UrJar
A Lighting Solution using Discarded Laptop Batteries

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In 2012, over 1.2 billion people (=20% of the world population) did not have access to grid-based electricity, almost all of whom live in developing countries.

44.7% of rural India do not have any access to electricity.
In US, 142,000 computers are discarded per day

India has 58,824 registered IT companies (2011), generating 8,00,000 tons of e-waste every year
Li-Ion Batteries

Li-Ion batteries power laptops, tablets and phones, form a key constituent of e-waste

IBM India produced ~10 tons of discarded laptop batteries (2013)

Recycling Li-Ion batteries is complex, labor intensive and costly

- Takes 6-10 times more energy to reclaim metals from recycled Li-Ion batteries compared to producing them through fresh mining
- Recycling Li-Ion batteries is not commercially viable
- Discarded laptop batteries end up in landfills, resulting in an adverse environmental impact
**Li-Ion Batteries**

**Charge Capacity**: Maximum amount of charge that a battery can hold at any one time

Tested 32 6-cell laptop batteries, 3-years used

Rated charge capacity of 85 Wh. Mean value: 64% (~55 Wh), sufficient to power **3 W LED bulb + 6 W DC fan + 3.5 W phone charger**, for ~4 hours
Solution: UrJar

UrJar = \textit{Urja} + \textit{Jar}

\textit{UrJar} uses discarded (but still usable) laptop battery cells to power low energy lighting (DC) appliances

\textit{UrJar} address the problems of

- laptop battery e-waste,
- lighting needs in developing countries
UrJar Target Users

‘Bottom-of-the-Pyramid’ users

People with access to intermittent power

- Roadside vendors with mobile carts
- Households in rural India

*UrJar* primarily powers a DC light bulb
Current Practices Study

To understand current lighting practices of people with no continuous grid access, we conducted a study

25 participants (21 male, 4 female), age: 20-45 years

- 21 street side vendors: 10 sold food items (noodles, fruits, sweets, fried snacks), 5 sold tea & cigarettes; 6 sold apparels
- 4 were slum dwellers

35 devices (26 in use, 9 past devices)

17 interviews in Hindi, 2 in English, 6 in Kannada
Each interview for 20-30 mins
Current Practices Results

- Petromax
- UPS-for-CFL
- Emergency Light
- SELCO
- Sun King Pro2
- UPS with Solar and LED
- CFL Lantern
- LED Array
I. Fossil fuel powered

Current: 1 using LPG-based Petromax
Past: 3 LPG-based + 3 oil-based
  - Switched to other battery-powered devices

Low capital cost INR 300 - 600
High fuel cost INR 750 - 1200 per month

mantle blows up every month... costs INR 40 to replace
unsafe to use
not aesthetic
very heavy
have to travel 1 to 2 kms to re-fill LPG
II. AC-Charged

CFL powered by battery

CFL Lantern

LED powered by battery

Emergency Light
II. AC-Charged

a box with battery and charging circuit

+ a light (CFL, LED, or tube)

23 out of 35 devices

Charged device at home using AC power from grid

15 CFL powered by battery (INR 1200-2800)
5 emergency lights (INR 350-2000)
2 LED powered by battery (INR 1000-2000)
1 CFL Lantern (INR 1400)
II. AC-Charged

Using for 2-36 months | 2-6 hours/day | Charge for 5-8 hours 
CFL/LED powered by battery = 12 months warranty

(CFL Lantern) runs for 3 hours at max, because of which I have to close my shop by 9 (PM). Ideally I would like something which works for 4 to 5 hours.

(CFL powered by battery) battery inside the box needs to be replaced every year, which costs INR 600-900.

(LED powered by battery) expensive but super good

(not aesthetically-pleasing)

(power backup duration was not sufficient)

(emergency light) lasted only 3 to 5 months and come with no warranty
III. DC-Charged

Solar panel + Battery + Light (5W LED)

3 Community Solar
2 Individual Solar
III. DC-Charged: Community

**Community Supervisor**

- Maintains charging station (6-large solar panels on roof)
- Collects batteries at 6 AM, connects it to the charging station, distributes charged batteries at 6 PM

Using for past 7-8 months, with bulb on for 12 hours daily
Subscription-based pricing model, INR 200 per month

- helps in avoiding rats, insects at night
- children can study at night
- get light during dinner
- wear and tear of the wire
- no way to charge mobile phones
III. DC-Charged: Individual

Sun King Pro 2 (INR 2400); a locally built solution (INR 3000)

Keep the solar panel on the roof of shop/home

Offers 12-months warranty, “so even if it lasts just a year, it is the same price as SELCO... also the hardware is ours”
Design Considerations

**Lighting**  ~6 hours daily

**Minimize Losses**  Minimal AC-DC conversion losses

**Modular Design**  Easily replaceable parts; Hide aesthetically unpleasing parts

**Pricing**  <INR 3000; Minimal recurring cost

**Clear instructions**  Prevent malfunctioning of UrJar or connected device

**Portability**  Street vendors can carry it easily

**Safety**  Minimize fire hazards by Li-Ion
UrJar Development

**Step 1** Source used laptop battery packs from eWaste

**Step 2** Disassemble packs to extract individual Li-Ion cells that can still deliver power

**Step 3** Connect re-usable cells to build a refurbished battery pack

**Step 4** Build a **charging circuit** for the re-furbished pack, with **step-up/step-down converters** and other electronics, to power external devices such as a LED light

*All UrJar prototypes were built by Radio Studio India*
UrJar Initial Prototype
UrJar Initial Prototype

DC light

DC Fan

Housing for electronics

Refurbished battery pack
Evaluation
Evaluation

5 participants (4 male, 1 female)
- 1 resident, 4 street-side vendor

Unsupervised settings

Focused on users’ experience with UrJar, including usage time, charging time, benefits, problems, shortcomings, additional ‘good-to-have’ features, amount of money willing to spend to buy it
Evaluation

Stage 1: Connect the three parts - circuit box (black-colored box), laptop battery (green-colored bar), and LED bulb - as per intuition

Stage 2: 15-mins training, including how to use, how to connect the parts, how to charge

Stage 3: After a week (3 months for one participant), conducted a 30 mins semi-structured interview
Results

Even after 3 months of usage, the participant was happy and satisfied.

3/5 participants were able to correctly connect the three parts without any help.

Used 4-6 hours daily (one used for 12 hours daily).

No one used UrJar for phone charging.

Willing to spend INR 1000-1500 with 1 year warranty.
Results

my (previous) emergency light needed charging everyday; with just one day of charge, this works for 2-3 days, from 6:30 to 11 PM

the lantern only used to last for a maximum of 2.5 hours daily, and hence I had to close my shop by 9 (PM)... now with UrJar I can keep it open until 11 PM

my (previous) emergency light needed charging everyday; with just one day of charge, this works for 2-3 days, from 6:30 to 11 PM

thicker wires so that rats cannot cut them easily

cheaper

safe

easy to use

no problem at all

brighter lights will help attract customers

need long wire to hide the device away
UrJar Final Prototype
Benefits

Environmental Benefits
- utilize the latent residual capacity in laptop batteries
- can incentivize organized collection of eWaste
- a cleaner, cheaper alternative than burning kerosene

Business Benefits
- offers potential business opportunity to companies engaged in rural electrification
- UrJar is easy to build, require minimal capital investment

Energy Efficiency Benefits
- uses Li-Ion batteries, powers DC appliances, uses LED bulbs
- Li-Ion batteries can sustain high depth of discharge, resulting in longer backup power duration before the need to charge again as well as longer life cycle
Video
Thank You!

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