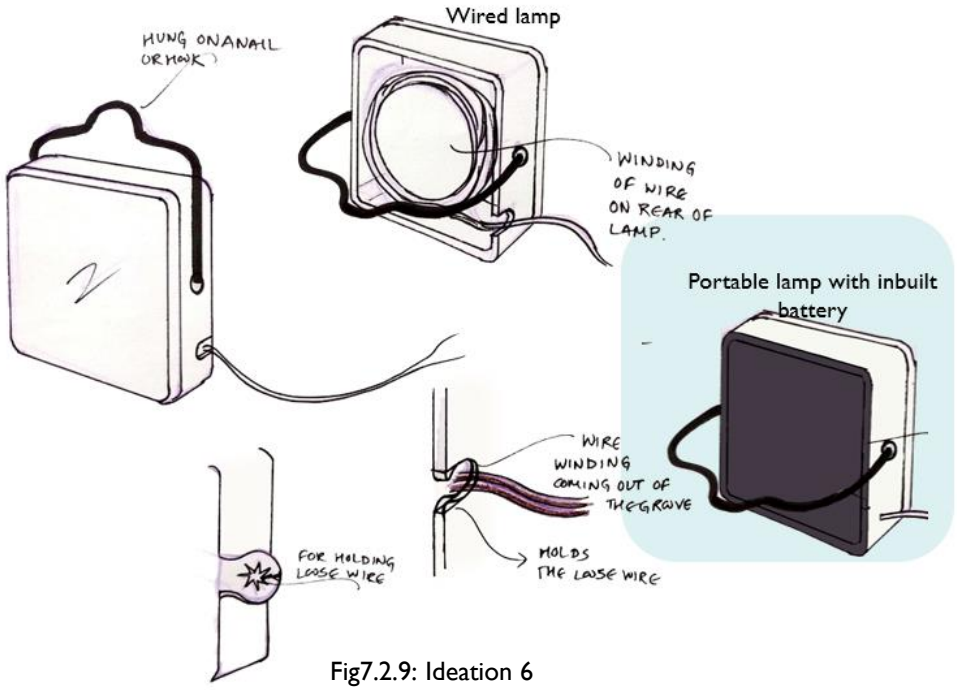


Fig7.2.9: Ideation 6

IDEATION 6

- Separate wired and portable lamps
- Extra wire is wound behind the wired lamp
- Portable lamps have inbuilt battery

IDEATION 7

- 1 led unit with a hinge for light direction adjustment
- 1 Battery unit
- Portable/Wired connection
- Easy portability
- Stands vertically

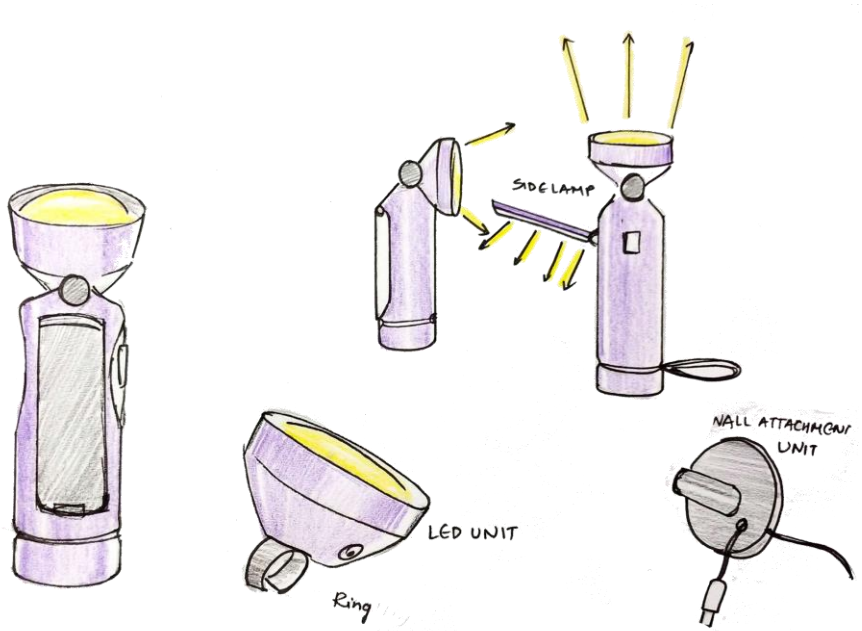


Fig7.2.10: Ideation 7

7.3 DC FAN

DC Fans are the fans which run on Direct current power. DC fans are widely regarded as the most efficient type of fan. They consume significantly less power than AC fans. In fact, DC fans consume up to 70 percent less energy to produce the same output as other fan types. DC fans consume less power, produce less noise, use lower voltage and has minimal electromagnetic interference. There are dc fans with plastic as well as metal blades. Metal blades mostly have airfoil section which has following advantage.

Airfoil- Used for a wide range of applications in many industries, fans with hollow, airfoil-profiled blades are designed for use in airstreams where high efficiency and quiet operation are required. They are used extensively for continuous service at ambient and elevated temperatures. Airfoil section of fan blade allows the fans throw high air throughputs with moderate pressure build-up. Full metal design, are robust and reliable, with a long operating life. In this project, we are using dc fans with metal blade which have airfoil section as shown in fig 7.3.1.

Fig7.3.1: DC Axial Fan

http://media.rs-online.com/t_large/R8258128-01.jpg

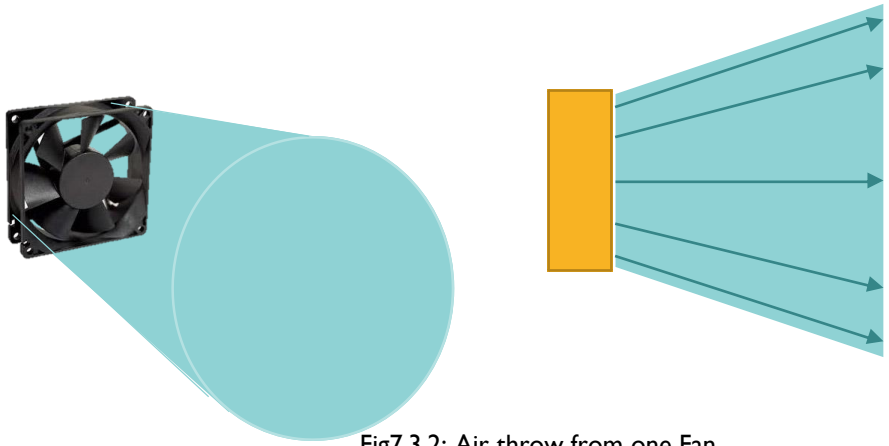


Fig7.3.2: Air throw from one Fan

A single dc fan throws the air in a conical manner forming a circular cross-section, where the intensity of air throw reduces as the distance from the fan increases.

After studying the various activities done in a day-to-day life of a rural family as recorded in fig 7.3.3, we got to know the requirements of fan in their house. There are major requirements which should be considered while designing the fan. First, a need of providing the air to members of family even when they are sitting in different direction. Eg, a case where family members are sitting together in a circular manner or in line, fan's air is needed by everyone.

Second, people mostly sleep on floor, in such case the air is needed only in the area where people are sleeping. This can be achieved by placing the fan in the same plane.

Fig7.3.3: Activities where fan is required

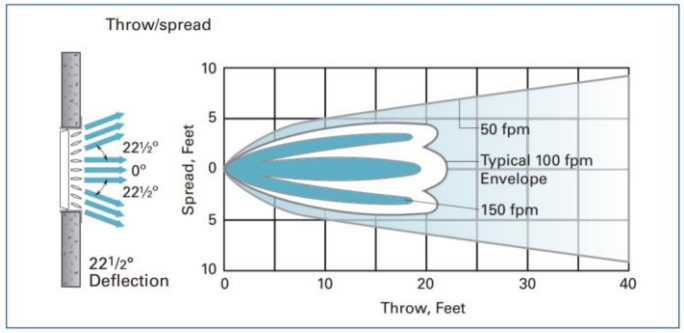
As our system works on DC, we need to design dc fan for the rural India. Existing product which are available in market were studied (fig 7.3.4) to understand the market requirement of DC fans and the possibilities of designing something which will serve the rural population.

The requirement found out for designing the fan were recorded:

- DC Fans
- Ability to provide air to more people for particular time and particular position efficiently
- Reduce air flow in unnecessary areas
- Sturdy for usage by rural people
- Minimum load and max efficiency

Fig 7.3.4: Existing products

As seen earlier, a single dc fan has a circular air throw which is much less than the requirement. Throw is the distance from the center of the outlet face to a point where the velocity of the air stream is reduced to a specified velocity, usually 150 [0.75], 100 [0.50] or 50 fpm [0.25 m/s]. To match with the requirements in these houses as mentioned earlier, there is a need to design the fan which will serve to these requirements. The first idea came to become a fan which will have more than one fans. Seeing the height of a human in sitting position and length of a person in sleeping position, we fixed to 4 dc fans of 6 inches each.



Fan being the important part of household, is required either while sitting or while sleeping. This concept is an assembly of 4 DC fans arranged in such a manner that it can be used in vertical (Fig 7.3.5) as well as horizontal position(useful while sleeping)(fig 7.3.6). Fans are axially mounted in vertical plane. Each fan can rotate about its axis.

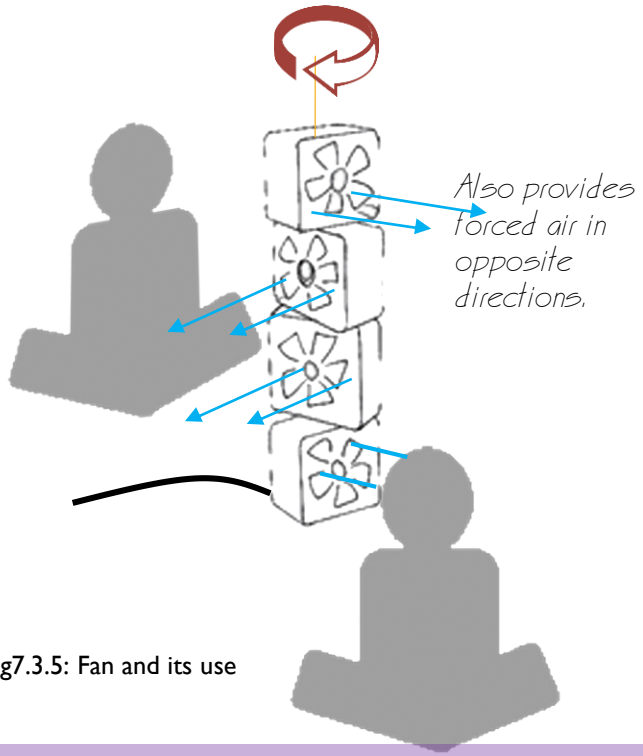


Fig7.3.5: Fan and its use

Normally single fan unit gives a throw which is more over conical. Here we are trying to make a throw which is more horizontal or more vertical.This will result in eliminating the possibility of wasting the air throw in unwanted region.

Horizontal fan while sleeping

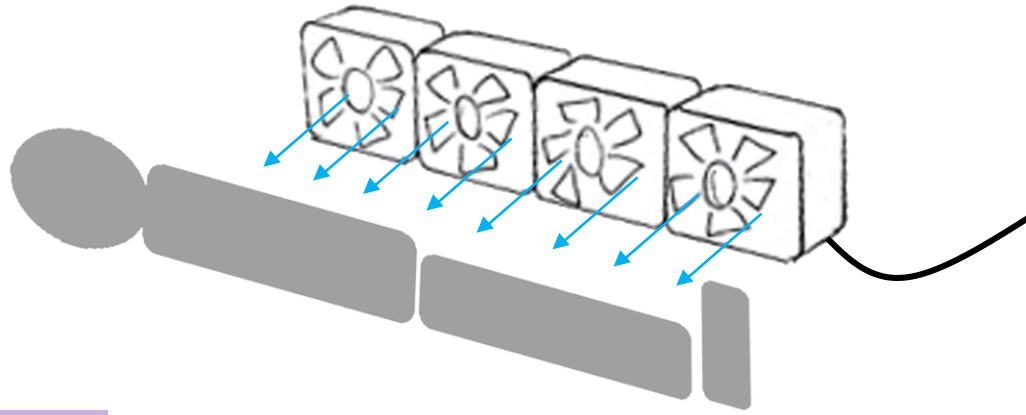


Fig7.3.6: Fan in horizontal position

IDEATION 1A

- DC fans
- Rotate about central axis
- Uses slip ring and carbon brush to connect electrically from 1 fan to another.
- Used vertically

Using slip ring

In this ideation for fan, to connect each fan together to reduce the wiring and to provide a 360 degree rotation, a slip ring and brush is used. Two fans are connected by connecting their terminals to the two slip rings which are insulated from each other and become the two terminals. This reduces the wire connecting the fans and also reduces the stress on wire inn case the fans are rotated more than once.

Narrow design and wider coverage area offers a space-saving design with a slim profile that is the ideal solution for small spaces. It fits easily into corners and areas where space is limited. Even though the fan has a narrow footprint, it allows wide throw coverage in both horizontal and vertical way.

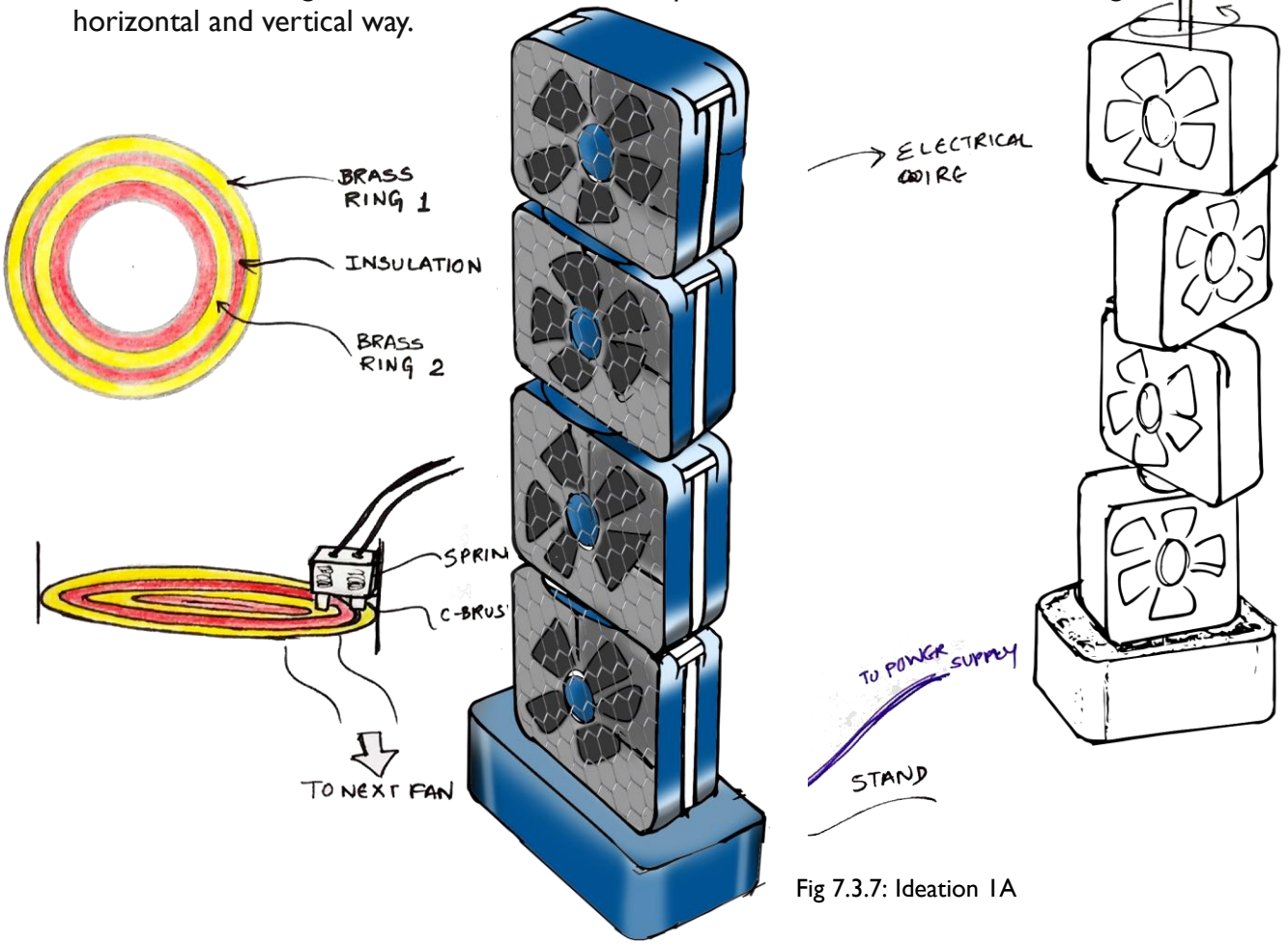


Fig 7.3.7: Ideation 1A

IDEATION 1 B

- DC fans
- Rotate about central axis
- Providing extra wire inside the assembly for compensating from tangled wire while fan is rotated

To keep the design such that individual fans can rotate independently and also will have electrical connections between them, a long neck with some extra wire can be provided as shown in the figure which will compensate to the stress on the wire during the rotation of the individual fan.

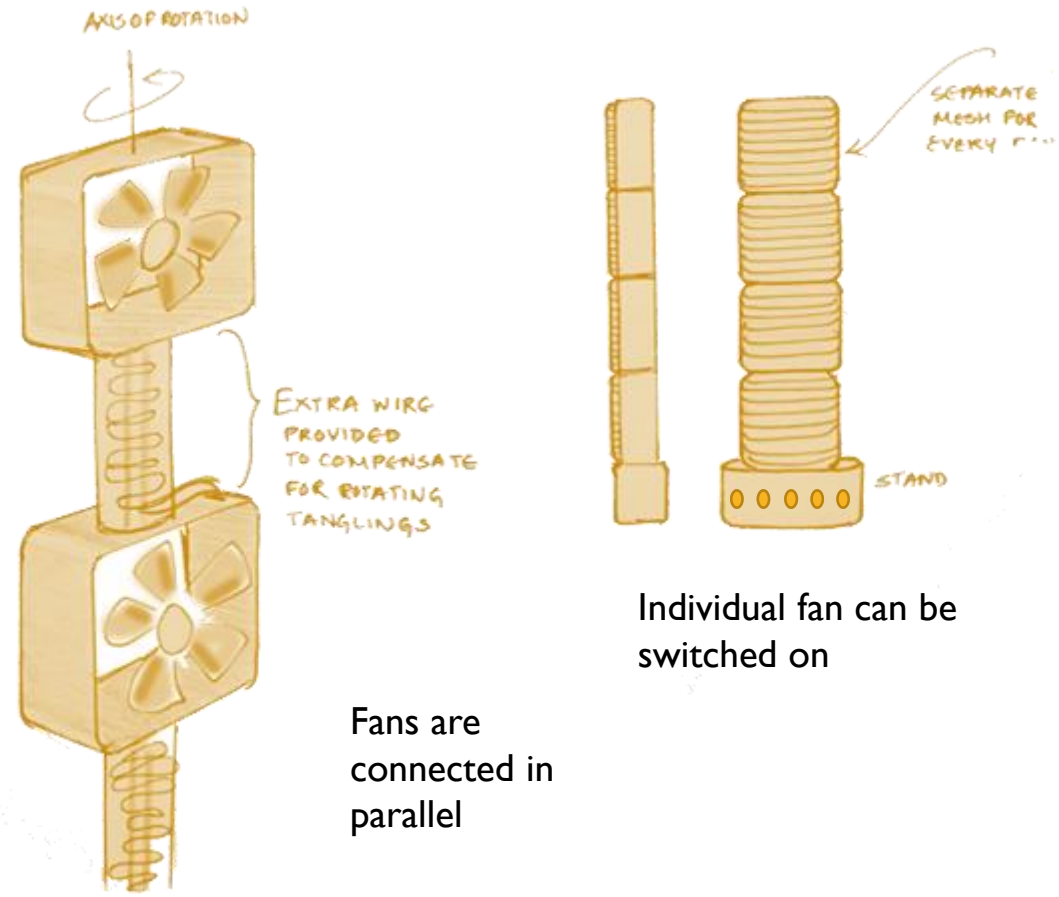


Fig 7.3.8: Ideation 1B

IDEATION 2

- DC fans
- 2 fans are connected/fixed.
- Can be arranged in 4 direction

Here, the fans are arranged together in a way that they can be either kept vertical, horizontal or can be assembled to get forced air in a concentrated part.

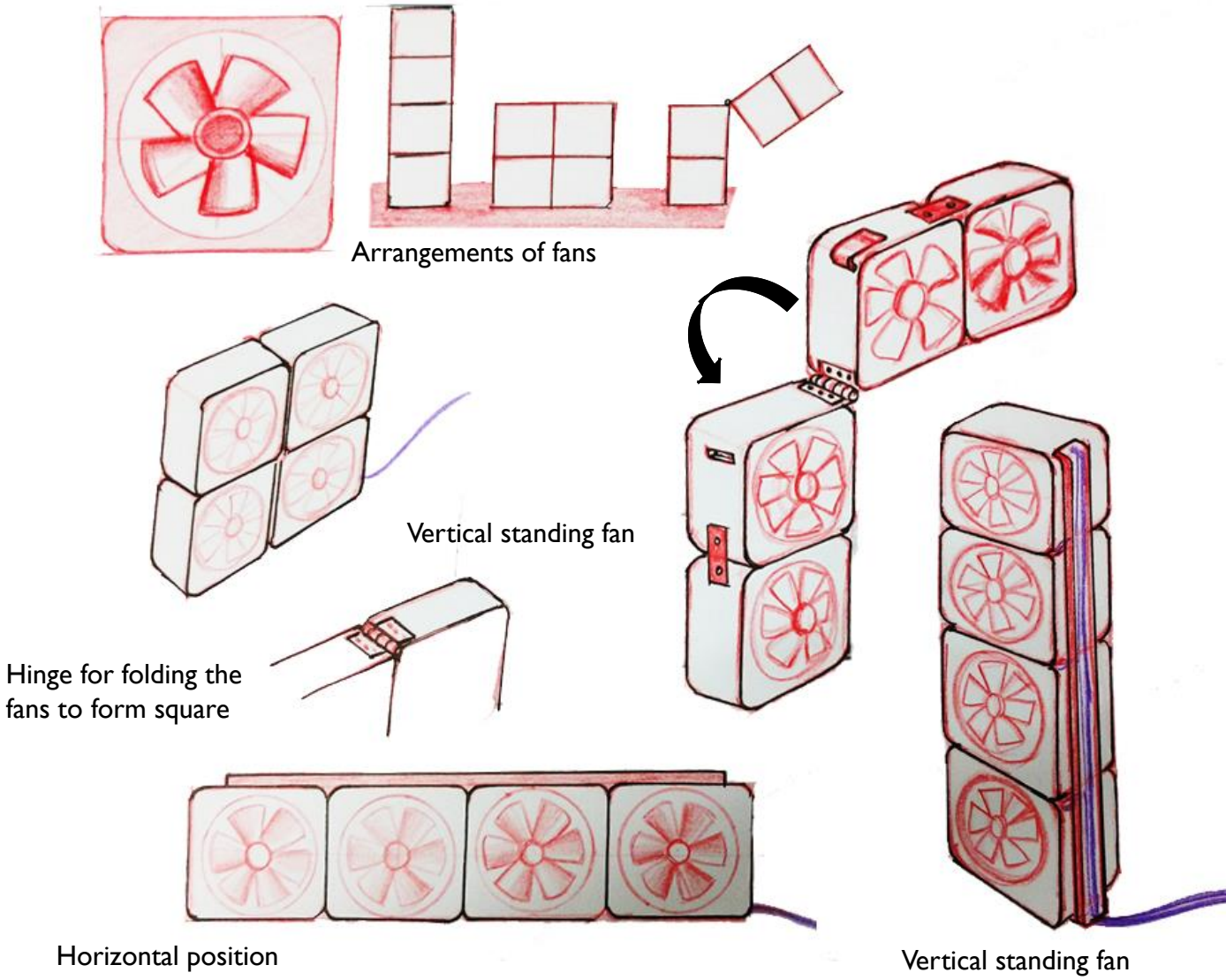


Fig 7.3.9: Ideation 2

7.4 RADIO

Radio is required by a typical rural family for entertainment purpose as well as for listening to the news to keep track of what is happening in the world. The radio unit is either used in house or some times people take it out in the farm to listen to the channels while working. In case of any natural hazards, radio is the only means by which these people can be alerted. This is the main reason for including the radio unit with the kit.

In rural regions of India, the channels work on AM waves rather than FM waves. AM waves are of the local channels available in these regions.
To understand the size and electronics of the radio unit, I tried to study the existing products available in the market.

Fig 7.4.1: Existing radios in market
Source: Google

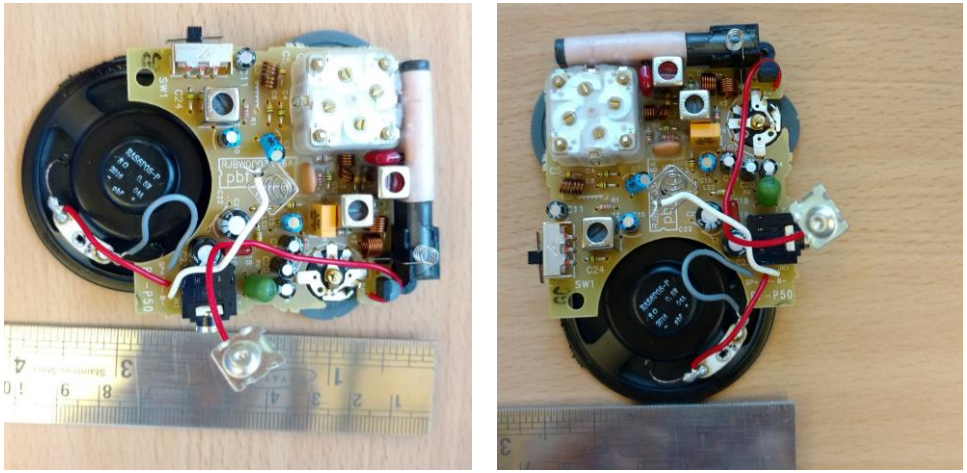


Fig 7.4.2: Radio transmitter circuit with speaker

The radio unit was designed by considering the electronics and dimensions of the radio transmitter unit seen above

8. CONCEPTS

The concepts are based on the preliminary sketches and were made keeping in mind the initial study about the multiple use cases and requirements by the villagers. The concepts were also designed to be used in case where solar panel is a separate entity. The concepts were designed such that they have the simplest of mechanism ensuring that they were easy to use and durable.

According to these ideations and initial concept generation stage, we came to three concepts for solar solution in rural scenario for a single house.

CONCEPT A

Different sizes of lamps without wiring: LED UNIT 3 nos

Wiring is different entity

Small Battery unit to be used in portable lamp

Centralised battery unit

CONCEPT B

Different sizes of lamps with wiring

Flashlight with inbuilt battery

Centralised battery unit

CONCEPT C

Lamps with inbuilt battery

I

The concept is based on wired system where all the devices will be powered via wire connected to the centralised battery using parallel connection. In this concept, lamps design has 3 elements namely: LED unit, holder unit and battery unit (for portability). The system is such that Led unit attached to the holder can be mounted on the wall or ceiling and if it is connected to the battery unit, it becomes a portable lamp. Lamp has 2 positions on the battery unit which enable user to use it hands-free, it can be kept on a table. Each holder unit has a 5m wire wound on its rear. The design of fan is such that it provides its flow 360 degree in horizontal direction by rotating. Fan can be kept horizontally as well as vertical according to the requirement of the user. The radio can be charged by connecting it to the battery unit.

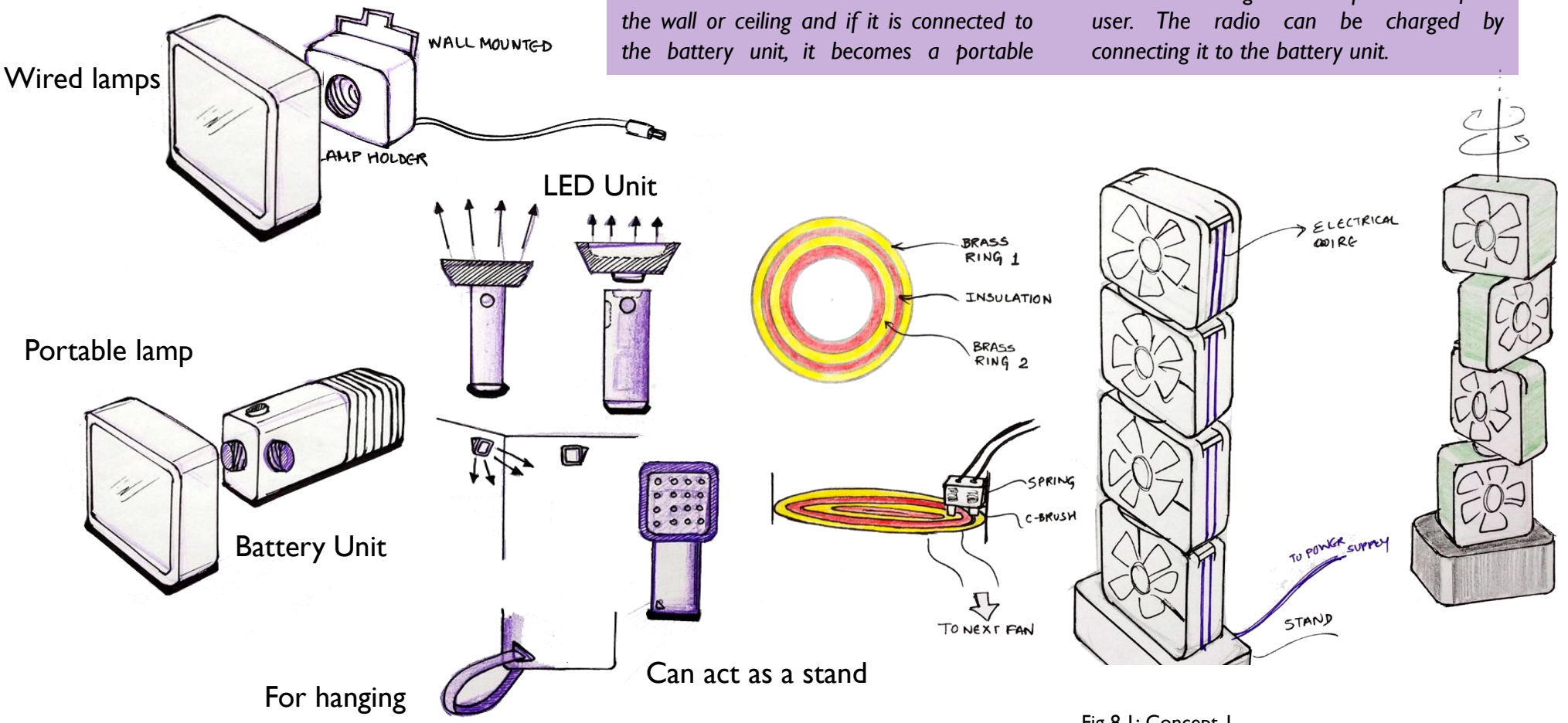


Fig 8.1: Concept 1

2

The concept is also based on wired system where all the devices will be powered via wire connected to the centralised battery using parallel connection. In this concept, lamps design has single element with extra wire provided and wound in the rear compartment. Design of fan is such that it provides its flow 360 degree in horizontal direction by rotating. Fan can be kept horizontally as well as vertical according to the requirement of the user. The radio can be charged by connecting it to the centralised battery

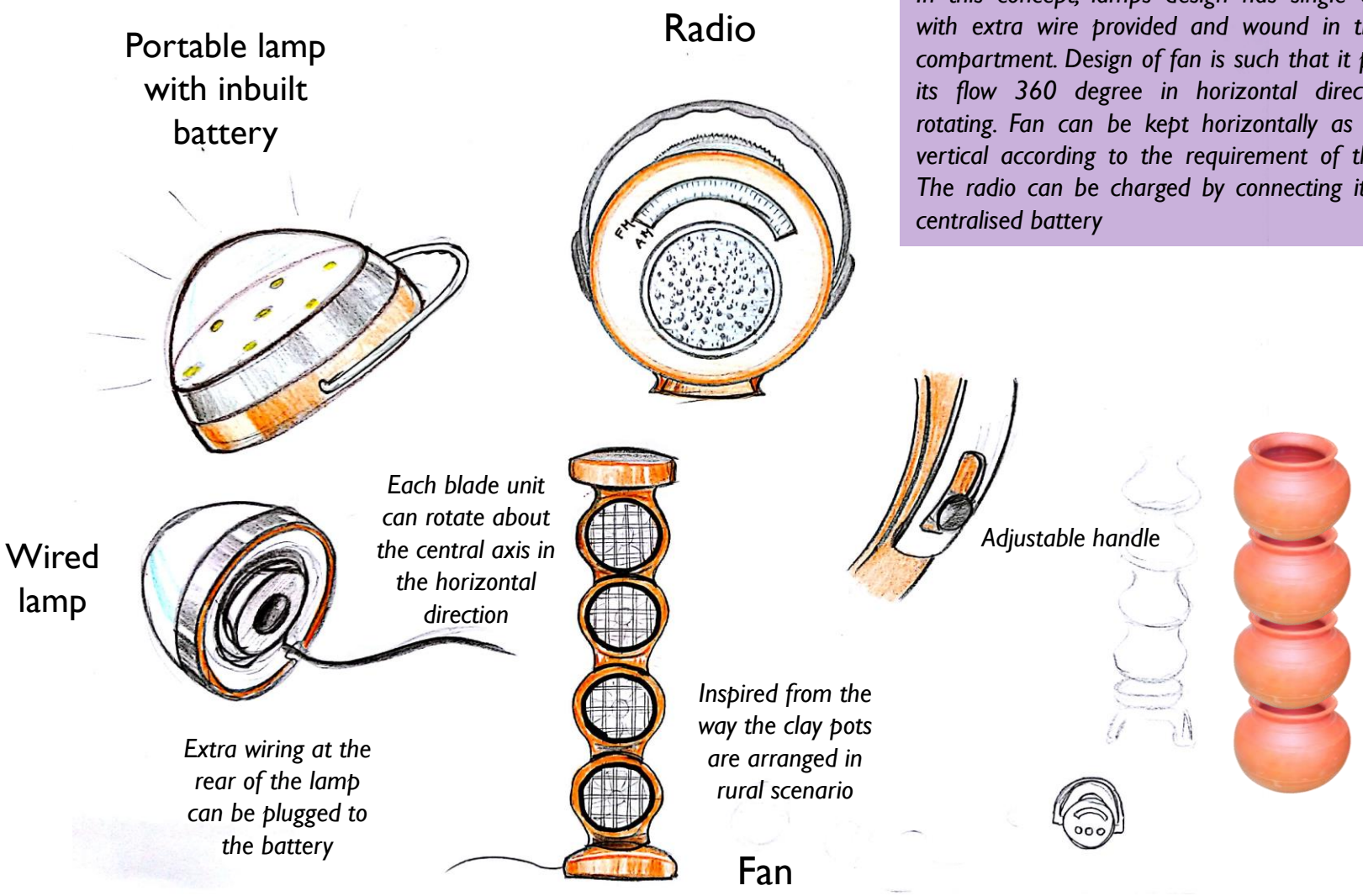
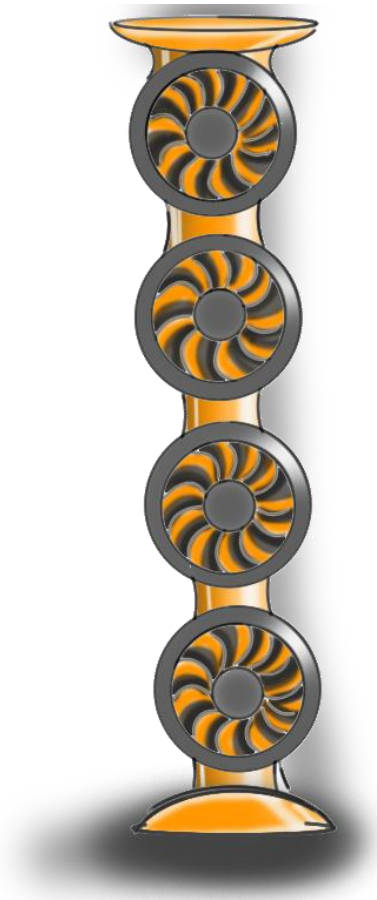


Fig 8.2: Concept 2

3

Lamp

Radio



Fan

This concept has all the lamps which are portable and has inbuilt battery. The concept works in a way that in the day time, all the lamps will have to be connected to the charge controller and solar panel which will charge the lamps for the whole day. These lamps can be further used in night for the activities as seen earlier. The fan concept is same as ideation 1A. In this concept, no centralised battery will be used as all the components already have inbuilt batteries in them.

Fig 8.3: Concept 3

9. MOCK-UPS

Some quick mockups were made in order to get a better understanding of the dimensions, size and proportions. The mock-ups were made of thermocol and styrene. They were tested at a basic level in different use conditions. The mockups were made keeping in mind the size of electronics, ergonomics, usability etc. The mock-ups were shown to the people of a village

Fig 9.1: Mock-ups of lamps

10. CONCEPT VALIDATION FROM RURAL POPULATION

To understand whether the rural population is ok agreeing with the concepts that were designed, a visit to a village **Chaurewadi** almost 19km from **Igatpuri** was conducted and feedbacks from the villagers were noted. There were houses which were small as well as of moderate size. One of the houses that I visited as shown in fig 10.1 had 3 rooms(living room, kitchen and a room) and a family of 6 people including children. The separation wall between the rooms was half the height of the ceiling so as to get more illumination as day time. The toilets were outside the house at a distance of 100m. The village has electricity supply to some of the houses only. Most of the houses don't have supply of electricity. For them, the only mean to lighting is kerosene lamps. Some houses also have flashlight with batteries which they need to buy every month. On an average they have 2 basic mobile phones at their home.

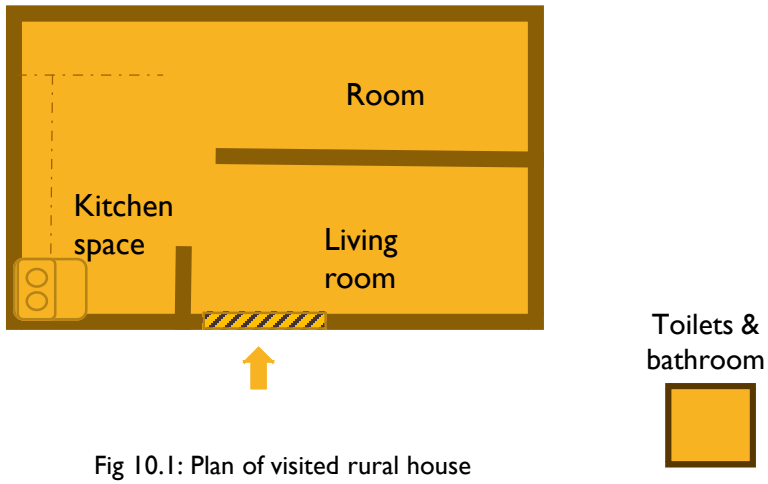


Fig 10.1: Plan of visited rural house

Scenario: One of the houses that I visited had 3 rooms(living room, kitchen and a room) and a family of 6 people including children. The separation wall between the rooms was half the height of the ceiling so as to get more illumination as day time. The toilets were outside the house at a distance of 100m.

Fig: 10.2: village scenario

Observation and explaining

The mock-ups and models were shown to the villagers. The concepts of the system were explained for them to get a better understanding of what we are designing. The existing products that they use are kerosene lamps. In some cases they used flash light with battery. After observing their daily routine, it was seen that they try to avoid the outdoor activities in the darkness. They schedule such activities for before sunset. Eg. Bringing water for morning bath a day before before sunset. Refer the photographs shown in figure 10.3.





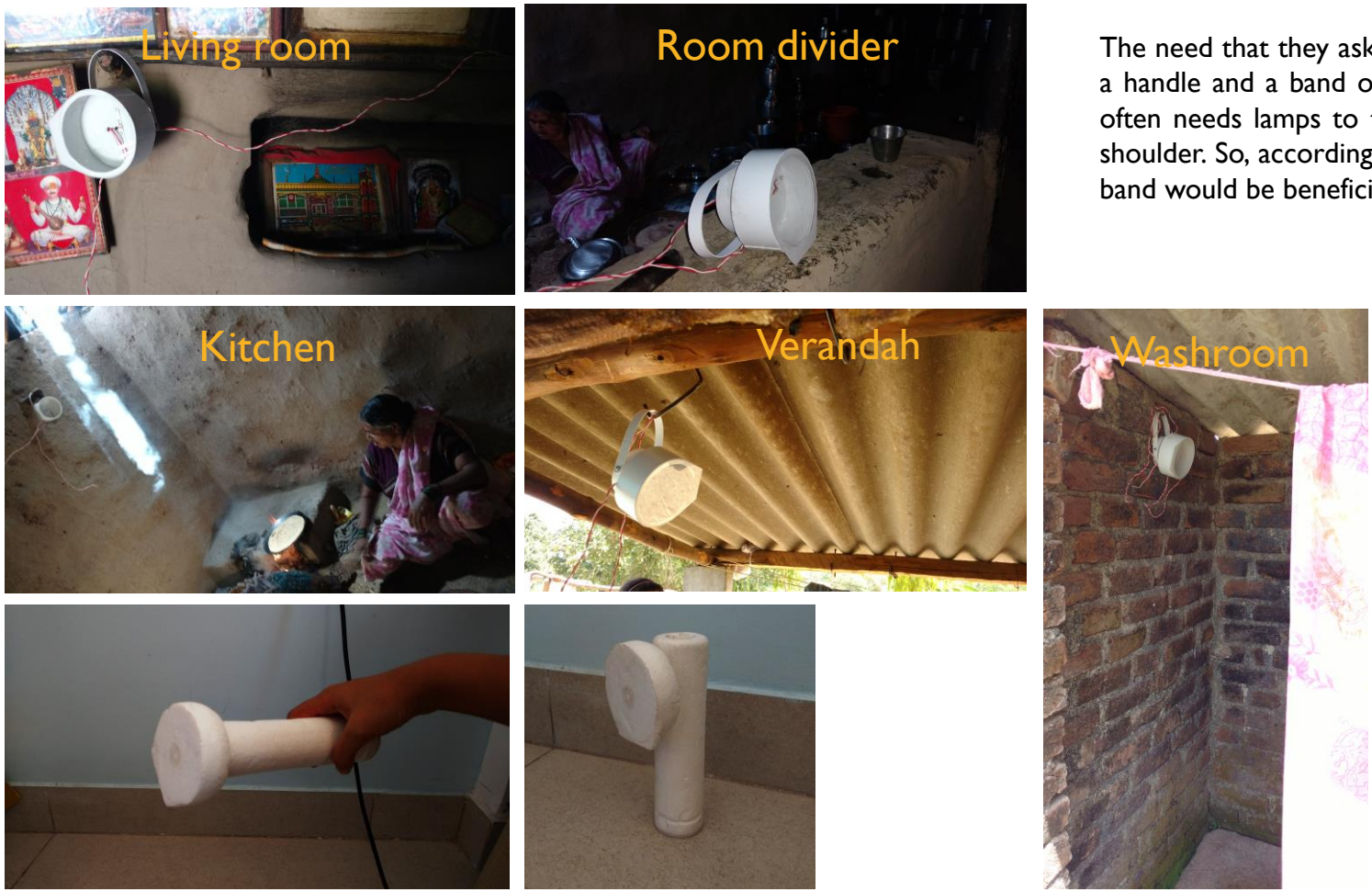




Fig: 10.3 Some observation and interaction with rural family

How concept can be useful in rural context

Concept testing and interaction was carried out with these villagers and possible use of the lamps were observed. The various places where this concept lamp can be used efficiently. As the concept had 2 components namely an LED holder and a LED unit, villagers seemed to like the concept as they can replace the existing led unit with desired power led unit.



The need that they asked for was that they wanted a handle and a band on the portable lamp as they often needs lamps to the farm and hang it on the shoulder. So, according to them, adding handle and band would be beneficial for them.

Fig: 10.4: Use of mockups of concept in this rural context

11. FINAL PROPOSED CONCEPT

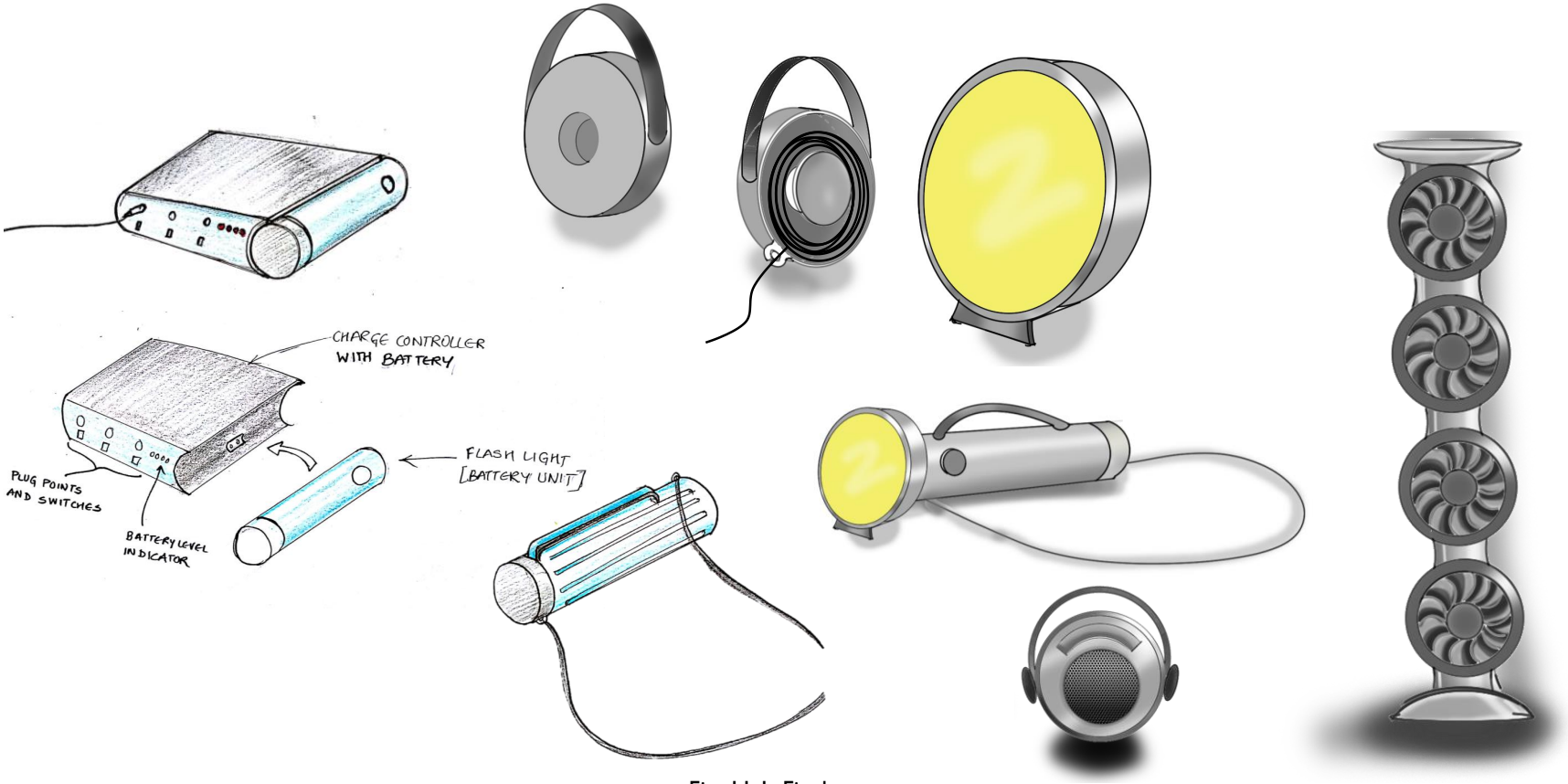


Fig: 11.1: Final concept

The above concept was finalised after the validation from the rural population. The concept is derived from concept A. Some modifications and refinements were done according to needs of the user. The battery unit of flash light can be connected to the charge controller(with battery) to make one unit. The battery unit of flash light can be disconnected after charging and connected to the led unit to become flash light.

After talking to the villagers, a need of flash where there is an inbuilt handle and a long band for easy carrying was introduced. So, there was a need to refine the flash light concept. According to the need, the battery unit of flash light was refined further.

Ways in which the lamps can be mounted in the house are pictured below. As observed from the visit, every house has these wooden rods mounted in wall itself which at present is used for mounting either a kerosene lamp or hanging a photo frame or a bag. These rods can be used to mount the lamps so that there will be no need to invest more money into installing new mounting points. These lamps can be mounted on ceiling, or wall, can be kept on floor. It also allows to adjust the angle of light according to requirement.

Fig: 11.2 Ways of mounting the lamp in the house

12. CONCEPT REFINEMENT AND DETAILING

Fan:

This fan concept has 4 DC fans which are mounted on a central axis. The space between the two adjacent fans is for the electrical connections where we are using 2 brass rings and 2 nodes as 2 terminals +ve and –ve. As we are using manual rotation and the rotations are not frequent or continuous, there is no problem of losses of friction between the electrical connections between fans. Figure 12.2 shows the basic internal structure of the final concept of fan. Figure 12.1 shows the model of fan from a previous project done in IDC, which was studied.

Fig 12.1: Previous project model of fan

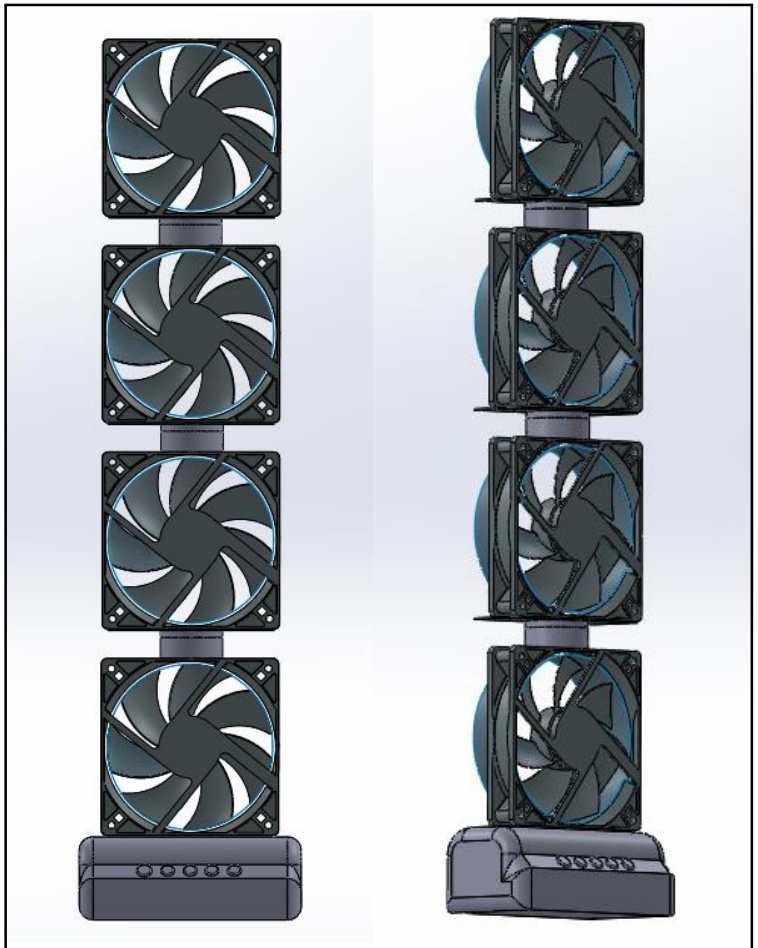
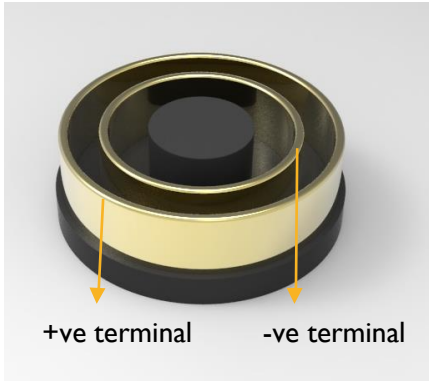
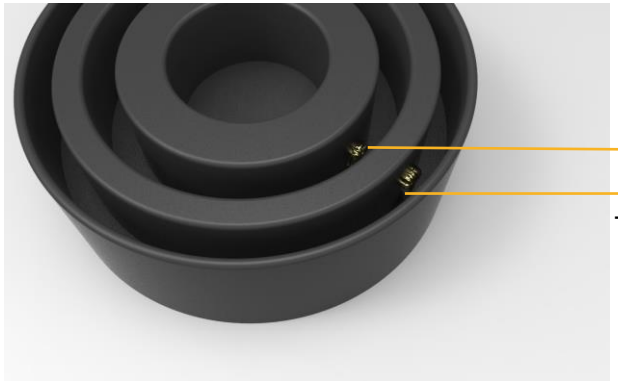


Fig12.2 : Basic 3D model of fan concept

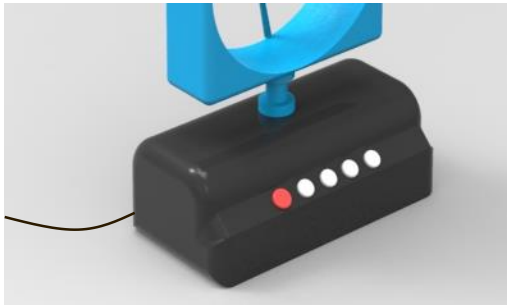
Detailing:

1. To prevent the wire to get tangled and stressed during the individual rotation of fans. We are using this small detail for connecting the adjacent fans electrical as well as physical. In this detail, female part has 2 brass rings represent the two terminal (+ve and -ve). The male part has cavity with two metal protrusions for two brass ring. This ensures that +ve always goes with +ve and –ve with -ve. So, whenever one of the fans is rotated manually, the electrical connections are not disturbed.





2. As the fans are connected in parallel arrangement, Each fan can be switched on individually, which prevents the need of switching ON all the fans when not required. Hence saving the electricity. Hence, 4 different operating buttons are provided at the base of the fan unit. All the electronic components including PCB, buttons and the extra wiring will be enclosed in the base unit which is also acting like a stand. Or the switches can be added to the top of the fan for easy interaction



Specification and power requirement:

Lamps:

Lamp 1	5W	4	(70*70*25)mm
Lamp 2	3W	5	(90*90*25)mm
Lamp 3	2W	6	(110*110*25)mm

Fan:

Fan is an assembly of 4 dc fans with 12V and 12W supply

Fan	48W	4	(650*145*160)mm

Radio:

Radio work for FM as well as AM. Needs 3V 0.15W supply and has 5.7cm dia speaker.

Radio	5W	4	(70*90*25)mm

Charge controller:

Charge controller houses a bunch of LI-ion batteries, PCB and electronics, buttons, plug points, USB mobile charging plugs for 2 mobile phones and I/P from solar panel.

Charge controller	(180*250*50)mm

Portable battery unit:

Portable battery unit will have 1/4th of the total batteries. This unit is to be connected physically and electrically in the charge controller for charging in the day time. The lamps will be connected to this battery unit. It will have 2 mounting points for 2 type of uses. The devices can harness energy from this battery unit even when it is connected to the charge controller.

Portable battery unit	(170*45*45)mm

The table below shows the approximate costing of the products and kit.

Particulars	**Quantity**	**Unit**	**Cost Rs**
PV Module	40	Watt	1800
Batteries	43.3	Ah	2600.24
Cables	150	M	150
Controller	5	W	475
Structure	59.8	Times	200
Installation	59.8	Times	400
Luminaries	10	Watt	500
Fan	12	watt	2600
Radio	0.5	Watt	100
			8824.36

Source: SoUL, IITbombay

13. FORM FAMILY AND EXPLORATIONS

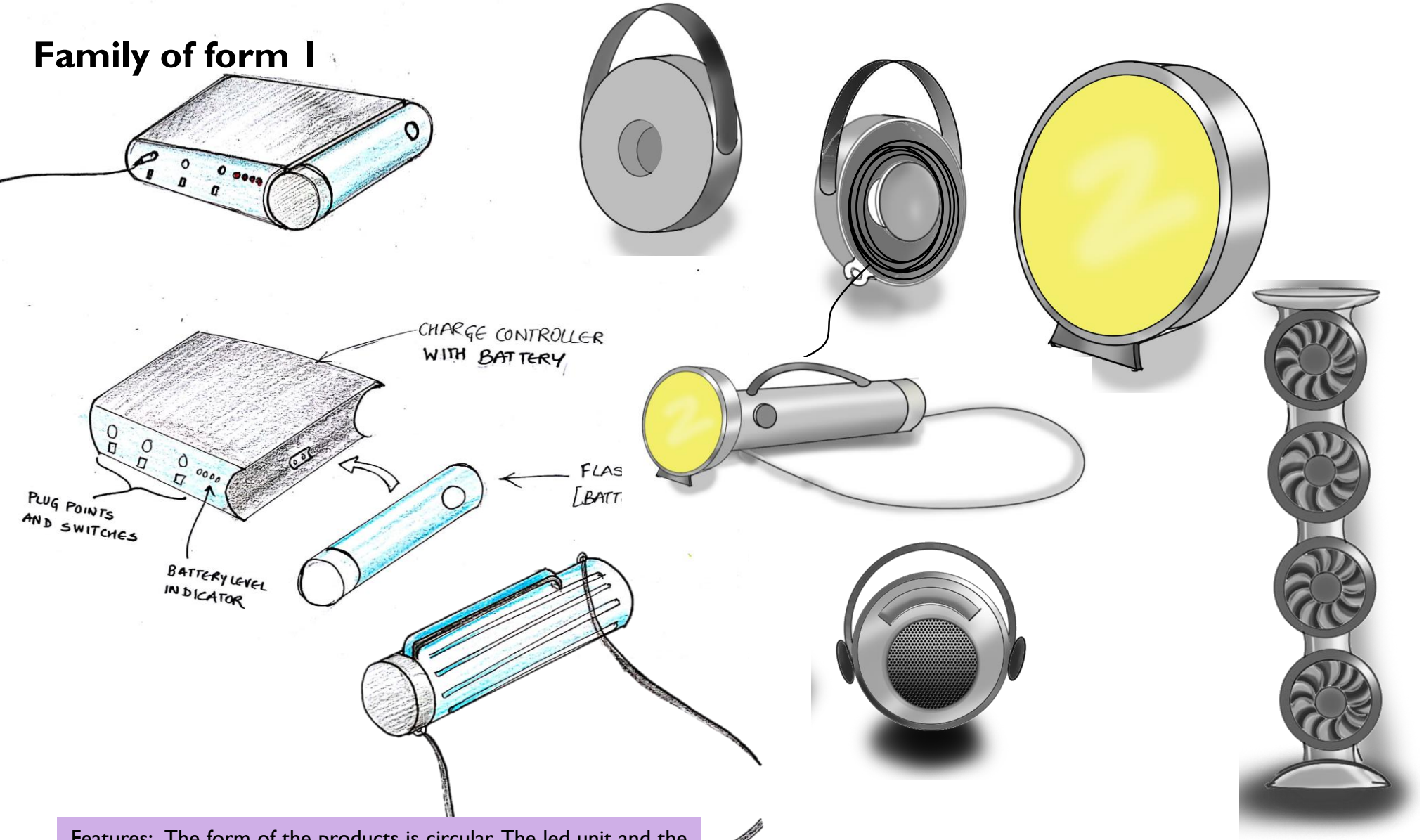
The components in the system are:

1. 3 Lamps
2. Battery unit
3. Lamp holder
4. Fan
5. Charge controller with inbuilt battery
6. Radio

All the above components in the system have to look similar is the reason for exploring the family of forms. Product family is a group of products derived from a common product platform. These goods or services use similar or same production processes, have similar physical characteristics, and may share customer segments, distribution channels, pricing methods, promotional campaigns, and other elements of the marketing mix. Products comprising a family are usually priced and discounted as a package. Several product families make up a product portfolio. Also called product group or product line. Product family becomes the identity of that product range and lets customer to recognize it by attracting them towards it. Some examples for product family are shown in fig 13.1.

Fig13.1: Some examples of product family
Source: www.google.co.in/productfamily

Family of form 1



Features: The form of the products is circular. The led unit and the led holder are attached using the Edison screws fitting is the reason for circular form, makes it easy to handle while screwing and unscrewing. The torch handle easily fits into the charge controller for charging. The form looks minimal and sober.

Fig: 13.2 Product Family 1

Family of form 2

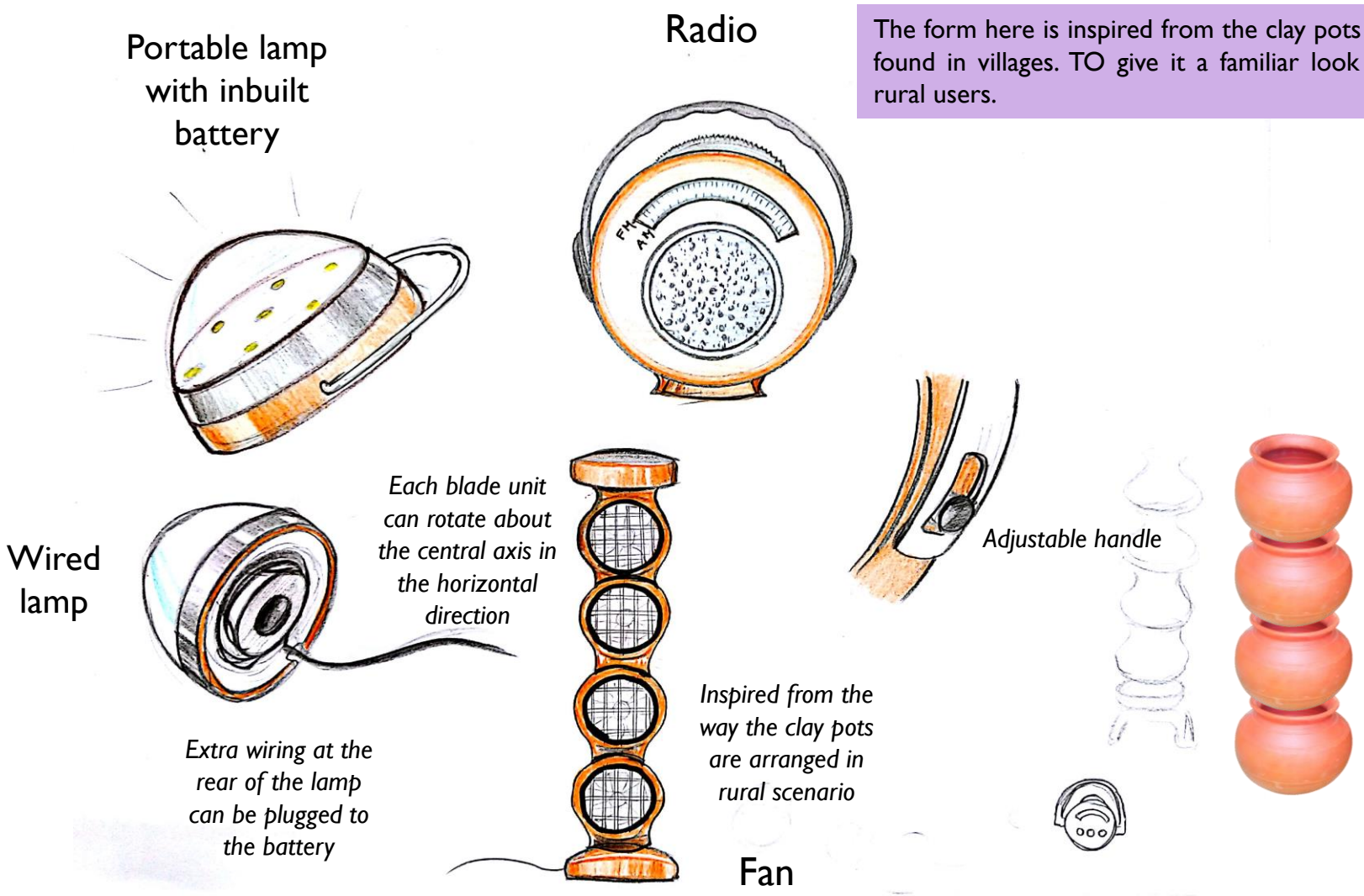
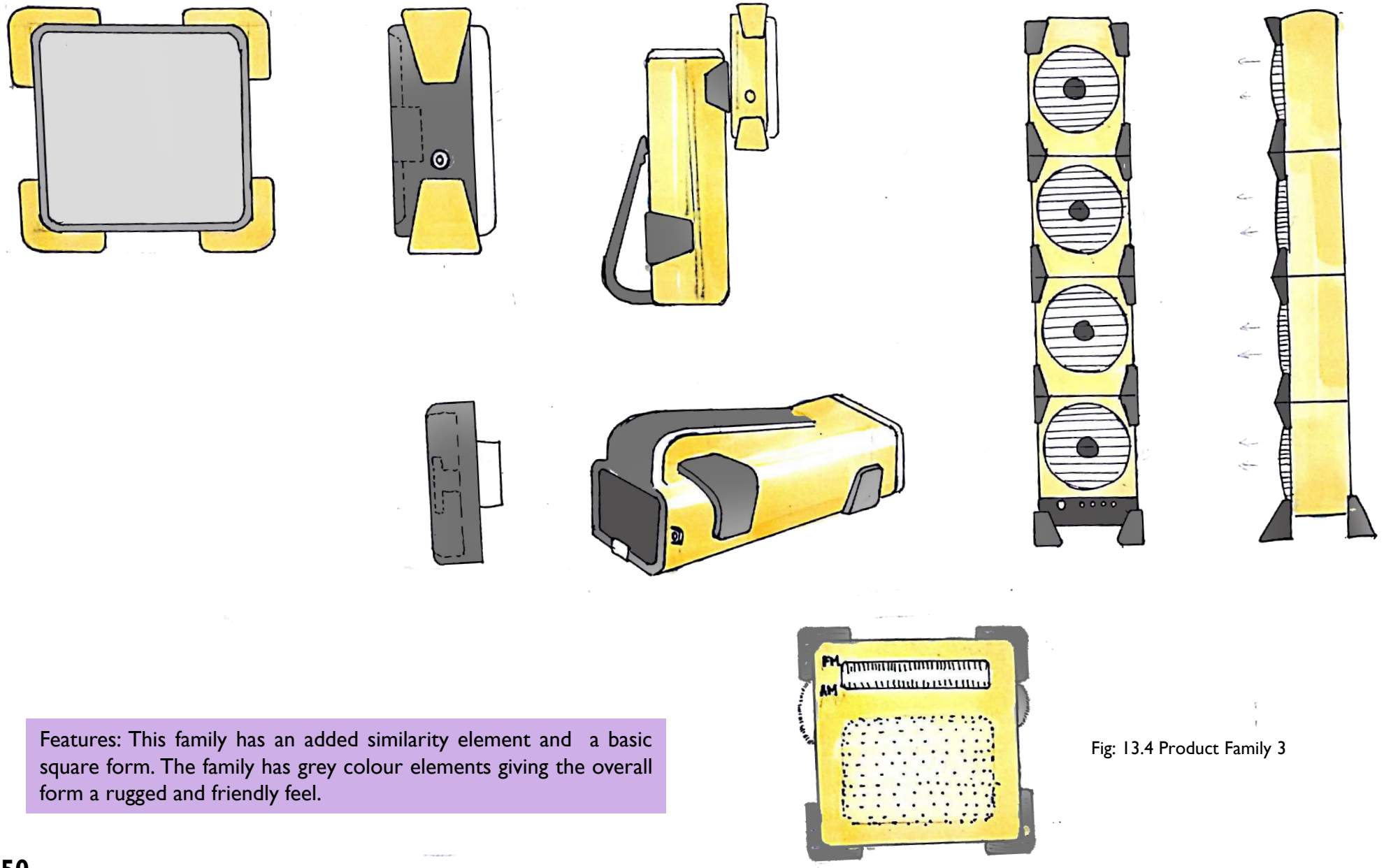


Fig: 13.3 Product Family 2

Family of form 3



Features: This family has an added similarity element and a basic square form. The family has grey colour elements giving the overall form a rugged and friendly feel.

Fig: 13.4 Product Family 3

Family of form 4

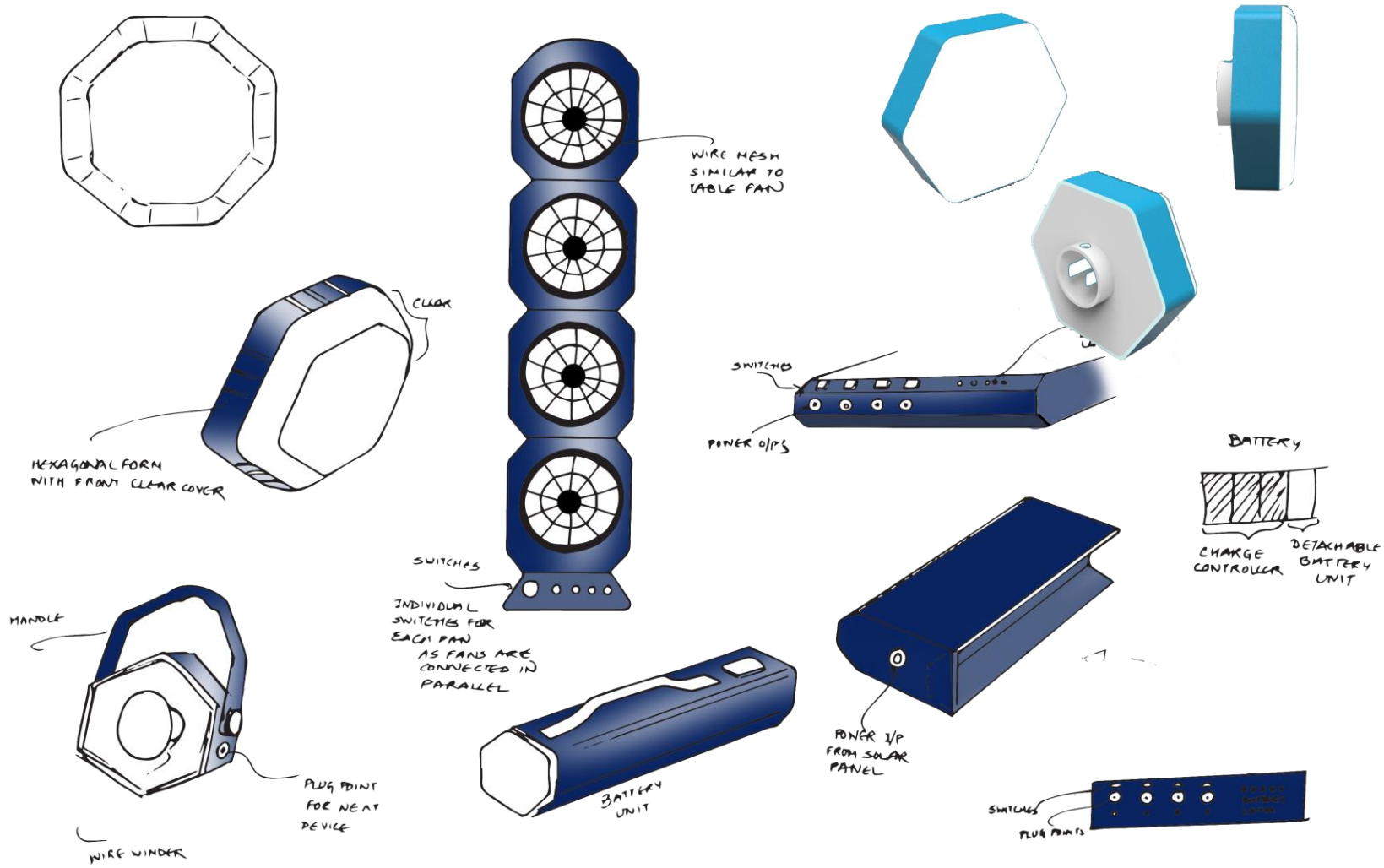


Fig: 13.5 Product Family 4

Features: Hexagonal shape is the basic form used here giving the family a friendly appearance. The edges are soft and the colour are opaque and dark which are used in rural areas.

Family of form 5

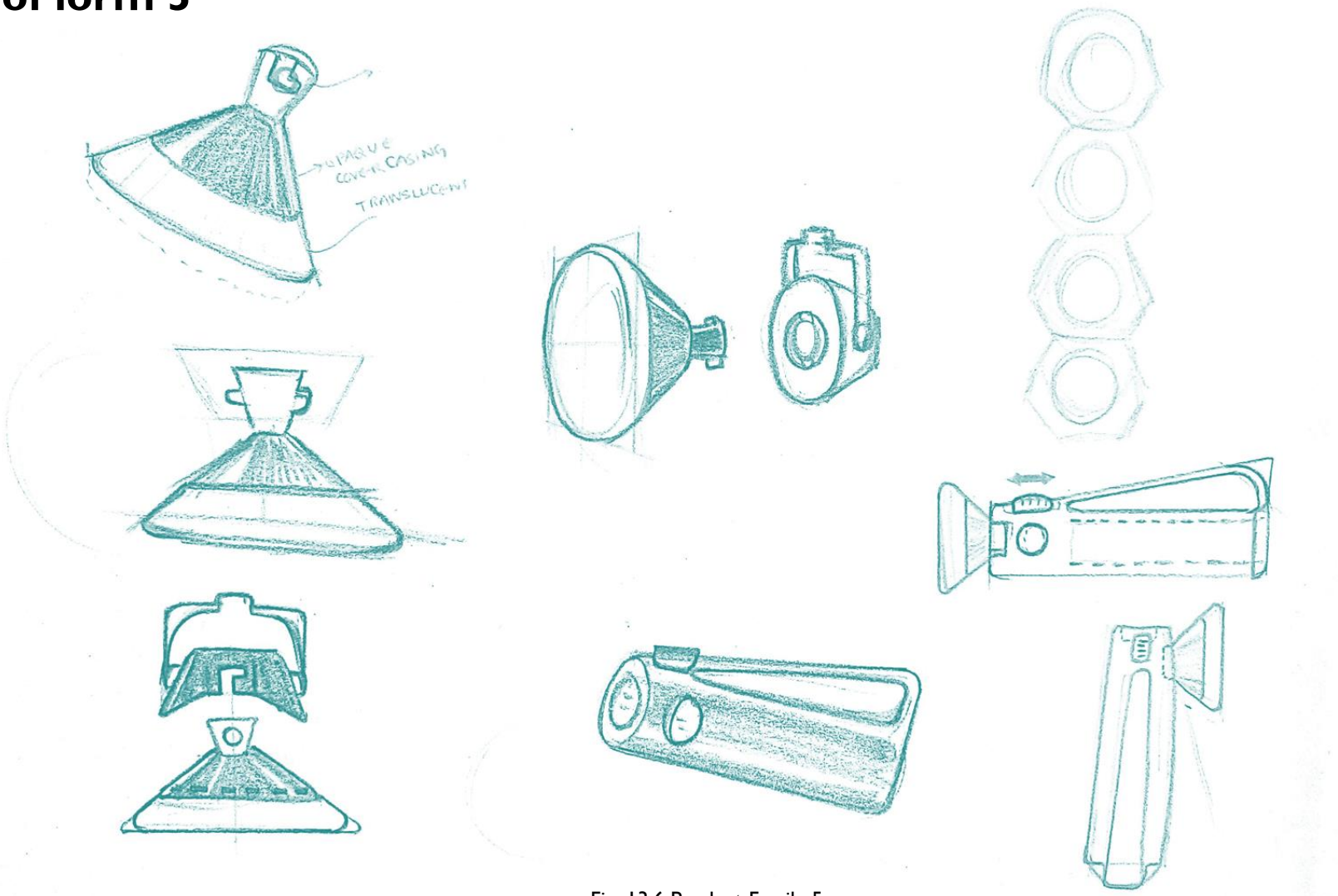


Fig: 13.6 Product Family 5

Features: The products have conical form which soft looking edges making it easy to handle and prevent accidental damages. Conical form was used for the spotlights which makes it disperse most of the light in a conical way.

Family of form 6

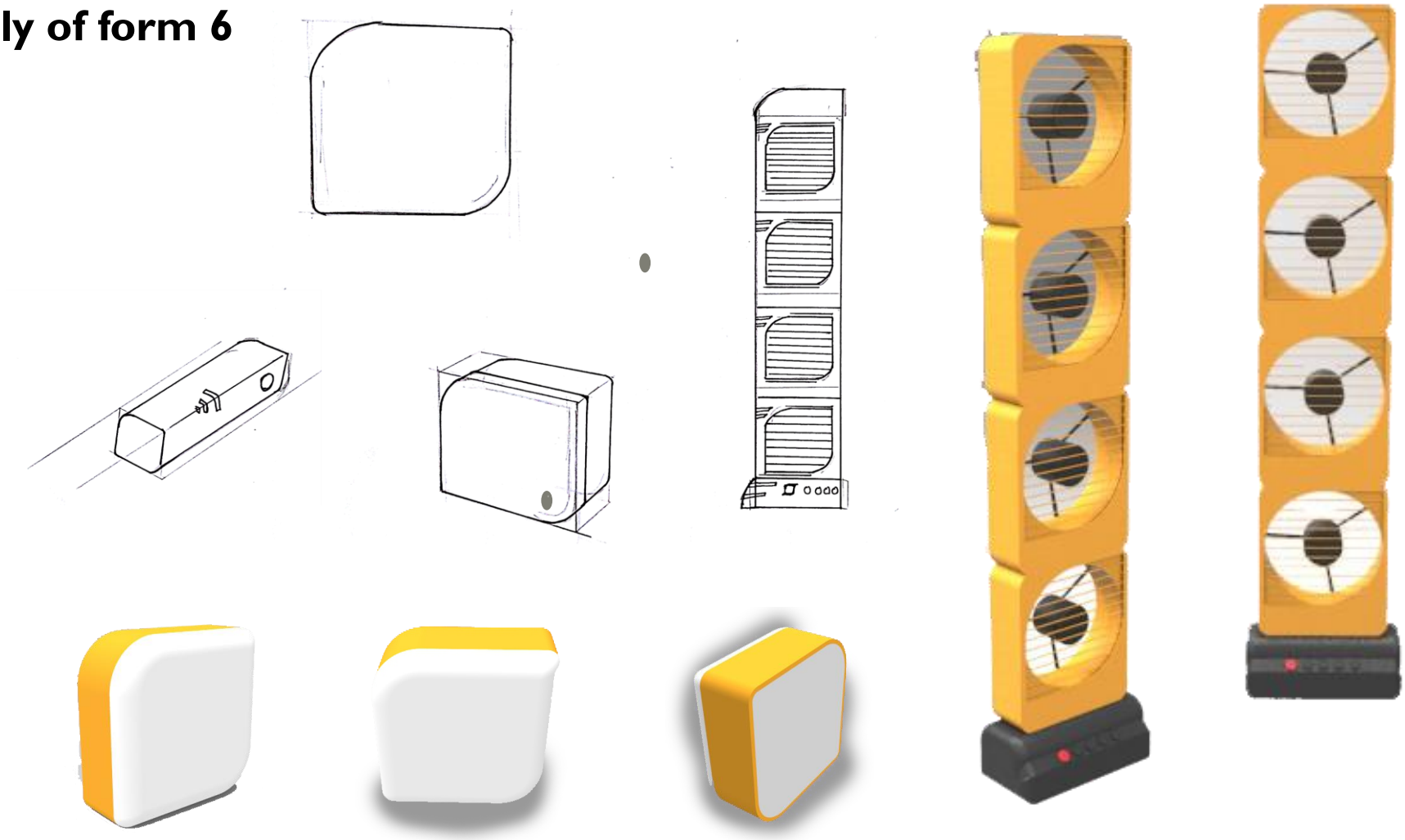


Fig: 13.7 Product Family 6

Features: Derived from nature, this family is inspired from leaf and doesn't use any additional component. The form is simple and elegant.

Form 3 was selected and taken further. Some more variation in this form and colour were explored.

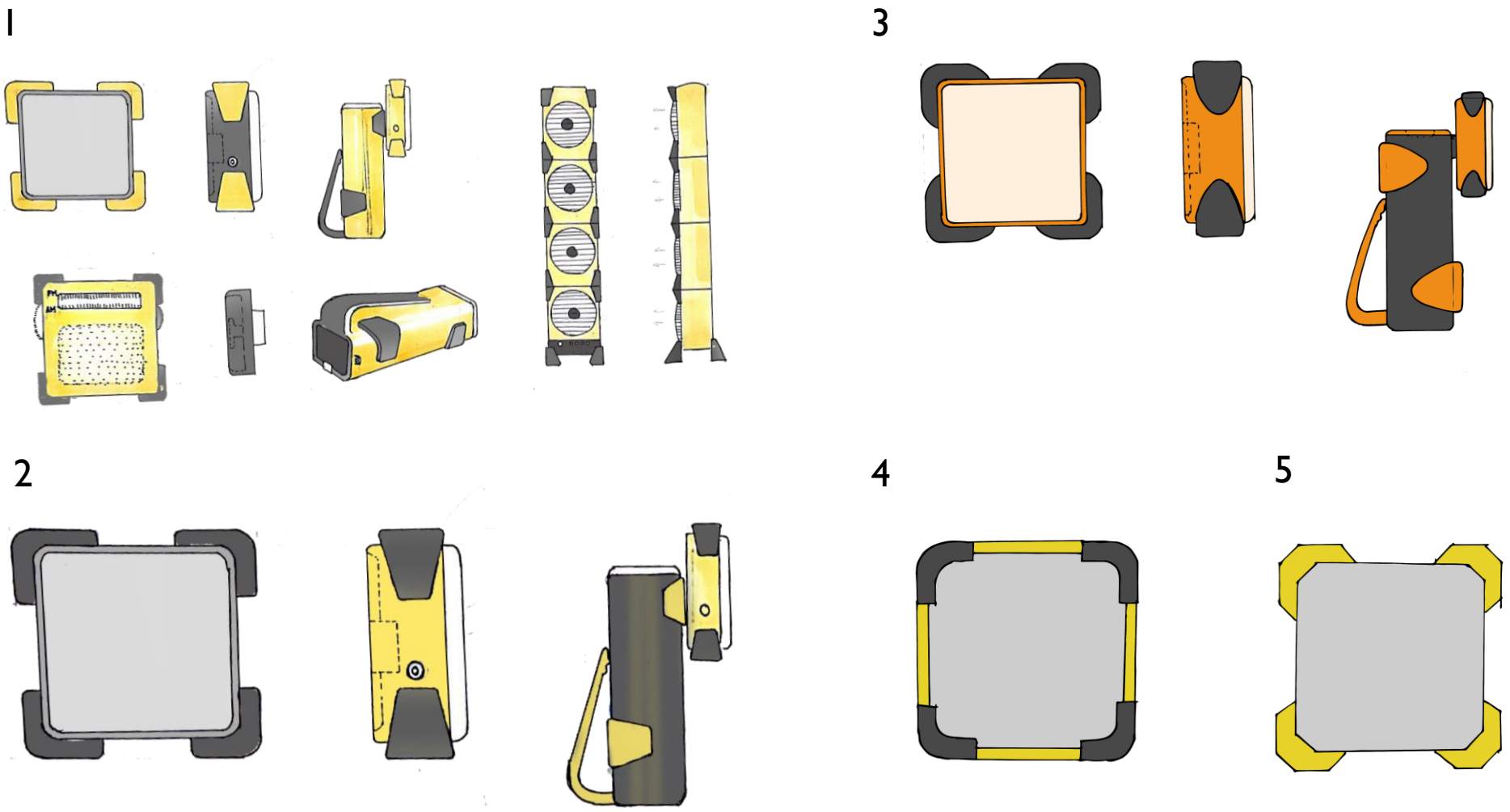


Fig: 13.8 Different versions of family 3

14. FINAL CONCEPT

Fan: The final concept of fan is based on the ideations done where there is an assembly of 4 DC fans arranged in a vertical fashion mounted on an axle where the connection is via brass ring mechanism as shown earlier. These fans are connected to the power supply from charge controller. The connection between the fans is in parallel connection so that it eliminates the probability of shorting the entire system in case of accident. Parallel connection also gives an added advantage of ability to switching ON the fan individually. The individual rotation of the fan allows multiple users to get the thrown air even when people are sitting in different directions. The fan can also be kept horizontal which makes it beneficial when people are sleeping in horizontal position. The height of the fan is decided by the height of the person in sitting position from ground is the reason for using 4 dc fans.
A handle is provided on the top for easy handling of the fan. The switches are provided at the base to make it simple to switch ON/OFF.

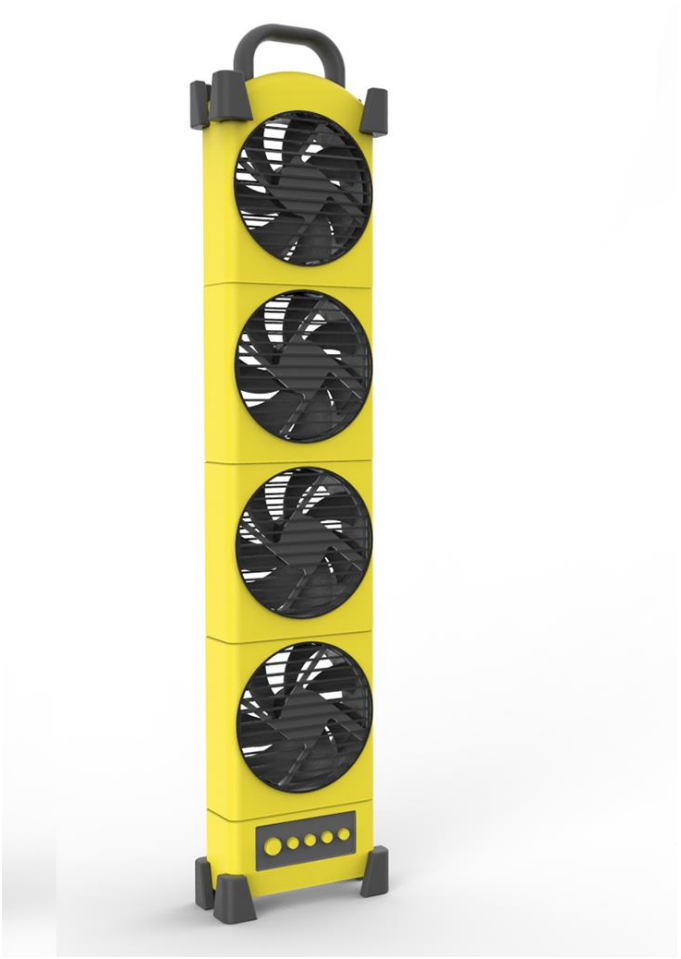


Fig: 14.1 Fan

3 D MODELLING

FAN

Fig: 14.2 Fan, 3D render

LAMP

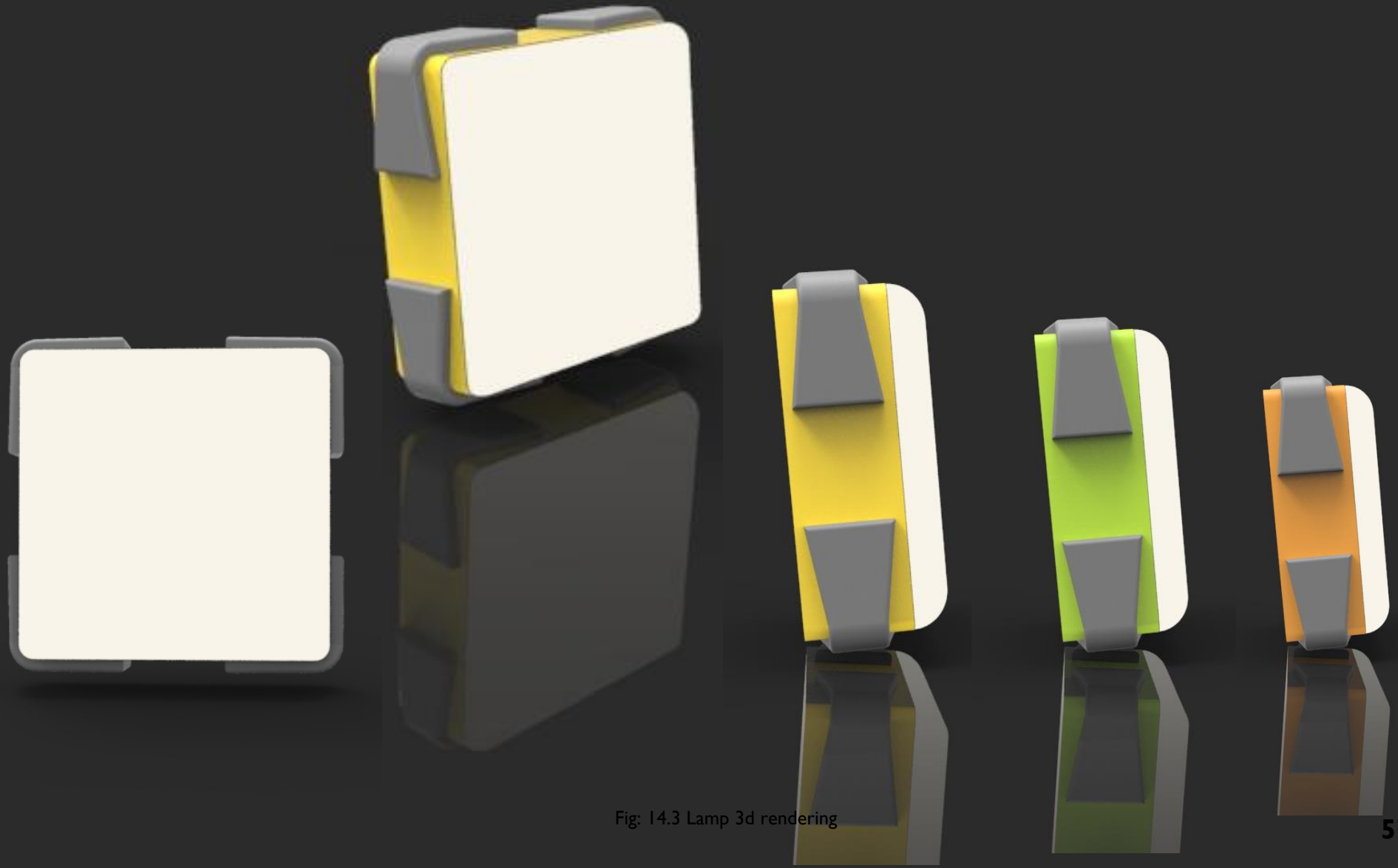


Fig: 14.3 Lamp 3d rendering

LED HOLDER

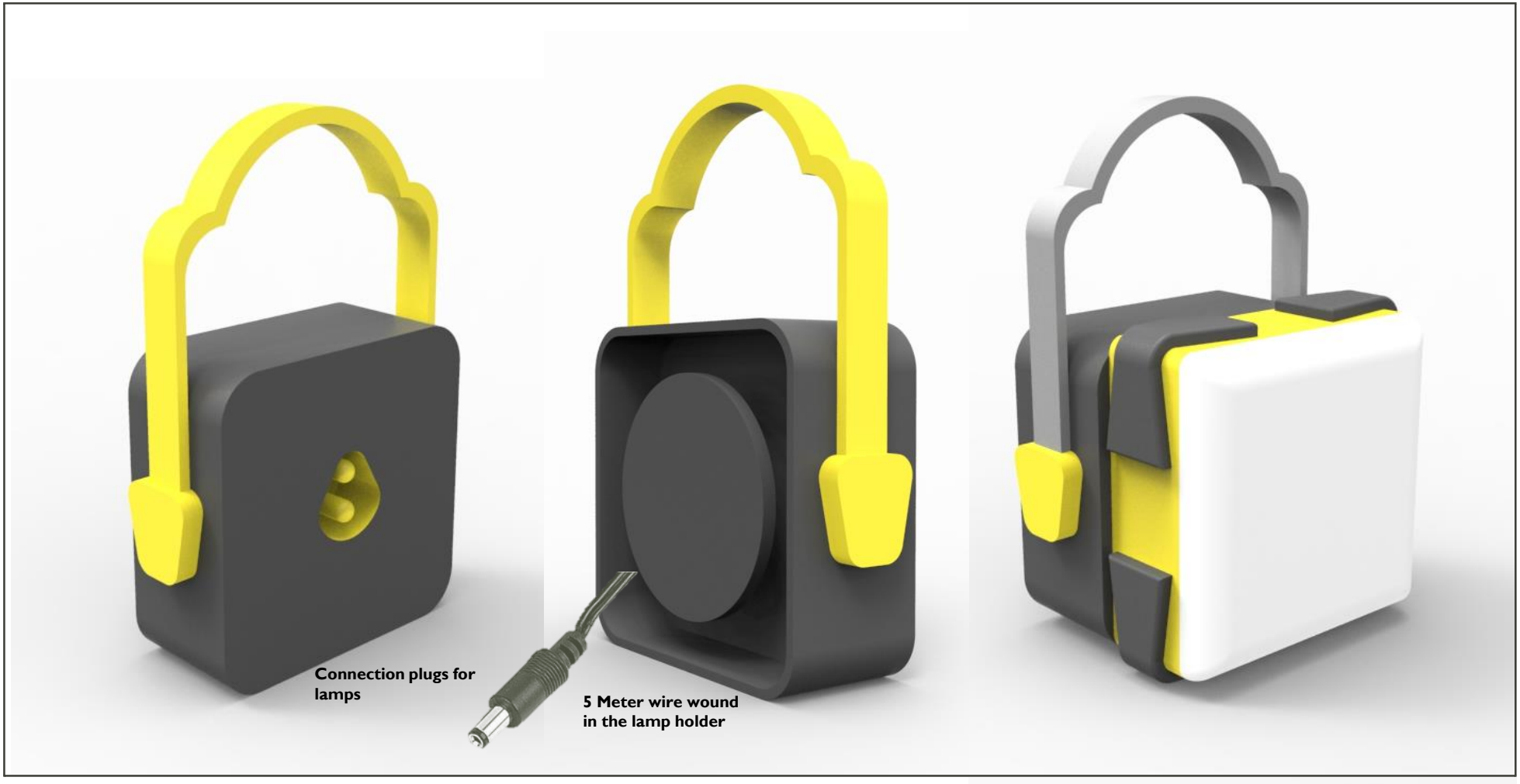


Fig: 14.4 Lamp holder

Fig: 14.4 Flash light

RADIO

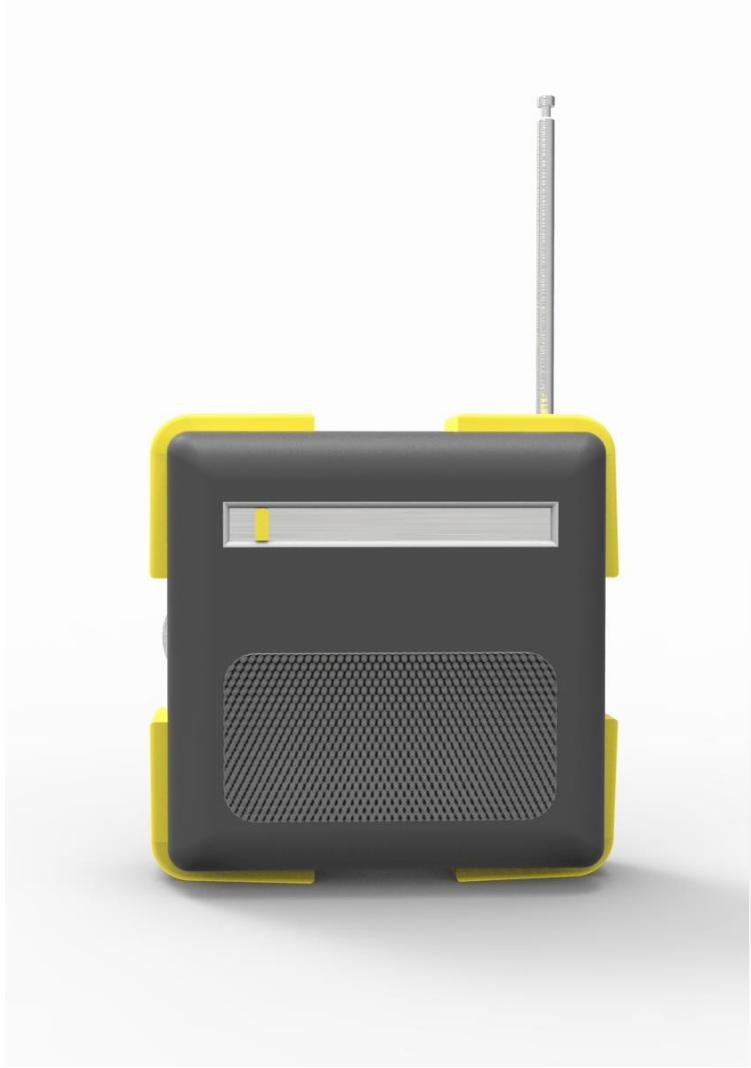


Fig: 14.5 Radio

CHARGE CONTROLLER

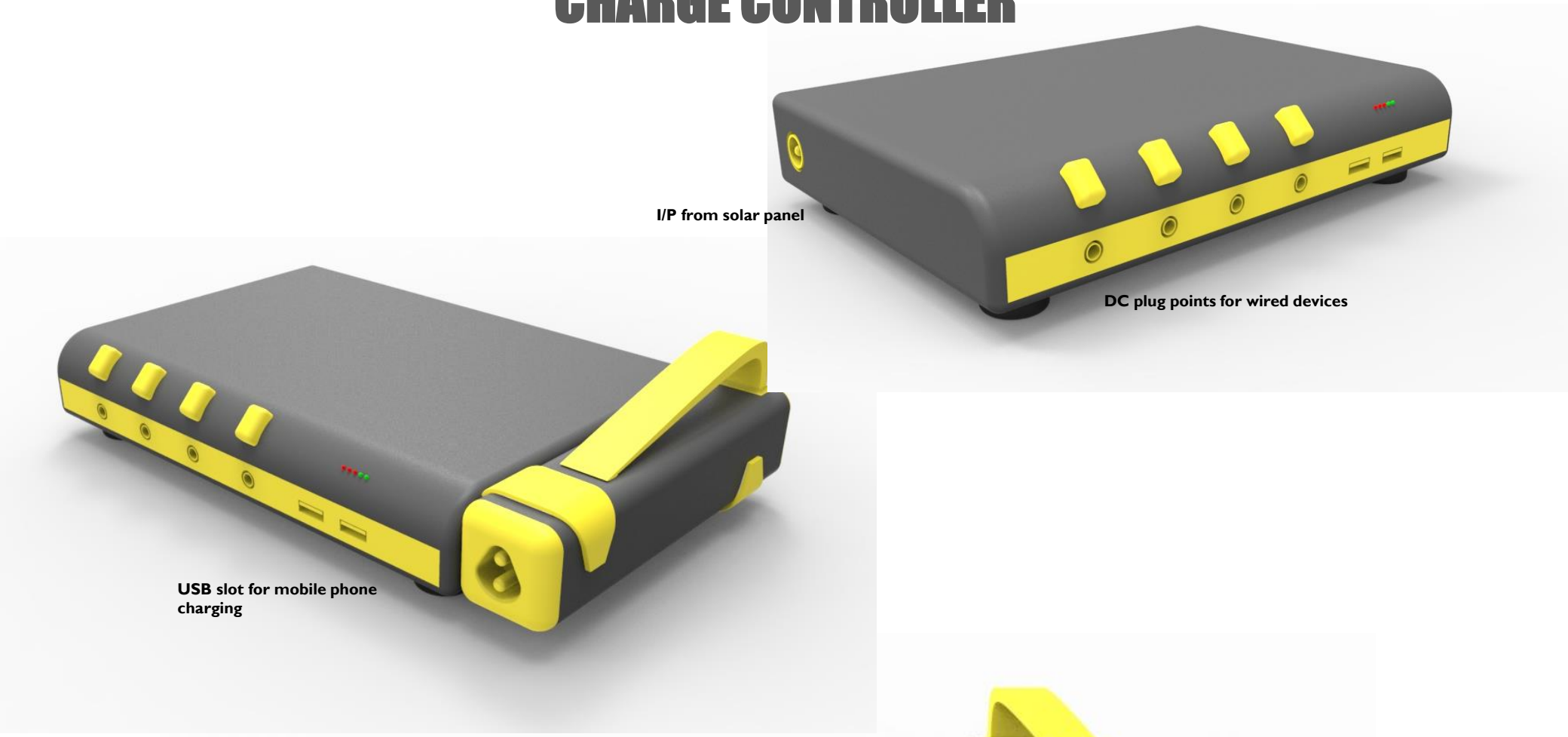


Fig: 14.6 Charge controller

THE KIT

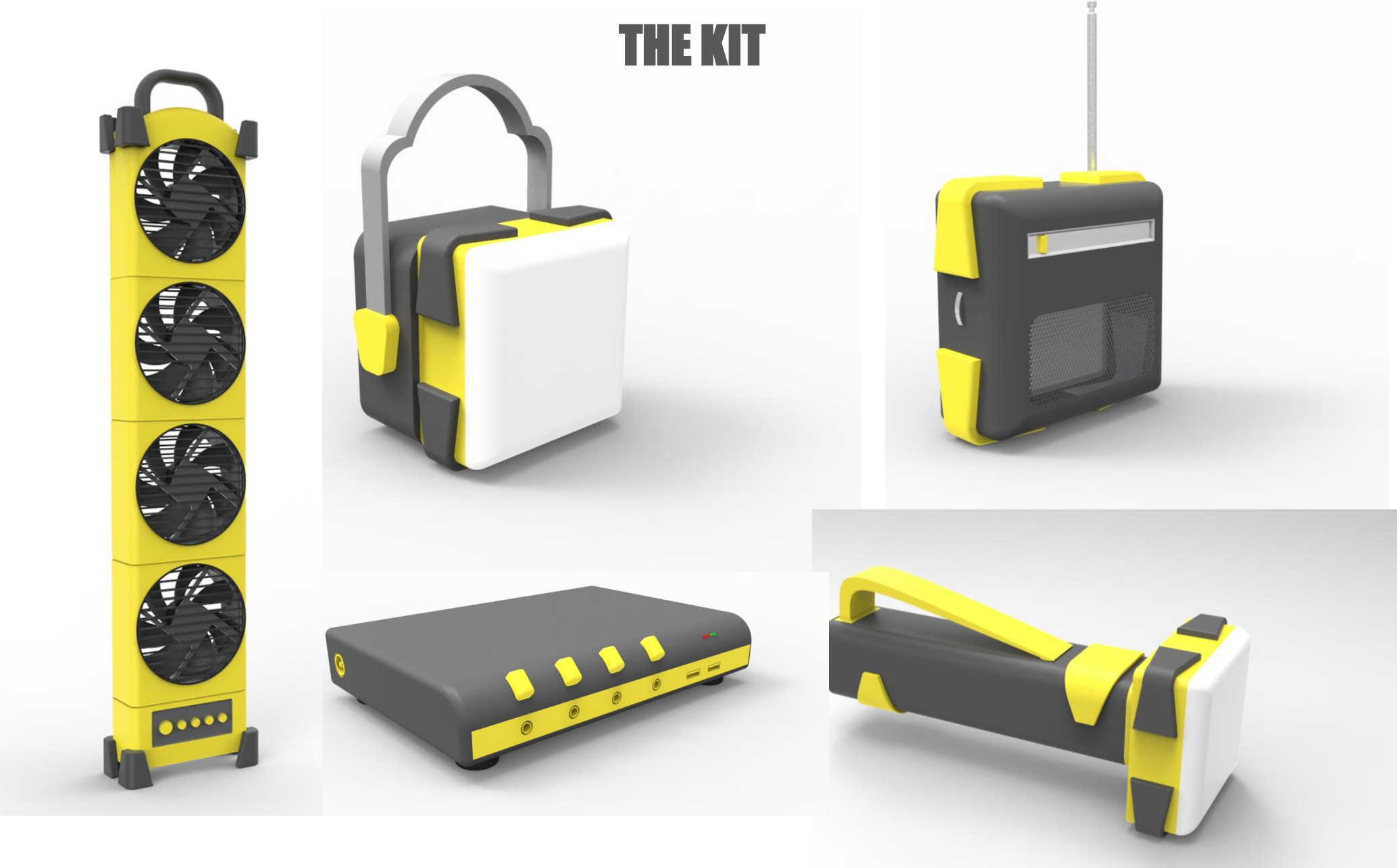


Fig: 14.7 Products in the Kit

15. PROTOTYPING

Prototypes were made using polystyrene and acrylic materials.

Fig: 15.1 Prototyping

Prototype: Fan

Fan in vertical position

Handle for easy portability

Switches at the base for easy push

Higher ground clearance for preventing wear due to rough floor at rural houses

Fan in Horizontal position for use while sleeping

Fig: 15.2 Prototype: Fan

Asymetric connection for easy connectivity and preventing from connecting wrong terminals

Fig: 15.3 Prototyping: Lamp and holder

LED/Lamp holder with arrangement for hanging

Lamp holder attached to the lamp can also be kept on floor if needed

Lamp hanging on a hook attached to wall

A small portable battery unit contains 1/5th of the total battery needed in the system. The same battery unit can be connected to the charge controller for everyday charging. Hence it also serves as a power bank when needed

Torch unit has connectors in 2 positions such that it can be kept vertically on floor or horizontally used as torch.

Lamp unit connected to portable battery unit to make a torch/flash light

Fig: 15.4 Prototyping: Torch

The battery unit can be connected to the radio making the arrangement portable. As rural people prefer the radio unit to be carried to their farm listen to it while working.

Fig: 15.5 Prototyping: Radio

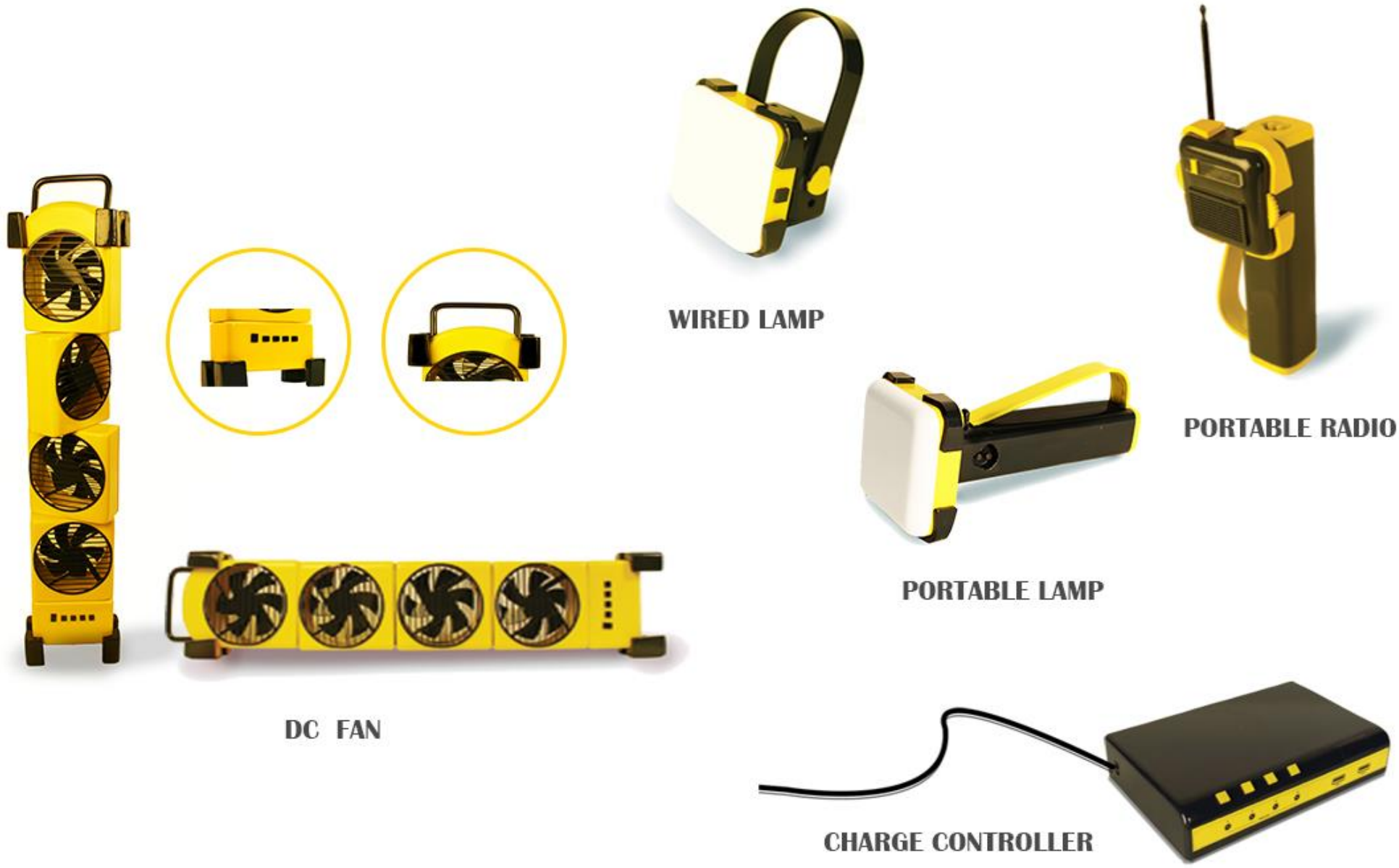
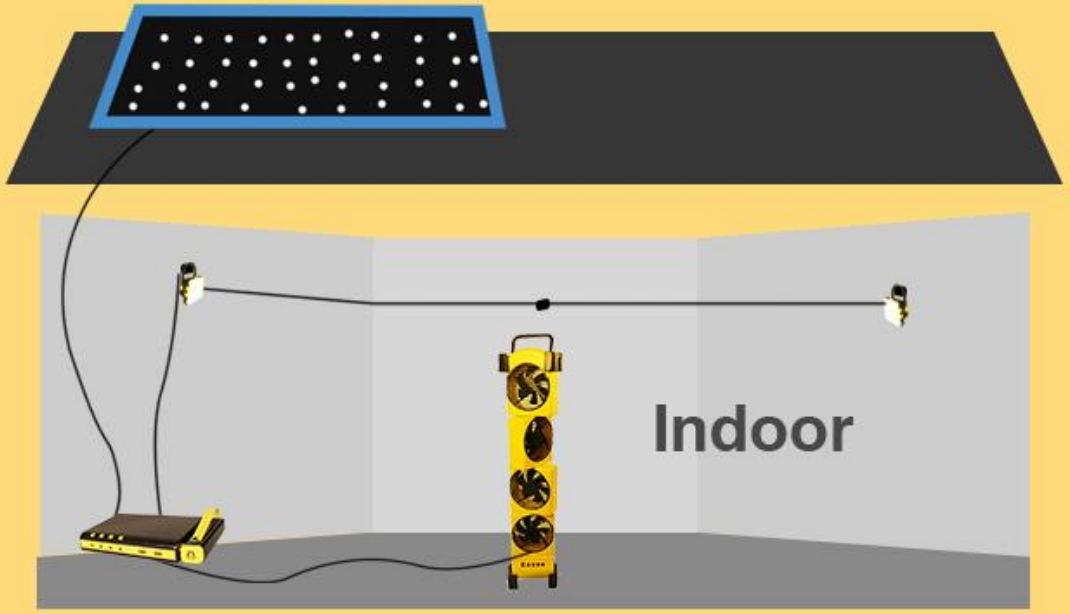
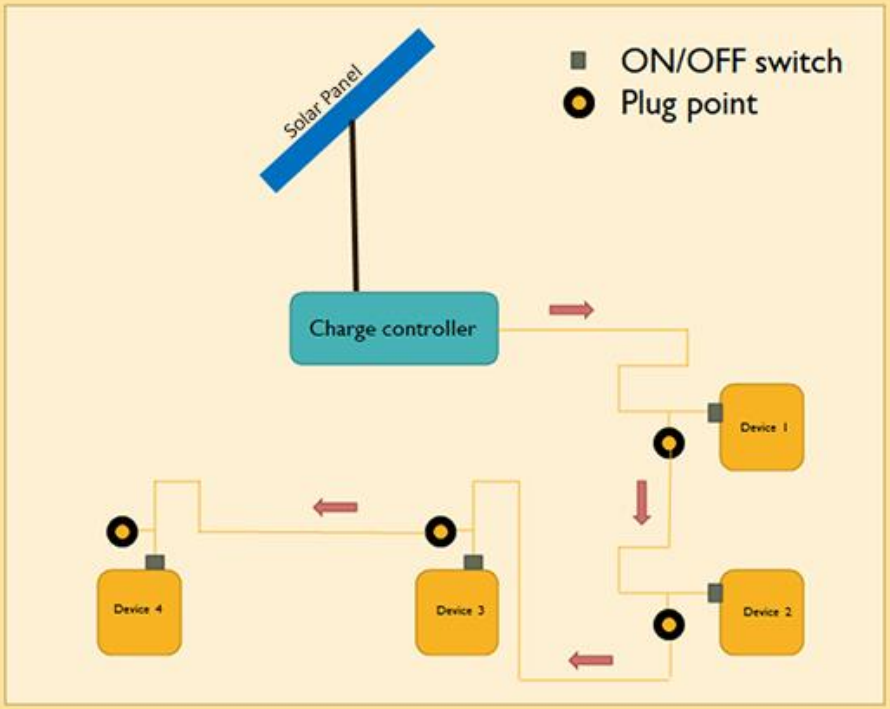


Fig: 15.6 Prototyping: The Solar Kit

System Design





Outdoor

An illustration depicting the probable arrangement of devices in the house, the connectivity and position of charge controlle, solar panel, lamps and fan.

Fig: 15.7 Prototyping: The system working

16. ASSEMBLY AND MEASUREMENT

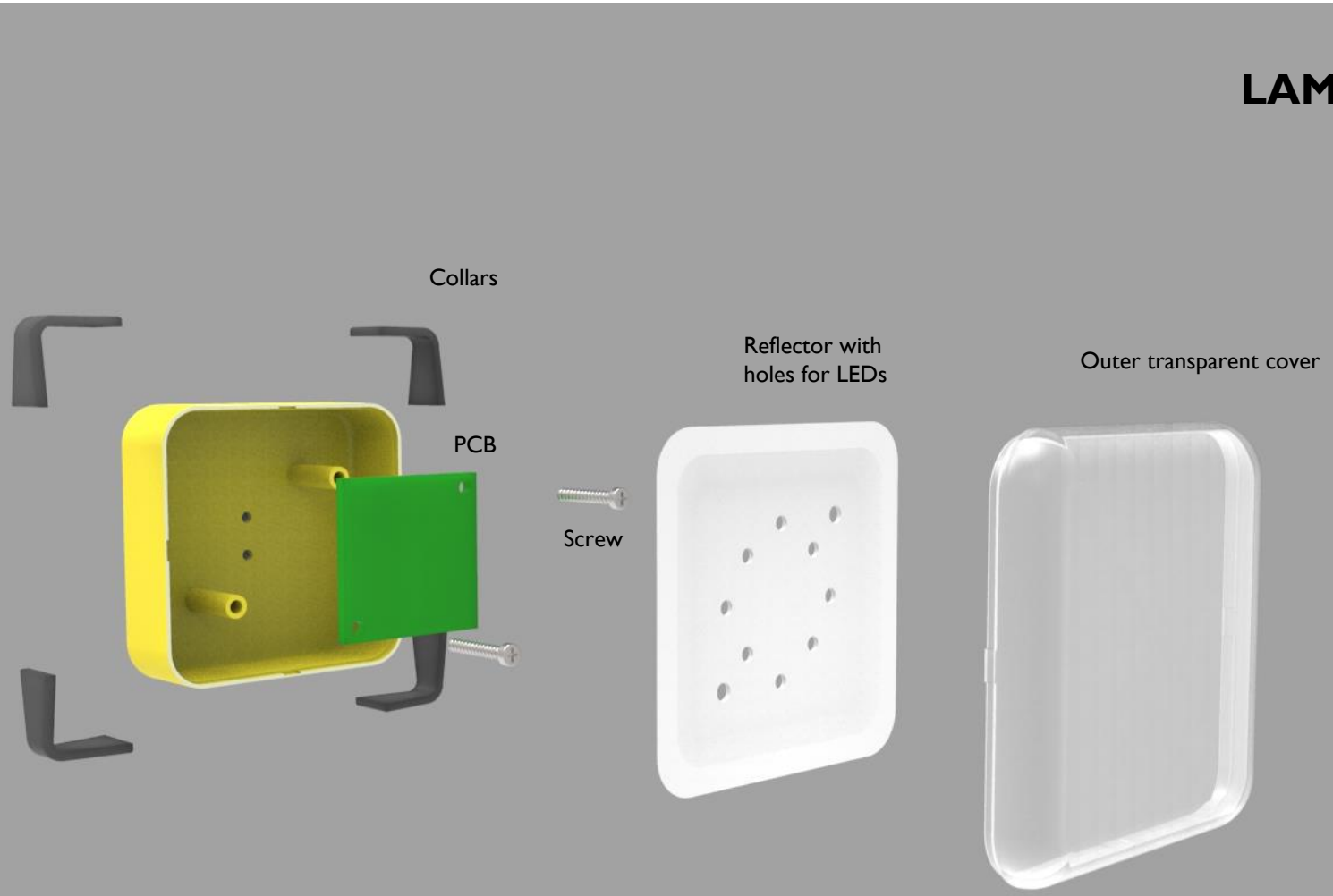
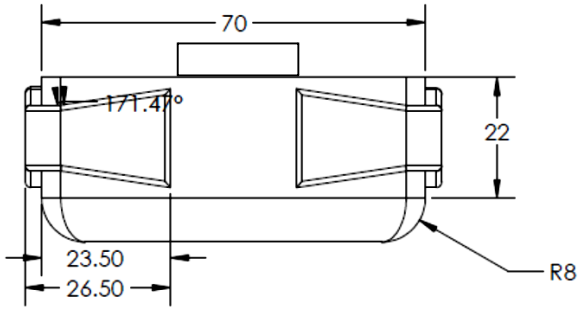
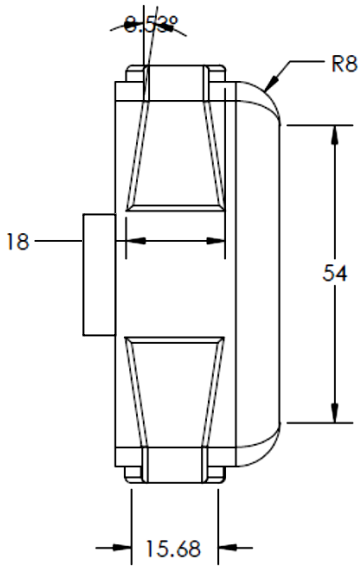


Fig: 16.1 Exploded view: Lamp

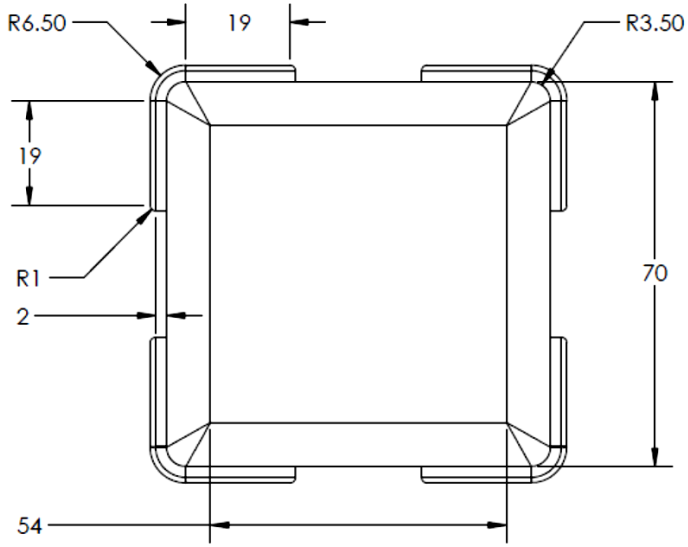
Dimensions



TOP VIEW



SIDE VIEW



FRONT VIEW

All dimensions are in mm

Fig: 16.2 Orthographic view: Lamp

RADIO

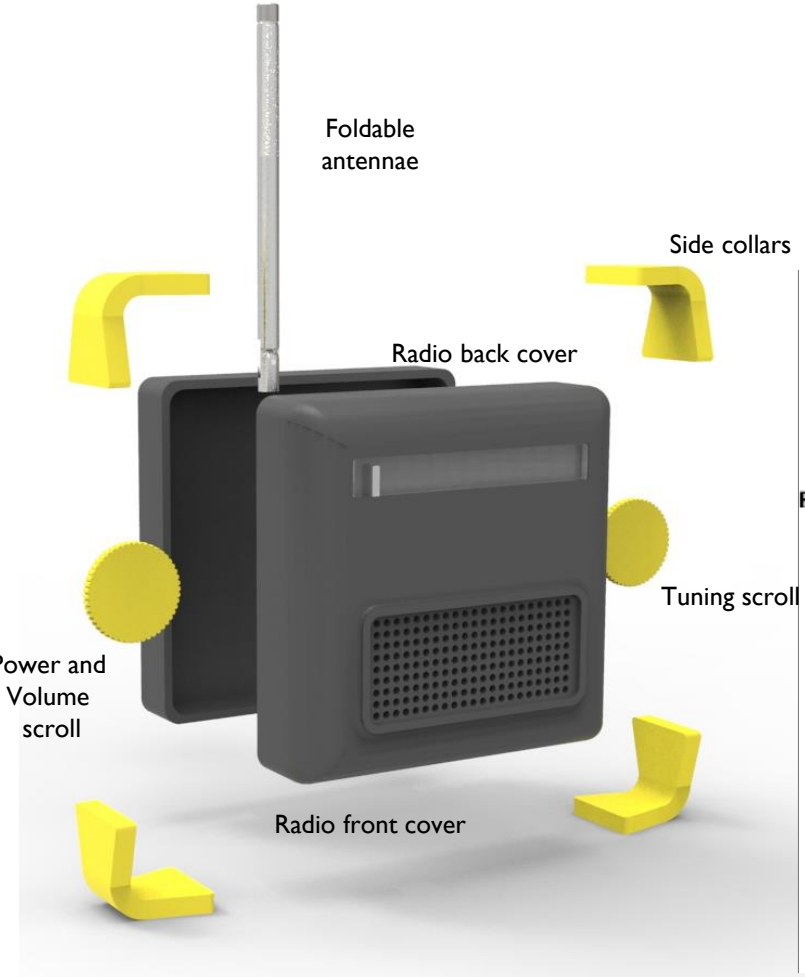
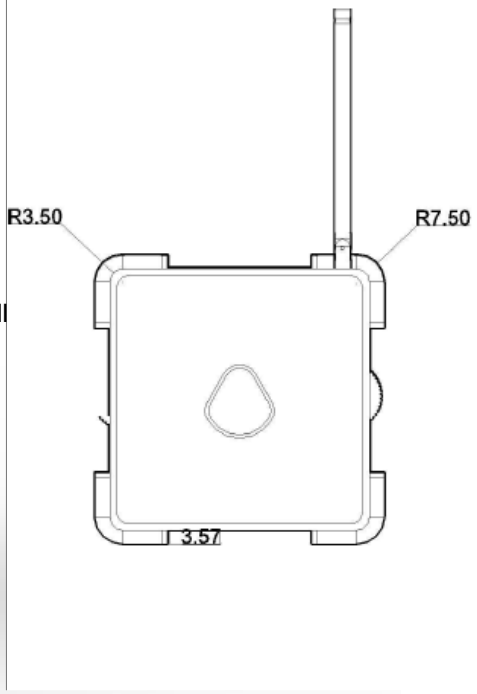
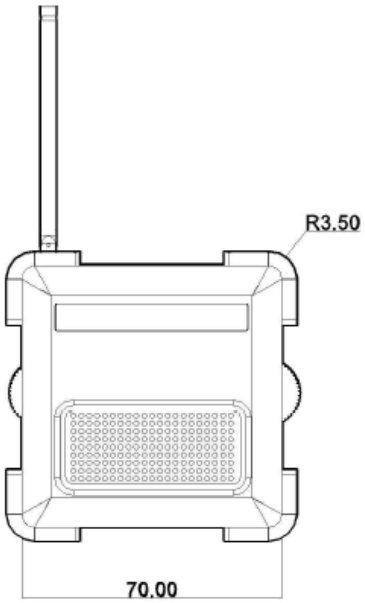


Fig: 16.3 Exploded view: Radio





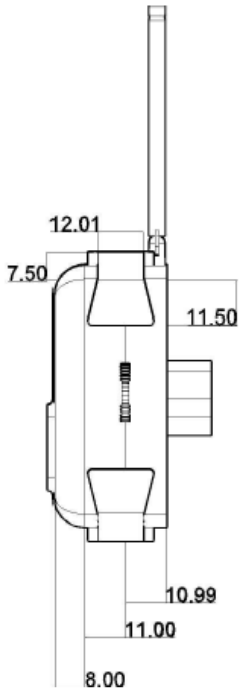


Fig: 16.4 Orthographic view: Radio

All dimensions are in mm

CHARGE CONTROLLER

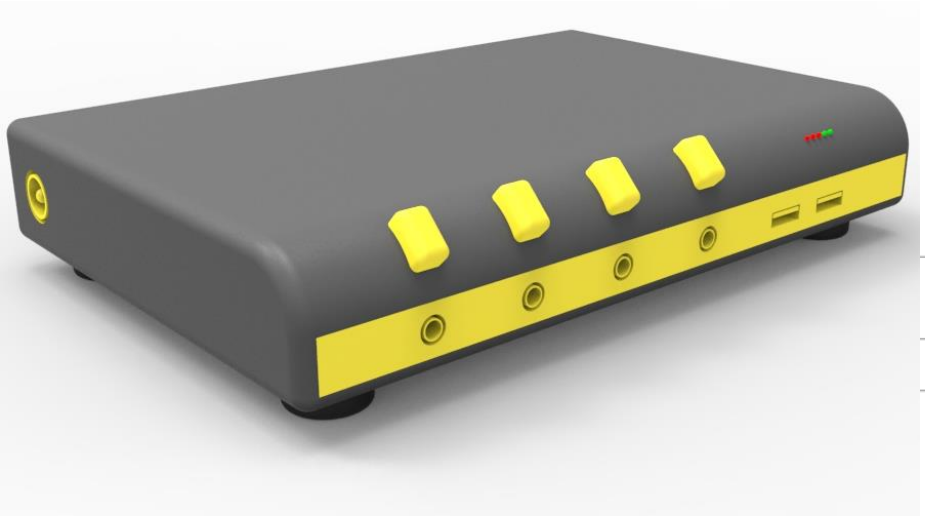
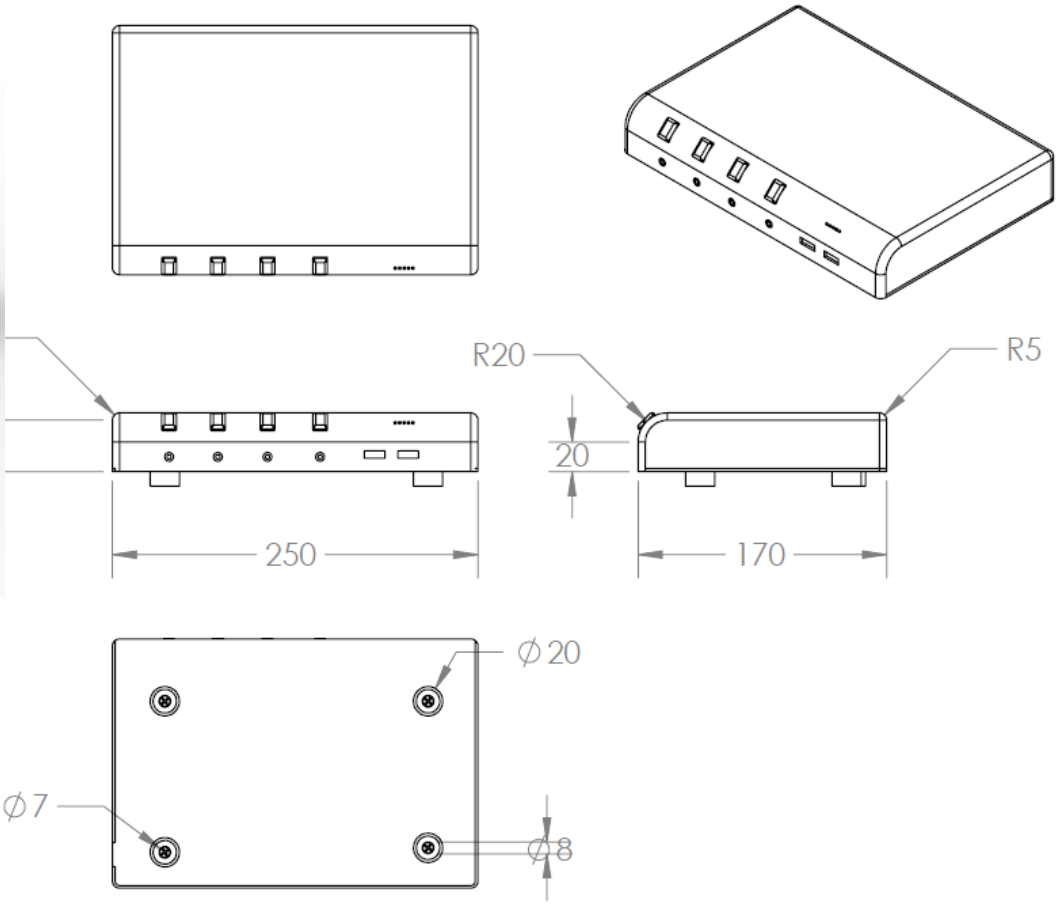


Fig: 16.5 Charge Controller

Fig: 16.6 Orthographic view: Charge controller



Manufacturing Process: Injection moulding
Material: HDPE

Dimensions of the assembled charge controller

All dimensions are in mm

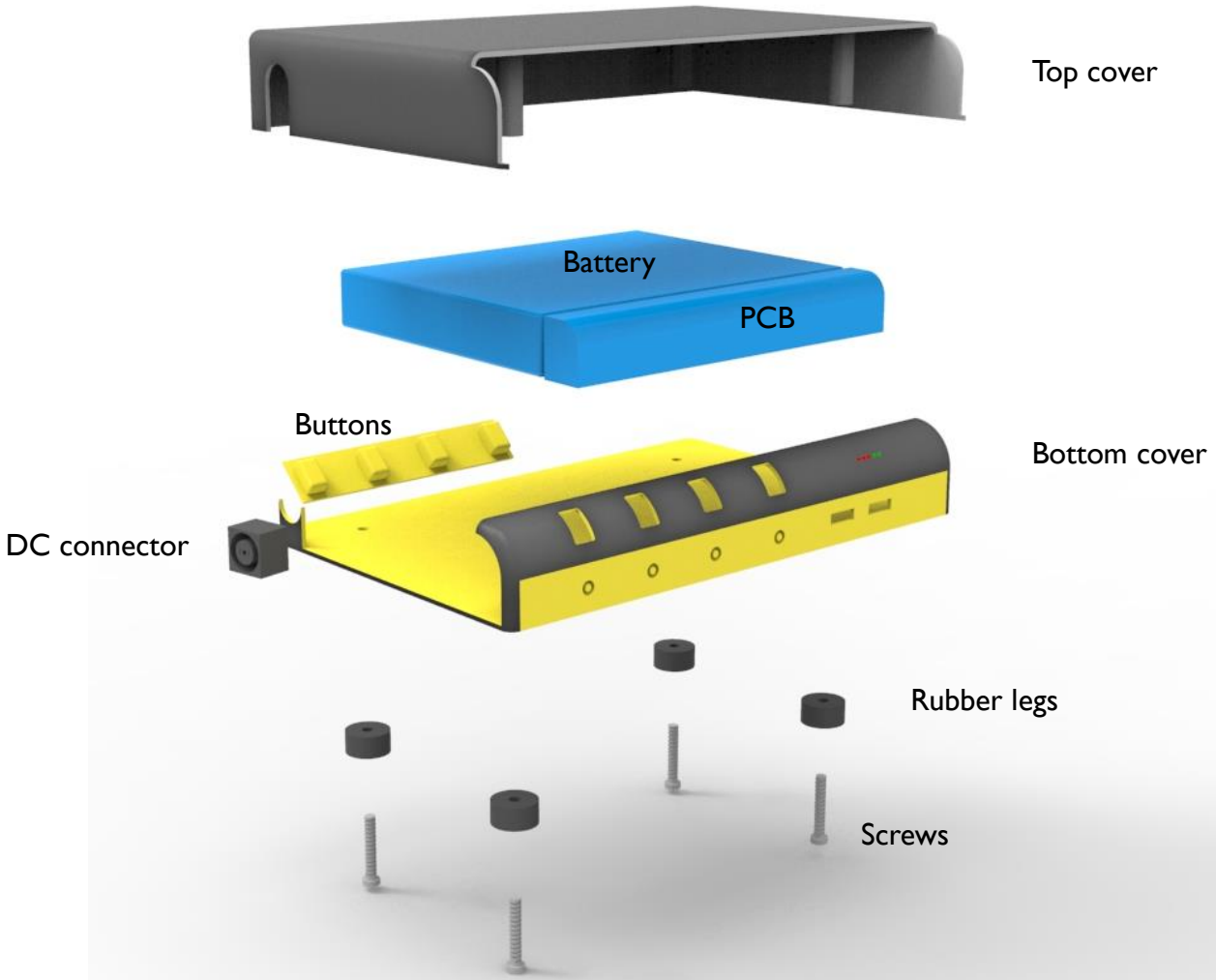
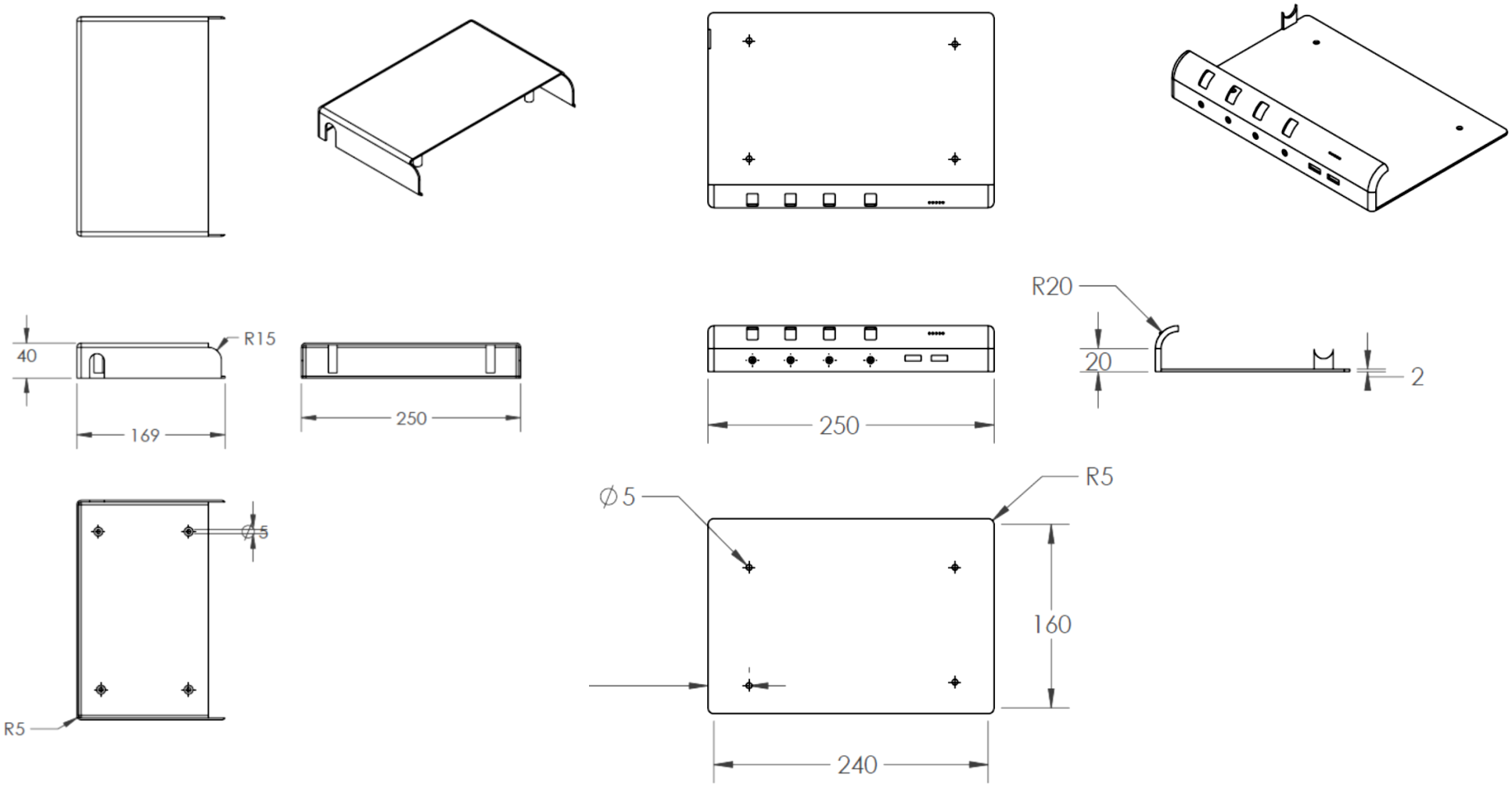


Fig: 16.7 Exploded view: Charge controller



Top cover

Bottom cover

Fig: 16.8 Parts and dimensions: Charge controller

All dimensions are in mm

LAMP HOLDER

Manufacturing Process: Injection moulding and co-moulding
Material: HDPE

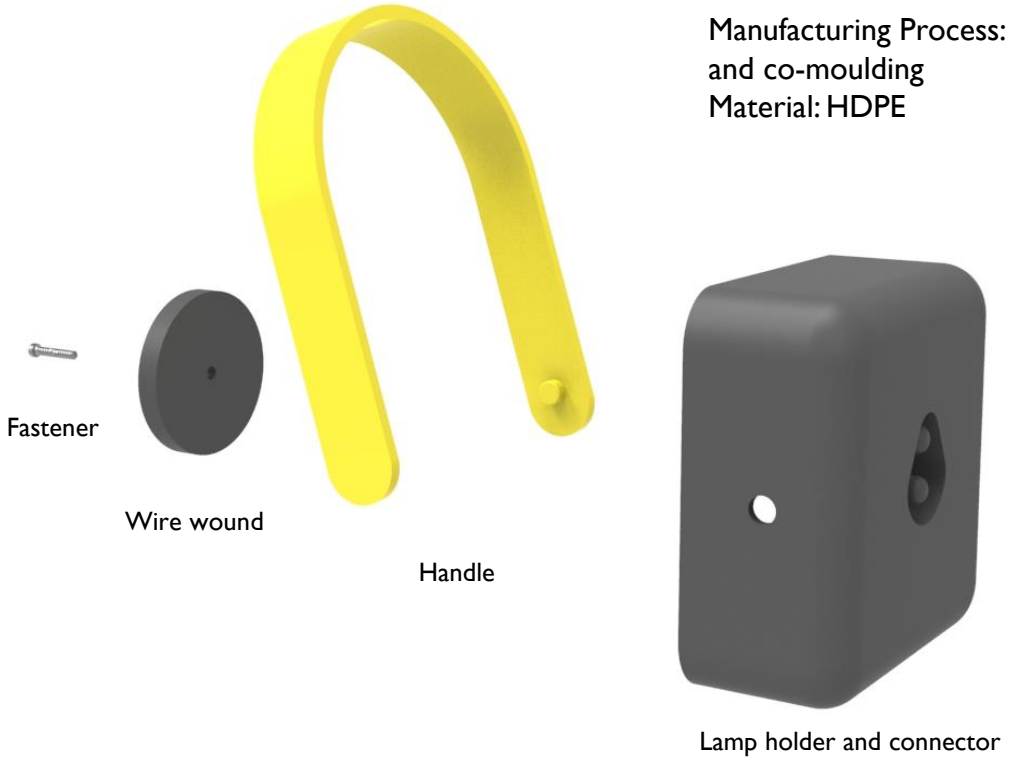


Fig: 16.9 Exploded view: Lamp holder

Fig: 16.10 Lamp Holder

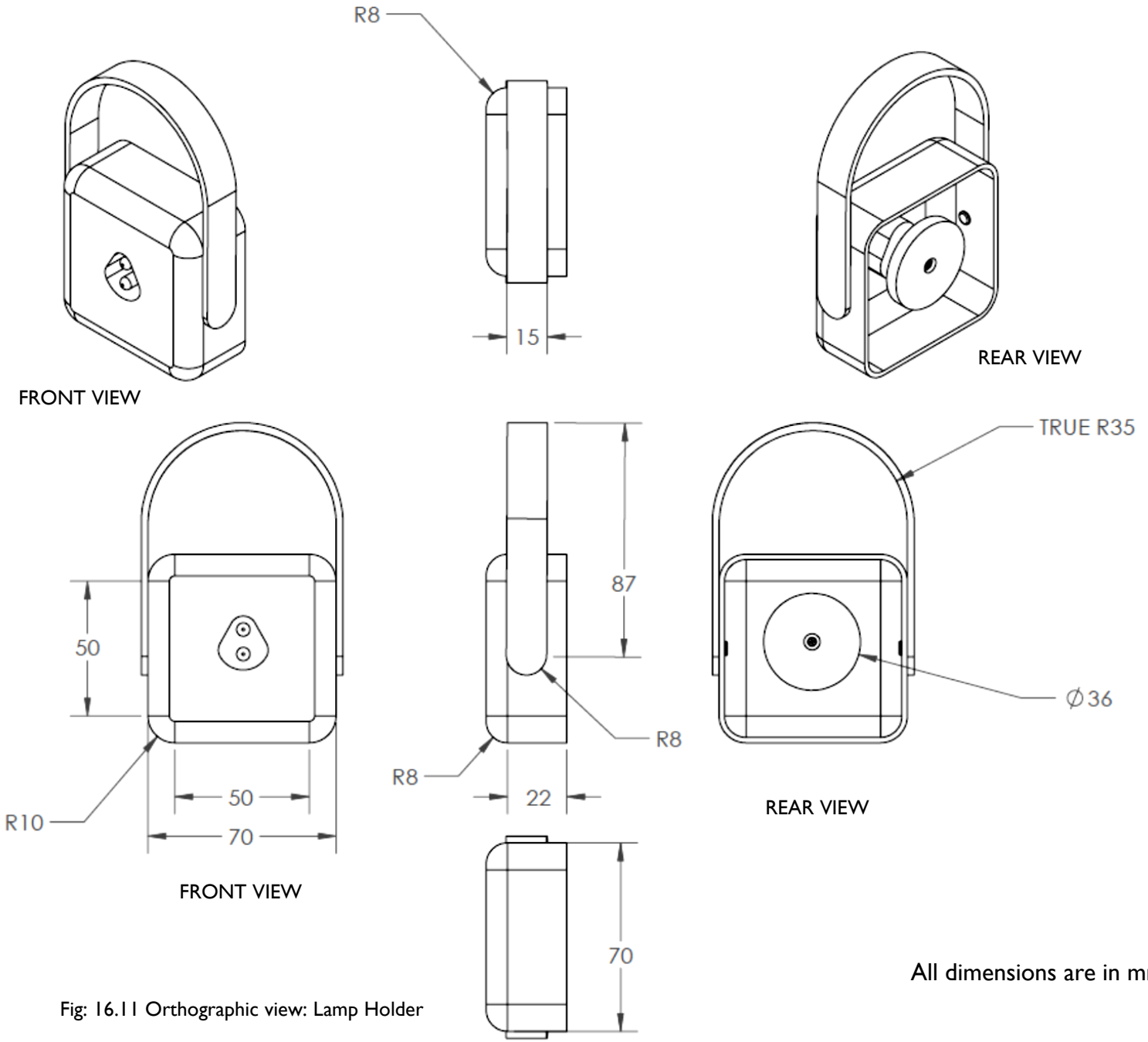


Fig: 16.11 Orthographic view: Lamp Holder

All dimensions are in mm

TORCH BATTERY

Manufacturing Process: Injection moulding and co-moulding
Material: HDPE

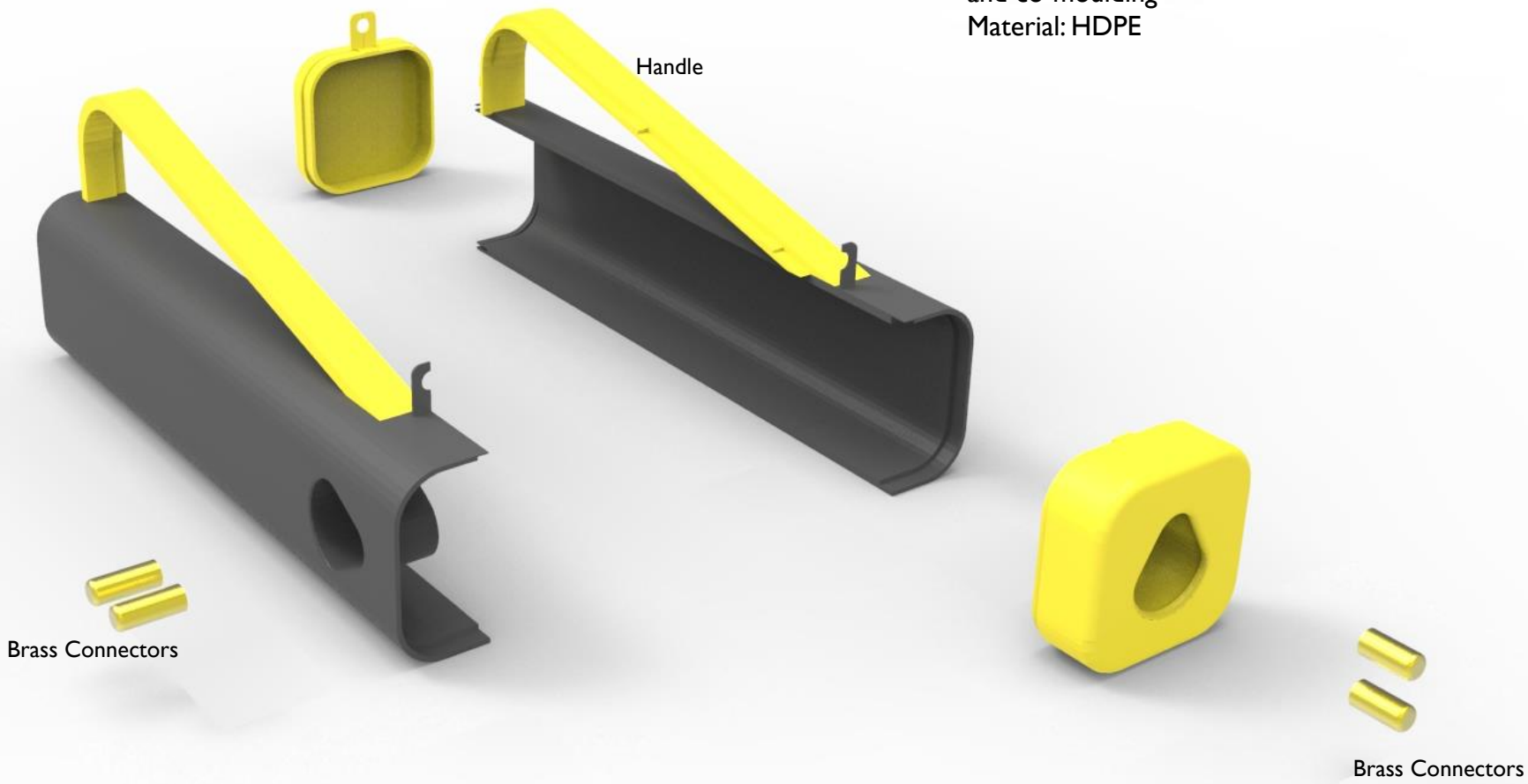


Fig: 16.12 Exploded view: Torch battery

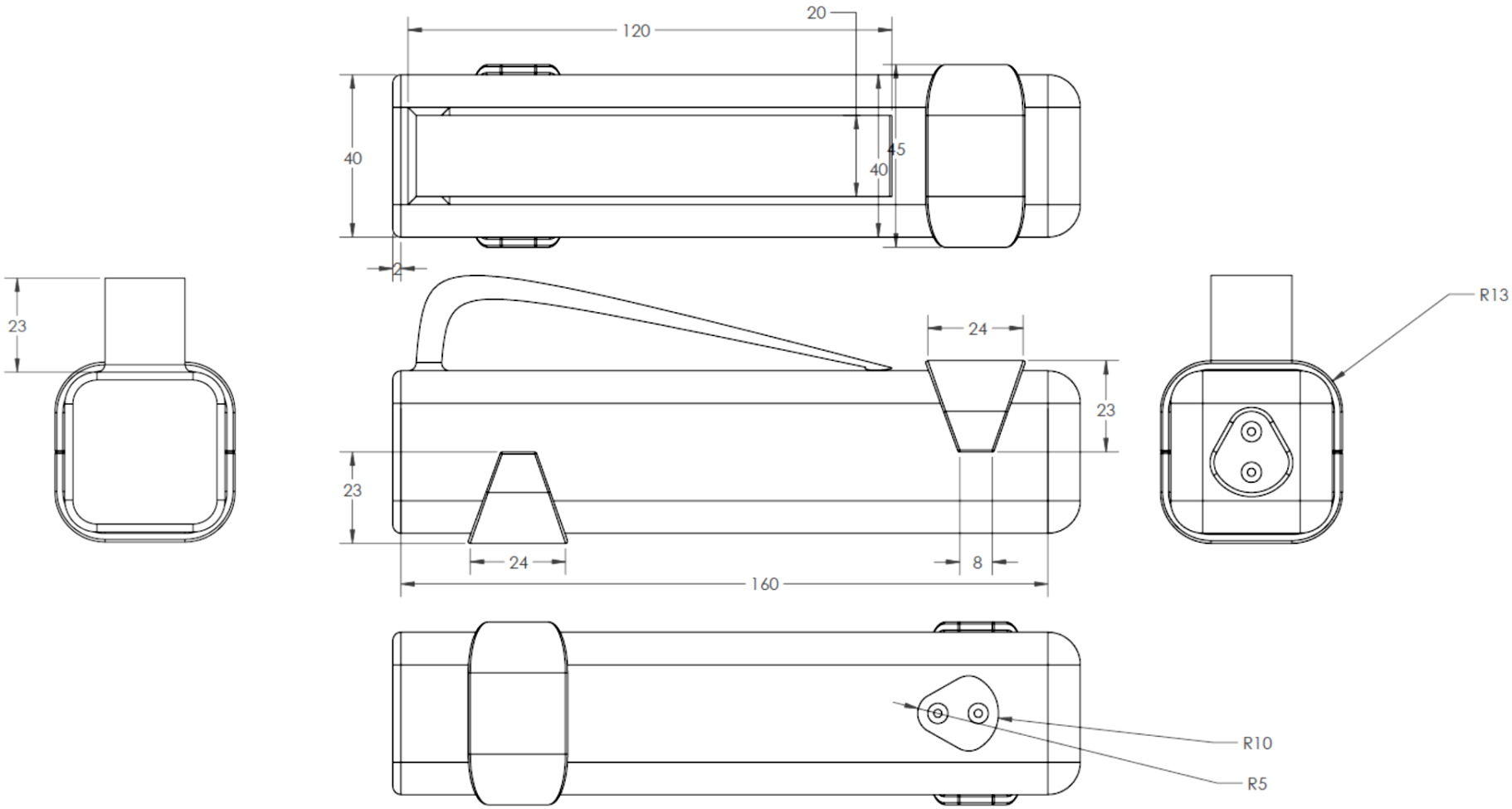


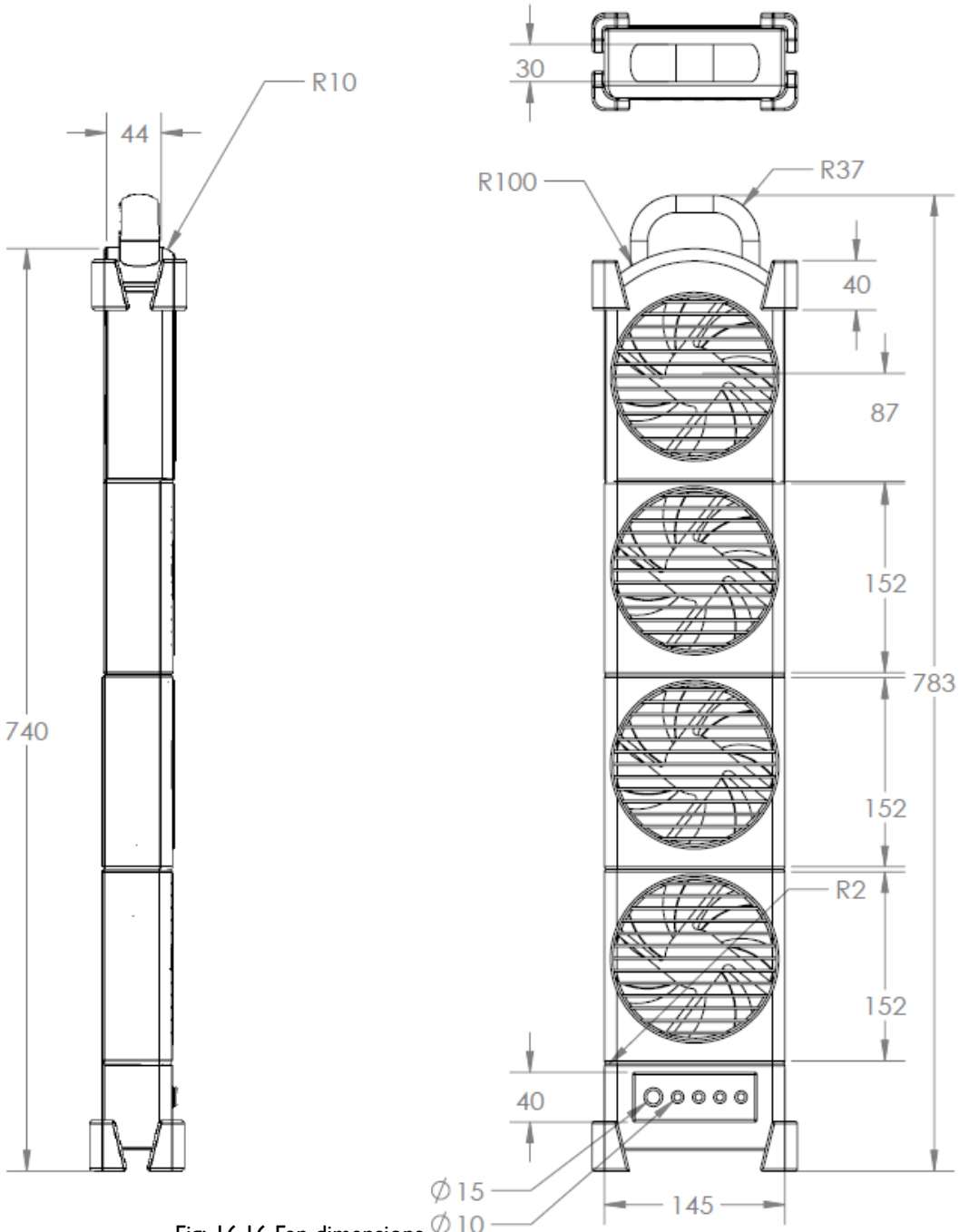
Fig: 16.13 Orthographic view: Torch battery

All dimensions are in mm

DC FAN

Fig: 16.14 Exploded view: DC Fan

Fig: 16.15 DC Fan



All dimensions are in mm

Fig: 16.16 Fan dimensions

CONCLUSION

According to the focus of the project, the system and its components were designed in an innovative way keeping in account the need for electricity for the regular household in Indian villages. The concept was finalised with approval of the locals visited during the project and further refinements were designed according to the usability and system requirement.

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