ENERGY CONSERVATION HANDBOOK

Prepared & Supported by:

Uttarakhand Renewable Energy Development Agency(UREDA)

University of Petroleum & Energy Studies, Dehradun

Bureau of Energy Efficiency, Ministry of Power, Govt. of India

This Energy Conservation Handbook is prepared for the participants of the Two Day National Level Workshop on "Energy Conservation – Policies & Initiatives", 28th Feb – 1st March , 2013, held at UPES, Dehradun. The contents of the Handbook has been contributed by UPES and UREDA ,with support from BEE, for providing a quick reference to Energy Conservation practices. No part of this publication may be stored or transmitted in any form without prior permission of the publisher.

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An Idea to energize all....

The guide aims to provide information needed to develop energy efficiency in Industrial, Commercial and Domestic sector.

The purpose is to

Promote improvement in energy efficiency in these sectors leading to a reduction in GHG (greenhouse gas) and a reduction in the incidence of fuel dependence.

Create awareness amongst the stakeholders to improve energy efficiency.

Provide up to date information on energy conservation and answer FAQ's.

Acknowledgment

We take this as a great opportunity to share with you this **"Handbook on Energy Conservation"** on the occasion of **Two Day National Workshop on Energy Conservation - Policies & Initiatives** held on 28th Feb-1st Mar 2013, at UPES Dehradun.

We are thankful to Bureau of Energy Efficiency (BEE) , Ministry of Power, Govt. of India, for providing the financial assistance and motivation to develop this handbook.

We would like to acknowledge and appreciate University of Petroleum & Energy Studies (UPES) Dehradun, for their technical support and assistance in compiling this Handbook.

Director
Uttarakhand Renewable Energy Development Agency (UREDA)
Department of Renewable Energy, Govt. of Uttarakhand

Introduction

If you want to save your business energy and money then you are reading the right book on Energy Conservation "Energy Conservation Handbook"

Almost all commercial building and industrial operations in India have areas of energy waste that can be greatly reduced by practical, energy–efficient upgrades. In a number of cases, enrichments to energy systems can improve comfort and productivity, as well as save energy and money.

The aim of this Energy Efficiency Handbook is to point out opportunities for energy savings and to improve energy efficiency of buildings and operations, and help obtain the correct assistance in identifying and implementing energy efficient projects.

Encapsulating the energy overview of the country and the state of Uttarakhand , this guide book offers solutions & recommendations for various sectors. In dedicated chapters of the Handbook, methods to reduce energy use in Commercial, Industrial, and the Domestic sectors are discussed.

Energy efficiency measures do not operate in isolation from one another. Here we discuss key energy efficiency measures, and how it is linked with efficient performance for the long term.

Some case studies are presented to underline the benefits accrued and facilitate learning from them .

Useful formulae of energy terms and conversions factors help calculate the energy consumption and perform calculations. In addition, the energy consumption tables, savings calculation table and payback calculation tables provide a handy and quick method to record & evaluate observations .

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Chapter 1

ENERGY SECTOR OVERVIEW

Energy is one of the most important building block in human development, and, as such, acts as a key factor in determining the economic development of all countries. In an effort to meet the demands of a developing nation, the Indian energy sector has witnessed a rapid growth.Areas like the resource exploration and exploitation, capacity additions, and energy sector reforms have been revolutionized. However, resource augmentation and growth in energy supply have failed to meet the ever increasing demands exerted by the multiplying population, rapid urbanization and progressing economy. Hence, serious energy shortages continue to plague India, forcing it to rely heavily on imports

- Driven by the rising population, expanding economy and a quest for improved quality of life, the total primary energy demand in India grows at 3.1% per annum on average in 2008-2035 and overall increase of 127 %.
- India's natural gas consumption is projected to rise from 8.5 % to 13 % in the period of year 2012-13 to 2021-22.The combination share of oil and natural gas in energy consumption was 24.7 % in 2011-12 and is expected to be same in 2021-22
- The use of coal for electricity generation in India is expected to increase by 1.5 %per annum during 2012-22, thus requiring an additional 66,600 MW of coal-fired capacity.
- Oil demand in India is expected to increase by 6-7% per annum during year 2012 - 25.

There is, therefore, an urgent need to conserve energy and reduce energy requirements by demand-side management and by adopting more efficient technologies in all sectors.

Despite increasing dependency on commercial fuels, a sizeable quantum of energy requirements (40% of total energy requirement), especially in the rural household , is met by non-commercial energy sources, which include fuel wood, crop residue, and animal waste, including human and draught animal power. However, other forms of commercial energy of a much higher quality and efficiency are steadily replacing the traditional energy resources being consumed in the rural sector.

Resource augmentation and growth in energy supply has not kept pace with increasing demand and, therefore, India continues to face serious energy shortages. This has led to increased reliance on imports to meet the energy demand.

The energy sector in India has been receiving high priority in the planning process. The ministry of power has set a target in the 11th Plan was 78700MW, but actual capacity added was only 54964MW. After the analysis of failures in the 11th plan, planning commission has issued IEP (Integrated Energy Policy) report projecting the energy requirements from 5.7% GDP rate. During 11th Plan actual capacity added was only 54964 MW against a target.

(Source: Integrated Energy Policy)

In the recent years, the government has rightly recognized the energy security concerns of the nation and more importance is being placed on energy independence.

UTTARAKHAND Energy Scenario

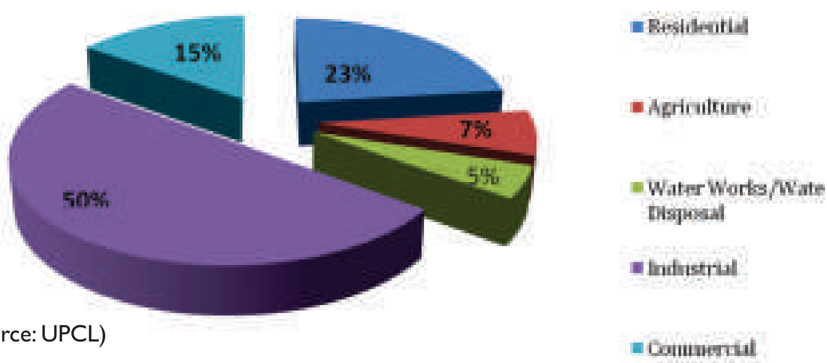
Uttarakhand State is richly endowed with natural renewable energy sources. These sources can be helpful for generating electricity. Most of this could be harnessed through environmentally clean Micro/Mini/Small Hydro Power Projects capacity up to 25 MW. In addition to this , the state has significant renewable energy sources that include Biomass/Agro residue, wind power , solar energy, cogeneration, Geothermal and Municipal Waste etc. There were 15761 inhabited villages as per 2001 census, out of 15761 villages 15593(98.9%) has been electrified under the RGGVY (Rajeev Gandhi grameen Vidhyutikaran yojna) till 30 june2012.

Power Supply Scenario

Particulars	Position
Average Daily Peak Load	1600 MW
Off peak load Demand	1466 MW
Net Generation from State	2410 MW
Daily Average Energy Demand	28 MU
Energy Availability	23 MU
Energy Deficit	5 MU

(Source: UPCL& CEA,UREDA)

Electrical Energy Consumption



(Source: UPCL)

The industrial and residential sector carries 20% and 15% energy conservation potential respectively.

Chapter 2

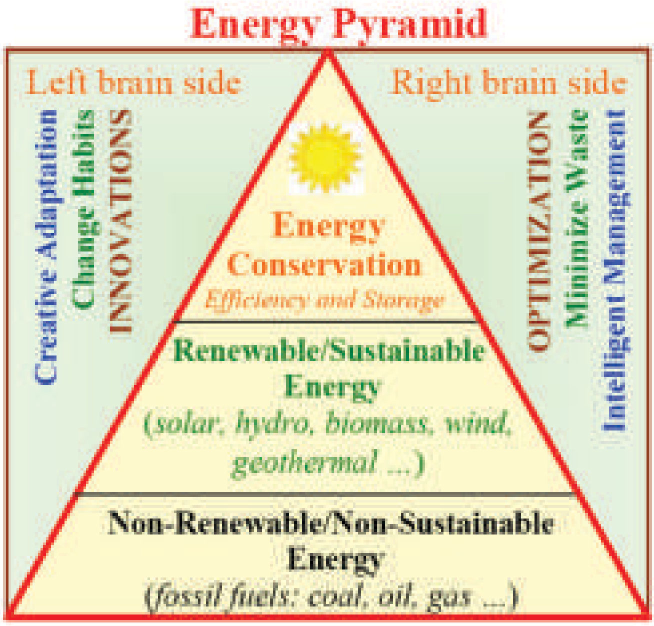
ENERGY MANAGEMENT AND ENERGY AUDIT

Energy Management

"The strategy of adjusting and optimizing energy, using systems and procedures so as to reduce energy requirements per unit of output while holding constant or reducing total costs of producing the output from these systems"

Objective of Energy Management

- To achieve and maintain optimum energy procurement and utilisation, throughout the organization
- To minimise energy costs / waste without affecting production & quality
- To minimise environmental effects.

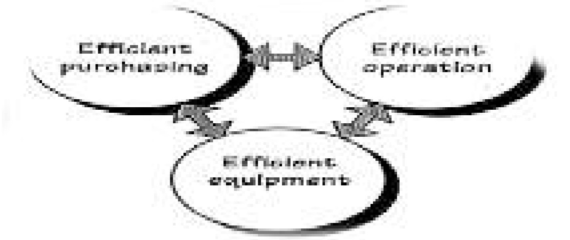


The basis of energy efficiency activities:

- To stop…… wastage
- To Decrease…… consumption
- To separate……intensity
- To look……over again and again and again........

Efficient energy use, sometimes simply called energy efficiency, is using less energy to provide the same level of energy service.

Energy efficiency and renewable energy are said to be the twin pillars of sustainable energy policy.



Energy Audit

Energy Audit is the key to a systematic approach for decision-making in the area of energy management. It attempts to balance the total energy inputs with its use,and serves to identify all the energy streams in a facility. It quantifies energy usage according to its discrete functions. Industrial energy audit is an effective tool in defining and pursuing comprehensive energy management programme.

Objectives

- How Much Energy Is Used?
- Where Is Energy Consumed?
- How Is It Used?
- How Can We Reduce Cost/ Consumption?
- How to Estimate Losses / Reduce Losses?
- Benchmarking For Various Processes/Systems?

PROCESS

START BUILDING A TEAM

↓

BE SPECIFIC ABOUT YOUR OBJECTIVE

↓

DRAFT AN AUDIT PLAN

↓

CONVERT PLAN INTO ACTIVITES

↓

TRAINING OF CONCERNED STAFF

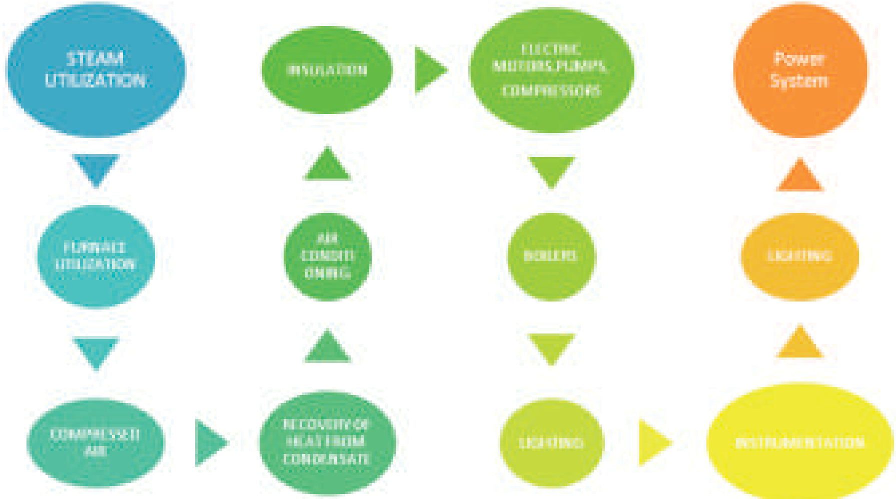
↓

BRING A CHANGE IN THE ATTITUDE

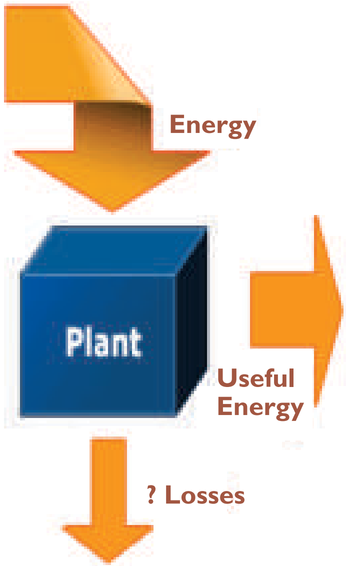
↓

INVOLVE PEOPLE UP THE LADDER AND DOWN THE LADDER

Areas generally covered in energy audit



TYPES



An analysis of existing energy consumption records to determine where, how and how much energy is being used in the plant. It will also seek to identify trends in consumption data.

A walk through audit that documents where the main areas of energy consumption exist within the plant. This phase will identify any obvious areas of wastage together with the most promising areas for potential savings.

Detailed analysis phases which will take the data obtained in the previous two phases and prepare detailed plans for energy savings options. These plans will include details on the energy use and cost of each stage of the production process as well as costing and expected payback periods of the various energy saving options proposed.

Energy Monitoring

"You can't manage what you don't measure". It essentially combines the principles of energy use and statistics.

Recording - Analyzing - Comparing - Monitoring - Controlling

The Metering system implementation has 3 basic elements

- The Consumer Energy Meter (CEM)
- The Meter Reading Instrument (MRI,
- The Base Computer System (BCS) for information management.

Monitoring and Targeting is a management technique in which all plant and building utilities such as fuel, steam, refrigeration, compressed air, water, effluent, and electricity are managed as controllable resources.

Chapter 3

Conservation Tips : DOMESTIC SECTOR

The following table shows the energy consumption of various appliances normally used home:

Appliances	Rating (Watts)	Operating Hrs/Day	Units/ Month
Incandescent Bulbs	40	6	7
	60	6	11
Flucrescent Tube light	40	10	12
Night Lamp	15	10	4.5
Mosquito Repellent	5	10	1.5
Fans	60	15	27
Air Coolers	175	8	42
Air Conditioners	1500	6	270
Refrigerator	225	15	101
Mixer/Blender/	450	1	13.5
Toaster	800	0.5	12
Hot Plate	1500	0.5	22.5
Oven	1000	1	30
Electric Kettle	1500	1	45
Electric Iron	1500	1	45
Water heater-Instant type (1-2 Ltr capacity	3000	1	90
Water heater-Storage type (10-20 Ltr capacity)	2000	1	60
Immersion rod	1000	1	30
Vacuum Cleaner	700	0.5	11
Washing Machine	300	1	9
Water pump	750	1	22.5
TV	100	10	30
Audio system	50	2	3

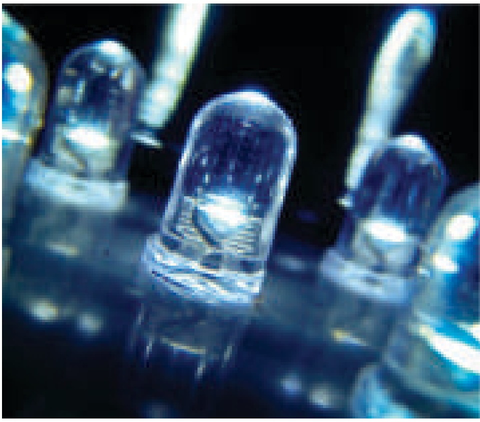
The Energy Rating label enables consumers to compare the energy efficiency of domestic appliances on a fair and equitable basis.

The Energy Rating Label has two main features:

- The star rating gives a quick comparative assessment of the model's energy efficiency.
- The comparative energy consumption (usually kilowatt hours/year) provides an estimate of the annual energy consumption of the appliance based on the tested energy consumption and information about the typical use of the appliance in the home. Air conditioners show the power consumption of the appliance (kW or kWh/year).

LIGHTING SYSTEM

1. Turn off lights when not required.
2. Fluorescent tube lights and CFLs convert electricity to visible light up to 5 times more efficiently than ordinary bulbs and also save about 70% of electricity for the same lighting levels.
3. Electronic ballasts can reduce power consumption by 20%.
4. Consider employing infrared sensors, motion sensors, automatic timers, dimmers and solar cells wherever applicable, to switch on/off lighting circuits.
5. 90% of the energy consumed by an ordinary bulb (incandescent lamp) is given off as heat rather than visible light.
6. Use task lighting, which focuses light where's it's needed. A reading lamp, for example, lights only reading material rather than the whole room.
7. Dirty tube lights and bulbs reflect less light and can absorb 50 per cent of the light; dust your tube lights and lamps regularly.
8. You can cut consumption by 10%-50% with T-5, slim tube lights that are star rated by BEE.
9. Use artificial lighting only when there is inadequate natural light in a space.
10. Use outdoor lights with timers or photocells so that they turn off automatically in day light.



LED LIGHTS

LED bulbs are rapidly expanding in household use .Energy efficient LEDs use only 20%-30% of the energy and last up to 25 years than traditional incandescent bulbs. In addition to standard screw in bulb, you will find LED in Lamp desk, kitchen under cabinet lightning , and even in holiday light strings

Comparison of power consumption and brightness

Incandescent Watts	CFL Watts	LED Watts	Lumens(Brightness)
40	8 – 12	4 – 5	450
60	13 – 18	6 – 8	890
75 - 100	18 – 22	9 – 13	1210
100	23 – 30	16 – 20	1750
150	30 – 55	25 – 28	2780

SAMPLE CALCULATIONS

CFL – Comparison of power generation vis-a-vis power savings

In case the Uttarakhand state electricity utility replaces 100W GLS lamps by CFLs of 20 Watt each for one million consumers, the savings would be

Load demand for GLS	100W
100 MWReduced Load demand for CFL	20W
20 MWSaving in power generation	80 MW
Saving in cost of generation @Rs.5crore/MW (overlooking cost of T&D and consequential losses)	Rs 400 crore
CroresCost of one million CFLs @ Rs.150/- each	Rs15 Crores
Savings in investment	Rs. 385 Crores
Saving in annual power consumption of power (4 Hrs/day for 300 days @ Rs.4/- per kwh)	Rs 38.4 Crores

TUBE LIGHTS LABELING

The measured values will be converted to star ratings for each point i.e. at 100 hours, 2000 hours, 3500 Hours and the average of the 3 ratings will be taken. This will be rounded of (<0.5 to lower level and =>0.5 to higher level) to the nearest integer which will be the star rating for the product

The star rating plan for tube lights is as follows:

STAR RATING	*	**	***	****	*****
Lumens per Watt at 0100 hrs of use	<61	>=61 & <67	>=67 & <86	>=86 & <92	>=92
Lumens per Watt at 2000 hrs of use	<52	>=52 & <57	>=57 & <77	>=77 & <83	>=83
Lumens per Watt at 3500 hrs of use	<49	>=49 & <54	>=54 & <73	>=73 & <78	>=78

If we consider 40W tube light, It will give up 2450 lumens in a room then the consumption for different rating can be find out as below,

Case I – single star

Lumens per watt = 52

The consumption by tube light = 48W

Working hours for 2000 hrs, total energy consumption per year will be = 1152 Units

Case II – Five star

Lumens per watt = 85

The consumption by tube light = 29W

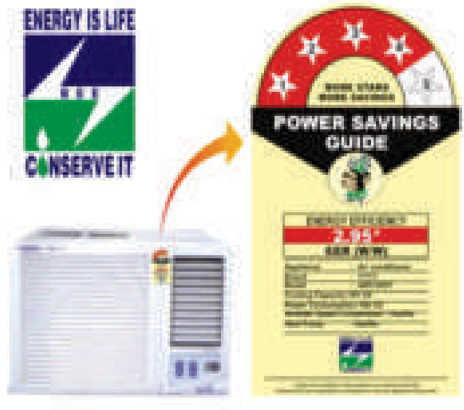
Working hours for 2000 hrs, total energy consumption per year will be = 696 Units

AIR CONDITIONERS

1. Use BEE star labelled products.
2. Use ceiling or table fan as first line of defence against summer heat. Ceiling fans, for instance, cost about 30 paisa an hour to operate – much less than air conditions (Rs.10.00 per hour).
3. One will use 3 to 5 per cents less energy for each degree air conditioner is set above 22°C (71.5°F), so far set the thermostat of room air conditioner at 25°C (77°F) to provide the most comfort at the least cost.
4. Reduce air-conditioning energy use by as much as 40 per cent by shading your home's windows and walls. Plant trees and shrubs to keep the day's hottest sun off your house.
5. Using ceiling or room fans allows you to set the thermostat higher because the air movement will cool the room.
6. A good air conditioner will cool and dehumidify a room in about 30 minutes, so use a timer and leave the unit off for some time.
7. Clean the air-conditioner filter every month. A dirty air filter reduces airflow and may damage the unit. Clean filters enable the unit to cool down quickly and use less energy.
8. Have your air conditioning unit checked every 6 months. If the Freon level is not correct, you will waste a lot of energy and your home will never be as cool as you want it.
9. The gaps around the windows and doors leads to A C loss. You can use a candle to look for drafts. It the flame flickers or dances, found the place to seal.
10. Draperies on windows help reduce energy loss.
11. Use electronic devices with occupancy sensors which switch on or off automatically by sensing if the room is occupied.
12. Switch to evaporative coolers from air conditioners during hot/dry summer months.
13. Buy split ACs instead of window ACs. They cost more, but they are more energy efficient and consume lesser electricity.
14. Do not install AC units on the west and south walls as these are exposed to direct sunlight through a major part of the day during summers.
15. Do not apply dark colours on the external surfaces (roof and walls) of the house. Dark colours absorb more heat than light colours, leading to increased use of the AC.
16. Ensure that the condenser of the unit must have enough space around it for air to circulate and help the refrigerant dissipate its heat easily.

AIR CONDITIONERS LABELING

It is important to buy an air conditioner that is the correct size for the room. Air conditioners remove heat and humidity from the air. Humidity is removed when the air in a room passes over the cooling coils of an air conditioner. If the unit is too large, it will cool the room quickly, but only remove a portion of the humidity. This leaves the room with a damp, clammy feeling to the air, since the air will not have been circulated enough. A properly sized unit will remove humidity effectively as it cools. Running a smaller unit for a longer time will use less energy to completely condition a room than running a larger unit for a shorter time.



The key measure of energy performance for labeling of air conditioners is the product's EER (Energy Efficiency Ratio). EER is the cooling capacity versus the power consumed. Thus higher the EER, better the energy efficiency of an air conditioner. Both types of air conditioners (window and split) are covered by BEE energy labeling programme. Due to the presence of large and organized manufacturers, some major brands have already qualified for a 5-star rating.

	EER (W/W)	EER (W/W)STAR
RATING BAND	MIN	MAX
1 STAR *	2.50	2.69
2 STAR**	2.70	2.89
3 STAR ***	2.90	3.09
4 STAR ****	3.10	3.29
5 STAR *****	3.30	

COOLING CAPACITY REQUIRED = 1.5 Ton = 5.25 KW
(cooling capacity in kw)

For Single star, Total power required = 5.25 / 2.5 =2.1 Kw

For Five star, Total power required = 5.25/3.3 = 1.59 Kw

REFRIGERATOR

1. Use BEE star labelled products.
2. Keep your refrigerator and freezer at the right temperature. If they are only 2-3 degrees colder than necessary, energy consumption may go up by approx 25%.
3. Make sure the door is sealed tightly. When it's dark, place a lit flashlight inside the refrigerator and close the door. If light around the door is seen, the seals need to replaced.
4. Make sure that the refrigerator is not place against outside facing wall or walls exposed to the direct sunlight.
5. Refrigerator motors and compressors generate heat, so allow enough space for continuous airflow around refrigerator. If the heat can't escape, the refrigerator's cooling system will work harder and use more energy.
6. Do no put uncovered liquids in the refrigerator. The liquids give off vapours that add to the compressor workload.
7. Allow hot food to cool off before putting it in the refrigerator.
8. Think about what you need before opening refrigerator door. You'll reduce the amount of time the door remains open.
9. Make sure that refrigerator's rubber door seals are clean and tight. They should hold a slip of paper snugly. If paper slips out easily, replace the door seals.
10. When dust builds up on refrigerator's condenser coils, the motor works harder and uses more electricity. Clean the coils regularly to make sure that air can circulate freely.
11. Defrost freezer compartment regularly for a manual defrost refrigerator.
12. Make sure that you are using a refrigerator that is approximately sized for your needs. If your fridge is too small, you may be overworking. If it is too large, then you are potentially wasting energy and home space.

In a frost-free system

- Cooling is provided by forced air circulation.
- The system is automatically operated to prevent permanent formation of frost on all refrigerated surfaces and
- No accumulation of ice or frost forms on stored food.

REFRIGERATOR LABELING

Energy efficiency standards and labeling for refrigerators in India was implemented initially, as a pilot project, for frost-free refrigerators, keeping in view the growing market share of this category. For refrigerators, comparative labeling was considered and implemented (and not endorsement labeling) keeping in view of the wide range of energy consumption of different brands. The energy label affixed to refrigerators includes information on brand, model, T=type, gross & storage volume as well as the standard test method used for arriving at average annual energy consumption as marked on the centre of the energy label.

Energy labeling for the direct-cool category of refrigerators has also been implemented. This extends the star label to the product category (direct-cool refrigerators) that presently has the major market share. Since refrigerators remain switched-on throughout the year, the nominal consumption and star rating has been calculated based on the annual electricity consumption.

The label will mention the following

1. Appliance: Refrigerator
2. Energy Consumption per Year (CEC)
3. Model Name/Number, Year of Manufacturing
4. Brand
5. Type
6. Gross Volume
7. Storage Volume

Similar to air conditioner, the energy consumption for different star rating can be calculated

	EER (W/W)	EER (W/W)
STAR RATING BAND	MIN	MAX
1 STAR *	2.30	2.49
2 STAR **	2.50	2.69
3 STAR ***	2.70	2.89
4 STAR ****	2.90	3.09
5 STAR *****	3.10	

OVENS / MICROWAVE OVEN

1. Microwaves use around 50% less energy than conventional ovens: they're most efficient for small portions or defrosting.
2. Check the seal on your oven door to see if there are cracks or tears in it.
3. Develop the habit of "lids-on" cooking to permit lower temperature settings.
4. Carefully measure water used for cooking to avoid having to heat more than is needed.
5. Begin cooking on highest heat until liquid begins to boil. Then lower the heat control settings and allow food to simmer until fully cooked.
6. Rearrange oven shelves before turning your oven on – and don't peep at food in the oven. Every time you open the oven door, 4°-5° is lost.
7. When preheating an oven for baking, time the preheat period carefully. Five to eight minutes should be sufficient.
8. For large items, stove-top cooking is most efficient, especially with gas.
9. Microwaves cook food from the outside edge toward the centre of the dish, so if you're cooking more than one item, place larger and thicker items on the outside.

WASHING MACHINE

1. Washing machines can account for as much as 20% of the electricity you use.
2. Use Cold water, as almost 90% of the energy consumed by washing machines goes to heating the water. Set the washing machine temperature to cold or warm and the rinse temperature to cold as often as possible.
3. Each was cycle uses up to 60 to 90 litres of water. Use washing machine on full load and plan washing periodicity to save on water too.
4. Adding too much detergent actually hampers effective washing action and may require more energy in the form of extra rinses.
5. Wash only full loads of clothing-but do not overload machine. Sort laundry and schedule washes so that a complete job can be done with a few cycles of the machine carrying its full capacity, rather than a greater number of cycle with light loads.
6. Soak or pre-wash the cloths for effective cleaning.

GEYSER / WATER HEATER

1. Install Solar Water Heating System.
2. By reducing the temperature setting of water heater from 60 degrees to 50 degrees C, one could save over 18 per cent of the energy used at the higher setting.
3. To help reduce heat loss, always insulate hot water pipes, especially where they run through unheated areas. Never insulate plastic pipes.
4. A dripping faucet wastes water and if it's dripping hot water, its wasting energy too. Often requiring nothing more then a new washer, fixing leaks is one of the quickest and least expensive ways of reducing the energy and water bills.
5. Another way to reduce waste is to take showers or baths depending on which uses less hot water then baths, other say baths use more. They are both right. Which is correct for you depends on how long and hot your showers are and how deep and warm your baths are.
6. Using less hot water may be easier than you think. Water conserving shower heads and faucet aerators can cut hot water use in half. To see if this will work for you, first determine what your faucet and shower flow rates are now.
7. To select the right water heater for your home, you need to consider family size and whether your usage would be considered high or low demand. It is assumed that you know your family size, so all you have to determine is your usage profile.

The Star Rating plan for a stationary type storage electric water heaters shall be based on the Standing Losses (kwh/24hour/45 oC difference) calculated the as per IS 2082:1993. The star rating plan is as indicated below:

Rated Capacity(Liters)	1 Star	2 Star	3 Star	4 Star	5 Star
	Standing Losses (kwh/24 hour/45°C)				
6	≤ 0.792 & >0.634	≤ 0.634 & >0.554	≤ 0.554 & >0.475	≤ 0.475& >0.396	≤ 0.396
10	≤ 0.990&>0.792	≤ 0.792&>0.693	≤ 0.693&>0.594	≤ 0.594&>0.495	≤ 0.495
15	≤ 1.138&>0.910	≤ 0.910&>0.797	≤ 0.797&>0.683	≤ 0.683&>0.569	≤ 0.569
25	≤ 1.386&>1.109	≤ 1.109&>0.970	≤ 0.970&>0.832	≤ 0.832&>0.693	≤ 0.693
35	≤ 1.584&>1.267	≤ 1.267&>1.109	≤ 1.109&>0.950	≤ 0.950&>0.792	≤ 0.792
50	≤ 1.832&>1.466	≤ 1.466&>1.282	≤ 1.282&>1.099	≤ 1.099&>0.916	≤ 0.916
70	≤ 2.079&>1.663	≤ 1.663&>1.455	≤ 1.455&>1.247	≤ 1.247&>1.040	≤ 1.040
100	≤ 2.376&>1.901	≤ 1.901&>1.663	≤ 1.663&>1.426	≤ 1.426&>1.188	≤ 1.188
140	≤ 2.673&>2.138	≤ 2.138&>1.871	≤ 1.871&>1.604	≤ 1.604&>1.337	≤ 1.337
200	≤ 2.970&>2.376	≤ 2.376&>2.079	≤ 2.079&>1.782	≤ 1.782&>1.485	≤ 1.485

COMPUTER

1. Computer that runs 24 hours a day, for instance, used-more power than an energy efficient refrigerator.
2. Screen savers save computer screens, not energy. Start-ups and shutdown do not use any extra energy, nor are they hard on your computer components. In fact, shutting computers down when you are finished using them actually Reduces system wear and saves energy.

3. Purchase flat-screen LCD monitors.
4. Setting computers, monitors and copiers to sleep-mode when not in use helps cut energy costs by approximately 40%
5. Activate and standardize 'power down' on new and existing PCs
6. If your computer must be left on, turn off the monitor; this device alone uses more than half the system's energy.

It is calculated that,

More than half of the power consumed by a desktop PC is wasted as heat. Even servers, that are typically more efficient than desktops, waste 30-40% of the power that they utilize. One of the prominent reasons behind this wastage is that although desktop PCs are set up to sleep or hibernate when inactive, about 90% of the time this functionality has been disabled. This results in higher energy consumption and an increase in electricity usage. In addition, IT users lack awareness about power saving features, which are already available in their computers.

CEILING FAN

1. Replace conventional regulators with electronic regulators for ceiling fans.

2. Height of the fan relative to the ceiling. If fan is too close to the ceiling, the airflow is restricted; that is, the fan will not be able to draw as much air through its blade as it has the potential to do. For this reason, "Hugger" style fans (those which mounted directly to the ceiling without the use of down rod) are all inherently disadvantaged. The distance that a fan should be mounted form the ceiling is directly correlated with its air moving potential; no fan should be mounted with its blade closer than 24 inches to the ceiling.

3. Pitch of the fan's blades. The angle at which the fan's blades tilted relative to X axis is referred to as the blade pitch. The steeper the pitch the greater the air flow. Since increased pitch also means increased drag, only fans with well made motors can support steep pitches. Cheaply made fans typically have a pitch between 9 and 13 degrees.

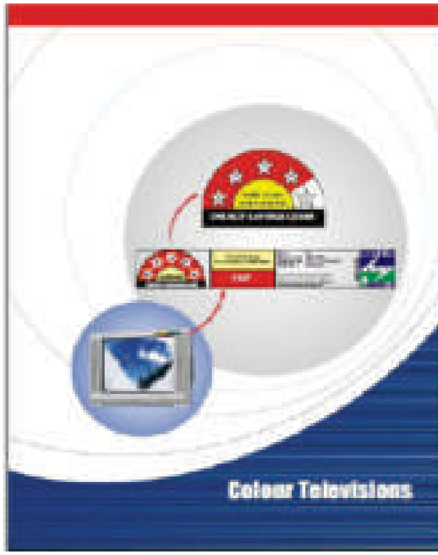
The star rating plan for ceiling fans is as follows:

Star Rating Index Calculation for Ceiling Fans	
Star Rating	Service Value for Ceiling Fans*
1 Star	≥ 3.2 to < 3.4
2 Star	≥ 3.4 to < 3.6
3 Star	≥ 3.6 to < 3.8
4 Star	≥ 3.8 to < 4.0
5 Star	≥ 4.0

* Where x is the base service value as per IS 374:1979. BEE has proposed a base service value of 3.2 at present and would upgrade it to higher value once the BIS value is finalized. *The BIS has proposed from the year 2010 the service value of 3.5.

* All ceiling fans covered under this standard shall comply with minimum Air Delivery of 210 cu m/min.

COLOR TELEVISION



1. Switch off your TV when you're not watching, this will do more to reduce energy use than anything else.
2. Manufacturers have improved standby efficiency - in most new TVs energy usage is typically below 1 watt - so this is an option if you have a new TV, but if you have an older model, this mode may be using energy unnecessarily.
3. Switch in to standby is better than leaving your TV on, but it's still more energy-efficient to switch it off completely.
4. Make sure the brightness of your TV is right for your room as the factory settings are typically brighter than necessary.
5. If you're listening to the radio through your TV, make sure you use the radio screen blanking feature - it's a handy way to save energy.
6. If you're buying a new TV, think about the size and type of screen you choose. An energy-efficient 32-inch LCD will typically use half the power of a model with a 42-inch plasma screen.
7. In general, the smaller your TV, the less it will cost you to run.
8. If you're buying a new TV, look for the energy-saving Trust recommended label, that way you can be sure you are buying a TV with optimized energy-saving features

The Star Rating Bands for LCD and Plasma TVs of typical Screen Size

Screen Size (cm)	Screen Area (sq cm)	Max Annual Power Consumption for 1 Star (kWh/Year)	Max Annual Power Consumption for 2 Star (kWh/Year)	Max Annual Power Consumption for 3 Star (kWh/Year)	Max Annual Power Consumption for 4 Star (kWh/Year)	Max Annual Power Consumption for 5 Star (kWh/Year)
		P = (0.984 x A) + 4.38	P = (0.876 x A) + 4.38	P = (0.788 x A) + 4.38	P = (0.701 x A) + 4.38	P = (0.613 x A) + 4.38
50.8	434.1	169	154	139	124	109
66.0	733.8	283	257	232	207	181
81.3	1111.5	425	388	349	311	273
94.0	1485.9	568	517	465	414	363
106.7	1914.7	731	665	598	533	466
116.8	2296.7	878	798	717	638	559
127.0	2713.2	1034	940	846	753	659
139.7	3283.2	1250	1137	1023	910	797

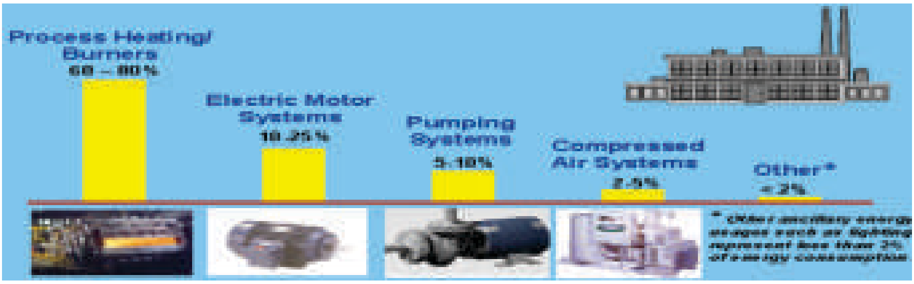
TRANSPORT

1. To obtain optimum fuel consumption, maintain car speed as far as possible, between 55 to 60 km per hour.
2. Do not use choke, unless necessary (only necessary in cold season or, if car is not properly turned).
3. When choke is used, put it off as soon as engine is warmed up.
4. Always start in 1st gear (to get max. power). Run up to appx. 10 km. per hour before changing to 2nd gear; 20/25 km.p.h. before changing to 3rd and about 30/32 km.p.h. before changing to 4th gear.
5. After braking to reduce speed, unless the car is brought to a dead stop, don't use first gear but only second or third depending upon the speed.
6. Never race engine when declutched. Declutch fully when changing gears. Never ride on clutch pedal (this increases clutch wear and fuel consumption).
7. Apply brakes gradually as far as possible. Break speed by changing to lower gears.
8. Anticipate need for braking.
9. Release clutch pedal gradually and simultaneously press accelerator to avoid engine racing and car jerking shuddering.
10. Avoid frequent starts/stops, to reduce fuel consumptions, battery wastage, and starter overheating/failure.
11. Don't run on hand-break – preferable install a warning light device.
12. Switch to lower gears on gradients (up/down) at the right time when you find the vehicle dragging / speeding.

Chapter 4

Conservation Tips : INDUSTRY

The industrial sector alone accounts for about 50% of the commercial energy. It uses both, the thermal and electrical energy in various equipments like boilers, compressors, furnaces, diesel generating engines, motors, pumps, refrigeration etc.



The strategies for achieving energy savings in industry are quite different to those for most other sectors. Industry is very diverse and is often controlled by very large multi-national corporations. In this context the appropriate approach needs to be carefully considered. Industry is generally receptive to efforts to cut its energy costs but it is less likely to be attracted to regulatory measures that increase its operating costs.

The industrial sector consumes about 33 per cent of the total electrical energy consumed in the country.

Energy Efficient Motor

Steps to Improving Electric Motor System Efficiency

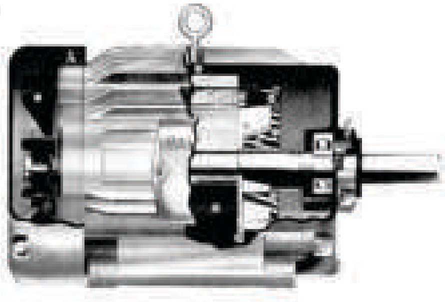
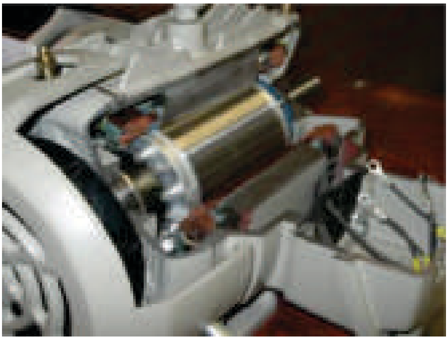
- Use Adjustable Speed Drives (ASDs) or two-speed motors where appropriate.
- Consider load shedding.
- Consider replacing existing V-belts with cogged belts.
- Choose energy-efficient motors for new applications. Consider replacement vs. repair for older, inefficient motors.
- Match motor operating speeds, and size motors for overall system efficiency.

Tips for energy saving

- The motors should be energy efficient.
- Convert delta to star connection for lightly loaded motors.
- Install soft start-cum-energy saver for lightly loaded motors.
- In case of centrifugal-blower pump, install variable voltage frequency (VVVF) drives for speed control of motors.
- Install multi speed motor.
- Optimize operating voltage level of motor for lightly loaded motors
- Replace eddy current controls with variable frequency drives for varying speed driven equipment?
- Provide interlock for electric motor to avoid idle running
- Replace motor generating sets with thyristor drives.
- Avoid frequent rewinding of motors. Greater the number of rewind, lesser the efficiency.
- Carry out preventive maintenance and condition monitoring schedule regularly.

Energy Efficient Motors

Energy-efficient electric motors reduce energy losses through improved design, better materials, and improved manufacturing techniques. Replacing a motor may be justifiable solely on the electricity cost savings derived from an energy-efficient replacement. This is true if the motor runs continuously, power rates are high, the motor is oversized for the application, or its nominal efficiency has been reduced by damage or previous rewinds.

Advantages of Energy Efficient Motors

- Reduced operating costs
- Less heat losses
- Extended winding lifespan
- Extended lubricating grease service life
- Lower noise levels than other motors
- Reduced energy costs. The higher purchase price investment pays off.

A. Existing standard motor details

Rating = 9.3 kW

Full load efficiency = 87%

B. Proposed energy efficient motor

Rating = 9.3 kW

Full load efficiency = 90%

B. Associated energy savings

Reduction in input power = (9.3/0.87)-(9.3/0.90)=0.356 kW

Annual energy saving = 2563kWh (@7200 hrs./year)

Annual saving in energy charges =Rs.10252 (@Rs.4/unit)

Investment in new motor = Rs. 25,000

Simple payback period =2.43 years

PUMP

- Pumping Systems Consumption: 5 - 10% of total energy usage.
- Potential Energy Savings: 10-20% of the pumping system energy cost

Tips for energy saving

- Select a pump of the right capacity in accordance with the requirement. Improper selection of pumps can lead to large wastage of energy. A pump with 85% efficiency at rated flow may have only 65% efficiency at half the flow.
- Matching of the motor with the appropriate-sized pump.
- Use of throttling valves instead of variable speed drives to change flow of fluids is a wasteful practice. Throttling can cause wastage of power to the tune of 50 to 60%.
- It is advisable to use a number of pumps in series and parallel to cope with variations in operating conditions by switching on or off pumps rather than running one large pump with partial load.
- Void valves in the pipe line throttle wastes energy. A positive displacement pump with variable speed drive is recommended.
- Proper installation of the pump system, including shaft alignment, coupling of motor and pump is a must. Drive transmission between pumps and motors is very important. Loose belts can cause energy loss up to 15-20%.
- Modern synthetic flat belts in place of conventional V-belts can save 5% to 10% of energy.
- Properly organized maintenance is very important. Efficiency of worn out pumps can drop by 10-15% unless maintained properly.

Steps to Improving Pumping System Efficiency

- Use adjustable speed drives or parallel pumps to meet variable flow requirements.
- Trim impellers, use slower speed motors and/or gear reducers or replace it with a properly sized pump where pumps are dramatically oversized.
- Use automatic start control or manually turn off a pump that is used intermittently or occasionally.
- Clean pipe systems to reduce frictional losses when pressure drop becomes excessive.
- Repair or replace pumps when performance degrades.

COMPRESSED AIR SYSTEM

Compressed air systems: 2 - 5% of total energy usage

Steps to Improving Compressed Air System Efficiency

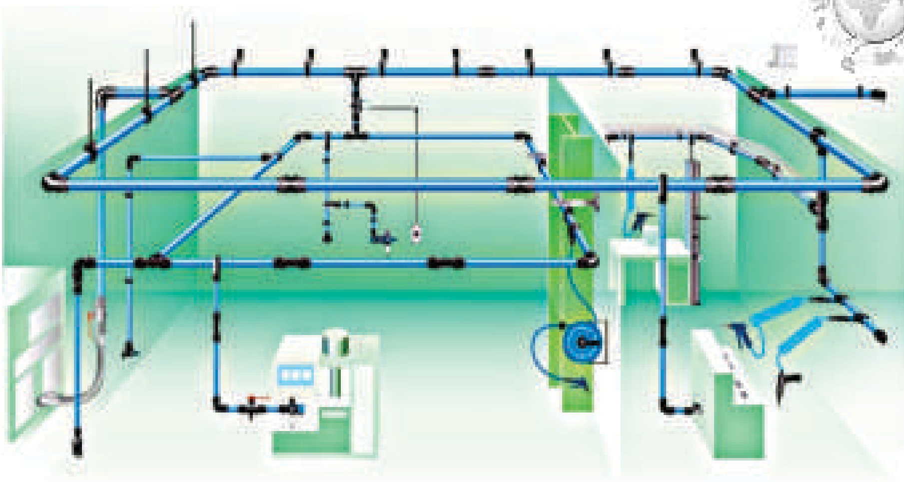
- Check, identify and repair air leaks.
- Review air pressure requirements for the processes and consider use of lower pressure blowers where lower pressure air is used.
- Ascertain compressor type, its control and the effect on your compressor. Turn off unneeded compressors.
- Proper maintenance of moisture control system to eliminate excessive moisture and contaminants in compressed air.
- Add adequate and dedicated storage for high-volume intermittent air requirements.

Tips for energy saving

- Compressed air is very energy intensive. Only 5% of electrical energy is converted to useful energy. Use of compressed air for cleaning is rarely justified.
- Ensure low temperature of inlet air. Increase in inlet air temperature by 3°C increases power consumption by 1%.
- It should be examined whether air at lower pressure can be used in the process. Reduction in discharge pressure by 10% saves energy consumption upto 5%.
- A leakage from a ½" diameter hole from a compressed air line working at a pressure of 7kg/cm2 can drain almost Rs. 2500 per day.
- Air output of compressors per unit of electricity input must be measured at regular intervals. Efficiency of compressors tends to deteriorate with time.

Energy savings from compressed air systems will usually result from savings in two areas

- Compressor unit
- Distribution system



In the leakage test in a process industry, following results were observed

Compressor capacity (m3/minute) = 35

Cut in pressure, kg/cm2 = 6.8

Cut out pressure, kg/cm2 = 7.5

Load kW drawn = 188 kW

Unload kW drawn = 54 kW

Average 'Load' time = 1.5 minutes

Average 'Unload' time = 10.5 minutes

Leakage quantity and avoidable loss of power due to air leakages.

a) Leakage quantity (m3/minute) $= \dfrac{(1.5)}{(1.5) + (10.5)} \times 35$

$= 4.375$

b) Leakage per day, (m3/day) = 6300

c) Specific power for compressed air generation = 188 kWh/(35 x 60) m3/day

= 0.0895kwh/m3

d) Energy lost due to leakages/day = 564 kWh

HEAT RECOVERY

Unfortunately, there will always be some efficiency losses in process heating due to boilers as a result of condensate. Boilers and recirculation systems which are fitted with condensate return systems are far more efficient than those where the condensate enters a waste stream. The efficiency gains are largely the result of chemical profile of the steam condensate, which is typically hot and free of oxygen. This liquid requires less energy to convert the already heated and deoxygenated liquid to gas (especially steam).

Tips for energy saving:

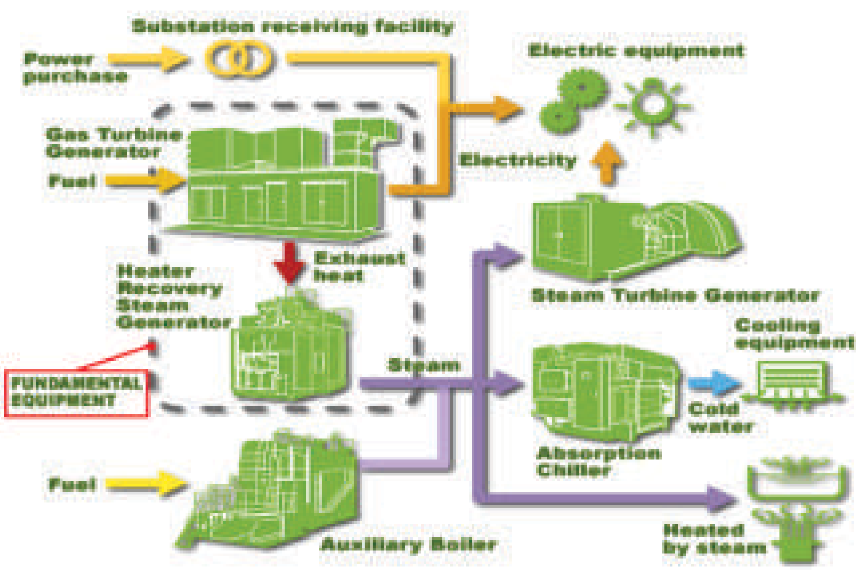
- All possible attention should be paid to control excess air by monitoring oxygen level in the flue gas and also by visual inspection of flame colour.
- Remove soot deposits when flue gas temperature rises 40oC. A coating of 3mm thick soot on the heat transfer surface can cause an increase in fuel consumption of as such as 2.5%.
- Soot blowers can always be maintained in perfect working condition so that their regular and periodic use does not suffer.
- Recover heat from steam condensate. For every 6oC rise in boiler feed water temperature through condensate return, there is 1% saving in fuel.
- Improve boiler efficiency. Boilers should be monitored for flue gas losses, radiation losses, incomplete combustion, blow down losses, excess air etc. Proper control can decrease the consumption up to 20%.
- Use only treated water in boilers. A scale formation of 1mm thickness on the waterside increases fuel consumption by 5-8%.
- Stop steam leakage. Steam leakage from a 3mm diameter hole on a pipeline carrying steam at 7kg/cm2 would waste 32 kl of fuel oil per year amounting to a loss of Rs. 3 lakh.
- Maintain steam pipe insulation. It has been estimated that a bare steam pipe, 150mm in diameter and 100m in length, carrying saturated steam at 8 kg/cm2 would waste 25 kl of furnace oil in a year amounting to an annual loss of Rs. 2.5 lakh.

CO GENERATION

Co-generation is the concept of producing two forms of energy from one fuel. One of the forms of energy must always be heat and the other may be electricity or mechanical energy.

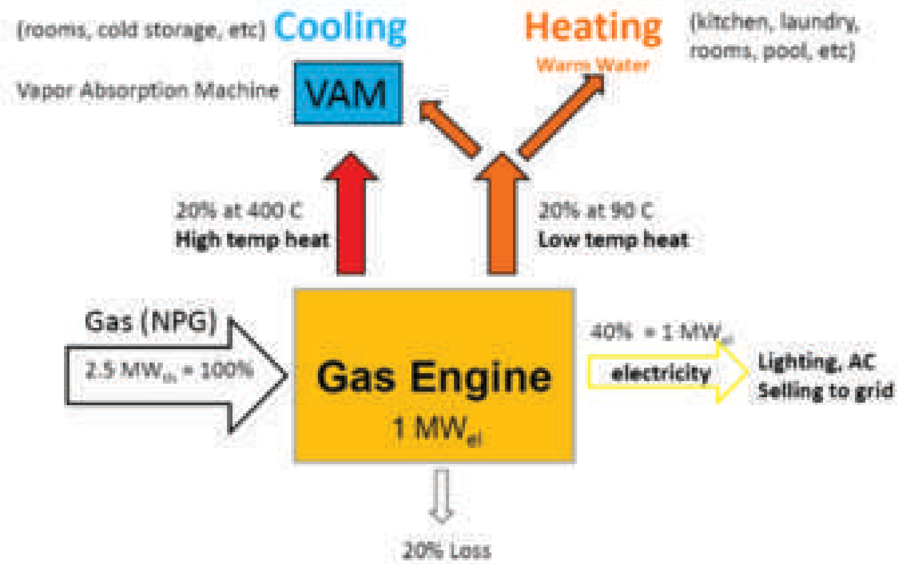
Since co-generation can meet both power and heat needs, it has other advantages as well in the form of significant cost savings for the plant and reduction in emissions of pollutants due to reduced fuel consumption.

Even at conservative estimates, the potential of power generation from co-generation in India is more than 20,000 MW. Since India is the largest producer of sugar in the world, bagasse-based cogeneration is being promoted. The potential for cogeneration thus lies in facilities with joint requirement of heat and electricity, primarily sugar and rice mills, distilleries, petrochemical sector and industries such as fertilizers, steel, chemical, cement, pulp and paper, and aluminium.



Topping cycle plants primarily produce electricity from a steam turbine. The exhausted steam is then condensed, and the low temperature heat released from this condensation is utilized for e.g. district heating or water desalination AND Bottoming cycle plants produce high temperature heat for industrial processes, then a waste heat recovery boiler feeds an electrical plant. Bottoming cycle plants are only used when the industrial process requires very high temperatures, such as furnaces for glass and metal manufacturing, so they are less common.

TRI GENERATION



Trigeneration takes cogeneration one additional step. Trigeneration is defined as the simultaneous production of three forms of energy - typically, Cooling, Heating and Power - from only one fuel input. Put another way, our Trigeneration energy systems produce three different types of energy for the price of one.

In comparison a cogeneration or Trigeneration system at the end users site, can reach overall efficiencies of 80%, as it can utilize the waste heat from power generation to cover the heating and cooling demand of the facility. In addition, there are no transmission losses. The benefits are even higher, since the decentralized cogeneration and Trigeneration units are lowering peak power demand. They even could provide costly peak power and reduce damaging power cuts in India if they are allowed to sell to the grid.

Most promising areas of Trigeneration application include hospitals, hotels, departmental stores, data centers, industries, etc. Overall it is estimated that there are several thousand potential sites in India where Trigeneration could be applied economically within a range of 200 kWe to several MWe per installed system.

FURNACES

Furnace - Tips for energy saving

- Recover and utilize waste heat from furnace flue gases for preheating of combustion air. Every 21oC rise in combustion air temperature results in 1% fuel oil savings.
- Control excess air in furnaces. A 10% drop in excess air amounts to 1% saving of fuel in furnaces. For an annual consumption of 3000kl of furnace oil means a saving of Rs. 3 lakhs. (cost of furnace oil Rs. 10 per litre)
- Reduce heat losses through furnace openings. Observations show that a furnace operating at a temperature of 100oC having an open door (1500mm x 750mm) results in a fuel loss of 10 lit/hr. For a 4000 hrs furnace operation, this translates into a loss of approx. Rs. 4 lakhs per year.

Improve insulation if the surface temperature exceeds 20oC above ambient. Studies have revealed that heat loss from a furnace wall 115mm thick at 650oC amounting to 2650 kcal/m2/hr can be out down to 850 kcal/m2/hr by using 65mm thick insulation on the 115 mm wall.

HVAC

Refrigeration and Air-Conditioning:

Refrigeration is the process of removing heat at a low temperature level and rejecting it at a relatively higher temperature level. Refrigeration is accomplished by various methods, such as the vapor compression system, absorption system, and steam jet refrigeration cycle. The most commonly used systems are the vapor compression and absorption systems. Further, even out of above two, the vapor compression system is more widely used.

Assess existing conditions:

To conduct a HVAC audit you will first need basic HVAC information such as type and number of units, hours of use, etc. to help you understand the current energy use attributed to HVAC systems in your facility. This information will help you understand how much you are currently spending and the potential savings available from HVAC efficiencies. A worksheet is available at the end of this document to assist in the assessment of your current HVAC conditions.

Assess opportunities for increasing HVAC energy efficiency:

Determine if the following opportunities exist for a given location. Each point represents an opportunity for energy savings, followed by suggestions on how to best take advantage of the opportunity.

- Reduce HVAC system operation when building or space is unoccupied.
- Reduce HVAC operating hours to reduce electrical, heating and cooling requirements.
- Eliminate HVAC usage in vestibules and unoccupied space.
- Minimize direct cooling of unoccupied areas by turning off fan coil units and unit heaters and by closing the vent or supply air diffuser.
- Turn fans off.
- Close outdoor air dampers.
- Install system controls to reduce cooling/heating of unoccupied space.

Tips for energy saving:

- Close doors and windows while running the air conditioning. Don't use a whole house fan or window fan while the air conditioner is on, but do use a ceiling fan.
- Use of double doors, automatic door closers, air curtains, double glazed windows, polyester sun films etc. reduces heat ingress and air-conditioning load of buildings.
- Maintain condensers for proper heat exchange. A 5°C decrease in evaporator temperature increases the specific power consumption by 15%.
- Utilization of air-conditioned/refrigerated space should be examined and efforts made to reduce cooling load as far as possible.
- Utilize waste heat of excess steam or flue gases to change over from gas compression systems to absorption chilling systems and save energy costs in the range of 50-70%.

- The compressor of the central air conditioner should be located in a cool, shaded place outside.
- Specific power consumption of compressors should be measured at regular intervals. The most efficient compressors to be used for continuous duty and others on standby.
- The air conditioning unit must be inspected; cleaned and tuned by a professional every two to three years to keeps it going longer and to using less electricity. If the refrigerant needs to be recharged, make sure it is done correctly. If it is overcharged, it would reduce operating efficiency and could damage the unit. If it is undercharged it would also use energy less efficiently.
- The duct system should be properly sealed. This could save 10 per cent to 15 per cent of the electricity into air conditioner.

Reduce HVAC operating hours.

- Turn HVAC off earlier.
- Install HVAC night-setback controls.
- Shut HVAC off when not needed.
- Adjust thermostat settings for change in seasons.
- Adjust the housekeeping schedule to minimize HVAC use.
- Schedule off-hour meetings in a location that does not require HVAC in the entire facility.
- Install separate controls for zones.
- Install local heating/cooling equipment to serve seldom-used areas located far from the centre of the HVAC system.
- Install controls to vary hot water temperature based on outside air.
- Use variable speed drives and direct digital controls on water circulation pumps motors and controls.

Reduce unnecessary heating or cooling.

- Set the thermostat higher in the cooling season and lower in the heating season.
- Allow a fluctuation in temperature, usually in the range of 68° to 70°F for heating and 78° to 80° for cooling.
- Adjust heating and cooling controls when weather conditions permit or when facilities are unoccupied.
- Adjust air supply from the air-handling unit to match the required space conditioning.
- Eliminate reheating for humidity control (often air is cooled to dewpoint to remove moisture, then is reheated to desired temperature and humidity).
- Install an economizer cycle Instead of operating on a fixed minimum airflow supply, an economizer allows the HVAC system to utilize outdoor air by varying the supply airflow according to outdoor air conditions, usually using an outdoor dry bulb temperature sensor or return air enthalpy (enthalpy switchover). Enthalpy switchover is more efficient because it is based on the true heat content of the air.
- Employ heat recovery A heat exchanger transfers heat from one medium to

Common types of heat exchangers are: rotary, sealed, plate, coil run-ystem, and hot oil recovery system.

- Install heat recovery ventilators that exchange between 50 and 70 percent of the energy between the incoming fresh air and the outgoing return (conditioned) air.
- Minimize the amount of air delivered to conditioned space The amount of air delivered to a space is dependent upon heating/cooling load, delivery temperature, ventilation requirements and/or air circulation or air changes. On average the air should change every five to 10 minutes.

Cooling system maintenance

- Clean the surfaces on the coiling coils, heat exchangers, evaporators and condensing units regularly so that they are clear of obstructions.
- Adjust the temperature of the cold air supply from air conditioner or heat pump or the cold water supplied by the chiller (a 2° to 3°F adjustment can bring a three to five percent energy savings).
- Test and repair leaks in equipment and refrigerant lines.
- Upgrade inefficient chillers.

Fuel-fired heating system maintenance (possible five to 10 percent in fuel savings)

- Clean and adjust the boiler or furnace.
- Check the combustion efficiency by measuring carbon dioxide and oxygen concentrations and the temperature of stack gases; make any necessary adjustments.
- Remove accumulated soot from boiler tubes and heat transfer surfaces.
- Install a fuel-efficient burner.

Control setting maintenance

- Determine if the hot air or hot water supply can be lowered.
- Check to see if the forced air fan or water circulation pumps remain on for a suitable time period after the heating unit, air conditioner or chiller is turned off to distribute air remaining in the distribution ducts.
- Implement an energy management system (EMS). An EMS is a system designed to optimize and adjust HVAC operations based on environmental conditions, changing uses and timing.
- Create an energy management system to automatically monitor and control HVAC, lighting and other equipment.

Evaluate thermostat controls and location.

- Install programmable thermostats.
- Lock thermostat to prevent tampering.
- Ensure proper location of thermostat to provide balanced space conditioning.
- Note the proximity of the heated or cooled air producing equipment to thermostat.

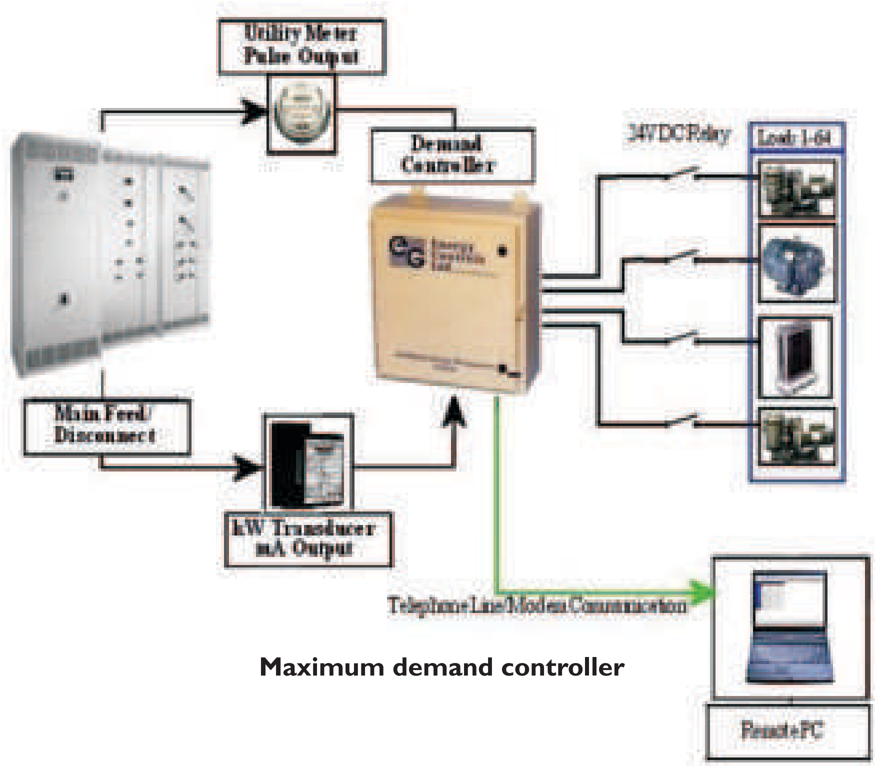
LOAD MANAGEMENT

The utilities (State Electricity Boards) use power tariff structure to influence end user in better load management through measures like time of use tariffs, penalties on exceeding allowed maximum demand, night tariff concessions etc.

The goal of any load-management program is to maintain, as nearly as possible, a constant level of load, thereby allowing the system load factor to approach 100%. The important benefits of load management are reduction in maximum demand, reduction in power loss, better equipment utilization and saving through reduced maximum demand charges. Load shifting, one of the simplest methods of load management, is to reduce customer demand during the peak period by shifting the use of appliances and equipment to partial peak and off-peak periods. Here no loads are being switched off, but only shifted or rescheduled, and hence the total production is not affected.

MAXIMUM DEMAND CONTROLLERS

High-tension (HT) consumers have to pay a maximum demand charge in addition to the usual charge for the number of units consumed. This charge is usually based on the highest amount of power used during some period (say 30 minutes) during the metering month. The maximum demand charge often represents a large proportion of the total bill and may be based on only one isolated 30 minute episode of high power use. Considerable savings can be realized by monitoring power use and turning off or reducing non-essential loads during such periods of high power use. Maximum Demand Controller (See Figure below) is a device designed to meet the need of industries conscious of the value of load management.

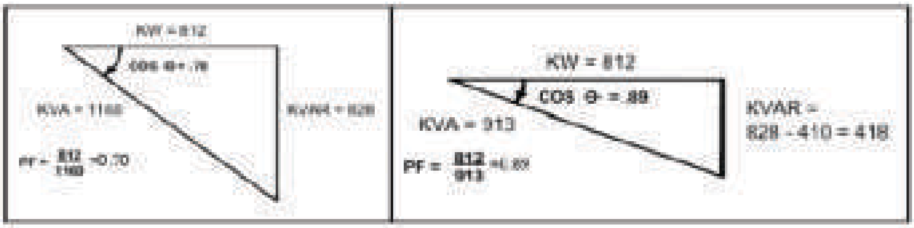


Maximum demand controller

Power Factor Improvement

Improve power factor by installing capacitors to reduce KVA demand charges and also line losses within plant.

A Pharma industry had installed a 1500 kVA transformer. The initial demand of the plant was 1160 kVA with power factor of 0.70. The industry added 410 kVAr capacitor banks in motor load end. This improved the power factor to 0.89, and reduced the required kVA to 913



Use of variable frequency drives, slip power recovery systems and fluid couplings for variable speed applications such as fans, pumps etc. helps in minimizing consumption.

Boiler feed pump rating = 41 TPH, 93 kg/cm2

Motor capacity = 200 kW

Operating discharge at full load = 36 TPH

Operating pressure at control v/v output = 70/72 kg/cm2

Measured load = 147kW

Energy Saving by Providing VFD

The speed of pump for the discharge pr. 72 kg/cm2 = (29752 X 72/93)1/2 = 2617 rpm

The power required at this speed = 147 * (2617/2975)3 = 100 kW

Saving in power = 147-100 = 47kW

Realizable savings = 0.8X47 = 38 kW

Annual Energy saving potential = 38 X 4000 hrs = 1.52 lakh kWh

Annual cost saving = 1.52 X 5.5 = Rs. 8.36 lakh

Cost of implementation = Rs. 9.0 lakh

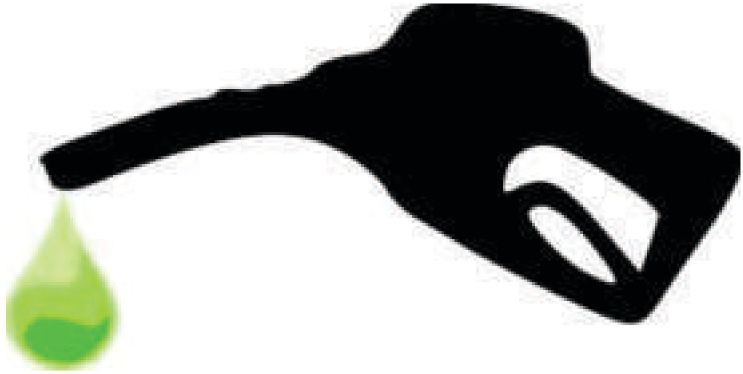
Simple payback period = 1.1 years

Diesel Generating Sets

With the gap between the demand and supply of electric power widening, the role of diesel generating sets in the Indian industry cannot be overemphasized.

Tips for energy saving:

- Maintain diesel engines regularly.
- A poorly maintained injection pump increases fuel consumption by 4gm/kWh.
- A faulty nozzle increases fuel consumption by 2gm/kWh.
- Blocked filters increase fuel consumption by 2gm/kWh.
- A continuously running DG set can generate 0.5 ton/hr. of steam at 10 to 12 bars from the residual heat of the engine exhaust per MW of the generator capacity.
- Measure fuel consumption per KWH of electricity generated regularly. Take corrective action in case this shows a rising trend.



Chapter 5

Conservation Tips: COMMERCIAL BUILDINGS

The regulation, promotion and facilitation of energy efficiency in commercial buildings is one of the key thrust areas of BEE.

Energy Conservation Building Code (ECBC)

- Specifies standards for new, large, energy –efficient commercial buildings.
- Energy Service Companies (ESCOs)
- Upgrade the energy efficiency of existing government buildings through retrofitting on performance contracting mode.

The Star Rating Program for buildings is based on actual performance of the building in terms of specific energy usage (kWh/sq m/year).

This programme would rate office buildings on a 1-5 Star scale with 5 Star labeled buildings being the most efficient.

Five categories of buildings - office buildings, hotels, hospitals, retail malls, and IT Parks in five climate zones in the country have been identified.

Energy conservation building code (ECBC)

- ECBC set minimum energy efficiency standards for design and construction.
- ECBC encourage energy efficient design or retrofit of buildings so that it does not constrain the building function, comfort, health, or the productivity of the occupant

- Lifecycle costs (construction + energy costs) are minimized.
- ECBC covering the following components prepared:
  - o Building Envelope (Walls, Roofs, Windows)
  - o Lighting (Indoor and Outdoor)
  - o Heating Ventilation and Air Conditioning (HVAC) System
  - o Solar Hot Water Heating
  - o Electrical Systems
- ECBC finalized after extensive consultation.
- Voluntary introduction of ECBC in May 2007; mandatory after capacity building and implementation experience.
- Impact of ECBC - Reduced Energy Use for buildings

Energy saving companies (ESCOs)

ESCO generally act as project developers for a wide range of tasks and assume the technical and performance associated with the project. They offer the following services:-

- Develop, design and finance Energy Efficiency projects.
- Install and maintain the energy efficient equipment involved.
- Measure, monitor and verify the project's energy savings.
- Assume the risk that the project will save the amount of energy guaranteed.

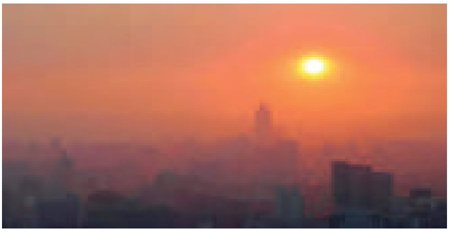
Energy saving tips

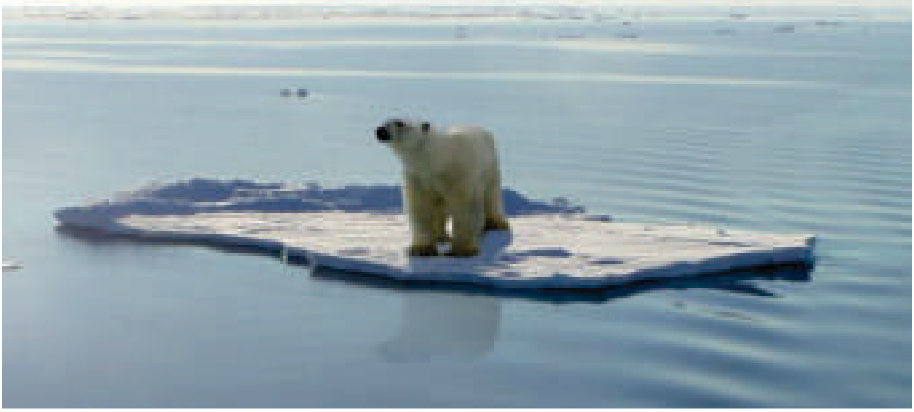
- Turn off or program office equipment to power down when not in use. Turning off one computer and monitor nightly and on weekends can save up to Rs 4000 a year.
- Setting PCs, monitors and copiers to sleep mode when not in use can help cut energy costs by up to 50 percent.
- Install programmable thermostats for better control of heating and air conditioning. Proper use of a programmable thermostat can save roughly one-fifth on your heating/cooling costs. Keep air conditioning set to 78° F or higher and heating set to 68° F or lower.
- Turn off lights in unoccupied spaces. Better yet, install motion sensors in conference rooms, closets, restrooms, and break rooms. Motion sensors can reduce lighting costs up to 40 percent in areas where lights are generally left on all the time.
- Have the janitorial services personnel clean together one floor at a time, lighting each floor as needed.
- Seal off unused areas and reduce or eliminate heating and cooling in these spaces.

Chapter 6

CLEAN DEVELOPMENT MECHANISM

Why It is Important?





- India signed UNFCCC on 10 June 1992 and ratified it on 1 November 1993.
- India acceded to the Kyoto Protocol on 26 August 2002.
- Since India is exempted from the framework of the treaty, it is expected to gain from the protocol in terms of transfer of technology and related foreign investments.

Principles of Kyoto Protocol

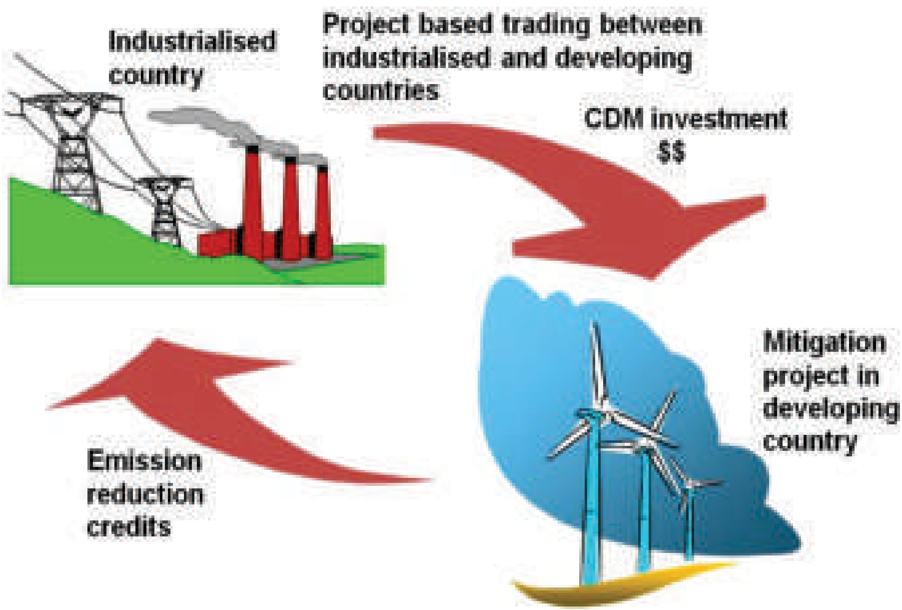
- Commitments.
- Implementation.
- Minimizing Impacts on Developing Countries by establishing an adaptation fund for climate change.
- Accounting, Reporting and Review in order to ensure the integrity of the Protocol.

A key feature of the Kyoto Protocol is the creation of the flexible mechanisms, namely…

- The Clean Development Mechanism(CDM),
- Joint implementation (JI), and
- International Emissions Trading (IET).

Creation of a 'clean development mechanism', in which climate-related projects in developing countries are funded by developed countries

How CDM Works?



What are the main project types?

CDM projects can be designed using established guidelines, or if none exist for the project type, guidelines can be established specifically for the project. These guidelines are referred to as a methodology, and split into three main types:

Small-scale: Includes renewables, energy efficiency and other project. Projects must be less than 15MW in the case of energy generation projects to qualify as "small-scale"

Non-small-scale methodologies and consolidated methodologies: which combine several different approaches. This category spans project types such as renewable energy, incineration of industrial chemical waste streams such as HFC23 and N2O, methane reduction activities such as landfill and animal waste management, and other types such as energy efficiency.

Forestry: Afforestation / Reforestation, typically remediation of degraded land. Methodologies for avoided deforestation are currently under discussion.

What are CERs?

CERs, or Certified Emission Reductions, are carbon credits generated by CDM projects which have completed the registration process. Each CER represents the abatement of one tons of carbon dioxide equivalent, and CERs are only issues by the CDM Executive Board once estimated abatement volumes have been validated independently, and a stringent verification process is in place for ongoing monitoring.

Issued CERs – these are already generated and issued to projects for emissions abatement already undertaken. However, projects must submit requests for registration by 31st March 2007, in order to qualify for these retroactive credits.

Forward streams of CERs – these are credits yet to be generated by projects that are typically under construction, but which are expected to come online in Phase I of the Kyoto Protocol (2008-2012). Such projects may sell expected volumes of CERs throughout their chosen crediting period, with payment by Buyers upon delivery of CERs at an agreed future date, in order to secure a revenue stream.

Chapter 7

SOLAR WATER HEATER –Financial incentives

General Category States- ***for all types of beneficiaries:***

30% capital subsidy or loan at 5% interest on 80% of the benchmark cost

Special Category States ***for domestic & noncommercial categories (not availing accelerated depreciation):***

60% capital subsidy or loan at 5% interest on 80% of the benchmark cost

Special Category States ***for commercial users category (availing accelerated depreciation):***

30% capital subsidy or loan at 5% interest on 80% of the benchmark cost

Benchmark cost

Evacuated Tube Collector (ETC)	Rs. 10,000/sq. m.
Flat Plate Collectors(FPC)	Rs. 11,000/sq. m.

Amount of Subsidy

ETC based system

Rs. 4500 per 100 LPD systems in General category states & Rs. 9,000 in special category states or 30%/ 60% of benchmark cost whichever is less.

FPC based system

Rs. 6600 per 100 LPD systems in General category states & Rs. 13,200 in special category states or 30% / 60% of benchmark cost whichever is less

Chapter 8

ENERGY SAVINGS

According to National productivity council (NPC) report on energy saving in the FY 2009-10 ,based on secondary data and stake holders interaction.

Verified Electrical Energy saving

Programme	BEE		NPC	
	Electricity Saved (MU)	Avoided Generation (MW)	Electricity Saved (MU)	Avoided Generation (MW)
Standard & Labeling	4369	2468.9	4350.92	2179.31
Industry EC Awards	2450.6	358.6	2450.6	358.6
Energy Savings - SDA	4588.25	855.66	1874.25	304.59
Buildings	144	27.5	21.06	3.08
Bachat Lamp Yojana	24	20	24	22.43
Total	11575.85	3730.66	8720.83	2868.01

Effective MU Savings

Year	Avoided Generation (MW)	Exclusive verified savings (MU)	Cumulative verified savings (MU)
2007-08	623.1	3731.5	3731.5
2008-09	1504.97	6528.15	13991.15
2009-10	2868.01	8720.83	32971.63

APPENDIX

APPENDIX A

Key Instruments for Energy Audit

Energy Audit Instruments

The requirement for an energy audit such as identification and quantification of energy necessitates measurements; these measurements require the use of instruments. These instruments must be portable, durable, easy to operate and relatively inexpensive. The parameters generally monitored during energy audit may include the following:

Basic Electrical Parameters in AC & DC systems - Voltage (V), Current (I), Power factor, Active power (kW), apparent power (demand) (kVA), Reactive power (kVAr), Energy consumption (kWh), Frequency (Hz), Harmonics, etc.

Parameters of importance other than electrical such as temperature & heat flow, radiation, air and gas flow, liquid flow, revolutions per minute (RPM), air velocity, noise and vibration, dust concentration, Total Dissolved Solids (TDS), pH, moisture content, relative humidity, flue gas analysis - CO_2, O_2, CO, SO_X, NO_X, combustion efficiency etc.

Tachometer

Stroboscope

Speed Measurements:

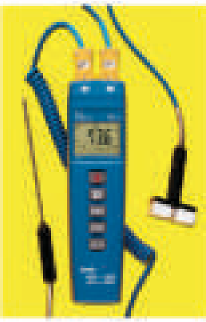
In any audit exercise speed measurements are critical as they may change with frequency, belt slip and loading.

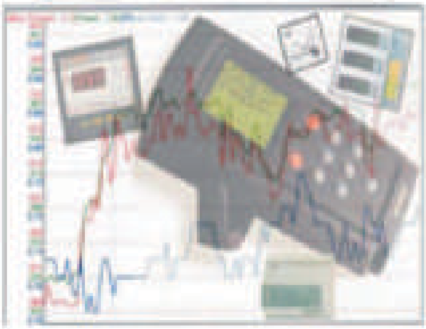
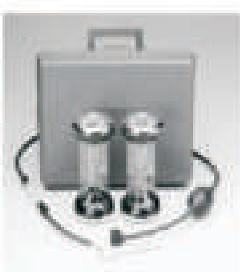
A simple tachometer is a contact type instrument which can be used where direct access is possible.

More sophisticated and safer ones are non contact instruments such as stroboscopes.

Leak Detectors:

Ultrasonic instruments are available which can be used to detect leaks of compressed air and other gases which are normally not possible to detect with human abilities.

	**Contact thermometer:** These are thermocouples which measures for example flue gas, hot air, hot water temperatures by insertion of probe into the stream. For surface temperature, a leaf type probe is used with the same instrument.
	**Infrared Thermometer:** This is a non-contact type measurement which when directed at a heat source directly gives the temperature read out. This instrument is useful for measuring hot spots in furnaces, surface temperatures etc.
	**Pitot Tube and manometer:** Air velocity in ducts can be measured using a pitot tube and inclined manometer for further calculation of flows.
	**Water flow meter:** This non-contact flow measuring device using Doppler effect / Ultra sonic principle. There is a transmitter and receiver which are positioned on opposite sides of the pipe. The meter directly gives the flow. Water and other fluid flows can be easily measured with this meter.

 	**Electrical Measuring Instruments:** These are instruments for measuring major electrical parameters such as kVA, kW, PF, Hertz, kVAr, Amps and Volts. In addition some of these instruments also measure harmonics. These instruments are applied on-line i.e on running motors without any need to stop the motor. Instant measurements can be taken with hand-held meters, while more advanced ones facilitates cumulative readings with print outs at specified intervals.
	**Combustion analyzer:** This instrument has in-built chemical cells which measure various gases such as O_2, CO, NO_X and SO_X.
	**Fuel Efficiency Monitor:** This measures oxygen and temperature of the flue gas. Calorific values of common fuels are fed into the microprocessor which calculates the combustion efficiency.
	**Fyrite:** A hand bellow pump draws the flue gas sample into the solution inside the fyrite. A chemical reaction changes the liquid volume revealing the amount of gas. A separate fyrite can be used for O_2 and CO_2 measurement.

APPENDIX B

Energy Audit : Quick Checklist

Answers to these questions should be found or asked for quick assessment of the status of energy efficiency

a) Lighting:

- Is your facility using the most energy efficient lighting options (fluorescent mercury vapor, etc.)?
- Are there areas that have excessive or unneeded lighting?
- Are you making effective use of available lighting, such as natural sunlight?
- Have you installed lighting management equipment such as dimmers, timers and sensors?

b) Building Envelope:

- Is the building well insulated?
- Does weather stripping around doors and windows need to be replaced?
- Are cracks around doors, windows and foundations properly sealed?
- Are there open doors around loading docks or other frequently accessed areas?

c) Heating and Cooling:

- Arc furnaces, boilers and air conditioning systems operating efficiently?
- Is there a regular maintenance and update schedule for these systems?
- Are filters replaced regularly?
- Is the building properly ventilated?

d) Motors and Equipment:

- Is your equipment maintained so that it is operating at maximum efficiency?
- Is equipment load compatible with manufacturer specifications?
- Are machines shut down when not in use?
- Are fan belts at the proper tension and in good condition?

e) Energy Behavior:

- Are lights, fans and equipment (computer, printers, etc.) turned off when not in use?
- Are building temperatures set back when not in use?
- Are thermostats set to higher or Lower than necessary in summer and winter?
- After finding answers to the check list and identifying areas of improvement, following possibilities maybe explored as energy conservation measures.

APPENDIX C

Useful Conversions & Formula

Energy Units

1 barrel of oil = 42 U.S. gallons (gal) = 0.16 cubic meters (m^3)

1 MW	1,000 kW
1 kW	1,000 Watts
1 kWh	3,412 Btu
1 kWh	1.340 Hp hours
1,000 Btu	0.293 kWh
1 Therm	100,000 Btu (British Thermal Units)
1 Million Btu	293.1 Kilowatt hours
100,000 Btu	1 Therm
1 Watt	3.412 Btu per hour
1 Horsepower	746 Watts or 0.746 Kilo Watts
1 Horsepower hr.	2,545 Btu
1 kJ	0.239005 Kilocalories
1 Calorie	4.187 Joules
1 kcal/Kg	1.8 Btu's/lb.
1 Million Btu	252 Mega calories
1 Btu	252 Calories
1 Btu	1,055 Joules
1 Btu/lb.	2.3260 kJ/kg
1 Btu/lb.	0.5559 Kilocalories/kg

Power (Energy Rate) Equivalents	
1 kilowatt (kW)	1 kilo joule /second (kJ/s)
1 kilowatt (kW)	3413 BTU/hour (Btu/hr.)
1 horsepower (hp)	746 watts (0.746 kW)
1 Ton of refrigeration	12000 Btu/hr.

Fuel to kWh (Approximate conversion)

Natural gas	M^3 x 10.6	kWh
	Ft^3 x 0.3	kWh
	therms x 29.3	kWh
LPG (propane)	m^3 x 25	kWh
Coal	kg x 8.05	kWh
Coke	kg x 10.0	kWh
Gas oil	litres x 12.5	kWh
Light fuel oil	litres x 12.9	kWh
Medium fuel oil	litres x 13.1	kWh
Heavy fuel oil	litres x 13.3	kWh

Prefixes for units in the International System

Prefix	Symbol	Power	Example	USA/Other
exa	E	10^{18}		quintillion
peta	P	10^{15}	pentagram (Pg)	quadrillion/billiard
tera	T	10^{12}	terawatt (TW)	trillion/billion
giga	G	10^{9}	gigawatt (GW)	billion/milliard
mega	M	10^{6}	megawatt (MW)	million
kilo	k	10^{3}	kilogram (kg)	
hecto	h	10^{2}	hectoliter (hl)	
deka	da	10^{1}	dekagram (dag)	
deci	d	10^{-1}	decimeter (dm)	
centi	c	10^{-2}	centimeter (cm)	
milli	m	10^{-3}	millimeter (mm)	
micro	µ	10^{-6}	micrometer (µm)	
nano	n	10^{-9}	nanosecond (ns)	
pico	p	10^{-12}	picofarad (pf)	
femto	f	10^{-15}	femtogram (fg)	
atto	a	10^{-18}		

Volume

To:	gal U.S.	gal U.K.	bbl	ft^3	l	m^3
From:	multiply by:					
U.S. gallon (gal)	1	0.8327	0.02381	0.1337	3.785	0.0038
U.K. gallon (gal)	1.201	1	0.02859	0.1605	4.546	0.0045
Barrel (bbl)	42.0	34.97	1	5.615	159.0	0.159
Cubic foot (ft^3)	7.48	6.229	0.1781	1	28.3	0.0283
Litre (l)	0.2642	0.220	0.0063	0.0353	1	0.001
Cubic metre (m^3)	264.2	220.0	6.289	35.3147	1000.0	1

Mass

To:	kg	t	lt	st	lb
From:	multiply by:				
kilogram (kg)	1	0.001	9.84×10^{-4}	1.102×10^{-3}	2.2046
tonne (t)	1000	1	0.984	1.1023	2204.6
long ton (lt)	1016	1.016	1	1.120	2240.0
short ton (st)	907.2	0.9072	0.893	1	2000.0
pound (lb)	0.454	4.54×10^{-4}	4.46×10^{-4}	5.0×10^{-4}	1

Energy

To:	TJ	Gcal	Mtoe	MBtu	GWh
From:	Multiply by:				
TJ	1	238.8	2.388×10^{-5}	947.8	0.2778
Gcal	4.1868×10^{-3}	1	10^{-7}	3.968	1.163×10^{-3}
Mtoe	4.1868×10^{4}	10^{7}	1	3.968×10^{7}	11630
MBtu	1.0551×10^{-3}	0.252	2.52×10^{-8}	1	2.931×10^{-4}
GWh	3.6	860	8.6×10^{-5}	3412	1

$$Annual\ Energy\ Consumption = \frac{Number\ of\ Bulbs \times Wattage \times Usage\ per\ day \times Days\ used}{1000}$$

Fixtures

$$Water\ used\ /month = Volume\ (ft^3) \times Water\ factor \times Number\ of\ cycles/month$$

$$Annual\ Energy\ consumption = Energy\ used/cycle \times Number\ of\ cycles/month \times 12$$

Insulation

$$Annual\ Water\ Usage = Gallons\ per\ minute \times Number\ of\ people \times Usage/day \times Duration\ of\ use \times Days\ of\ use$$

$$Available\ R-value = R-value\ per\ inch \times Thickness\ of\ material\ (inches)$$

Motor Efficiency

$$Motor\ Efficiency\ (\eta) = \frac{Operating\ hours \times Load}{Energy\ Consumption}$$

$$Hourly\ Cost = \frac{0.001 \times Air\ flow\ rate \times Cost\ of\ fuel\ in\ \$/unit \times required\ heat\ in\ BTU/hr/1000cfm}{Available\ heat\ per\ unit\ of\ fuel}$$

Equation for estimating replacement air heating costs on yearly basis

$$Yearly\ Cost = \frac{0.154 \times Air\ flow\ rate \times Annual\ degree\ days \times operating\ time\ in\ hrs\ or\ week \times cost\ of\ fuel\ in\ \$/unit}{Available\ heat\ per\ unit\ of\ fuel}$$

APPENDIX
D

Sheets for Saving Calculations

Saving Calculation for Lighting

S. No.	Parameter	Value	Unit	Remarks
A) Present Status				
1.	Present rate of electricity		Rs	
2.	Consumption for existing tube light		W	
3.	Total no. of tube lights being replaced from rooms		No	
4.	Operating hours/year		hour	
5.	No. of tube lights being replaced from other places (e.g. staircase)		No.	
6.	Operating hours/year		hour	
B) Proposed Modification (sample)				
1.	Replacing each FTL with high lumen TL& Electronic ballast		W	
2.	Delamping the single FTL which illuminates the ceiling		No.	
C) Saving				
1.	Saving on account of replacing FTL in rooms		kWh/ year	
2.	Saving due to delamping		kWh/ year	
3.	Total energy saved due to lighting modification		kWh/ year	
4.	Total amount saved due to lighting modification		Rs lakhs	
D) Investment				
1.	Cost per high lumen TL with electronic ballast		Rs.	
2.	Total Investment		Rs lakhs	
E)Payback			Years	

Saving Calculation for Pump

A) Present Status

S. No.	Parameter	Value	Unit	Remarks
1.	Present rate of electricity		Rs	
2.	Rating of pump		kW	
3.	Power consumption pump		kW	
4.	Present efficiency of motor-pump unit		%	
5.	Running hours of pump during working day		hours	
6.	Running hours of pump during holiday		hours	
7.	No. of working days/month		days	
8.	No. of holidays/month		days	
9.	Pump running months/year		months	
10.	Annual energy consumption		kWh	

B) Proposed Modification

1.	Replace the motor-pump with a mono block pump set			
2.	Motor-pump efficiency of new pump		%	

C) Saving

1.	Annual energy saving due to replacement		kWh/year	
2.	Total amount saved due to replacement		Rs	

D) Investment

1.	Capital investment for the mono block pump	Rs.		
	Payback		Year	

Saving calculation for pantry/canteen area

A) Present Status

S. No.	Parameter	Value	Unit	Remarks
	LPG			
1.	Average consumption of LPG cylinders per month.		No.	
2.	Cylinders used only for heating water.		No.	
3.	Capacity of each LPG cylinder		kg	
4.	Total LPG consumption for heating water		kg	
5.	Cost of LPG per kg		Rs	
	Electricity			
6.	Power consumption of geyser used for plate washing (hot water)		kW	kW* No. (for each type)
7.	Power consumption of boiler in pantry		kW	kW* No. (for each type)
8.	Running hours of boiler in pantry per day		Hrs	
9.	No. of actual working days per month		Days	
10.	Total kWh consumption for the year		kWh	Calculated
11.	Cost of electricity per kWh		Rs.	
B)	**Established facts**			
1.	100 litres of solar hot water system		kWh	
	can save electricity per year			
2.	100 litres of solar hot water system can save LPG per year		kg	

Saving calculation for HVAC system

Cooling	Average SPC of existing air conditioners		kW/TR
	Present condensing temp, (winter season)		deg.C
	Average condensing temp. during summer		deg.C
	Increase in SPC of compressor due to higher condensing temp. (Taking that for every 1 deg. C rise in condensing temp., there is 2.0 % increase in SPC of compressor)		%
	Expected SPC of air conditioners during summer		kW/TR
	Presently installed capacity of AC with a diversity of 25%		TR
	Capacity of central AC system required		TR
	Installed window AC		Nos
	Installed AC load		kW
	Present AC running load from Energy bill		kW
	Presently delivered TR		TR
	Loading with Cenetral AC plant with 75%		TR
	Power required by central plant/TR		kW
	KW consumption of central AC plant with 75% loading		kW
	Power Saving		kW
	Working Hrs /day		
	Working days /year		
	Working Hrs /Yr		
	Energy cost		Rs/kWh
	Energy saving kWh /year		kWh
	Energy saving Rs. /year		Rs Lakhs

Saving calculation for HVAC system

Heating	Room heating Load for two months/year		kW
	Energy consumed for room heating /Year		kWh
	Energy cost/yr		Rs Lakhs
	Equivalent kcal (capacity of hot water generator)		Lakh kcal
	Hot water flow required to carry the above heat (35/40 deg. C)		M3/Hr
	Calorific value of LDO		kcal/kg
	Thermal efficiency of hot water generator		%
	Annual LDO requirement		kg
	Cost of LDO/Kg		Rs.
	Running energy cost for pump & FC /year		Rs. Lakhs
	LDO cost/year		Rs. Lakhs
	Annual savings		Rs. Lakhs
Total system	Total saving		Rs. Lakhs
	Investment		
	Central AC plant		Rs. Lakhs
	Hot Water generator		Rs. Lakhs
	Total		Rs. Lakhs
	Payback period		Years

TEMPLATES FOR CALCULATING ENERGY SAVINGS

Following tables can be used for conducting and showing step-by-step calculations for energy savings in different areas:

A) Saving for Lighting

S. No.	Item	Formula	Unit	Remarks
1.	No. of running h ours per day	H	Hrs	As per baseline
2.	No. of actual working days per month	D	Days	From actual month calendar
3	Average consumption per existing tubelight	WI	Watts	As per baseline
4	Total no. of fittings	Ns	No.	To be replaced by efficient lighting
5.	To tal no. of excess lighting points (e.g. of ceiling illumination)	Nd	No.	To be disconnected since identified as excess lighting points
6.	Rate of electricity	R	Rs/kWh	As per electricity bill
7-	Average consumption per lighting point after modification	W2	Watts	From actual measurement after modification
8.	Monthly saving due to delamping of lights which are extra (e.g. lights for ceiling illumination)	Sd = Nd*W1*H* D/1000	kWh	Calculated
9.	Monthly saving due to modification of single fitting	Ss = Ns* (W1-W2)*H*D/1000	kWh	Calculated
10.	Total monthly saving	S = Sd + Ss	kWh	Calculated
11.	Total monthly amount saved due to lighting modification	A= S*R	Rs	Calculated

It should be ensured and declared that the lighting level after the proposed retrofitting would not be below recommended lighting levels according to nature of activity

B) Saving for Pump

S.No.	Item	Formula	Unit	Remarks
1.	No. of running hours per day	H	Hrs	As per baseline
2.	Present power consumptionof pump	PI	kW	Measured
3.	Present water flow rate	FI	MVSec.	Measured
4	Present head developed	Hdl	Metre	Measured
5.	Present pump efficiency	E1=9.81*Hd1* F1*100/P1	%	Calculated
6.	Rate of electricity	R	Rs/kWh	
7.	Power consumption of new pump	P2	kW	From actual measurementafter modification
8.	Water flow rate from new pump	F2	MVsec.	Measured
9.	Head developed by new pump	Hd2	Metre	Measured
10.	New pump efficiency	E2=9.81*Hd2*F 2*100/p2	%	Calculated
11.	Energy saving/month	Se=(H*P1* (E1-E2)/100	kWh	Calculated
12.	Total monthly amount saved due to the modification	A = Se*R	Rs.	Calculated

C) Saving for changing from electric heating to gas heating

S.No.	Item	Formula	Unit	Remarks
1.	Total LPG consumption for heating water	Ncyl	No.	As per baseline
2.	Total energy consumption for heating water	Et	kWh	As per baseline
3.	LPG Consumption to achieve the desired temperature if required	N (cylfut)	No.	From current month
4.	Rate of electricity	RO	Rs./kWh	As per baseline
5.	Rate of LPG cylinder	R1	Rs./Cyliner	As per baseline
6.	Saving due to redundancy of boiler and geyser	Se = Et*RO	Rs.	Calculation
7.	Saving due to Reduced usages of LPG	Slpg = (Nycl- N (cylfut)* R1	Rs.	Calculation
8.	Total savings	S = Se + Slpg	Rs.	Calculation

D) Saving for HVAC system

1) AC system

S.No.	Item	Formula	Unit	Remarks
1.	No. of running hours per day	H	Hrs	As per baseline
2.	No. of actual working days per month	D	Days	From actual month calendar
3.	Total no of window a/c units	Nwac	Nos.	As per baseline
4.	Specific power consumption for window a/c unit	SPCwac	kW/TR	As per baseline
5.	Energy consumption for new screw chiller	Psc	kWh	From actual metering
6.	Total TR developed by new chiller	Ttr	Ton -hour	From actual metering
7.	Minimum Ton -hour developed by new chiller (based on the current running pattern & 75% loading) month	Trmin.	Ton -hour	As per baseline
8.	Ton -hour considered for calculation	Teal = Max. of(Ttr of Trmin.)	Ton -hour	As per baseline
9.	Energy consumption by auxiliaries like Ch.W pump, Cond W Pump, CT and FCU's.	Paux	kWh	From actual measurement after modification
10.	Total energy consumption by new Chiller System	Ptotal=Psc+Paux	kWh	Calculated
11.	Specific power consumption of New Chiller	SPCsc=Ptotal/Ttr	kW/TR	Calculated
12.	Estimated consumption for existing system for future running hours.	Pexis = SPCwac* Teal	kWh	Calculated
13.	Monthly saving due to modification of A.C. System	5=Pexis-Ptotal	kWh	Calculated
14.	Rate of electricity	R	Rs/kWh	From current bill
15.	Total monthly amount saved due to A.C modification	A=S*R	Rs.	Calculated

D) Saving for HVAC system

2) Room heating system

S.No.	Item	Formula	Unit	Remarks
1.	Total no of heaters	Nh	Nos.	As per baseline
2.	Rating of each heater	Rh	kW	As per baseline
3.	Running hours per month	H	Hrs	As per baseline
4.	Energy consumption per month	Ph=Nh*Rh*H	kWh	Calculated
5.	Fuel consumption for hot water generator	F	Lit	From actual metering
6.	Future rate of fuel	Rf	Rs/lit	Market rate
7.	Energy consumption for pump and FCU's	Pp	kWh	From actual metering
8.	Monthly energy cost for heating system	C=(F*Rf)+Pp* R)	Rs/month	Calculated
9.	Total monthly amount saved due to Heating System modification	A=(Ph*R)-C	Rs/month	Calculated

TABLES FOR MONITORING OF ENERGY CONSUMPTION

A) Daily monitoring of overall energy consumption

	kWh	kW	Amps	Volt	PF	Maximum Demand kVA	
HVAC chillers							
Chilled Water Pumps							
AHUs							
Lighting							
Equipment							

B) Monthly monitoring chart

	Actual measured consumption								
	Designated kWh/month	Jan	Feb	March	April	May	June	July	...Dec
Total building consumption									
Common lighting									
Space cooling									
Pumps & miscellaneous									
AHU fans									

C) Monitoring of air handling units (hourly/daily)

AHU No	Supply air temperature	Return air temperature	Modulating Valve %	duct Pressure	VFD Speed	Filter status
1.						
2.						
3.						

D) Performance monitoring of chillers

Chiller No	On/off status	No. of compressors working	Chilled water temperature	Condenser water temperature	Compressor discharge pressure	Chilled and condenser water temperature difference
1.						
2.						
3.						

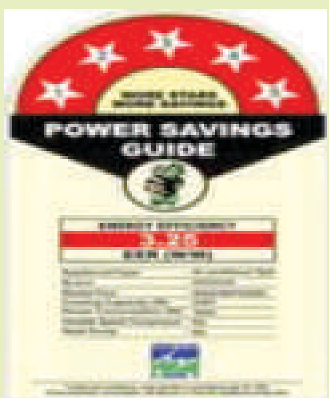
E) Specific energy consumption of chiller (daily/monthly)

Chiller No	Chilled water entry temperature	Chilled water leaving temperature	Cooling load TR	Calculated kW/TR	Designed kW/TR
1.					
2.					
3.					

A Energy Star Home

		Non-Star Equipment		BEE Energy Star Equipment		
Particulars	***Usage Details***	***Requirement of Energy***	***Energy Consumption***	***Requirement of Energy***	***Energy Consumption***	***Energy Saving***
Tube Light (6 Nos)	6 Hrs/day (350 days/year)	**54 W**	**113 Units**	**28 W**	**61 Units**	327 Units
Fan (4 Nos)	16 Hrs/day (200 days/year)	**75 W**	**240 Units**	**35 W**	**112 Units**	512 Units
Television (1 No)	4 Hrs/day (350 days/year)	**150 W**	**210 Units**	**80 W**	**98Units**	98 Units
Refrigerator (1 No)	10 Hrs/day (365 days/year)	**250 W**	**913 Units**	**190 W**	**694 Units**	219 Units
Geyser (1 No)	2 Hrs/day (150 days/year)	**2000 W**	**600 Units**	**1350 W**	**400 Units**	200 Units
Cooking Gas	12 cylinders per annum	**15 Kg per cylinders**	**180 Kg**	**9.6 cylinders**	**145 Kg**	35 Kg

This is approximately annual saving of 2250 units or Rs. 7000/- & CO2 reduction of 1250 kgs.



Technical Advisory, Energy Audit, Renewable Energy Advisory, Trainings

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Energy_CO_2

1 kWh = 0.8 ~ 0.9 kg CO_2

Coal_CO_2

1 kWh = 1.3 ~ 1.6 kg CO_2

Fuel oil_CO_2

1 litre oil = 3 ~ 3.5 kg CO_2

LPG_CO_2

1 Kg LPG = 3 ~ 3 kg CO_2

Doing more with less

- Use Daylight As Much As Possible

67% of our Electricity comes from Burning fossil fuels....!!!!

1 unit saved = 3 units saved at the power plant

Not Considering the emissions reduced; Cost savings are incentive enough to make our Homes/Office *Leaner* in terms of Energy

Contact Detail of SDA:

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