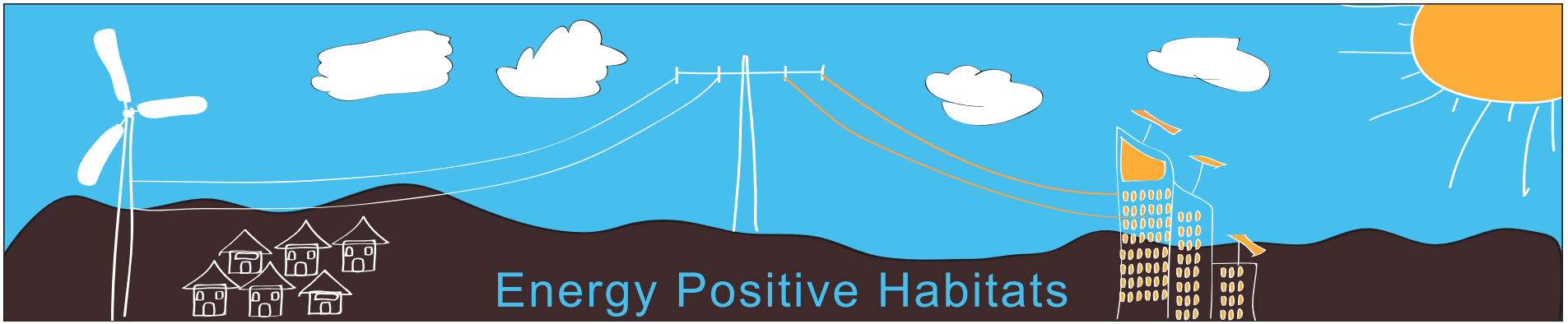
Auroville
Green Practices

A three-day workshop
30 Aug to 1 Sept, 2012
Auroville (near Pondicherry)



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 is 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

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09.00 – 12.30
Day 2 Workshop Session

Site survey

09.00 – 12.30
Day 2 Workshop Session

Explaining the designing deficiency of balcony being exposed to the sun…

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Day 2 Workshop Session

Entrance lights are on during the day time…

The fully glazed staircase capturing sunlight and heating up the inner space during morning hours…

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Measurements

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Explaining the functioning of the energy analyzer…

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Assessing the energy performance of the laser printer…

A 2-Star air conditioner demanding higher power to deliver the same cooling…

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13.30 – 17.30
Day 2 Workshop Session

Developing typical daily load pattern

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Developing the base case with several assumptions…

Base Case: Energy consumption of typical appliances/month

Appliance	Demand (W)	No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Total (kWh)
Standard tube lights	40	30									0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75								
Halogens	50	12	1	1	1	1	1	1													1.0	1.0	1.0	1.0	1.0	1.0	
CFL	36	20									0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75								
Fans	70	14									0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75								
Air conditioners	2500	6									0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9								
PCs+LCD	100	12									0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9								
Printers (Laser)	400	3									0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05								
Inverter	2400	1	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
Standard tube lights	40	30	0	0	0	0	0	0	0	0	900	900	900	900	900	900	900	900	900	0	0	0	0	0	0	0	8.10
Halogens	50	12	600	600	600	600	600	600	0	0	0	0	0	0	0	0	0	0	0	0	600	600	600	600	600	600	7.20
CFL	36	20	0	0	0	0	0	0	0	0	540	540	540	540	540	540	540	540	540	0	0	0	0	0	0	0	4.86
Fans	70	14	0	0	0	0	0	0	0	0	735	735	735	735	735	735	735	735	735	0	0	0	0	0	0	0	6.62
Air conditioners	2500	6	0	0	0	0	0	0	0	0	13500	13500	13500	13500	13500	13500	13500	13500	13500	0	0	0	0	0	0	0	121.50
PCs+LCD	100	12	0	0	0	0	0	0	0	0	1080	1080	1080	1080	1080	1080	1080	1080	1080	0	0	0	0	0	0	0	9.72
Printers (Laser)	400	3	0	0	0	0	0	0	0	0	60	60	60	60	60	60	60	60	60	0	0	0	0	0	0	0	0.54
Inverter	2400	1	720	720	720	720	720	720	720	720	720	720	720	720	720	720	720	720	720	720	720	720	720	720	720	720	17.28
			1320	1320	1320	1320	1320	1320	720	720	17535	17535	17535	17535	17535	17535	17535	17535	17535	720	1320	1320	1320	1320	1320	1320	175.82

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.

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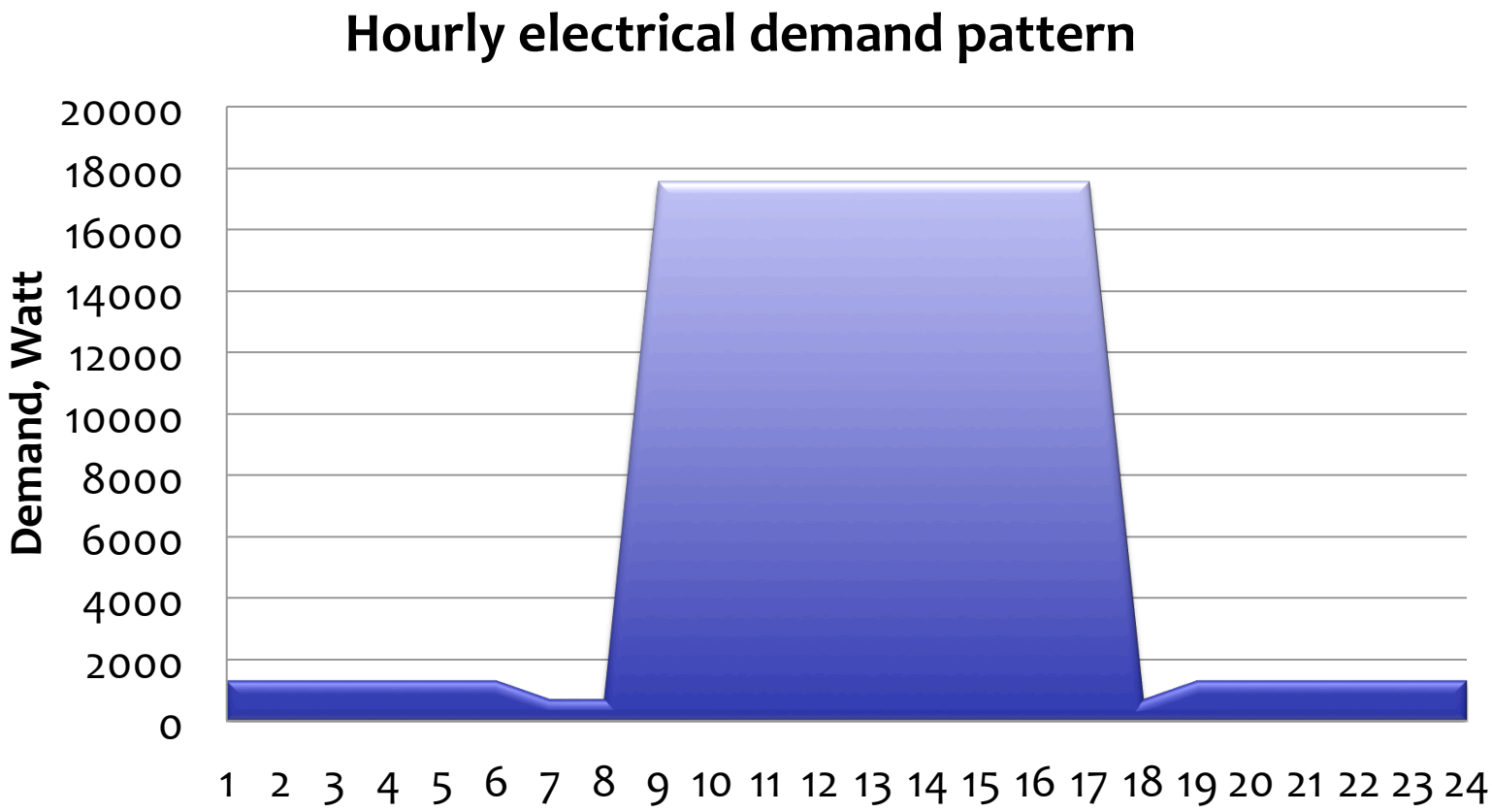
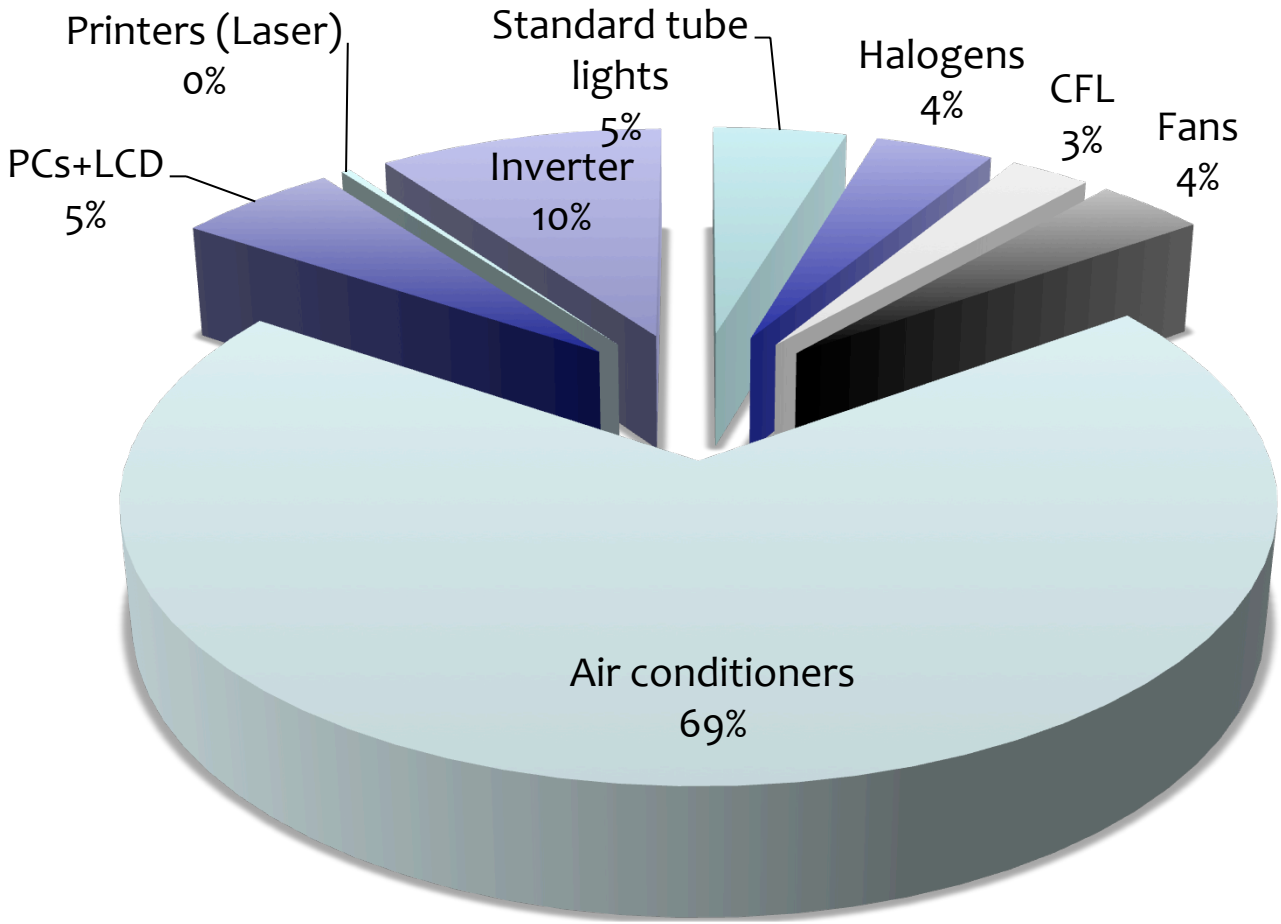
Day 2 Workshop Session





Share of electrical load in the building (base case)

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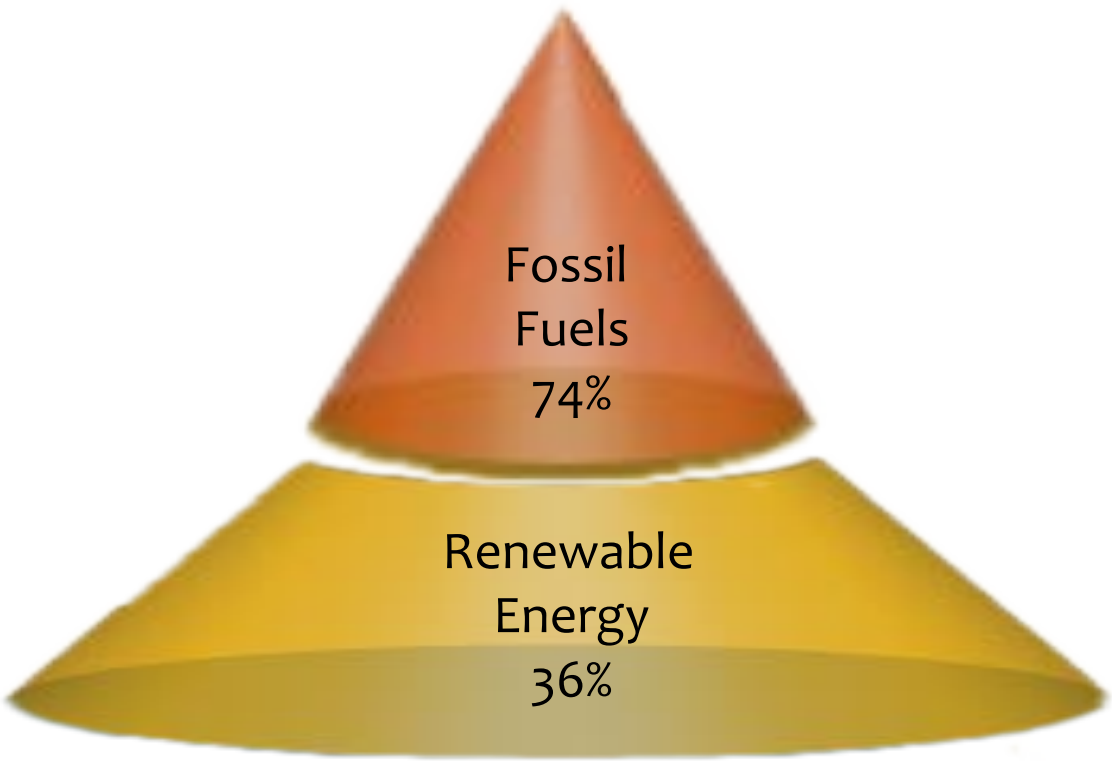

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13.30 – 17.30
Day 2 Workshop Session

Analysis of an alternative option… scope for reducing the demand

Efficient tube lights	9000	28	20	0	0	0	0	0	0	0	0	0	420	420	420	420	420	420	420	420	420	0	0	0	0	0	0	0	3.78
LEDs	15600	7	12	84	84	84	84	84	84	0	0	0	0	0	0	0	0	0	0	0	0	0	84	84	84	84	84	84	1.008
CFL	0	36	10	0	0	0	0	0	0	0	0	270	270	270	270	270	270	270	270	270	0	0	0	0	0	0	0	0	2.43
Efficient fans	19600	45	14	0	0	0	0	0	0	0	0	473	473	473	473	473	473	473	473	473	0	0	0	0	0	0	0	0	4.2525
Efficient air conditioners	210000	1750	6	0	0	0	0	0	0	0	0	9450	9450	9450	9450	9450	9450	9450	9450	9450	0	0	0	0	0	0	0	0	85.05
Notebook computers	420000	30	12	0	0	0	0	0	0	0	0	324	324	324	324	324	324	324	324	324	0	0	0	0	0	0	0	0	2.916
Printers (Laser)		400	3	0	0	0	0	0	0	0	0	60	60	60	60	60	60	60	60	60	0	0	0	0	0	0	0	0	0.54
Inverter		1200	1	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	8.64
Total Investment	674200			444	444	444	444	444	444	360	360	11357	11357	11357	11357	11357	11357	11357	11357	11357	360	444	444	444	444	444	444	444	108.617

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Cost benefit analysis

Calculation of the cost of energy savings

Efficient tube light	3.13	Rs/kWh
LED	1.51	Rs/kWh
CFL delamping	0	Rs/kWh
Efficient fans	2.24	Rs/kWh
Efficient air conditioner	5.19	Rs/kWh
Notebook computer	41.67	Rs/kWh

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

So the notebook computer option is not retained. The total investment goes down to Rs 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.

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Developing the load pattern by incorporating cost-effective energy saving options

Calculation of the cost of savings without changing computers

	Investment (Rs)																											
Efficient tube lights	9000	28	20	0	0	0	0	0	0	0	0	420	420	420	420	420	420	420	420	420	0	0	0	0	0	0	0	3.78
LEDs	15600	7	12	84	84	84	84	84	84	0	0	0	0	0	0	0	0	0	0	0	0	84	84	84	84	84	84	1.008
CFL	0	36	10	0	0	0	0	0	0	0	0	270	270	270	270	270	270	270	270	270	0	0	0	0	0	0	0	2.43
Efficient fans	19600	45	14	0	0	0	0	0	0	0	0	472.5	472.5	472.5	472.5	472.5	472.5	472.5	472.5	472.5	0	0	0	0	0	0	0	4.2525
Efficient air conditioners	210000	1750	6	0	0	0	0	0	0	0	0	9450	9450	9450	9450	9450	9450	9450	9450	9450	0	0	0	0	0	0	0	85.05
PC and LCD	0	100	12	0	0	0	0	0	0	0	0	1080	1080	1080	1080	1080	1080	1080	1080	1080	0	0	0	0	0	0	0	9.72
Printers (Laser)		400	3	0	0	0	0	0	0	0	0	60	60	60	60	60	60	60	60	60	0	0	0	0	0	0	0	0.54
Inverter		1200	1	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	8.64
Energy savings																												60.39
Total Investment	254200			444	444	444	444	444	444	360	360	12112.5	12112.5	12112.5	12112.5	12112.5	12112.5	12112.5	12112.5	12112.5	360	444	444	444	444	444	444	115.42

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%!

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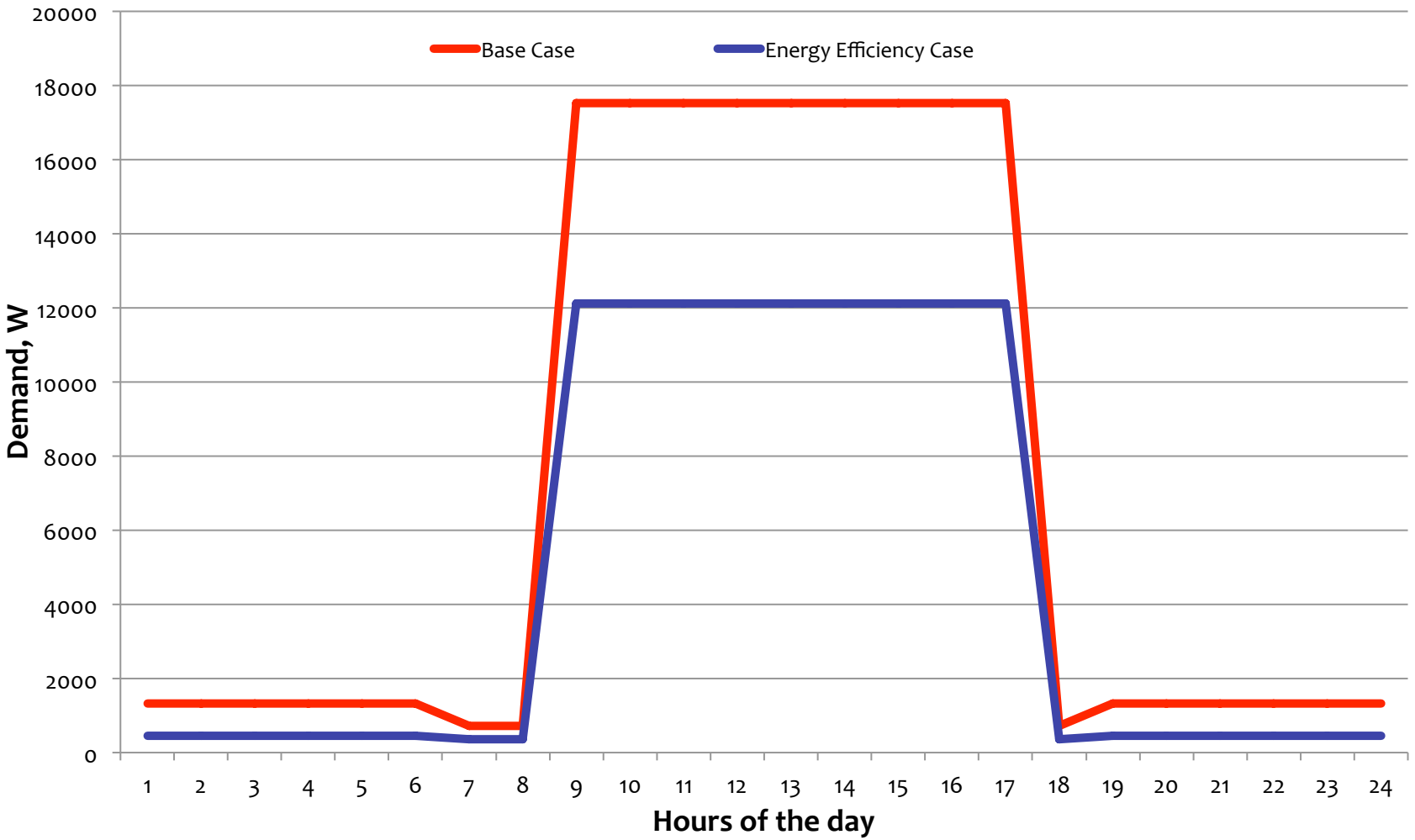
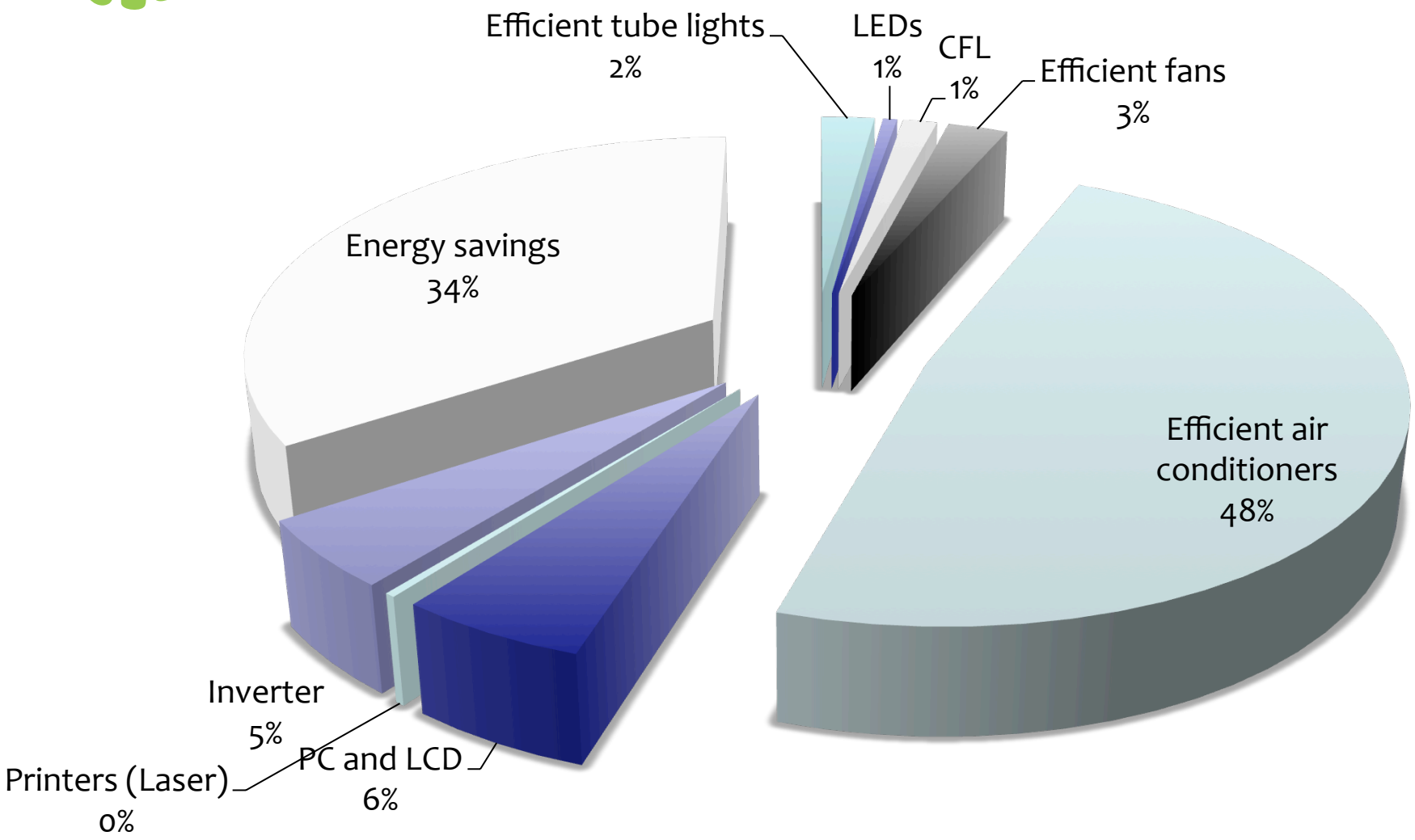




Share of electrical load in the building (efficiency case)

Investing the remaining capital on the solar PV system

Investment	100000	Rs/kW
Annual elec. Production	1500	kWh/year
Elec. Production in 20 years	30000	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

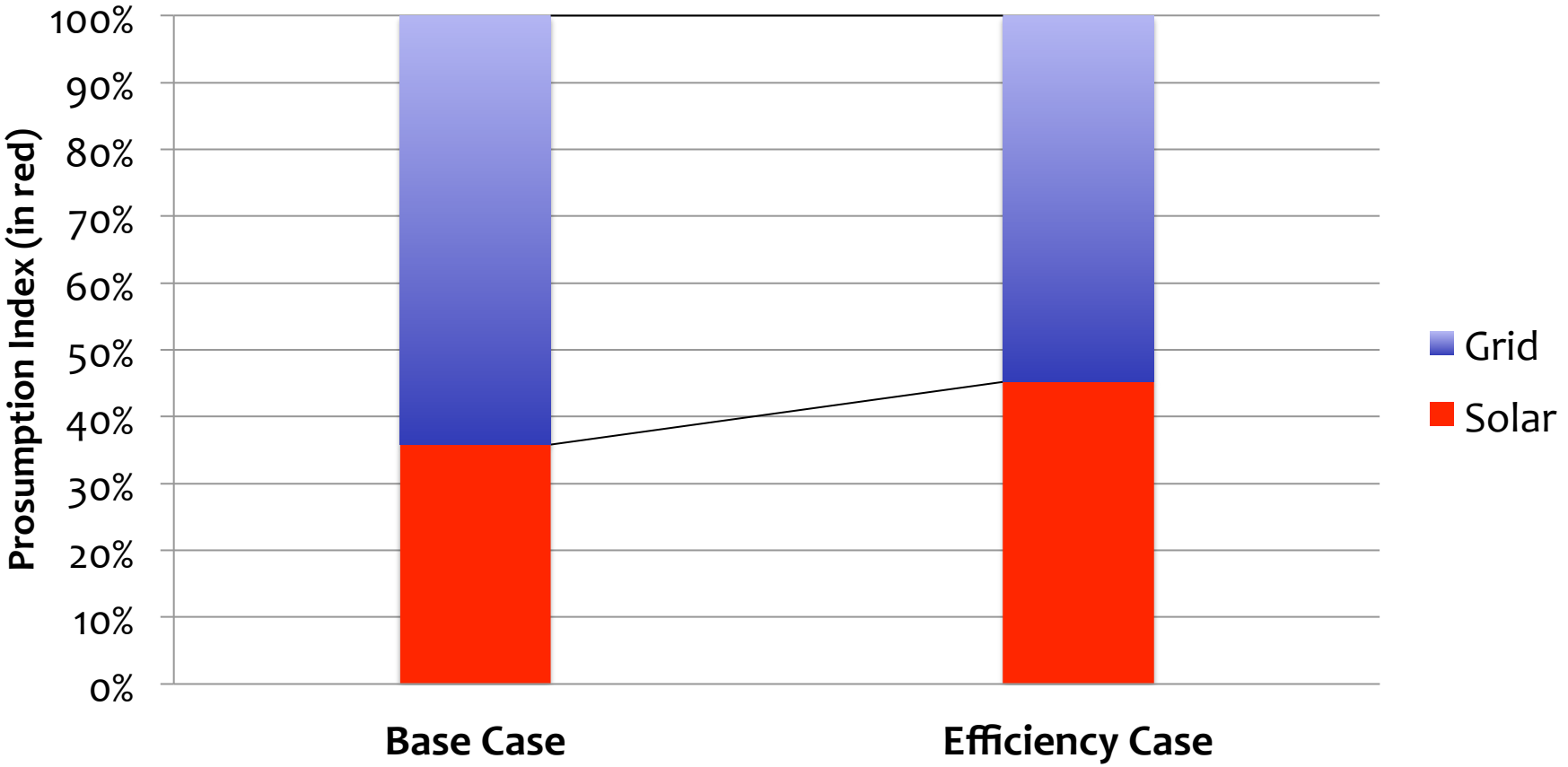
This investment allows to set up a solar system of 12.45 kWp capacity.

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)



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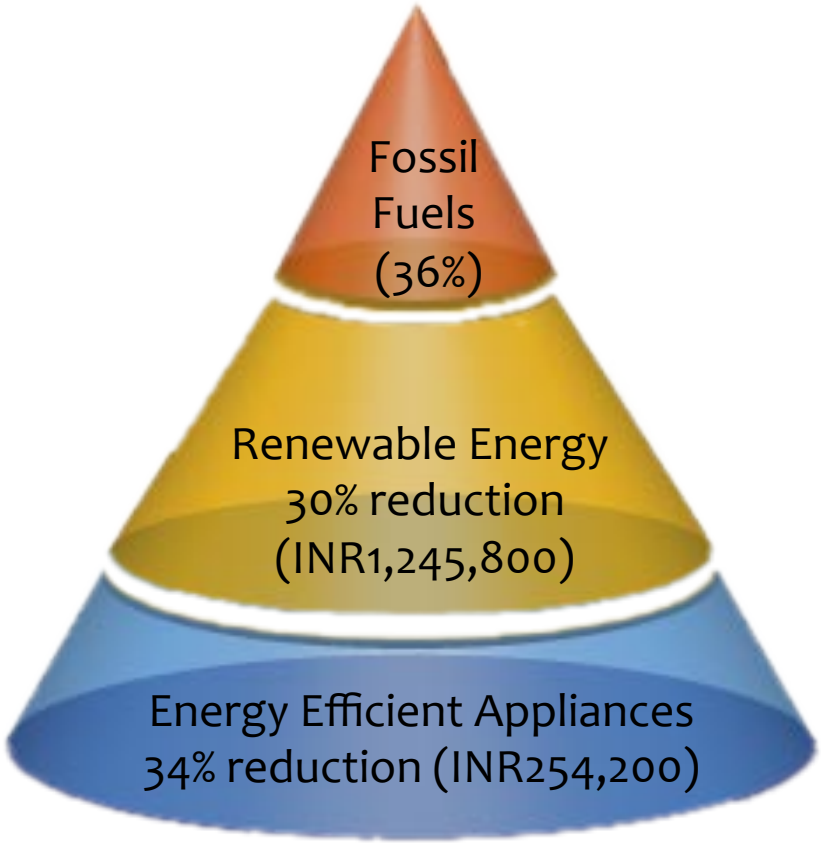

Recommendations

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%**

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Proposal for Innovative policy to promote prosumption

P-FiT

Prosumption feed-in tariff

So that every consumer is encouraged to become a producer