Summary Presentation: Building Energy Auditing and Management
Brahmanand Mohanty (Asian Institute of Technology)
The Auroville Foundation Office plans to install a grid connected solar system of 15kVA.

A study is conducted to assess if there is any better alternative to the above proposal.
Overview:

- Theory
- Site visit
- Measurements
- Developing typical daily load pattern
- Supply side solution (grid-tie solar PV)
- Combined demand and supply side solution
- Cost benefit analysis
- Conclusions
Why conduct an energy audit?

- To assess the present status
  - How is the energy performance of the building?
  - Is there scope for saving energy without investment?
  - Is the size of the solar system proposed well justified?
  - Is there any possibility of demand management that is cost-effective?

- Importance of conducting periodical energy audit
  - Prices keep changing (electricity tariffs, appliance costs, etc.)
  - New opportunities arise
Audit process: Systems approach

- Check need
- Lighting
- Supplementary loads
- HVAC load
Site survey
Explaining the designing deficiency of balcony being exposed to the sun...
Entrance lights are on during the day time...
The fully glazed staircase capturing sunlight and heating up the inner space during morning hours…
Measurements
Explaining the functioning of the energy analyzer...
Assessing the energy performance of the laser printer...
A 2-Star air conditioner demanding higher power to deliver the same cooling...
Developing typical daily load pattern
Developing the base case with several assumptions...

### Base Case: Energy consumption of typical appliances/month

<table>
<thead>
<tr>
<th>Appliance</th>
<th>Demand (W)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
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<th>19</th>
<th>20</th>
<th>21</th>
<th>22</th>
<th>23</th>
<th>24</th>
<th>Total (kWh)</th>
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<tbody>
<tr>
<td>Standard tube lights</td>
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<td>Halogens</td>
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<tr>
<td>CFL</td>
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<td>Fans</td>
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<td>Air conditioners</td>
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<td>PCS+LCD</td>
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<tr>
<td>Printers (Laser)</td>
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<td>0</td>
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<td>0</td>
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<td>0</td>
</tr>
<tr>
<td>Inverter</td>
<td>2400</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>2</td>
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<td>4</td>
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<td>19</td>
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<td>23</td>
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</tbody>
</table>

Total elec. consumption: **176 kWh/day**

If investment is made on 15 kW solar system, the total cost would be 1.5 million Rs and one can expect to produce 63 kWh/day of solar electricity per day. The solar electricity would represent (63/176)% = 36% (Prosumption index)

**Solar PV system will cost INR1.5 million and will meet 36% of the daily electricity demand.**
Hourly electrical demand pattern

13.30 – 17.30
Day 2 Workshop Session
Share of electrical load in the building (base case)
Fossil Fuels 74%

Renewable Energy 36%
Analysis of an alternative option... scope for reducing the demand

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>Cost (USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficient tube lights</td>
<td>9000</td>
</tr>
<tr>
<td>LEDs</td>
<td>15600</td>
</tr>
<tr>
<td>CFL</td>
<td>3600</td>
</tr>
<tr>
<td>Efficient fans</td>
<td>19600</td>
</tr>
<tr>
<td>Efficient air conditioners</td>
<td>210000</td>
</tr>
<tr>
<td>Notebook computers</td>
<td>420000</td>
</tr>
<tr>
<td>Printers (Laser)</td>
<td>400</td>
</tr>
<tr>
<td>Inverter</td>
<td>1200</td>
</tr>
<tr>
<td>Total Investment</td>
<td>674200</td>
</tr>
</tbody>
</table>

13.30 – 17.30 Day 2 Workshop Session

AGP  Energy Positive Habitats  August 2012
Cost benefit analysis
Calculation of the cost of energy savings

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost/kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficient tube light</td>
<td>3.13</td>
</tr>
<tr>
<td>LED</td>
<td>1.51</td>
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<tr>
<td>CFL delamping</td>
<td>0</td>
</tr>
<tr>
<td>Efficient fans</td>
<td>2.24</td>
</tr>
<tr>
<td>Efficient air conditioner</td>
<td>5.19</td>
</tr>
<tr>
<td>Notebook computer</td>
<td>41.67</td>
</tr>
</tbody>
</table>

The only measure for which the cost of electricity saving is much greater than the cost of purchasing electricity!

So the notebook computer option is not retained. The total investment goes down to Rs 254,200 and the electricity consumption reduces to 115 kWh.

So we redo the calculation without including the substitution of personal computer by notebook computer.
Developing the load pattern by incorporating cost-effective energy saving options

<table>
<thead>
<tr>
<th>Calculation of the cost of savings without changing computers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investment (Rs)</td>
</tr>
<tr>
<td>Efficient tube lights</td>
</tr>
<tr>
<td>LEDs</td>
</tr>
<tr>
<td>CFL</td>
</tr>
<tr>
<td>Efficient fans</td>
</tr>
<tr>
<td>Efficient air conditioners</td>
</tr>
<tr>
<td>PC and LCD</td>
</tr>
<tr>
<td>Printers (Laser)</td>
</tr>
<tr>
<td>Inverter</td>
</tr>
<tr>
<td>Energy savings</td>
</tr>
<tr>
<td>Total Investment</td>
</tr>
</tbody>
</table>

Demand side investment (Rs 254,200) allows to reduce the daily electricity consumption from 176 kWh to 115 kWh per day.
This is equivalent to 34% Energy savings

A reasonably small demand side investment of INR 254,200 allows to reduce the energy consumption by 34%!
Auroville Green Practices

Demand, W

Hours of the day

13.30 – 17.30 Day 2 Workshop Session

Base Case

Energy Efficiency Case

Day 2 Workshop Session
Day 2 Workshop Session

Efficient tube lights 2%
LEDs 1%
CFL 1%
Efficient fans 3%

Inverter 5%
PC and LCD 6%
Printers (Laser) 0%

Energy savings 34%
Efficient air conditioners 48%

Share of electrical load in the building (efficiency case)
Investing the remaining capital on the solar PV system

Investment: 100,000 Rs/kW
Annual electricity production: 1,500 kWh/year
Elec. Production in 20 years: 30,000 kWh/life
Cost of solar electricity: 3.33 Rs/kWh

(not considering time value of money)

The remaining money is invested in the solar system (Rs1,500,000 - Rs 254,200) = Rs 1,245,800
This investment allows to set up a solar system of 12.45 kWp capacity.
Solar electricity production = 52.29 kWh/day

The solar electricity would represent (52/115)% = 45% (Prosumption index)

**A combination of demand side and supply side measure allows to increase the prosumption index from 36% to 45% for the same total investment of INR 1.5 million!**
Increase in prosumption index from 36% to 45% (no change in total investment)
Fossil Fuels (36%)

Renewable Energy
30% reduction (INR 1,245,800)

Energy Efficient Appliances
34% reduction (INR 254,200)
Recommendations
Divert a part of RE investment into Demand management: Reduce energy need before thinking “Solar”

- Replace T-8 fluorescent by T-5 tubes
- Replace halogen lamps by LEDs
- Replace fans with energy efficient fans
- Replace air conditioner by efficient air conditioners
- Increase temperature in air conditioners to 26 (and keep fans at low speed to increase air ventilation)
- Reuse water from air conditioners for building use

Invest the balance amount in solar
Why focus on Prosumption?

- Only with solar option,
- Solar contribution: 36%
- Prosumption index: 36%
- **Dependence on fossil fuel: 74%**

- With demand management and solar option,
- Energy efficiency: 34%
- Solar contribution: 30%
- Prosumption index: 45%
- **Dependence on fossil fuel: 36%**
Proposal for Innovative policy to promote prosumption

P-FiT

Prosumption feed-in tariff

So that every consumer is encouraged to become a producer