

Design, Technology and Innovation
Prof. Chetan Solanki and Prof Jayendran V
IDC School of Design
Indian Institute Technology Delhi

Lecture-5
Challenges of Reaching a Million Users Part 1

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What also we are doing at IIT Bombay is, I am heading what is called NCPRE which people visited National Centre for Photovoltaic Research in Education where we are really kind of researching on the very fundamental aspects of the materials,

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NCPRE researcher loading wafers into the Diffusion Furnace

solar cell design, fabrication of solar cells, modules, reliability of modules, power electronics, whatever under the sun that you need to know, from right from the material till the integration with the generation of power integrate, everything we are doing it. But as I said, what I am not going to talk to you is about technology. Lot of us actually develop a, really wonderful technologies but not every technology reaches the people.

And therefore this experience that I am going to share with you, with my colleague Mr. *Chandran*, we have been working on this project together for many years now, is an example of how that can be done. So, the solar project is called Solar Urja Lamp project, you know, SoUL, and it is really touching to the souls of millions, millions of students. So, Solar Urja lamp is actually the lamp for study purpose.

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But before that let me give the background that there are 17 sustainable development goals, you might be aware about it. One of the goals, that is goal number 7 is a very important goal. What it says is, ‘ensure access to affordable, reliable, sustainable and modern energy for all’. It is about energy but it touches every other sustainable development goal whether it is about the Poverty, whether it is about Literacy, GDP, Income Empowerment, or even Climate Change, everything as a relationship with this goal number 7.

So, basically I wanted to tell you in 2017, what is the status of the world, you know. 1 billion people still did not have access to electricity. 1 billion is almost 13-14% of the world population.

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2.8 billion People did not have access to clean cooking, 40% of the world population.

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So they would be using biomass, cow dung, wood, coal kind of, you know. Can you imagine this scenario? That we are in the modern, the most modern world and we have all kinds of technologies reaching to the moon and Mars and what not? But about 40% of the people in the world still do have access to clean cooking. The worst problem is, use of energy is also affecting the climate change. So whatever action that we do using energy it is affecting the climate change.

And we need energy because energy drives our growth but on the other hand energy is also resulting in the climate change. So these are the two opposite ends of the problem.

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India is young: needs more energy

- Population (2011) = 1189 million

- 0-14 years: 29.75%
- 0-35 years: 64.9%
- > 65 years: 5.5%

- India needs more energy supply

- Population growth
- Economic growth

Also for Indian perspective particularly, but it is actually not only India's perspective, many countries are passing through this phases that they are, most of the population is very young. Almost 30% people in India are very young. We need a lot of energy. There is a population growth that requests energy. There is GDP growth that requires more and more energy. And India also imports a lot of energy from outside by the way. We are one of the biggest importers of coal, we import oil, we import gas, we import, you know, nuclear fuel, all kinds of things.

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India is young: needs more energy

- Electricity current status

- Total electricity 1240 billion units (2016-17):
1000 units per capita

- Future Requirements

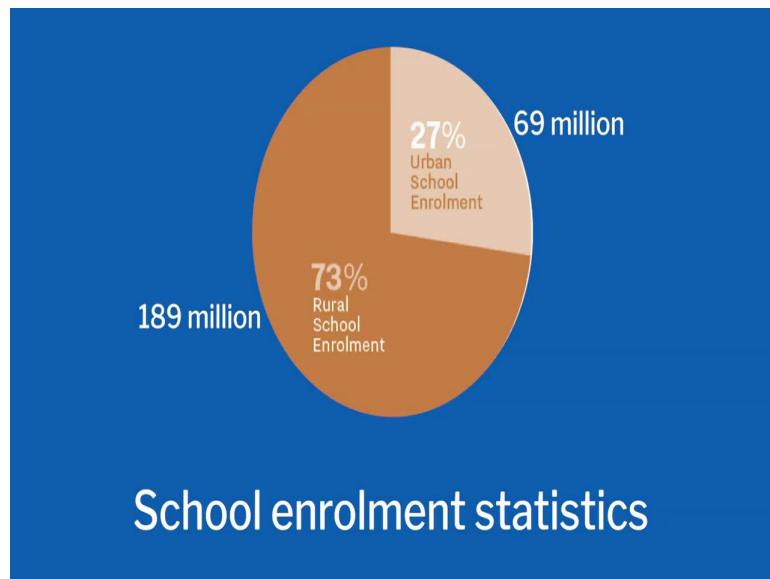
- For reasonable HDI, 3500 units per capita required:
India needs 800,000 MW plant capacity

The current per unit capita electricity consumption is almost about 1000 units. And if we go by the average of the world that is about 3500 units, you need 800 thousand megawatt of power plant capacity in India. Right now we are about 350 thousand units. So, again huge capacity addition is

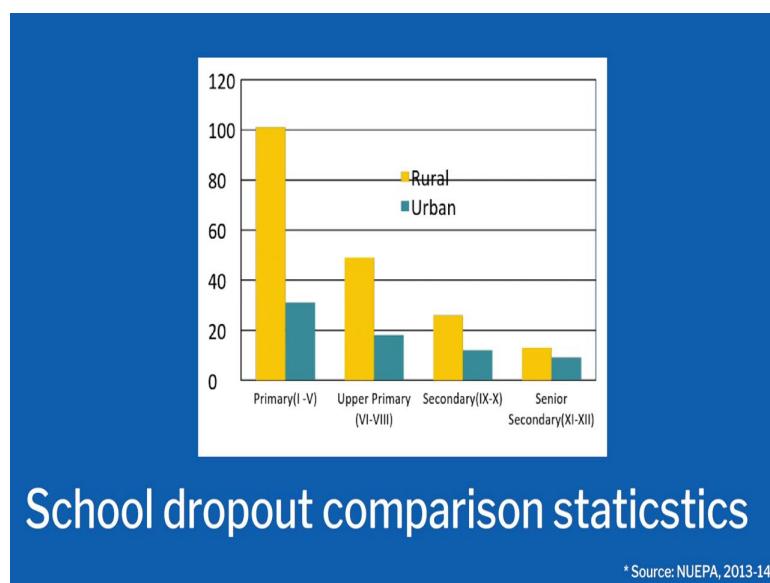
required. Why I am putting this context because you should understand that this path if we continue to walk on this path, you know, it is not really going to give sustainable solution.

Why this lamp which I am going to talk about is very important because education is very enabler, great enabler in every country.

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And in India, particularly, a lot of students in a rural area is almost more than 70%. And if you look at the number of enrollment of the students in an urban area and in a rural area, you will find that the dropout rates, i mean the curve is much steeper.



* Source: NUEPA, 2013-14

The yellow one is much deeper for the students in the rural area as compared to urban area. Now, there can be many reasons for that you know. Access to the school itself, the teacher, the quality, everything, but one of the reasons that is important, that plays a role here is availability of electricity. Until and unless there is a reliable, electricity solutions are available to them it does not work, the continuity of education is not there.

So as a result of that, many countries around the world, what people do is provide them solar lamp. Why because solar lamps are very simple, standalone devices. You can buy it in supply it and you can supply it in a very quickly.

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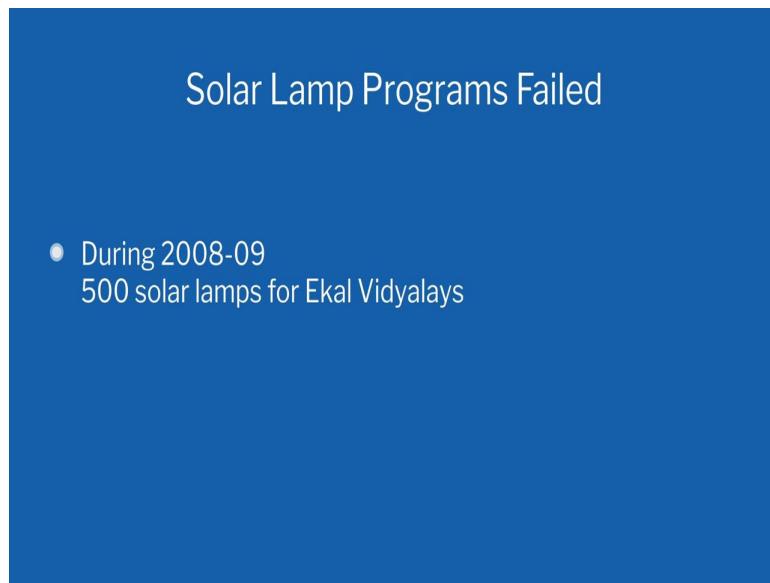
If somebody really wants to provide a basic light, it can be done using solar lamp. And everybody has been doing it, right? In India? or why India everywhere in the world. So, if you look at the first kind of solar lamp came in India in 1976. So, it is almost more than four decades that such a programs have been happening but it is not very successful. And that is where the innovation that we are done, in terms of the technology, in terms of the operations, in terms of the materials, in terms of the supply chain. Everything is very important. That is what I am going to share with you. Before that let me show a small video to put the whole thing in a context.

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Could you notice, what is the solution? Solution is of course a solar lamp, but the way we provide the solar lamp is very important. And as I mentioned that what we do is we involve local communities to do each and everything. But how we have come to this idea. I would like to share two kinds of project which did not work very well.

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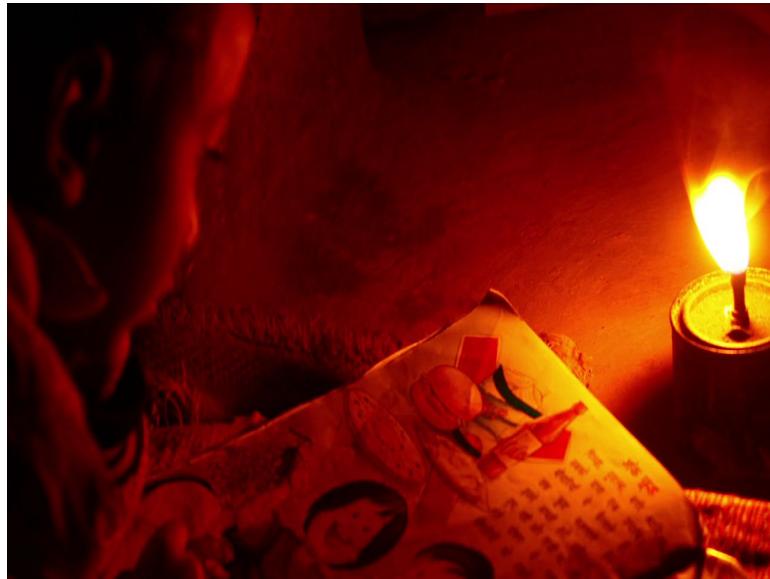
One of the projects which we started in 2008 and 09, Ekal Vidyalaya is like a one school teacher and these are the very informal schools, run in a very remote rural areas where children go to the field in the daytime and they could not access the regular school. So they actually go to the schools in the evening. When I went first time to this village in middle of somewhere, you know, we stopped and I said probably we lost the road. They said no sir.

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The place where you are standing is actually the road. So, we could not even figure out the ways to reaching to this village and there are many villages like that.

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I found what people used to do is study like this in kerosene lamp, and so this Ekal Vidyalay's what will people do, they will take a kerosene lamp, they will walk to the school. The school is very informal as I said.

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It is in somebody's house they gather together and study in the kerosene.

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So what we have done is, we have provided them a solar lamp. Now at that time this lamp is as you can see here is about a 5 watt CFL based lamp and around 20 people 25 people would sit.

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And we got a sponsorship at that time when we provided solar lamps to nearly 500 villages. This went to many places in UP, in Madhya Pradesh, even this photo I think belongs to Tamilnadu somewhere.

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So, there are like, it was very nicely distributed and as every other solar program there is a lot of fun fair that, you know, project implemented, 500 villages, so many students are using this. One of the problem of this kind of approach was that the light was not reaching everywhere.

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So we did a small experimentation. Why don't we put it, you know, above the ground? Then as soon as we put above the ground then you will have the shading problem that the base will actually shade the light everywhere else.

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So then we said why don't we hang it upside down. So what I have done is, I have separated the base of the lamp. This is a very old photograph. Somehow I got access, and then we connected another wire in the light was hang on the top so that way the distribution was fine. Well these were some of the experiments we did but within 5 month, 6 months, 7 months the lamp stopped functioning. Sometimes, the battery will not be charged, the fuse will not be working.

Or even if some people, you know, tell us that even my lamp is not working, we couldn't do anything, because there is no way we could reach out to so many different places.

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At the same time, I did another project as I said, with the TERI that a, Light a Billion Lives project where the whole model was a little different what, in this model was that you actually create a central charging station, charge all your lights at one place. The user will actually pay the rent for using it. So the user will come to the centre, take the lamp in the evening the charged lamp, use it overnight and then bring it back in the morning so that it can be charged again.

So, I did three villages with this kind of model, you know, in my village, and the neighbouring villages. But the, after 5-6 month, one year it was the same, the lamps stopped working. Nobody will come to repair it, lamps were also expensive, so people could not afford it.

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So, in 2012, so one of the problems that I identified is this mechanism of 'Buy and Sell'. What everyone will do? State government, Central Government, NGOs, for those who were running the program, they would buy and sell, as a result the core product will become expensive. Why? Because somebody will make it, somebody will buy it, then it will be transported. Second problem I figured out is that there is no technical support.

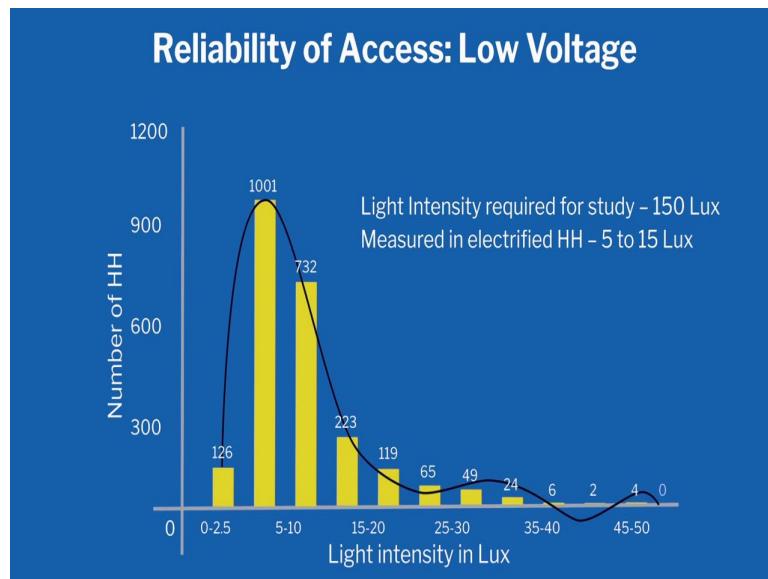
So many times a lamp is a very simple device and the problems that were with the lamp were very simple. Sometimes the fuse in the lamp will not be working so you need to change the fuse. Sometimes the soldering point will, you know, get off so you need to solder it again. Sometimes the, the battery will not be a properly charged, so it is a very simple thing. But as a result of this the product will actually fail prematurely. They will not work throughout their life.

And that is the case not only with the solar lamp but all kinds of solar products. It is the same story. The third problem is every time because you are buying and selling the continuity is not there. So if somebody is, you know, buying and providing 500 lamps, if somebody wants to buy one more lamp, (say) 501, it is not available. Right? As a result of that, the Solar solution never becomes continuous. Availability is not there.

So you understood? Everyone? So this is a basic problem. Not only this technology, I believe with every technology. Your mobile phones are working everywhere because you find some guy who

can actually give recharge of 10 rupees also. You can find someone who can actually repair phones in every corner. So, similar thing was required. And not only required, then we also found that even if there is electricity connection in the houses of people still solar lamp is required, because when we talking about study purpose, for studying you need about 150 Lux of light.

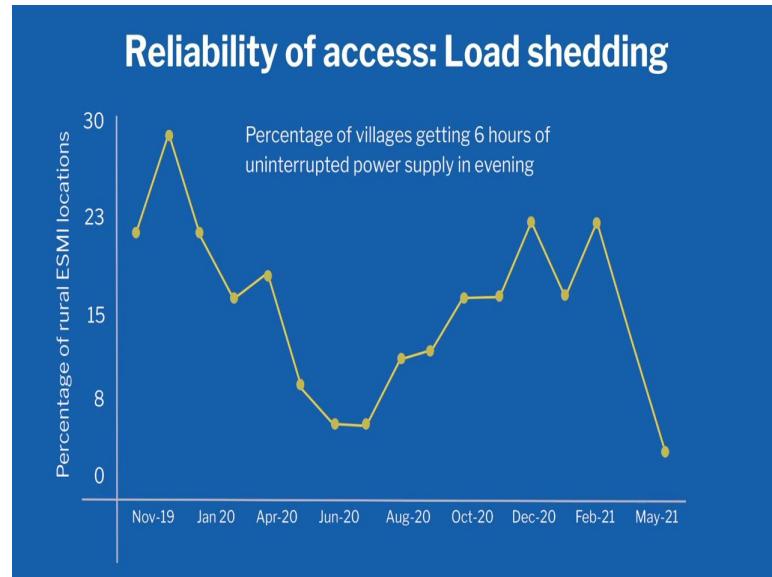
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Lux as a unit of light, you measure how much lux is there, say for example, on your table you will have something about 150 lux of it. That is the kind of intensity that we need. We measure this in various houses, almost more than 2000 houses we measured this in various states, like, you know, Punjab, Haryana, UP, Rajasthan, Maharashtra, and Madhya Pradesh. What we found among 2000 households is that the majority of them will have the light level very, very low.

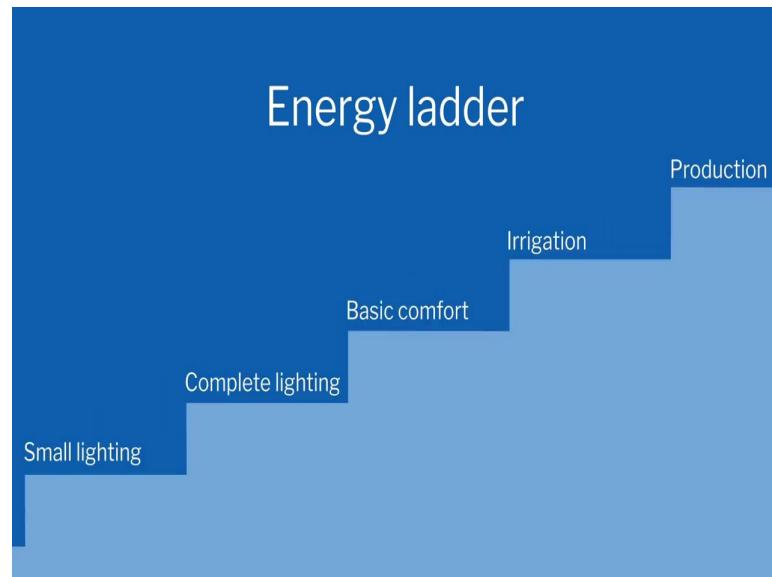
What is this tell you that even if there is electricity there is not sufficient light on the, on the book and in villages there is no table chair, right? So the distance between the light and the floor will be higher. The light will be typically hanged in between the door of the two rooms. So therefore it will be distributed to wider areas.

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And another problem even if there is electricity connection, the supply is not continuous. So, there is fluctuation in voltage, fluctuation in the availability of the power voltage. There is a power cuts. All those kinds of things will be happening. So together, first of all, when there is no electricity we need a solution. Even if there is a full episode 24 by 7 we need a solution and even if there is partial electricity, we need a solution.

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So people need electricity or energy for basic purpose lighting, ones, you know, basic lighting like torch in the flashlight that you use, ones that is completed people would like to illuminate every room, every house, ones that is there you like to have a fan, you would like to have refrigerator, TV then you would like to of course irrigate the farms and then finally if more energy is available you will use it for the production purpose.

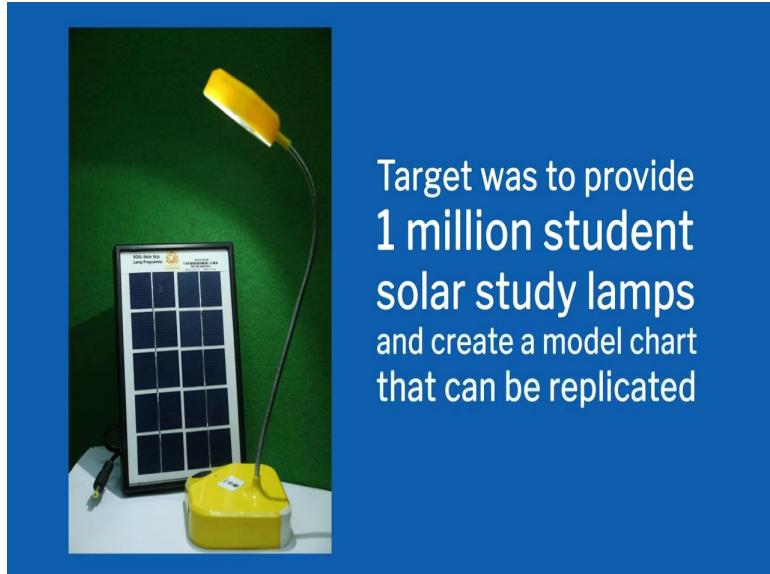
You would run some manufacturing, do some processing. So this is the entire energy ladder that we needed to work. But one of the most basic things is providing them light for study purpose as I told you earlier, that we wanted to solve this problem of access to the light so that everybody can study well.

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Now, the three problems that I have told you, we thought there could be 3 solutions. Solutions included: How do you find and make the product affordable? How do we involve the local community? and, How do we saturate the area with which we work?

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Target was to provide
**1 million student
solar study lamps**
and create a model chart
that can be replicated

By the way, the program for 1 million, Solar Lamp, you know, that we thought we implemented it from IIT Bombay. 1 million is a big number by, by any standard. And we wanted to do in one year time, so therefore the speed of the whole operation, the scale of the whole operation and the skill that is required in the local community was, was very important aspect of it.

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Lecture-6
Challenges of Reaching a Million Users Part 2

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The very, the basic components that are included are actually the Solar panel, I am sure all of you know. A basic, I would say, power plant for the students.

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Then, what do you need is the basic components like a, the battery, is designed in a manner that it can give sufficient life. The circuit, the important part of the device, you need plastic body to hold it, and then all basic switches, wires, LEDs.

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Once you have it, you can actually get the lamp assembly like this, and this beautiful and very powerful device. So it's a very simple small solar lamp. And this is designed in a manner that it can work in multiple modes. So in a low operation mode, you press it once it switches on and this battery is good enough, because the whole thing is very efficient.

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The whole thing is it actually works for 12 to 15 hours on a, this intensity mode.

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And if you press it once more it will be even brighter.

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In this mode, it can work 5 to 6 hours.

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So if you see here, if I put it on the table this gives sufficient light and as bright as whatever you are getting from so that this basically solves the problem.

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What we really found out is that this lamp is designed for study purpose. But it is not only used for study purpose, but it is used for anything and everything.

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So mother will use in the kitchen, somebody will go to the field.

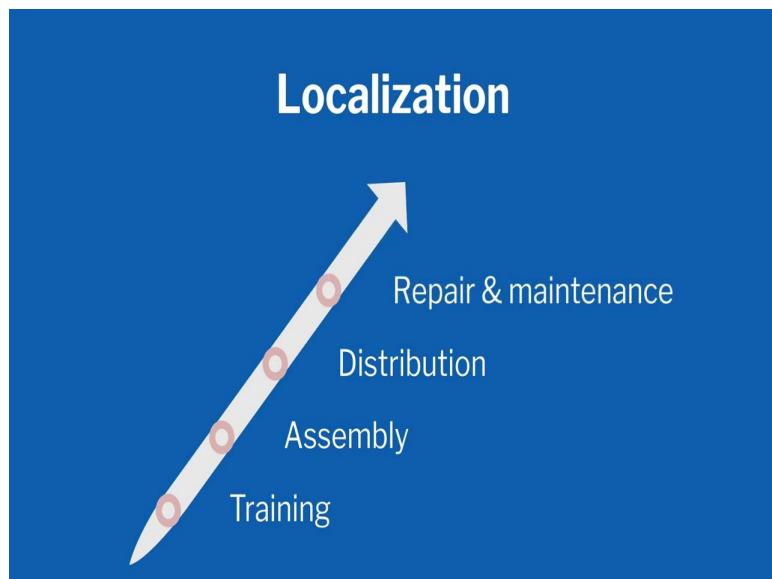
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You know, delivering the babies in the, I mean when there was no power available in the night, taking bodies to the funeral, everything. So from birth to death everything. Many times we found that people would actually put it like this and their hands will become free and when the hands are free, you can actually do the irrigation, you can milk the cows, you can walk in, you can actually tie it up here, mothers can actually use it and hang it anywhere they want.

And they can just rotate this head wherever you want the light. Rights? So if you want it upside down, this way, that way. So this will become a very very useful device. And that is how it can become very powerful.

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Now, the three components included: One is, localize the whole solution. What does it mean that, let the local community be involved in each and every operation. Once we do the localization, what are the benefits you can get? Number one, your cost of operations will go down because you do not have to have the units and manufacturing units. Your labour will be cheaper and the important thing is your services, repair services will be available right there.

You do not have to really rely on somebody else. How each and every component can be manufactured in India as much as possible.

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So except two components, the battery which nobody manufactures here and the LED. These two components come from outside, but everything else is manufactured here. What we have also done in various projects here is we have standardized the technology. Right now you Google and say, Solar Lamp, you will find 200 different kinds of solar lamp, and the problem with each of those different lamps is that they will have their own design, they will give their own circuit, they will have their own battery, everything.

And therefore the components are not interchangeable. As a result of that, no single device can be promoted and even if it is supplied to some area, you will not find the spare parts, but if we have standardized the whole thing, the entire technology is open source right now. So if you go to the,

our website you will find every design of the body, of the circuit open source. Some of the IDC students were actually involved in helping us to design the Solar lamp. The second problem was: How to make it affordable? Now, one of the ways to make it affordable is to appropriate the technology for the use. In this case, we thought it should be study purpose.

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And for study purpose you need 150 lux of light. In the light you required in about, you know, 145 CM diameter area.

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So any book will fit into that.

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Now, as soon as we do that you will realise that light wastage is not there. So this light is there where it is required. Right? So there is no unnecessary wastage. So earlier I showed you, it was a 5 Watts solar lamp. This LED is just 1 Watt. So, in less power you can do that. Our circuit is very efficient. So that itself has resulted in a cost reduction, but still it used to cost about 500 rupees and we figured out that 500 rupees is not affordable.

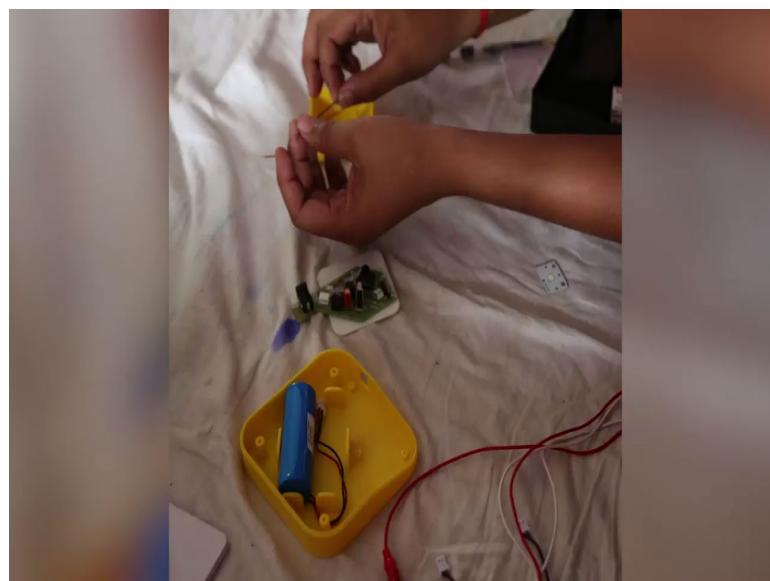
So then, we devised a kind of method in which we said ‘Let the cost of the solar lamp be equally borne by students, society and the government’. It’s the society’s responsibility that every child should be educated. It is government responsibility that the child should be educated.

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Government by the time had, you know, given this Right to Education, and based on that we also said that our project is a Right to Light project, that every child should have a guarantee of a minimum quality of life. So that was our project and it clicked very well. Government liked it very well because we did not ask all the money from the government. Society liked it because the government is part of it and they were giving so they do not have to give all the amount. The student also could afford it.

Third thing, what we did is to reduce the operational cost of the whole project. What are the operational cost required?

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That somebody has to assemble the lamp. Right?

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And once assembled, the lamp is assembled, it has to be sold because it is not given free. Somebody has to go and sell it.

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Once the selling is done, and if there is any problem with the lamp, somebody has to repair it.

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So, these are operations involved. If your scale is not large, all these operation costs will be very high. So, one thing that we realised in the very beginning that what we are going to do is we are not going to identify students by their class, category, this and that. We have decided that everybody would be a beneficiary. Everybody could actually buy the lamp in our project. And we decided the minimum geographical area that we need to cover is a block. Right?

I hope you are aware, there are the states and the districts, and under the district we have blocks. For the block level typically 50 to 100 villages. So we identify a block, every student in those 50 to 100 villages will be eligible to buy. Now, as a result, what happens suddenly you have a big scale. In every block will have 15 thousand students, 20 thousand students. If you go to some, UP and Bihar you will find 25, 30 thousand students.

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Decrease in operational cost of

- Assembly
- Distribution/sale
- Repair/ maintenance

So as a result of that our operational cost of assembly, the cost of distribution and sale, and the cost of repair, maintenance has come down. And what we realise that this is not only applicable to the solar lamp program, but every other solar program that you want to do, would actually have the same issues.

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So once we standardized the technology, we started giving training to the group,

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and as I said solar technology is so simple that it does not require a very high technical knowledge and anybody actually can learn it.

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And we have developed a training program where not so very literate people also can actually understand, measure the circuit is working or not,

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measure the battery if it is charged or not,

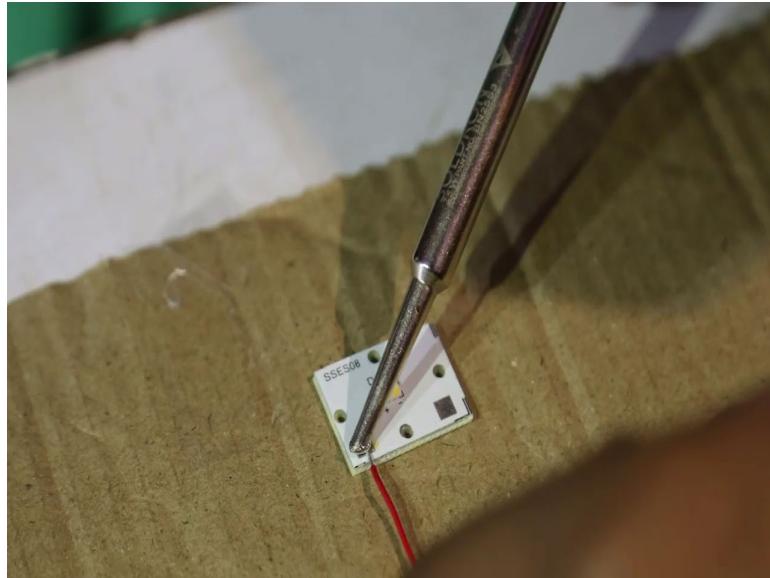
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measure the panel if it is giving in enough power or not, enough voltage or not,
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how to do the soldering,
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some basic screwing and all that they need to do it.

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All those things, operations can be done.

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And they can make this lamp. Now, when we were doing all this, one of the basic, the doubt in everybody's mind was, whether this lamp will be of the same quality as you buy the lamp in the market. Right? Because the people from the rural area are going to do it.

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Therefore we have established, all kinds of quality checks after the assembly,

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so that eventually the lamp that goes in the hands of people is of a good quality.

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So, after the lamp is assembled. The next was get it distributed,

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to the students in rural areas. Distributed means, at some cost it has to be sold. Right?

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It is not given free. This was only the beginning of what we started doing. So now I will show another video that, what is our overall plan in our SoUL, S-O-U-L: Solar Urja Lamp project has become SoULS: Solar Urja through Localisation for Sustainability. So as we started doing this solar lamp project we actually went to the bigger and bigger kind of solutions.

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Just have a look at this video.

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By now we have reached to more than 6 million students. Now, how it all happened? I have only told the conceptual level but how it will all happen will be told to you by Prof. *Jayendran*.

I am *Jayendran*. I am a faculty in Industrial Engineering in Operation Research, IIT Bombay, IEOR. Apart from working with many big industries this was a very interesting challenge where some of these concepts of consultants is also applicable in rural areas.

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- JV is a Professor of Industrial Engineering and Operations Research (IEOR) at IIT Bombay.
- Research interests are in modelling & analysis of complex socio-economic systems, systems modelling & simulation, last mile supply chain ecosystem, & energy access.
- Consultant for many industries such as General Mills, Hindalco, ICICI, John Deere & energy access.

Now coming to this aspect of the technology intervention which *Chetan* talked about, pretty much what we want to do is improve the energy access by providing an appropriate type of intervention in this particular case, which happens to be a solar study lamp.

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But whatever intervention that we want to do, like you know, we can have really lofty goals but that has to be appropriately translated to operational processes and procedures and down the line, so that the entire goal and vision can actually be a success. That is pretty much similar to what is the goal of a supply chain of a very large company can be. Whether they are in the business of ensuring the right product, reaches the right customer at the right time at the right price is pretty much that what we want to do.

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But the added challenge here is the people we want to benefit are the people (who) are not able to afford the product at the current price point. So that makes it a little more challenging and they are at various locations.

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Supply Chain

- Role: To provide the right product/service, at the right time, right place and at the right cost to the customers.
- In sync with Solar Urja through Localization for Sustainability (SoULS)

So, some of the research we are regularly working on is related to supply chain has a nice sync with the Solar Urja Localised and Sustainability initiatives that we had started. So we started working on that and I wanted to see how various aspect supply chains becomes relevant here.

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SoUL Objective & Scope

To provide

**high quality,
affordable,
clean light**

(solar lamp) to millions of school students,
in rural India in fastest possible way

The objective of the SoULS is pretty much what you want to do is provide high quality, affordable, clean light that is a solar lamp to millions of school students in rural India at the fastest possible way.

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SoUL Objective & scope

- To provide 1 Solar Urja Lamp (SoUL) to every student
- Generate sustainable employment in rural areas
- Generate local capabilities for sale, repair & maintenance
- Seed rural solar markets for accessibility & availability of solar products
- **fastest possible way:** duration 1 year

It is to provide 1 solar lamp to each student. It is not that 1 million goes to one person. We need to ensure that everybody gets it, equitable access. It should generate a sustainable employment, generate local capabilities. It should be able to seed the rural market for accessibility and availability of solar products in the future. And we gave ourselves the goal of the fastest possible way which is approximately say, 12 months, before which all the millions of students must be able to get access to the solar product.

It is not just a lab prototype, right? We need to produce millions. So we need to develop the vendors. We need to provide them the capability to actually manufacture it, supply chain network has to be designed, assembly distribution centers has to be setup. It is one thing to say that we can empower local people to assemble and distribute. It is quite a different thing to actually empower thousands of people to start making the lamp but the quality level we want. Right?

Then production, sales, planning, scheduling, after sale service, all these things are, will have to come into play in the SoULS project. All these attributes, in a time bound manner which makes it much more interesting and exciting, unlike Apple, which can come up with new versions every few months, what we want to do is ensure this, it reaches as many people as possible.

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So, broadly speaking we had decisions like strategic decisions, which pretty much talked about what kind of supply structures, what kind of financial models we want to work on, which is then translated into tactical decisions which most of the time involved more short decisions that was given the current constraint to manage the delays and uncertainties. All this has to help in making operational activities at the ground level so that the actual student gets a high quality lamp at the price that we actually want.

Strategic decisions are always important because that pretty much locks in what kind of intervention, what kind of scope your entire activities can have.

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Strategic Decisions

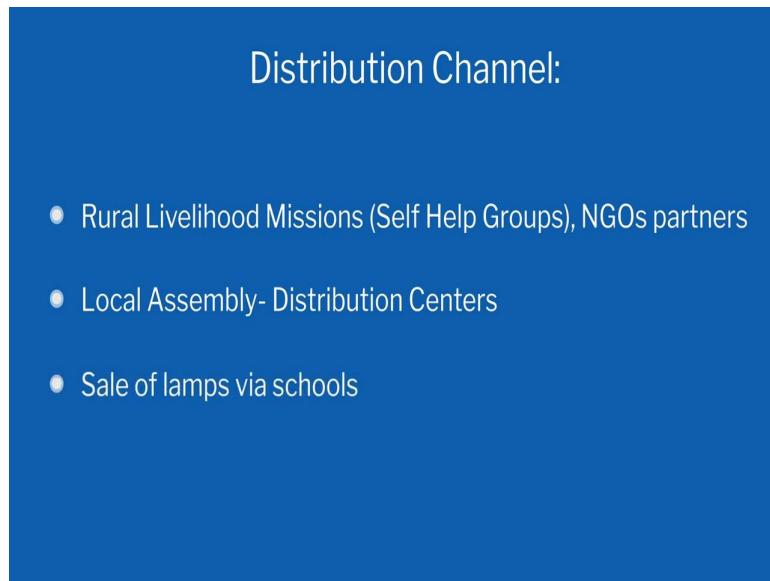
- Pricing of lamp: to be affordable
- **Sourcing:** Empanelled set of vendors to supply lamps-in-kit-form
- **Intervention area:** Block (sub-district) with target to saturate.

First of course, the pricing of the lamp should be affordable which *Chetan* explained how we went ahead, going, making it affordable. Sourcing, so we had to iterate and empanel a set of vendors. So this lamp has been designed by IIT Bombay and has been released as an open source, as an open source hardware which means anybody connected download the design files and manufacture this lamp. This can significantly reduce the cost of the product and cannot enable many small players, to at least start making this product. We also involved in large scale tendering which actually reduced the cost significantly, which can allow us to reach to more students.

So one of the things that we targeted was ‘let us just focus on one block’, so that way we can actually go deep in one location rather than spreading thin at every location. But we want to repeat it in multiple such blocks across the country. So the selection of it is also quite an interesting challenge like, I’ll just give you an example, State of Bihar, all except two blocks were all eligible blocks. Eligibility criteria was kept as the percentage of households that depended on kerosene as per 2011 census and percentage of marginalised households within that block.

Based on that when we shortlisted eligible blocks, all except two blocks in Bihar was eligible. And the number of students enrolled there itself is about, I think, 10 or 12 million students already there, just in one State.

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So we used these multiple criterias, then the distribution channels, they partnered with State Rural Livelihood missions and their self help groups where in and various NGOs were partnered to reach the ground level. The purpose of these missions is to create local self help groups which are independent autonomous units which are formed by community or bringing together women from every household and forming a community organisation who are then empowered to take decisions, do some microfinance and use it for their own training and skill development, so we partnered with them.

And through them we set up local assembly and distribution centres, which is manned completely by the local women who run these assembly and distribution centres on their own. Now, how do you sell the lamp to the students? Since the already targeted population is students or the children, expectations are that they are enrolled, so the sale of lamp was conducted for all the schools in the State, whether it is government school, or private school, does not matter.

So that actually is your point of dissemination. So we can ensure that actually the target audience indeed get the lamp.

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These things are actually really big especially in India because there is, it is prone to leakages and corruption. Imagine a product which is available in 100 rupees, but competition in the market 500 rupees. It is almost natural for people to buy for 100 and sell it for 200 rupees somewhere because the desire for economic improvement is much higher than the actual need for the lamp. So how do you prevent the leakage, by empowering these local organizations and advertising well and saying look everybody in this area is definitely going to get a chance to buy.

So, thereby we can reduce the chances that people will actually, so even if somebody wants to sell it, others may not buy it because they know that they will get their turn within a short period of time. They do not have to wait for years and years for that.

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Lecture-7
Challenges of Reaching a Million Users Part 3

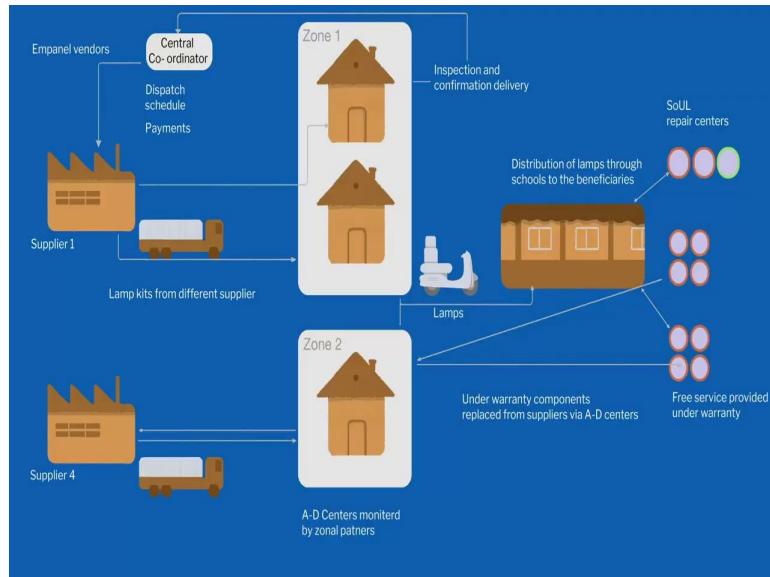
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Various activities are involved towards doing this, especially setting assembly distribution centers, repair and maintenance centers, both involve identification set up, training as well as the actual operations. An entrepreneurship development also happened where we are doing entrepreneurship development training for those people who are involved in making the lamp, and can actually continue their livelihood using solar.

And being an IIT we were also strongly involved in continuing to be doing this documentation and research on all these aspects.

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A quick idea of the operational flow we ended up creating is we have a central coordinator who we first empanel various vendors and based on the target population there, we decide how much quantities to send them. The quantities are directly told to the vendor and vendor supplies last mile up to that particular location which itself is quite an interesting task because the visibility is very low I am sure all of you have used, say, purchased through Flipkart and Amazon everything, right? Here you can really track what is happening.

Like, you know, whether it has reached warehouse, whether it has left the warehouse etc., but if you want to supply anything to some of these locations visibility will stop somewhere at Patna. You say reach Patna, left Patna and then you have got no news for next 7 days and then says 'Delivered'. It so you have no visibility in the last mile even though India is very well connected. People all have mobile phones still many of these locations where we need to go are very remote locations.

And as we told the quality is very important. Inspection confirmation of delivery happens, 100% is inspected and then once it is come from then the payments happen to the suppliers. These are some assembly and distribution centres are, so it is 1, 2, 3 blocks. 100% inspection of components happens. They actually make the lamps and sell it through schools to the end customers that are the school students, but of course school students are going to use it in their houses.

The people who had helped in setting up, running the assembly and distribution will now be empowered to set up repair centers, the solar lamp repair centers which provide free service under a warranty and during the warranty period. So, these represent a set up at the *Panchayat* level so the accessibility is more. You cannot go and repair the lamp at every school. But, and, again they cannot even come up to the block level or the district headquarters to repair the lamp so the repair centers are at the *Panchayat* level which has much more accessibility.

And all, what all components, bad components comes, it gets through the repair AD Center goes to suppliers for replacements.

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Additional training is provided for entrepreneurship development to all the people who are engaged in the repair and maintenance activities in the hope that at least some of them will succeed and become entrepreneurs. So, various process systems are ended up, setting up mainly in form of guidelines and training and manuals, then translated in the local language, then training videos etc. were set up. Then we established the processes, created flowcharts. Imagine we have to ensure that they have to assemble in the exact same way as they will do in an industrial setting.

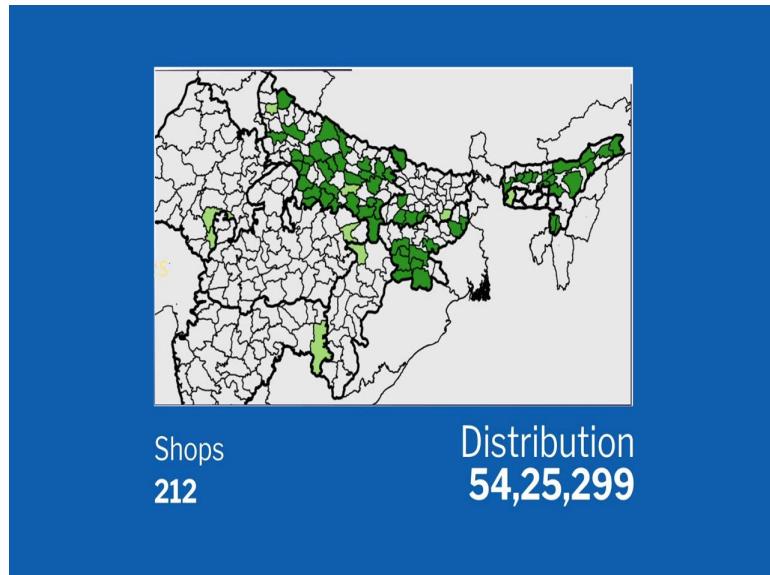
We gave various record books did not show that indeed all the processes are followed and all the data is accurately recorded and there is a clear trace back and every lamp was coded so that given a lamp code you can actually trace it back to whom it was actually sold to and in fact we can even trace it to say, where it was made and which supplier actually made it up to that level we can actually trace it back all through the help of just simple record books.

Various softwares were also employed in the form of, so here we can get the information all back here and data entering is easy there but anyway get it here so we used scan utilities, we used apps, whatever technology was helpful for which our activity we used all sorts of things. Finally all coming together in our solar lamp SoULS website where you can get the latest information about the project.

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So, *Chetan* introduced a 1 million solar lamp project. After we completed, when we presented the report to the ministry, soon they sanctioned a much larger project for about 7.5 million lamps.

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So, we are still involved in the central coordination of this pan India project, which is now the world's largest involving local communities. So, it is currently happening, right now the project in 9 States, 70 districts, 230 blocks. Nearly 7,500 people have been trained, 7,500 people trained and the current distribution stands at around 54 lakh lamps, and 212 people have actually moved from the R&M (repairs and maintenance) centers and set up their own shops where they are actually selling the solar products.

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Various interesting things happened when we gave the basic assembly and we just told them you know you have to assemble it. Everybody got the same training. But some of these centers actually thought for themselves and they told ‘No, individually let us not make lamps, let us just form an assembly line. So let us, let us put two people doing only the first step, another two in the second step, another two in the third step and so on’.

So actually they created their own assembly line and then we took that best practices and shared it with others. So, the innovation doesn't stop just because we did not tell them. They are free to think and we gave them a sounding board to raise their ideas. So, we could get a lot of such interesting things coming out.

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Distribution was even more interesting because dialect changes every 50 kilometers. So we had projects in, the border between Gujarat, Madhya Pradesh and Rajasthan. There we teach in Hindi but finally the school kids learnt about the lamp on how to use the lamp in a, the language which is a mix of Gujarati as well as Rajasthani and some bits of Hindi also. So, it is extremely interesting how the same thing was actually conveyed last mile which is not possible if, even if, you know, we had trained really good people here and sent them there, the message would not have reached.

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Only because we included the local community, we were able to ensure that this happened. That happened just automatically because they are just used to that language they knew in their how to reach and they reached it.

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The repair and maintenance shops. As soon as they told that we can actually set up a center and then they could feel that they can earn some livelihood they took a lot of initiatives. They painted their phone number in various locations so people can actually call them and get the services.

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We are the central coordinators but various agencies has been involved. MNRE is the funding agency, to various field implementation partners, to vendors, to procurement partners.

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And for research here also collaborating with Boston College School of Social Work to understand the social impact of all these activities along with the Prof. N.C. Nayarayanan in CTARA (IIT, Bombay).

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- To examine impact of sustained use of solar lamps on
 - Educational outcomes of children in rural Indian schools
 - And on economic, social, health outcomes of households
- To examine the determinants of adoption and sustained use of solar technologies in rural India
- To explore the impact of skill-development of solar technology providers on their livelihood opportunities in India

Where you are also trying to examine the impact of sustained use of lamps on the education outcomes of the children as well as the economic social health outcomes of the households and what determines the adoption of sustained use of technologies are broad questions. So, people whom we train, they are exploiting the impact of skill development on their livelihood opportunities in rural India.

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So, they are currently gathering this through both quantitative as well as qualitative approaches. That we are having surveys as well as focus group discussions and interviews. Okay, we have done the lamp distribution itself involving the local community where in research and evaluation just,

you know, questionnaires where they are very passive. Can we actually involve them in the research aspect also? So that is where the community-based research is coming in.

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Research process involves community



Problem Identification

We created the research process where we can involve the community. What we first do is we select people from the community, sat with them and actually discuss what is the actual problem that we want actually model.

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Research process involves community



Develop Reference modes

Worked with them. Identified what kind of issues or dynamics that is happening with the community. Identify key variables that they say will affect the problem.

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Research process involves community

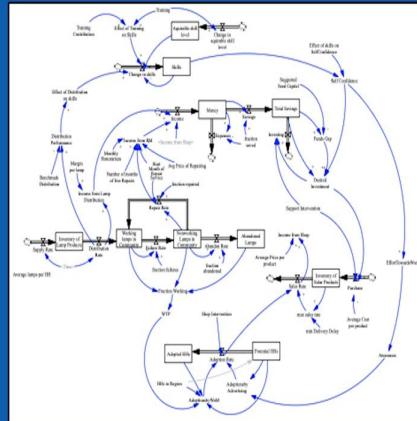


Causal Loop Diagramming

Work with them to actually build the model as what we call as a Causal Loop, that is a cause and effect mapping, the Causal Loop diagram or cause and effect model refinement and action plan was all discussed like what do you want to improve.

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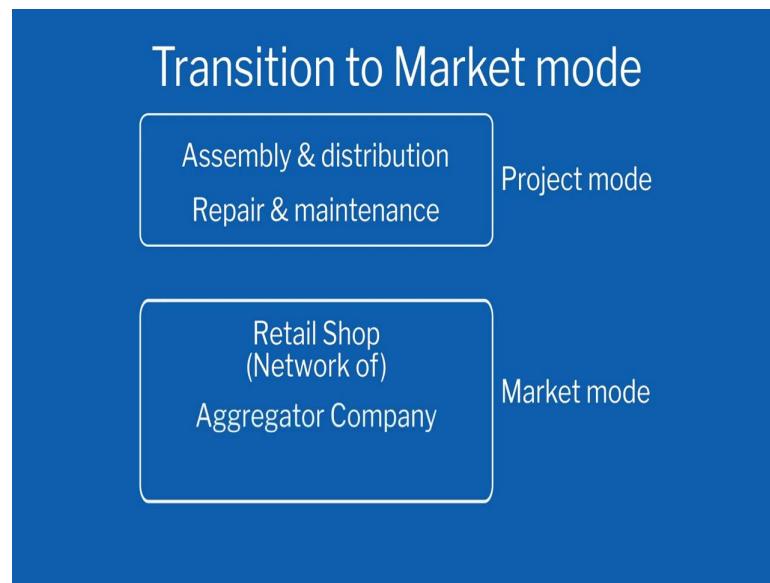
Research process involves community



Simulation Modeling

And actual working mathematical simulation models which accurately now represent the problem that they actually want to have. So we were able to bring in this aspect of localization into the research aspects also. Then why are we doing all these research and stuff, because research of course is essential so that we can actually transition to the next level where we have a lot of uncertainty. We want to provide energy access to the community by engaging with community institutions.

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So, what do you mean by that till now we have been doing assembly, distribution, repair and maintenance which has been running in a Project mode. Large money was done, we could empanel vendors and then we could do it at a much larger and bulk scale. But now we want to transition to Market mode where the retail shops that we have set up or network of it, has to actually function as a retail shop and they should continue to earn their livelihood. At the same time the community must be able to get adequate energy access as per their needs.

So, this is just a network of retail shops or we need to transition to more aggregated companies who can now channelize, you know, so many 1000s of shops that can, 100s of shops that is going to be all over the country in every *Gram Panchayat*. How do we get there, get them together or can we actually even scale up to become a manufacturing company. To help answer all these things a core research component is necessary.

So that aspect again I think *Chetan* will be coming and talking to you about the last three aspects beyond the solar lamp, he is going to be talking about. To help with that transition we will have one more video.

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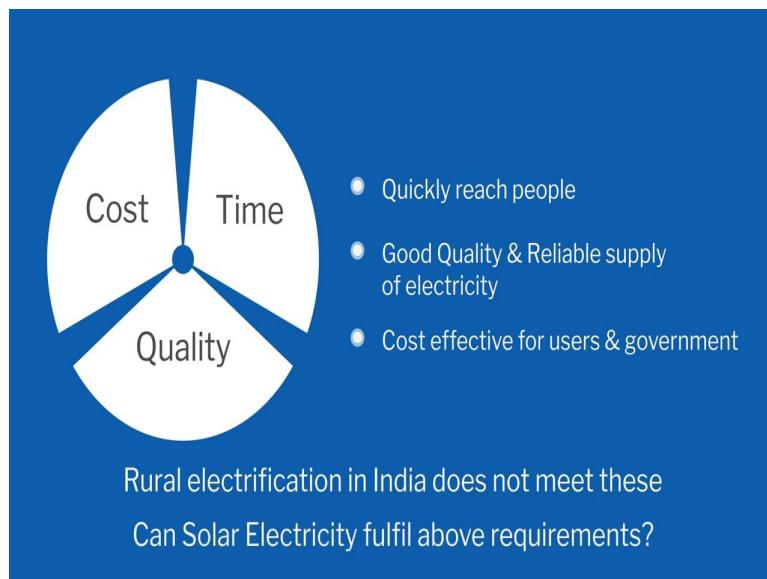
All right, getting an idea what are the various elements that are involved to implement a project which is going to millions of families. Right? Obvious question that has always been asked, you know, that 'Is the solar lamp is going to be enough?' You know. What is the solar limit? Ultimately it is a very tiny lamp which is not very powerful.

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But, you know, when you look at the sustainable development goals say, when it actually talks about the complete affordable, reliable, modern energy solution. So, we used to talk about rural electrification but in the current context of what is happening in terms of the climate change,

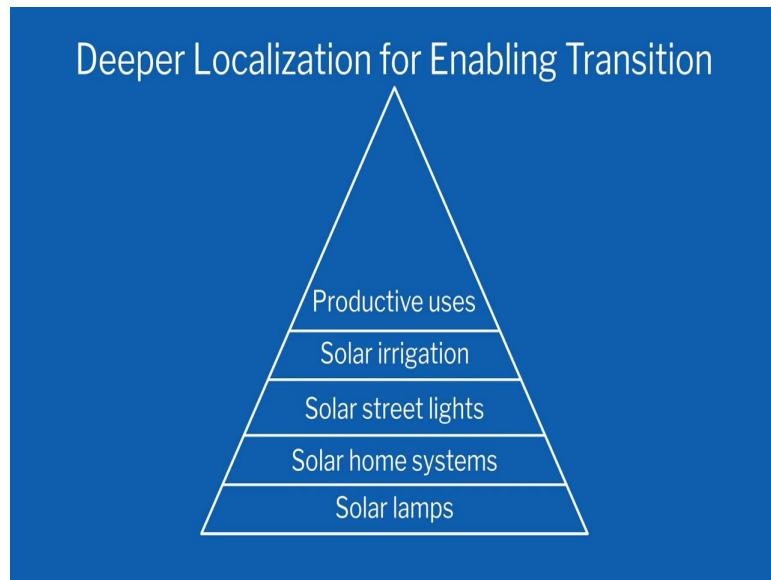
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you know, you should talk about the complete overall electrification. So, we thought three things are required. You need to really quickly reach two people there's still 2.8 billion people who do not have access to clean cooking, something which is of good quality and it should also be affordable. So, these are the basic problems of every country in the world. We have been developing various kinds of solar products so as I said this technology is open-source hardware.

So this circuit actually can be utilized to power and make many other devices. For example, if you look at the flashlight that also has 1 watt of power, half watt of power. If you look at the various component home lighting systems, you know, that can also be in similar range so once we do this we can actually have many other products.

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Only thing what you need to do is have a different body parts. You need to have a different battery, you need to have a different panel depending on the need. Then street light is a little bit higher power, you need 6 watt and 12 volt and 18 watt. So what we have done over a period of time we have, kind of, standardized various circuits which can actually take care of many products. So, we have released all of them. We designed it and released it in open source so that everybody can do that and we can do it further.

So, slowly building technology solutions, so that the knowledge of the technology or the availability of technology does not remain a bottleneck.

Provide solar lamp study	Enterprise Development	Localized Manufacturing
<p>For school students at a subsidized rate (Rs.100/lamp)</p> <p>Locals assemble & distribute the lamps</p> <p>Locals provide Repair & Maintenance services during warranty period (12 months)</p>	<p>Locals will be nurtured as entrepreneurs</p> <p>Key to provide access to higher & solar products & continued maintenance</p> <p>Development of 100s of solar shops through cohesive groups (viz. company) for demand & supply aggregation</p>	<p>Set up of local community owned manufacturing facilities for solar panels & other solar products</p>

Whole idea was that if the solar shops are there and if they keep buying the material, you know, whether the panel and battery from outside and circuit from outside, the money from the local economy goes out of the economy. So, the idea was that why do not we locally manufacture it.

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For example, the sole panel making is a very simple technology. Only one complicated step that is involved is a kind of lamination. So, the solar panel making, using solar cell, is nothing but lamination. You must have seen the paper lamination right? Earlier we used to do, give your paper and get laminated as a plastic. Exactly the same thing.

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So, what we thought is why cannot we think of this as an ecosystem, you know, which is run by the local and is for the local, that if you are producing locally, the panels, if you are producing various components locally and this local products are actually useful for the problem solving for the local themselves and for their own need.

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Then what could be better than to create such an ecosystem. This year by the way we are celebrating the 150th birth anniversary of *Mahatma Gandhi* who always proposed that not the mass production but production by masses is required. You heard of this? Because mass production always results in a centralization. It always results in an accumulation of resources to one place.

And in fact that is exactly the problem if you look at the economic history of the world of last 150 years you will find that the world is becoming more and more unequal.

On the other hand if you do production by masses, then there will be a more equal distribution and therefore this solution that we have been building is exactly kind of production by masses and energy is really key. Especially now when the technology is improving and when the products are becoming very efficient.

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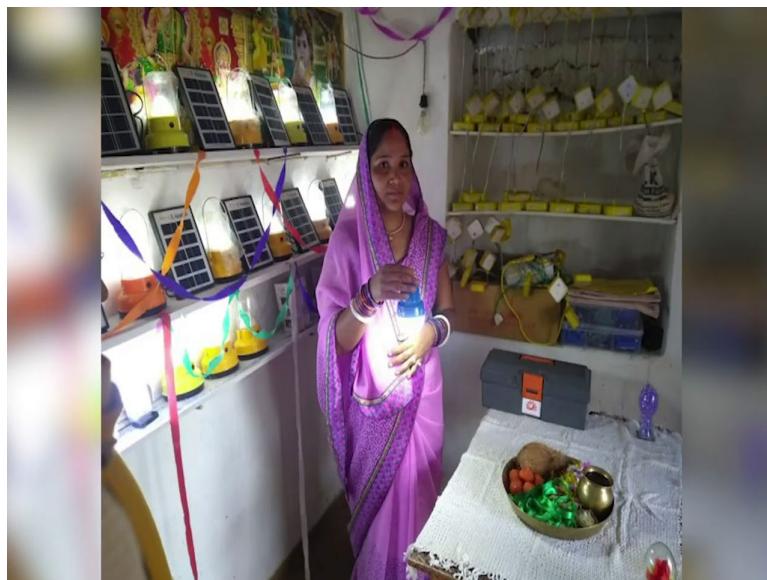
So for example if you have a house where there are lights and fans radio TV mobile charger all this thing in a house you can actually do all these devices if they are very efficient devices which are now available in just 16 units.

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So, what we have been also doing in our project is enable people to assemble this product and sell this product at the market mechanism.

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There are for example 200 shops that are running right now. All of them are on their own investment and they are selling products at the market rate.

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Not only that, we give them further training so they can do the entire electrification of the house. This is one of the projects that we did a small trial where we have asked people to surrender their electricity connection and go 100% on solar. So there are several houses that are of this nature. All, everything is done by the women.

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So, this is one of the unique factories established in Dungarpur, Rajasthan, which is owned by women and operated by them. And this is a 2 megawatt module manufacturing plant, so whatever module that I showed here, they make similar kinds of modules. And not only that they can make a 5 watt module, 10 watt module, 20 watt module, so whatever are the needs of the local area they can manufacture it and supply it.

So that is how empowering it can be. The CEO of this factory is *Rukmani Devi* and *Rukmani Devi* is only 8th passed. And couple of weeks ago when I, when I visited the *Dungarpur* and I was asking (**FL: 17:08**) “*Rukmini Ji kaisa chal raha hai factory?*” (Translation: Rukmani ma’am, how is the factory working?). You know what she replied?

(**FL Start Time: 17:10**) “*Sir acha chal raha hai. Abhi dollar ke rate thode badh gaye hai toh hamara raw material ka 75 paise bad gaya hai per watt ka, toh hamara panel itna 1 rupaya mehenga ho gaya*” (Translation: Sir the work is going fine. Now the dollar rate has increased a little so our raw material is costing us 75 paise more per watt, so our panel has become 1 rupee costlier.) (**FL End Time: 17:18**)

That is what the empowerment. So that is what this localization of this technology that it can bring. So, this is the example how *Dungarpur* in this particular place has really evolved from a very simple,

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Deeper Localization at Dungarpur



Assembly

so, this very woman started with the solar lamp program. They set up the repair centers then they started some solar shops and now they are actually running the model manufacturing factory.

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Prime Minister's Award for Excellence



And this was such an involvement for everyone within the district also, that this project was also nominated and also won the Prime Minister's Innovation Awards by the district under this project. The next and the ultimate idea I think we are working on is what I call is Energy Suraj.

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Idea of Energy Swaraj

Like *Gram Swaraj*, you heard of *Gram Swaraj*? What was the idea of *Gram Swaraj*? You know? Production by masses. That every community be self-sufficient in fulfilling their own needs, that is *Gram Swaraj*. Right? Can we not do the same thing with the energy now. And if you can do that it becomes Energy Swaraj.

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What is required: why do not we locally manufacture, why we locally service and why we locally use, locally finance. Everything if you can do that. In a lot of institutions that we have been working in our project the State Rural Livelihood Mission actually have a very good established the local financing mechanism so, that is already there. IIT Bombay anyway working on the technological solution, making it open source, that is possible. And of course there are local consumers. So,

when we do this we can create a complete ecosystem. And this model by the way is not only valid for rural areas but it is also valid for urban areas.

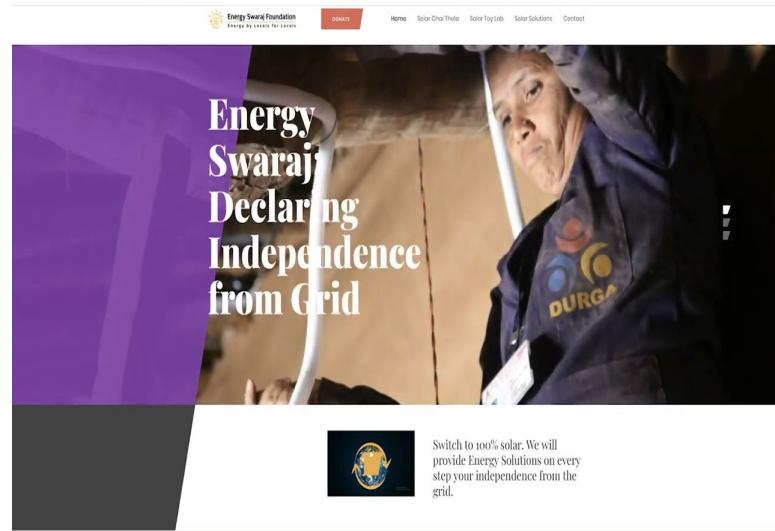
Basically what I am trying to show you is it is indeed possible that we do that completely energy self-sufficiency locally.

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And if you can do that I believe that the advantages are really enormous and job creation is one of the major problems of any young growing country, so a lot of jobs can be created because by nature decentralization of anything requires more men, by nature. It will create a skilled manpower, you know, Skill India, then Make in India, local assets in the economy once the local manufacturing units are set up the economy becomes stronger.

The robust after sales and services and maintenance because people are local, the local economic development climate change mitigation, lot of benefits I can see happening from here. And not only that it will also result in a shift from the Program mode that we have been doing so far to the Market mode.

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So, just to give a glimpse of it I have been, I have undertaken what is called Gandhi Global Solar Yatra to go around the world, talk to people and say, ‘Look guys, climate change is a really, really serious threat’. It is very scary and solar energy solutions are actually viable today and without subsidies without grants we can do that. We have been showing how we can reach to millions and millions of families. So, if you go around and whether you go to South Asia, you go to Africa, you go to Latin America, everywhere you can find that such a model can do a great deal of benefit for the various economies.

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Some of the examples how the solar lamps is now reaching to millions and millions of people not only in India but outside also.

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So, what we have done is last year, we organized a student solar ambassador workshop where we have trained more than one lakh thirty two thousand students all over the country on a single day. It was a Guinness World Record. So this was in our Gymkhana ground here. So more than 5,700 students got together and they learned to make their own solar lamp. They all took a pledge of non-violence to the environment.

And it was a Guinness world record this year in 2019 this event is now taking place all over the world with more than 1 million students on a single day going to learn to make their own solar lamp. So, that is how, as I said, is starting with the solar lamp where we have done lot of innovation in various levels at the technology level, at the operations level, at the financing model and the more important is working with the community.

So, now we are kind of creating a base on or whatever learning and experience creating as an Energy Swaraj as a movement. I believe that the governments around the world cannot actually solve the problem of climate change, because the government's are elected for a short term 4 years or 5 years. The climate change or the sustainability requires thinking of 50 years and 500 years and it is only general public that has to become aware broadly and start taking and generating our own energy needs.

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And if we can do that we have formed a foundation called Energy Swaraj Foundation. We are going to start inviting people to surrender your electricity connection. So, if anybody is interested to surrender your connection you are most welcome, you can join it. At home we have stopped using the refrigerator, washing machine, microwave, AC, geyser, we do not use any of it. So, for me it is very easy to surrender.

So one of the basic principle or the formula of sustainability is what *Gandhi* ji told, you know, that ‘There is enough in the world for everybody's need, but not anyone's greed’. You heard of this? And it is very clear that whatever modern lifestyle that we are living, it is impossible for the planet earth to sustain, impossible. You cannot do it for everyone. And therefore until unless you are just limited to your needs there is no way you can sustain.

And therefore even if it is energy, even if I have a magic wand and convert all the solar, all the energy needs of the world into solar, the climate change will still not stop. So, the first principle is to become a disciplined user, and once you become a disciplined user, it is very easy to surrender your connection and go 100% with the solar. So, with this on behalf of *Chandran* and would like to thank you again, and one of the things that the lamp has done is; we have found out from various anecdotes and also research that the number of deaths due to the snakebite has come down wherever our lamp is gone.

Because in the low mode it can run for overnight you know 12 to 15 hours. What people will do is they will switch on and sit and sleep and whenever they wake up they do not have to, you know, walk on the snakes, you know. So, they can figure out where to sit and avoid it, so that has been a, you know, surprisingly for us also has been a kind of contribution that this lamp has resulted in a reduction of the number of deaths, alright. Thank you.