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D'source Project

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Case Study Project

Design Thinking & Innovation

Case Study: Usability Studies

Redesigning a Solar Powered Cookstove

Section: C14, Week 14

Design Thinking & Innovation (DT&I)

Section: C14

Week 14

Design Thinking & Innovation (DT&I)

Presented by:
Prof. Ravi Poovaiah
IDC School of Design, IIT Bombay

DT&I Case Study

C13 Case Study Project:

Redesigning a Solar Powered Cookstove

by Rohan Kumar
and Prof. B. K. Chakravarthy

Module C13:

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C14.1

Redesign of Solar Powered Cookstove

Case Study:

Redesign of **Solar Powered Cookstove**

by
Rohan Kumar (MDes student)
and Prof. B.K. Chakravarthy (Mentor)

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Project II

Redesigning a Solar Powered Cookstove.

By Rohan Kumar
Roll No. 196130012, Industrial design,
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Project Guide: Prof. B.K.Chakravarthy,
Shenoy, Innovation Center, IDC School
of design, IIT Bombay.

Content:

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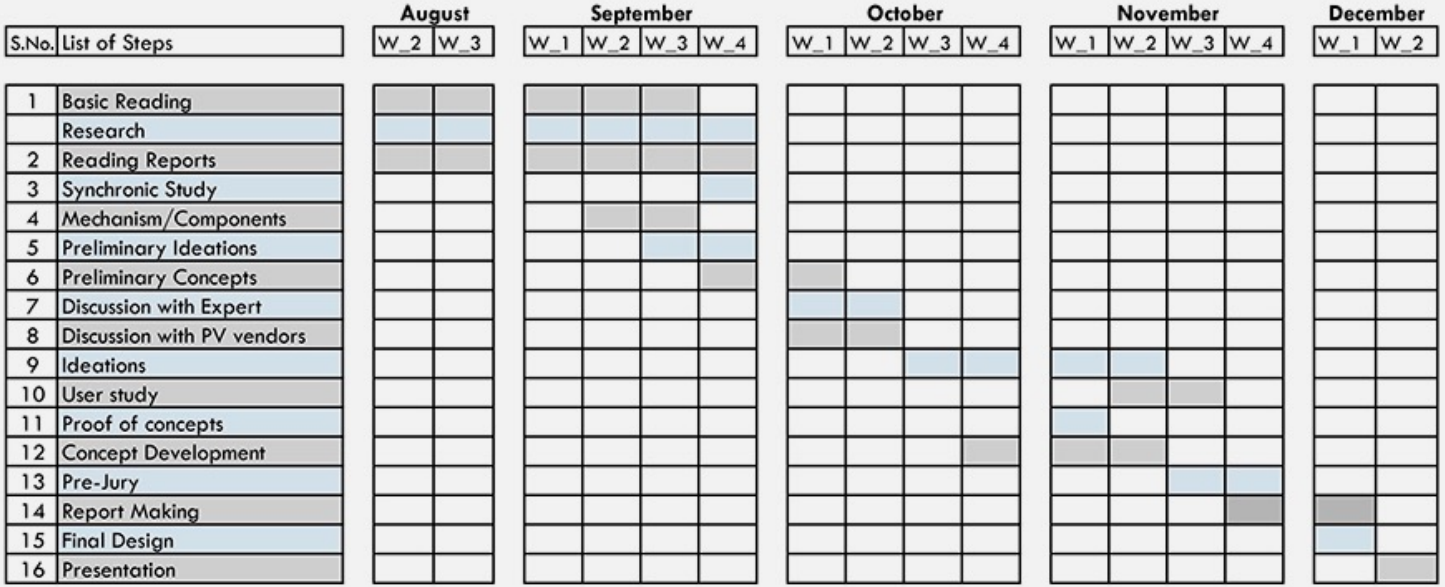
Project Timeline:

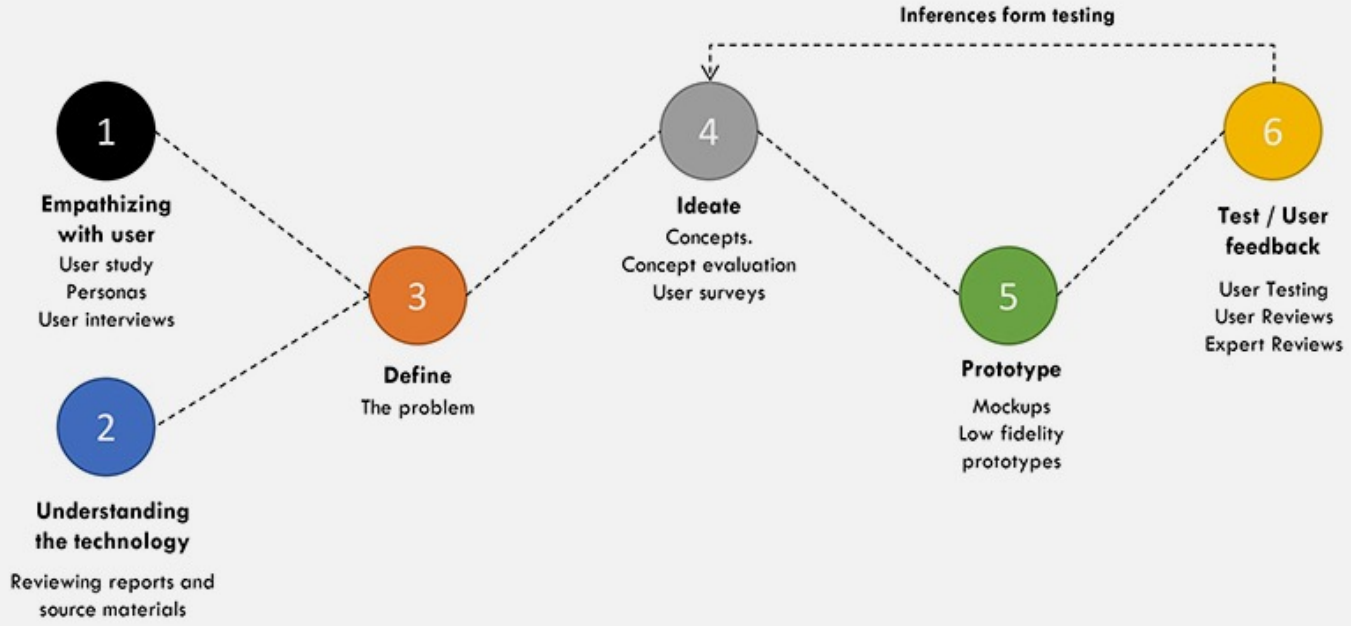
In order to plan and execute the entire project, the following timeline had been planned. Various factors including occasions, tests, holidays etc. were taken into consideration with buffer time for the smooth execution of the project. Below is the table of steps on the left side which are weekly followed. The weeks are denoted as 'W_(no. of the week on the given month)', for example, W_3 in August means the third week of August.



S.No.	List of Steps	August		September				October				November				December	
		W_2	W_3	W_1	W_2	W_3	W_4	W_1	W_2	W_3	W_4	W_1	W_2	W_3	W_4	W_1	W_2
1	Basic Reading																
	Research																
2	Reading Reports																
3	Synchronic Study																
4	Mechanism/Components																
5	Preliminary Ideations																
6	Preliminary Concepts																
7	Discussion with Expert																
8	Discussion with PV vendors																
9	Ideations																
10	User study																
11	Proof of concepts																
12	Concept Development																
13	Pre-Jury																
14	Report Making																
15	Final Design																
16	Presentation																

Methodology

The following diagram shows the approach that has been implemented in this project. The methodology includes literature study which involves understanding the hand pump and its context followed by the field study involving semi structured interviews and observations. Analyzing the data from the studies are done along with ideations in parallel. Concepts are developed and further refined as per the inspirations, studies, expert reviews, jury comments and feedbacks from the users.



Literature Search

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a. Synchronic Analysis

- **Box type solar cookers**

Conventional box-type solar cooker consists of insulated box with the transparent glass cover. Sun light radiations incident on the reflector plate get reflected toward glass cover and energy in the form of radiations gets trapped inside the insulated box cooker by the phenomena of the greenhouse gas effect. Schematic of the conventional solar cooker is shown in figure 4.1. Trapped radiations inside the insulated box increases the temperature of the medium inside the box up-to 100 o C. Heat energy gets transferred to the food material in the utensils placed inside

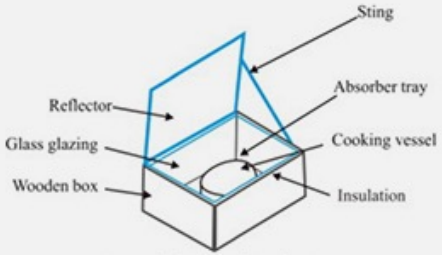

Image 4.1. Box type Solar Cooker

the insulated box. Trapped heat that transferred to the food through the cooking vessel helps in the cooking process.
Although the cooking with conventional box type solar cooker is the clean cooking practice with no recurring cost, but this type of solar cooker has got poor user acceptance due to various cooking constraints such as this solar cookstoves compels to cook outdoor in the open sunlight.

- **Induction type cookers**

Induction Type cookers is performed using direct induction heating of cooking vessels, rather than relying on indirect radiation, convection, or thermal conduction. In an induction cooktop, a coil of copper wire is placed under the cooking vessel and an alternating electric current is passed through it. The resulting oscillating magnetic field wirelessly induces an electrical current in the vessel. This large eddy current flowing through the resistance of the vessel results in resistive heating.

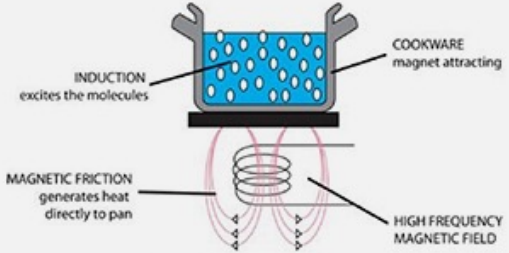

Image 4.2. Induction type Cooker

Although the induction type cookers are most efficient mode of cooking food but because induction coils require AC current, the DC current form the solar Panels would required to be changed to AC current and then stored in batteries for further use, which increases the overall cost of the system.

Literature Search . . .

Hot plate would be the ideal solution for creating this kind of low powered heating solution. The hotplate does not only eliminate the possibility of oxidization of the heating element, the breaking of the heating element but also help to distribute the heat uniformly because of the insulation compound used in hotplates that is a mixture of talc, magnesite and water.[4]

Image 4.9. A typical portable hot plate

Some of the key components which helps in functioning of a hot plate is the Heating element, cast iron top, insulation, and thermostat. [4]

The cast iron top is used because of its property of heat retention. The Thermostat is used to control the temperature of the device i.e., when it is

Image 4.10. Insulation used in hotplates

used in a household 220 v supply, where it can reach up to 250 c. But the purpose for which the hotplate we will be using will not reach to that level and hence is not required.

Image 4.11. Thermostat used in hotplates.

User study

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a. Preliminary User survey

A preliminary user survey was conducted to understand the acceptance rate of PV cooking. A selective sampling was done where a total of five people with different occupation were taken and asked whether they prefer PV over other modes of cooking.

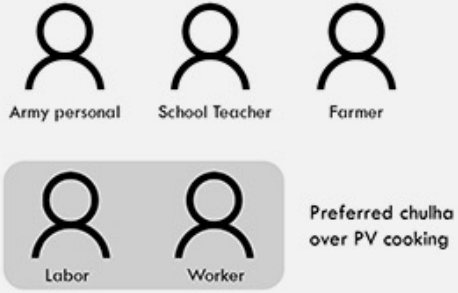

Image 5.1.User survey with selective sampling.

Out of 5 people, 3 people were in favor of solar PV cooking. The users who were of low-income group preferred a traditional Chula over PV cooking.

This analysis showed that the choice of the end-user about cooking methodology depends upon awareness, economic condition, the traditional habit of cooking, and the ease of cooking.

The users who would benefit it the most were the people form rural areas as since, the inception of PMUY, 94.3 % Indian population had access to LPG gas but only a fraction of PMUY users could avail for the refill because of economic factors. A low-cost solar PV cooker would help the users in rural areas but because of limitations on travelling and resources the study was restricted to urban areas.

The primary users were in between middle class and upper middle class residing in urban households. Based on the primary research and secondary research. User personas were created to understand the users better.

b. User personas

Based on the interviews and observations following user personas were developed.

Busy Bhupinder, 45yrs old

" I am always busy some work and I hate it when the cylinder runs out while I am cooking, I always forget to order the cylinder on time ! "

Frustrations

- I hate when my distraction causes me to have failed dinner attempt.
- Environment should be preserved , I already have some solar cookers in my house, but they takes too much effort.
- I seriously don't have time to order a new cylinder every month.

User study . . .

Needs

- Something which can reduce the number of times I have to order a cylinder.
- Something which is little forgiving when I have to cook and do the work.
- Something which doesn't need me to buy a special utensil, I have a lot of utensils already.

Lathargic Lata, 35 yrs old

" As much as I love cooking, I hate it when I have to change cylinders every few weeks. I want to save some money, I wish there was a cheaper alternative. I could really use some extra cash. "

Frustrations

- Lives in a residential flat on the fourth floor, usually required assistance with the cylinder more so than often.
- Doesn't like to change the cylinders every two weeks.
- Doesn't have a gas pipeline installed in locality.

Needs

- It cost around 10,000 every year that I can put to some other use.
- I would like to same some cash.
- An alternative source of cooking.
- Something which is economically viable.
- something which doesn't need me to buy a special utensil

Woke Wadhavi, 27 yrs old

" I belong to a middle class family but I am very woke about the environment. Climate change is a big issue and transitioning to using free energy might help to solve this issue tremendously. "

Frustrations

- Most of solar cookers forces me to be out in the sun.
- If any renewable energy is used there's some technology which must be used with a special utensil.
- Most of the induction i.e. Solar powered stoves, requires a lot of initial capital to invest in.

Needs

- Something good for the environment.
- Something which lets me the part of change.
- A stove which is also functional.
- A stove that isn't like a solar stove that forces to me to be in the sun.
- Something which is economically viable.

Next Step :

Based on personas created , Three different concept paths were devised .

Preliminary Ideations 1

a. Concept Ideation one.

Since 94.3% Indian population have LPG stoves in their houses, we can use the existing eco system to reduce the cost of further developments. A modified burner cap that can be fitted on the existing LPG stove, which can provide LPG + Solar energy at the same time.

The resistive heating element will be embedded in the pan and powered by a female connector at the base. The modified burner cap will have a male connector which will be connected to the pan to provide heat produced by the solar panels.

Double vaulted air-column for maximum thermal efficiency. A lid would be required to further contain the heat inside the pot. Different variation of the pot can be produced that include saucepans, sauté pans and further down the line.

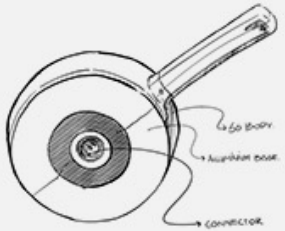

Image 6.1. Connection as Electric kettles

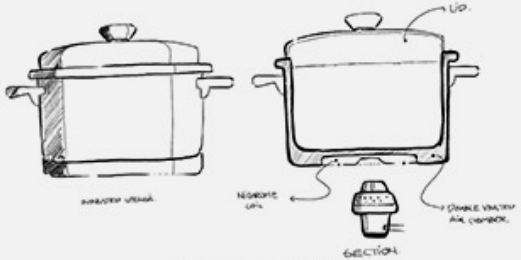

Image 6.2. Special Utnesils needed

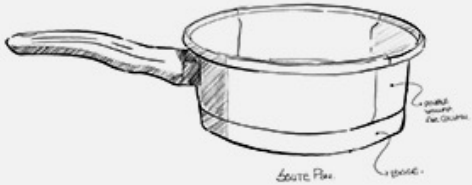

Image 6.3. Different types of pan

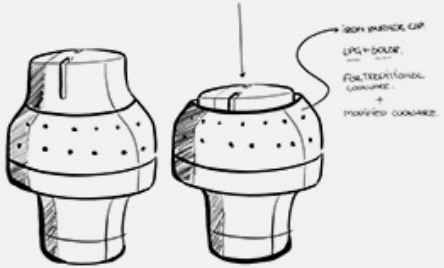

Image 6.4 . Ideations for a retractale option

Image 6.5. 3d printed concept

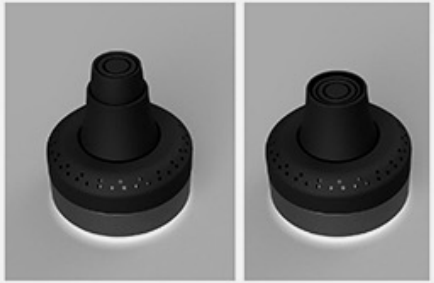

Image 6.6. Rendered concept

Preliminary Ideations 2

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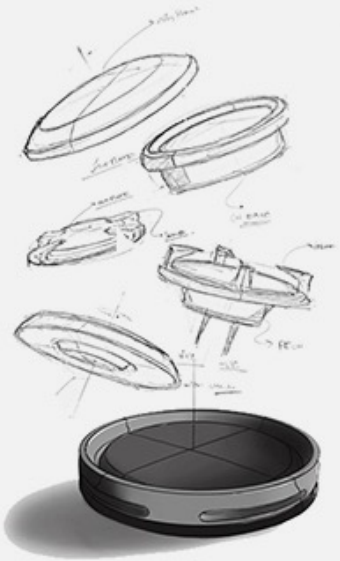
b. Concept Ideation two.

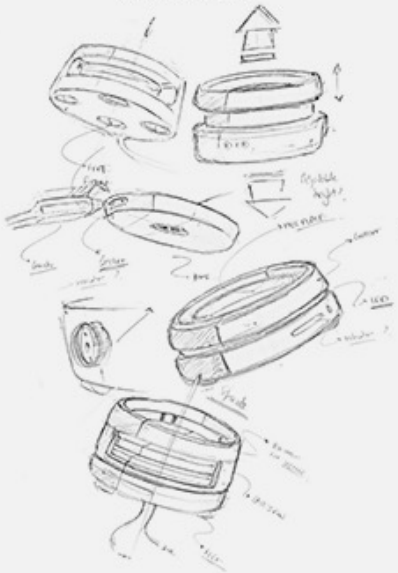
Using the same idea as before i.e. To modify the burner cap but this time using resistive elements like nichrome to create a hot plate for all the conventional utensils.

Hotplate because this kind of device can be used as an addon without changing the stove itself and can be used according to the users demands and will. i.e., The device can be placed aside when all the burners are to be used but can be kept on the burner when all the LPG burners aren't being used.

Double walled with external control knob.



Double walled with Adjustable height



Double walled with inbuilt controls

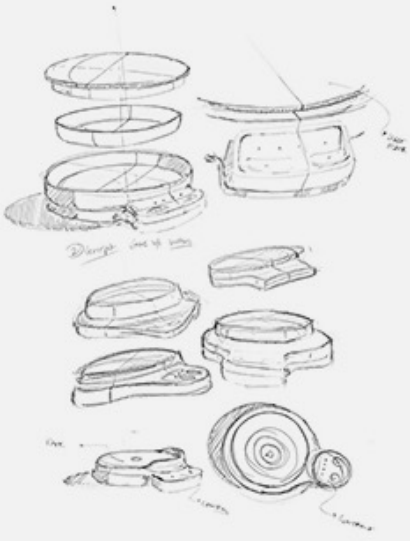
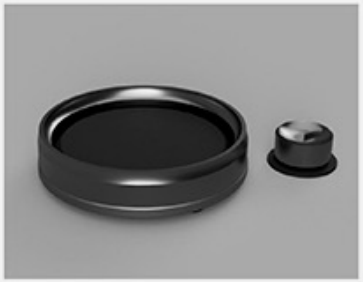


Image 6.8. 3D concept render with pot on top

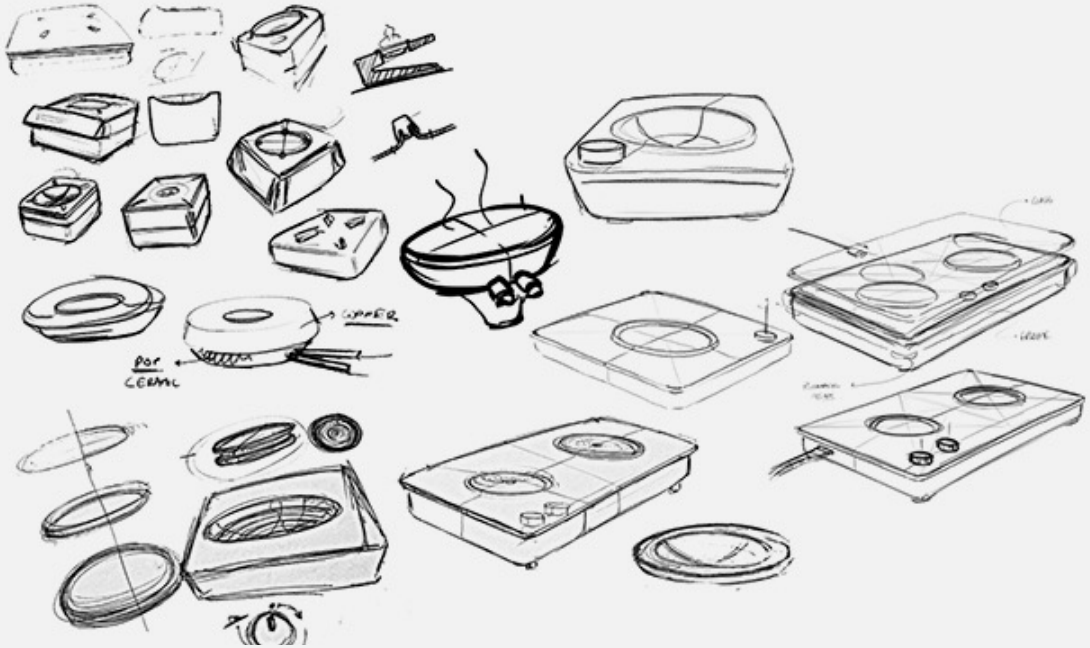


Preliminary Ideations 3

c. Concept Ideation three.

If the solar panel with 1KV are used the above design would not be required as 1kv of power is sufficient for all cooking purposes- frying, chapati making, boiling etc.

This concept was developed as entirely a separate product. Which will not be a part of the existing eco system. It would function like a separate stove on the side of existing stove. The pot would be submerged inside the cavity to gather heat from all the sides of the utensil.



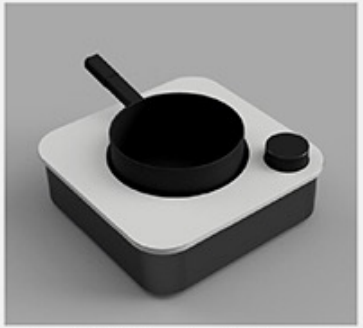
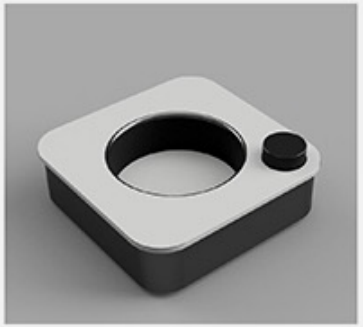


Image 6.11. 3D Concept render with pot on top



Concept Evaluation

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For Evaluation, I created a pros and cons list. The benefit of creating the pros and cons list was to make the users understand the difference between the concepts which would help them to ultimately rate the best concept out of all.

So, a user survey was conducted where I expressed their points to the user and asked them to choose the best one out of the three ideations.

1

- Only one type of utensil can be used. ✗
- Works with the existing eco-system. ✓
- Extra counter space not required. ✓
- Extra storage space not required. ✓

2

- All utensils can be used. ✓
- Works with the existing eco-system. ✓
- Extra counter space not required when a burner needs to be used. ✗
- Extra storage space not required. ✓

3

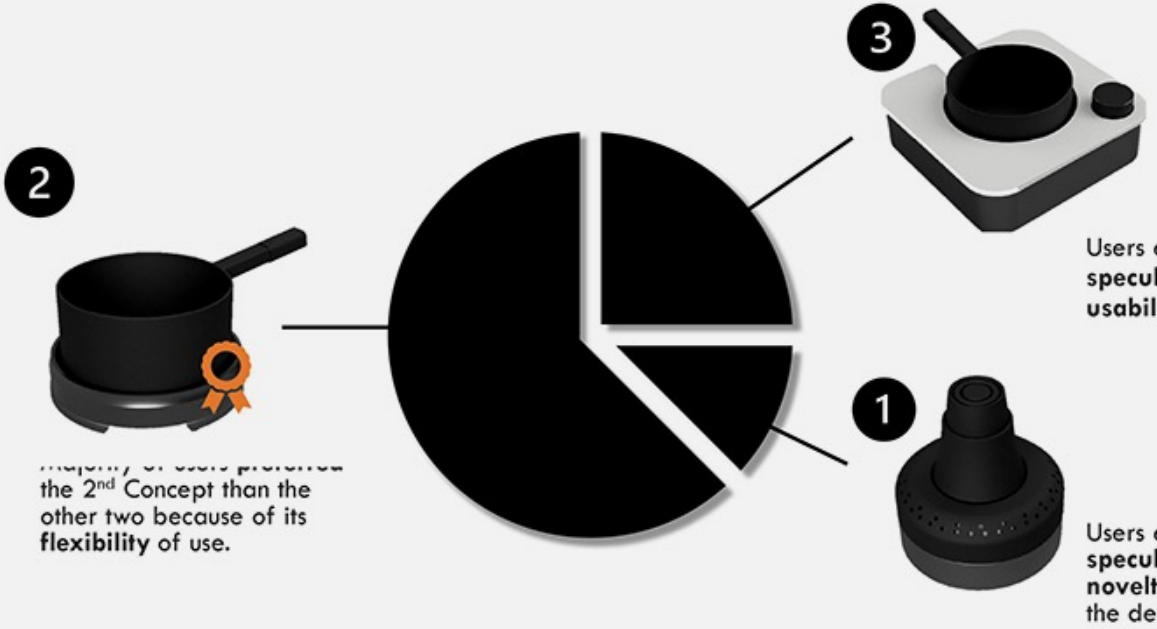
- Limited utensils can be used. ✗
- Doesn't work with the existing eco-system. ✗
- Extra counter space required. ✗
- Extra storage space required. ✗

Concept Evaluation . . .

THINK! DESIGN

So a user survey was conducted where i expressed there points to the user and asked them to choose the best one out of the the three ide-ations.

The data was gathered form a total of 48 users caliming to be of middle class households residing in urban areas. As you can see, the majority of the users prefered the second concept because of ots usability and poossibly familiarity to the existing idea of hot plates.
The first concept was chosen the least because of it novalty and usability contraints.



Proof of Concept:

A Working prototype was constructed to understand the usability aspects and functioning. Once the technical aspect was taken care off, the next step in the process was to do a kitchen study.
The idea behind why the walls on the side might be needed is that without the walls the heat escapes from the sides. But when the walls are there, it traps the heat and, allows the utensils with round bottoms to be placed on the top.

A rig was created using coils in parallel and by using a voltage regulator that turns the voltage down from 220v to 47v, to mimic the effect that the solar panels would have caused.

It worked on the same idea that making the walls around the heat source would trap the heat and allow better thermal performance.

it was based on the works done in the master's report.

Product Development - Grip:

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c. Grip

The minimum space between the bottom surface and the handle needs to ergonomically correct. Handle size needs to be such that it can be accessed when a utensil is placed on the top. Handle placement was decided to be at the conventional space as the controls were decided to be put according to the burner configuration.

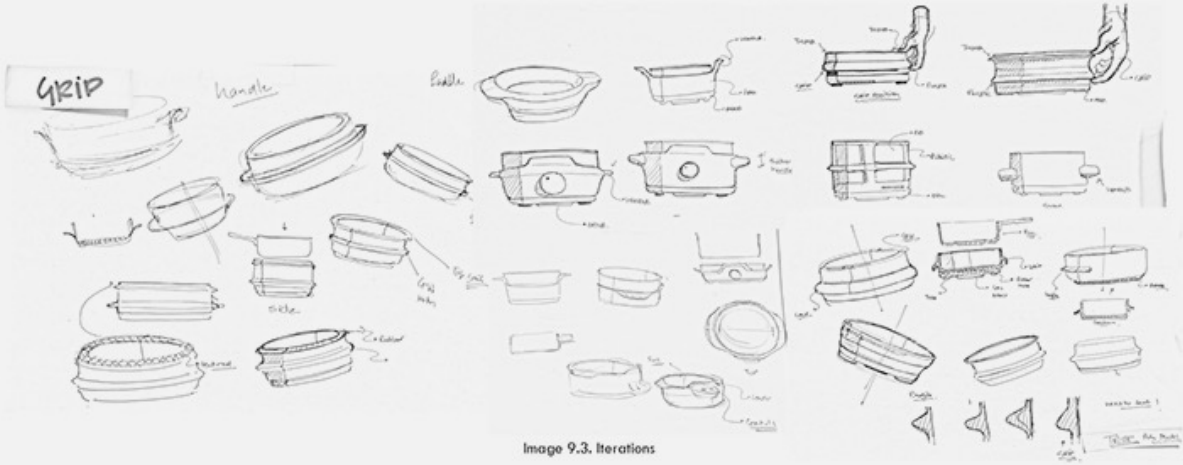

Image 9.3. Iterations

Product Development - Controls:

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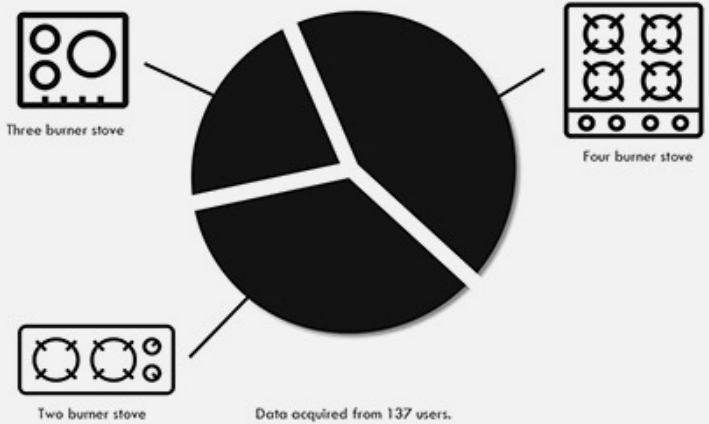
The next step was to understand where the controls must be to achieve the best factor of safety. Whether it should be on top, or sides or front. for that a user survey was conducted, asking the users claiming to be of middle-class families to determine what kind of stoves they had in their homes. A total of 123 users participated in the survey.

So from analyzing the responses from the survey, it can be seen that majority of the users had a four stove burner in their houses. which implied that the controls must be kept on the side and not in the front of the device.

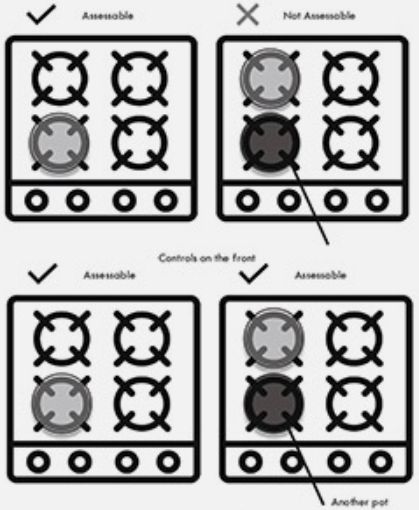


Based on the data controls were decided to be put on the sides as it allowed

Easy access to the controls when put on a four-stove burner.

Putting the controls on the front will not be ideal as it would not be reachable if placed on the back burners.

Handle placement was decided to be at the conventional space as the controls were decided to be put according to the burner configuration.



Product Development – Preliminary Concept:

g. Preliminary Concept

So, a CAD model was made with all the ideas and solutions combined. Like the overflow channel, Visual feedback LEDs, the controls on the side I also 3D printed a low-fidelity prototype, to see where i lack in terms of usability, dimensions, etc.

But more importantly to help user understand the product better. So, with the help of CAD and printed model, I got some interesting feedback form the users.

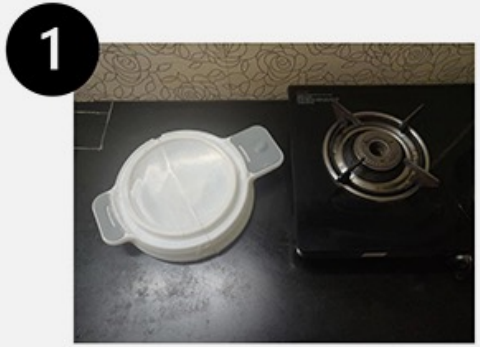
Image 9.9. CAD Model for wholistic concept

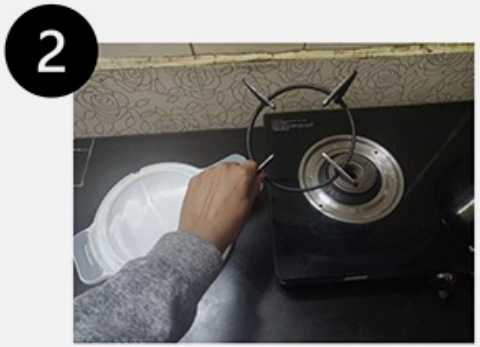
Final Proposal:

Final Proposal . . .

- The top of the device would be made from punched stainless steel and the bottom an injection molded part.
- It is easy to clean because of the concave surface and doesn't make you think the food should be cooked on the surface.
- Soft touch material will be used as they are hydrophobic in nature they would not allow any spill overs to stay on top.
- The bottom would be again be of stainless steel to avoid any accidental burning and melting.
- The legs are required as if there is any fire burning it would be visible.

User Feedback:





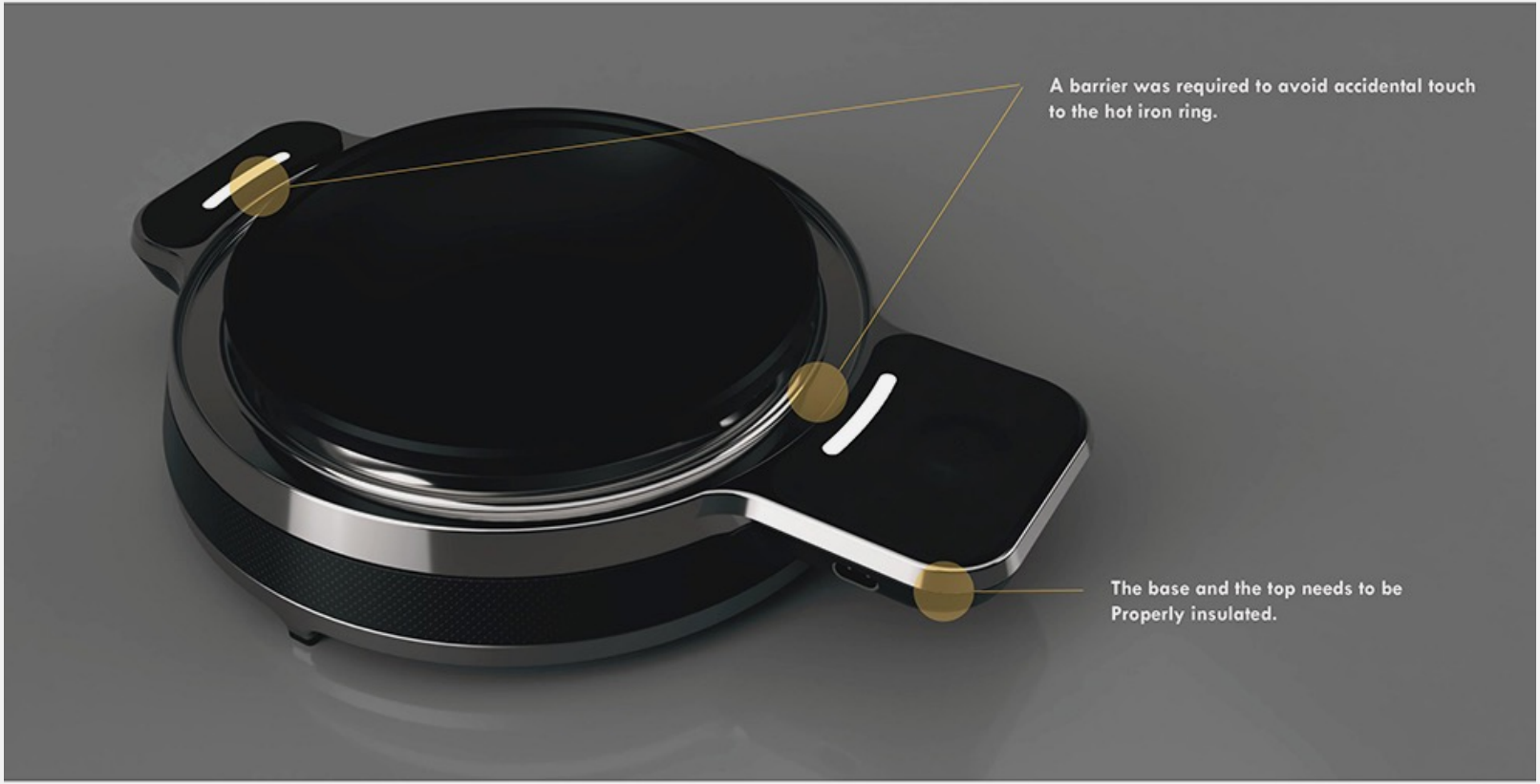
A medium fidelity 3D printed prototype was made to understand the usability flaws in the final design.

To avoid accidental burning of the stove,

The existing gas burner caps and the iron stand are needed to be removed before operating the electric stove. (when using it on the LPG stove.)

The images shows the process of ow the stove will be kept on the LPG stove. When using it on the LPG stove. The exisiting gas burner caps and the iron stand are needed to be removed before opreating the electric stove.

User Feedback . . .

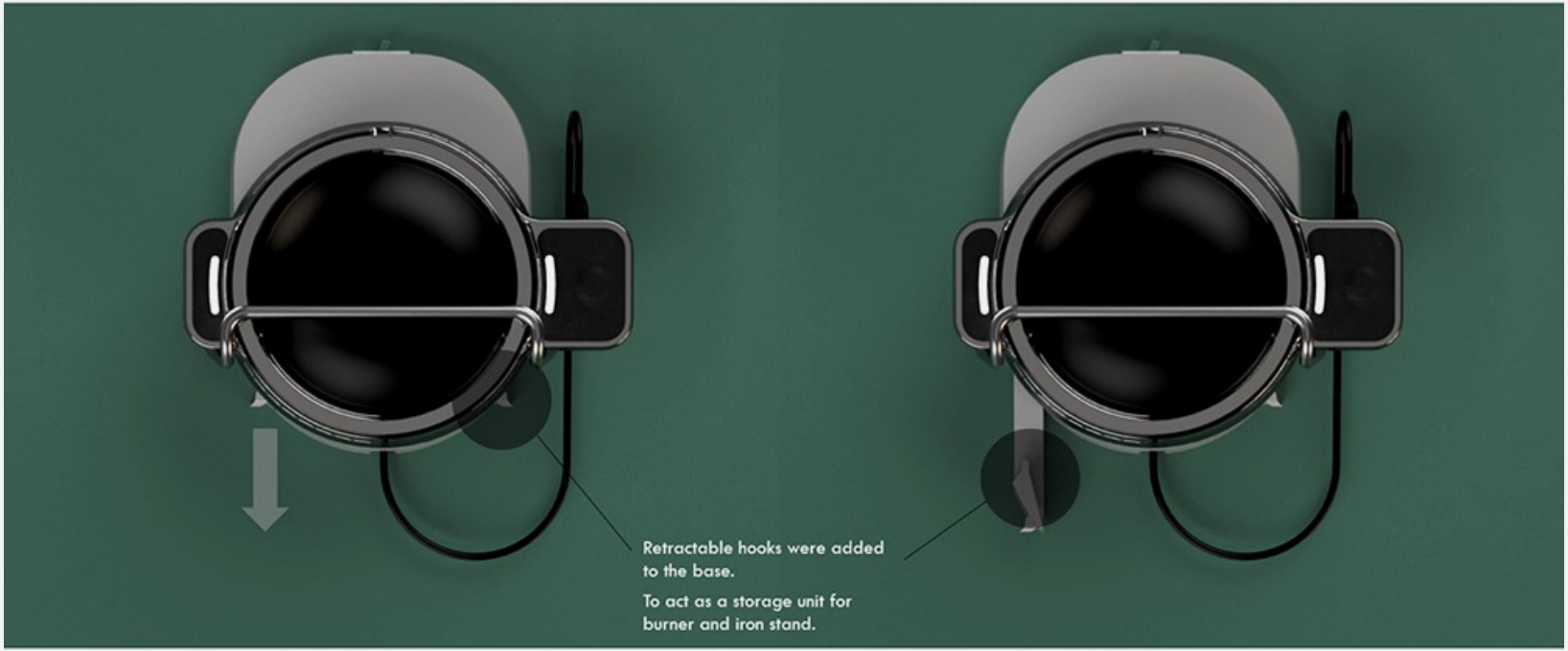


Changes:

Since, there's an activity of removing the burner stand and the burner cap, there was a requirenment of a space to store the two objects.

The users expressed that there must be a place required to put the burners once there are not in use.

So, a retractable hook was added to the base where the burner and stand can be hanged.



Changes . . . .

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During the product development phase, I realised that the exisitng geometry was very complex in terms of manufacturing and required to be made much simpler.

So a simple geometery was developed for the same stove.

Protector fins or the barrier were added to avoid accidental touches to the iron ring.

Handles were seperated from the main body and will be injection moulded, the body would be stainless steel punched and will be joined via nut.

Changes . . . .

Exploded view :

Changes . . .

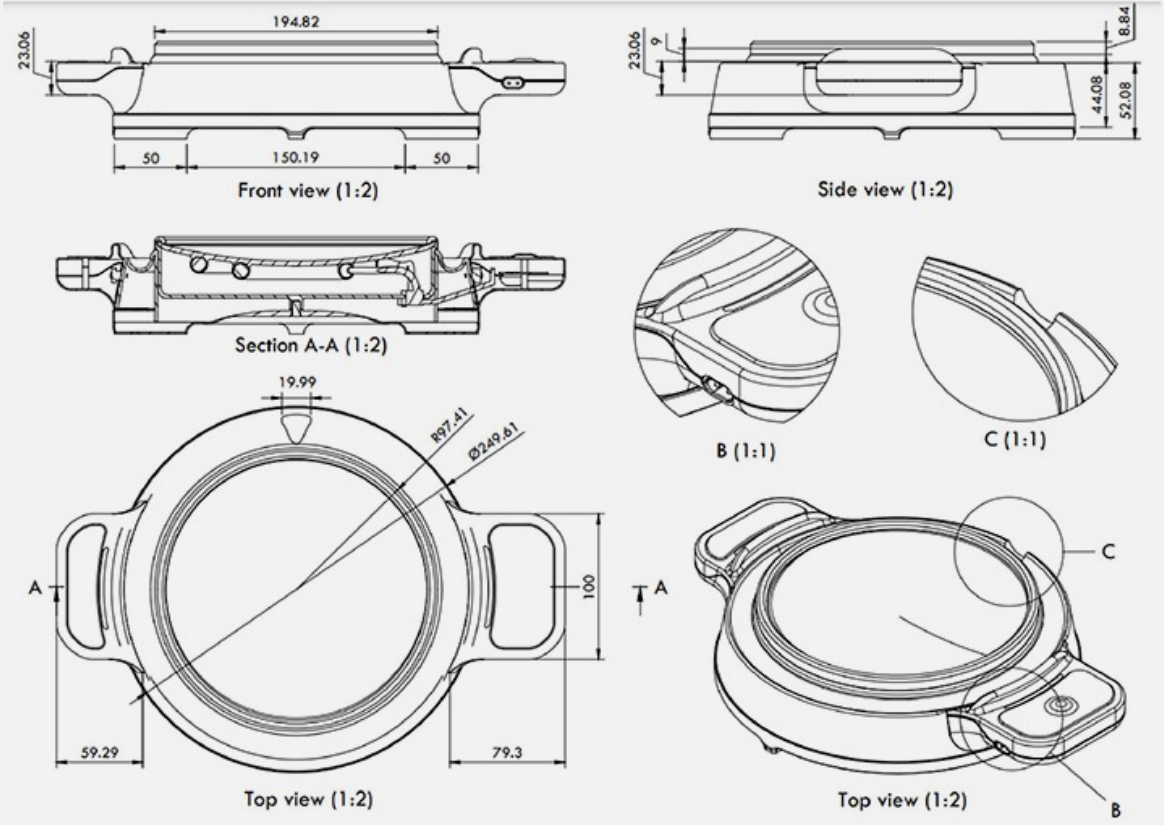
As a precaution againt accidental burning and leaking of LPG gas, there needs to be a way to stop the leakage manually.

In this case, it was possible to avoid accidental burning by removing the burner cap. But it wasn't possible to manually stop the flow of LPG from the gas.

So, a visual reminder was added as an injection moulded part which can be slipped on or off to the knob on the stove.

The color of the reminder part will be of light color to create contrast and act as a reminder to check the knob is on or off.

Drawings:


194.82
23.06
50
150.19
50
Front view (1:2)
23.06
9
8.84
44.08
52.08
Side view (1:2)
9.13
7.93
11
Section A-A (1:2)
B (1:1)
C (1:1)
R43.96
R31.44
CAUTION
R7.07
30
19.99
R97.41
Ø249.61
A
100
59.29
79.3
Top view (1:2)
A
C
B
Top view (1:2)
CAUTION

Conclusion:

The proposed solar PV based cooker can **provide a consumer-friendly indoor cooking alternative over box type of solar cooker.**
Direct solar photovoltaic cookstoves have the potential to provide low-cost alter- natives to LPG based cookstoves and also to the induction-based solar photovoltaic cookstove.

Using the proposed solar cookstove as an add-on device with the exist- ing LPG stoves, the overall LPG consumption can be also minimized.
So, it is more likely that proposed solar PV based cooking solutions will get more end-user penetration than that of the box type of solar cooker.

References:

[1] [https://www.energyinfrapost.com/indias-ujjwala-scheme-provided-lpg-access-but-failed-to-promote-its-use-study

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[3] Masters's Project report by Prasad Kulkarni

[4] https://www.youtube.com/watch?v=s9CXk-ZFrYI

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Thanks for Listening

DT&I Case Study

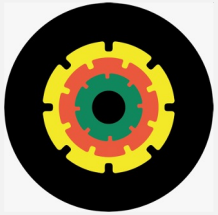
Section: C14

Week 14

DT&I Course – Week 14:

DT&I Process
(20%)

> **Usability Studies, Feedback and Iterations**
> Make use of user feedback and iterate
> Methods of getting User Feedback
> Finalise Design



DT&I Tools
(20%)

Usability Studies
> Observation
> Conversations
> Think-aloud protocol
> Usability Testing
> Iterate
> Finalise Design

DT&I Project
(50%)

Apply
> Usability Studies
> Iterate and Finalise

DT&I Cast Study
(10%)

> Case Study Project: **Redesigning a Solar Powered Cookstove**

THINK!
DESIGN

Supporting Organizations:

D’source

D’source Project

Open Design School

MoE’s Innovation Cell

THINK!
DESIGN

D'source Project

Open Design School

MoE's Innovation Cell

Credits:

Redesign of Solar Powered Cooker:
by Rohan Kumar, MDes student

Mentor for Case Study:
Prof. B.K. Chakravarthy
IDC School of Design, IIT Bombay

Credits:

Presented by:

Prof. Ravi Poovaiah

D'source Project

Open Design School

MoE's Innovation Cell

Credits:

Camera & Editing:
Santosh Sonawane

D'source Project

Open Design School

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Credits:

Think Design Animation:
Rajiv Sarkar

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Credits:

End Title Music:
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