Project III

Hybrid Sourced Lighting

By

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Declaration

I declare that this written submission represents my idea in my own words and where other's idea or words have been included. I have adequately cited and referenced the original source. I also declared that I have adhered to all principles of academic honestly and integrity and have not misrepresented or fabricated or falsified any data/fact/source in my submission. I understand that any violation of the above will cause for disciplinary action by the Institute and can evoke penal action from the sources which have thus not have been cited or for whom proper permission has not been taken when needed.

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Date: 31·05·14

Approval Sheet

This Industrial Design Project 3 entitled Design of Hybrid sourced Lighting for areas with high load shedding. by Vinoth VV, 126130005, is approved in partial fulfilment of the recruitment for Master of design degree in Industrial Design.

Project Guide:

Chair Person:

Internal Examiner:

External Examiner:

Date: 31.08.14

Place: Mumbai

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Acknowledgement

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Abstract

Lighting is one of the major issues during the long power shut down in energy sparse country like India. Though there are alternate ways of power generation, they are highly seasonal, not very cost effective or require human effort, which leads to hybrid options. And the most viable solution lies in the energy harvesting methods.

The project evolved in two phases with the first phase on general research of alternate power, lighting and experimentation on few techniques. With the inferences from the first phase, the second phase of the project was highly focused on the power production using Thermo electric generator (TEG) and the scenario in which it could be used.
Initial ideation covers the possible chances of producing power using TEG in the house scenario, without doing much labour.
After a series of research, the context of kitchen, which is one of the most sought after places and require adequate lighting at any time of the day, is chosen for power generation as there is heat generation happening at least two times a day.

During cooking, almost two third of the heat is wasted in the surrounding, the idea of the project is to harvest that energy using Thermo Electric Generator and produce power which could be used for lighting and charging low power gadgets. Thus, the project aims at developing a reliable secondary source of light and power. And increasing the overall efficiency of energy utilization in the house.

Based on that, user study and market study is conducted to understand the scenario and the possible applications of TEG.

Actual Thermo electric generator is used to conduct experiments and various levels of heat exchange possibilities were understood and the concepts were generated based on that.
Structural design for the product is chosen for the uncomplicated manufacturing and easy maintenance.

The product will act as a secondary source of task light during load shedding and can support charging of low power gadgets.

Content

Content

Introduction

The idea of doing a project on lighting raised long back in my mind, when I saw the usage of electric light bulbs when there is abundant light outside during daytime. As lighting consumes major part of our electricity, I pitched my intention as P3 topic and started exploring on different ways of saving power and enhancing the lighting and experience around it.

Idea of combining natural and artificial light is achieved by the Hybrid lighting concept which uses optical fibre to transfer natural light inside the building. which is also more reliable and saves power.

The word hybrid leads to find, other options to increase the efficiency of light and save power, One way is by combining day to day human activities to generate power and hence support lighting.

The elaborate research begins with the study of light, lamps and lighting systems. Then the different non-conventional power sources and how they can support lighting.

The design cannot exist without considering the user. For my scenario, I choose one of the most power craving country like India, where power black out is a common problem. The user, their context and their activities during the power cuts are analysed to come up with the design.

Also from the technological insights through literature and experiments, ideation, detailing and prototyping, final design solution is evolved.

By considering the future possibility of technology, user feedback and design scope, I choose Lighting using Thermo electric generator(TEG) as the source of power combined with the grid power.

Scope of the Project:

Thermo electric generator is not a new invention, but due to the high power requirements of the early lighting and instruments, it couldn't catch up in the mainstream research.

Since the advent of the semiconductor devices in lighting, communication and also the desire to conserve resource, TEG's are identified as one of the best alternative for the power generation.

This project aims at the design of a device which can act as secondary source of power generation and lighting during power black outs, as a replacement for rechargeable torch lights and emergency lights for the middle class users of India.

Light

Light is the only radiation which is visible to human eyes which makes us see things, It is the Natural agent that simulates sight and make things visible. Light is a form of energy and can be measured in energy units (joules, calories) or in quantum units (quanta, Einstein's).

Wavelength and colour

The only difference between the several forms of radiation is in their wavelength. Radiation with a wavelength between 380 and 780 nanometres forms the visible part of the electromagnetic spectrum, and is therefore referred to as light.

The eye interprets the different wavelengths within this range as colours – moving from red, through orange, green, blue to violet as wavelength decreases. Beyond red is infrared radiation, which is invisible to the eye but detected as heat.

Light can be measured subjectively, based on the brightness seen by the human eye. Units include candles, lumens, foot-candles and lux.

Few technical terms of light and lighting;

Sight
Vision
Colour
Illuminance
Contrast
Adaption
Glare
Measurement
Photometry
Health effects

Lighting

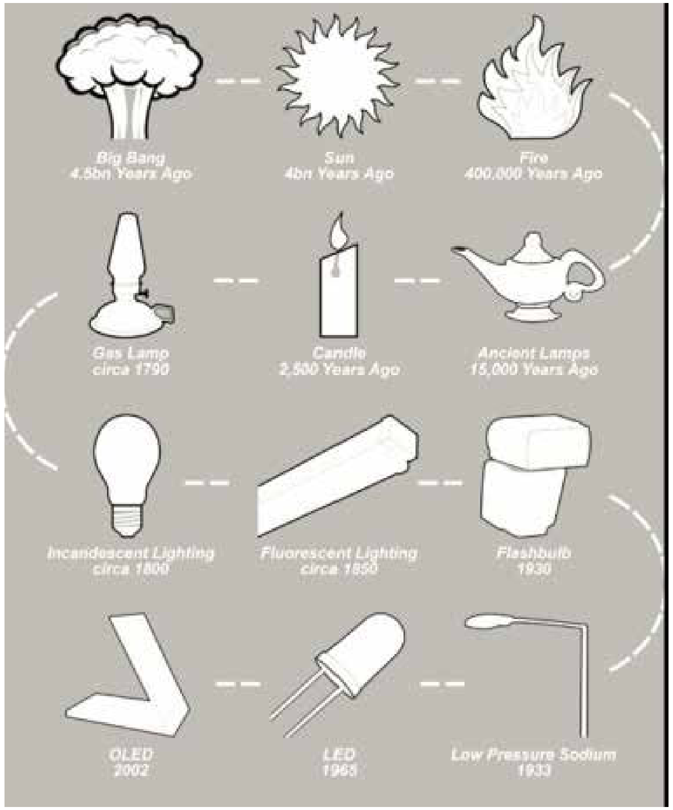
Lighting or illumination is deliberate use of light to achieve practical and aesthetic effect.

Lighting can be achieved by Natural and Artificial ways. Artificial lighting is created by lamps, which is of different categories starting from incandescent lamp to laser lights.

http://tinyurl.com/nsg8sq9

http://tinyurl.com/pyo5a45

History of Lighting at a glance:



http://tinyurl.com/nmdtr7h

Man made lighting starts with the discovery of fire to latest advent of semiconductor lights like LED's. The modern semi conductor era opened up new avenues of lighting with lesser power usage.

Lighting system

General lights:

Ambient lighting provides overall illumination for a room, and is intended to create a uniform light level throughout a space, independent of any special lighting.

Task Light:

Targeted to a particular area of a room, task lighting is intended to illuminate a specific function. Areas of a home that require task lighting include kitchen counters where food will be prepared; living room seating areas where reading will take place; and home office desk surfaces where paperwork will be done.

Accent Lights:

Its called highlighting, accent lighting draws attention to a particular object, such as artwork, sculpture, plants or bookcases. Accent lighting is often used outdoors, to highlight a beautiful tree, plant or water feature.

Lamp:

While the lamp is the primary source of light, reflectors and lamella are required to help spread the light and direct it where it's needed. The luminary is the apparatus that performs these functions. It contains elements for distributing, filtering and transforming the light emitted by a lamp and includes all items necessary for fixing and protecting the lamps and for connecting it to the power supply.

Img 01(a-c)

Img 02

Images from the book 'Phillips Lighting Solution'

Luminaire

The luminaries are device used to create artificial light, and the design of luminaries in itself is a vast and challenging field for designer, where you deal with both the light, shadow and form of the product.

Luminaire types:

- Recessed-mounted luminaires
- Spots/projectors
- Surface-mounted luminaires
- Decorative luminaires
- Pendant luminaries
- Free-floor-standing luminaires
- Up lights
- Trunking lighting systems
- Down lights

Img 03 (a-g)

Different fixtures and position of lighting is shown in that image aside.

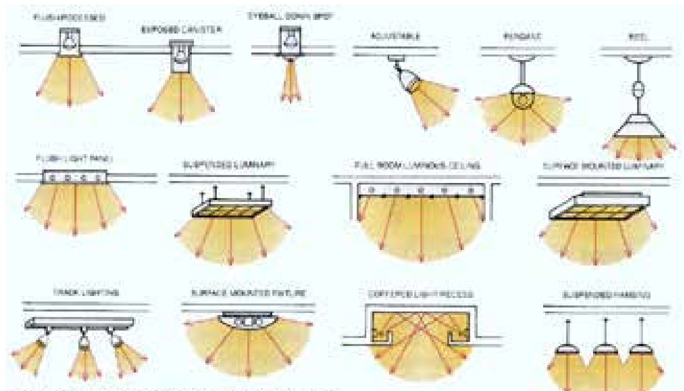


Fig. 31-16 ■ Examples of types of ceiling fixtures.
http://tinyurl.com/k8xujwt

But one thing which is common in all these lighting types is that all of these are grid connected, without which the system can not work. As mentioned in the introduction that the project aims at improving the lighting efficiency and saving power, which will be difficult to achieve with the grid connected lighting.

From the study it is understood that day light combined with artificial light is achieved through Hybrid lighting systems.

We will ponder this in detail by the progress of the report.

Causes and Application:

- To save energy spent on lighting during day time and also energy spent on maintaining temperature.
- Health benefits for users from natural light since we spent considerable amount of time working inside the building
- It could be used as direct ambient lighting or indirect task light or accent light.
- Retrofitting to incorporate in the old buildings is a possibility and is highly efficient for public places and commercial buildings.

First Design brief:

To come up with a design solution to harvest natural light and bring artificial light using the same provision or luminary.

Alternate power sources for lighting

Understanding lighting alone wont help in designing a effective solution, It also involves the power production. Since the goal is to produce more reliable and energy efficient lighting solution, it is apparent that we have to look in to the non conventional power production.
In our case we are going to explore few of the below mentioned non conventional sources along with few other like human powered, gravity powered, thermo electric methods of power generation for lighting purpose.

The consumption of energy is directly proportional to the progress of the man kind.
Energy generated by using wind, tides, solar, geothermal heat, and biomass including farm and animal waste as well as human excreta are known as non-conventional energy. All these sources are renewable or inexhaustible and do not cause environmental pollution. Renewable energy replaces conventional fuels in four distinct areas: electricity generation, hot water/ space heating, motor fuels, and rural (off-grid) energy services.

The aim of different sources is to produce power, For ease of categorization and design intervention, It can be classified as follows.

- Using solar energy directly to produce power
- Mechanical means of converting the source / work in to power.
- And an open category (which include bio mass, thermo electric,piezo electric, soil.)

Solar

It is the free abundant source of energy available during day time , which is harvested through Photo voltaic cells and stored in battery for many application. The power extracted depends on the size and property of the panels used for power production.
Solar street lights provide public lighting without use of an electrical grid; they may have individual panels for each lamp of a system, or may have a large central solar panel and battery bank to power multiple lamps.
In India Solar lamps, commonly called solar lanterns, using either LEDs or CFLs, are being used to replace kerosene lamps.

Pros:
Best Renewable and off the grid energy solution.
Abundantly available Green,clean energy.
Great number of research in this field, supports the technology and fast phase development.

Cons:
This is Seasonal power, only available during day time and sunny weather,
Need batteries for storing and usage during the night.
High initial cost for installing huge solar cells.

Img 04 (a-d)

Liter of Light

Lighting using the refractive property of water bottle to light the dark interiors during day time.
The device is simple, it is a transparent 1.5 - 2 liter plastic bottle, typically used for carbonated drinks, filled with water plus a little bleach to inhibit algal growth, fitted through the roof of a house. During daytime the water inside the bottle refracts sunlight, delivering about as much light as a 40- to 60-watt incandescent bulb to the interior. A properly installed solar bottle can last up to 5 years.
This is a open source project installed in many parts of the third world as efficient day lighter and alternate for incandescent lamp.

Pros:
Self sufficient method of interior lighting. Production cost is very low.
Zero carbon emission involved and highly sustainable.
High efficiency in conversion ratio of solar energy to light.

Cons:
Problem in sealing the bottle.
Need for a sky facing roof for installing the module.
Wont work effectively during the cloudy days.

Img 05 (a-c)

Hybrid Light

Hybrid solar lighting or hybrid lighting systems combine the use of solar with artificial light for interior illumination by channelling sunlight through fibre optic cable bundles to provide solar light into rooms without windows or skylights, and by supplementing this natural light with artificial -typically LED- light as required.
They use rooftop collectors, large mirrored dishes, that track the sun. The collectors adjust to aim the sunlight onto 127 optical fibres which are conducted into a single chord. A single collector can power up to eight hybrid light fixtures covering 1,000 square feet
It is getting popular among the housing societies and commercial buildings in US. The solution requires a system level change.

Pros:
It Saves power bill by using day light.
Natural light comes with the health benefits.
One collector device can supply enough light for the whole house.

Cons:
Not a very cost effective solution, since it requires system level change and it can only be used in rooms with direct roof access
Fibre optics technology for light transfer
has not reached its optimum.

Img 06 (a-c)

Mechanical: Gravity light

Gravity light is a mechanically operated gravity powered lamp as a replacement for kerosene lamps in third world countries. It uses a bag filled with rocks or earth, attached to a cord, which slowly descends similar to the weight drive in a cuckoo clock. This action powers the light for up to thirty minutes.
It takes 3 sec. to lift the weight of rock or earth attached to it, which slowly descends, puling a strap that spins gears and drives a motor(mechanical conversion), which continuously powers an LED
There are no operating costs after the initial purchase of the appliance.

Pros:
Its a self sufficient energy generator.
No operating cost for the device.
Clean energy and very less initial investment.
Efficient energy harvesting.

Cons:
Devoid of portability.
Difficult for old people and children to lift
20kg weight
Inconsistent energy, have to reload it every 25 minutes.


a


b


c

Wind power

Wind power is produced by using wind generators to harness the kinetic energy of wind, It uses wind turbines to produce electrical power, windmills for mechanical power, wind pumps for water pumping or drainage, or sails to propel ships.
It is used in both small and large scale application. Small scale wind turbines are used in water pumps, street lights, Equipment such as parking meters, traffic warning signs, street lighting or wireless Internet gateways may be powered by a small wind turbine, possibly combined with a photo voltaic system, that charges a small battery replacing the need for a connection to the power grid.
Wind power acts as one of the main contributor for Off the grid system and for alternate power.

Pros:
Utility grid-tie, off-grid & critical backup power applications
Highly customizable
Low maintenance and long life

Cons:
Highly seasonal, though in long term, it may seem consistent. It varies more in short term.
Portability issues and can’t be reliable completely.

Img 07 (a-c)

Human powered

It is the conversion of muscle power (physical action) to charge the battery through a dynamo or magnetic induction by shaking, cranking, pedalling, etc.
Body parameters like heat, movements, pulses are also sometimes used to generate power for wearable devices.
Human powered devices are used in wide variety of applications from charging lamp,radio, kitchen appliances, as emergency lights and rescue operation.
Powering electronic devices using human power is one of the trending research topic.

Pros:
Best alternate source of energy during emergency.
Highly dependable and mostly portable form of energy generation.
It is scalable depending on power requirement.

Cons:
Efficiency depends upon person to person and the device conversion/gear ratio.
Continuous human labour needed for power production,
And battery to store energy.

Img 08(a-d)

Piezo electric

Piezoelectricity is the electric charge that accumulates in certain solid materials (such as crystals, certain ceramics, and biological matter such as bone, DNA and various proteins) in response to applied mechanical stress. The word piezoelectricity means electricity resulting from pressure.
It is becoming popular in energy scavenging, mostly for wearable devices and centralised body worn power packs charging. which is a shift form the industrial and commercial application.
Power generated by Piezo electric device is very less, but still it could be used for lighting by single battery, since the power requirement of semi conductor lighting is low.

Pros:
Convenient way of producing power by our daily activities.
Efficient energy scavenging.
Size of the Piezo sensor is comparitively small .

Cons:
Piezo electric is not a very cost effective solution.
Continuous human labour needed for power production.
Storage of energy is required for continuous performance of the device.


a

b


c

Img 09 (a-c)

Soil powered

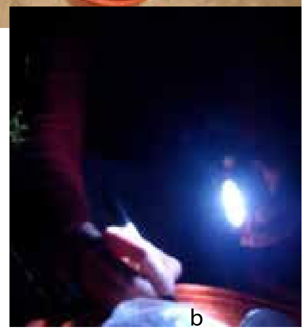
Soil naturally contains energy conducive metals like zinc, copper, iron and microbial fuel cells (sometimes referred to as an earth batteries) are capable of converting electrolytes in soil into usable energy. Dutch designer Marieke Strap's Soil Lamp uses conductive plates made from copper and zinc buried within the soil to provide constant and (nearly) eternal light for an LED bulb.
This technique offers a wealth of possibilities, because the more cells there are, the more electricity they generate. The only thing that the lamp needs is some watering every now and then.
The implications of creating energy from soil are promising – as a free and abundant resource, nearly everyone in the world has access to dirt. Because of its naturally occurring conductivity, soil is easily converted into energy that will last far beyond the lifetime of an incandescent bulb, so long and its properly watered. The power is sufficient to light 1-2 LED's for four to five hours per evening

Pros:
Easily available raw material for
power generation.
Eco friendly and self sustaining solution.

Cons:
keeping it wet every often.
Power generation depends on the
area of the graphite sheet, which means size is an issue.
Maintaining the moisture is a problem.


a





b

Img 10 (a,b)

Thermo Electric generator

Thermoelectric effect is the direct conversion of temperature differences to electric voltage and vice versa. A thermoelectric device creates voltage when there is different temperature on each side.
It works on the seebeck principle, which function like heat engines. They have a use in power plants for converting waste heat into additional electrical power (a form of energy recycling), and in automobiles as automotive thermoelectric generators (ATGs) for increasing fuel efficiency. Space probes often use radioisotope thermoelectric generators with the same mechanism but using radioisotopes to generate the required heat difference.
TEG is one of the finest green replacement for conventional grid power, which is gaining popularity.

Pros:
The sensor is very light and modular,
Scalable upto the required temperature.
Since it has no moving parts involved maintenance is easy.
High reliability, 20+ years of long life of the device.
Continuous operation in any climate (hot, cold, wet, dry)

Cons:
Typically the module is more expensive because of lesser production.
Efficiency of the device is low, around 6%-8%.

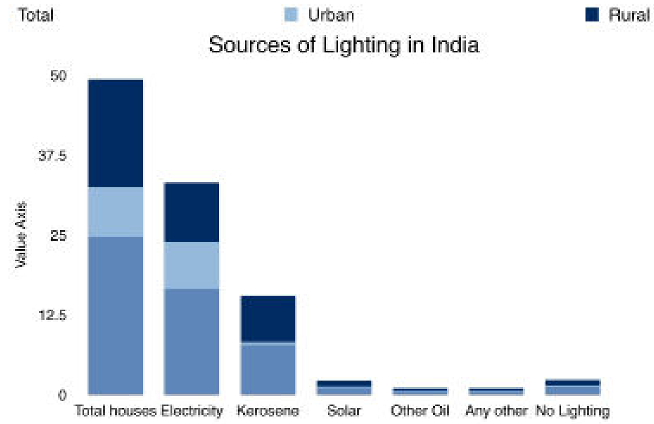
Img 11(a-d)

Context

From the beginning, the project revolves around the house hold need for power saving and lighting. In India with 72% population living in villages, Power shortage is one of the acute problem and during power black outs people depend on alternative source of power ranging from candles, kerosene lamps, emergency light, solar lamps ,oil generators etc.,
These products and solutions comes with their own limitation like the few technologies we deliberated before. which clearly shows that, power shortage is an important problem area which is to be addressed with most operative solution.

Rural need

According to the India census report; as on 31st August 2013, a total of 32,227 villages of India are yet to be provided with electricity access, out of a total of 593,732 inhabited villages.
The national average of households using electricity and solar energy for lighting is just 67.2 percent. For the study of a typical state with severe power black out problem and product positioning, State of Tamil Nadu is been chosen and the power scenario of the state is been studied.



Data is from India Census report-2013

Scope of the project

The hybrid solution as such can be applied in both Rural and Urban scenario based on the power need and user interest on energy saving.
But if the solution is self sufficient and dependable off the grid, it will be more suitable for rural areas of India from the statistics of GOI, which are as follows.

Household by source of power in every district of Tamil Nadu

Households by main source of lighting						
Total number of households	1,84,93,003	95,63,899	89,29,104	100.0	100.0	100.0
Electricity	1,72,65,059	86,83,426	85,81,633	93.4	90.8	96.1
Kerosene	10,95,489	7,91,493	3,03,996	5.9	8.3	3.4
Solar	13,669	8,720	4,949	0.1	0.1	0.1
Other oil	27,853	19,254	8,599	0.2	0.2	0.1
Any other	8,971	5,294	3,677	0.0	0.1	0.0
No lighting	81,962	55,712	26,250	0.4	0.6	0.3

Distribution of Households by source of lighting

State/ District Code	India[#] /State/ District	Distribution of households by source of lighting						
		Total No. of Households (Excluding institutional households)	Electricity	Kerosene	Solar energy	Other oil	Any other	No lighting
1	2	3	4	5	6	7	8	9
00	**INDIA**	**24,66,92,667**	**67.3**	**31.4**	**0.4**	**0.2**	**0.2**	**0.5**
33	**TAMIL NADU**	**1,84,93,003**	**93.4**	**5.9**	**0.1**	**0.2**	**0.1**	**0.4**
01	Thiruvallur	9,38,822	96.9	2.6	0.1	0.1	0.0	0.3
02	Chennai	11,06,567	99.1	0.8	0.0	0.0	0.0	0.1
03	Kancheepuram	9,93,809	96.7	2.7	0.1	0.1	0.1	0.3
04	Vellore	9,27,318	93.4	5.8	0.1	0.2	0.1	0.5
05	Tiruvannamalai	5,93,264	92.6	6.8	0.1	0.2	0.0	0.3
06	Viluppuram	8,04,343	93.1	6.4	0.1	0.1	0.0	0.3
07	Salem	9,18,899	90.9	8.1	0.1	0.2	0.1	0.6
08	Namakkal	4,77,757	92.3	6.8	0.1	0.2	0.1	0.6
09	Erode	6,58,734	90.4	8.4	0.1	0.2	0.1	0.8
10	The Nilgiris	1,98,922	90.6	8.7	0.1	0.2	0.1	0.3
11	Dindigul	5,63,172	88.8	10.0	0.1	0.3	0.0	0.7
12	Karur	2,87,848	92.0	7.3	0.0	0.1	0.0	0.5
13	Tiruchirappalli	7,00,852	93.0	6.4	0.0	0.1	0.0	0.4
14	Perambalur	1,49,401	90.9	8.4	0.0	0.3	0.0	0.4

Distribution of Households by source of lighting

State/ District Code	India[#] /State/ District	Distribution of households by source of lighting						
		Total No. of Households (Excluding institutional households)	Electricity	Kerosene	Solar energy	Other oil	Any other	No lighting
1	2	3	4	5	6	7	8	9
15	Ariyalur	1,98,106	89.6	9.7	0.0	0.2	0.0	0.4
16	Cuddalore	6,37,422	93.9	5.6	0.0	0.1	0.0	0.3
17	Nagapattinam	4,12,656	92.6	6.9	0.0	0.1	0.0	0.3
18	Thiruvarur	3,27,971	92.4	7.1	0.0	0.1	0.0	0.3
19	Thanjavur	6,05,074	91.8	7.6	0.0	0.1	0.0	0.4
20	Pudukkottai	3,90,628	90.7	8.5	0.1	0.1	0.0	0.4
21	Sivaganga	3,41,960	91.9	7.1	0.1	0.2	0.0	0.7
22	Madurai	7,97,939	94.5	4.8	0.0	0.1	0.0	0.5
23	Theni	3,40,965	91.6	7.4	0.2	0.2	0.1	0.5
24	Virudhunagar	5,40,132	93.7	5.6	0.0	0.1	0.1	0.5
25	Ramanathapuram	3,28,966	88.6	10.3	0.2	0.2	0.1	0.7
26	Thoothukkudi	4,64,324	94.3	5.0	0.0	0.1	0.1	0.5
27	Tirunelveli	8,20,327	95.0	4.2	0.0	0.1	0.1	0.6
28	Kanniyakumari	4,89,201	95.2	4.0	0.2	0.2	0.0	0.4
29	Dharmapuri	3,80,924	88.7	10.3	0.1	0.3	0.1	0.6
30	Krishnagiri	4,50,062	90.9	8.1	0.1	0.2	0.1	0.6
31	Coimbatore	9,45,943	94.8	4.7	0.1	0.1	0.0	0.3
32	Tiruppur	7,00,706	93.5	5.7	0.1	0.2	0.0	0.5

Power production cost of different sources

Source of Fuel	Generation Cost per kWh (Rs.)	Transmission Infrastructure Cost Per Km for a load of 100kW	Other Maintenance costs/distribution on infrastructure etc (per kWh)	Total Cost of Generation per kWh per km	Total Cost of Generation per kWh at a 5 Km distance from Grid/33KVA line	Total Cost of Generation per kWh at a 10 Km distance from Grid/33KVA line	Total Cost of Generation per kWh at a 15 Km distance from Grid/33KVA line	Life of the Unit
Coal	Rs. 2.00	Rs. 1	Rs. 0.50	Rs. 3.50	Rs. 7.50	Rs. 12.50	Rs. 17.50	30 years
Solar PV	Rs. 9.00	Nil	Rs. 0.20	Rs. 9.20	Rs. 9.20	Rs. 9.20	Rs. 9.20	25 years
Biomass	Rs. 4.25	Nil	Rs. 0.50	Rs. 4.75	Rs. 4.75	Rs. 4.75	Rs. 4.75	15 years
Micro Hydro	Rs. 4.20	Nil	Rs. 0.30	Rs. 4.50	Rs. 4.50	Rs. 4.50	Rs. 4.50	25 years
Wind	Rs. 4.50	Nil	Rs. 0.30	Rs. 4.80	Rs. 4.80	Rs. 4.80	Rs. 4.80	25 years

Power Shortage across India

36% of the total households receive electricity supply for 20 to 24 hours, while 30% of the households get less than 12 hours
of electricity supply, with 23% of the households getting less than 8 hours of supply and the balance of 11% had either no supply or were getting just less than 4 hours of supply every day.

Based on the statistics user survey is conducted to understand the problem and the ways people approach the power shortage, I conducted initial user survey via Phone and analysing the Video footages of a Village in Maharasthra
And of course, being raised in a village of the southern part of India, I first handily experienced the situation and personally used most of the contraption mentioned by people. This knowledge helped me in framing my design brief.

Also power production in a house using the daily regular activities were also noted to use that for the best possible design solution.

Questionnaire

A questionnaire was prepared for the user survey with an analysis protocol for the questions.
which is as follows;

What is the duration of power cut in your region?

What is the amount spent every month on electricity?

What is the first source of light after the power off?

What are your activities during power cut off?

What are the alternate source of light they use to face the power cut off or do you use any?

If yes:

Is it rechargeable one, if so how much power and time needed for recharge?

Is it self sustaining or require human power for operation other than switching it ON?

How long your device can provide light?

What is the cost for your source of energy?

If no:

Do you like to generate your own power,
have you tried any?

Do you like to spend more on device for power production?

Insights from User study

- *Major problem for students during exam days*
- *Mobile is the first source of light for most people when power goes off*
- *Increasing UPS culture*
- *LED bulbs are trending*
- *We would like to go for our own power instead of de-pending on the govt.*
- *We plan our activities according to the power availability*
- *Will be great, if we can pro-duce power without much effort*
- *Kerosene lamps are always there for help*
- *People buy generator as a backup for UPS*
- *Solar is very seasonal and not affordable*
- *Power theft*
- *Rent CFL lamps time to time*

First revised Design Brief

From the analysed data, considering Tamil Nadu power crisis as initial model of study and context, the brief is modified as below.

To design a hybrid lighting solution using the Solar or Thermo Electric Generator or gravity or human powered alternate technology (to be fixed after experiments) to address the need of power crisis in India considering off the grid solutions.
Design should be self sustainable, clean and locally viable. It should produce value even when it is connected with the grid

Experiments

After the understanding from the primary research, experiments where carried out to prove few of the techniques for adopting it to my concepts.

Mechanism of the cranking torch and its parts was studied to understand the mechanical conversion based power generation and the gear ratios.

Experiments were conducted with the liter of light concept, to understand how long the water tubes can take light through internal refraction when the tube is elongated.

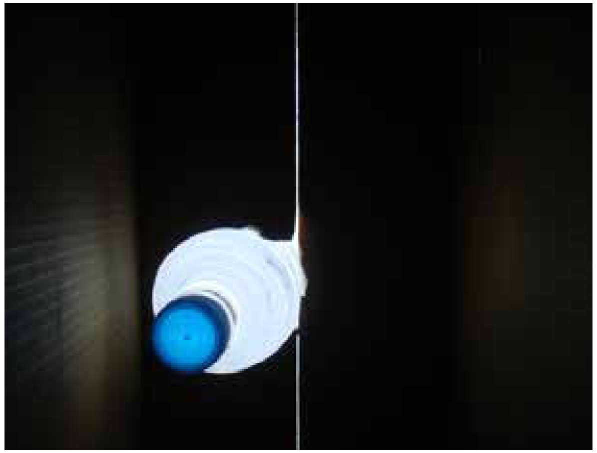
The experiment proved to be working well, with the vertical elongation, but the light refraction is wasted where it is not necessary,
Then the same technique was tried in an opaque PVC pipe with transparent ends, But that doesn't work as the internal reflection was not supported by the surface and hence it has to be coated with reflective material.

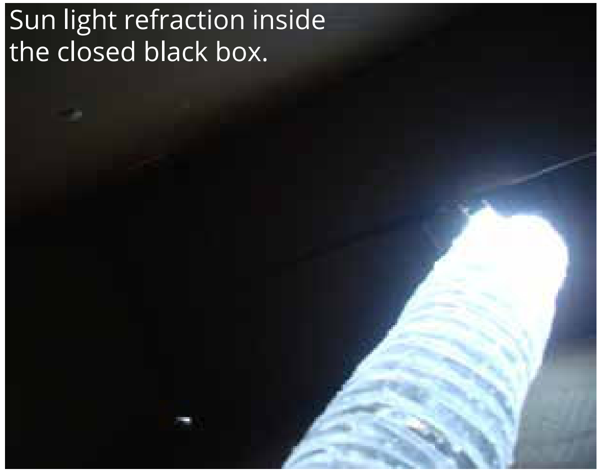
Different components of a cranking torch

Experiments

long transparent tube
using PET bottles

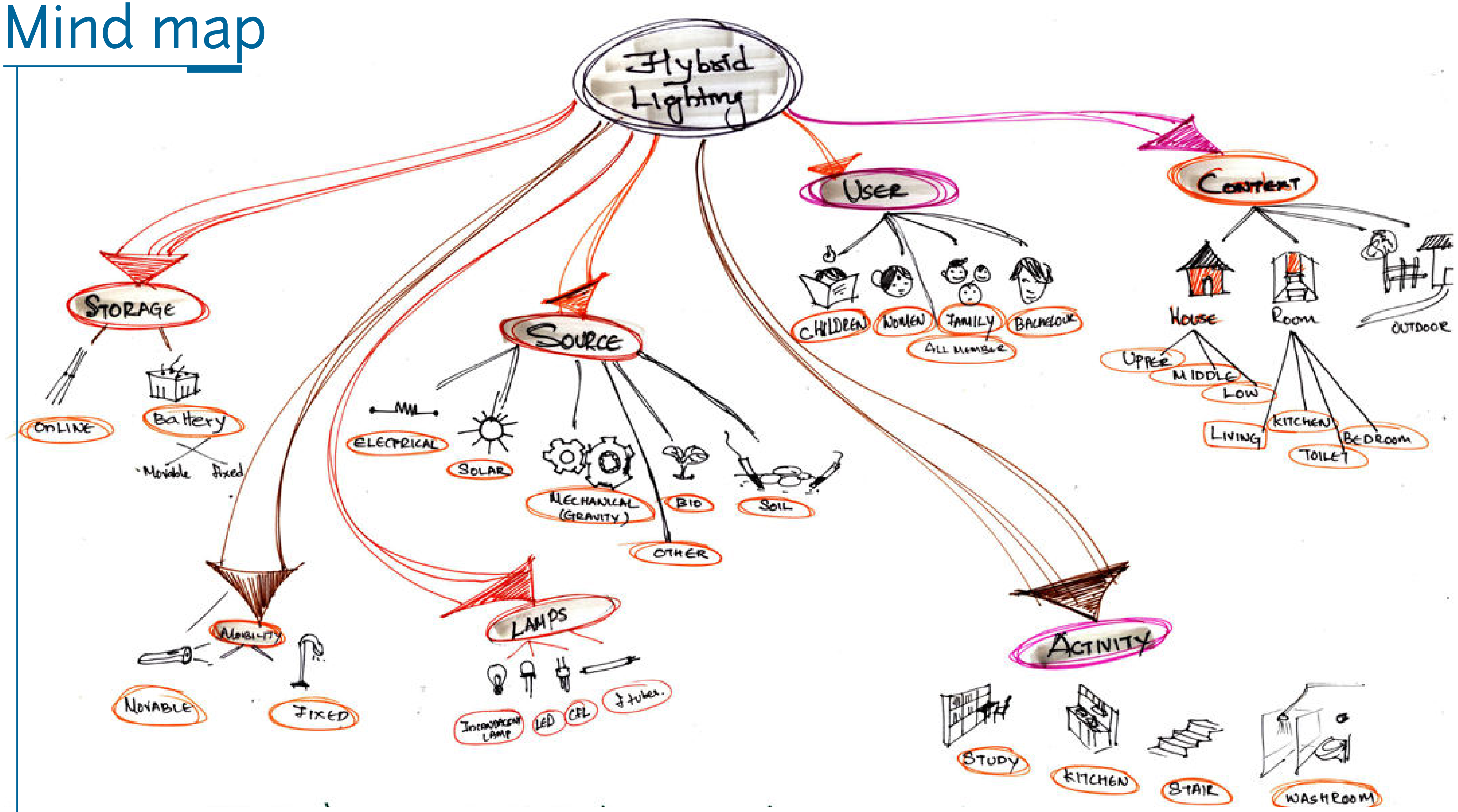
long opaque tube using
PVC pipe and transpar-
ent reflector at both ends





Sun light refraction inside
the closed black box.

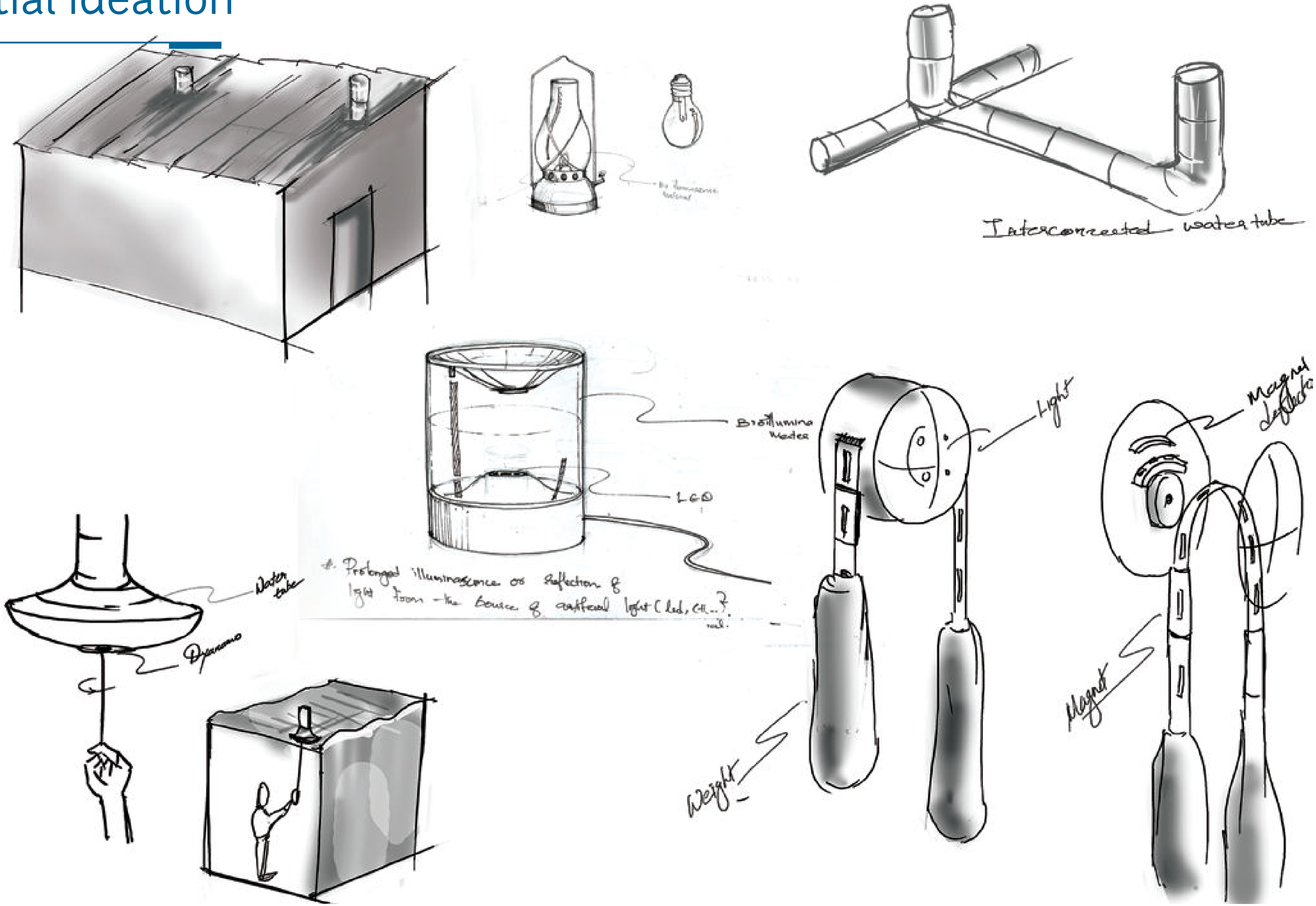
Mind map



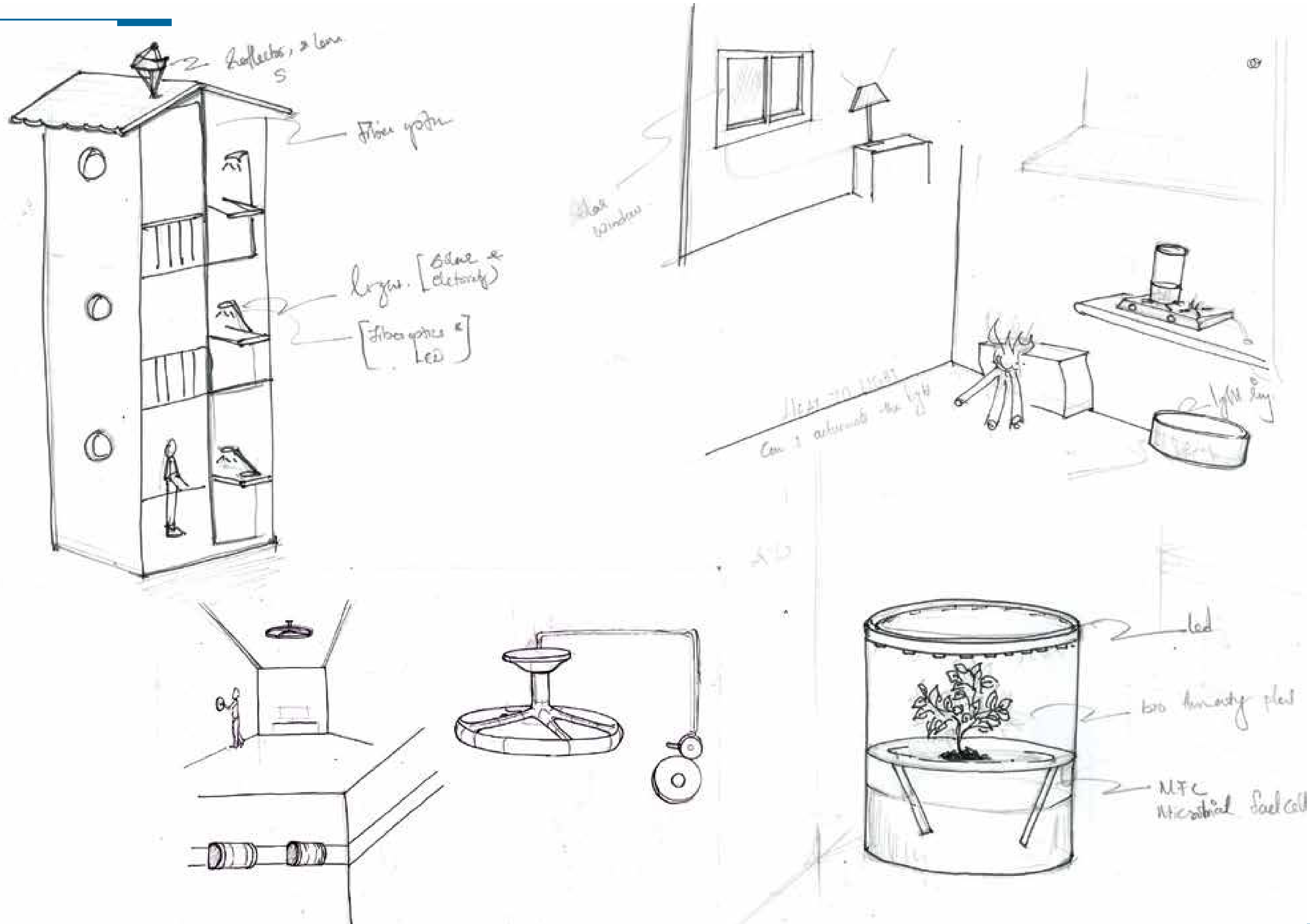
It is understood from the mind map that the living room, kitchen and toilet are the three important place in the house where the power is mandatory during power black out.

The activities in the house which has potential for power generation are sub categorised as walking, door open/close, sitting, tv remote, kitchen stove, water storing, grinding in the kitchen, stairs,exercising etc. Based on these, few initial ideations are as follows

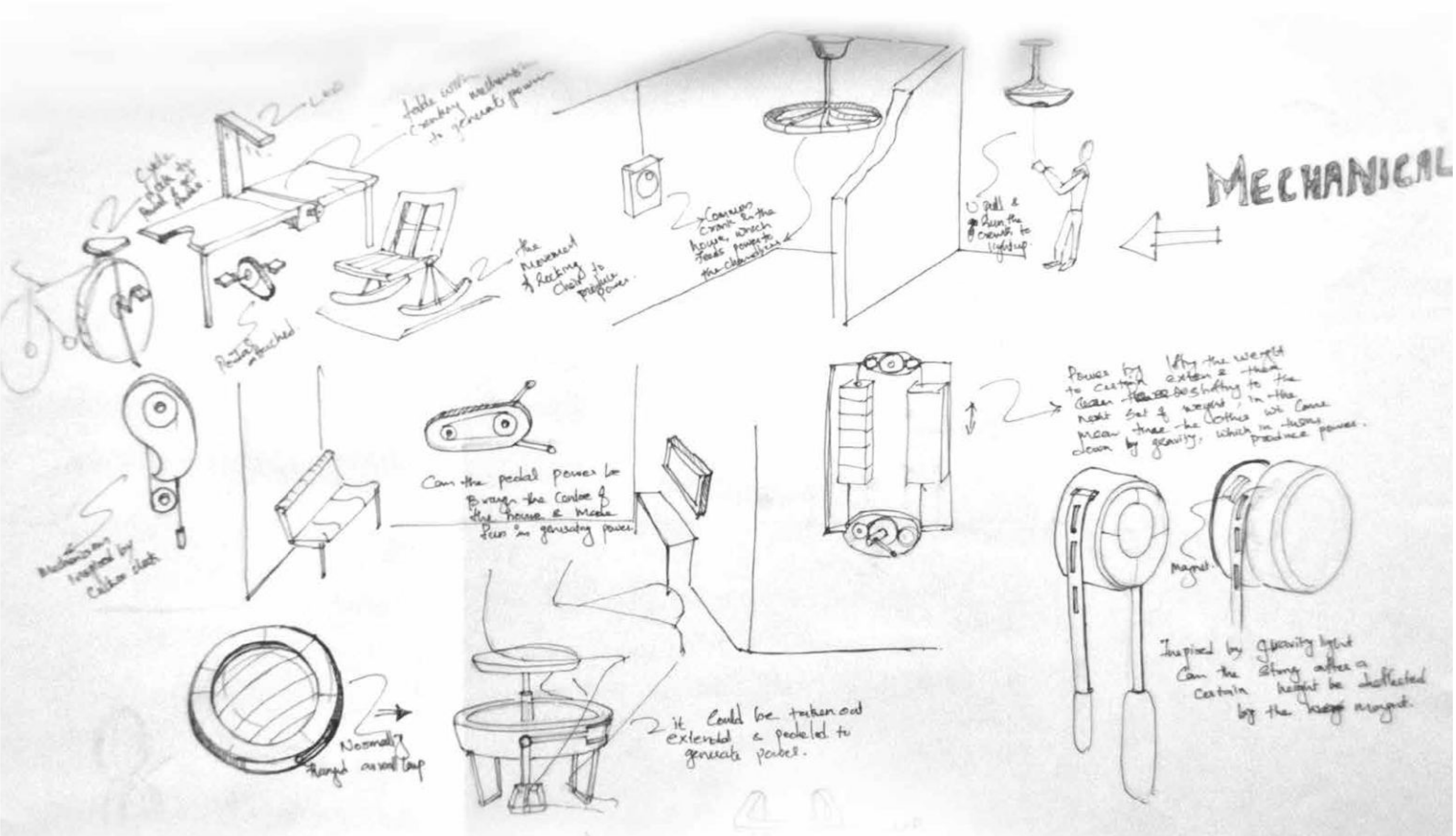
Initial ideation



Initial ideation



Ideation based on mechanical conversion methods



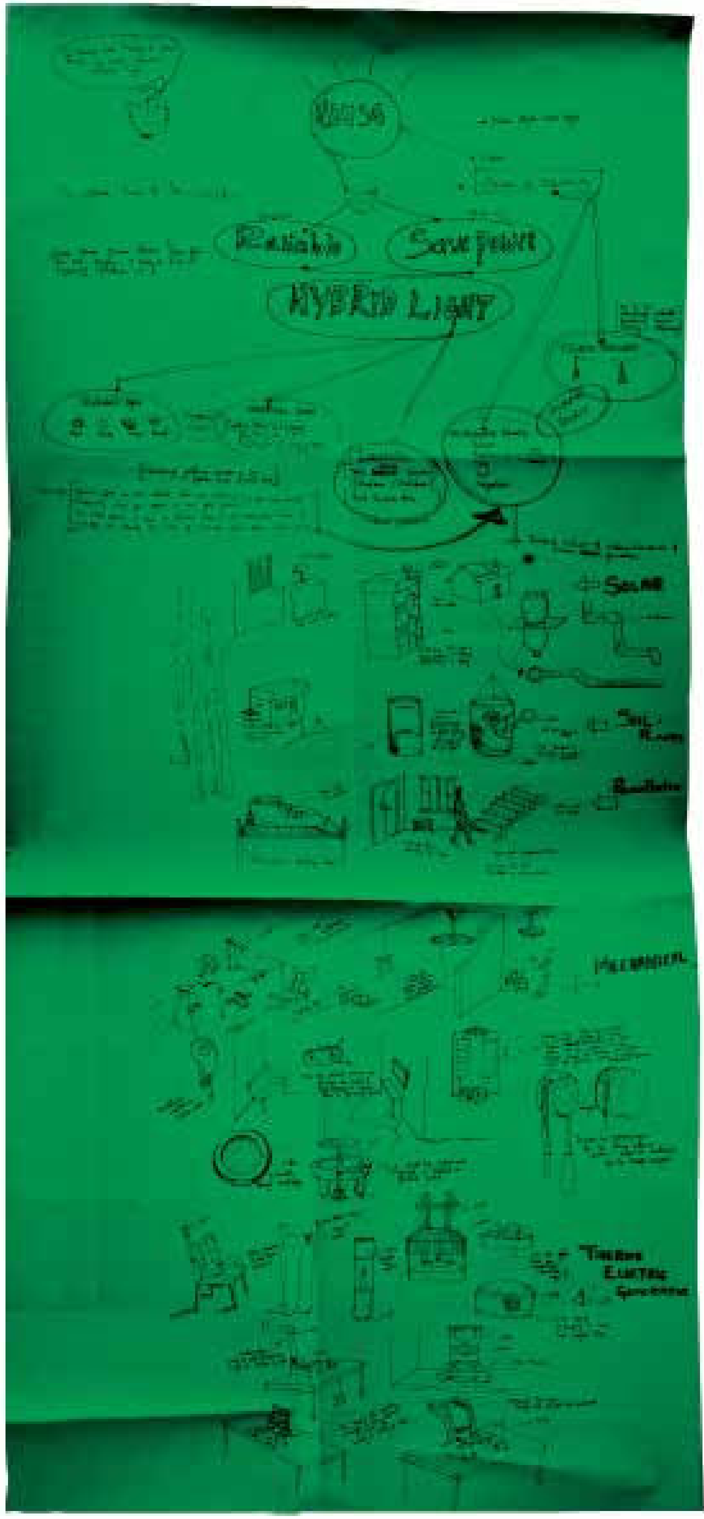
Insights and the process

The initial ideation phase started without much constraints in mind, exploring the possibilities of power production and the hybrid lighting mainly using solar, mechanical, gravity, micro fuel cell, pedal power, etc.,
System level approach of design were also considered during the initial phase.

Human powered, power generation is further explored. Though usage of muscle power for power production is existing for long time, their possibilities are still huge and it is one of the most reliable mode of power generation.

Initial ideation gave an understanding that the project is leading towards a hybrid power source and hybrid lighting is difficult without system level change in the scenario.

The initial ideations are grouped together and the categorised in a chart for analysis.
That gave a broad view of the overall work and research which is been done and helped to find out the possible context for design brief.



With the consolidated chart of all the work done, the possibilities have increased and it gives a direction to proceed further. Based on the consolidated chart of ideation, experiment and research understanding, following design briefs were reached,

1. Luminary for hybrid light:

Design a Luminary which will support both conventional and unconventional light sources. which should be adaptable to existing lamps and increase the efficiency of lighting.

2. Hybrid energy source which support lighting:

Design a device which helps in producing power using non conventional methods, with the regular activities in the house and support lighting with less effort. The device also should support the existing grid operated lighting. The main objective is to enhance the reliability and efficiency of lighting by saving cost and power.

3. Design a alternative energy source:

Design a device which will support power production using the non conventional method and help as additional source of power, by utilizing the regular activities inside the house.

Phase II
Introduction

From the literature review, research, experiments and from the scope of P3 duration, One out of three final design scenarios was chosen as mentioned earlier and it is explored further technically and practically to come up with final design brief.

So far the design brief evolved from increasing the efficiency of lighting to power generation to localized scenario based solution.

Considering the power scenarios in a country like India. Reliable, continuous power is one important thing to address, even before solving the lighting. Hence lighting combined with power generation seems more relevant.

Also from the analysis of people and the activities they prefer to do, it implied that power generation with less effort is an important factor to consider.

Hybrid power generation is considered in terms of increased reliability and efficiency in lighting, than a grid connected system.

By all these insights,analysis and user feedback. Designing a hybrid energy source and using **Thermo electric generator (TEG)** for lighting, seems to be the most suitable choice (brief 2).

As it involves human intervention in power production and every home will have a kitchen, which is active at least two times in a day and a lot of energy is been wasted other than cooking in the kitchen, It can be harvested and could be used for power generation.

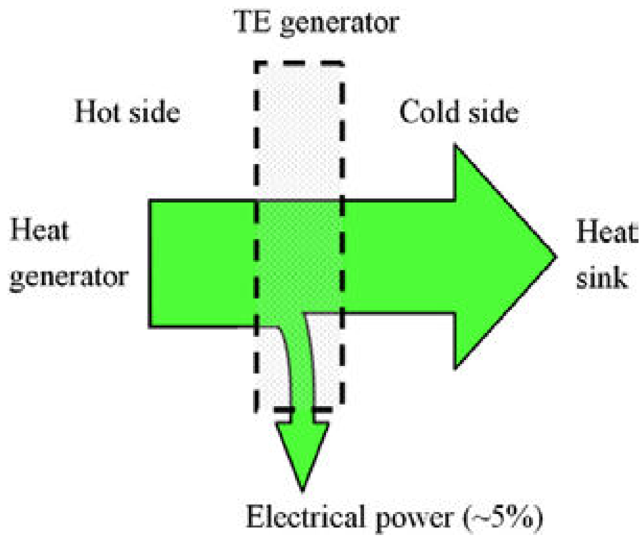
The stored energy can also be used for charging low power electronic devices and gadgets.

Literature Review

Thermoelectric generators are an intriguing way to generate renewable energy directly from waste heat. However, their efficiencies are limited due to their thermal and electrical properties being dependent on each other. Nevertheless, their solid state scalable technology makes them appealing and even more efficient in selective applications. Implementing thermoelectric generators on vehicle exhaust manifolds would help reduce fuel consumption, which in turn would help preserve the world natural resources and reduce carbon emissions.

As mentioned above, thermoelectric generators are not new inventions. There was an initial period of research that spanned the 1800s, and a great hopeful era in the 20th century when researchers believed the thermoelectric generator would replace the internal combustion engine.
By the 1920s, battery-free radios powered by thermoelectricity were widely used in the Soviet Union. The radios came equipped with bimetal rods, and if you place one rod in the fireplace and one rod outside in the cold, you would produce the electricity required to operate the device. Similar kerosene-powered radios were manufactured by the Soviets and USA during the cold war.
Beyond radios, researchers largely found it difficult to create satisfactory consumer solutions that utilized thermoelectric generators. Efficiency had improved but was still low, and by 1970 thermoelectricity fell out of favour.

Few of the literatures reviewed are mentioned with their references below,



Schematic of Thermo electric generator

Generating Light from Stoves using a Thermo-electric Generator

Dan Mastbergen, dmast@engr.colostate.edu
Dr. Bryan Willson, Bryan.Willson@colostate.edu
Engines and Energy Conversion Laboratory
Department of Mechanical Engineering
Colorado State University

This paper begun with the justification of lighting in kitchen using waste heat to produce clean energy. They also give an idea of selection process of Thermo electric module, heating and cooling fins and fan.
The other modes of energy conversion using combustion engines were bulky and noisy, as compared to the TEG. Their suggested requirement for the device should be cost effective with minimal maintenance and acceptable lifetime and without a battery. Comparatively TEG stands out with its modularity. It also states about the selection of each components like heat exchanger, cooling fan, power electronic and the load.

Some technical insights from the paper:
The hot side heat exchanger has larger gaps within the fins for better performance using natural convection. It is also a solid extruded piece so there are no bonded joints that could melt.
The cold side heat exchanger must be much more efficient. The air used to cool
the cold side of the module can only be as cold as the ambient air.
The thermal resistances at the interfaces between the module and heat sinks are also
important to keep to a minimum. This requires very flat surfaces (within .001”), high temperature thermal grease, and uniform clamping pressure (up to 200 psi).

Further reductions in cost proposed in the paper are as follows;

If the cold heat sink could be made locally, its cost may be reduced.
Also, if the cold, heat sink is large enough, it may be possible to operate without a fan. This would make the heat sink more expensive, but would eliminate the cost of the fan and greatly simplify the electronics required.
If the hot side can be placed near the combustion chamber where the temperature is high enough, it may be as simple as a steel block to distribute the heat further reducing costs.

Projected costs

Component	Single unit cost	High volume cost (10,000+)	Natural convection (10,000+)
Module	$100	$10	$10
Hot Sink	$10	$3	$3
Cold Sink	$16	$8	$12
Fan	$7	$3	$0
Hardware	$2	$0.50	$0.50
Electronics	?	$4	$1
LED	$7	$4	$4
Total	$142	$32.50	$27.50

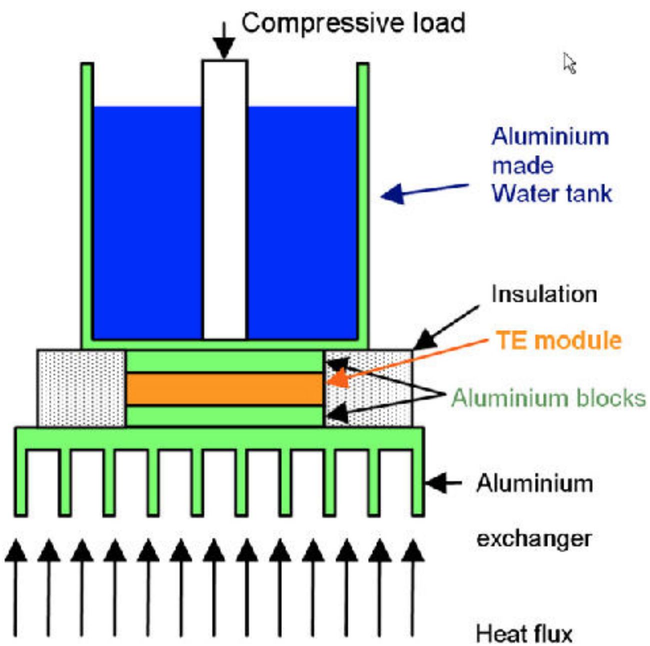
Design and testing of a locally made loop-type thermosyphonic heat sink for stove-top TE Generators

R.Y. Nuwayhid*, R. Hamade
Department of Mechanical Engineering, Faculty of Engineering and Architecture,
American University of Beirut, Riad El Solh 1107-2020, Beirut, Lebanon

The paper talks about the TEG in general, efficiency and application of it, but mainly on the selection of heat sink which is an important criteria for TEG. TE power generation has been in existence for over 100 years. The efficiency of conversion has not managed to exceed about 10% for temperature ranges of practical interest. Thus, power generation applications have been limited to special deep space probes (Pioneer, etc.) which use radioisotope heat sources and generate relatively low power sufficient for the task at hand.
The other application is in remote power for Polar regions, petroleum platforms or other similar instances. These systems use fossil fuel heat source, and considering weather and other factors, may have a marginal advantage over power generating using other methods such as photo voltaic.

It is shown that power is proportional to the square of the temperature difference across the thermoelectric module. Thus, the task becomes to minimize the cold side temperature. Typically, the stove top temperature would be around 200–230C (about 500 K), and as a worst case, an average ambient temperature of 20–28C (293–298 K). It talks about the cooling factor as, Heat sinks for thermoelectric generators can be based either on natural convection to the ambient or on forced cooling.
Because of water's superior heat transport properties, forced water-cooling is also considered but once again, parasitic pumping power is required. This leads to the consideration of natural cooling using water (the alternative is
to use an air-cooled natural convection system but this would lead to a very large system). For compactness' sake, a closed-loop, water-based, natural circulation

Insight:
The performance of a thermoelectric generator, among other aspects, depends on the use of an effective heat sink. While forced cooling using either air or water (or other coolants) is efficient, it is parasitic on the generated power and/or bulky and inconvenient.



Conceptual Design of a Thermo-electric Edu-Kitchen System

Akshaya Srivastava, Daryl Duran, Mark Pinder,
Vrishank Raghav, Narayanan Komerath
School of Aerospace Engineering
Georgia Institute of Technology;
Atlanta,GA, USA

This paper tried to come up with a context of creating a concept design of power generation using Thermo electric generator from wood burning kitchen stoves to bring electric lighting, pollution control and water sterilization to underprivileged communities around the world.

It states the power generated using TEG which will be of 5-8 watts could be used for DC fan, which drives air into the stove, optimizing the fuel-air ratio to improve heat release and reduce smoke, soot and other pollutants.
A 5-watt light emitting diode flood lamp will provides steady lighting so that a child may learn in the kitchen.
A milliwatt LED is used to sterilize drinking water. and it will power a rechargeable battery
The Edu kitchen system described in this paper uses a thermoelectric module from spacecraft technology

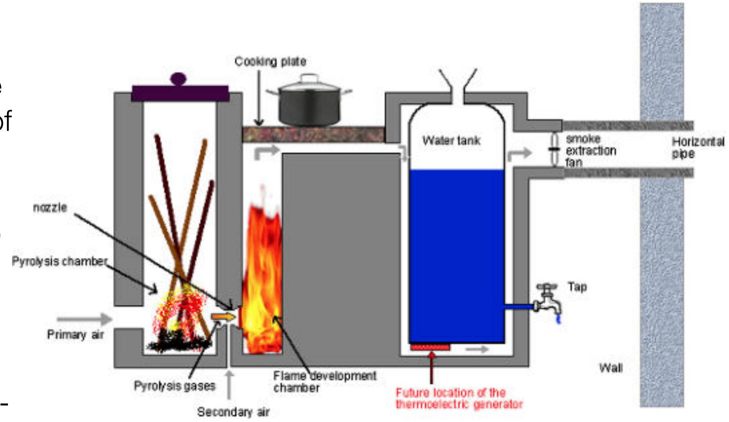
Clearly one consideration in the researchers' minds was the high cost per unit power of as thermoelectric converter, making it harder for poor families to justify the cost of such devices, whereas middle-class users in regions with unreliable grids might serve as customers at least at the initial market stages.

In this paper they have considered the unit cost of each component in small quantities, and it stating that, the price will come down when mass produced. which is highly possible in the future.
Insight from the paper:
It justified the idea of power production in the kitchen using TEG. It also opened lot of other avenues to use the produced power inside the kitchen, improving health condition of people using UV LED's, lighting for kids education and increasing the efficiency of the stove.

Study of a TE (thermoelectric) generator incorporated in a multifunction wood stove.

D. Champier a,*, J.P. Bédécarrats b, T. Kousksou a, M. Rivaletto a, F. Strub c, P. Pignolet a

The other papers on power production using thermo electric generator, mostly revolved around the concept of using the house kitchen stove and talks about the green energy, sustainable solution, future of power production, modularity, poverty quotient of third world countries, storage, cost factor, etc.,



This is one of the prototype discussed in the paper, in which kitchen is completely redesigned, to accommodate the TEG based power production.

A lead-acid battery has been chosen because it currently available in terms of price, energy efficiency, lifetime and availability in developing countries.

Insights and Design Scope

Benefits of using a TEG:

(Insights from both Wood, gas & diesel stove based experiments)

- It does not require extra energy from the stove.

- The TE generator is incorporated into the cook stove and requires no electrical link with the outside world, unlike solar panels.

- It is silent in operation as it involves no moving parts.

- The maintenance is very light, nothing moves, everything is inside the house, only the battery needs to be changed when it is done for.

- The TE generator works when the stove is on, day and night in good or in rainy weather (monsoon period) unlike solar panels.

- The battery does not need to be oversized as each use of the stove recharges the battery unlike a solar system.

- Forced cooling using either air or water (or other coolants) is efficient,but it is parasitic on the generated power and/or bulky and inconvenient.

- Middle-class users in regions with unreliable grids might serve as customers at least at the initial market stages.

Some technical insights from the study:

The hot side heat exchanger should have larger gaps within the fins for better performance using natural convection. It is also a solid extruded piece so there are no bonded joints that could melt.

The cold side heat exchanger must be much more efficient. The air used to cool the cold side of the module can only be as cold as the ambient air.

The thermal resistances at the interfaces between the module and heat sinks are also important to keep to a minimum. This requires very flat surfaces, high temperature thermal grease, and uniform clamping pressure.

The DW-ST-15W Wood Burning Stove Thermoelectric Generator can be placed on the top of a heat source such as a wood stove to charge a battery, power a 12V DC device, or charge a cell phone with its handy 5V DC USB output.
To ensure adequate temperature difference for power generation, the low temperature side of the Thermoelectric Generator is cooled with an electric fan.

These Russian stoves are solid fuel heating and cooking stoves with a built-in thermal electric generator which transforms the thermal energy of burned fuel into electric power. While working in its primary mode that is heating and cooking the stove generates a direct electric current of 12 Volts and up to 60 Watts.

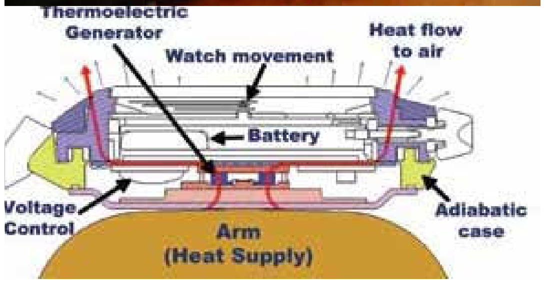
http://www.tegmart.com/thermoelectric-generator-products/

http://tinyurl.com/ms57sjt

This Seiko watch when it is worn on the wrist, the watch absorbs body heat from the back case and dissipates it from the front of the watch to generate power with its thermal converter. The power generating capacity depends on the air temperature and individual differences in body temperature.

The Power pot is a pot that you fill with water and place directly onto any heat source. This may be a campfire or a propane or alcohol stove. Once the heat is applied, the current begins to charge your USB device. The flexibility in the product is that you can put it onto any heat source available.
They have the 10W & 50W models for sale along with practical meters and power packs.

The heat from the fire generates electricity via a thermoelectric generator to power a fan creating airflow for improved combustion. Surplus electricity is sent to the USB port for charging devices.
The inside view is shown in the below image.



http://www.powerpractical.com

http://www.biolitestove.com/products/camp-

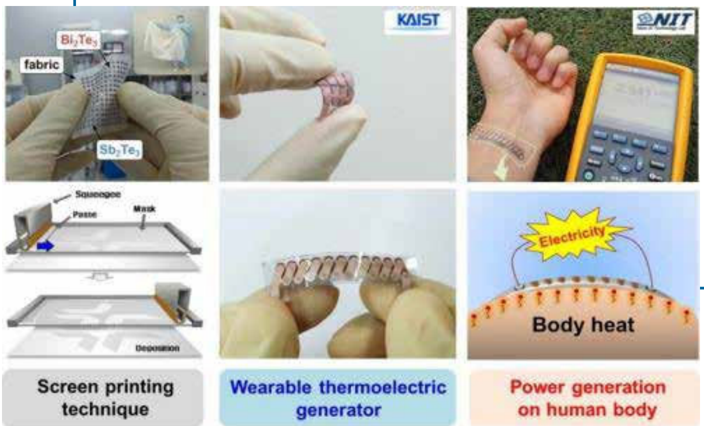
Future of TEG

http://tinyurl.com/o6tyjqy

This battery-less flashlight for the Google Science Fair that utilizes Peltier tiles, which produce electricity when you apply heat to one side of the tile (from gripping it with your hand) while the other remains cool. The result is a homemade flashlight that can shine a light for over 20 minutes.

The STATS Charger converts your body heat into electricity. It can work as long as the temperature difference between your body and the surrounding air is between 1 and 40 degrees Celsius and can reach up to 104 V.

https://m.facebook.com/iecbi?v=feed



http://tinyurl.com/lz9vxcf

They developed a thermoelectric (TE) generator that takes the form of a wristband. The generator itself is malleable and It holds inorganic TE materials while the substrates are being eliminated. He explained that “the glass fabric itself serves as the upper and lower substrates of a TE generator, keeping the inorganic TE materials in between. This is quite a revolutionary approach to design a generator.

The shirt, which consists of 16 “thermopiles” (the components responsible for generating electricity from body heat), is capable of producing anywhere from 1mW when the wearer is sitting at room temperature to 4mW when he is running.

http://tinyurl.com/n82ympf

Componentsusedforthe experiment and their Specification

1. Thermo Electric Generator(TEG)

Temperature (degrees)	20	40	60	80	100
Open circuit voltage(V)	0.97	1.8	2.4	3.6	4.8
Current (MA)	225	368	469	558	669

Dimension: 40*40*3.6 mm

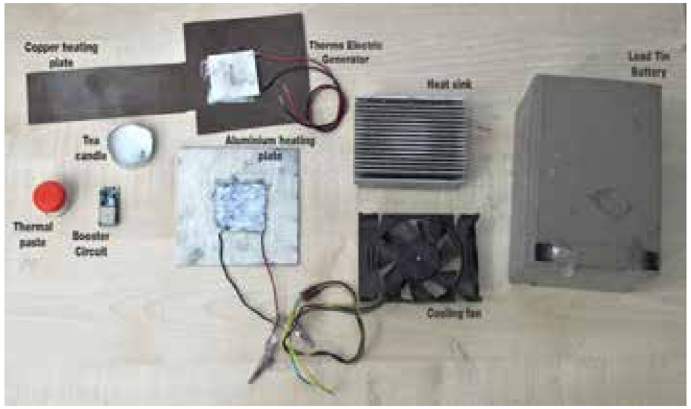
2. Heat Sink
Old CPU Cooling Fan (12v) and Heat sink (aluminium)

3. Thermal Paste:
Heat sink compound paste.

4. Heat exchanger used:
Aluminium vessel and plate of 2 mm thickness.
Copper plate of 1 mm thickness.

5. Light: LED
Colour: Blue
Operating Voltage: 2.6 - 2.8 V
Operating Temperature : -40~+85 °C
Power dissipation : 120 W
Lumen : 0.3 Lumen

6. Battery: Pure LED TIN Battery
Voltge: 12V
Capacity: 12Ah



7. Heat source
Tea candles and Gas stove

8. Booster cicuit
5v booster board to regulate the output power.

Experiments

To prove the concept of Thermo electric power generation and to know the technicalities of the device, experiments were conducted. Insights were recorded for the design considerations.

	Exp 1	Exp 2	Exp 3
Heat source:	3 Tea Candles	3 Tea Candles	3 Tea Candles
Heat side sink:	Rectangular aluminium plate of 2mm thickness	Rectangular aluminium plate of 2mm thickness	Rectangular aluminium plate of 2mm thickness
Cool side sink:	Aluminium vessel with 1/2 litre water.	Aluminium vessel with 1/2 litre water.	Aluminium vessel with 1/2 litre water.
Distance from heat source to sensor:	Direct	15 cm	10 cm
Max voltage recorded:	4.2V	0.9V	1.2V
Light output:	good -Blue LED was ON	No output	No output
Time:	4 mins		

Experiment with water cooled sink and direct heating which produced the maximum voltage of 4.2 volts(Img. 1-6)

	Exp 4	Exp 5	Exp 6	Exp 7	Exp 8	Exp 9	Exp 10	Exp 11
Heat source:	3 Tea Candles	3 Tea Candles	2 Tea Candles	3Tea Candles	3Tea Candles	Commercial gas stove	3 Tea candles	4 Tea candles
Heat side sink:	Rectangular aluminium plate of 2mm thickness	Rectangular aluminium plate of 2mm thickness	Rectangular aluminium plate of 2mm thickness	Rectangular aluminium plate of 2mm thickness	Rectangular aluminium plate of 2mm thickness	Rectangular aluminium plate of 2mm thickness(24x5)	Rectangular Copper plate of 2mm thickness(24x5)	Rectangular copper plate of 2mm thickness(24x5)
Cool side sink:	Aluminium vessel with 1/2 litre water.	Aluminium vessel with 1/2 litre water.	CPU cooling sink with fan	CPU cooling sink with fan	CPU cooling sink without fan	CPU cooling sink with/without fan	CPU cooling sink without fan	CPU cooling sink with/without fan
Distance from heat source to sensor:	8 cm	4 cm	Direct	Direct	Direct	15 cm	15 cm	4cm
Max voltage recorded:	1.3V	1.5V	1.2V	2.8V	2.2V	2.1V	0.7v	2.9V
Light output:	No output	No output	no output	light on	light off	No output	No output	yes
Time:			5 mins	6 mins	3 mins	15 mins	10 mins	5 mins

Experimenting with long plate to understand effect of heat exchange (Img 7,19,10,12)

Experimenting with fan cooled sink and cooper heat sink.

Experiment with commercial gas stove and fan cooled sink.


7

8


9


10


11


Melted aluminium plate


12

Insights from the experiment:

-Direct heating of the sensor with aluminium vessel filled with water produced the maximum voltage, which is by far the maximum difference of temperature.
But the consistency of voltage will be lost, when the temperature keeps rising.

-When the distance of heat source is extended from the sensor the transfer of heat is inefficient.

-But the water cooling is unmanageable in size, when compared to the fan cooled sink.

-The output voltage with fan cooled sink has produced a decent voltage for powering a light, but it needs additional power to run the fan. which is difficult to achieve with the available sensor.

-Aluminium plate can't stand the high temperature (660.32 °C), and the efficiency of heat transfer is low, compared to copper(1084.62 °C), hence copper which is a best available heat exchanger can replace aluminium.

.
-The distance between the heat source and the sensor has to be maintained as close as possible, for more efficient heat transfer.

-Initially it takes some time to generate the required power. Have to look for alternative to sort this.

Scenario study:

With the insights from the experiment further user study is conducted to understand the user behaviour and the context of the user.

The experiments clearly shows the need for high temperature and cooling to produce sufficient power. Complying with the search for energy harvesting in the house, Kitchen provides the most appropriate place for harvesting energy, with its possibility like heat from stove, cooling using ventilation and water from the sink.

To study the context of kitchen, kitchen stove, and the place around it and the users around the kitchen is studied and the final design brief is made around it.

User scenario study to understand the activities in a kitchen

Observations:

This is a kitchen in Mumbai apartment, where the working space is very less.
The stove is kept very close to the wall.
There is no task lighting for the activity around the stove. Its just the general light from the ceiling.
The wall behind the stove is quite clean.
There is provision of power plug over the stove.

This is a separate house in a rural area Tamil Nadu, where the space is not an issue in the kitchen.
The stove is kept at a distance from the wall and the place around the stove is clean.
The lighting is general lighting, and the place is brightly illuminated.
There is provision for power plug around the stove.
Regularly cleaned.

User scenario study to understand the activities in a kitchen

Observations:

This is another kitchen from rural area, which has a lot of space around the stove for the other activity and they use it for keeping Dosa Pans.
The place is poorly lit, only one general light from the side wall.

This is a kitchen from rural area. They have space around and behind the stove.
The wall behind is not clean, lot of spillages while cooking.
Not very frequently cleaned.
Averagely lit and no power plugs around the stove.

User scenario study to understand the activities in a kitchen.

Observations:

This are images from different kitchens and people working near the stove.

Image 1&2 are from a rural hotel kitchen.

Image 3, is from a urban house, where they have sufficient place to keep things around the stove. And it is supported with a power plug for their kitchen appliances.

The water tap and sink is very close to the stove in Images of kitchen 1,3 and 4.


1


2


3


4

Evolution of Design Brief

First Design brief:

To come up with a design solution to harvest natural light and use artificial light using the same provision or luminary.

First Revised Design Brief:

To design a hybrid lighting solution using the Solar or Thermo Electric Generator or gravity or human powered alternate technology (to be fixed after experiments) to address the need of power crisis in India considering off the grid solutions.
Design should be self sustainable, clean and locally viable. It should produce value even when it is connected with the grid

Second revised Design brief from Phase I: Hybrid energy source which support lighting:

Design a device which helps in producing power using non conventional methods, with the regular activities in the house and support lighting with less effort..
The device also should support the existing grid operated lighting. The main objective is to enhance the reliability and efficiency of lighting by saving cost and power.

Final Design Brief

Design a device to produce power, using Thermo electric generator and use it for the secondary lighting during power cuts and load shedding.

The device should function as a replacement for the torch lights and emergency lights in middle class houses of India which uses gas stoves.

It should also have to work with the conventional grid power and should support charging of mobile phones and low power gadgets.

The main objective is to enhance the reliability and efficiency of lighting by saving cost and power.

The device should go with the other kitchen elements.

Design constraints from a TEG based power generator:

1) The system must capture enough electric power during an average evening cooking cycle, of a family of 4, using a wood fire in a mud-and-brick domestic stove or a gas stove, to recharge a battery to compensate for the demands on the battery.

2) The battery must support the continuous operation of the activities in the kitchen without interruption and student should be able to study around it.

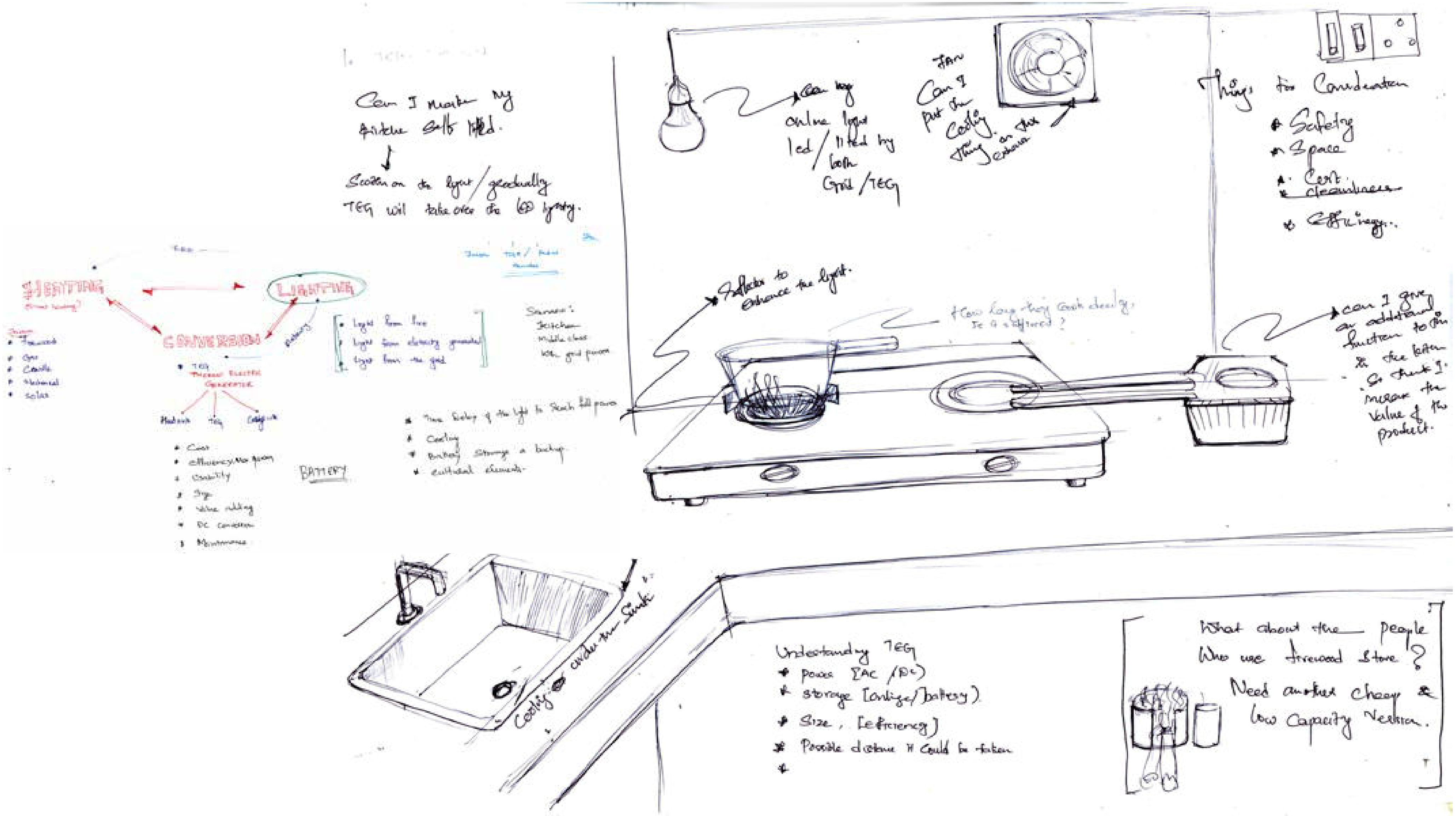
3) The battery must provide enough power to operate a power booster circuit.

4) The resulting system must be compatible with the present lifestyle of families in the customer area, and require only minimal instruction to operate safely.

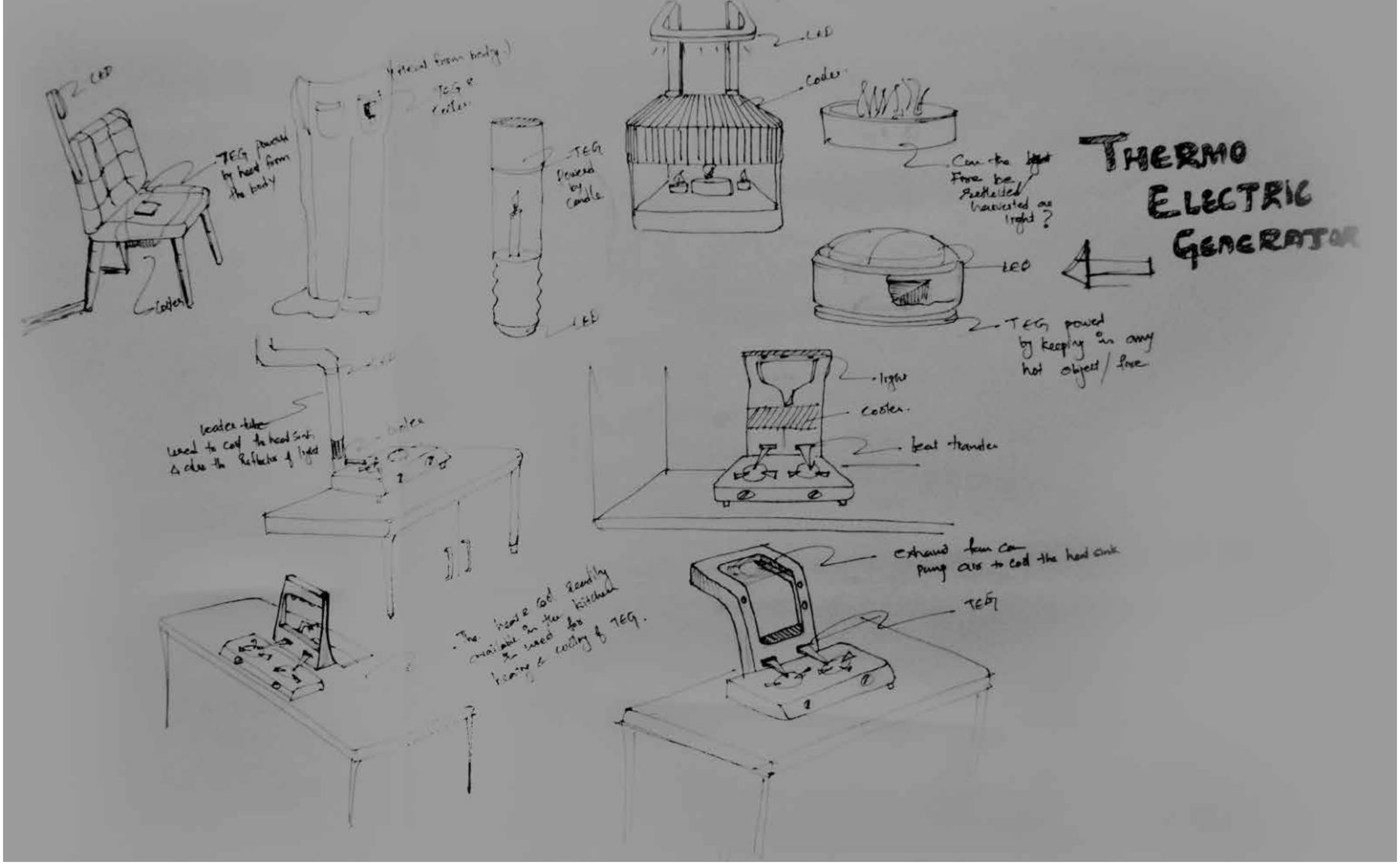
5) The system must be robust enough to survive normal wear and tear as well as the occasional spills and mechanical shocks that may be expected in a cramped and poorly lit family kitchen.

6) The system mass produced cost per unit must be well below the amount they spent on secondary power and lighting sources like batteries,torch light and emergency lights.

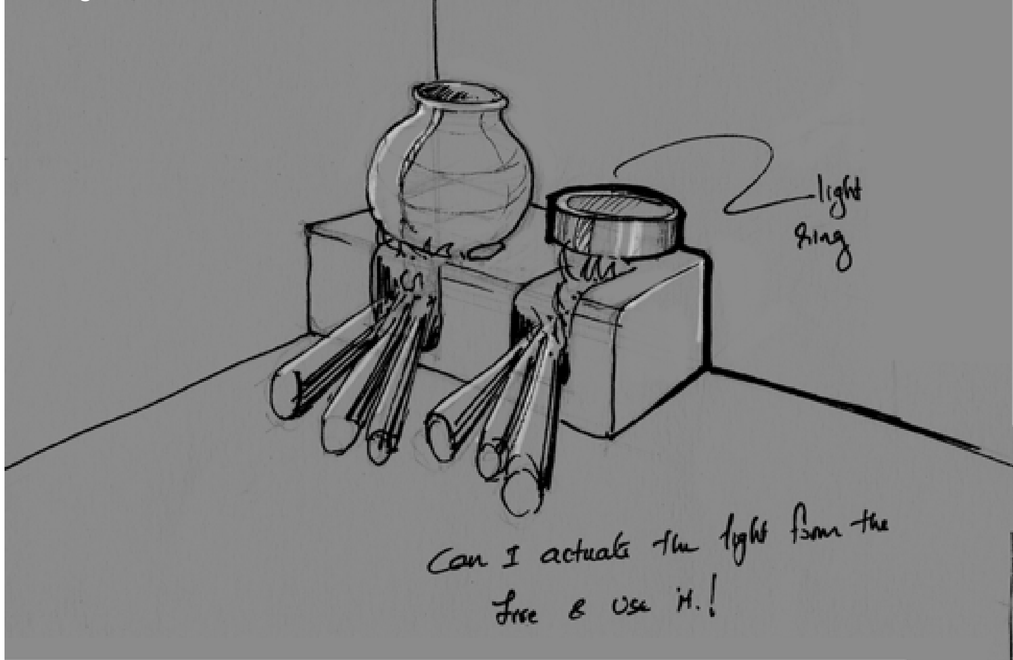
Mind map

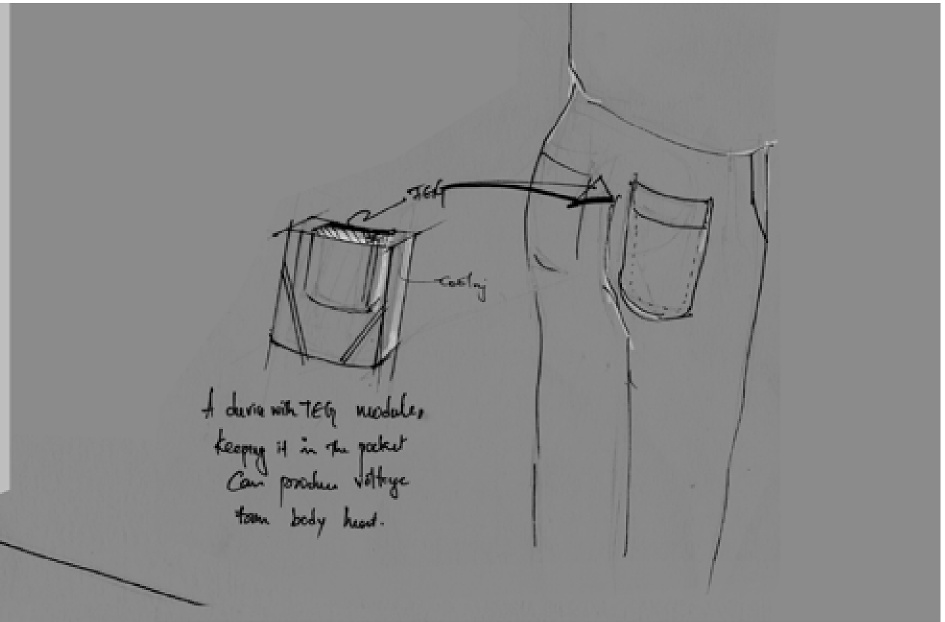


Initial ideation

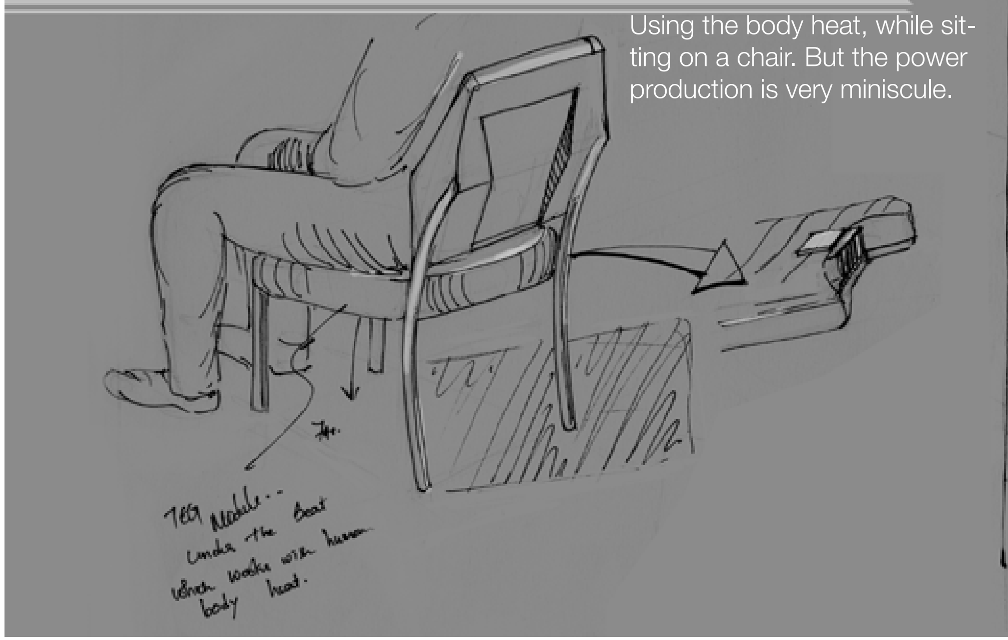


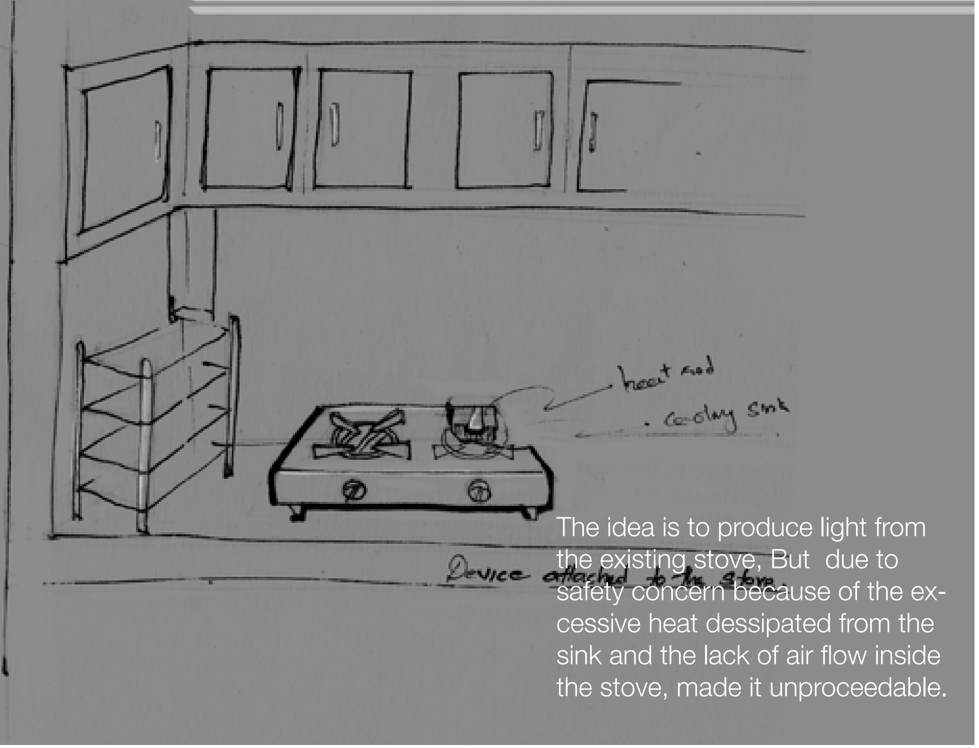
Idea 1: TEG Powered by existing sources and energy harvesting method.



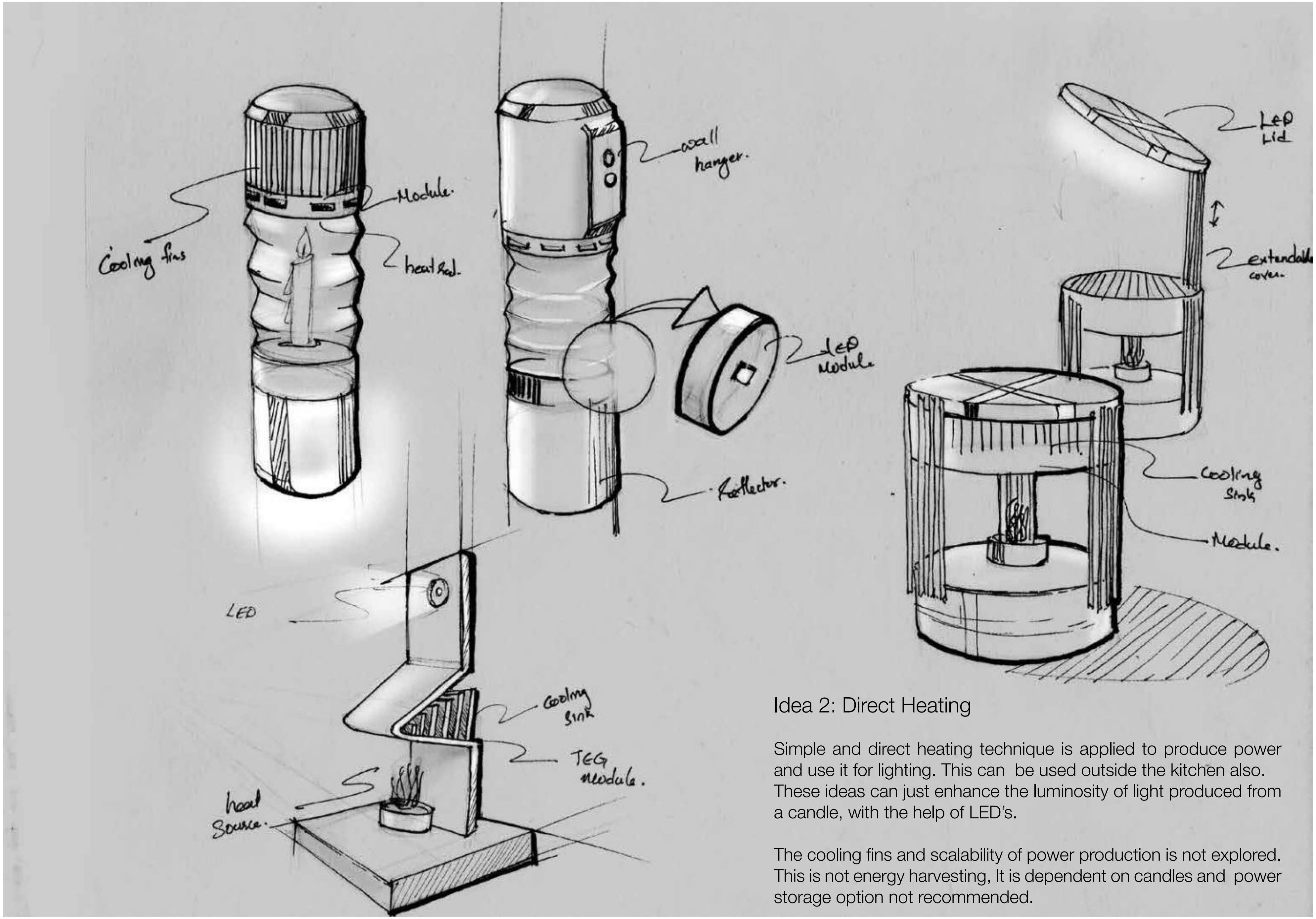


Using the body heat, while sitting on a chair. But the power production is very miniscule.





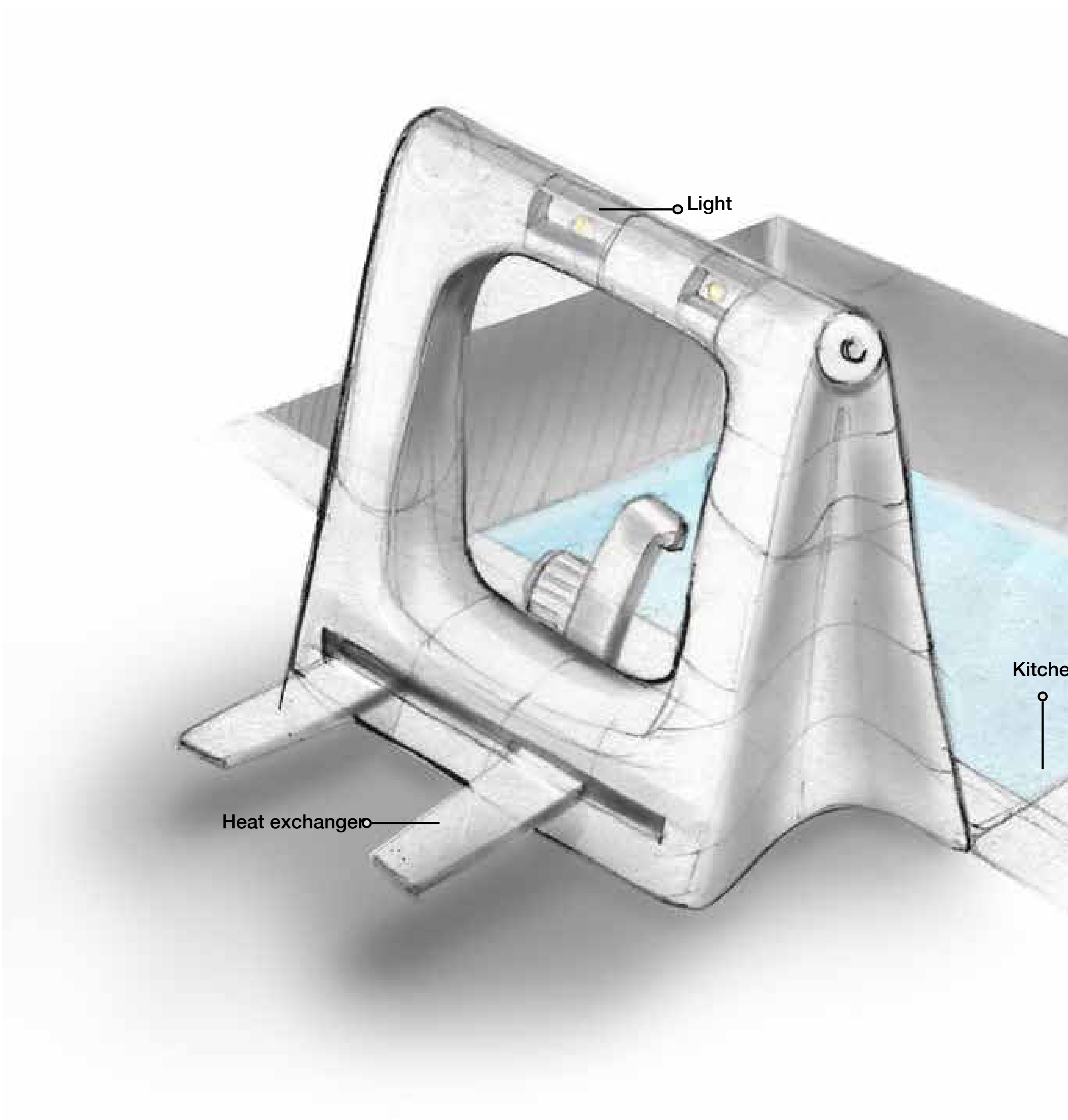
The idea is to produce light from the existing stove, But due to safety concern because of the excessive heat dessipated from the sink and the lack of air flow inside the stove, made it unproceedable.



Idea 2: Direct Heating

Simple and direct heating technique is applied to produce power and use it for lighting. This can be used outside the kitchen also. These ideas can just enhance the luminosity of light produced from a candle, with the help of LED's.

The cooling fins and scalability of power production is not explored. This is not energy harvesting, It is dependent on candles and power storage option not recommended.

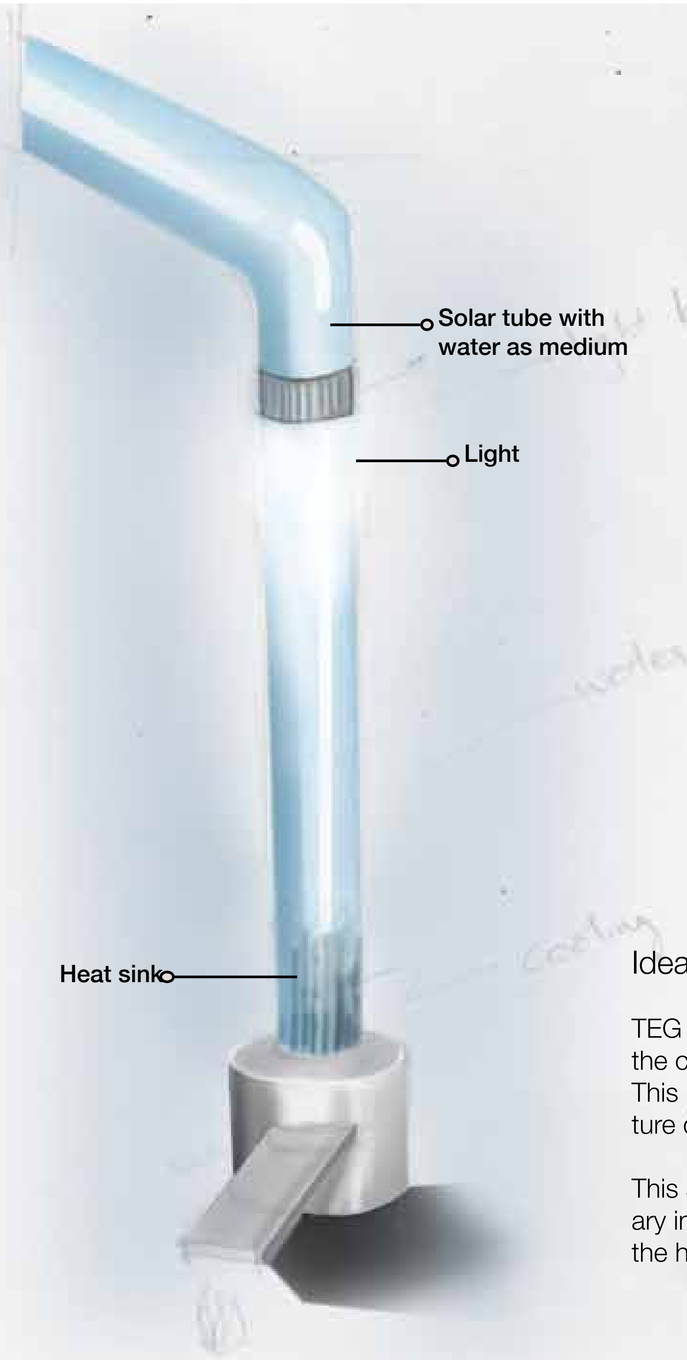


Idea 3: Water based cooling

TEG is powered by using the heat from kitchen stove and the cooling from the water sink.

This idea gives the possibility of producing high temperature difference.

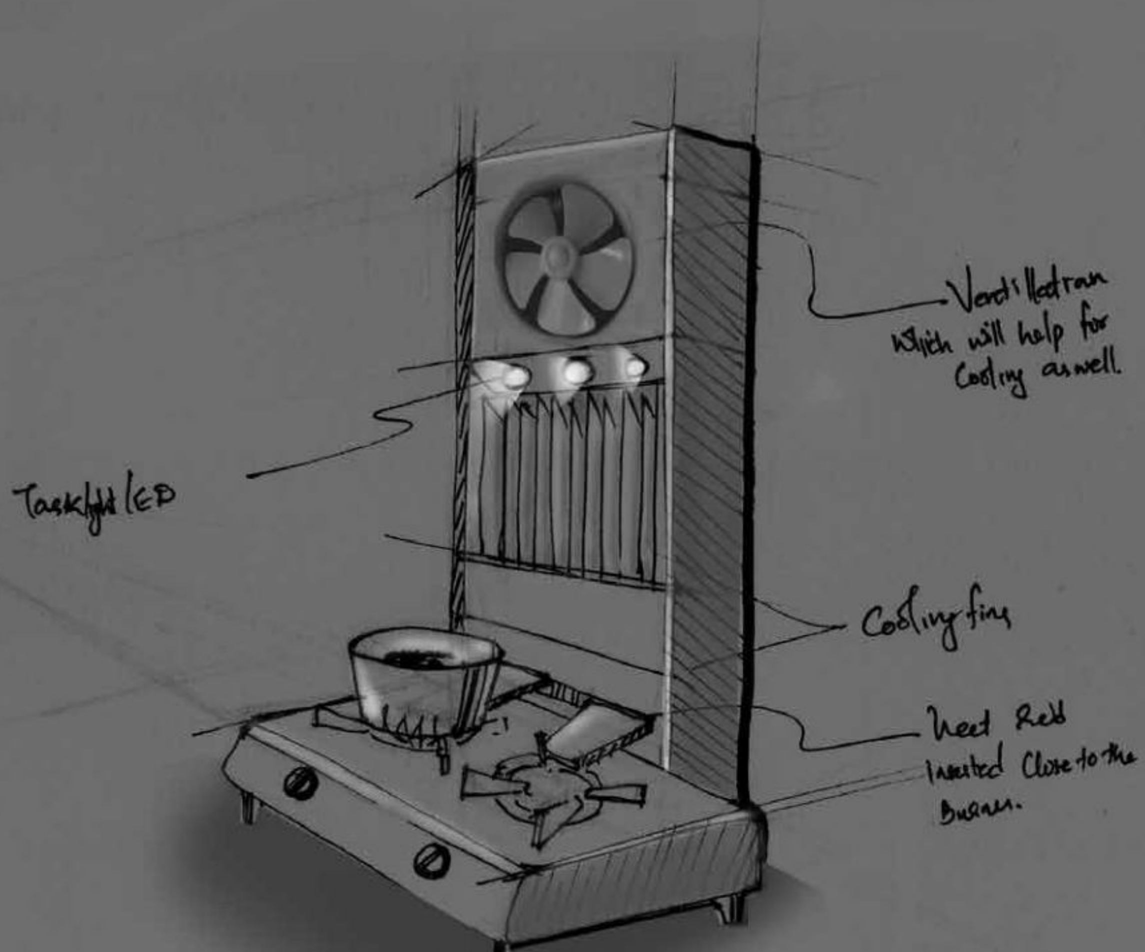
This could work only in island kitchen. hence it cant be applied to the existing stoves



Idea 3: Water based cooling

TEG is powered by using the heat from kitchen stove and the cooling from the water tubes, which are solar tubes. This idea gives the possibility of producing high temperature difference.

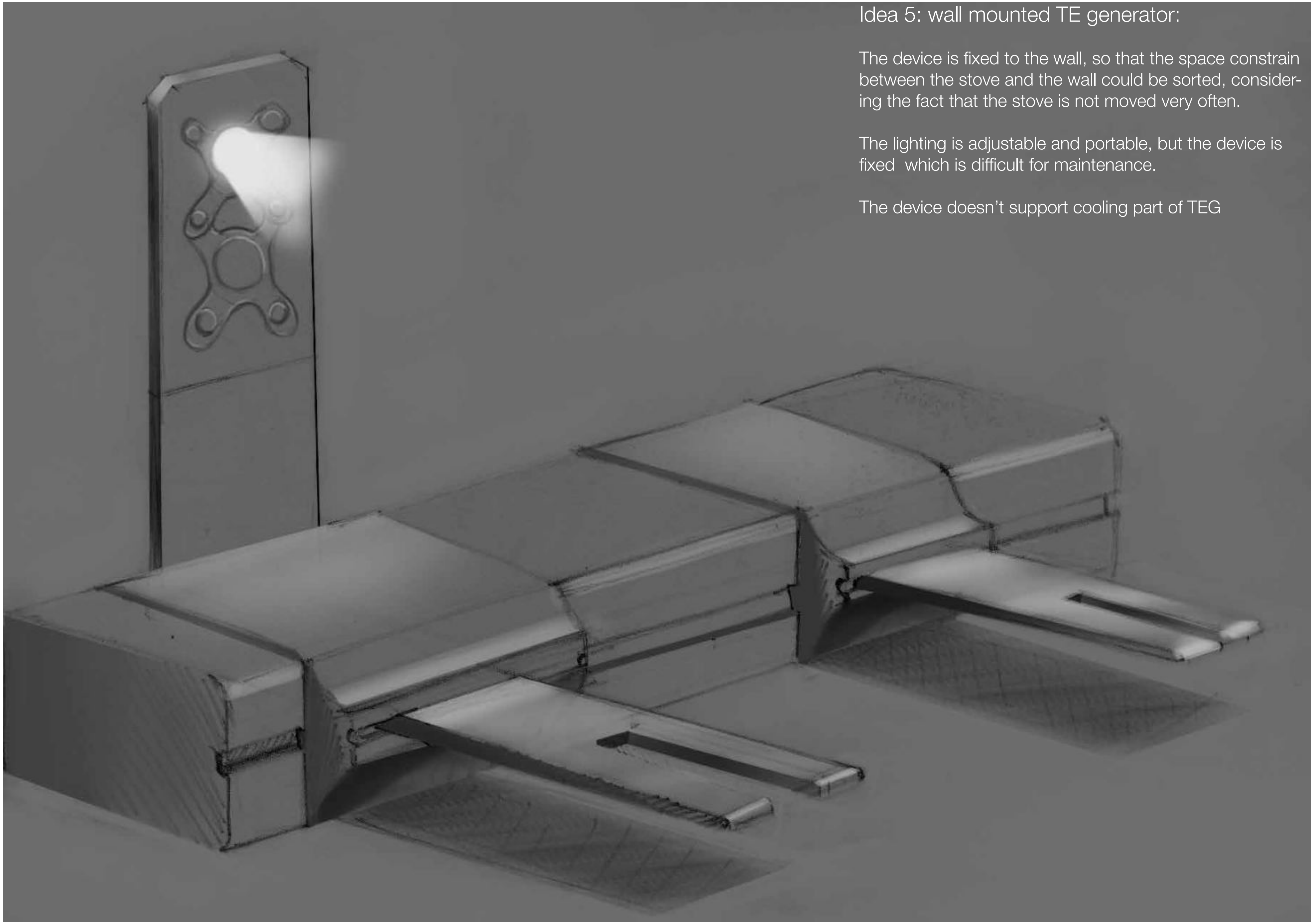
This actually is a hybrid lighting, but water which is stationary inside the tube tend to get heated very fast because of the heat sink.



Idea 4: Cooling using ventilation in the kitchen

This uses the heat from kitchen stove and the cooling is done by the ventilation of the kitchen, which is powered by either grid power or power from TEG .

Ventilation is not very common in many of the houses in India, and running the fan in itself very power demanding

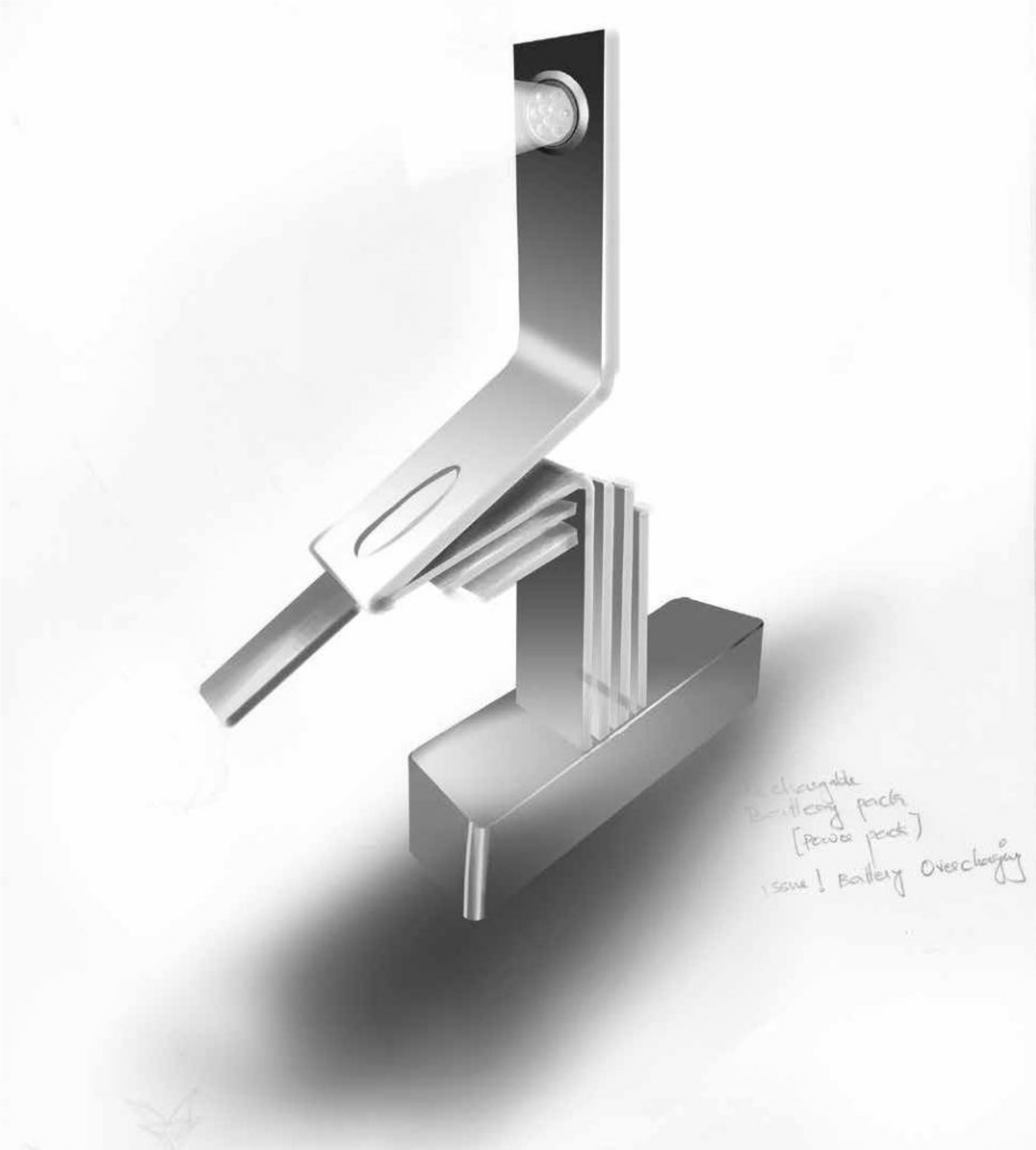


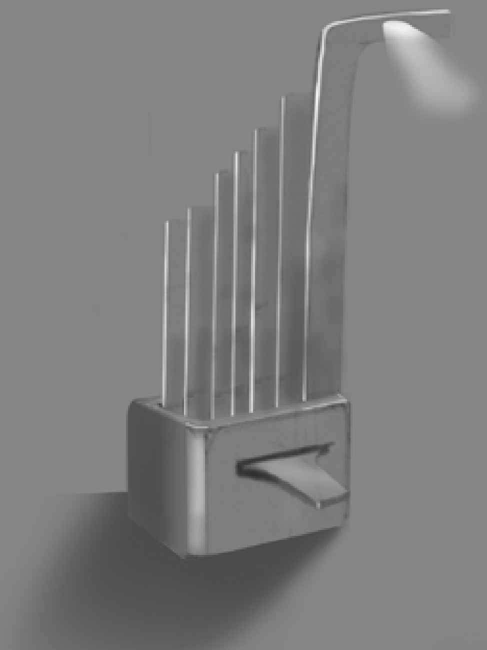
Idea 5: wall mounted TE generator:

The device is fixed to the wall, so that the space constrain between the stove and the wall could be sorted, considering the fact that the stove is not moved very often.

The lighting is adjustable and portable, but the device is fixed which is difficult for maintenance.

The device doesn’t support cooling part of TEG

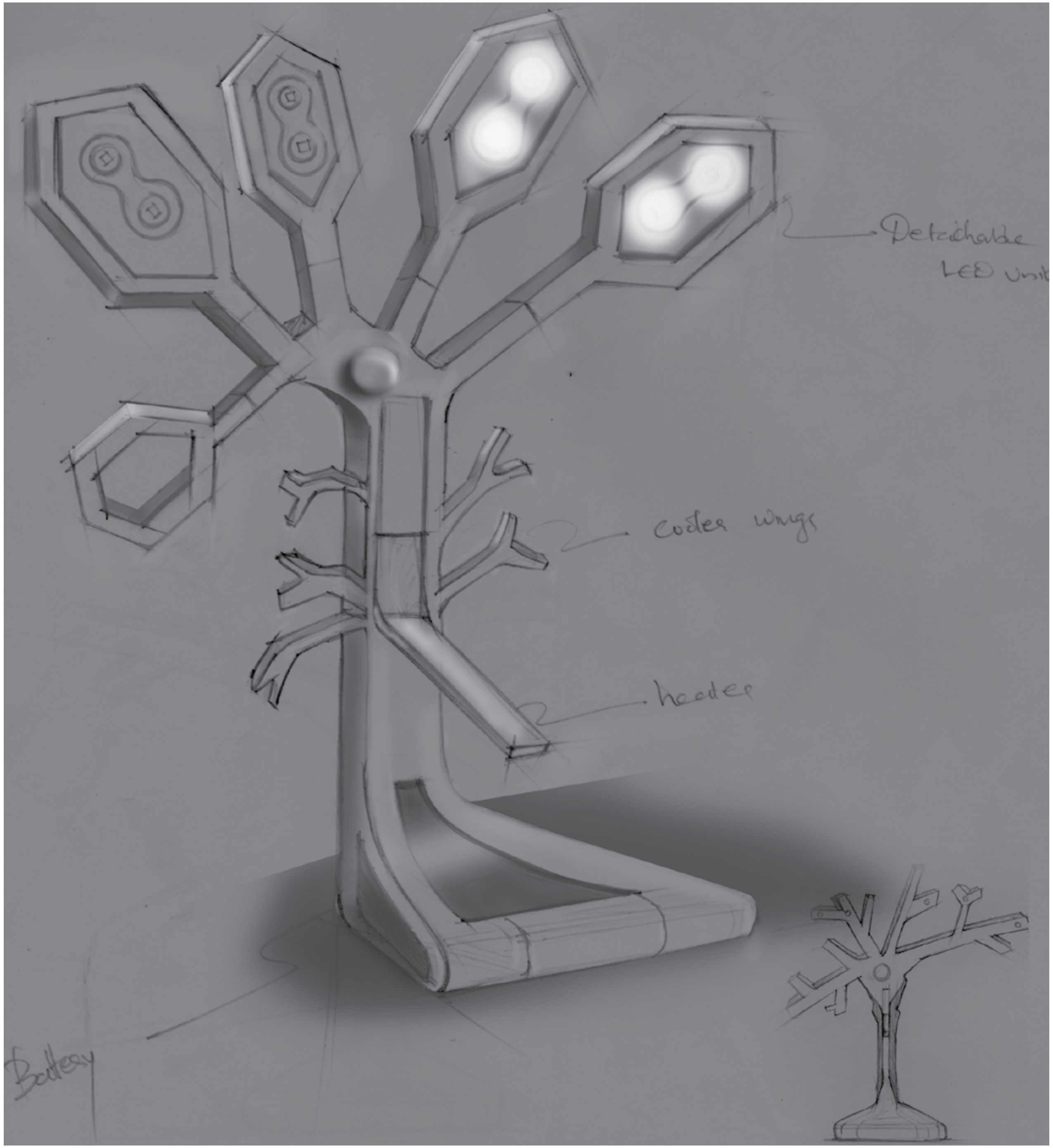




Idea 6: Cool cool fins

The device supports the cooling end. It will increase the efficiency of power production, but the base of the form is not compatible with the less and cramped kitchen space around the stove.

The form in itself will help in cooling the TEG.

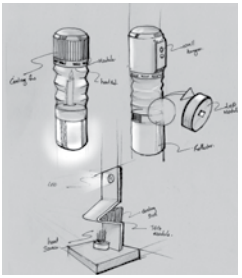


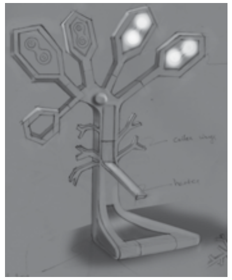
Idea 7: Power Tree

The device has the modular lighting , which will help in the portability of light as separate element.
And the whole tree can act as the heat dissipating unit.
The device wont occupy much space behind the kitchen.
Like a tree the elements keep on increasing.

The problem is, dissipation of the heat is not standardised.
And it may affect the components.
Difficulty in maintaining the device from the spillages around the stove.

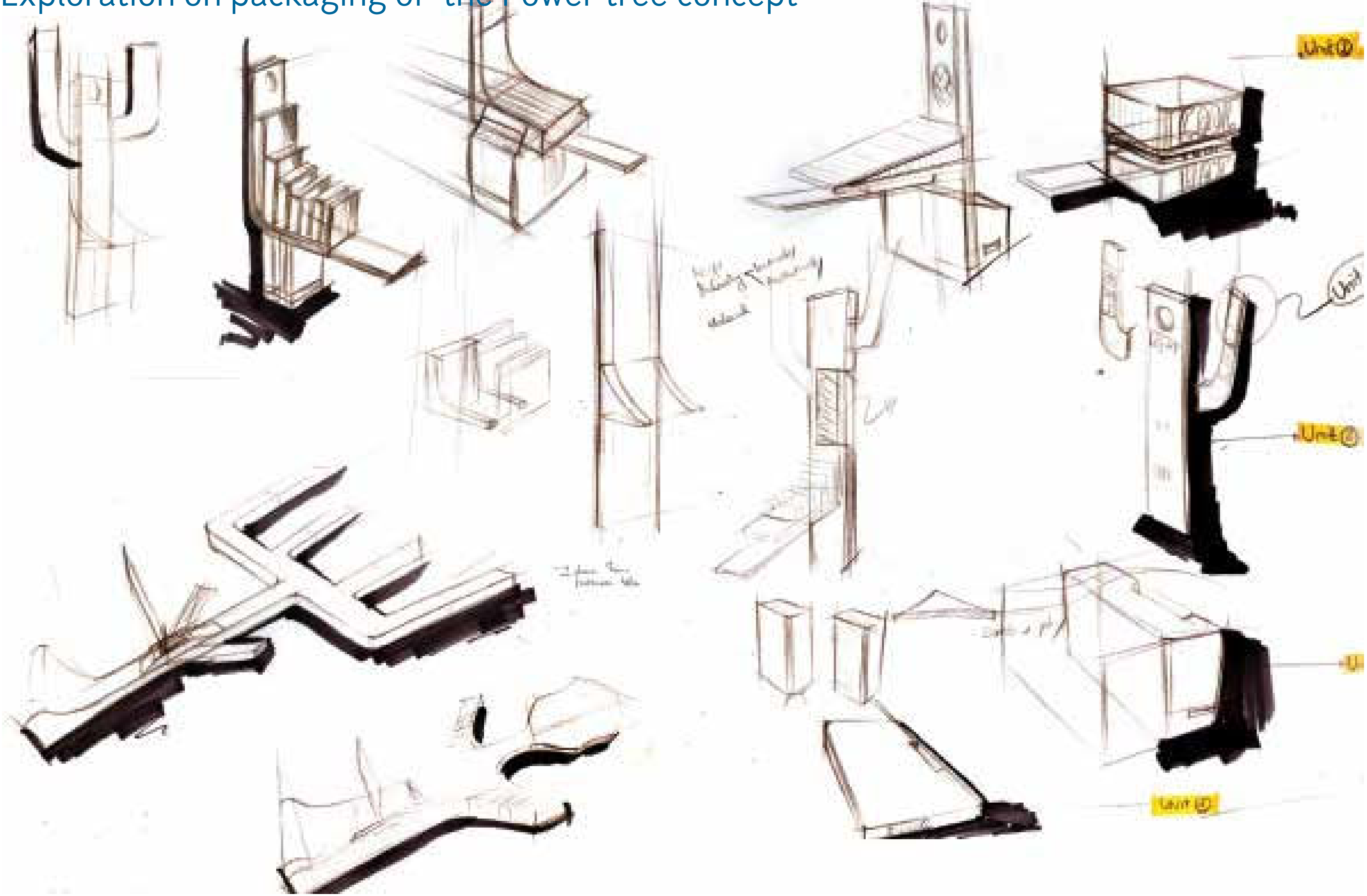
Idea Evaluation



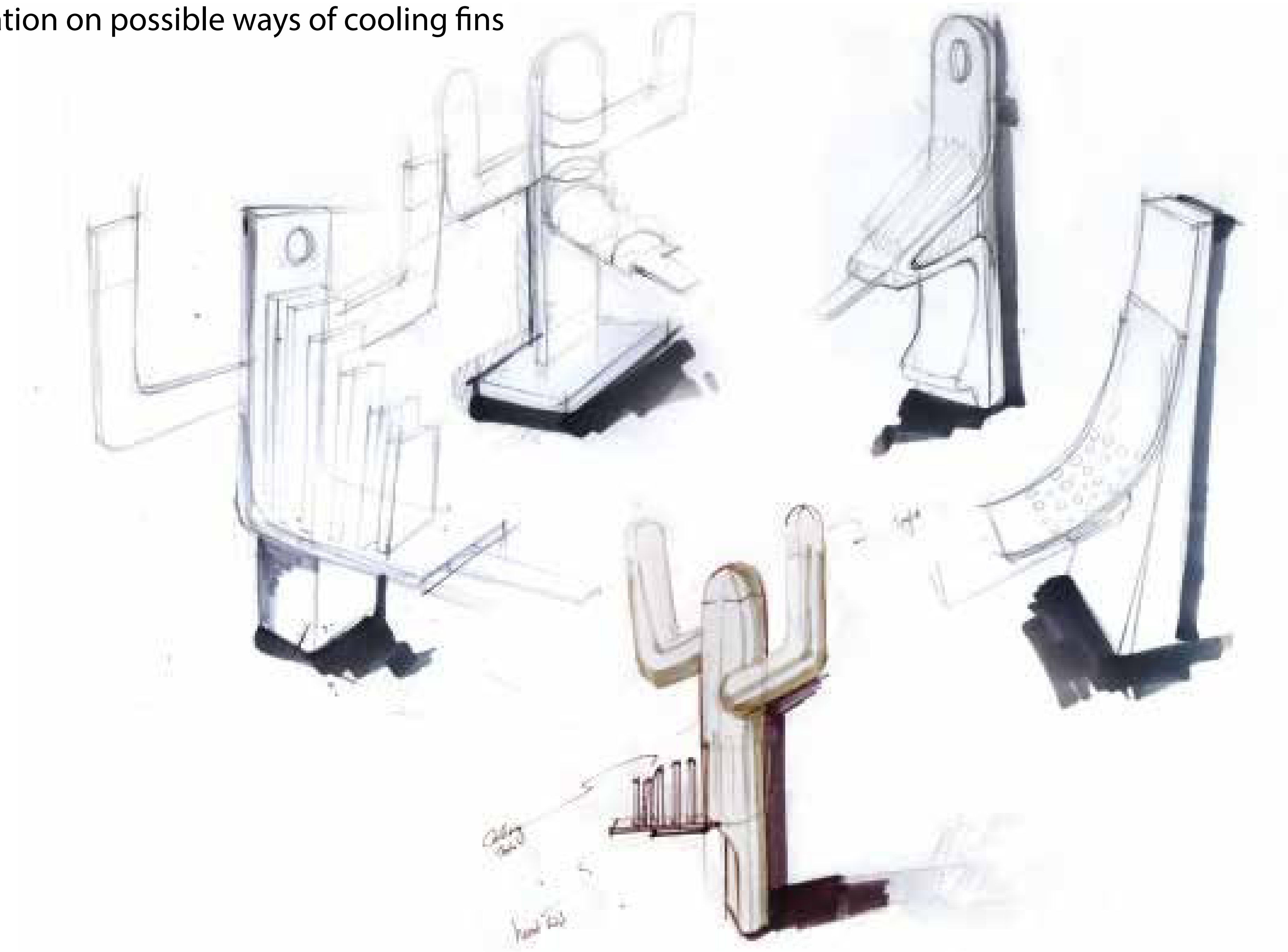


	Idea 1 (Direct Heating)	Idea 2 (Forced air-fan ventilation)	Idea 3 (Wall mounted)	Idea 4 (power tree)	Idea 5 (Cool cool sink)	Idea 6 (water cool)
Efficiency of Heating	4	3	2	3	3	3
Efficiency of Cooling	3	4	1	3	4	4
Portability and adjustability	4	2	1	4	4	2
Modularity of light	3	3	2	4	2	2
Multi functionality	2	4	2	4	2	4
Maintanance	4	3	4	3	4	2
Manufacturability	3	3	3	3	3	3
Total	23	22	15	24	22	20
Quanlitative:						
Battery capacity	no	yes	no	yes	no	yes
Additionla support for power generation	yes	no	no	no	no	yes
Charging option	no	yes	yes	yes	no	yes
Grid connected	no	yes	no	yes	no	yes/ no

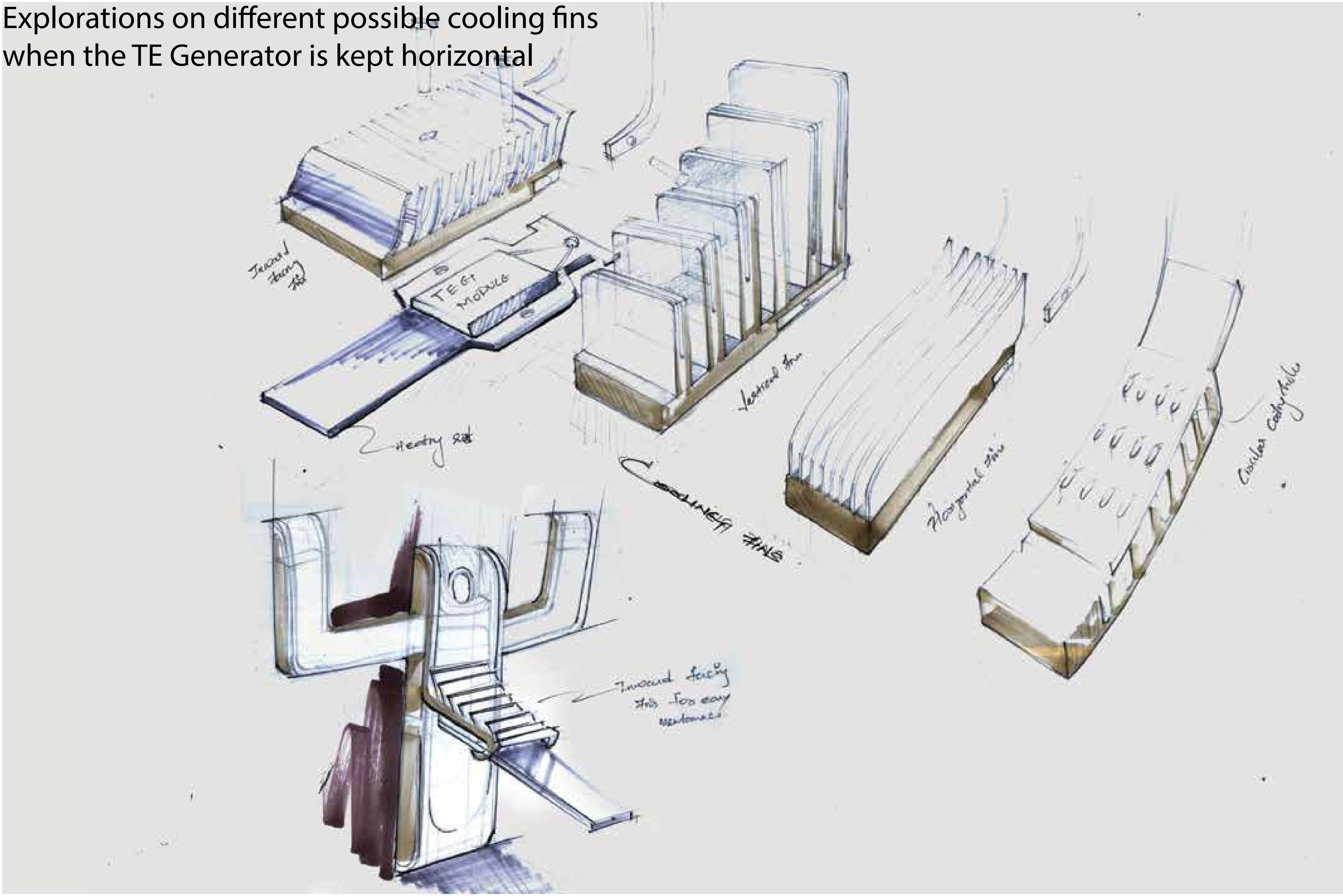
Exploration on packaging of the Power tree concept



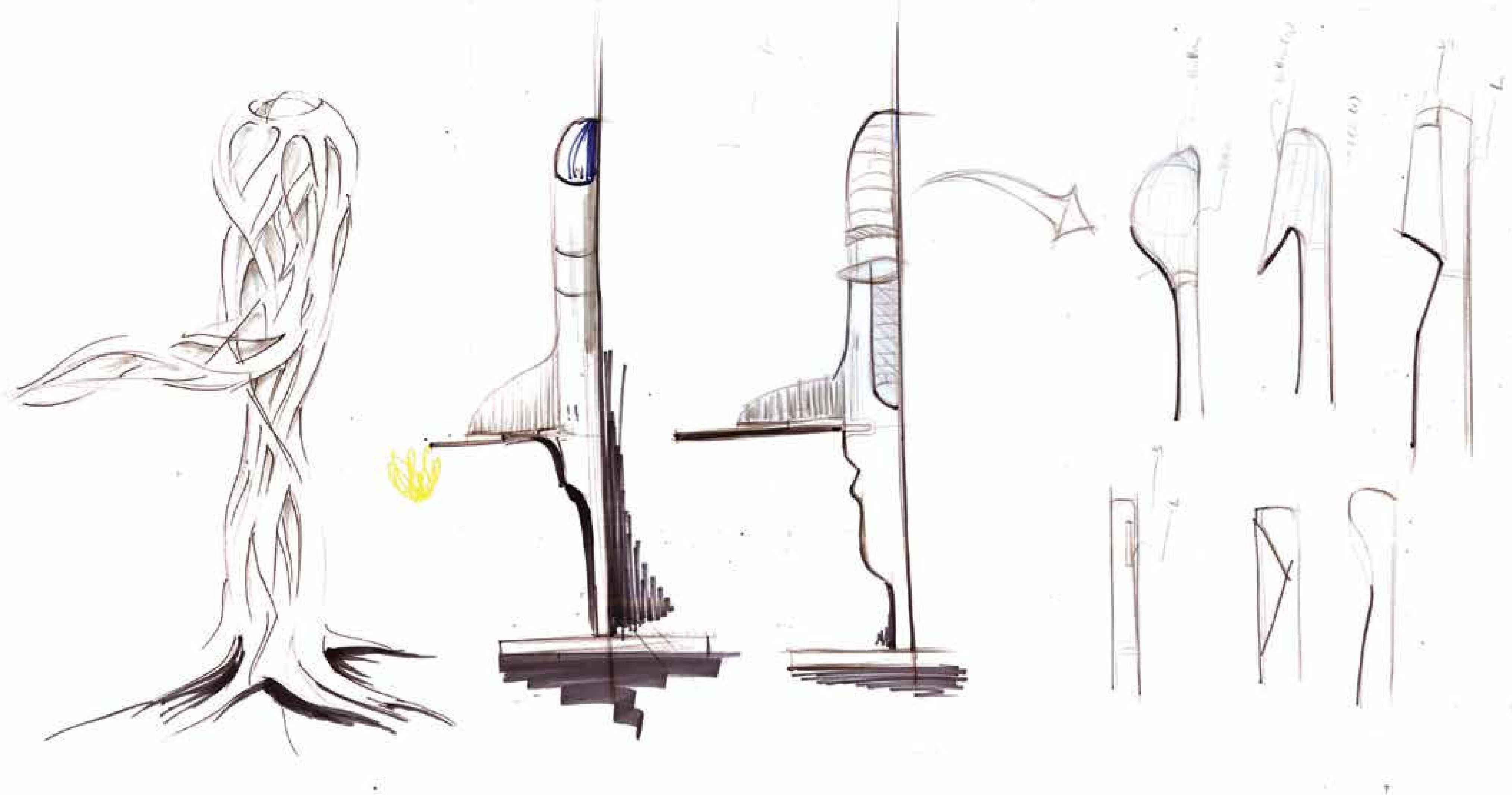
Exploration on possible ways of cooling fins

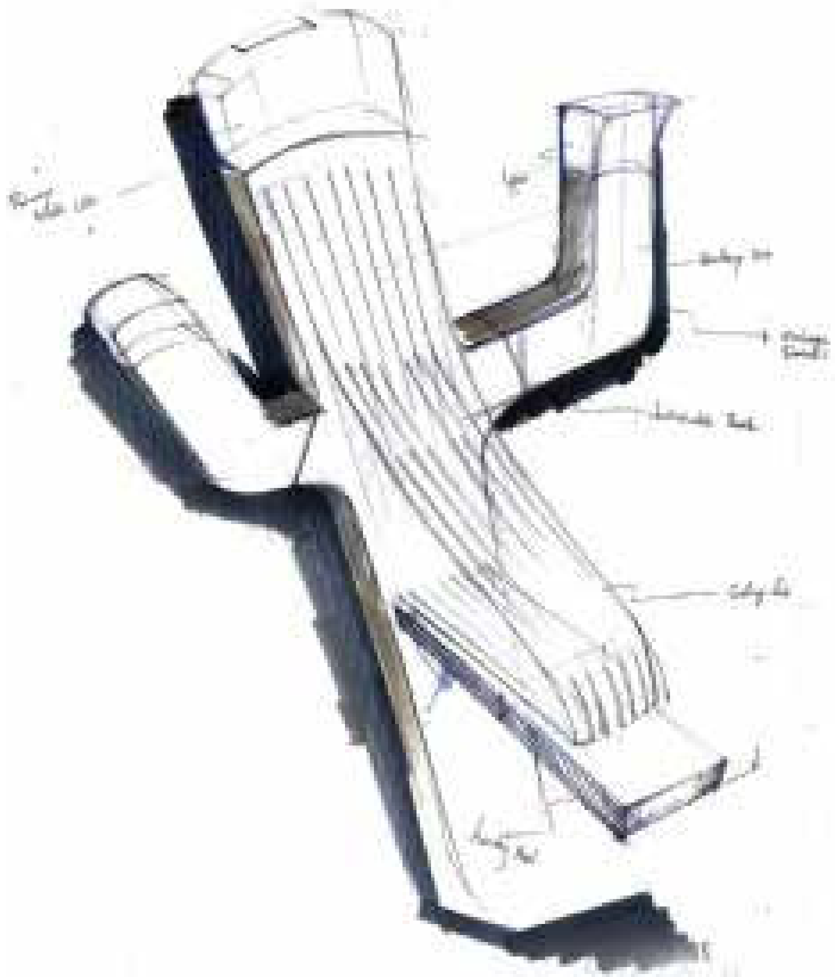


Explorations on different possible cooling fins when the TE Generator is kept horizontal

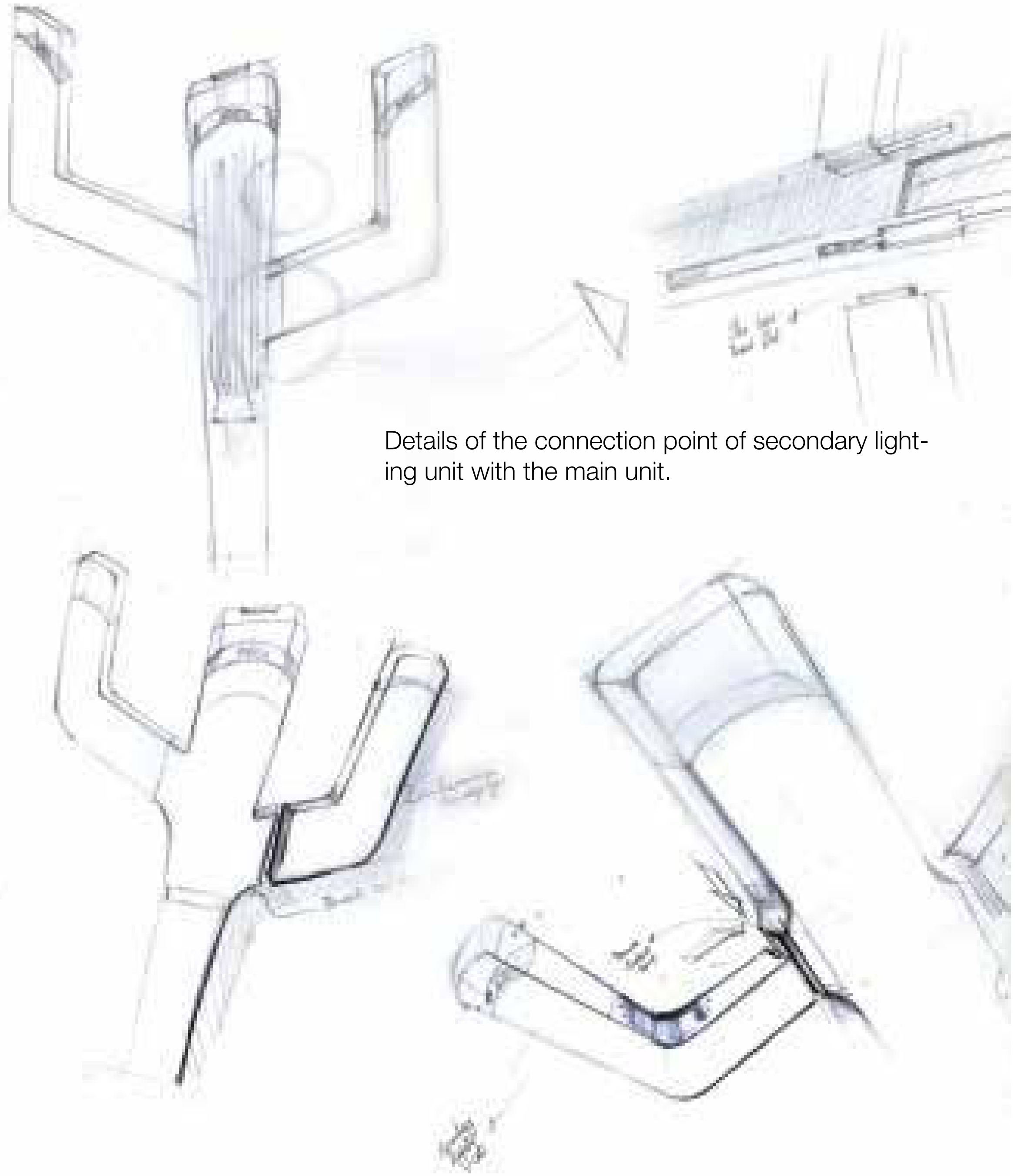


Explorationsofdifferentlightingelementforthe main unit and the secondary units





The form resembles the Cactus Tree and then the inspiration from cactus tree is taken for the further exploration in form.



Details of the connection point of secondary lighting unit with the main unit.

Rig model study

A rig was build to understand the proportion, volume and the size of the design. It is tested with actual single burner gas stove. It was mostly experimented with the horizontal and vertical positioning of TE generator. Understanding from variants are as follows.

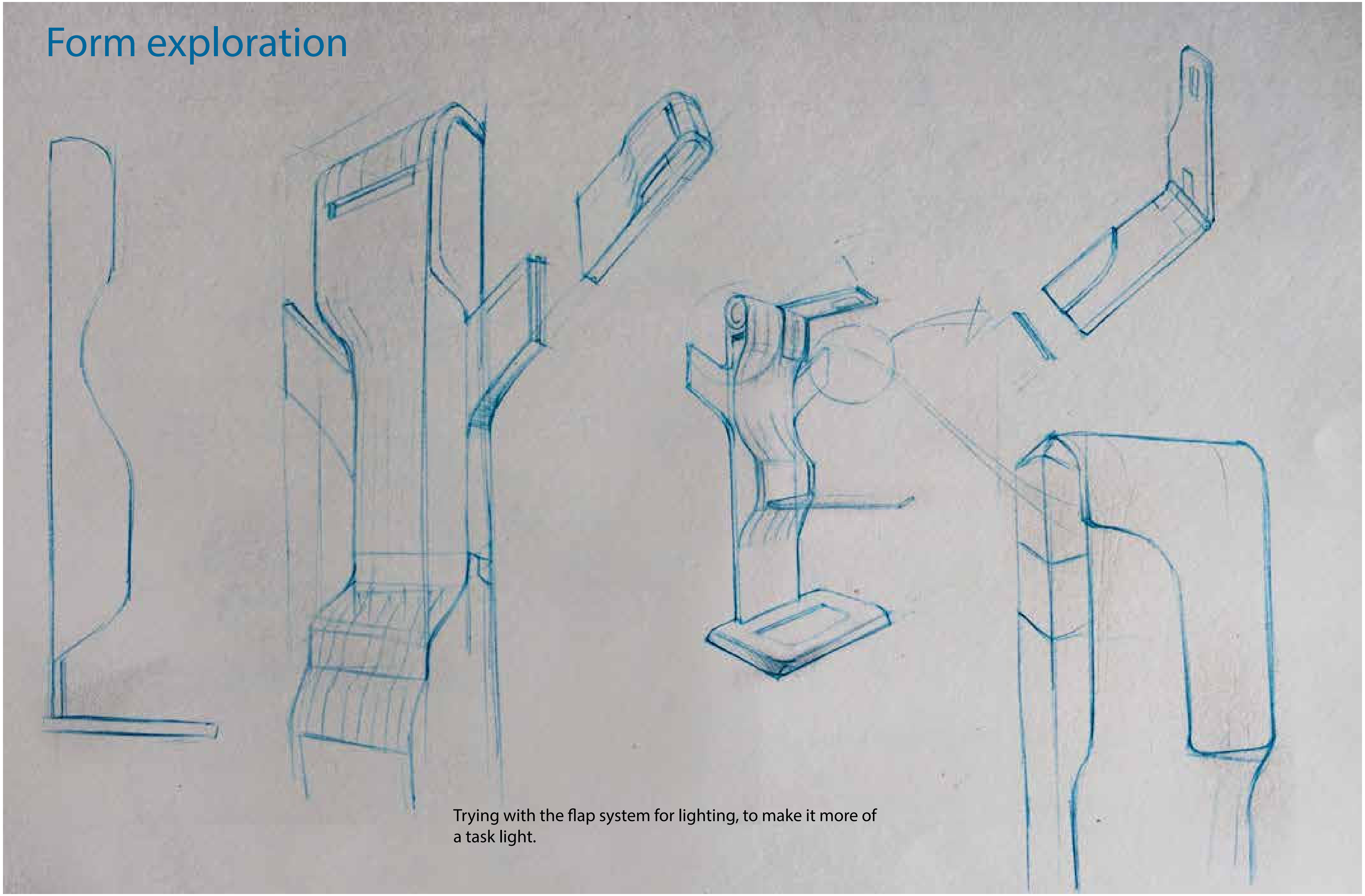
The heat rod without cooling sink is kept to understand the size and impact on the gas stove.

The vertical heat sink model is tried, which can also work with the horizontal positioning of TEG, It is disturbing the utensil kept on the burner.

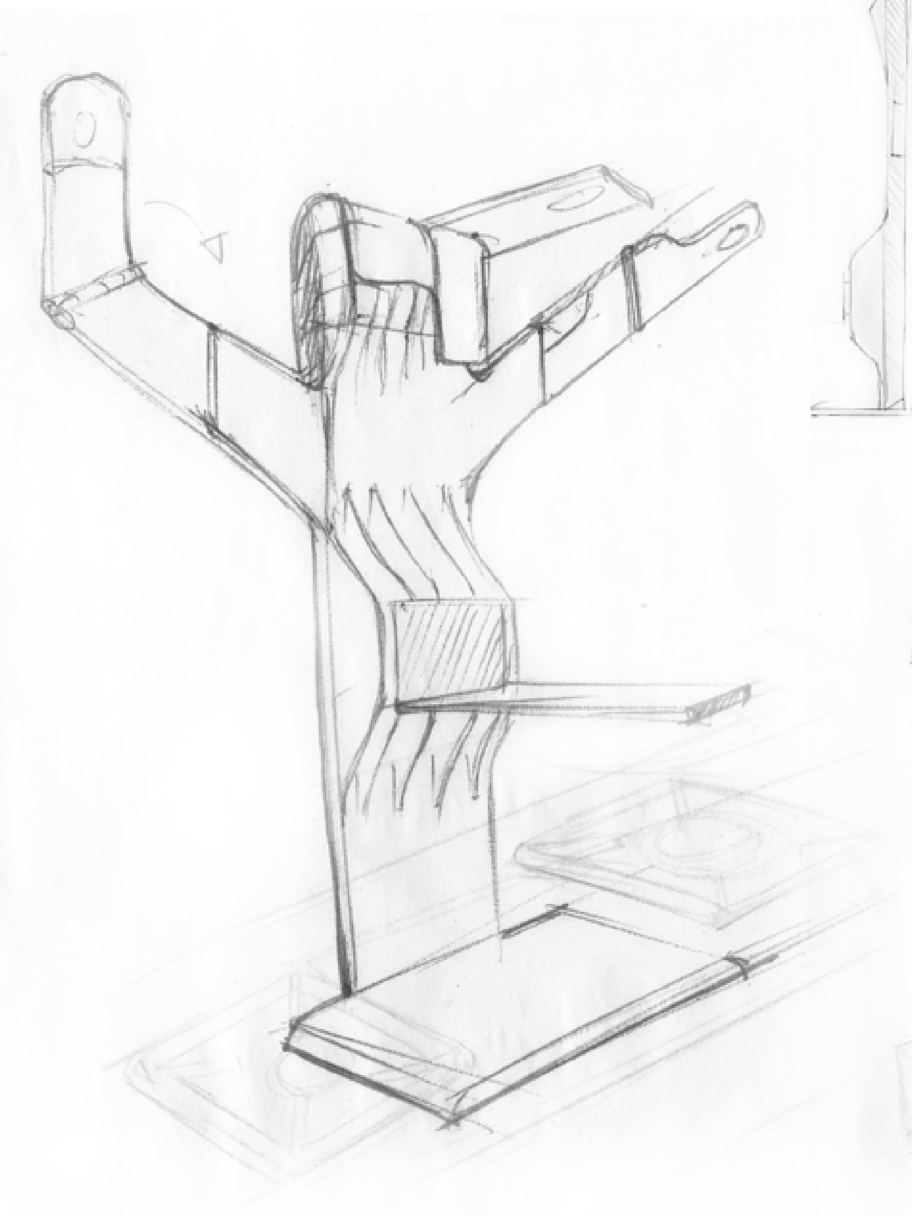
In this horizontal positioning of TEG, The height of its positioning is increased. Which will reduce the heat exchange ratio.

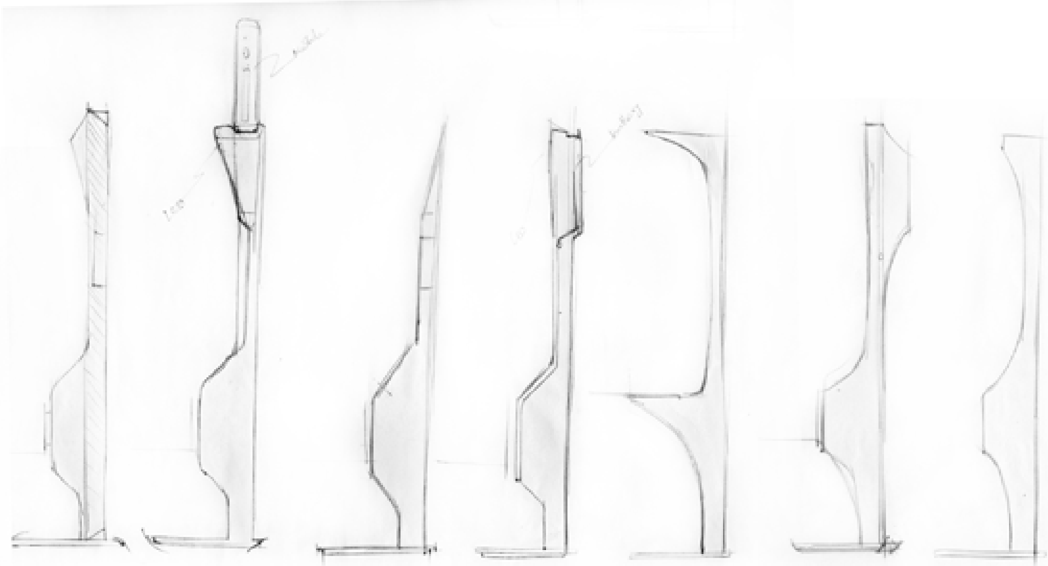
In this, heat sink is spread across its volume and its balanced.

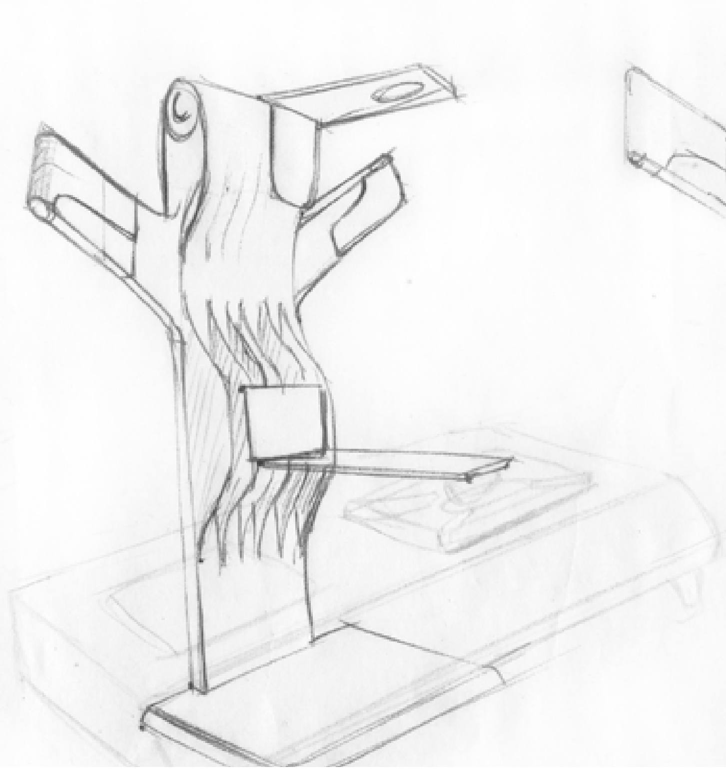
Form exploration

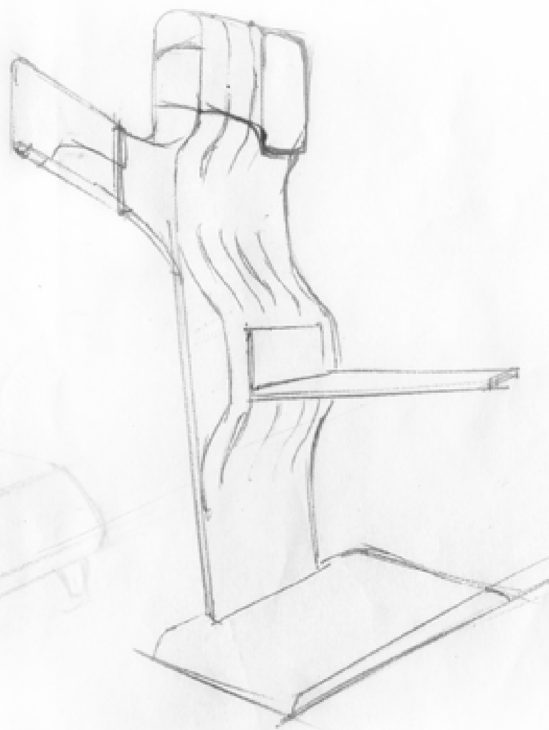


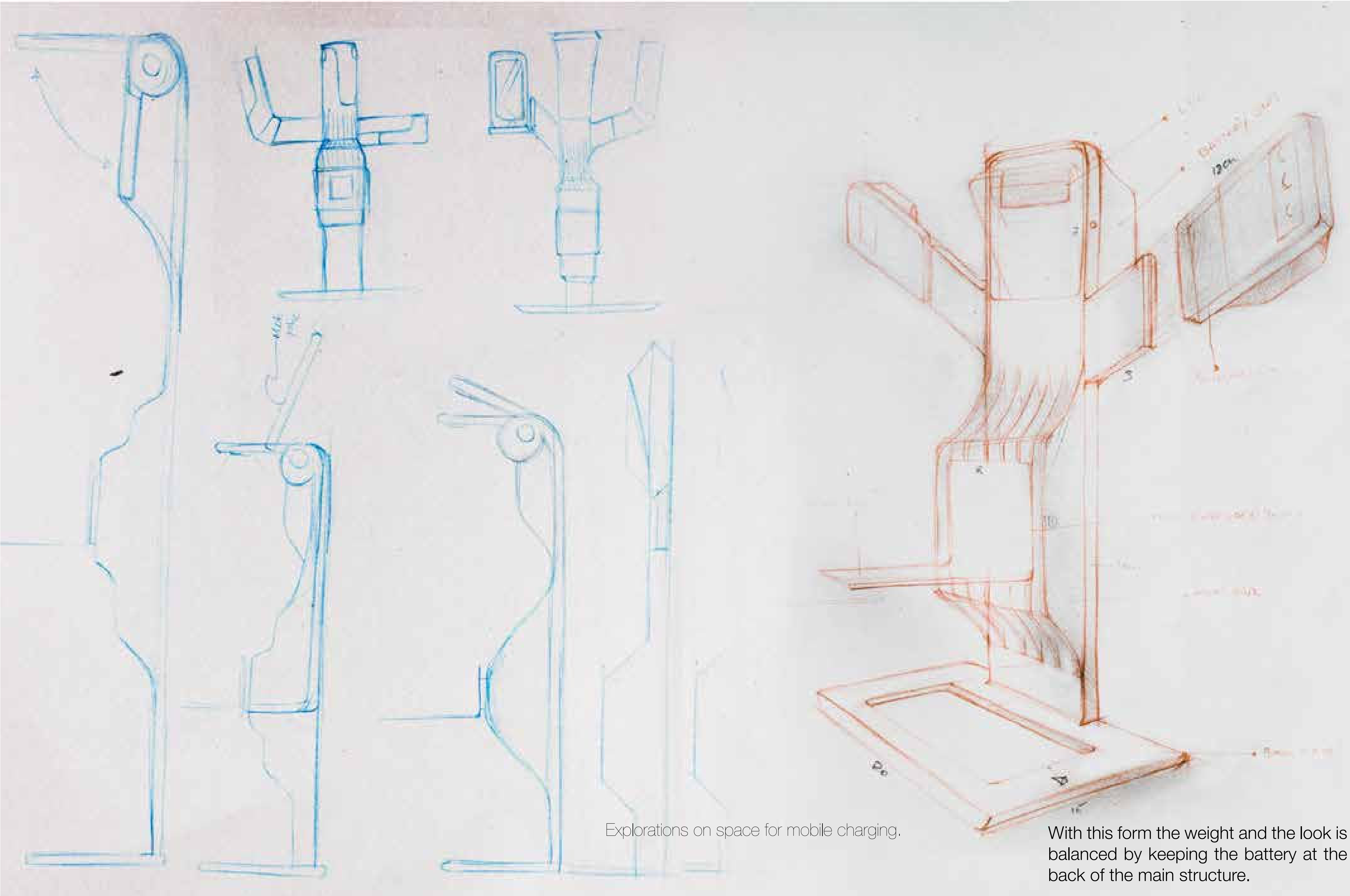
Trying with the flap system for lighting, to make it more of a task light.







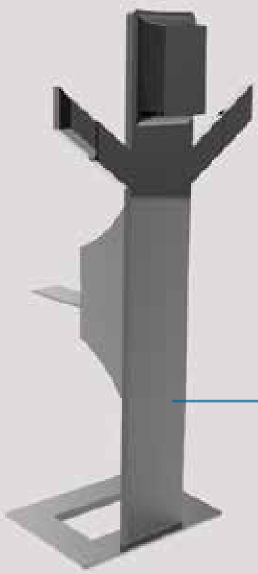




Explorations on space for mobile charging.

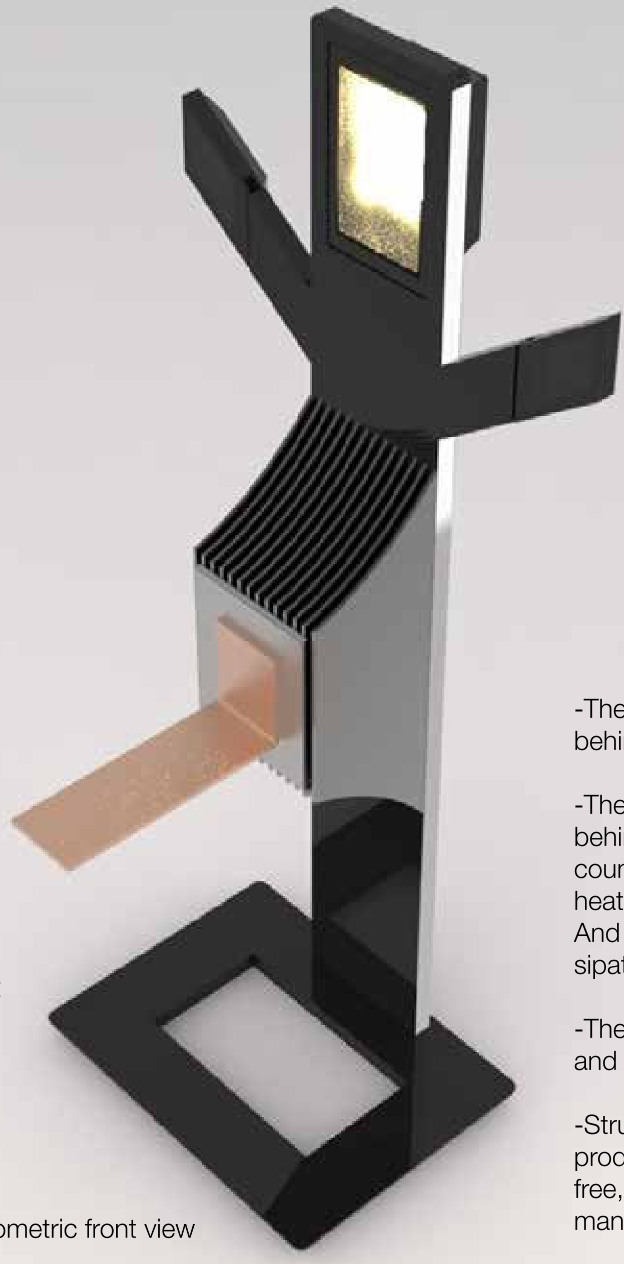
With this form the weight and the look is balanced by keeping the battery at the back of the main structure.

CAD



The bottom half of the device is designed naked and thin , so that it doesn't occupy a lot of space when kept behind the stove.

The isometric back view



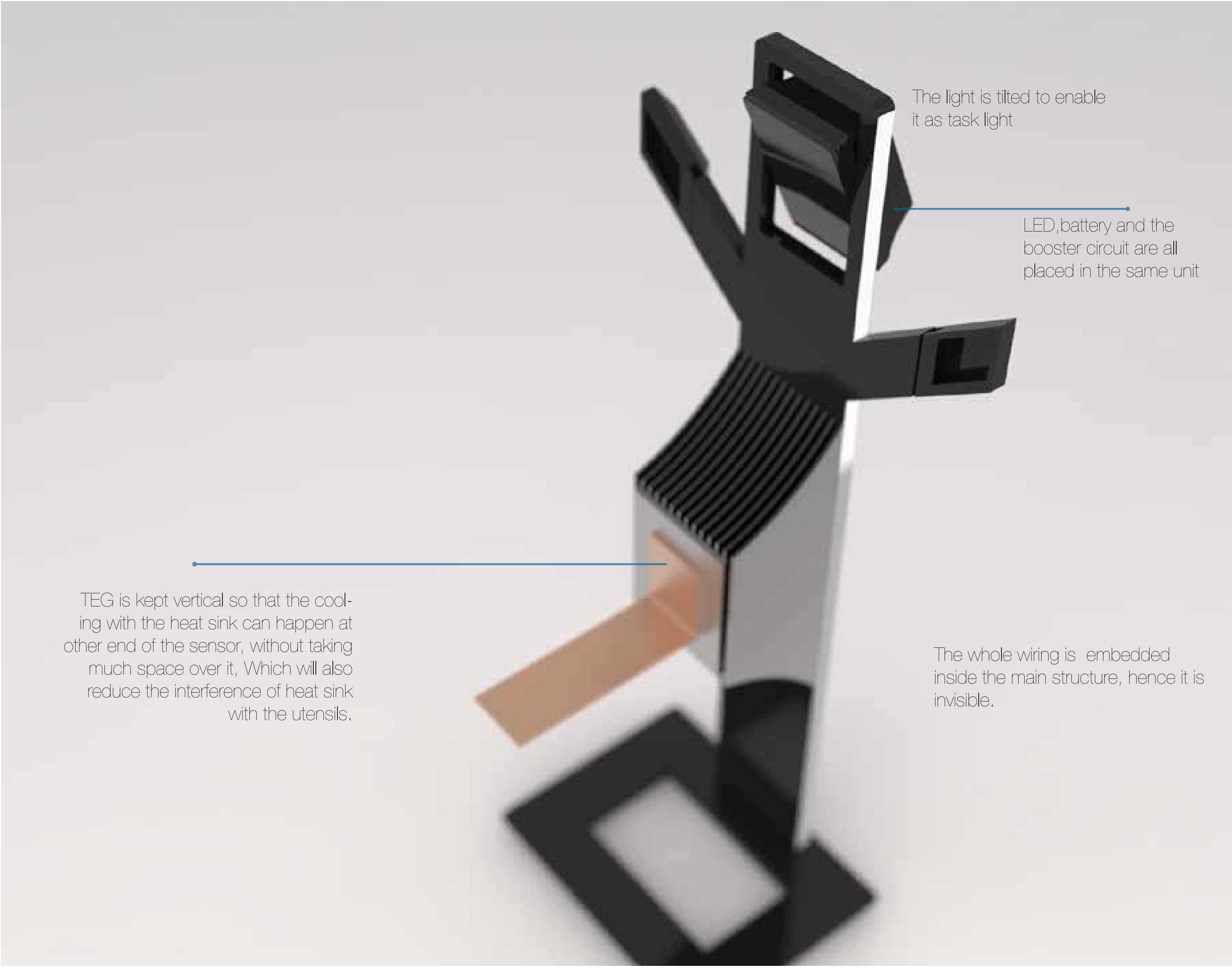
The isometric front view

-The form helps to keep the device behind the stove.

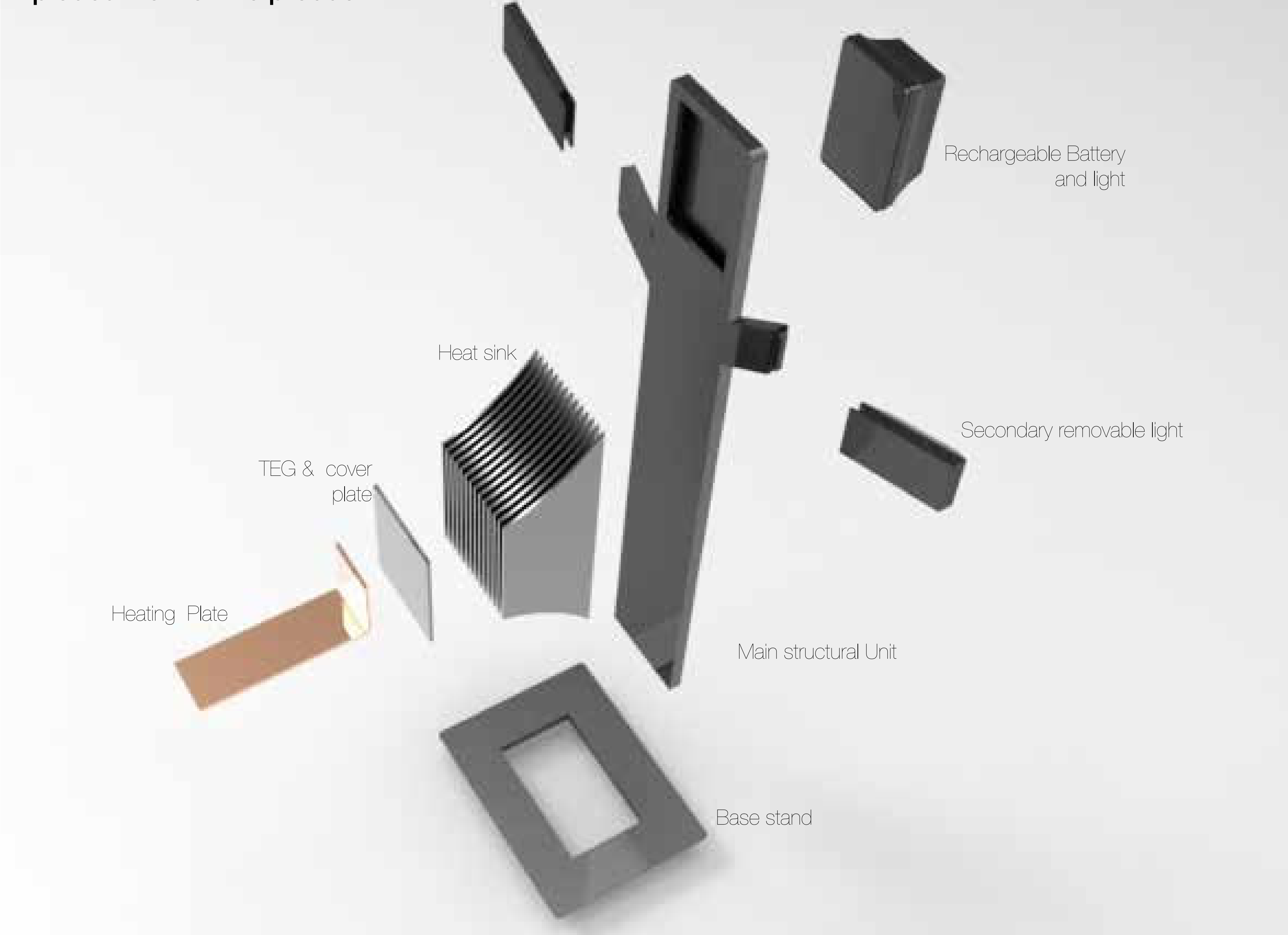
-The broad base and the battery behind the main structure helps to counter balance the weight of the heat sink.
And it will also act as a heat dis-sipater.

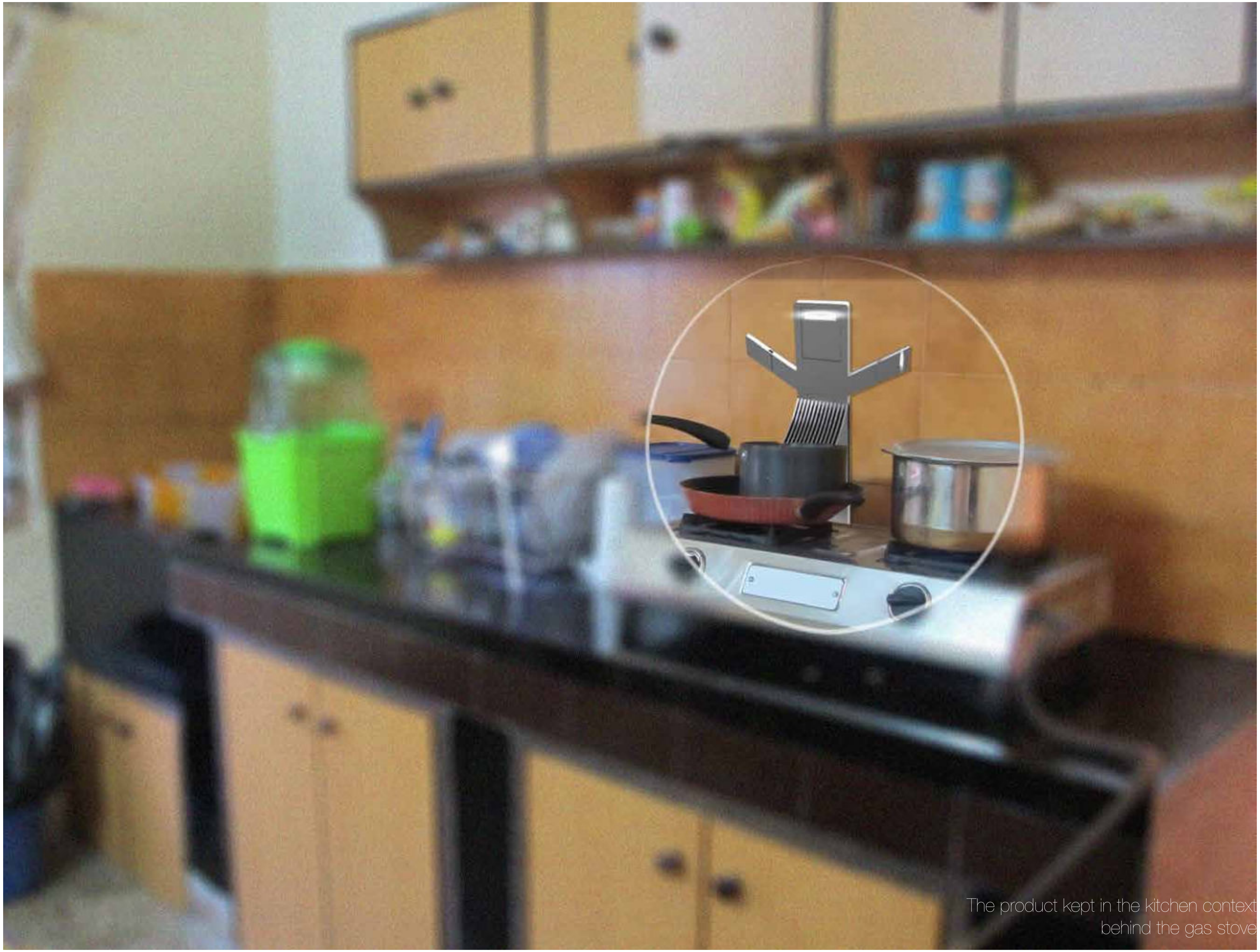
-The secondary light is detachable and can be used as torch.

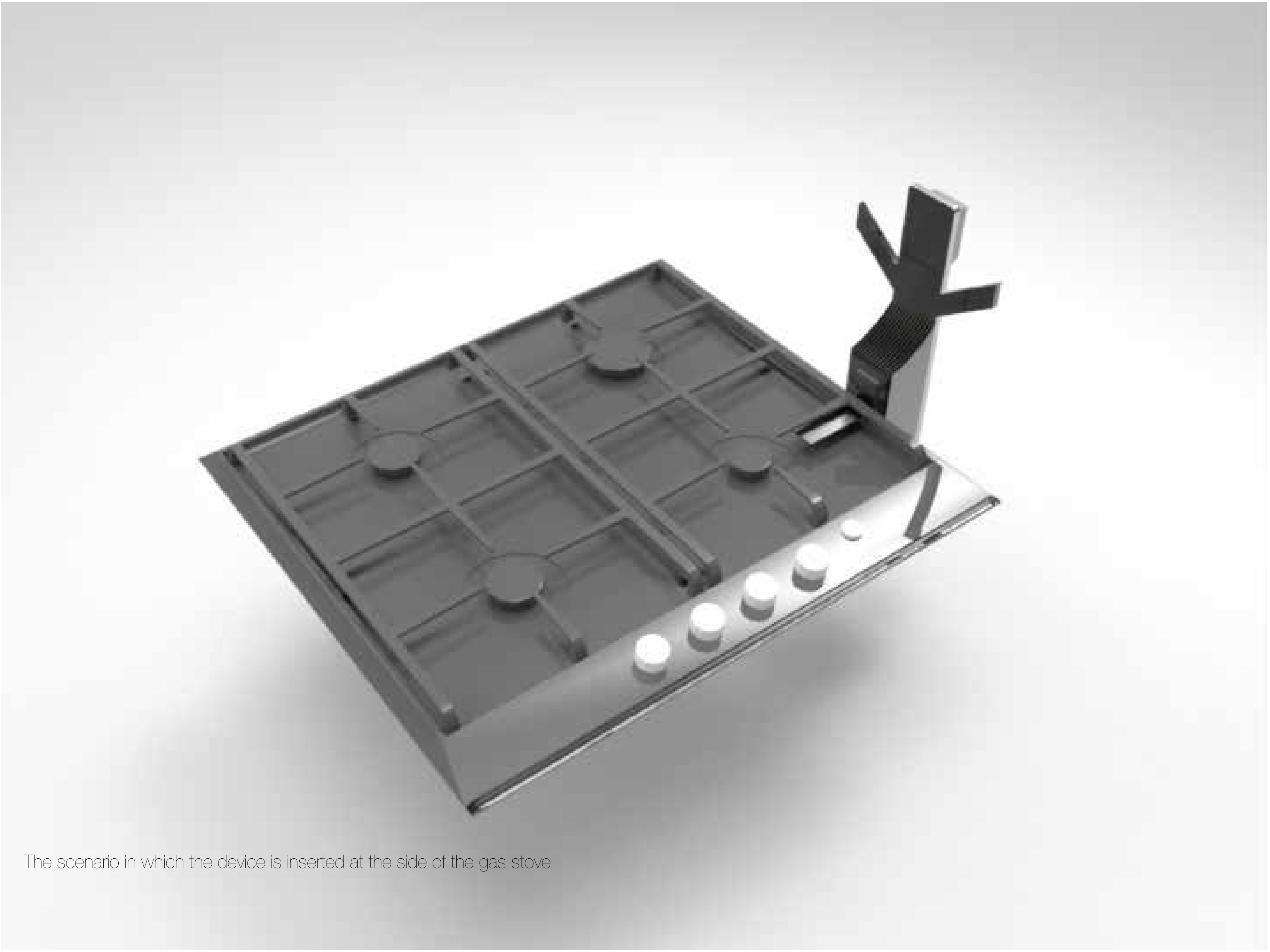
-Structural form is chosen for the product so that, it is maintenance free, and easy for assembly and manufacturing.


The light is tilted to enable
it as task light
LED,battery and the
booster circuit are all
placed in the same unit
TEG is kept vertical so that the cool-
ing with the heat sink can happen at
other end of the sensor, without taking
much space over it, Which will also
reduce the interference of heat sink
with the utensils.
The whole wiring is embedded
inside the main structure, hence it is
invisible.

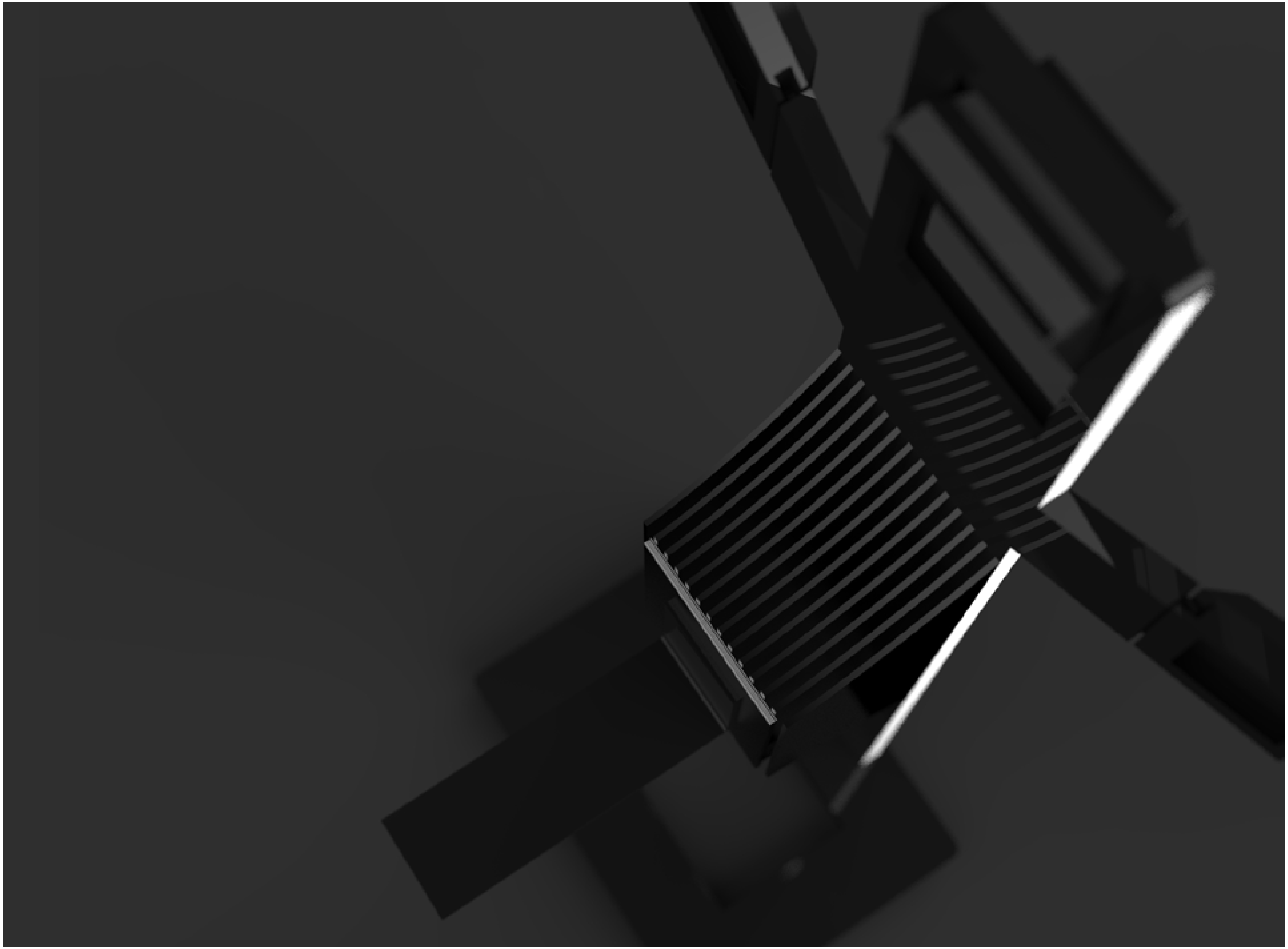
Exploded view of the product



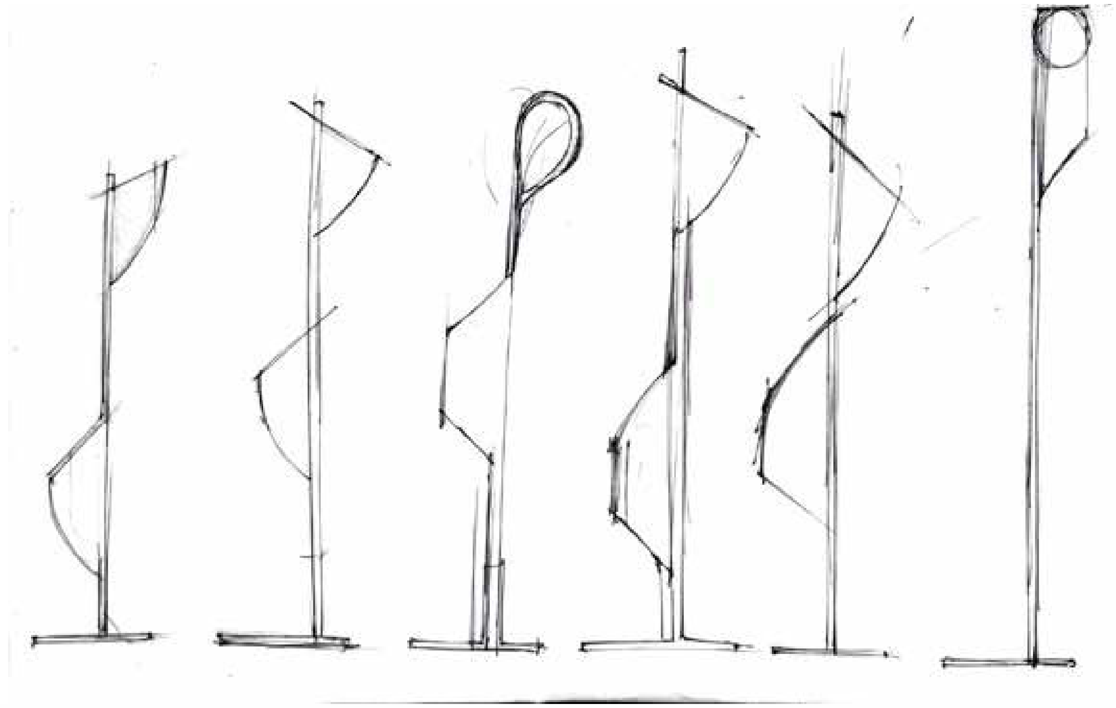

The product kept in the kitchen context
behind the gas stove

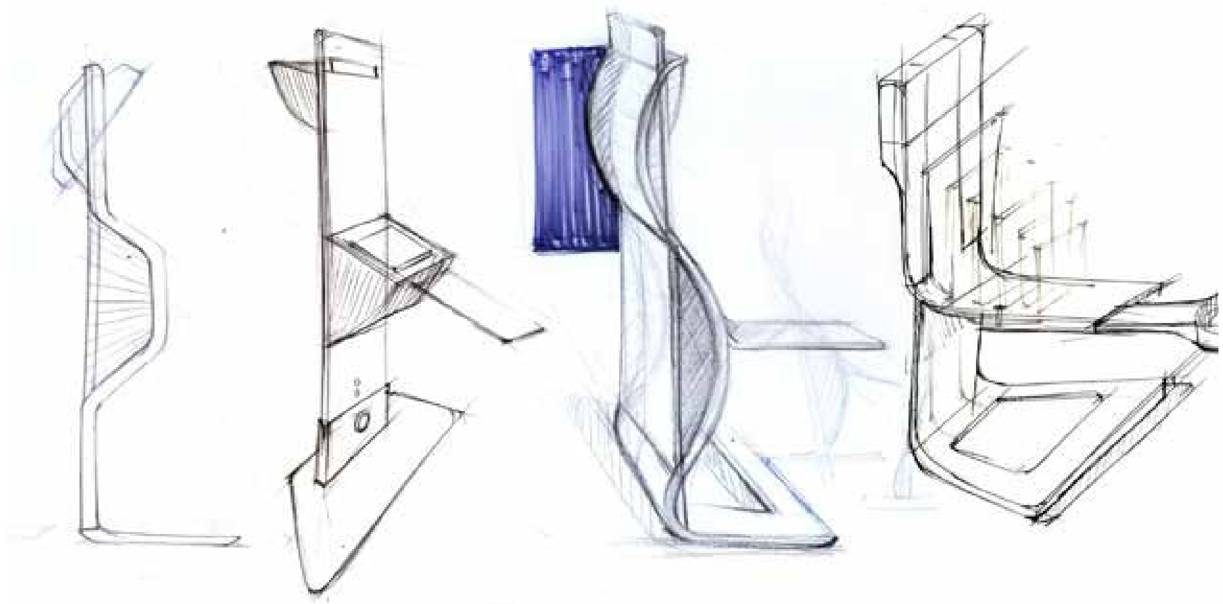


The scenario in which the device is inserted at the side of the gas stove



Further exploration of form

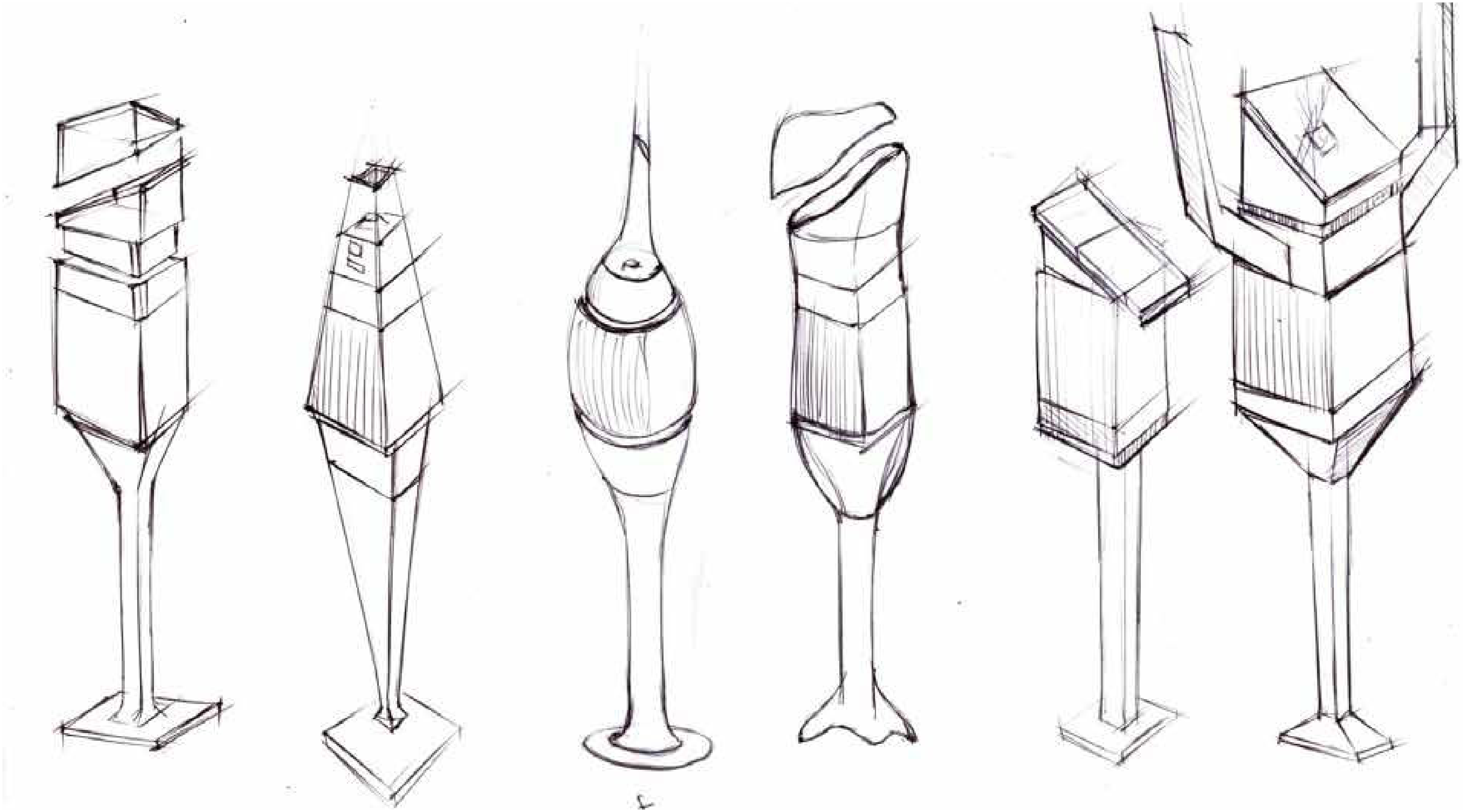




Structural form is explored further to optimise the function and increase the usability factor.

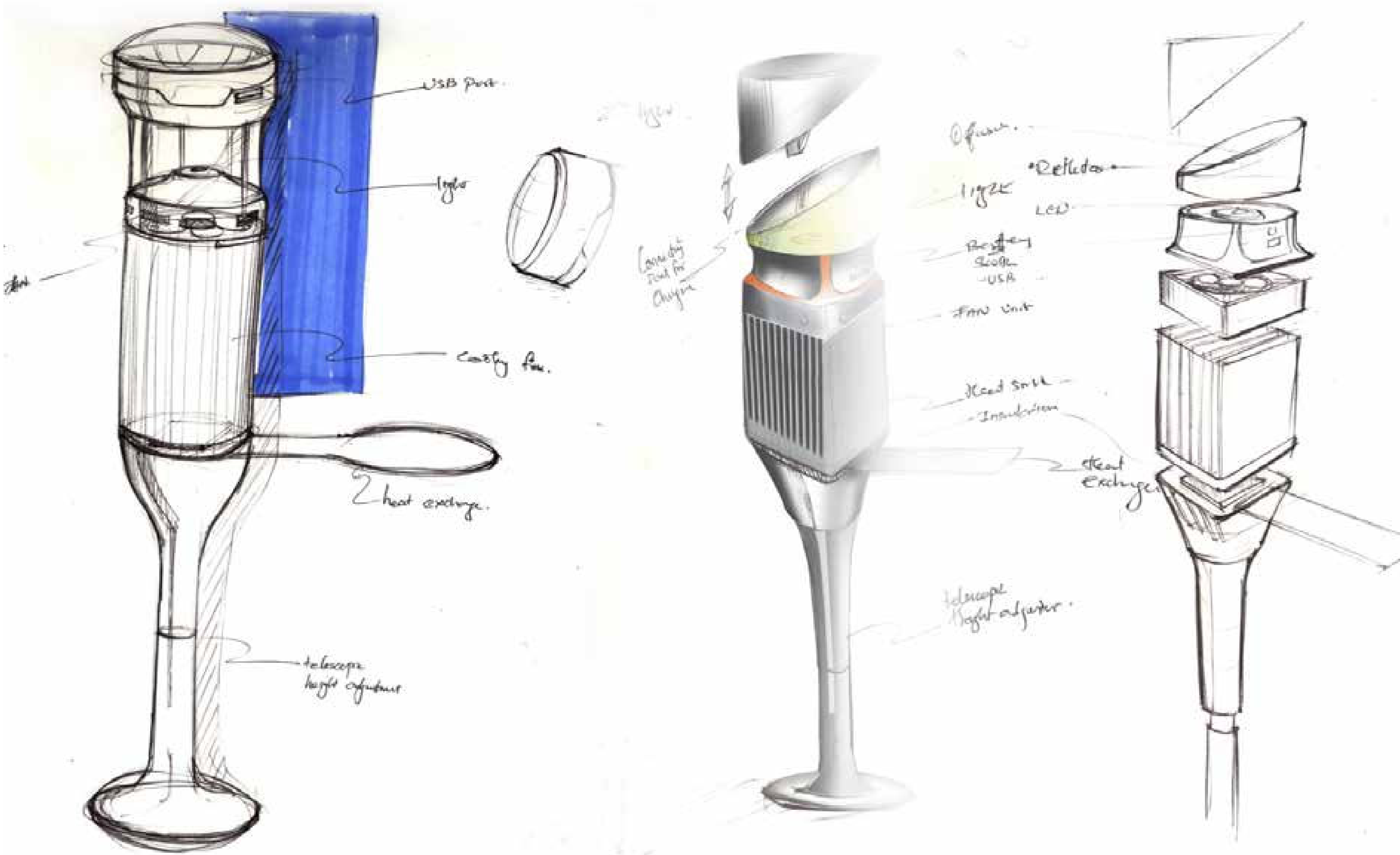
Different possible ways of packaging the heat sink and lights is shown aside.

Exploration based on overall form which will have semantics of kitchen products.

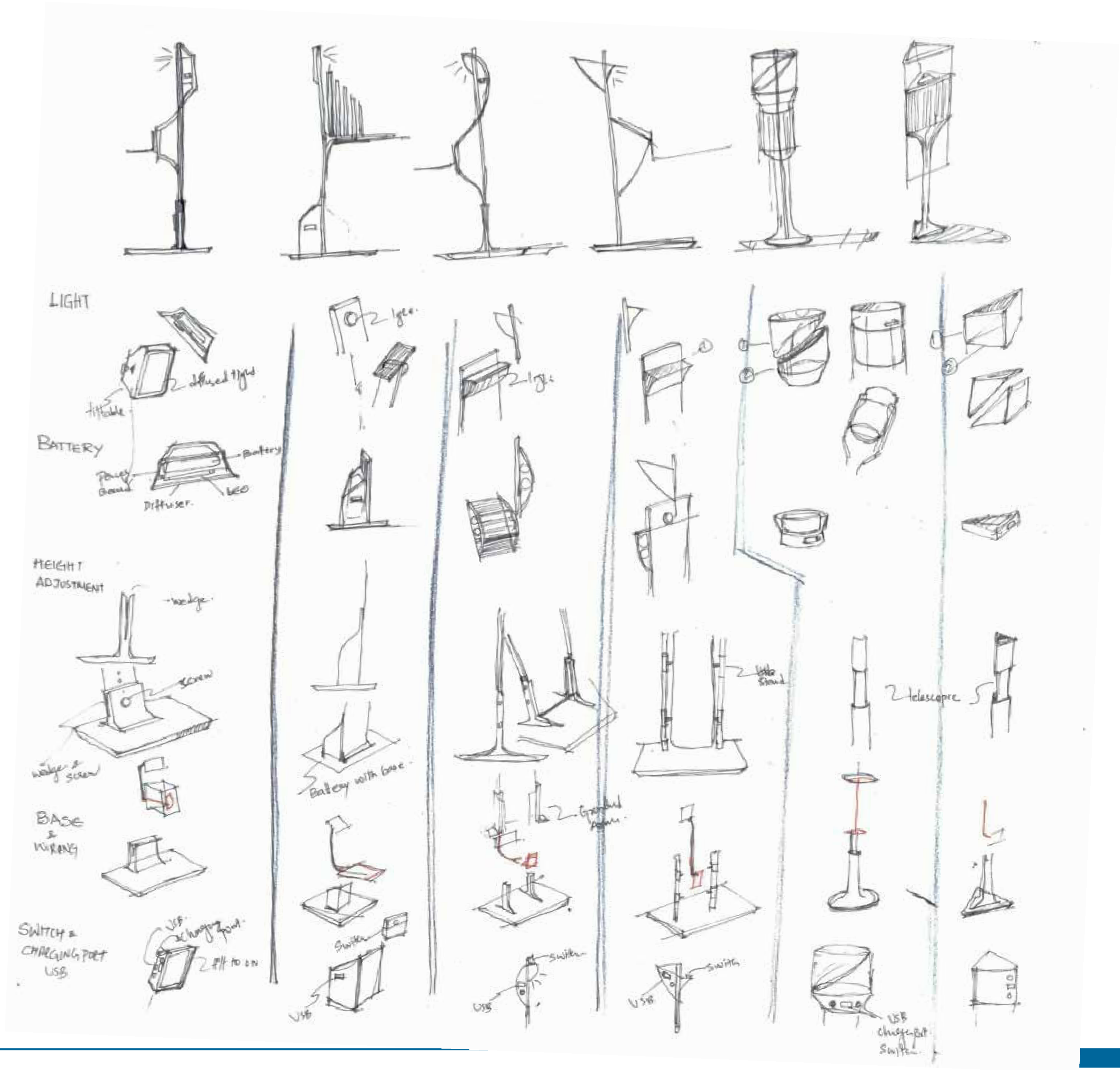


Detailing

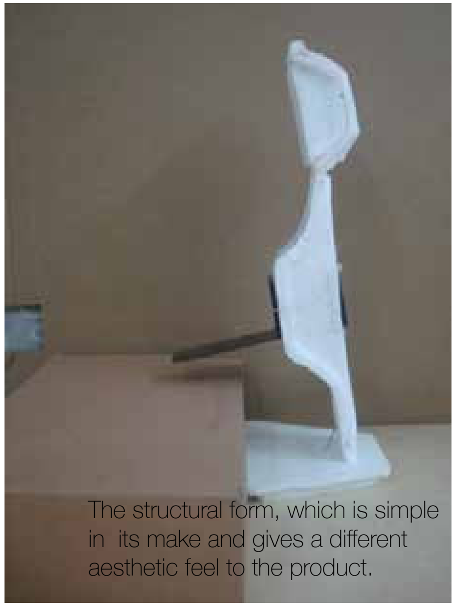
Detailing of the exploration based on overall form which will have semantics of kitchen products.. They posses the advantage of accommodating elements in a closed package and the cooling efficiency can be improved by this.



Possible details with each form



Mock Up models



The structural form, which is simple in its make and gives a different aesthetic feel to the product.

Mock up models of the selected ideas where made to understand the form and the usability factor of it. It gave more insights in to where to add details and

Form inspired by kitchen products. people could perceive more of this as kitchen product.

Finally structural design for the product is chosen based on technical and aesthetic consideration

Product Description:

The device is detailed out to make it manufacturing and maintenance friendly.

It has a main structural plate made of aluminium, around which a frame connects the components of the product. The structural plate will also act as a heat sink.

The looping frame is hollow and the wiring is taken inside through it.

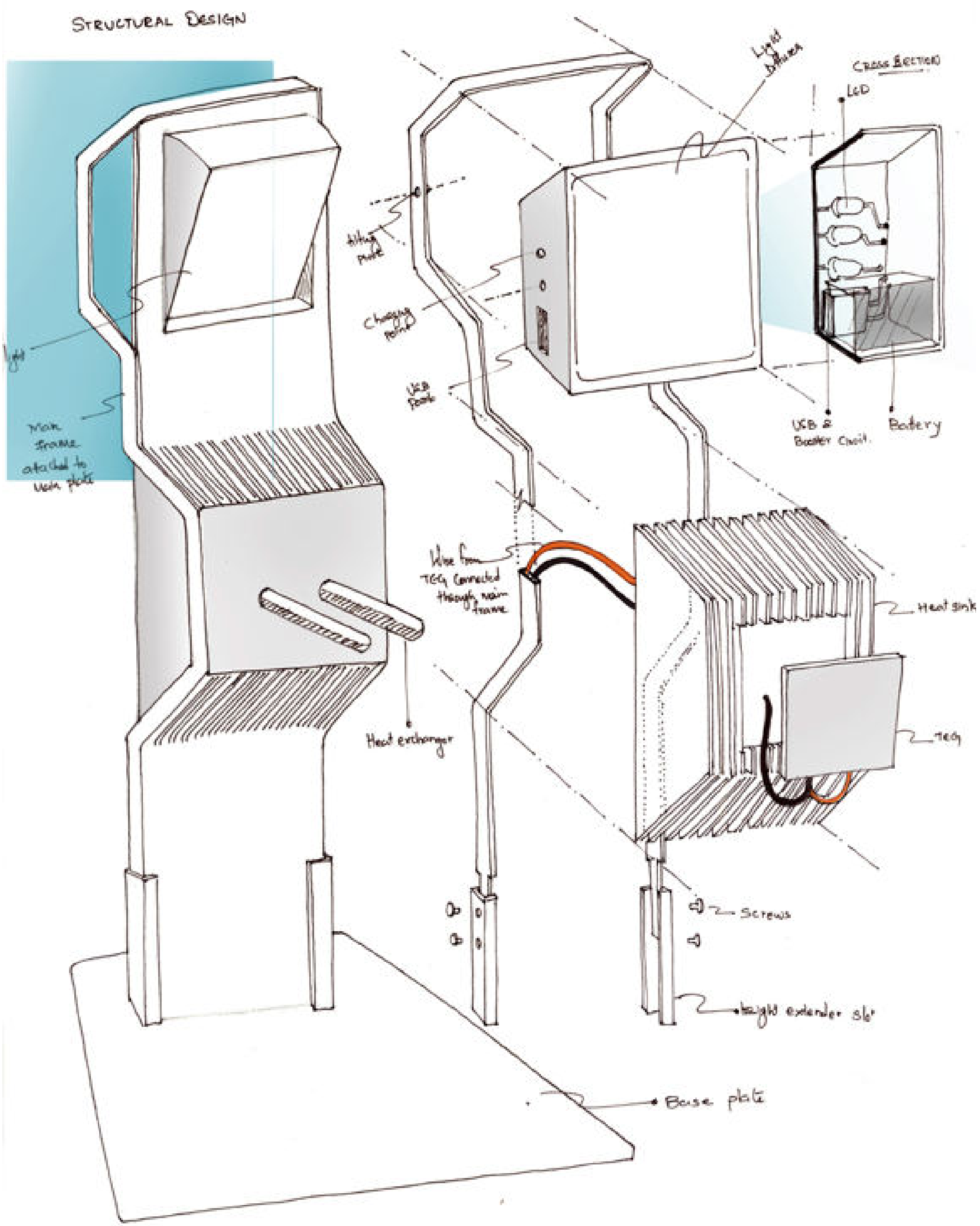
The structure of the heat sink made of aluminium is such that, it allows the convection by supporting the air flow from the top and bottom of it.

The heat exchanger is the two heat rods made of copper, attached to the cover plate of TEG.

A cooling fan is attached to the main structure, which could be used at times, when there is very less air circulation. It is connected to the battery.

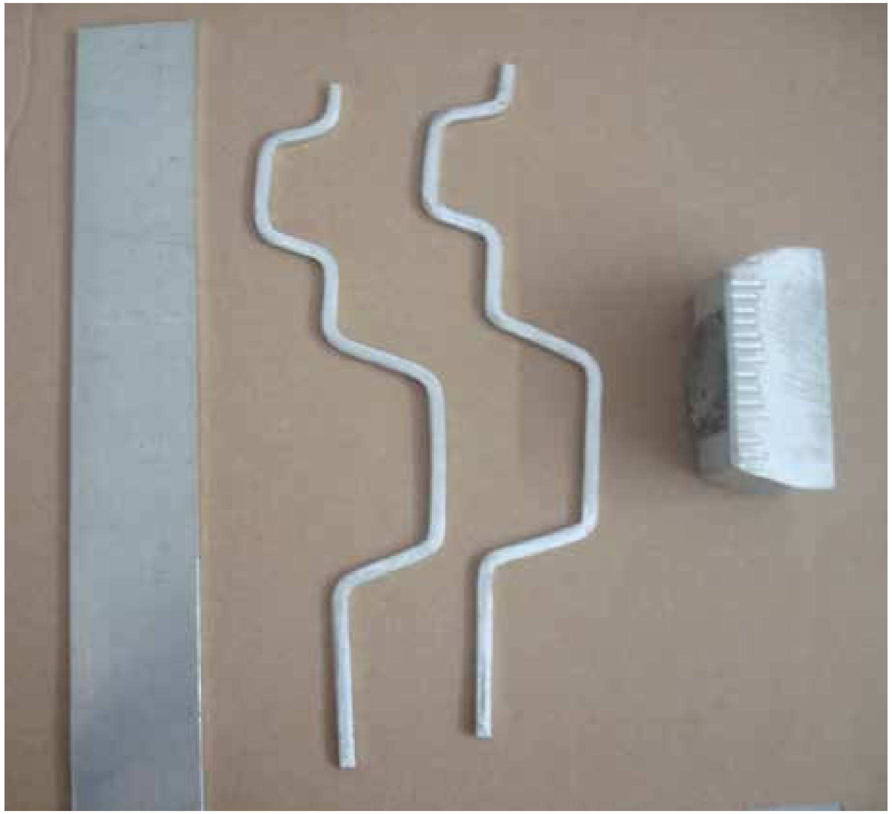
The base plate is a solid surface, which balance the whole structure. It has two slots attached to it for the height adjustment of the main unit.

The light unit is tilted to switch it ON, It houses high power LED and a rechargeable battery inside that and It also contains the USB charging port and booster circuit. The light enclosure is made using injection moulding technique.



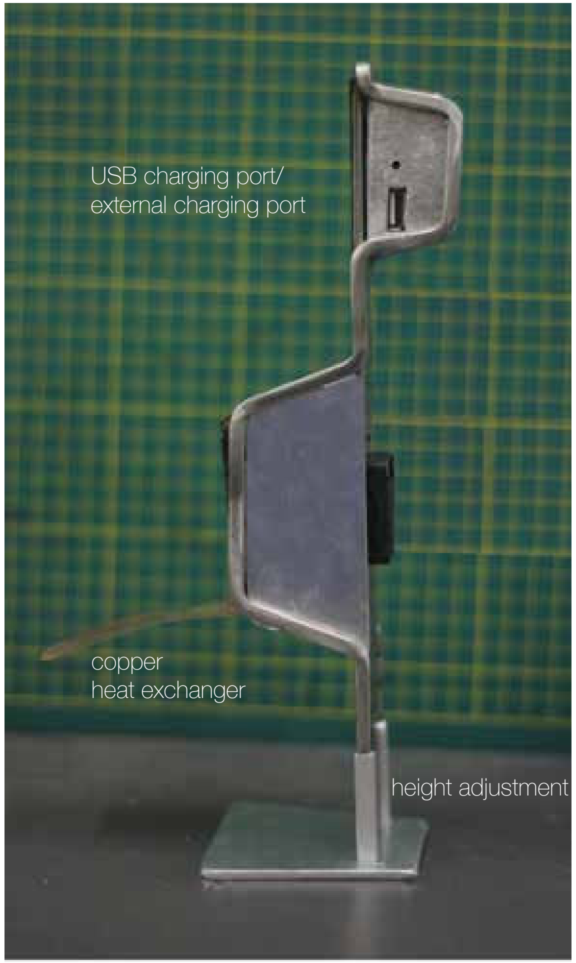
Prototyping

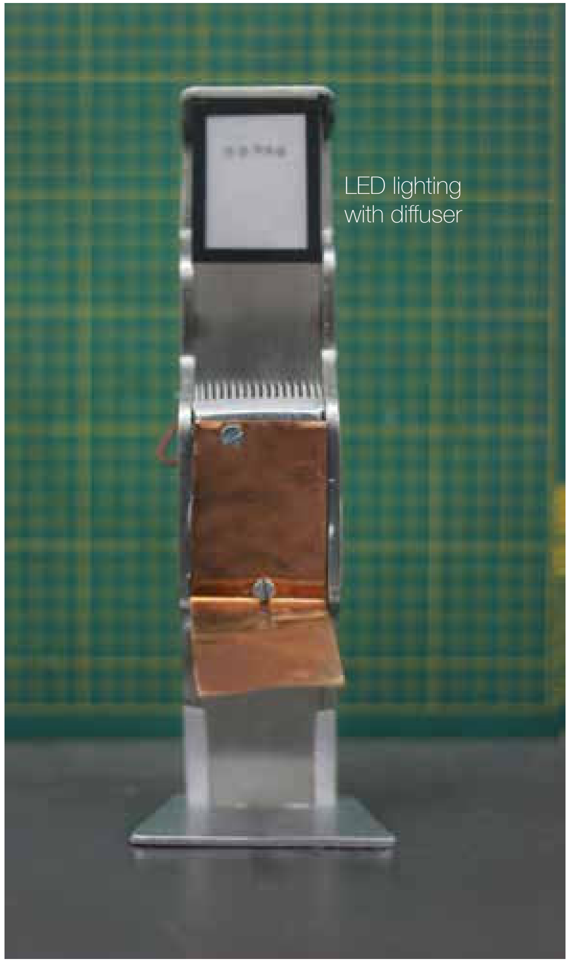
Initially, the prototype was tried in aluminium, because of its technical difficulties, later stainless steel is chosen for the model making.

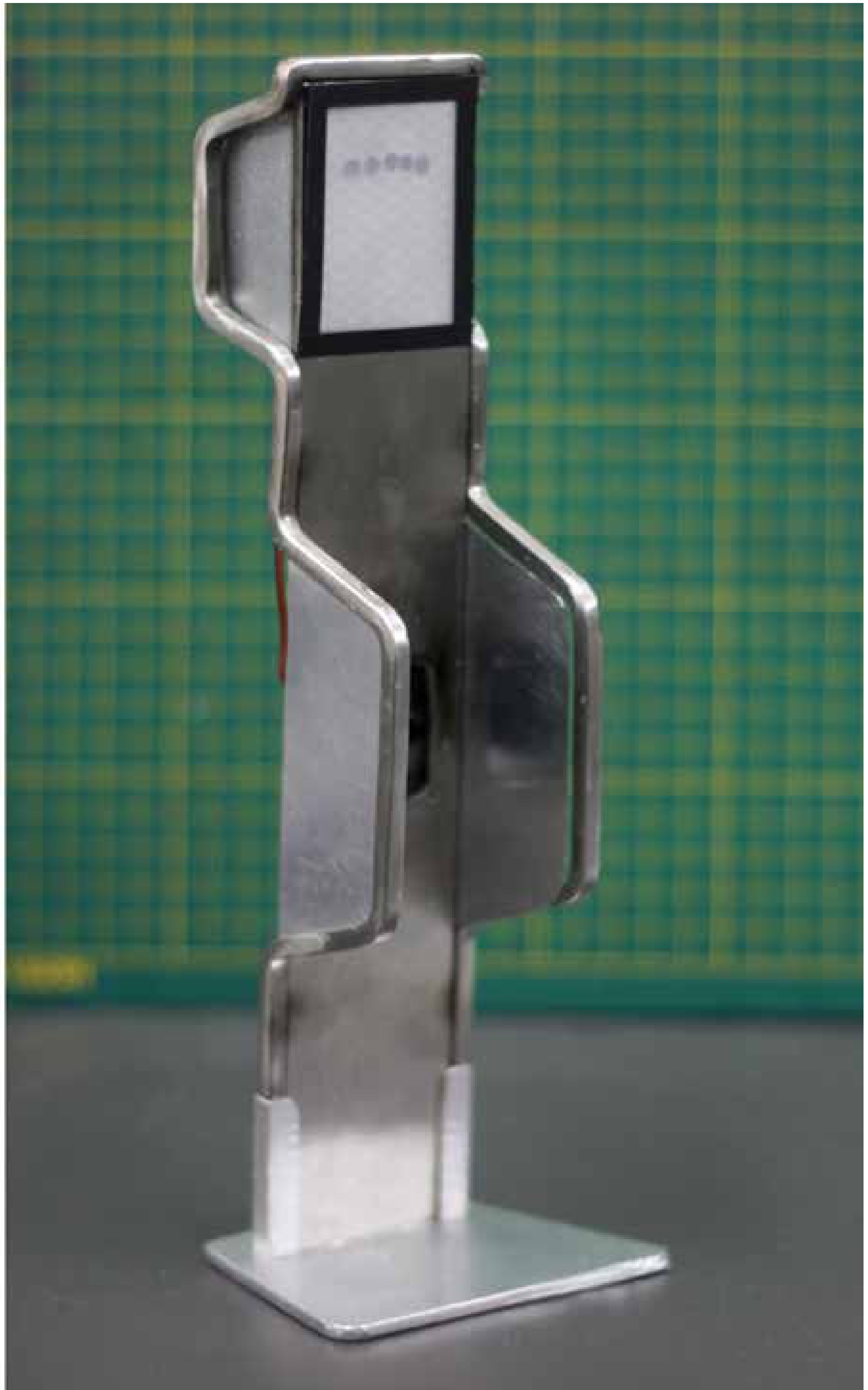


Below image is from a fabrication workshop in Ghatkopar, where the structural frame is made using a 5 mm steel rod by bending and forging. Later it is assembled to the other parts of the device.

1:2 ratio prototype is made to study the working and the form factor of the product. The details of the actual design is slightly compromised to demonstrate the working of the device.







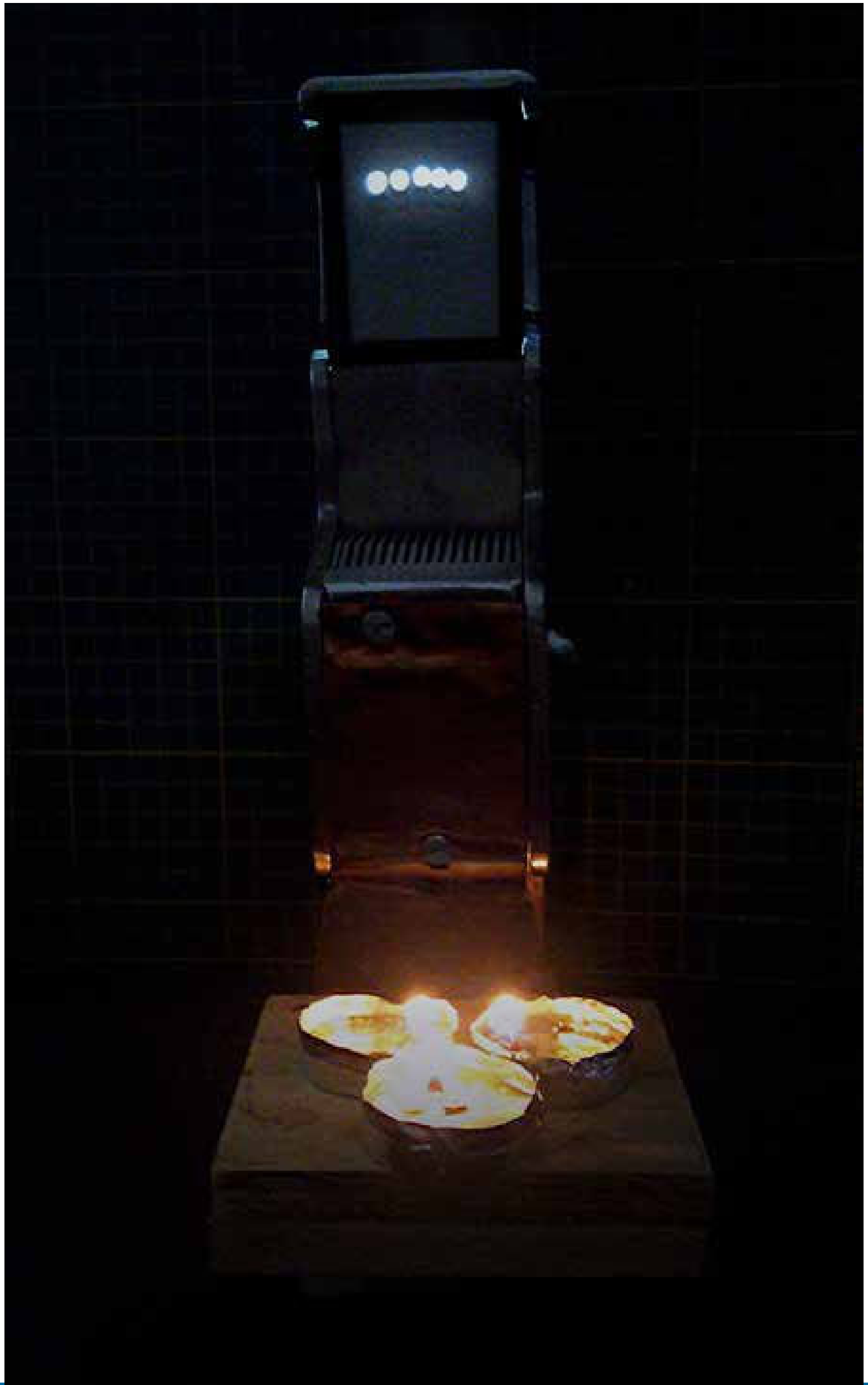
Testing

The prototype is tested using the setup designed with the TEG.
3 tea candles where used as heat source and it is used to lit up the LED in the top housing.

It produced around 1.8 volts, which is sufficient for the low power LED used in the device.

Cooling is expedited with the help of a cooling fan, to increase the air convection.

Though the power produced is miniscule, it can generate continuous power when used in the real scenario of the kitchen.



Reference:

Img 01 (a-c): http://www.hgtvremodels.com/home-systems/home-lighting-types-ambient-accent-task/index.html

Img 03 (a-g): http://www.ies.org/lighting/sources/luminaires.cfm

Img 04 (a-d): http://www.suryadhan.com/product-lighting-system.html
https://thejetrest.com/products/solar-torch-keyring
http://www.tradeindia.com/fp686570/Solar-Lantern-Liti.html

Img 05 (a-c): http://aliteroflight.org/

Img 06 (a-c): https://www.innosite.dk/idea.php?id=148
http://www.naturalux.com.br/
http://www.daviddarling.info/encyclopedia/H/AE_hybrid_solar_lighting.html

Img 07 (a-c): http://www.evolo.us/architecture/bamboo-lamp-flow-brings-safety-ashore-alberto-vasquez/
http://www.ikea.com/us/en/catalog/products/00268937/

Img 08 (a-d): http://inhabitat.com/bicycle-powered-led-lamp-runs-completely-off-the-grid/untitled-9-4/
http://en.wikipedia.org/wiki/Mechanically_powered_flashlight
http://www.ecofriend.com/private-light-run-with-your-socks-on-to-dazzle-the-dark-path.htmlpiezo

Img 09 (a-c): http://www.sustainabledanceclub.com/products/sustainable_dance_floor/
http://en.wikipedia.org/wiki/Energy_harvesting
http://cdn.intechopen.com/pdfs-wm/40613.pdf

Img 10 (a-b): http://greenupgrader.com/6427/dirty-clean-energy-powered-lamp/
http://www.energyharvestingjournal.com/articles/dirt-powered-battery-for-rural-africa-00001774.asp?sessionid=1teg

Img 11 (a-c): http://www.biolitestove.com/products/campstove/
http://www.powerpractical.com/