



Lighting for Rural India

P-III

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126130012

Guided by Prof. R. Sandesh

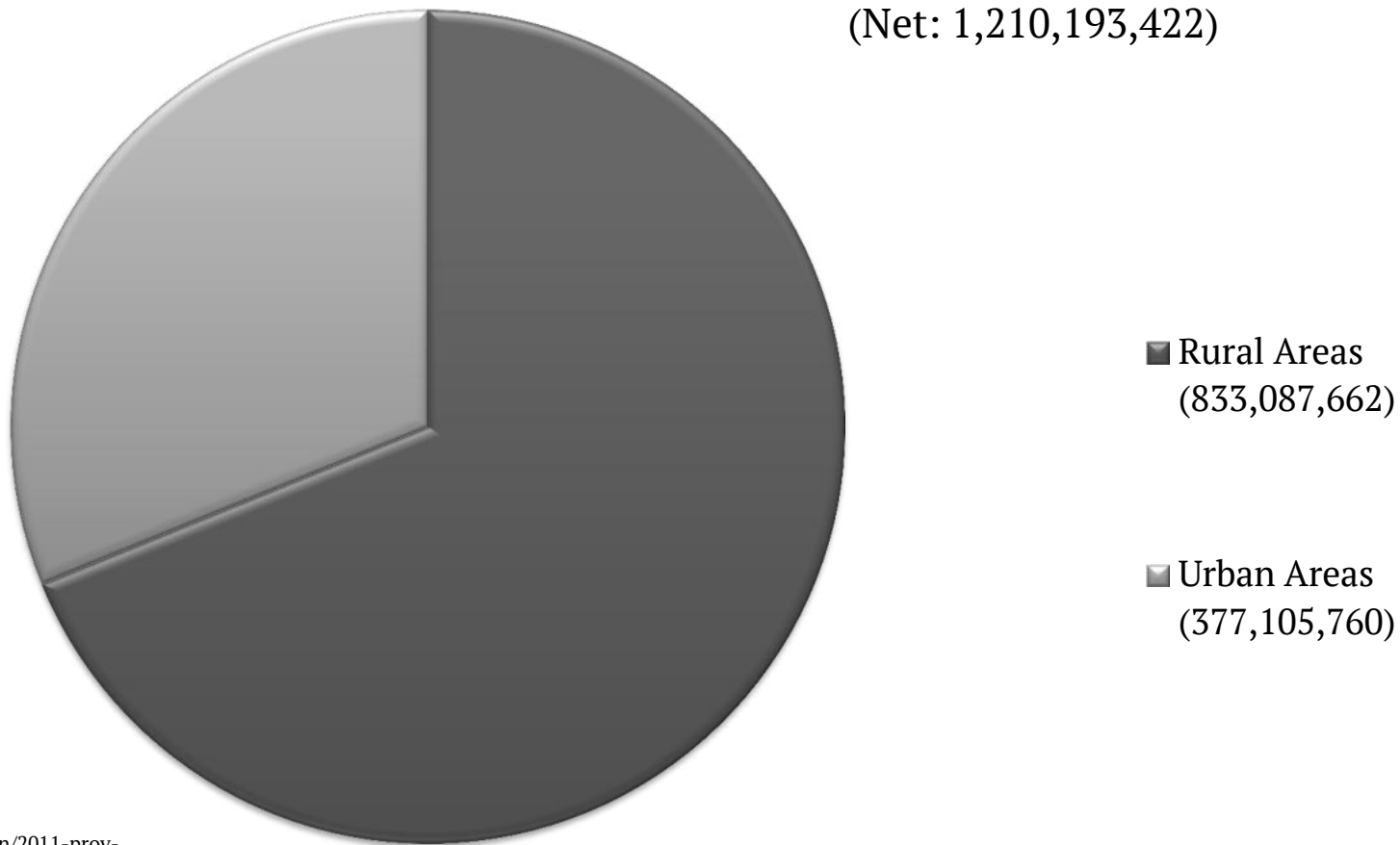


*“India lives in her seven and half lakhs of villages...
If villages perish, India will perish too...”*
-M.K.Gandhi

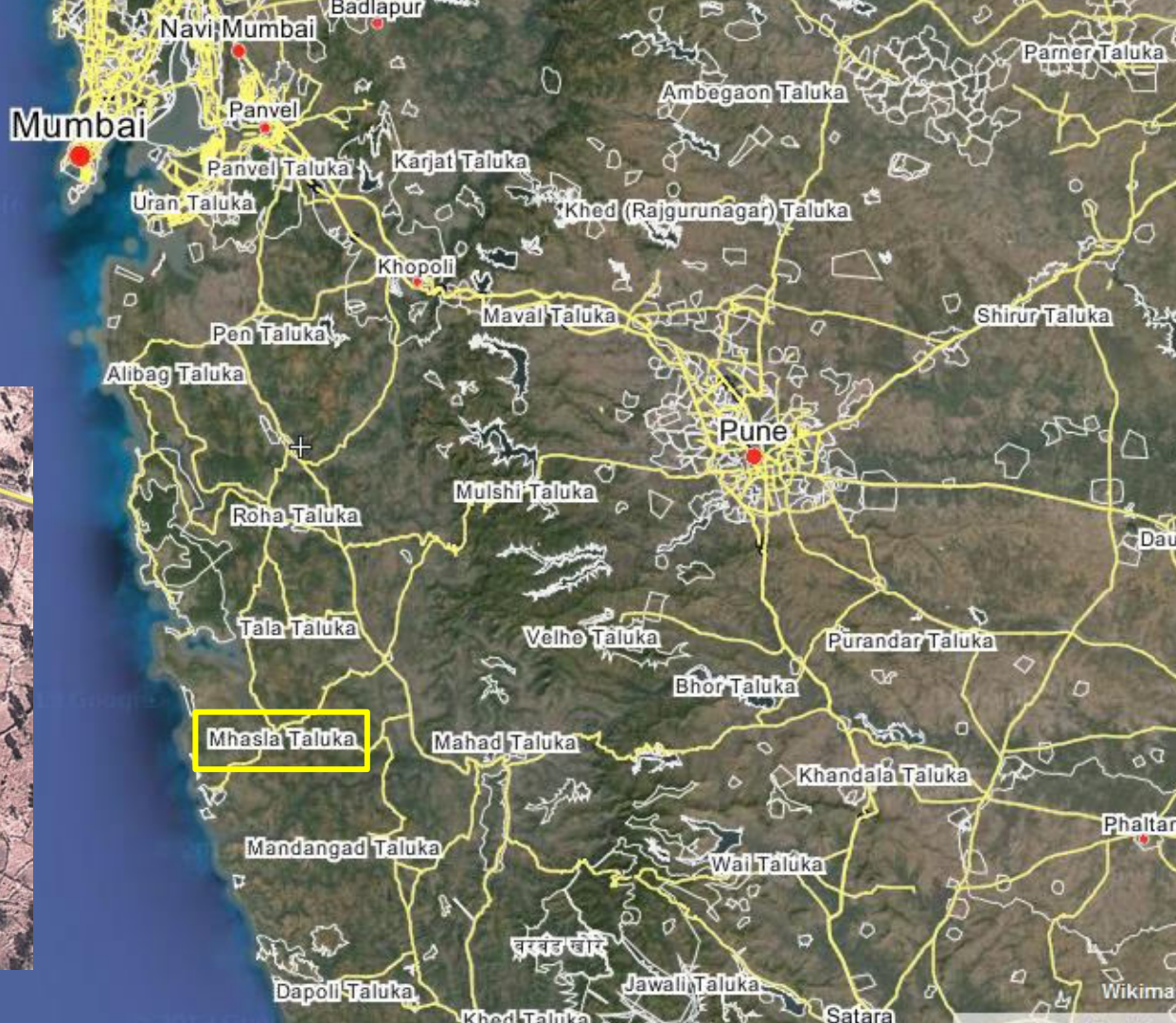
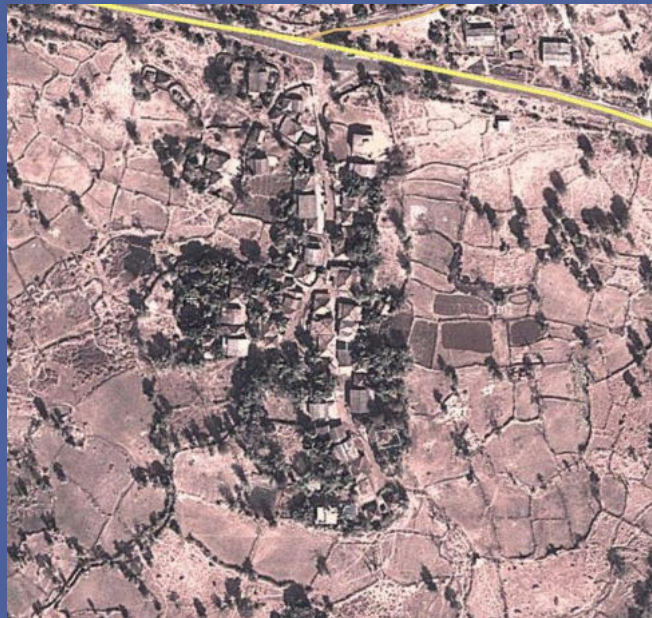


Baban Kadu at
Linganwadi, Raigad,
Maharashtra

India Population Distribution (Net: 1,210,193,422)



Khamgav, Raigad



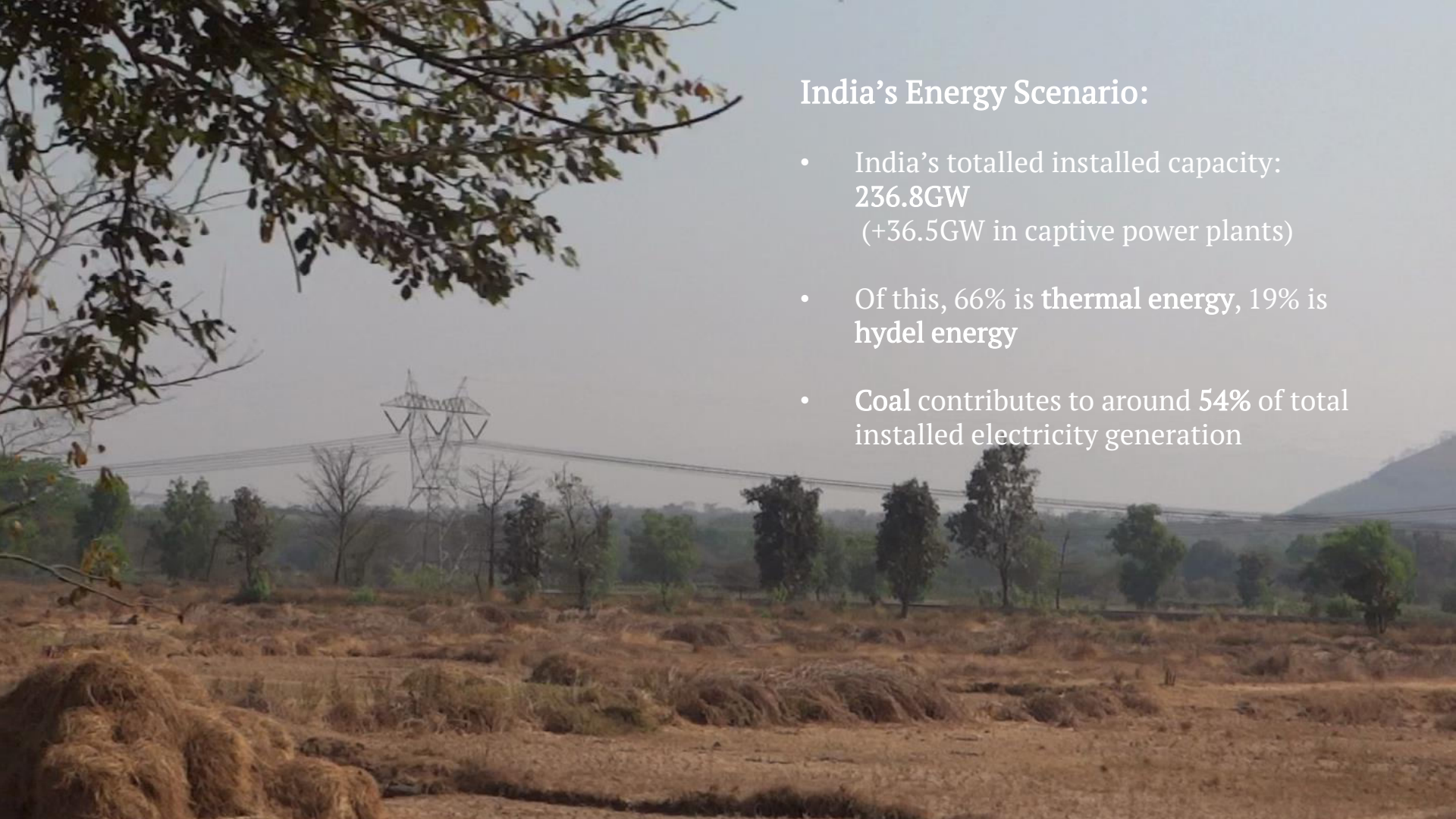


Solar powered water pump



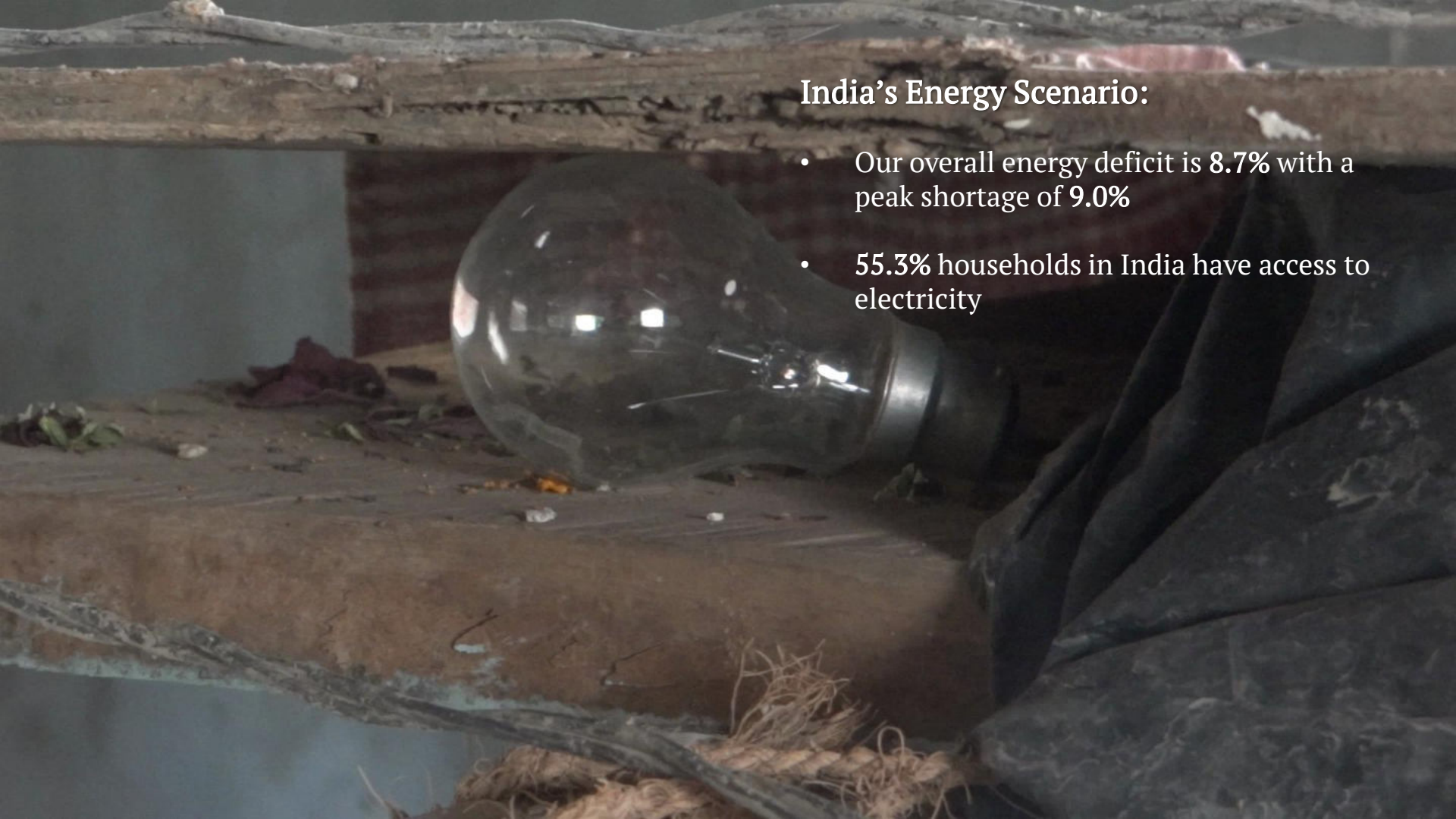
Solar powered street lamp

Socio-Economic Classification	Characteristics	Lifestyle attributes
R1 (Baliram Sawant)	Landlord farmers, traditionally rich, exposed to urban environment, children studying in schools and colleges in nearby towns, having a number of urban comforts and goods in households viz TV, sofa, music systems, cupboards, refrigerators etc., owns durables like tractors, other vehicles	Aspire to meet urban standards, politically and socially well connected, technology adapters, eager to experiment new farming methods and add new sources of income, big spenders on social occasions
R2 (Akshay Shirke, Savita Shirke)	Rich farmers with upto 5 acres of land, may not be educated, children studying in schools and colleges in nearby towns, friends and relatives in urban areas. Owns durables like tractors, two wheelers.	Want to get educated, consult friends and relatives while adapting new technologies, conscious of status, aspire to be well-known within political and social circles
R3	Avg. land-holding 2-5acres, manage savings, send children to village schools, own durables (self and rental basis).	Opts for time-tested technologies, low risk taker, desires knowledge, followers, seekers
R4 (BalkrushnaSawant)	Have little or no land, agricultural labour living below poverty line, major purchaser from public distribution system and govt. schemes.	Averse to new technologies, laggards, averse to risks, uninformed(at times ill-informed)



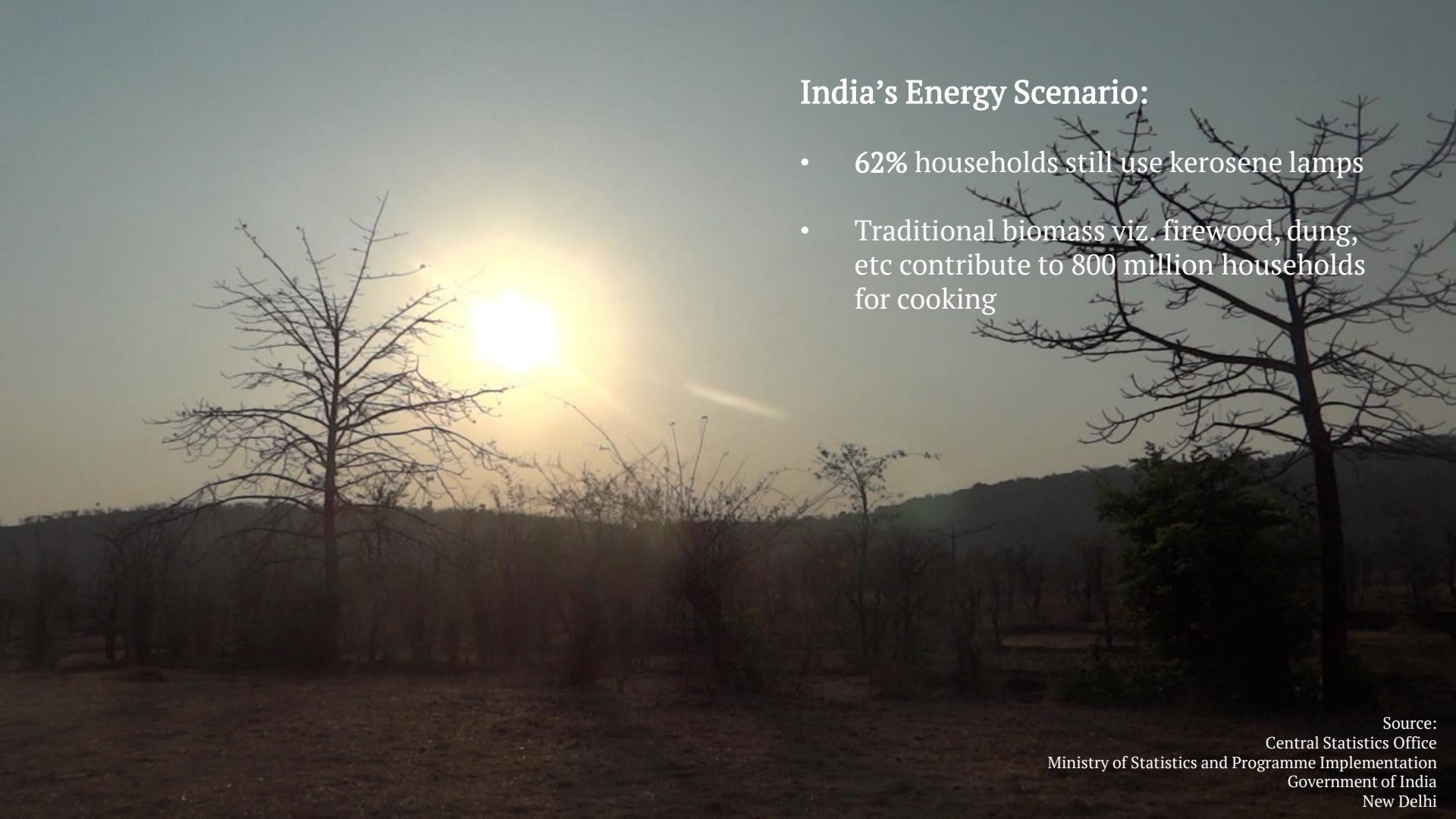
India's Energy Scenario:

- India's totalled installed capacity:
236.8GW
(+36.5GW in captive power plants)
- Of this, 66% is **thermal energy**, 19% is **hydel energy**
- **Coal** contributes to around 54% of total installed electricity generation

A photograph of a broken lightbulb lying on a wooden surface. The bulb is shattered, with glass fragments and a visible filament. The background is dark and cluttered with various objects, including what looks like a piece of wood or a branch at the top and some debris on the surface. The lighting is dim, highlighting the broken bulb.

India's Energy Scenario:

- Our overall energy deficit is 8.7% with a peak shortage of 9.0%
- 55.3% households in India have access to electricity

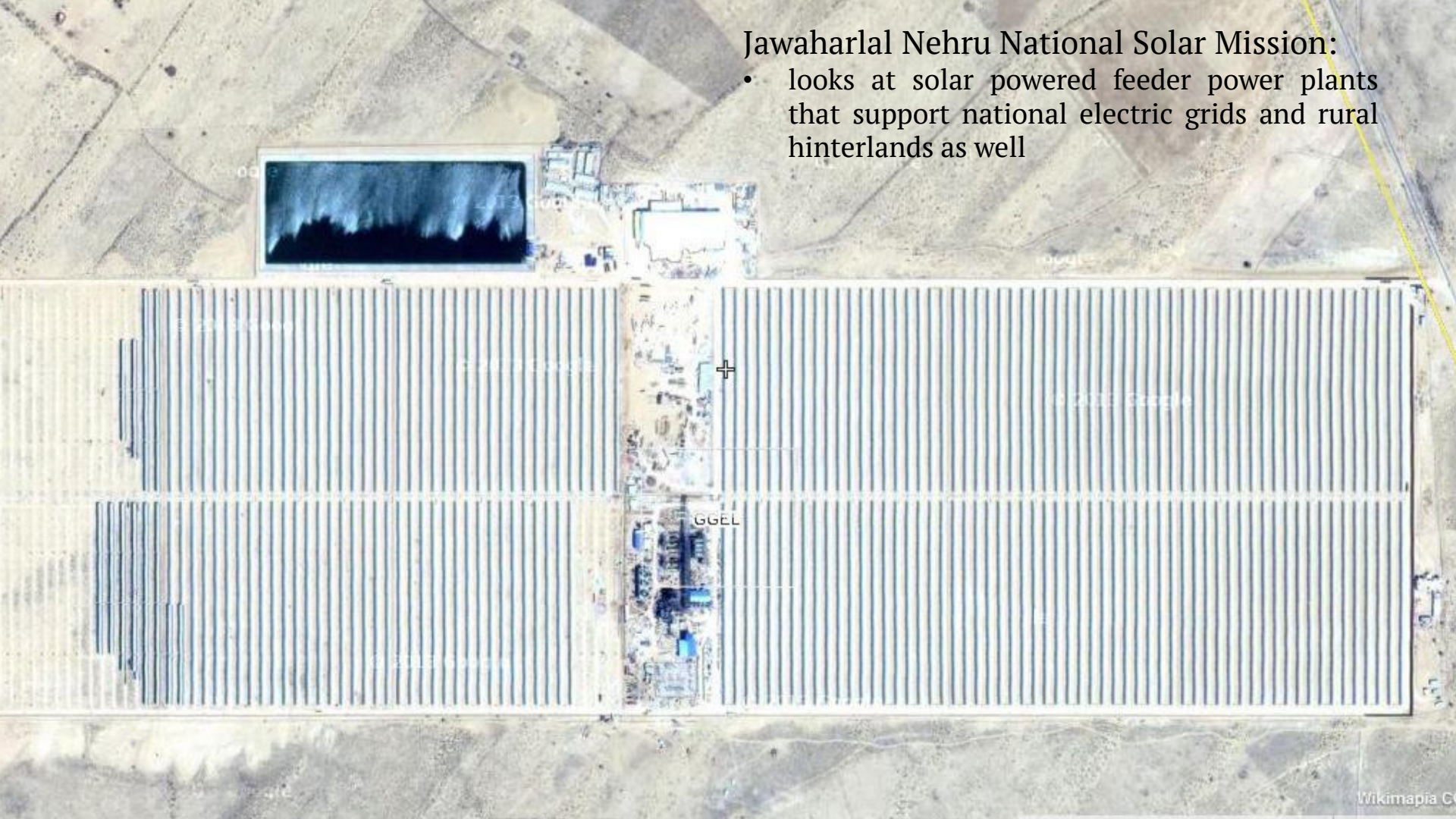


India's Energy Scenario:

- 62% households still use kerosene lamps
- Traditional biomass viz. firewood, dung, etc contribute to 800 million households for cooking

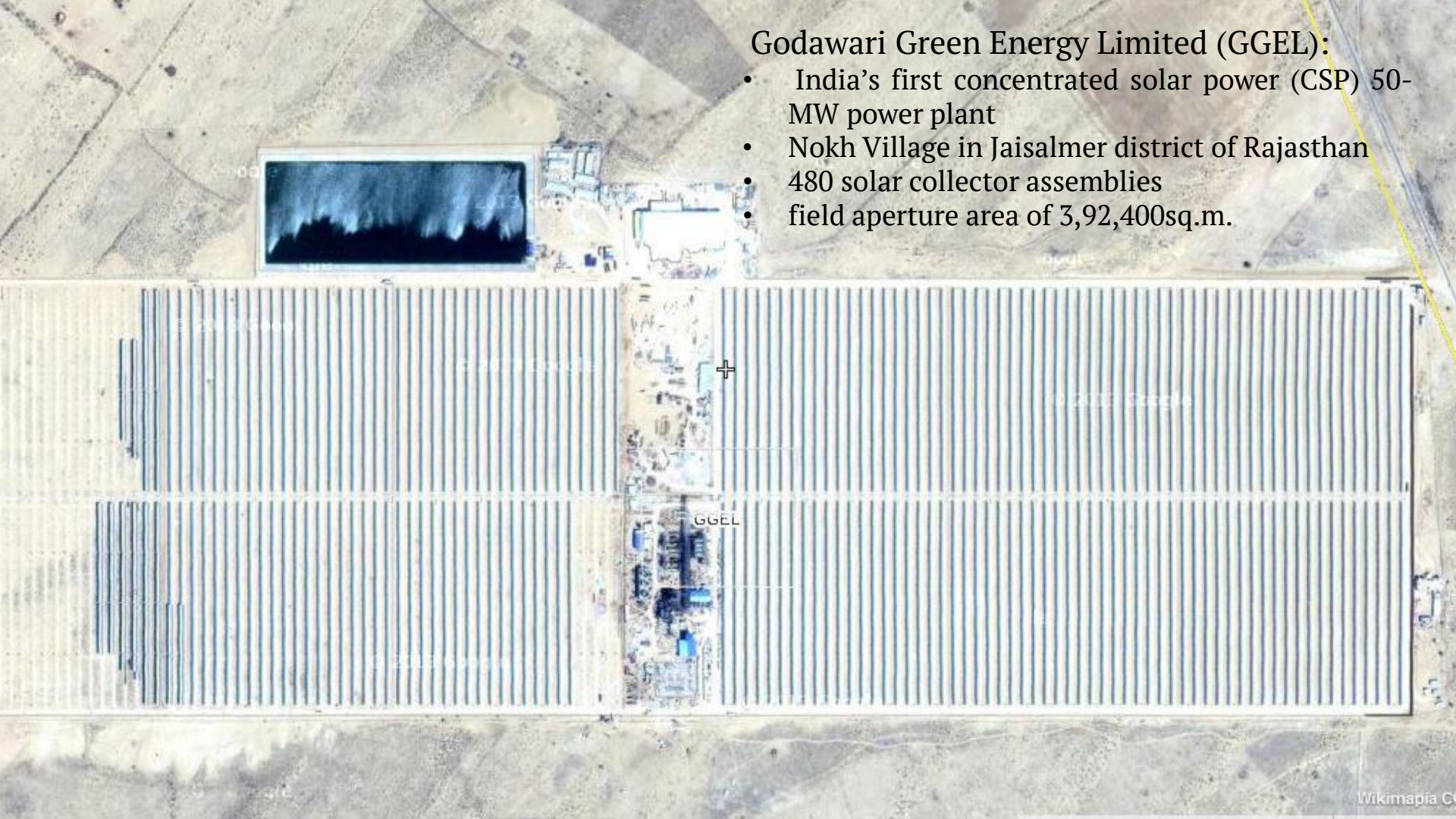
Jawaharlal Nehru National Solar Mission:

- looks at solar powered feeder power plants that support national electric grids and rural hinterlands as well



Godawari Green Energy Limited (GGEL):

- India's first concentrated solar power (CSP) 50-MW power plant
- Nokh Village in Jaisalmer district of Rajasthan
- 480 solar collector assemblies
- field aperture area of 3,92,400sq.m.



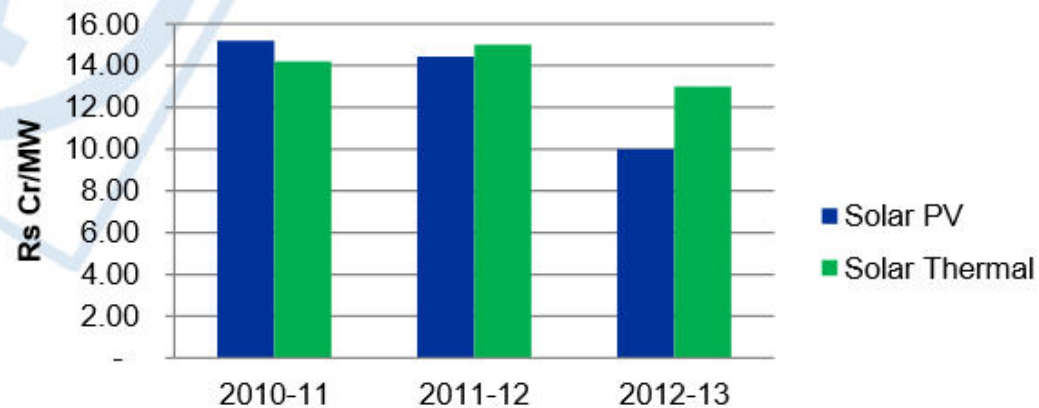
Delays and failures of JNNISM:

- Government's loss of interest
- Tendering process: first tender for CSP projects resulted in a race to offer the lower prices per kWh and the higher local content, something that left many of the international recognized players out of the top positions
- Plants that are delayed/cancelled:
 - KVK Energy , Askandra, Rajasthan (100MW)
 - Lanko Solar, Rajasthan (100MW)
 - Corporate Ispat, Jaisalmer, Rajasthan (50MW)
 - Aurum Renewables, Porbandar, Gujarat (20MW)

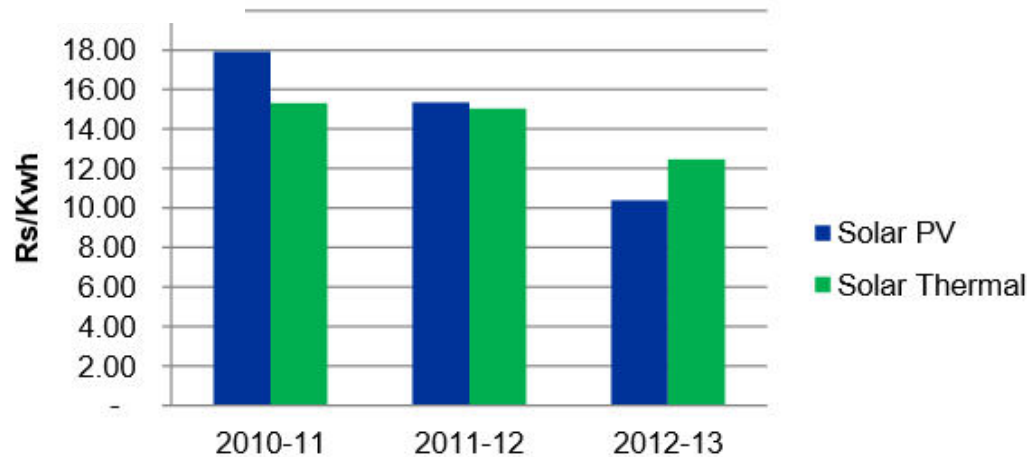
Source:

<http://www.csp-world.com/news/20140324/001335/indias-jnnism-csp-program-epic-fail>

Cost of solar PV & Solar Thermal



Solar Tariff





Other players:

- NGOs (viz. Swades foundation)
- Stand alone projects (viz. One child One Light)
- Social entrepreneurs (viz. SELCO)

Solar Electric Light Company (SELCO) :

- Founded by Dr. Harish Hande (IIT-KGP alumnus)
- SELCO's product range: PV powered lighting, water pumping, communications, computing, entertainment, and small business appliances
- SELCO's success proved wrong that:
Poor people cannot afford sustainable technologies;
Poor people cannot maintain sustainable technologies;
Social ventures cannot be run as commercial entities
(as said by Dr. Hande)



Nokia 1100:

- Opened up cellular phone market in real sense for India
- 'Made for India'
- Replace-able back-covers, body panels, num-pads, attaching straps for personalised touch
- Head LED
- Later included FM and other multimedia



Source:
Jagdeep Kapoor,
chairman and managing director of Samsika Marketing Consultants

Image:
<http://0.tqn.com/d/cellphones/1/0/V/c/nokia-1100-multi.jpg>



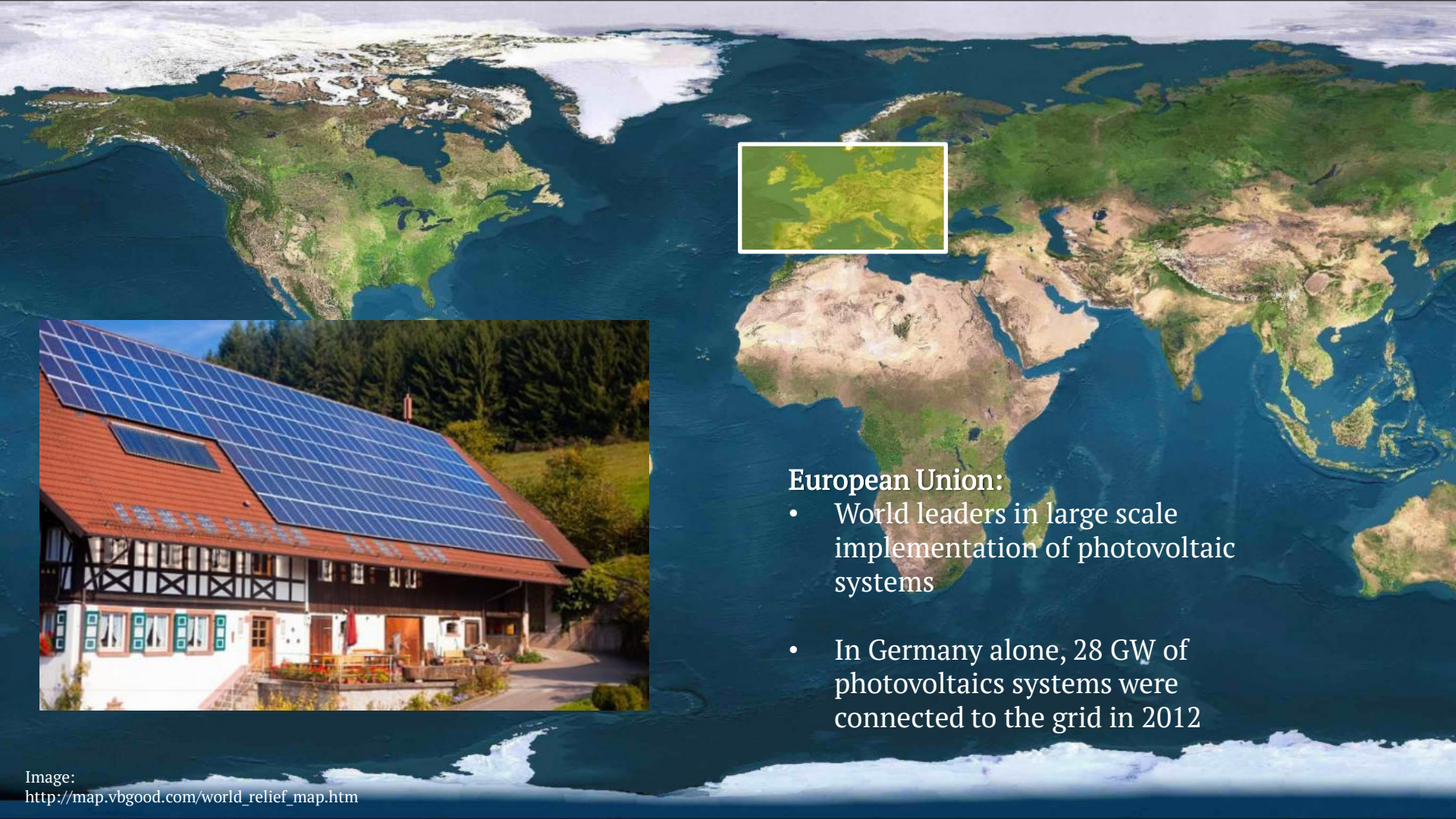
- **rational need** through proper pricing
- **emotional need** through connectivity to near and dear ones
- **aspirational need** through placing a desirable product of a desirable brand at the bottom of the pyramid
- **physical need** through apt sizing and comfort
- **spiritual need** through sms-es and other media for devotional/religious purposes

Latin America:

- world's birthplace for small rural solar electric systems used for residential power, refrigeration, distance education and hybrid systems, as early as 1980s



50 Wp PV lighting system installed in Talayotes, Moris County, Chihuahua.



European Union:

- World leaders in large scale implementation of photovoltaic systems
- In Germany alone, 28 GW of photovoltaics systems were connected to the grid in 2012



Africa:

- every country from the rest of the world with surplus resources reaches out to African countries and contributes to these weaker economies
- Indian govt. and NGOs too are actively participating in supporting the African cause



Indian Market for Solar LED Lanterns



Images:
<http://pimg.tradeindia.com/00409843/b/1/LED-Solar-Lantern.jpg>
<http://pimg.tradeindia.com/00508059/b/2/Solar-LED-Lantern.jpg>
<http://2.imimg.com/data2/BC/WM/MY-3551186/solar-led-lantern-6-watts-250x250.jpg>
<http://2.imimg.com/data2/IL/YV/MY-3551186/solar-led-lantern-3-watts-250x250.jpg>
http://stat.homeshop18.com/homeshop18/images/productImages/253/rico-solar-lantern-sel-1008-large_7a2aafd0f1a158bac3c10b27d359dc9d.jpg
<http://www.easyphotovoltech.com/pcat-gifs/products-small/solar-lantern-led-based.jpg>
<http://3.imimg.com/data3/LX/XG/MY-2369247/portable-led-solar-lanterns-250x250.jpg>
<http://3.imimg.com/data3/AH/XV/MY-6582696/solar-led-lantern-250x250.jpg>
http://mbcenergy.com/images/Solar_Lantern_Light.jpg

Indian Market for Solar LED Lanterns

Faceless

Expressionless

Cheap, plasticky

Lack of innovation

Unsatisfied consumers



★★★★★

Vikram Singh

22 October 13

CERTIFIED BUYER

WORST

i bought this product few days ago, flipkart's service is good, but the product is not good. there is only one led. if you have mobile phone with led light then don't buy this product the light is very low, your mobile led light is better than this product.

1 of 1 users found this review helpful.

★★★★★

Sonia10

11 July 13

Bad Switch with Bad Light

I have seen this product - and my spouse bought it from flipkart. It is really shame that Indian companies produce such filthy products with bad quality plastic and workmanship.

I am seriously depressed and would warn everyone NOT to buy Mitva and choose branded products.

0 of 0 users found this review helpful.

[Permalink](#) [Report Abuse](#)

★★★★★

Vishnu T S

08 June 13

CERTIFIED BUYER

USELESS PRODUCT

Don't believe other review, it is useless product.

pros:-

1. average light for a room.
2. less price.
3. easy to handle.

hate:-

1. too small.
2. no enough light for a room and for reading.
3. only one LED

★★★★★

Sandeep Bisht

15 April 13

CERTIFIED BUYER

Not Satisfied

I ordered this product last week and got it the next day. Fastest delivery I had ever had since the time I started using online shopping. Thanks to Flipkart.

But I am not satisfied with the product. The intensity/focus of the light is very bad. Instead of this a normal candle or a LED torch has much better focus than this light. There is a AC adapter with this product but not sure how to use that.

In a nut shell a total waste of money.

★★★★★

Ashok

29 January 14

CERTIFIED BUYER

Very poor customer support at BPL Service center

Not working properly & Very poor customer support at BPL Service center. Called CC five times. given wrong service center number. visited 1 service center in solapur, Maharashtra & come to know that, they r not working for BPL.

0 of 0 users found this review helpful.

[Permalink](#) [Report Abuse](#)

★★★★★

Sanjay Naik

12 September 12

CERTIFIED BUYER

Not good

In 30 days the red button used to switch on the light messed up and after few days the emergency light stopped charging on AC mains. Very sad experience. Flipkart packing and shipment was amazing but the product sucked badly.

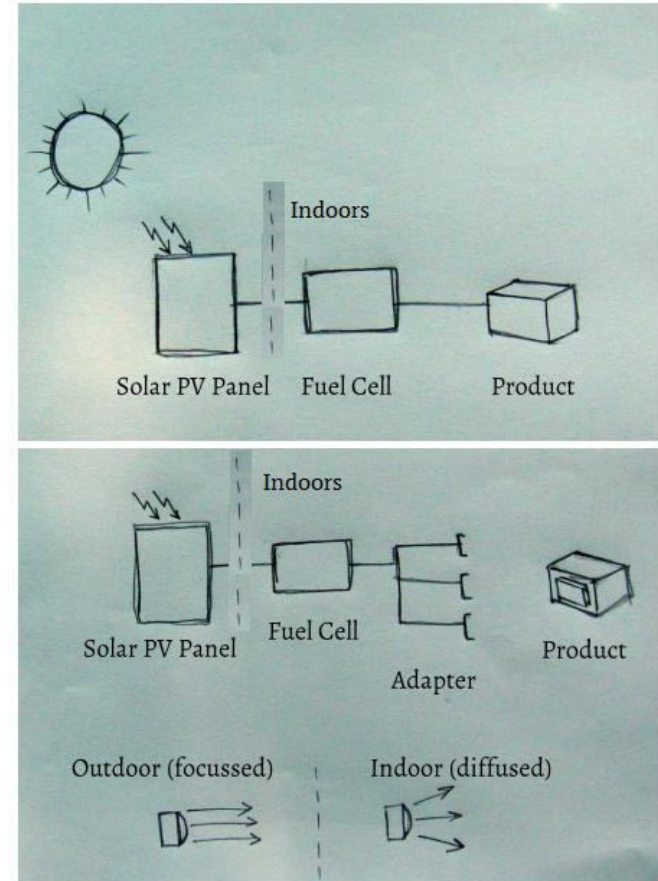
1 of 1 users found this review helpful.

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Possibilities

Possible Scope 1:

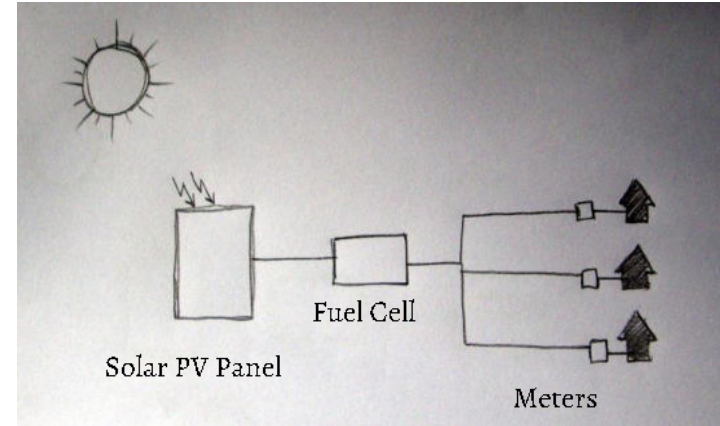
- A simple handheld light source powered by solar energy
- Can act as an auxiliary tool for numerous activities
- Could be developed further, wherein the product could be attached/detached from wall fixtures wired to a common energy storage fuelled by a solar power source
- Ownership is individual based



Possibilities

Possible scope 2

- community based lighting system.
- Small, independent, self-sufficient solar banks fuel a common energy storage
- Since the consumption of different households may vary, the share-holding depends on the number of consumption points in the respective households

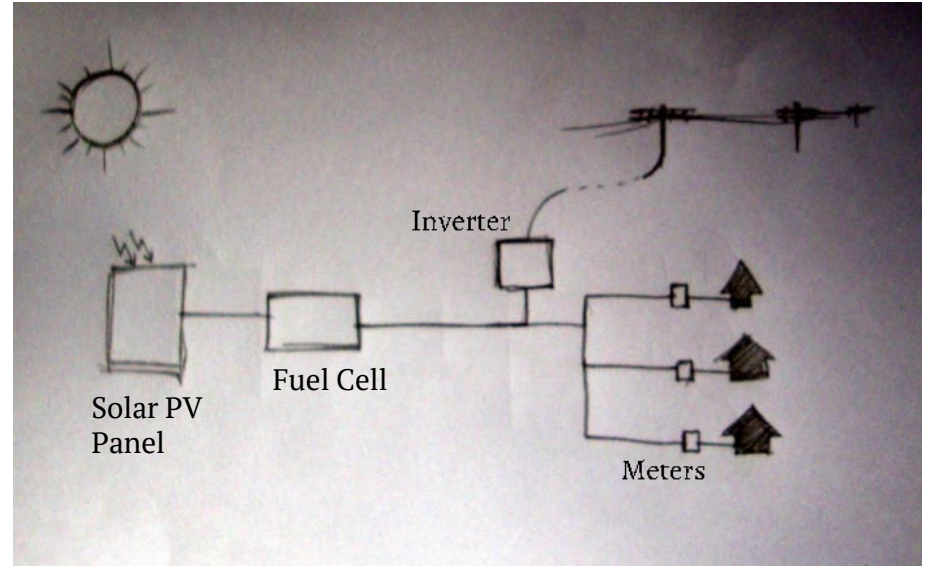


- a simple meter could calibrate consumption patterns
- For remote areas, remote, inaccessible hamlets totally
- Could also power utilities as streetlights, boring wells, common areas as temples etc.

Possibilities

Possible scope 3

- Grid connected system
- Solar power feeds into the grid in normal conditions
- When the power supply from the grid fails, the solar power steps in
- Decreases dependence on the grids and ensures the best of both worlds



Possibilities

Design Interventions:

- maintenance free, hassle free, something that can be operated without even reading an instruction manual
- Possible local maintenance
- Should be in context of rural India
- A common thread of simplicity and Indian-ness should be present in all the components of the system
- Vulnerable parts will have to be identified and taken care of, right down to the last screw

Design Brief

To design a solar powered lamp for rural India that is handy for a variety of *rural activities*. These include:

- Outdoor usage
- Indoor general lighting

The *functionality* should be simple and yet cater to the robust usage of the rural environment.

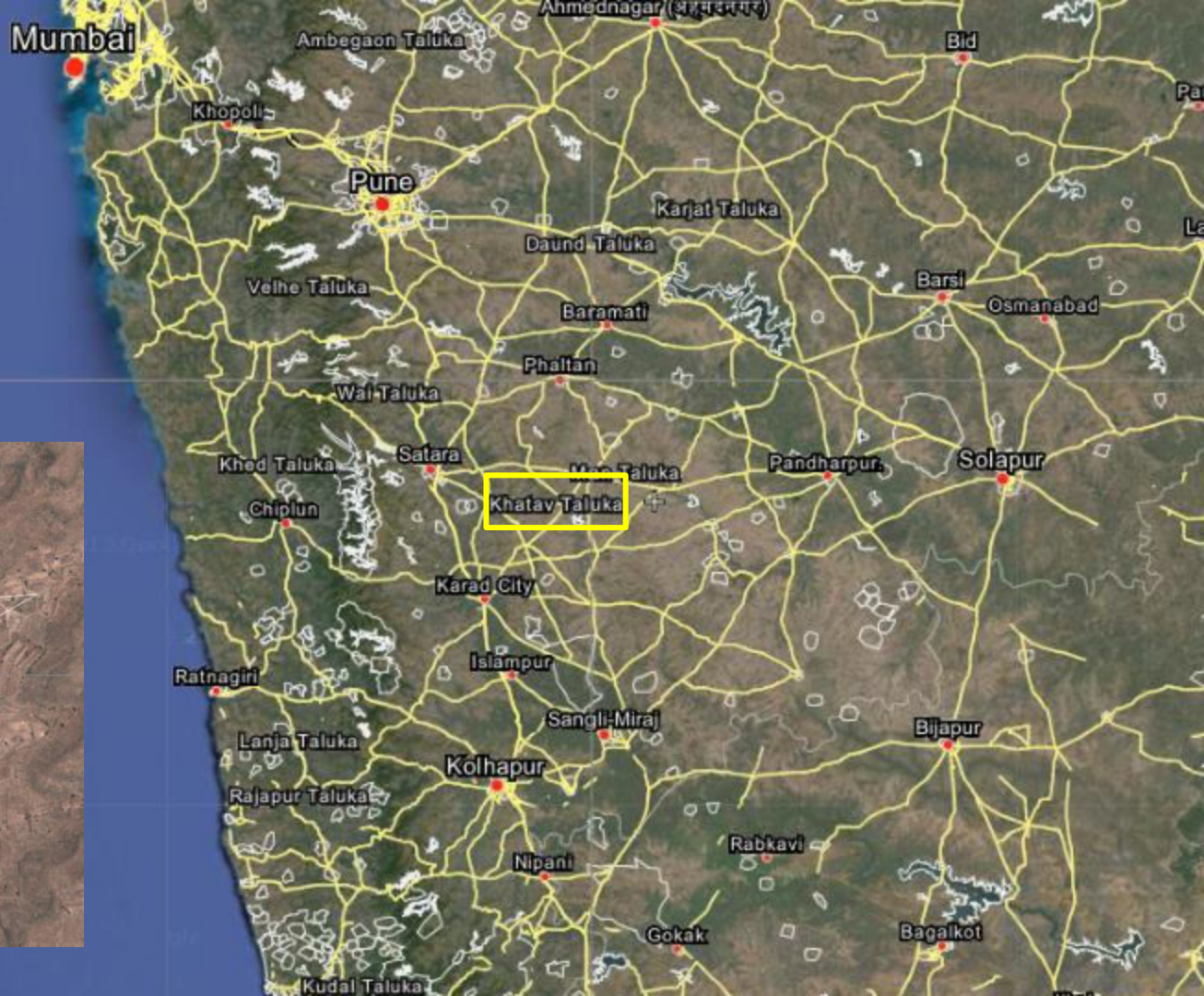
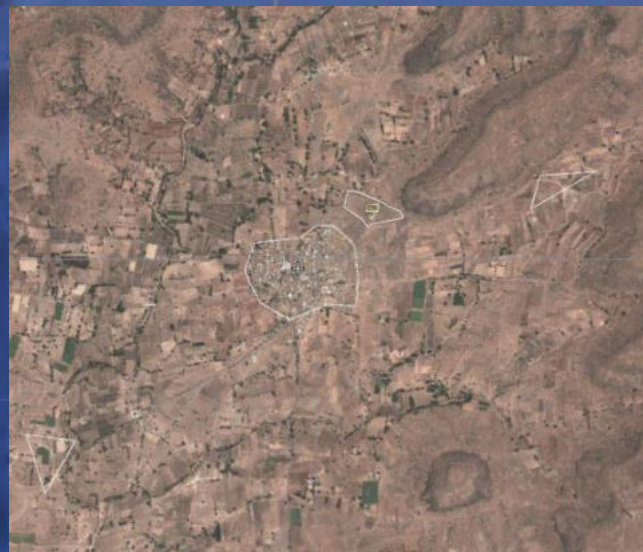
For **better usability**, the tasks to which it caters should be clearly defined and be reflected in the form.

The *assembly* should have minimum number of moving parts and the product should have scope for possible local repair and maintenance.

All this should happen within the Indian rural context.



Pachwad, Satara





Typical rural house façade with lamp
being hung outside



Solar panel and lamp



Solar panel kept on roof



Lamp in washroom



Lamp being hung
on door

- User insights
- Usage patterns
- Usage and post usage activities
- Look and feel

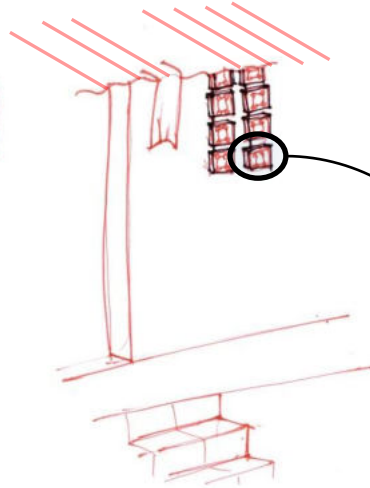


Opportunity Area 1:

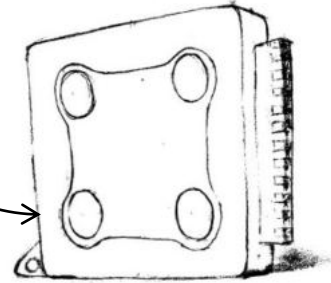
- Light source cum PV source
- Can be inserted in special slots on appendages that are attached to powerlooms, sewing machines or devices for medium and small scale industries, handicrafts, etc.



Lights installed on a power loom



Lights being charged



Details of the cell with connector pins with LEDs on front side (shown here) and a solar panel on the backside

Opportunity Area 2:

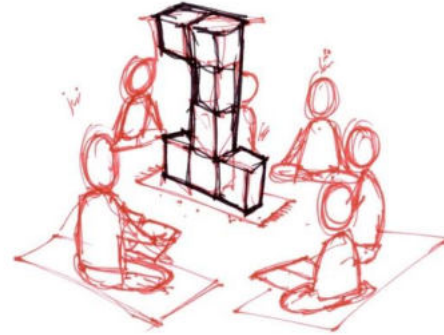
- Simple form cluster lights
- Can be used for general lighting and can be clustered to illuminate social gatherings, meetings, etc



Carrying the lights



Stacking the lights



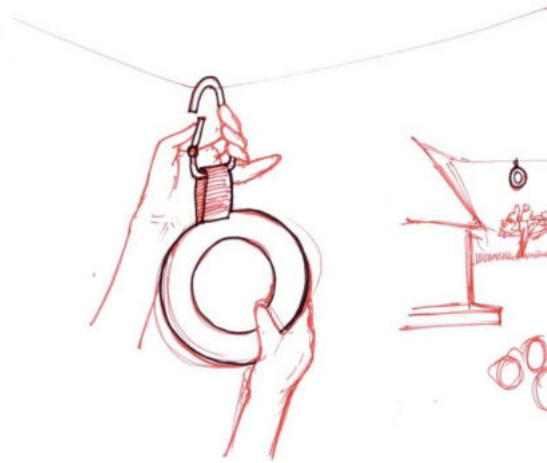
Seating around the arranged lights

Opportunity Area 3:

- thick circular disks with possible silicon/rubber casing with electronics mounted on a central chip
- Central aperture provides light from one side and has solar panel on the opposite side
- Carabineer like attachment helps to make it portable and versatile in terms of hanging, carrying around and other activities



Wayfinding



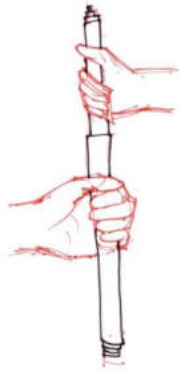
Hanging on a rope with a simple accessory



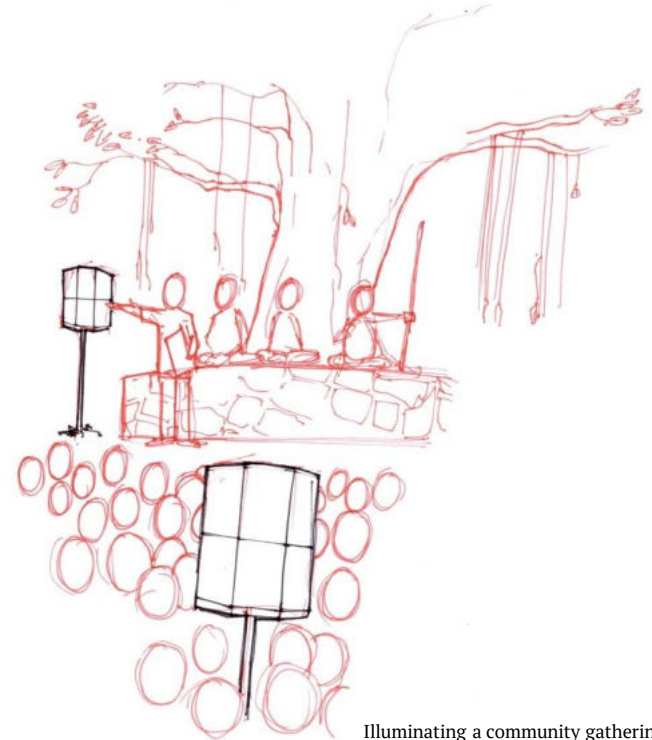
Lighting up a 'Kirtan'

Opportunity Area 4:

- Clustered lights mounted upon a central collapsible stand
- Typically community owned
- For community gatherings, responsible people assemble stands collect lamps from attendees and light up the place
- Create a sense of harmony and unity

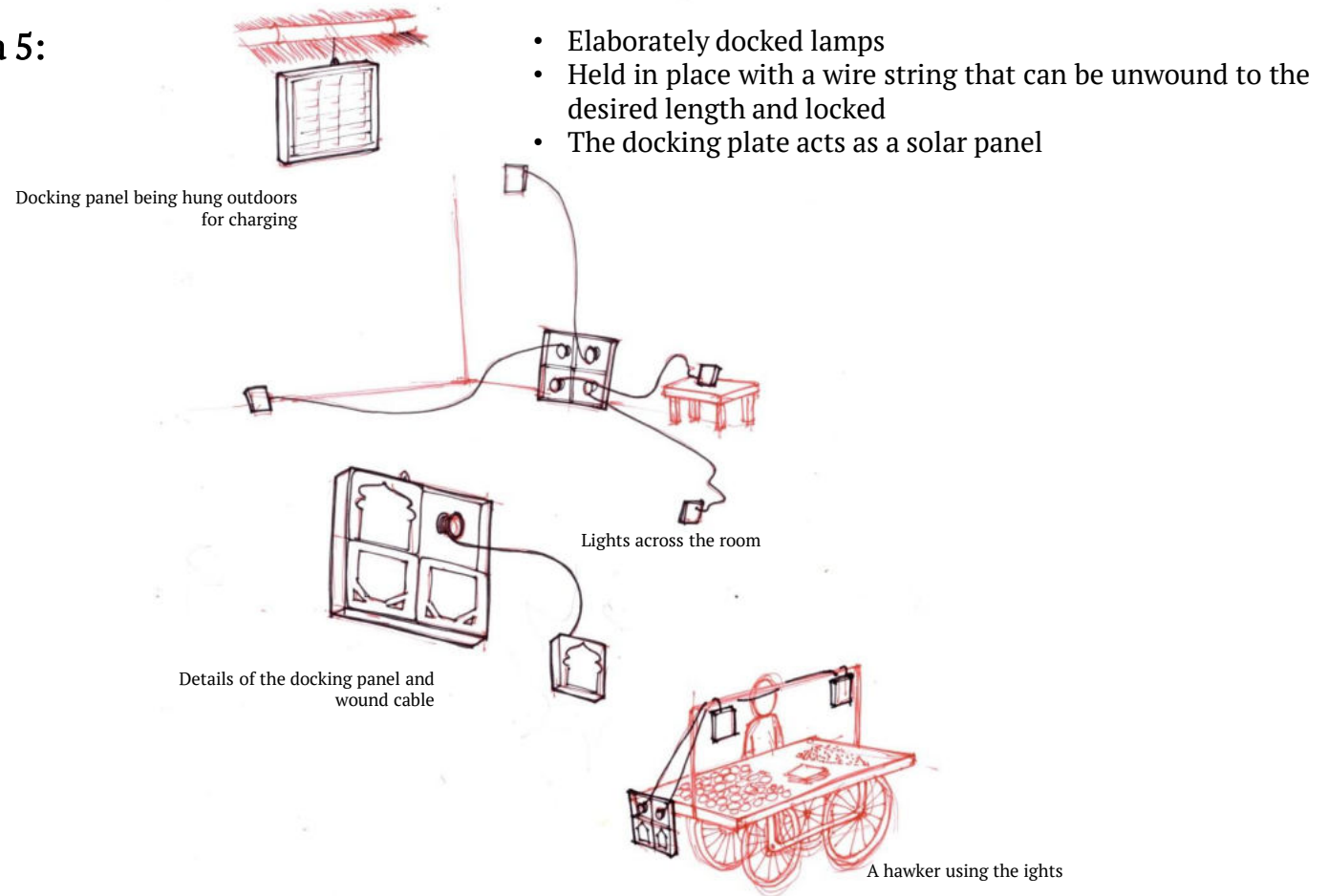


- Assembling the lamp
- (i) Extending the rod
 - (ii) Attaching the base plate
 - (iii) Clustering the lamps on it



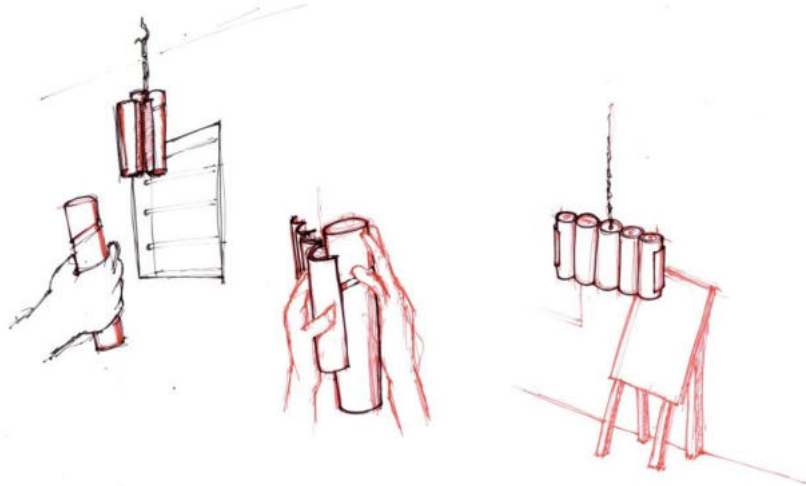
Illuminating a community gathering

Opportunity Area 5:

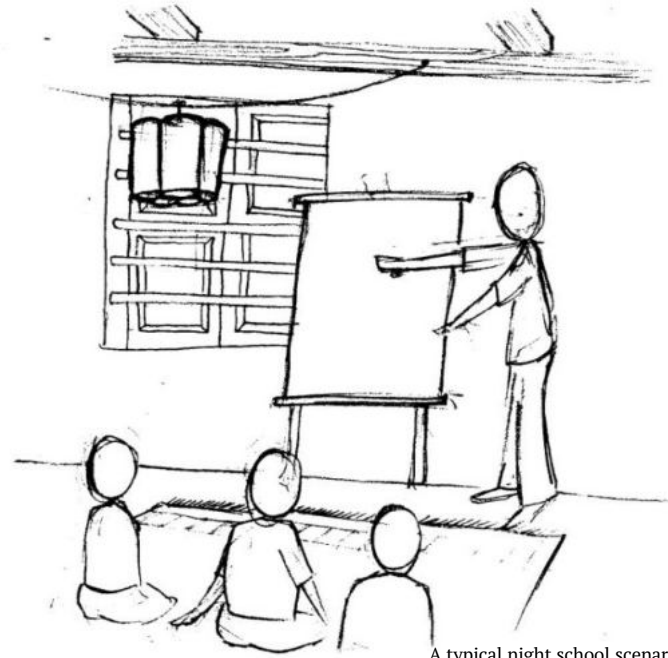


Opportunity Area 6:

- Scenario for a night school, where a simple hand held lamp fits into a dock
- Since it is suspended from the top, it ensures proper distribution of light



Docking the lamps in the holder



A typical night school scenario

Opportunity Area 7:

- Formally clustered lamps with each lamp for a dedicated purpose
- One lamp can go outside the house, others can illuminate the house



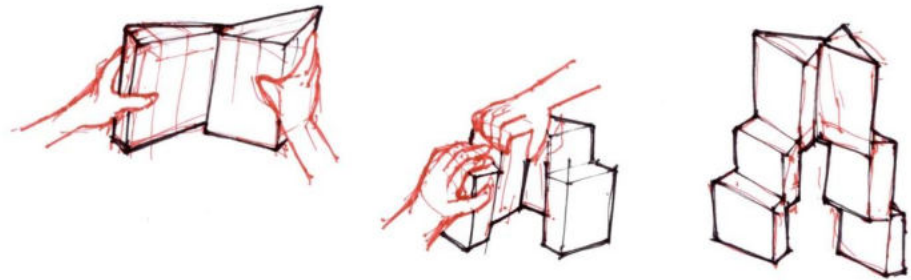
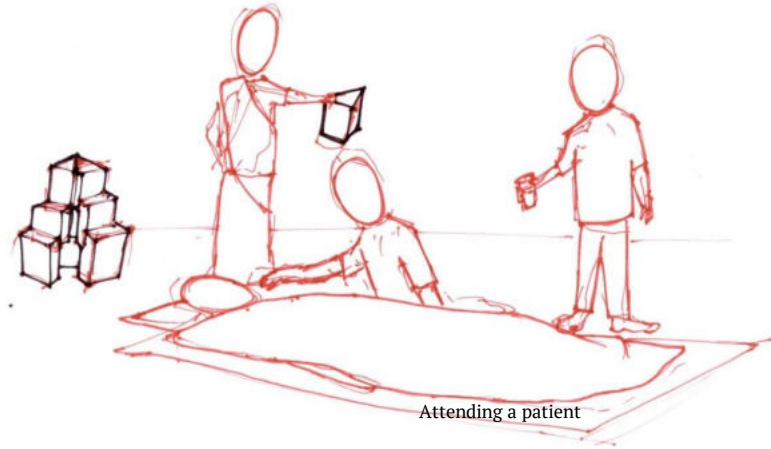
Detaching the light



Wayfinding

Opportunity Area 8:

- lifting the source to a certain height above the ground.
- typical application would be a medical emergency



Opportunity Area 9:

- lamp with a flexible goose-neck
- It can be detached from the base and the neck can be wound around the user's hand or a stick



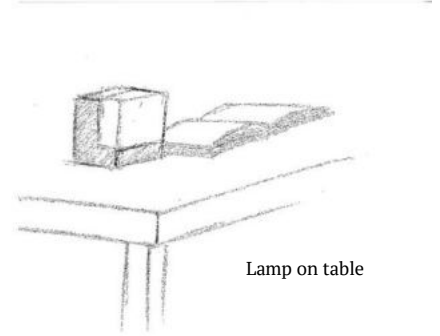
Lamp

Opportunity Area 10:

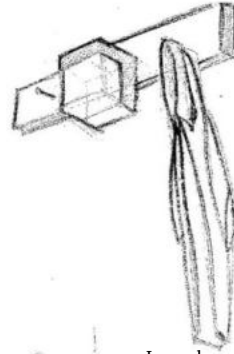
- Simple soft cubical form
- The top face has a solar panel embedded in it
- It can be mounted on the wall, placed on the ground thus making it apt for simple rural indoor tasks
- An additional strap can be attached to help in carrying it around



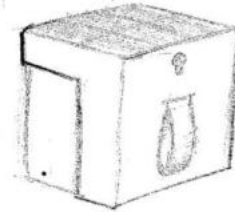
Lamp views



Lamp on table



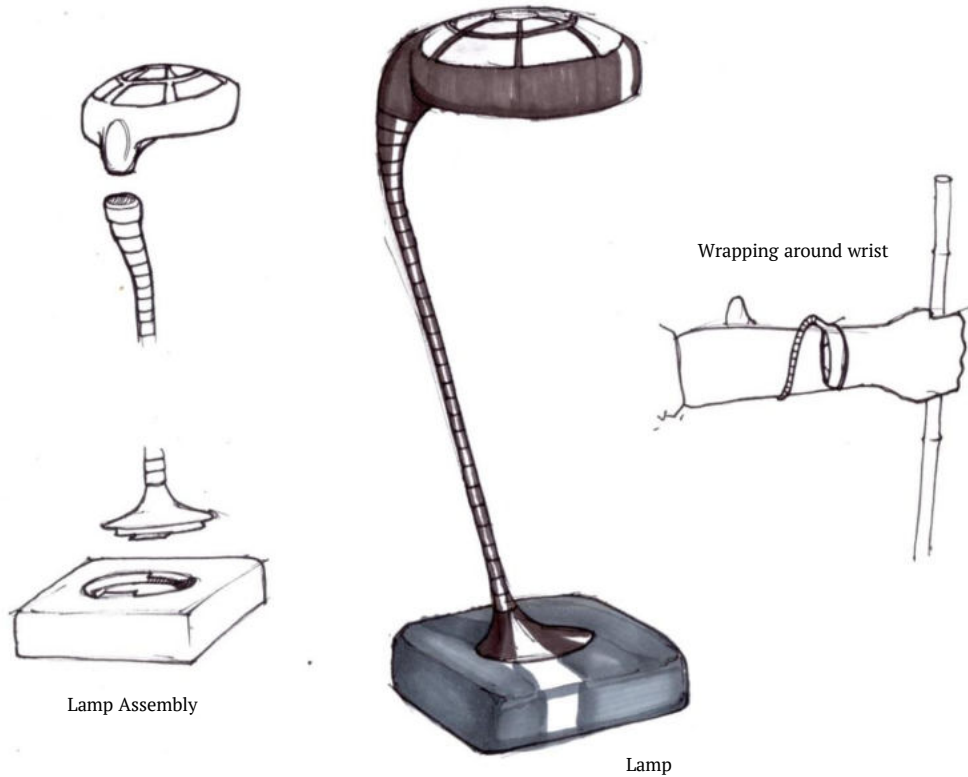
Lamp hung on wall



Lamp on ground with strap visible



Family eating around lamp



Detachable Goose-Neck Lamp:

Advantages:

- Dual functionality for both indoors and outdoor
- Customisable handle, shape of which can be decided by the user

Disadvantages:

- Just an added functionality to simple table lamp
- Form looks weak and alien
- Low power

Lamp



Detaching the lamp



Holding the lamp



Wrapping around the wrist





Lamp assembled



Solar panels on backside



Lamp being detached

Value Lights:

Advantages:

- 3 possible value applications, each considering rural activities
- Comes together as a single form
- Getting more out of a single product

Disadvantages:

- Increased chances of component getting lost or stolen

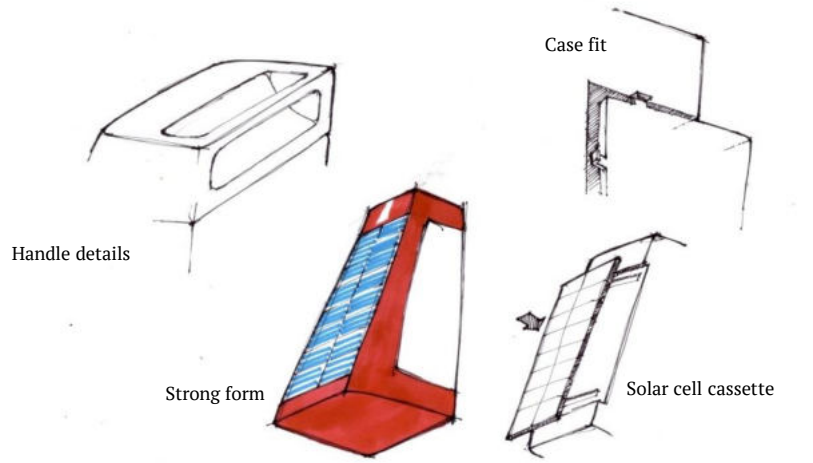
Courtesy: Author



Detaching the upper light



Assembled lights



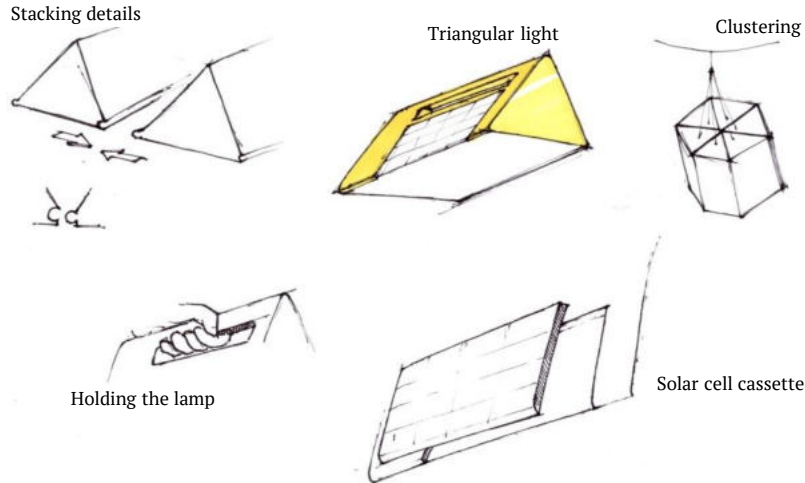
Triangular Lights:

Advantages:

- Ease of handling

Disadvantages:

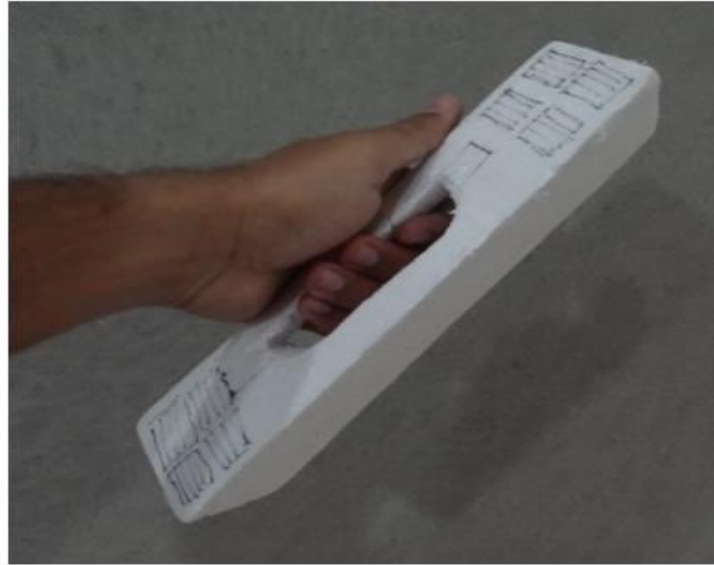
- Neutral form
- Limited usage



Courtesy: Author



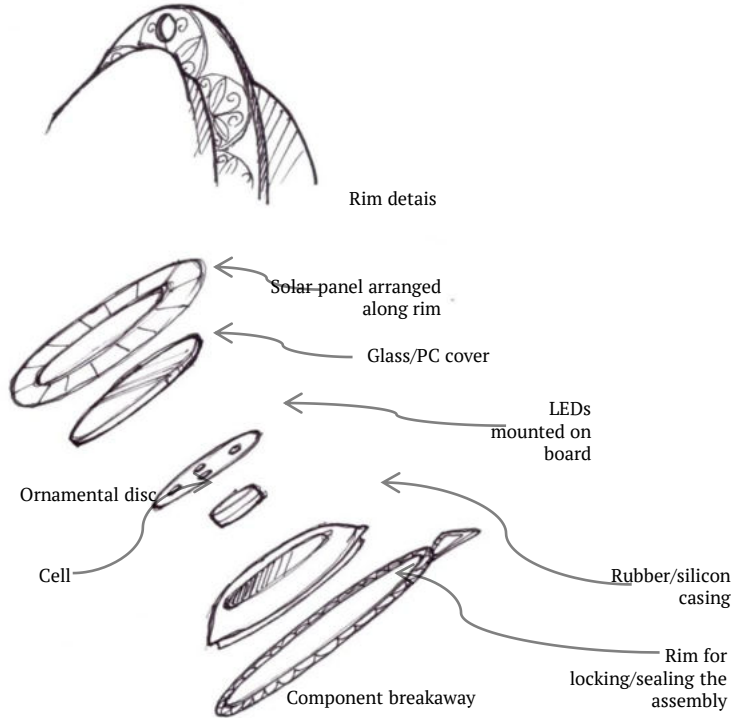
Triangular Lights



Holding the light



Lamp with handle in
the form



Disc Lights:

Advantages:

- Protection from elements of nature
- Form and material gives scope for ornamentation
- Ease of use

Disadvantages:

- Limited area for light diffusion
- Limited functionality
- Problems in orientation, cannot be kept standing without being suspended or supported

Courtesy: Author



Disc light variations

Light Cylinders:

Advantages:

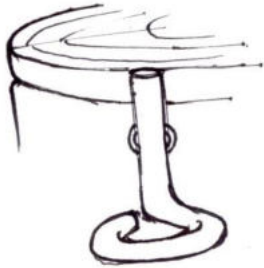
- Varieties of clustering possible

Disadvantages:

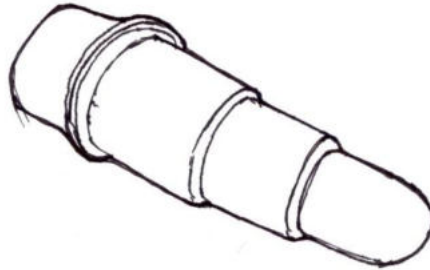
- Either too minimalistic or elaborate



The chandelier
inspired solar
panel cum
holder

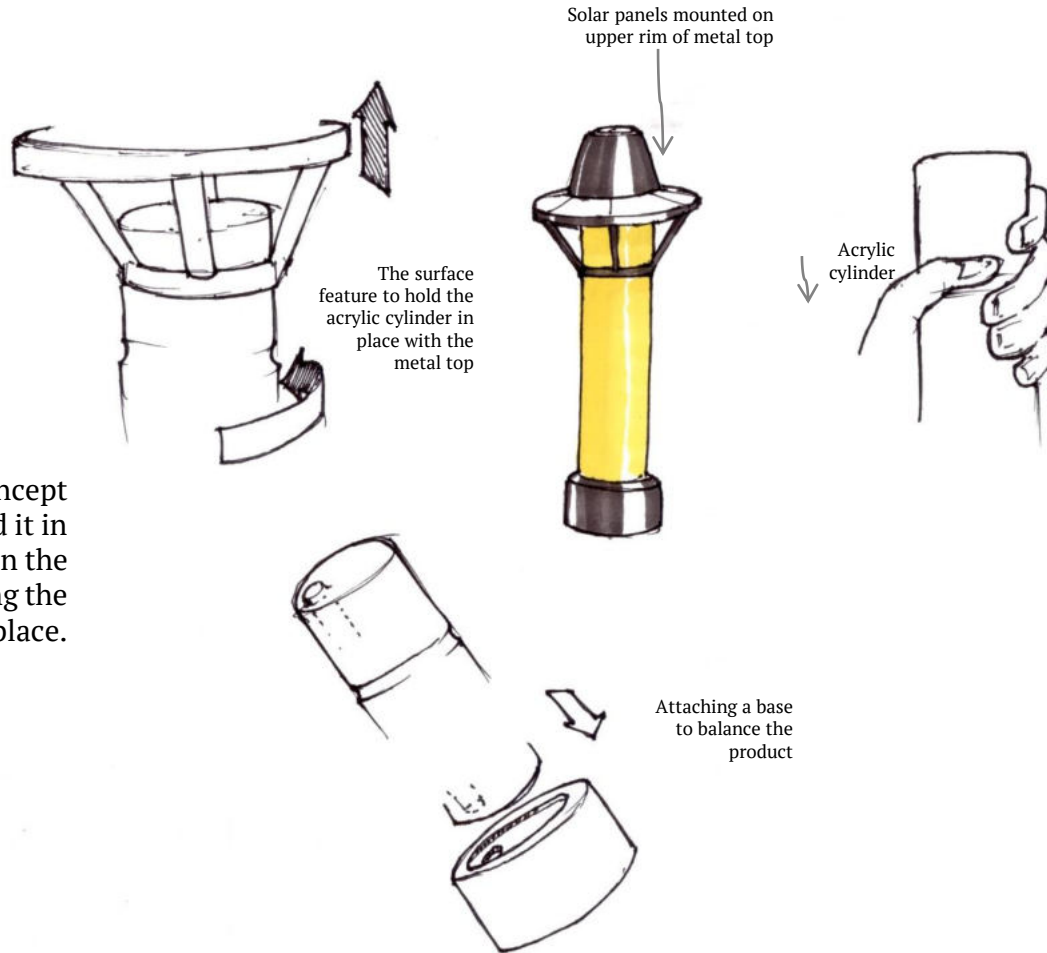


The holder for
cum charger for
lights



The retractable light
cylinder

An inspiration from a traditional chandelier, where lights fit into holders that double up as contact chargers. The upper face acts as a solar panel. The lights are retractable for easy portability.



A variation of the concept with piping to hold it in place. The feature on the surface helps in locking the cylinder in place.



Fig.84 Lamp



Fig.85 Lights arranged
along central axis

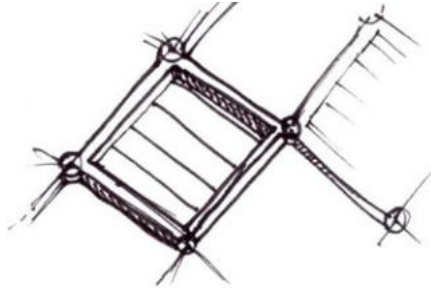


Fig.86 Details of framed
solar panel

Globular Lamp:

Advantages:

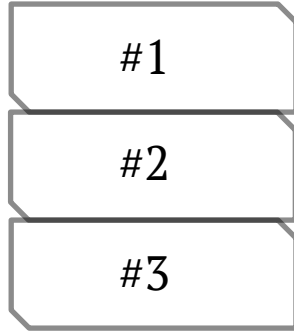
- Resembles a traditional lamp
- Beautiful accent lighting possible

Disadvantages:

- Complex assembly, with too many
- Does not satisfy need for general lighting
- Difficult to move around with

‘Value Lights’ as a Design Direction

The thought is to provide the user with more than one light for dedicated tasks. The lights come together to form a single product whose combined value is more than the sum of its individual.



Approach:

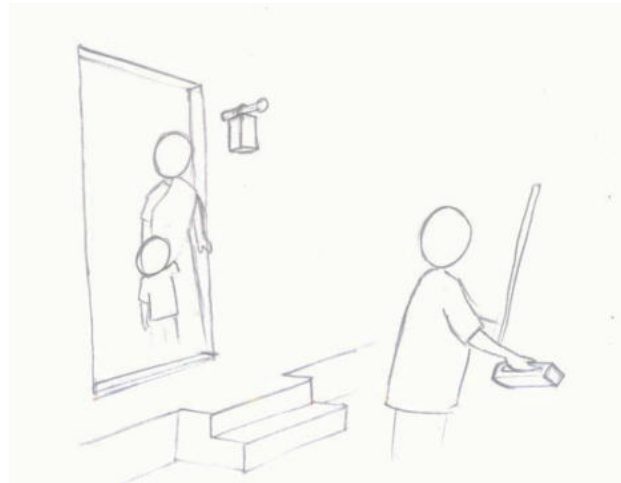
- Simple stacking
- Vertical combination
- Semantically wall mounted product
- Distinct hierarchy and separation of purpose
- Vertically stacked components.

Typical Tasks:



Detaching the
central fixture

Using the central
light



Taking the upper light outdoors and hanging the
lower light in the verandah

Revised Design Brief:

To design a lamp within the context of an Indian rural house-hold.

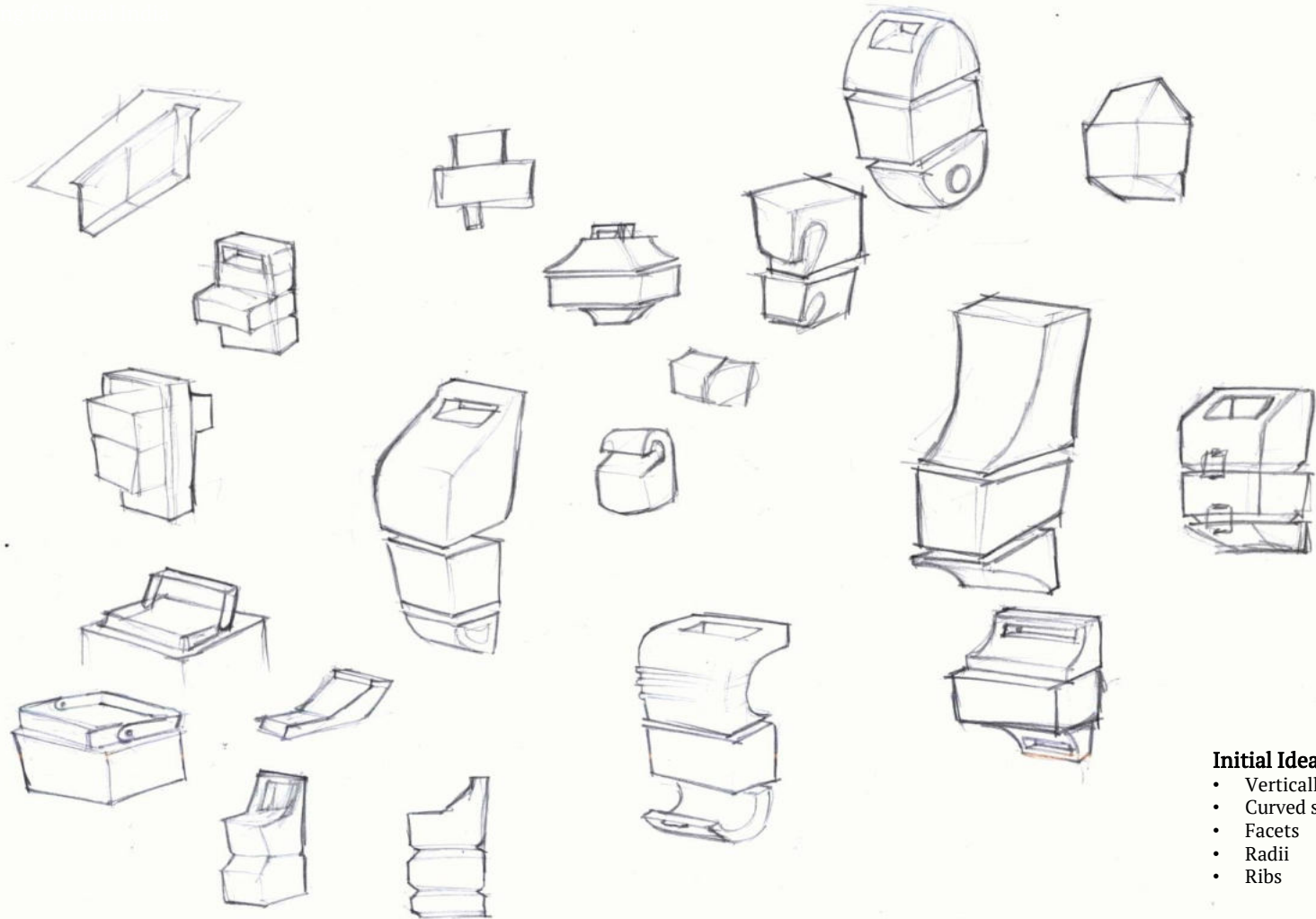
It consists of three separate lights for three value-based purposes. These include:

- Outdoors
- General lighting for indoors
- Secondary multi-purpose lighting

The product focuses on stacking and integration of form despite the three separate components.

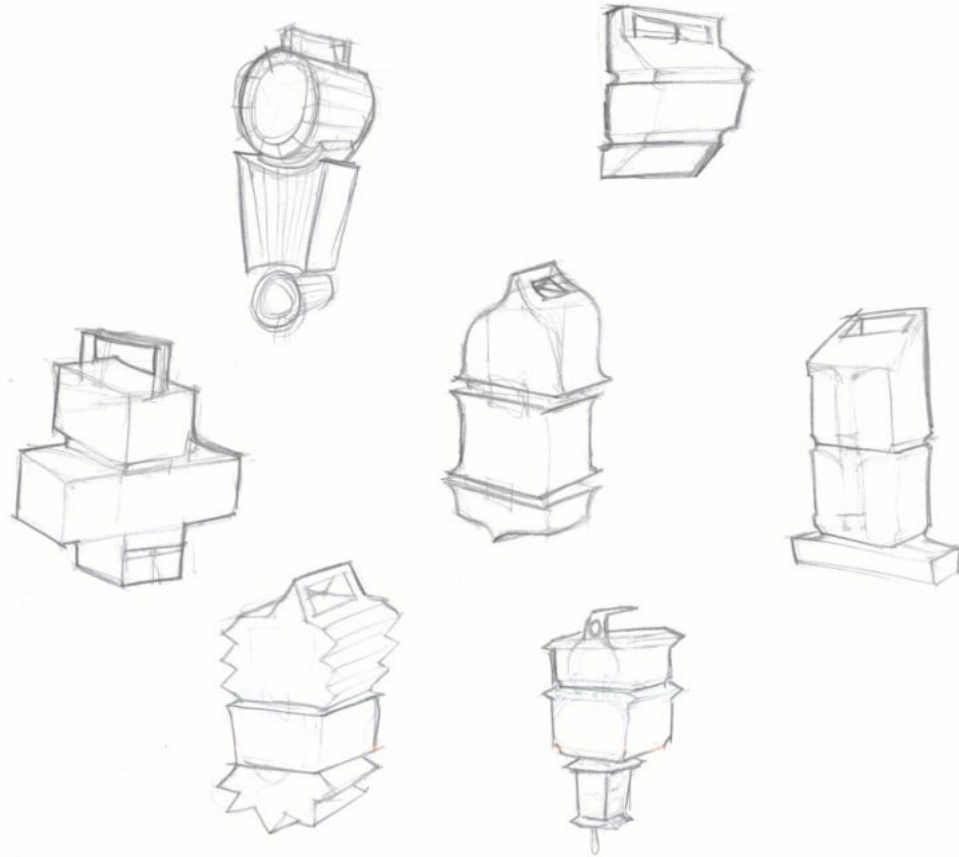
The form arises from the distinct functions that these components are meant to perform.

The lights are powered by a separate solar panel which doubles up as a docking panel.



Initial Ideations:

- Vertically stacked lights
- Curved surfaces
- Facets
- Radii
- Ribs



Initial Ideations:

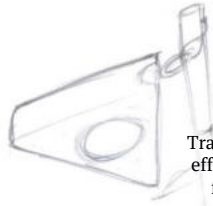
Keywords:

- Medieval
- Ornate
- Basic shapes
- Lantern
- Traditional pattern

Initial Ideas and Exploration



Lantern form:
Like a typical wind
lantern, except with
LEDs inside



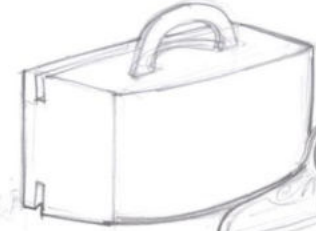
Traditional form: an
effort to break away
from flat surfaces
with traditional
lamps in mind



Pottery inspired
form:
Like earthen pots
stacked on top of
each other with
apertures for light to
filter through

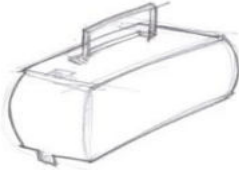
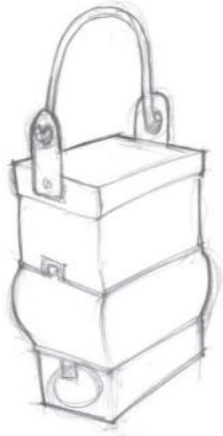


Wall-hanging inspired
form:
Like typical wall-organisers
and stacked along edges



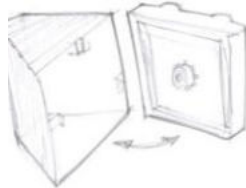
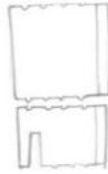
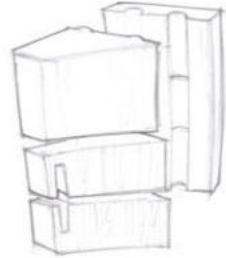
Typical wall
mounted form:
minimalistic, urbane
form

Initial Ideas and Exploration



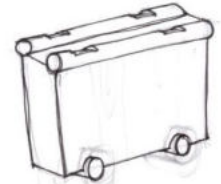
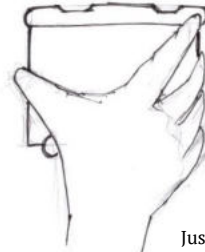
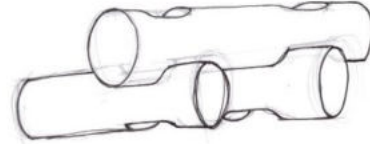
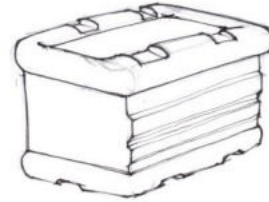
Lantern form:

An idea inspired by traditional lanterns looking at metal-plastic interfaces for the product



Trapezoidal form:

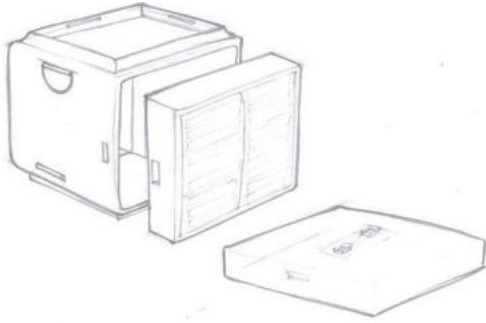
A different form, much stronger than a simple triangular form. The handle is incorporated into the front face.



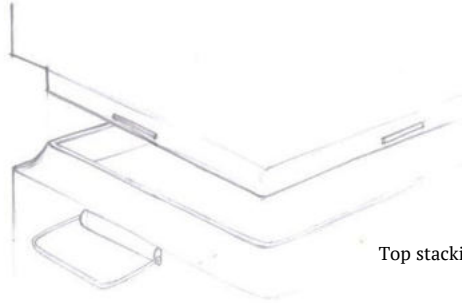
Log-like locking:

Just like wooden log houses, where wooden logs are stacked on to each other through simple notching, here the upper and lower border have notches that latch onto their partner in the other component.

Clustering and Stacking:



Possible details of back panel



Top stacking

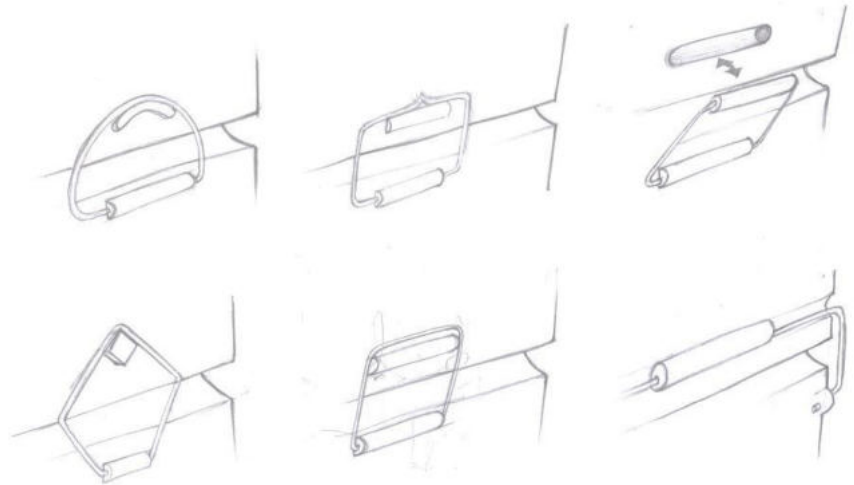
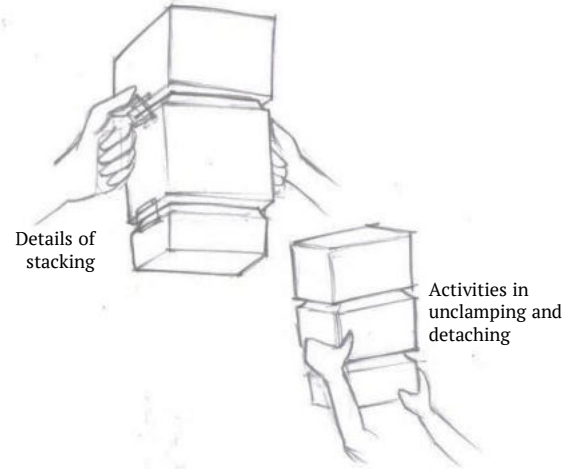
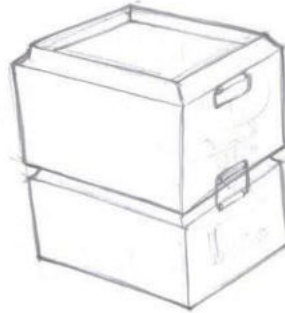
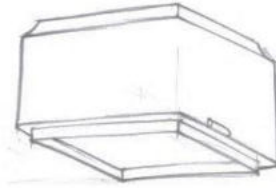
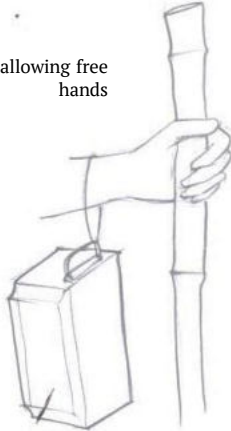


Fig. 109 various holders/clamps

Clustering and Stacking:



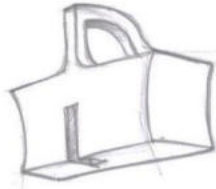
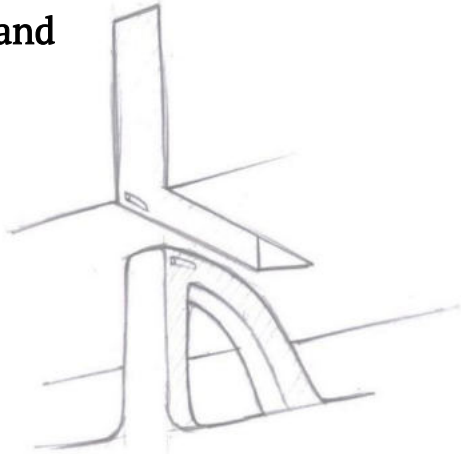
Strap allowing free hands



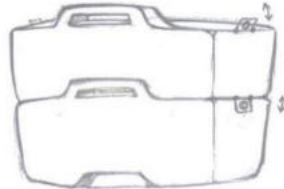
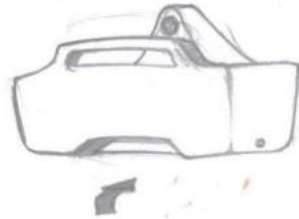
Holding the lower light in fingers via the clamp



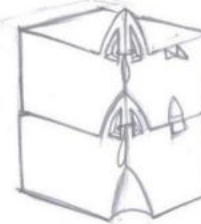
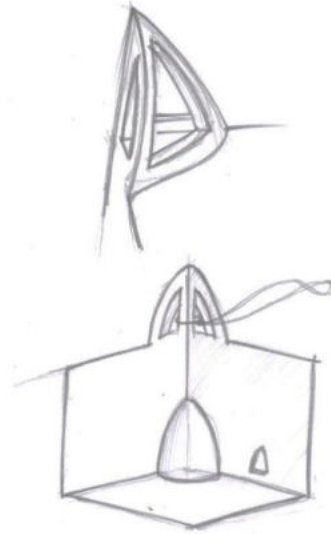
Clustering and Stacking:



Fin -like locking and stacking: The protruding fin fits into negative space on other component through a press fit. It doubles up as a handle too.

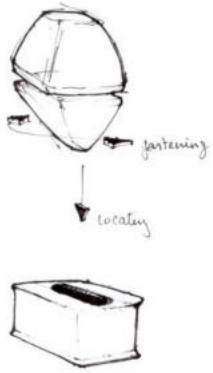


Bucket
Form: The handle again doubles up as stacking component fitting into the negative space. The idea is to have a voluminous form which is complete in itself.

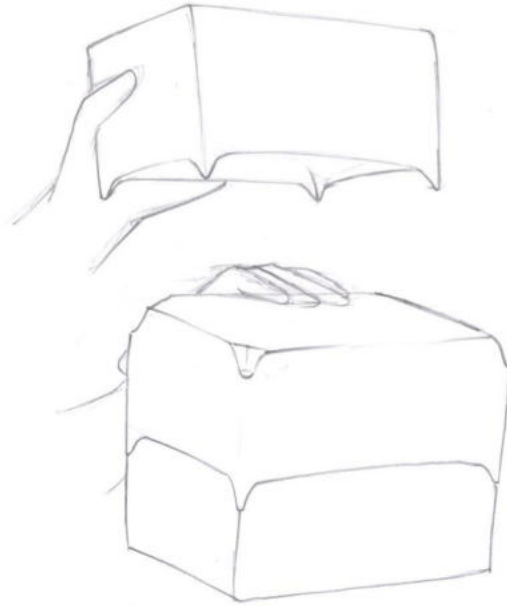


Diya-like notch for locking and stacking: here, the notch doubles up as a stacking component along with a space to pass holding straps and other accessories

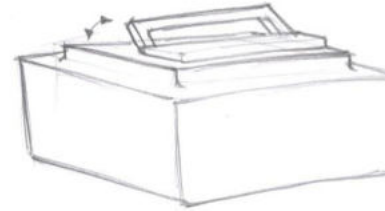
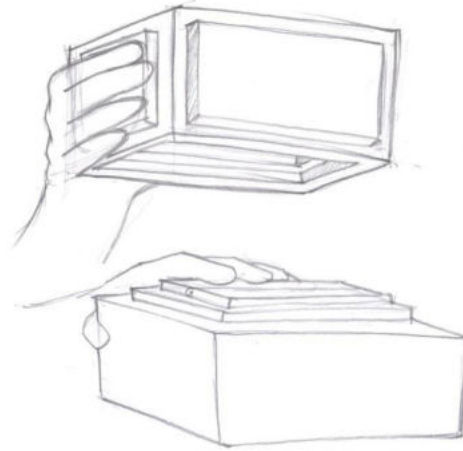
Clustering and Stacking:



Locking details of freight container:
This is a world standard for container locking where the male part is guided into its female counterpart and then twisted for locking

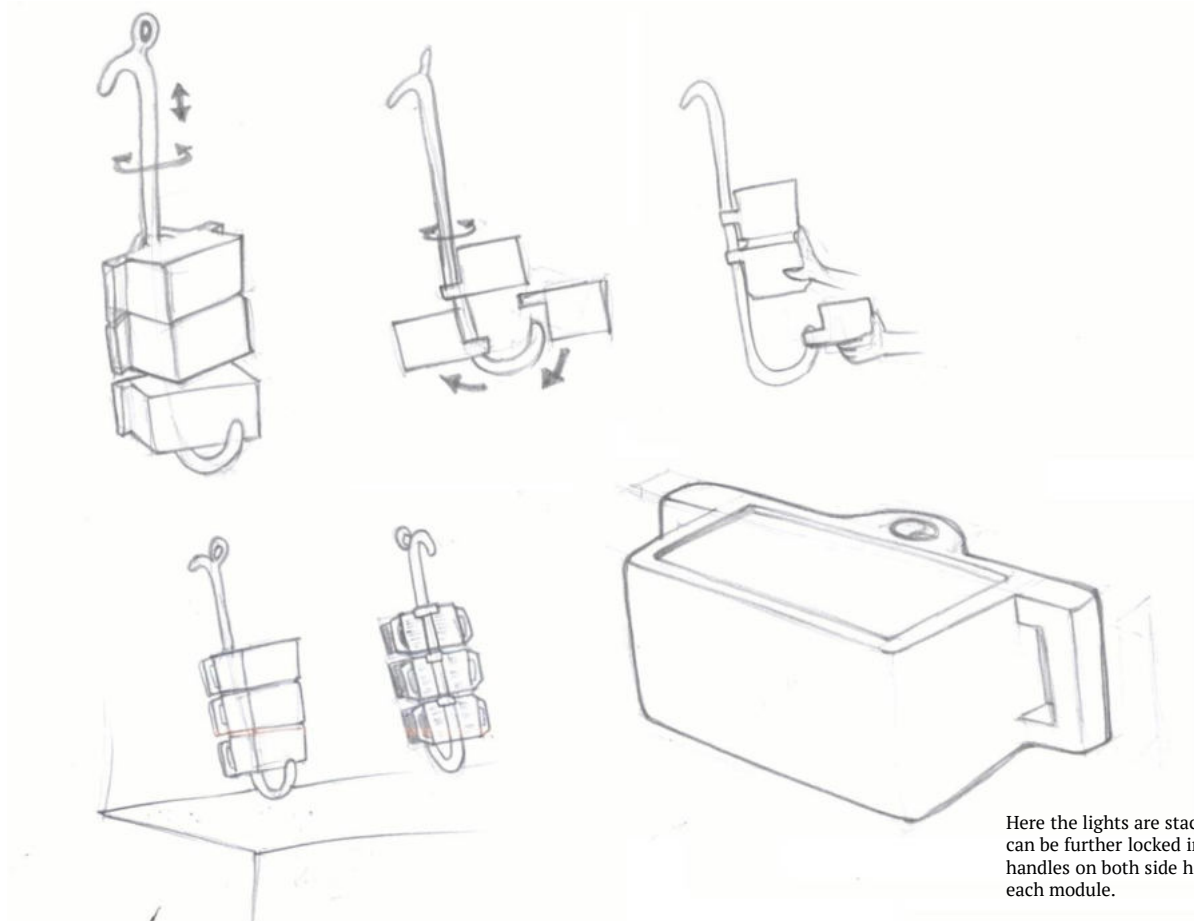


Container like stacking:
here the form is blockish, much like a container where the protruding legs acting as press fits with possible lego block-like locking in the fit cavity



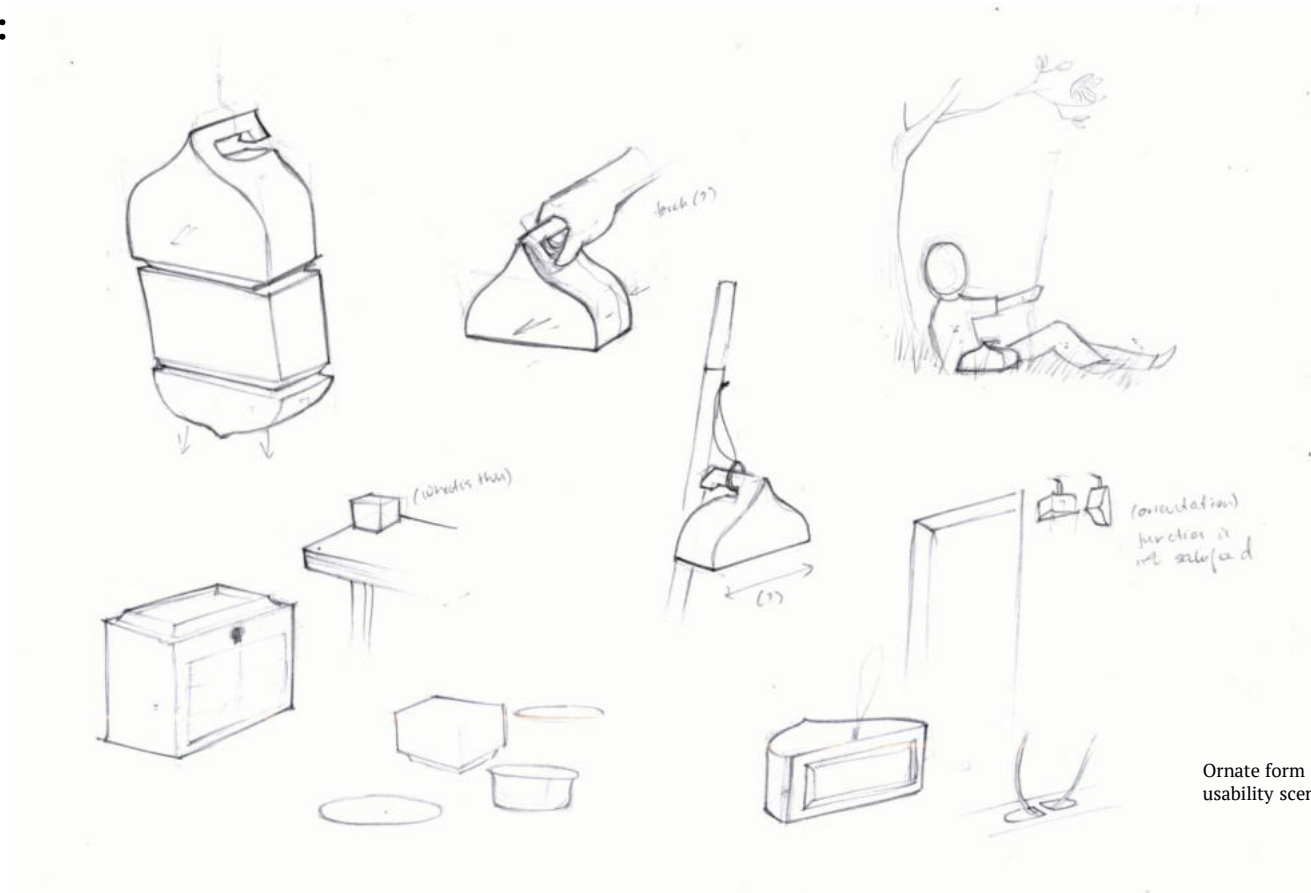
Pyramidal stacking:
The stepped features act as fits, with handle incorporated into the handle

Explorations:



Here the lights are stacked on a stick. They can be further locked in position. The handles on both side help interact with each module.

Explorations:



Ornate form
usability scenario

Mockups:

Courtesy: Author

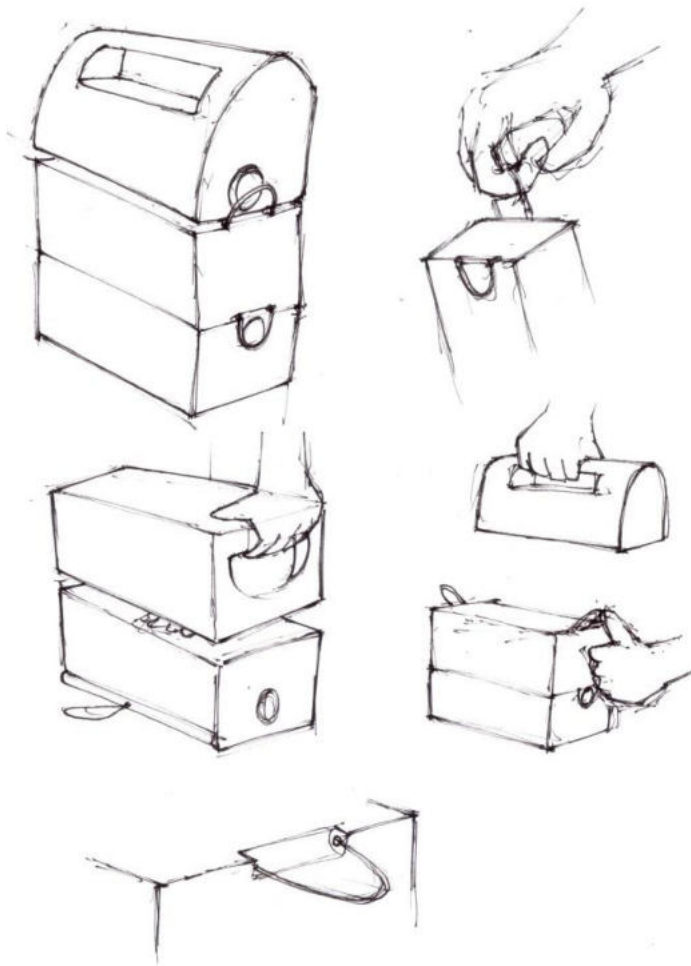


Docked lights and detaching them

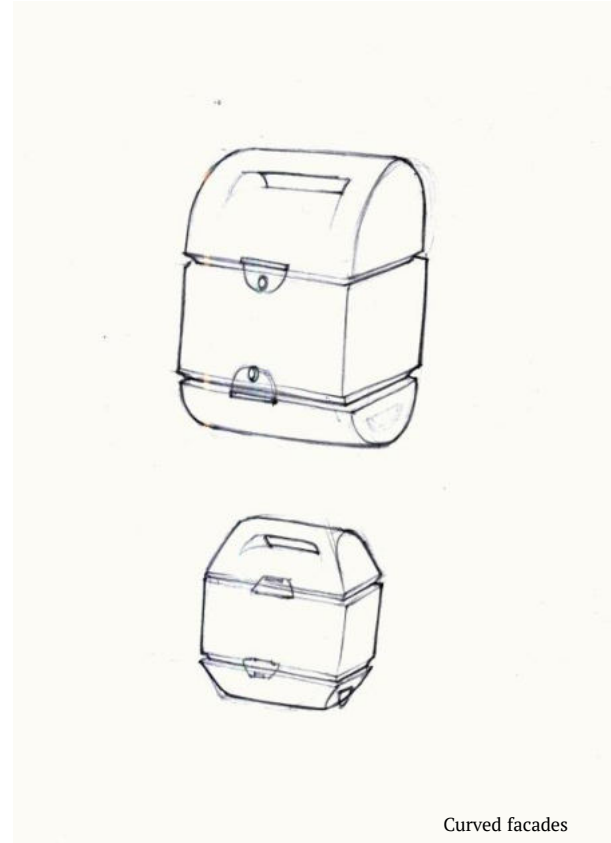


Docked lights with two smaller lights and detaching the smaller light

Handling:

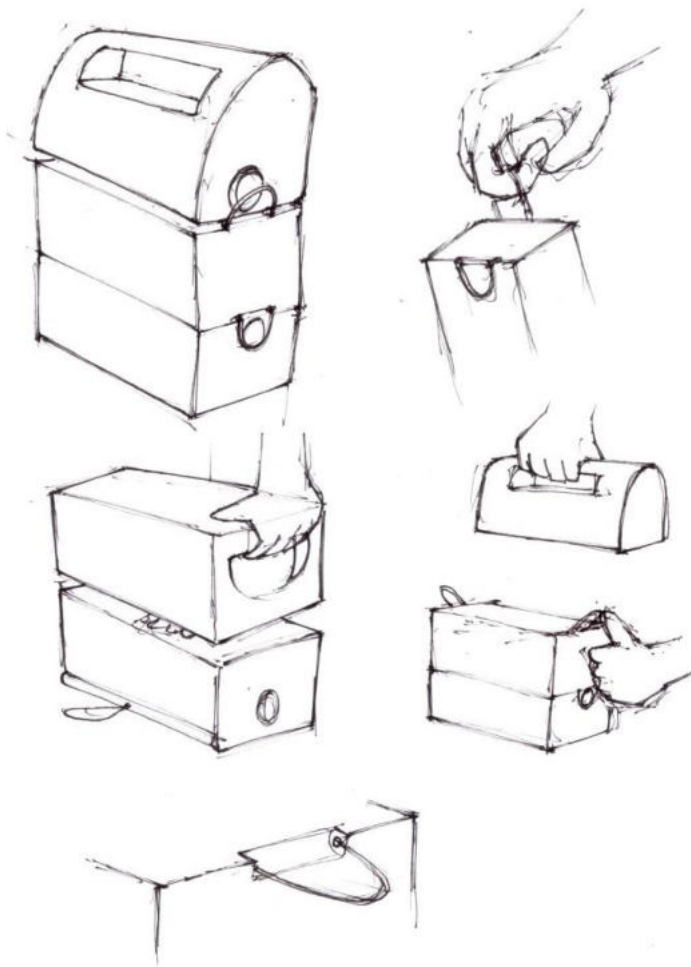


Details of activities
in detaching, and
holding

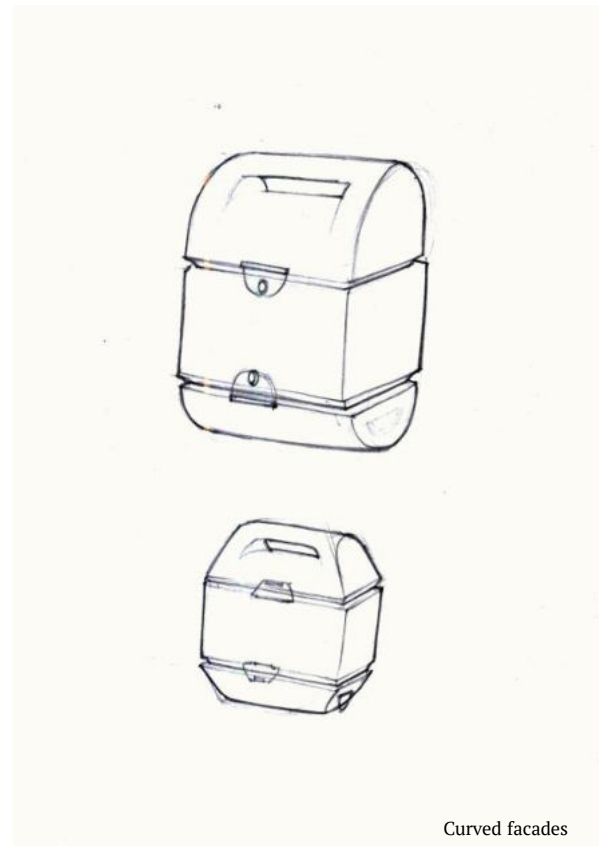


Curved facades

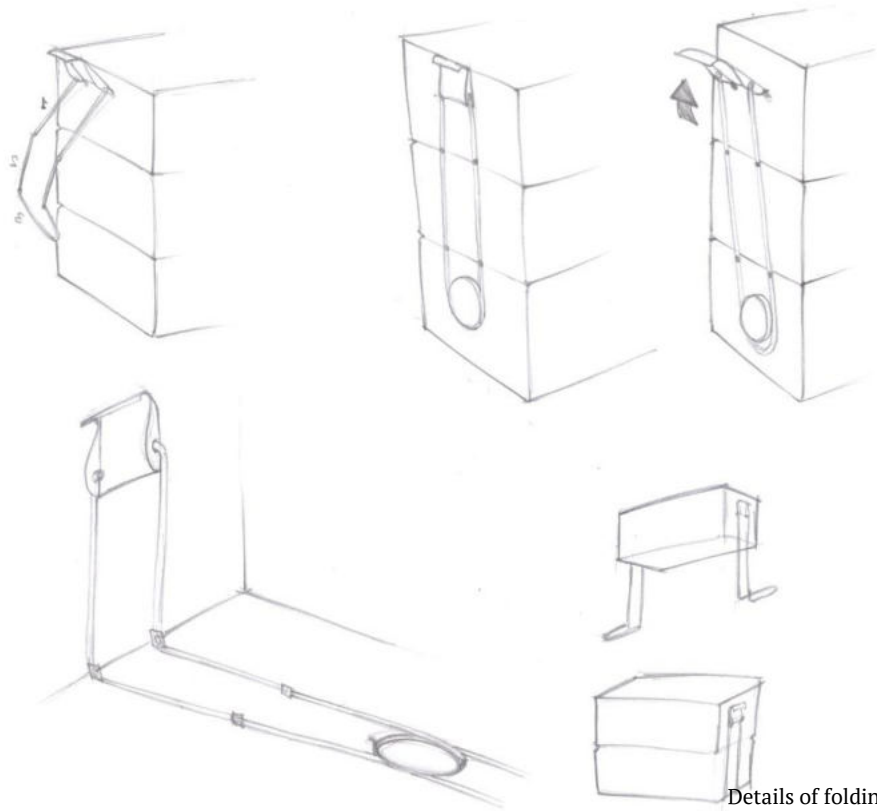
Handling:



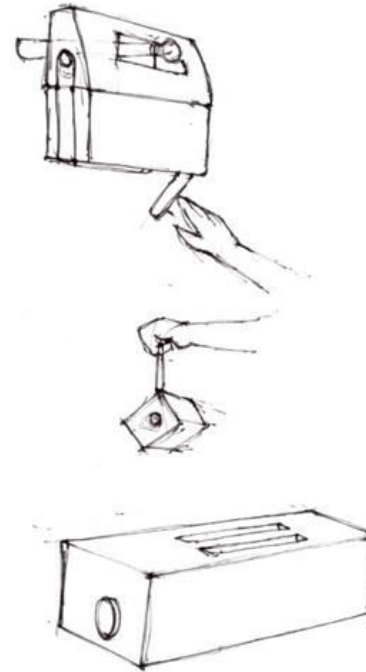
Details of activities
in detaching, and
holding



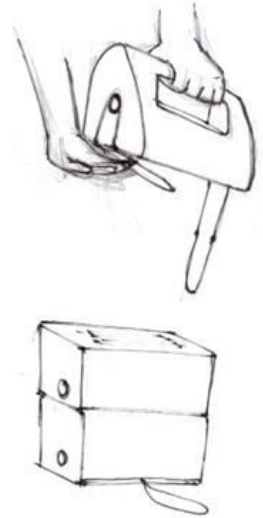
Curved facades



Details of folding
and locking for
metal
clamps



Handling:



Activities to
unclamp and fold
metal clamps

Ergonomics:

Hand Grip length:

	5 th percentile	50 th percentile	95 th percentile
Male	39	50	65
Female	41	50	63
Combined	40	50	64



Hand breadth (with thumb):

	5 th percentile	50 th percentile	95 th percentile
Male	86	99	111
Female	77	86	95
Combined	81	95	109



Hand breadth (without thumb):

	5 th percentile	50 th percentile	95 th percentile
Male	72	81	90
Female	66	71	79
Combined	68	79	90



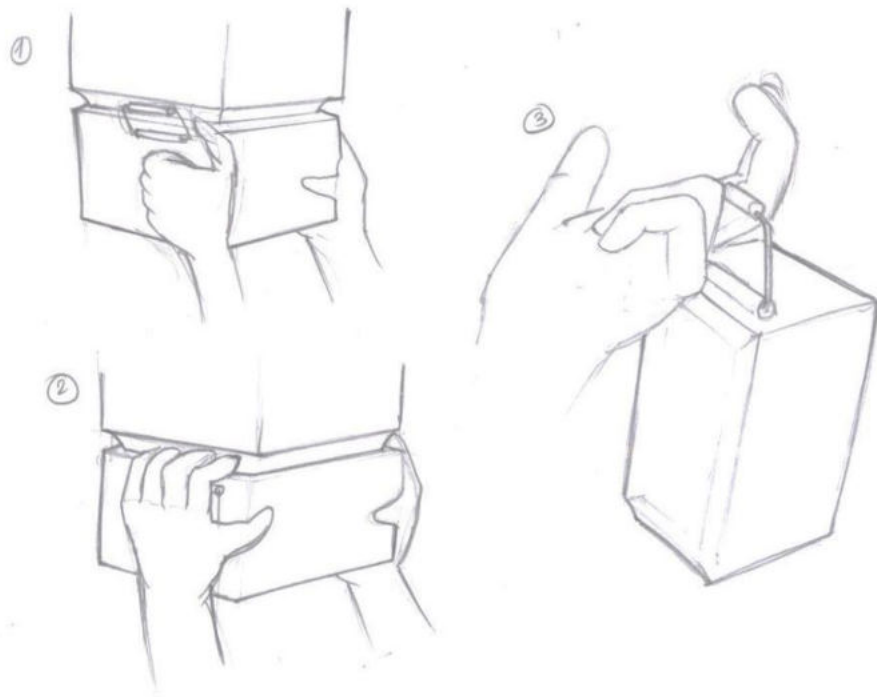
Fingertip breadth:

	5 th percentile	50 th percentile	95 th percentile
Male	11	13	15
Female	8	10	13
Combined	10	13	15

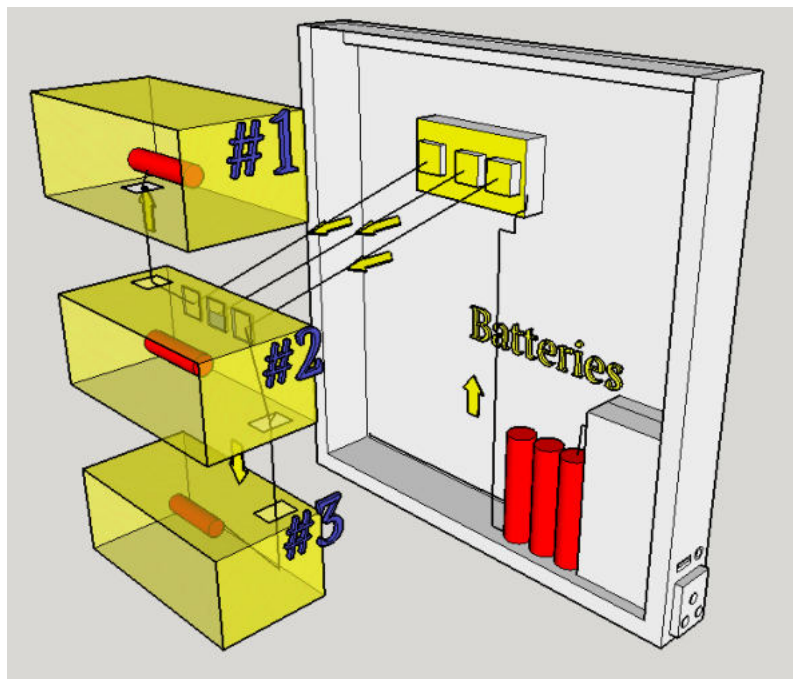


Data sourced from Indian anthropometric dimensions for ergonomic design practice.
Debkumar Chakrabati

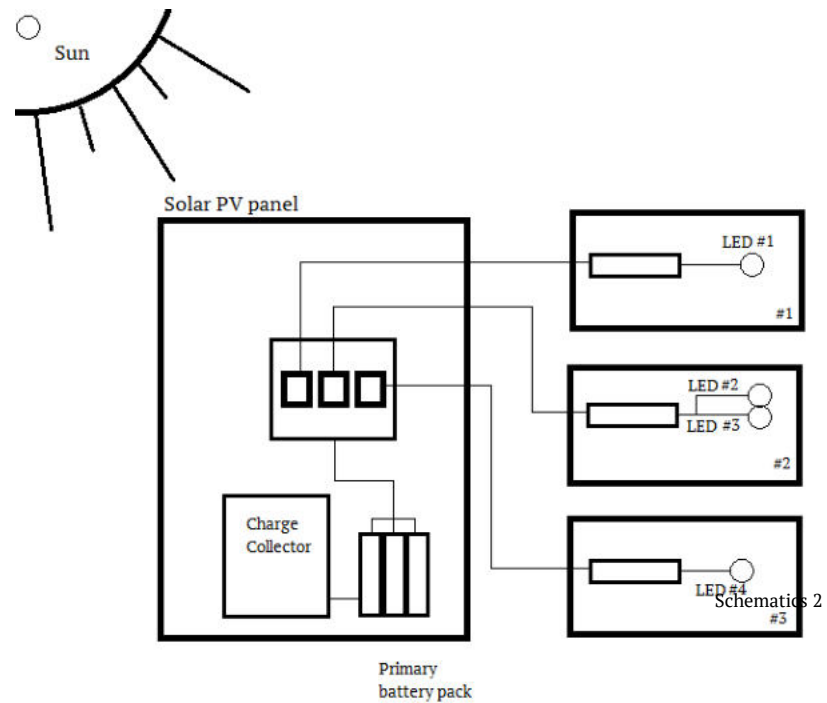
Handling



Typical usage for detaching and holding

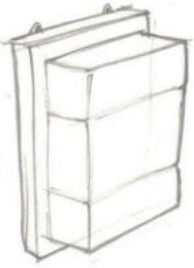


Schematics 1



Schematics 2

Charging:



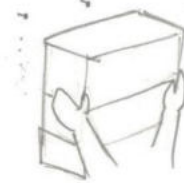
(i) The lights docked on the panel



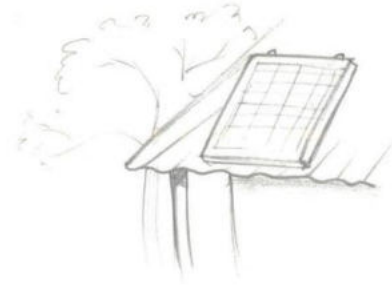
(ii) The lights being un-docked from the panel



(iii) The details on the backside with holes for the nails to be hung on the wall



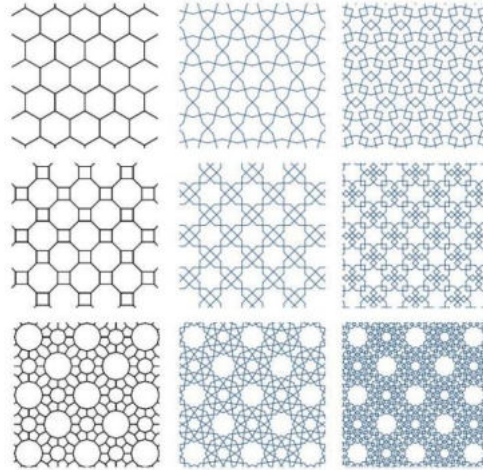
(iv) The lights being hung on the wall



(v) The panel kept outdoors for hanging



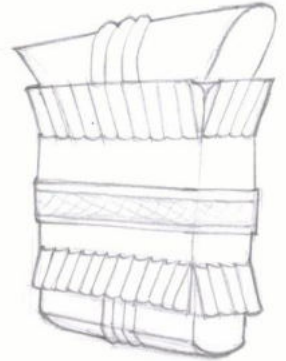
Mughal Jali
patterns at
Red Fort



Islamic patterns



Floral
patterns



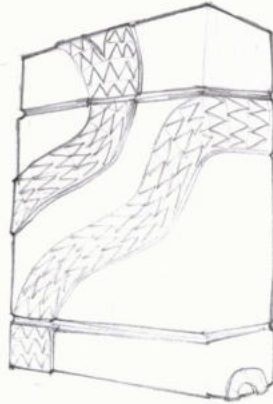
Architectural
patterns



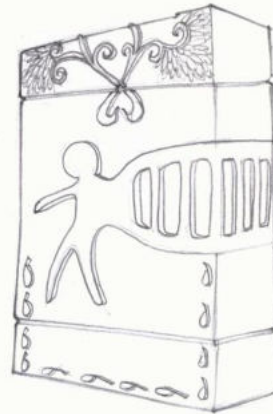
Madhubani patterns



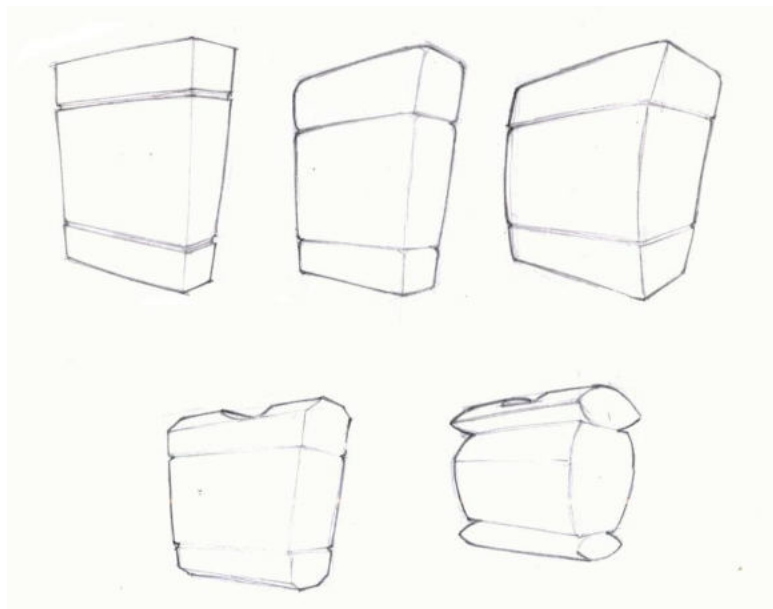
Floral patterns



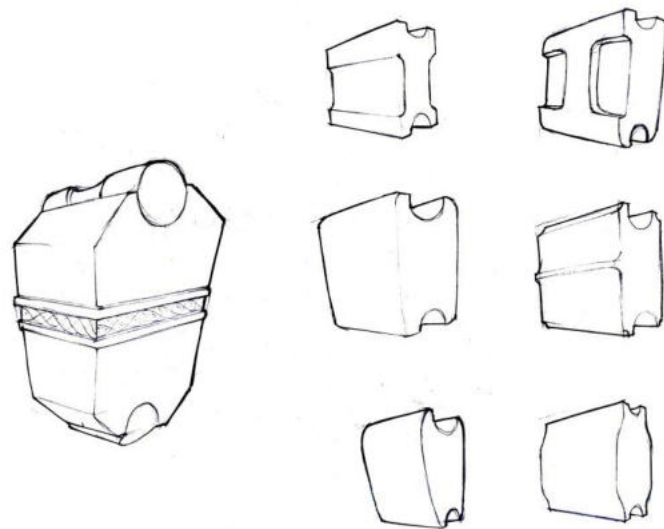
Serpentine patterns



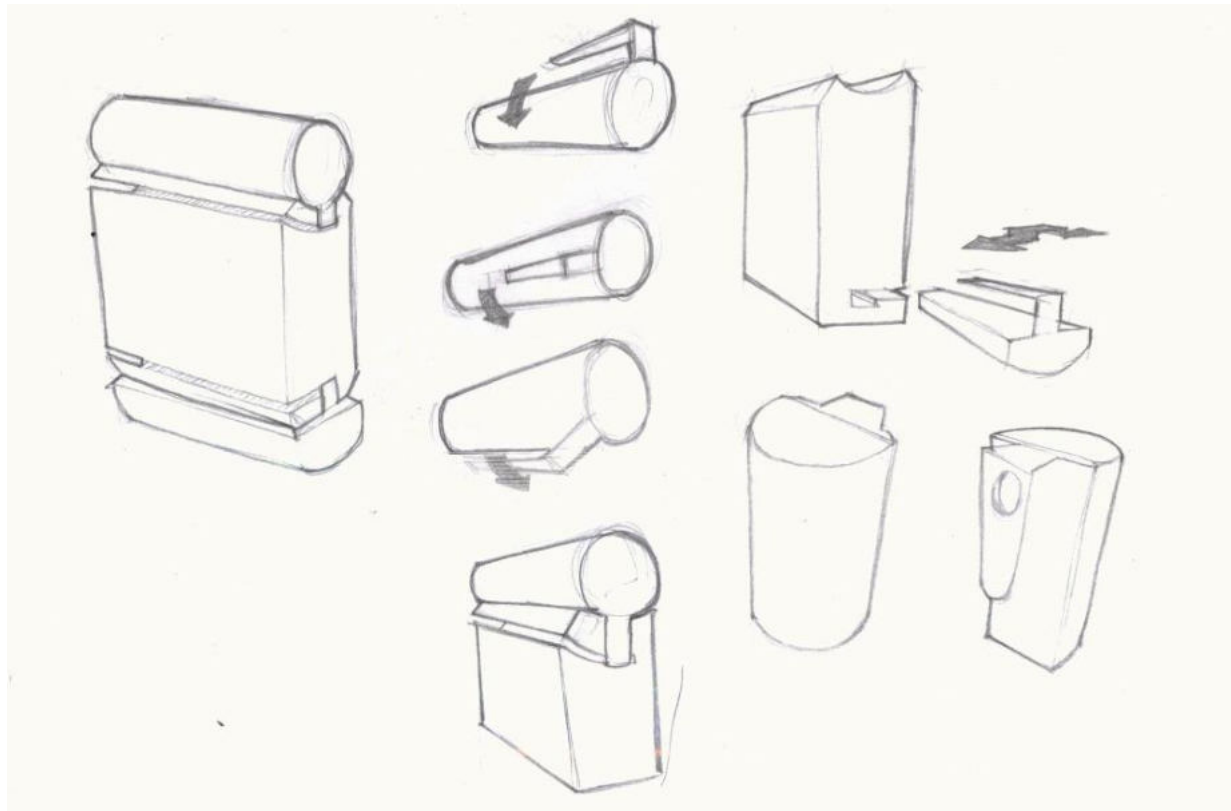
Bhil art



Form exploration in grids



Form exploration for torch-on-top idea

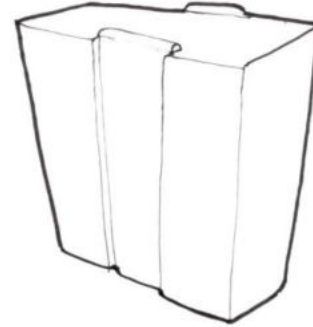
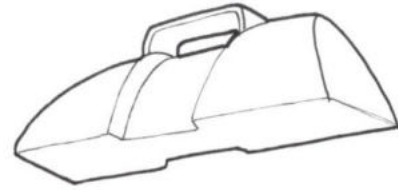
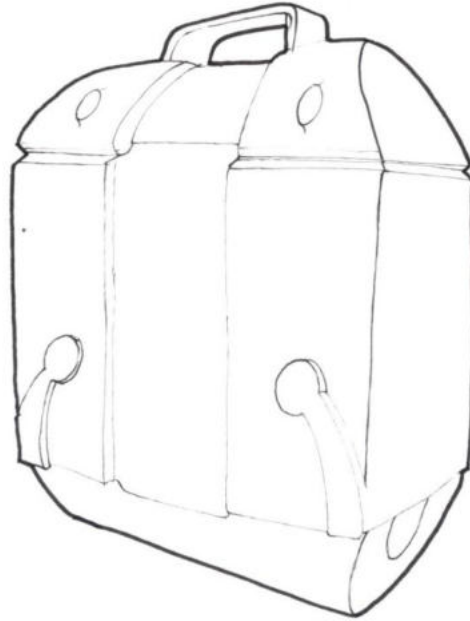


Ideation with groove to attach torch and lower light

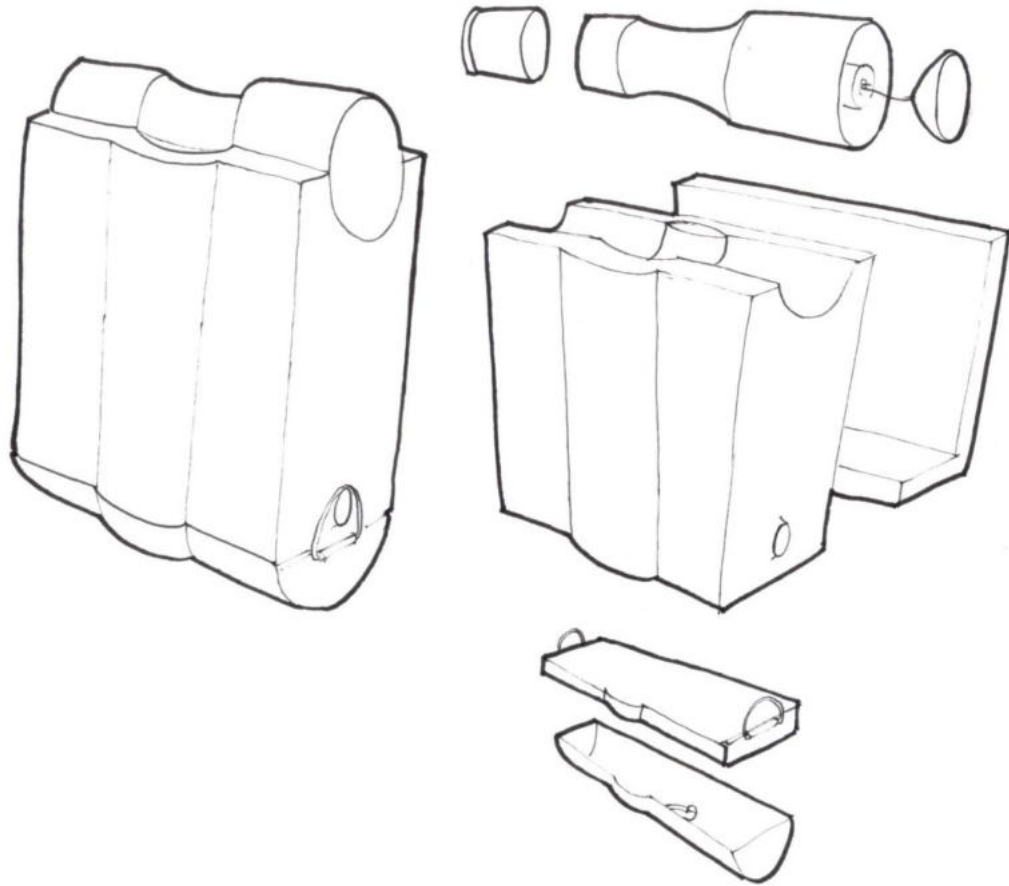
Final Concepts:

Concept 1:

- Dynamic
- Strong edges and distinct surfaces

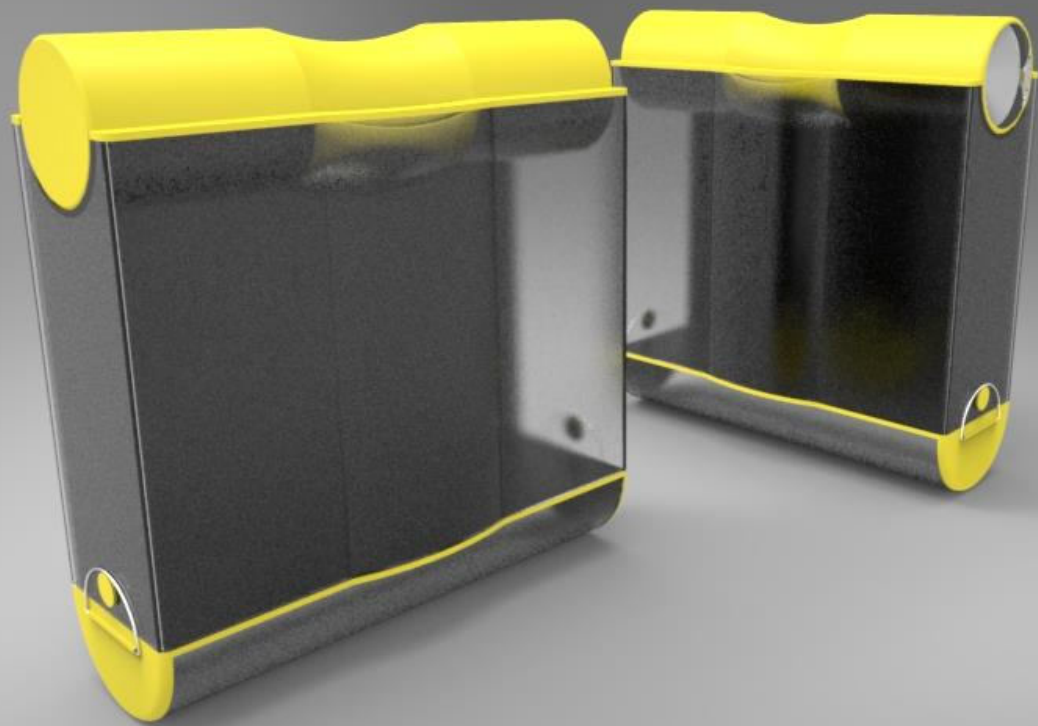






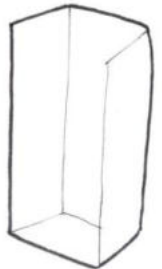
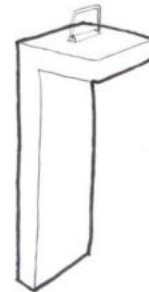
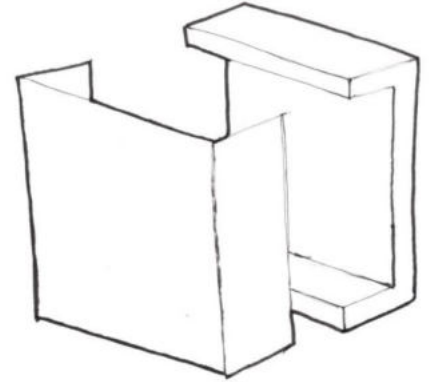
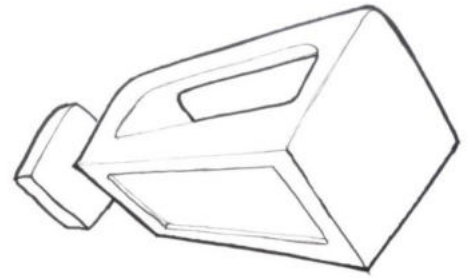
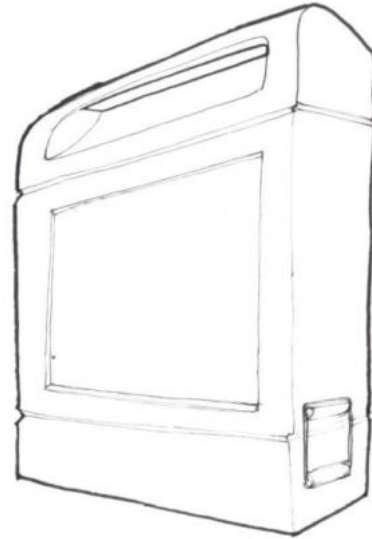
Concept 2:

- Accommodating
- Surfaces
- Futuristic

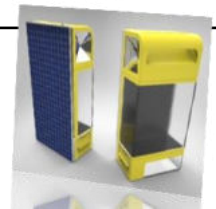
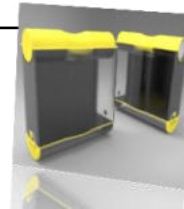


Concept 3:

- true to its purpose
- affordance to hold
- Scope for ornamentation and other features



Criteria	Concept 1	Concept 2	Concept 3
Size	Moderate	Compact	Big
Manufacturability	Considerably complex	Complex	Simple
Portability	Easy portability	Not easy	Easy portability
Stackability	Good	Very good	Good
Form	Contemporary	Futuristic	Contemporary
Scope for solar power	Moderate	Low	High
Fitting in rural scenario	Yes	Somewhat	yes



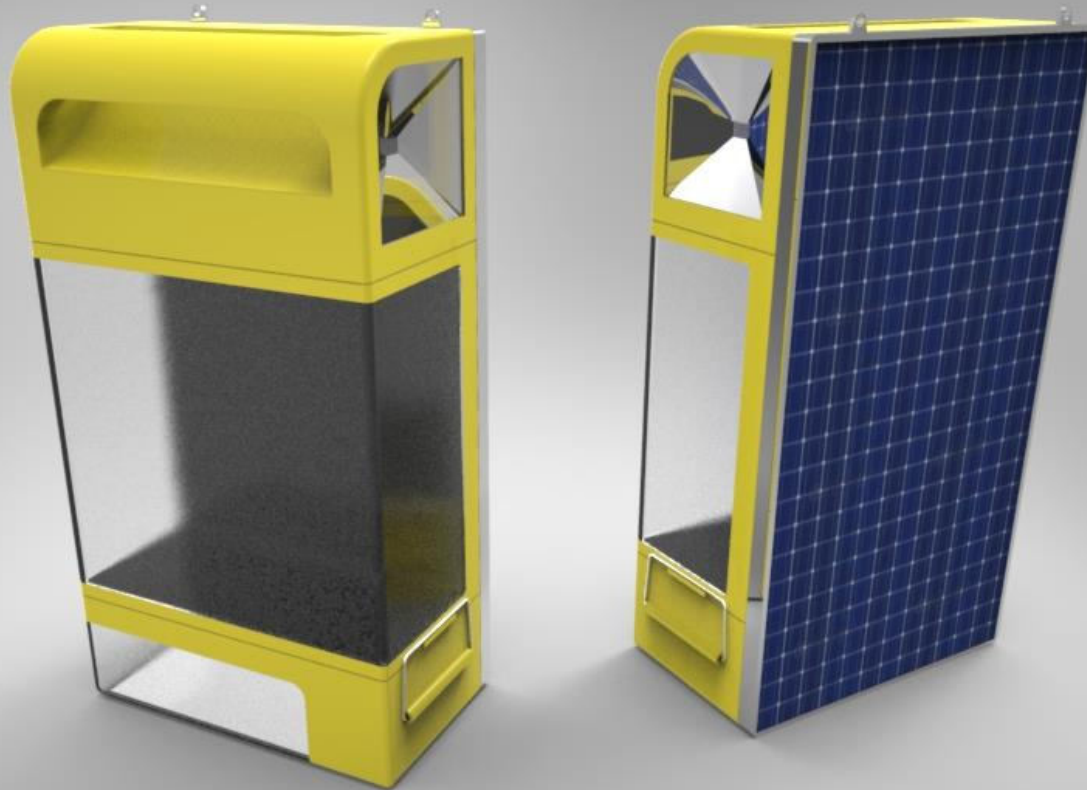
Fits perfectly in rural
household

Scope for
ornamentation

Range of products
based on patterns

Affordance for
upper torch

Neutral, stable
lower light

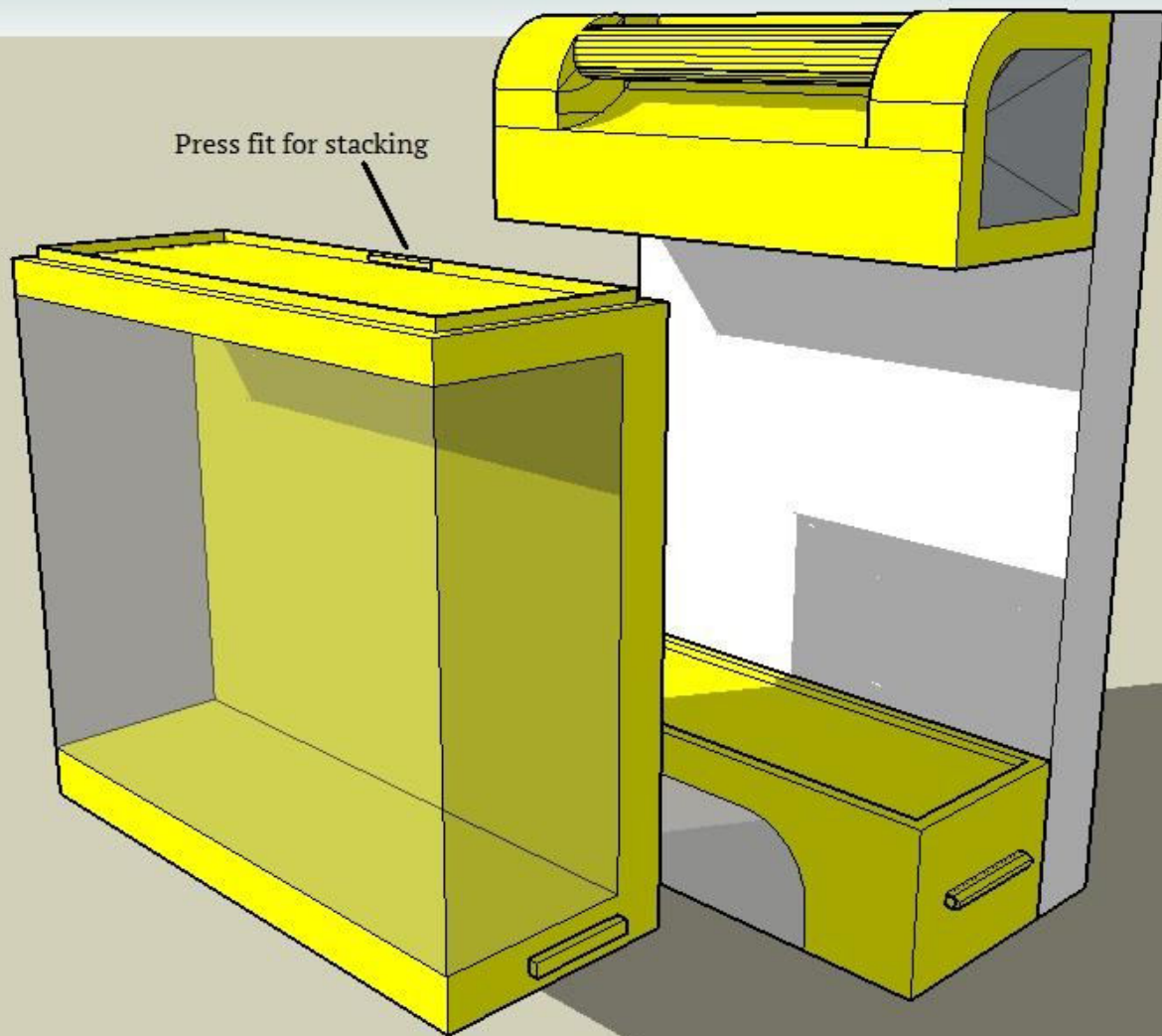


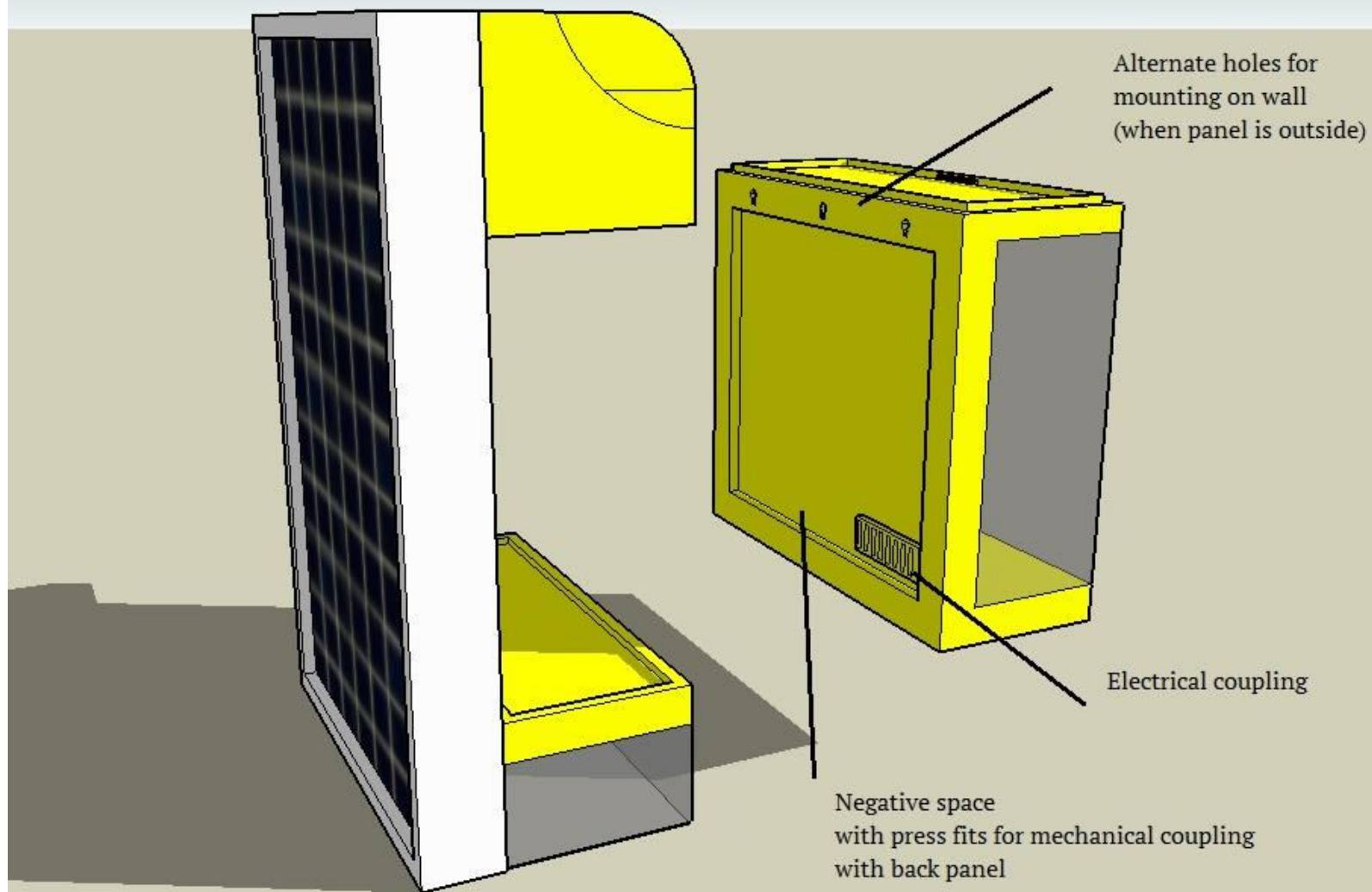
Grounded,
truthful to
purpose

Simplified
assembly

Ease of
manufacturing

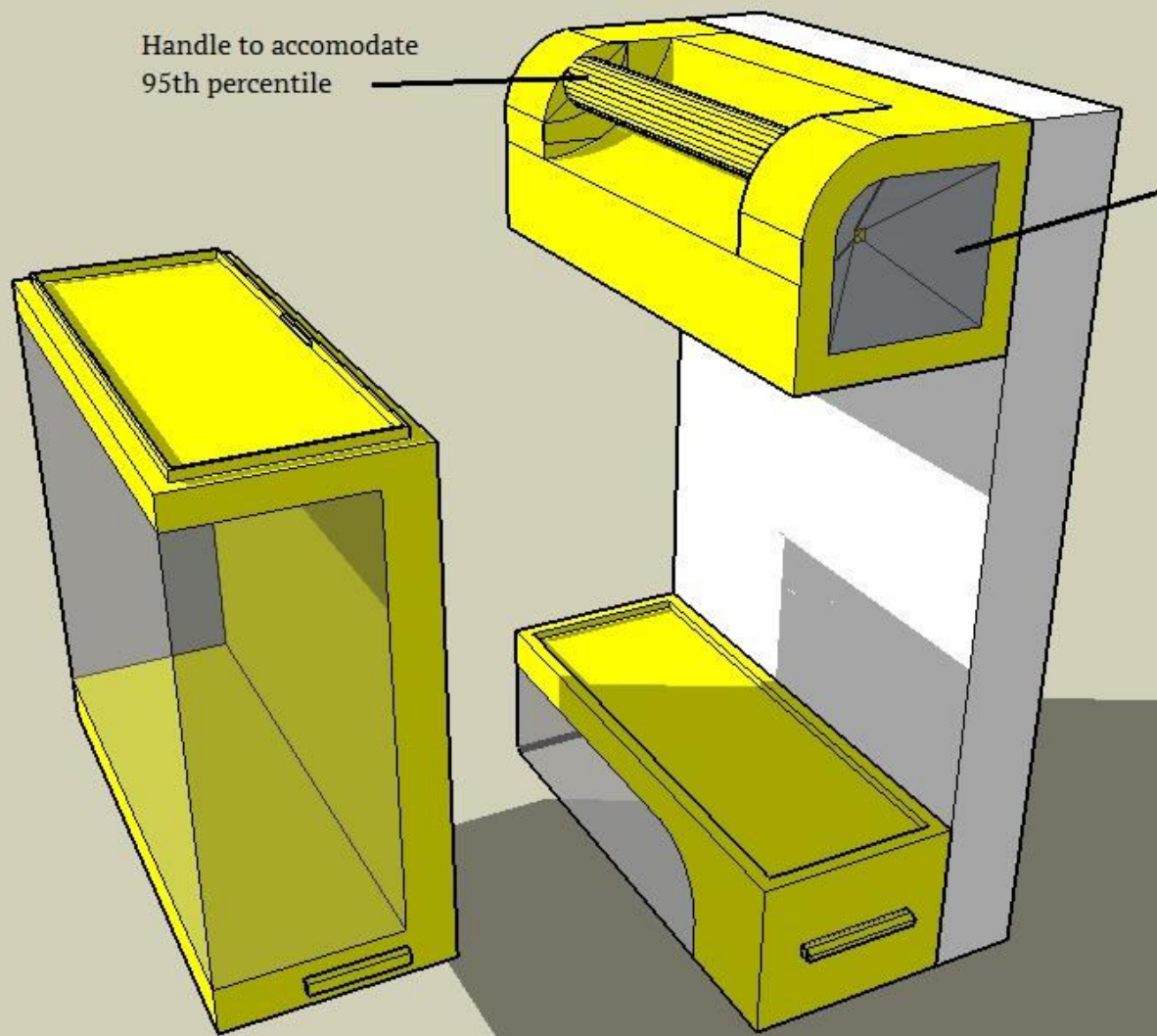
Press fit for stacking

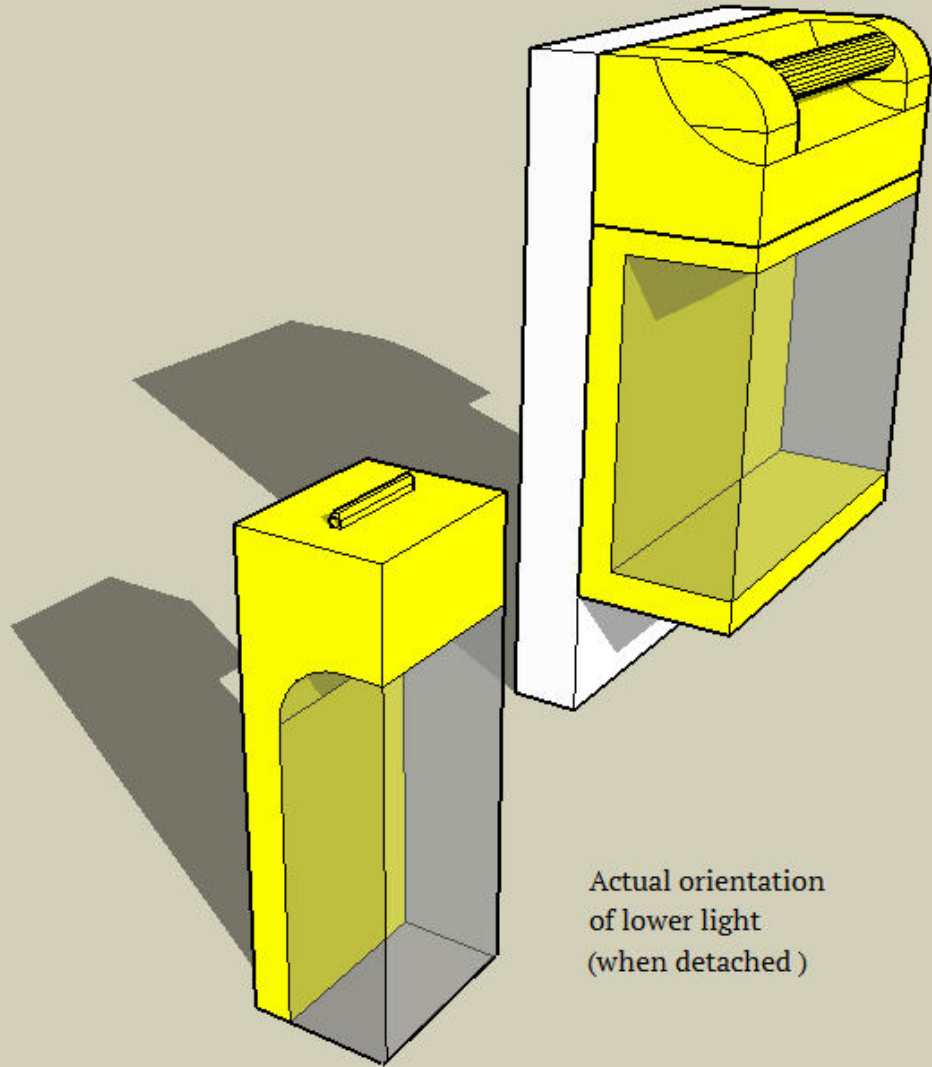




Handle to accomodate
95th percentile

Possible reflector
for torch





Actual orientation
of lower light
(when detached)

Technical specifications

Power:

Type of solar panel:

Monocrystalline silicon solar panel

Total area available for solar panel:

504sq.cm

Power output for given area:

6W approx.

On average (as a general "rule of thumb") modern photovoltaics (PV) solar panels will produce 8 - 10 watts per square foot of solar panel area
(<http://www.solar-estimate.org/?page=solar-calculations>)

Optional connections:

Charging through main grid

Micro-USB charging

Smart Circuits:

Control charging-discharging

Prevent over-charging

Monitor usage

Technical specifications

Lights :

Upper light: 1x 1W
Middle light: 2x 2W
Lower light: 1x 1W

Suggested LEDs:
Cree LEDs (300Lumens/Watt)
Philips LEDs (200Lumens/Watt)

Batteries:
8x 3.6V Lithium ion batteries
(4 for primary battery pack,
2 for middle light, 1 each for
upper torch and lower light)

Light	Suggested lumens	Light Temperature
Upper light (torch)	150 (focused light with beam angle upto 30 degrees max.)	4000-5000K
Middle light (general ambient light)	250-300 (diffused light through PMMA sheet with 2mm max. thickness)	1500-2000K
Lower light (secondary ambient light)	150 (diffused light through PMMA sheet with 2mm max. thickness)	1000-2000K

(Further optimisation to reduce costs is possible by reducing wattage of LEDs in middle light by bringing it down to 1W each. This will also help in reducing number of batteries)

Proposed strategies:

- Corporate social responsibility:
Companies come forward, adopt a specific region and sponsor the product partially or wholly
- Government scheme:
Wherein the product is distributed to the user through targeted scheme. Can include participation of NGOs.
- Social entrepreneurship:
Wherein the company sells the product at a nominal value, binding the users to a sustained payment scheme

Issues to be tackled:

- Heating of lithium batteries in primary battery pack
- Charging time optimisation
- Market wide acceptance of LEDs as a light source (other than CFLs and incandescent bulbs)
- Setting up supply chain and awareness

“When you are in doubt, or when the self becomes too much with you, apply the following test:-
Recall the face of the poorest and the weakest man whom you may have seen, and ask yourself,
If the step you contemplate is going to be of any use to him?
Will he gain anything by it ?
Will it restore him to a control over his own life and destiny ?
In other words, will it lead to ‘Swaraj’ for the hungry and spiritually starving millions ?
Then you will find your doubt and your ‘self’ melting away.”
-M.K.Gandhi



Appendix #1

Typical Cost estimates:

Based on typical online markets

LEDs:

US \$0.12 - 0.25 / Piece i.e.Rs.7.29

Type:InGaN

Working voltage: 3.2V

Luminous efficiency:160lm/W

Color rendering index:80

Color temperatures: 1500-20000K

Lifespan: 40000hrs

[http://www.alibaba.com/product-detail/Hot-sale-Epistar-led-light-emit_1799126124.html?s=p]

Batteries :

Panasonic 3.6V Li-ion battery 2250mAh

US \$2 i.e. Rs 121

Bulk cost would come down to around Rs.80

[<http://www.amazon.com/Panasonic-CGR18650CG-Rechargeable-Battery-2250mAh/dp/B001WBH2NE>]

Typical Cost estimates:

Molding typical costs:

- On hourly basis
- Shape has been optimised to simplify molds and include no moving dies
- Possible symmetry along axes has been considered to decrease number of distinct molds
- Looking at large volumes, so price can be brought down

Appendix #2

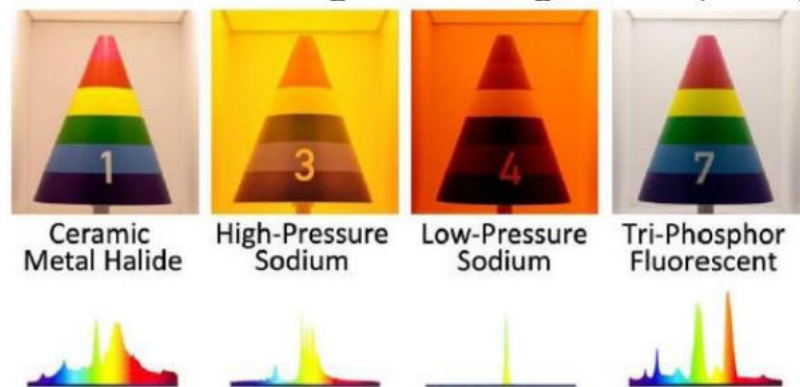
Light and its properties



Source: en.wikipedia.org/wiki/File:Incand-3500-5500-color-temp-comparison.png

Correlated Color Temperature (CCT)
apparent color temperature

Color Rendering Index (CRI) quantitative measure of the ability of a light source to reproduce the colors of various objects faithfully in comparison with an ideal or natural light source.



Source: http://sustainabilityworkshop.autodesk.com/sites/default/files/styles/large/public/core_page-inserted-images/rainbow_cones_n_spectra_labeled.jpg

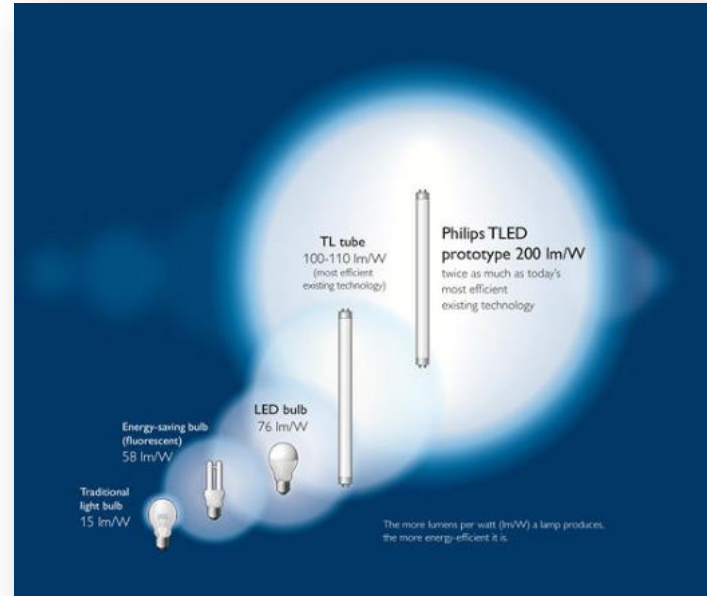
Cree LED breaks 300 lumen per watt barrier

[<http://www.cree.com/News-and-Events/Cree-News/Press-Releases/2014/March/300LPW-LED-barrier>]



Philips breaks 200 lumen per watt barrier

[http://www.newscenter.philips.com/main/design/news/backgrounders/inside-innovation-philips-breaks-200-lumens-per-watt-barrier.wpd#_U_MJ3fmSw1M]



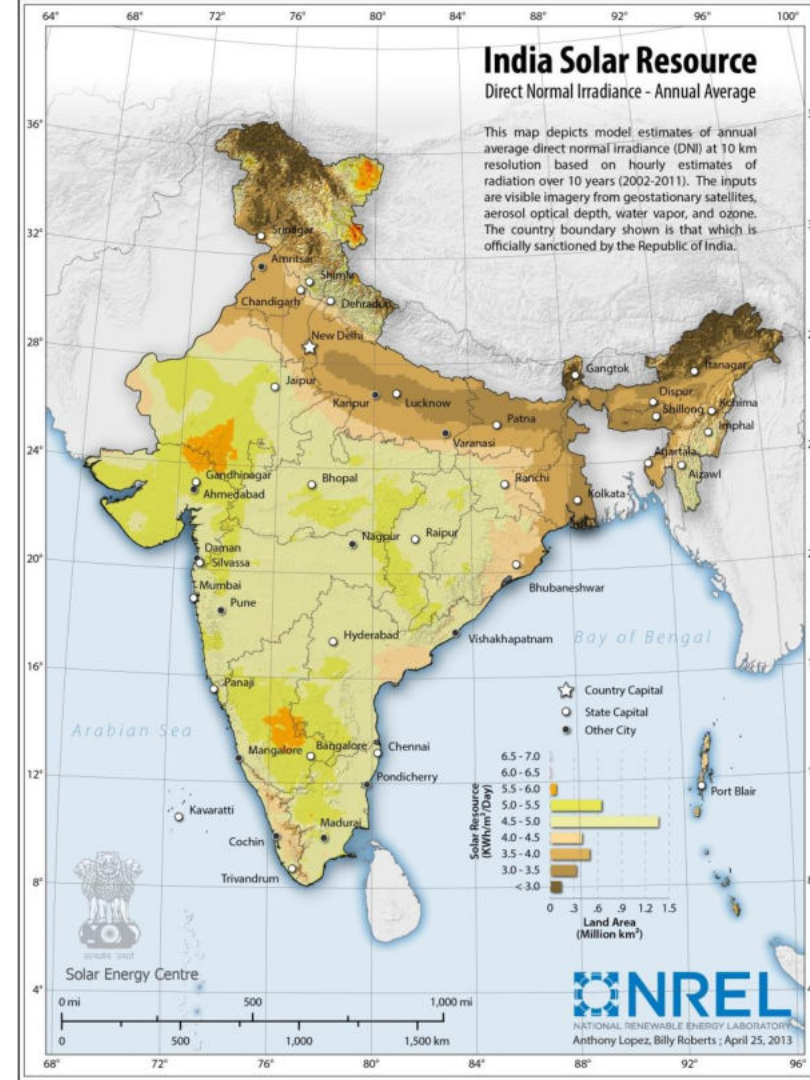
UltraFire S5 3.6V 3W 200 Lumens
Aviation Aluminum Cree Q5 LED Flashlight

[<http://www.aliexpress.com/item/UltraFire-S5-3-6V-4-2V-3W-200-Lumens-Aviation-Aluminum-Cree-Q5-LED-Flashlight-Black/1161504542.html>]



Appendix #3

India Solar energy irradiance (KwH/sq.m/day)



[Source:http://www.nrel.gov/international/ra_india.html]

