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ENVIS Newsletter
State Environment Related Issues
DEPARTMENT OF FORESTS, ECOLOGY & ENVIRONMENT, GOVERNMENT OF KARNATAKA

Domestic Energy Audit in urban dwellings

Vol.1 No.5 December 2005
ENVIS is a project of Ministry of Environment & Forests, Govt. of India

Energy is a basic and strategic tool that is needed to attain the minimum quality of life. The demand is increasing across agriculture, Industry, commercial and domestic sectors. With a gross domestic product (GDP) growth of 8 per cent set for the Tenth Five-Year Plan, the energy demand in the country is expected to grow at 5.2 per cent annually.[1]

Domestic energy consumption scenario

Energy consumption in homes is for lighting, cooking, heating and convenience or comfort appliances. While the average growth in household income has shown a marked increase in the last few years, the energy consumption rates in many countries seems to have stabilized. This can be attributed to the switch over to more efficient fuels and devices. In urban areas in our country, cooking gas and electricity are the chief source of energy and firewood is the dominant energy source in rural homes.

Energy consumption patterns[2] in the Indian residential sector vary widely not only among the rural and urban areas but also across various income classes. Analysis of the current (primary) cooking fuel use patterns shows that LPG is used by 33.6 million (or 17.5% of the total) homes. In urban areas, the most commonly used fuel is LPG (47.96%), followed by firewood (22.74%), and kerosene (19.16%). In rural areas, 90% of homes still depend on some traditional form of biomass, with firewood by far, the most important fuel (64.10%), followed by crop residues (13.10%), and cow-dung (12.80%).

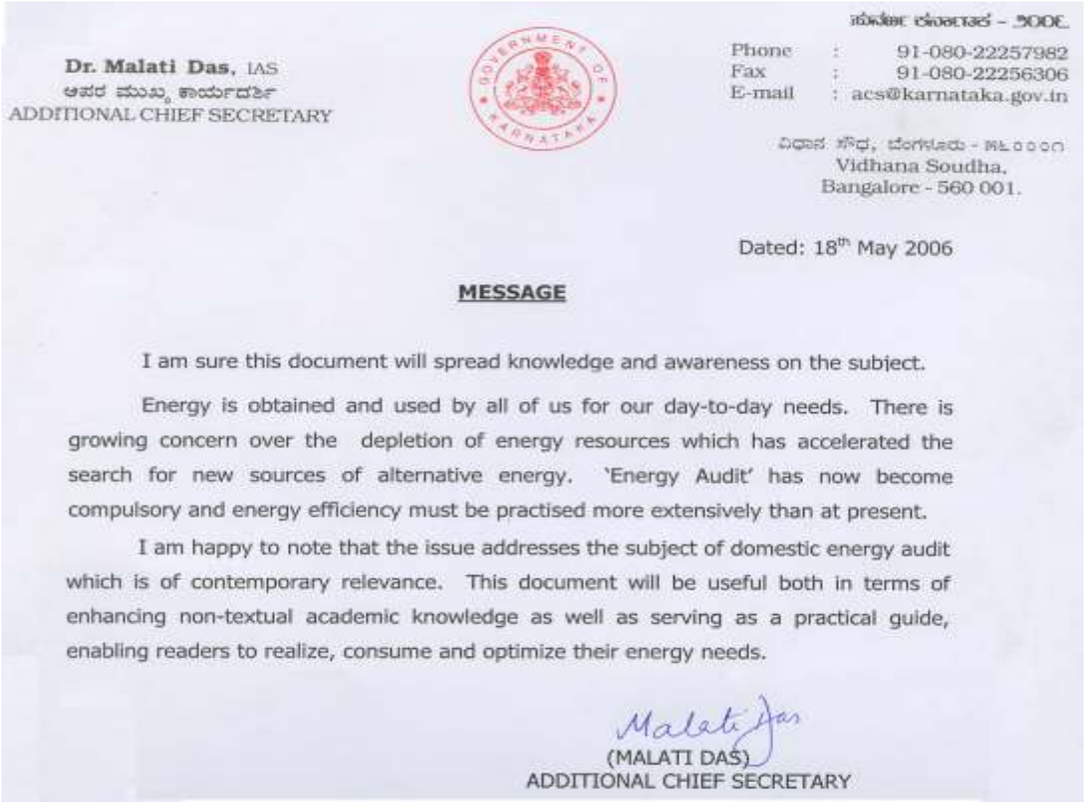
Animal waste is an important fuel in the regions which are agriculturally prosperous but where the fuelwood supply is inadequate. The consumption of dung as fuel is nearly 100 mt/annum.[3] However, most of it is used as manure in the fields. Crop residue is the least preferred biomass fuel as, being in the unaggregated form, the rate of combustion is high and difficult to control. As a consequence, it is also an inefficient fuel. However, this acts as a back up fuel whenever there are scarcities of fuelwood, and is gaining prominence, as fuelwood availability is decreasing. It is estimated that about 100 Mt of non-fodder crop residue (other than fuel wood) is produced and consumed as fuel in different parts of the country.[3]

There are various parameters which decide the type and forms of fuel consumed by the household sector. These include income levels, size of settlements, households, city, price of fuels, the availability and accessibility of modern commercial fuels, and the efficiency of the end-use equipment. Differences in energy-use lie both in terms of per capita energy consumption and in choice of fuel to meet the energy demands. With higher levels of development in the economy and rising per capita income, households tend to move towards fuels that are cleaner, more efficient, convenient, and generally more expensive.

48 % of commercial energy consumption in Karnataka is accounted by electrical energy. Petrol, diesel, LPG, firewood, biogas and solar energy comprise the rest. Growing urbanisation has led to the demand for quality energy. The challenge is to meet this demand without harming the environment and imbalancing foreign exchange reserves. Minimising transportaion losses, investing in energy efficient devices and processes are measures adopted by the industrial sector which need be adopted in the domestic sector.

In Karnataka, of the total 20128 million units of electricity was consumed in 2004, the domestic sector accounted for 4504 Million units (.22.37%). LPG consumption in the state went up from 3,10,245 MT in 1999-00 to 5,00,880 MT in 2003-04. Petrol and diesel consumption figures for the above mentioned period stood at 5,09,918 MT and 22,98,370 MT respectively

By 2010, India will progress from the sixth to the fourth largest consumer of energy, after the USA, China and Japan.



Dr. Malati Das, IAS
ಅಪರ ಮುಖ್ಯ ಕಾರ್ಯದರ್ಶಿ
ADDITIONAL CHIEF SECRETARY

ಕರ್ನಾಟಕ ಸರ್ಕಾರ - ೫೦೦೯.

Phone : 91-080-22257982
Fax : 91-080-22256306
E-mail : acs@karnataka.gov.in

ವಿಧಾನ ಸೌಧ, ಬೆಂಗಳೂರು - ೫೬೦೦೦೧
Vidhana Soudha,
Bangalore - 560 001.

Dated: 18th May 2006

MESSAGE

I am sure this document will spread knowledge and awareness on the subject.

Energy is obtained and used by all of us for our day-to-day needs. There is growing concern over the depletion of energy resources which has accelerated the search for new sources of alternative energy. 'Energy Audit' has now become compulsory and energy efficiency must be practised more extensively than at present.

I am happy to note that the issue addresses the subject of domestic energy audit which is of contemporary relevance. This document will be useful both in terms of enhancing non-textual academic knowledge as well as serving as a practical guide, enabling readers to realize, consume and optimize their energy needs.

Malati Das
(MALATI DAS)
ADDITIONAL CHIEF SECRETARY

With increasing cost of energy, the domestic energy expenditure increasing and is fast garnering a sizeable share of the total domestic expenditure.

Energy scenario in the near future

According to the Bureau of Energy Efficiency, Government of India, the projected (peak) demand for power will touch 115705 MW by the end of the 10th Plan period (2006-07). The power available or generated during the above mentioned period will however be only 101725 MW. This indicates a national shortfall of nearly 13980 MW (12.1%). According to the 10th Five Year Plan, the projected demand for oil is expected to rise by 3.7 per cent per annum as opposed to the global rate of 2 percent. There is scope for meeting the shortfall by harnessing alternative energy sources like solar, biofuels, wind, etc while simultaneously patronizing energy audit processes and use of energy efficient devices.

Domestic energy audit

It refers to a process of evaluation of energy consumption, in a home or industry in order to determine ways in which energy usage can be reduced by :

- Analyzing the sources of energy input
- Studying the energy transformation efficiency of devices and
- Output\ efficiency of usage

Domestic energy audit process enables assessing domestic energy consumption and pinpointing sources of wastage in order to optimise output.

Domestic energy audit is thus the key to a systematic approach for decision-making in the area of energy management in our homes.

The objectives behind performing an energy audit include:

- Knowing the total cost incurred on energy in the household
- Isolating the devices\process which are relatively less energy efficient
- Reduction of energy losses
- Determining potential to substitute with renewable energy sources
- Reducing the monthly energy costs

Running time for consumption of 1 unit of electricity for common household appliances.

Appliance	Wattage Rating	Running time for 1 unit of consumption(approx)
Low wattage equipment		
CFL	15 W	66 hrs 40 mins / Unit
Incandescent Bulbs	40 W	25 hrs / Unit
Incandescent Bulbs	60 W	16 hrs 40 mins / Unit
Incandescent Bulbs	100 W	10 hrs / Unit
Fluorescent Tubelight 24"	20 W	50 hrs / Unit
Fluorescent Tubelight 48"	40 W	25 hrs / Unit
Night Lamp (zero candle)	15 W	66 hrs 40 mins / Unit
Mosquito Repellent	5 W	200 hrs / Unit
Fans	60 W	16 hrs 40 mins / Unit
Transistor Radio	15 W	66 hrs 40 mins / Unit
Tape Recorder	20 W	50 hrs / Unit
Stereo System	50 W	20 hrs / Unit
High wattage equipment		
Mixer/Blender/Juicer	450 W	2 hrs 15 mins / Unit
Toaster	800 W	1 hr 15 mins / Unit
Hot Plate	1000-1500 W	1 hr to 40 mins / Unit
Oven	1000 W	1 hr / Unit
Electric Kettle	1000-2000 W	1 hr to 30 mins / Unit
Iron	450-700 W	2 hrs 15 mins to 1 hr 25 mins / Unit
Water Heater		
1 1/2 - 2 litre capacity(Instant Geysers)	3000 W	20 mins / Unit
10-20 litre(Storage Type)	2000 W	30 mins / Unit
Immersion Rod	1000 W	1 hr / Unit
Vaccum Cleaner	700-750 W	1 hr 25 mins to 1 hr 20 mins / Unit
Washing Machine	325 W	3 hrs / Unit
Water Pump (1HP)	750 W	1 hr 20 mins / Unit
Water pump (0.5HP submersible)	370 W	3.10 hours/ Unit
T.V. Color	60-120 W	16 to 8 hrs / Unit

In case of homes, the input source will be one but the points of energy consumption will vary and is often more than one. Transformation efficiency refers to the amount of work done as compared to the energy used.

Energy audits often involve understanding the patterns of energy consumption. It is already a common practice in industries and commercial establishments in many countries. In homes, one can segregate the devices into various categories. Electronic devices can be categorized as high or low energy consuming based on the amount of electricity needed for operation. Devices like geysers, iron, toasters, pumps, mixers\grinders and electrical heaters come in the former category while bulbs, tubes, fans etc come in the later (heating loads, mechanical energy /gadgets, electronic applications, lighting loads, etc..

In order to know the extent of power consumed by equipment, one must look at the wattage rating displayed on its label. For example, bulbs have watt rating of 15(compact fluorescent lamps, CFL), 25, 40 (4ft tube light), 60 and 100 (incandescent lamps). Various devices having different wattage rating are used for varying hours in a day. The wattage rating of a device and the time for which it is used are the two main parameters that decide the power consumed by it. For example, an incandescent bulb having a wattage rating of 25W will consume 1 unit if used for 40 hours (25W X 40h = 1000Wh or 1kWh). Similarly, a refrigerator (165 liters) having a wattage rating of 90W will consume 1 unit (kWh) in 11h10min. The simple rule here being that 1000 W if burned for 1 hour results in consumption of 1 unit of energy. So,

$$1\ \text{KWh or } 1\ \text{unit} = \frac{\text{Watt rating of the device X hours used}}{1000}$$

If we have to calculate the number of units consumed by a fan having a wattage rating of 60 W running for 33 hours, 30 minutes is:

$$\frac{60 \times 33.30}{1000} = 2\ \text{units}$$

Thus the power consumed by this device will be approximately 2 units.

Scenario: A (as it is happening currently, monthly consumption)

Device used	Wattage rating[a]	Time period[b]	Power consumed (in units) =a X b / 1000	Cost per unit*	Cost (unit X per unit charge)	Percentage contribution to monthly energy bill
Bulb	60 X3	150 hours	27			
Tubes	40 X 3	150 hours	18			
Fan	60	180 hours	10.8			
Television	80	120 hours	9.6			
Water heater (electric)	2000	30 hours	60			
Iron	700	4 Hour	2.8			
Washing machine	325	14 hours	4.55			
Vaccum cleaner	700	9.3 hours	6.5			
Water pump	750	15 hours	11.25			
Refrigerator (twin cooler /compressor)	180	540 hours	97.2			
Total units used			**247.7**			

Scenario: B (how energy and costs can be saved in the future)

Device used	Wattage rating[a]	Time period[b]	Power consumed (in units) =a X b / 1000	Cost per unit*	Cost (unit X per unit charge)	Percentage contribution to monthly energy bill
Bulb CFL	15X6	150 hours	13.5			
Fan	60	180 hours	10.8			
Television	80	120 hours	9.6			
Iron	700	1 Hour 20 minutes	1			
Washing machine	325	14 hours	4.55			
Vaccum cleaner	700	9.3 hours	6.5			
Water pump (submersible)	370	15 hours	5.5			
Refrigerator (single cooler /compressor)	90	540 hours	48.6			
Total units used			**100.05**			

** May vary according to slab charges*

As far as domestic electricity consumption is concerned, two scenarios can be envisaged. Scenario 1 is a typical house having common household appliances without worrying about energy efficiency or costs. In Scenario 2, these appliances are replaced by energy efficient ones and the results are quite apparent. In a scenario where CFLs, submersible pumps, single compressor refrigerators and solar heaters are used, up to 147 units can be saved. This can lead to substantial savings in the power bill every month.

Table b: Fuel audit chart

Fuel	Frequency of purchase	Quantity	Cost per unit	Cost per month	Percentage contribution to monthly energy bill
Petrol	Once in 5 days	2 litres	50/L	600	66
LPG	1 cylinder/month	14.2 Kg	306	306	34

The above examples are for illustrative purposes only

After knowing this information, one can prepare a chart on the lines of Scenario 1 and 2 tables. This will help in knowing the amount of power consumed in a month.

Similarly, a table for the fuel consumed can also be prepared. Preparing a chart for fuel consumption is relatively easier. In this case one can know the amount of fuel consumed for every kilometer of travel or every hour of cooking. By adding up the costs for electricity and fuel , one can obtain the monthly energy bill for a household.

After conducting an energy audit in your home, you will get an idea of the areas and devices where energy and costs can be saved. Devices which are wasteful or consume more energy can be replaced by the energy efficient ones. For example, incandescent bulbs can be replaced by compact flourescent lamps (CFL). Monitoring energy consumption in every socket may be tough but, room wise consumption can be monitored by noting down the time of usage for each electrical device. Targets can also be set for reduction in energy expenditure by conducting an audit.

Do you live in an energy efficient dwelling ?

Questions	Yes	No
Are CFLs being used in the house?	8	-
Are pressure cookers used for cooking?	5	-
Are lamps used in the daytime?	-	5
Is the wiring of the house older than 10 years?	-	10
Is the wiring of the house older than 10 yrs?	-	10
Are lamps and fans switched off in empty rooms at all times?	6	-
Are vehicles used for short distance travel? (< 3 km)	-	5
How often do people in the house hold travel by bus\public transport? (frequently=yes)	5	-
Is the house well ventilated reducing the need for fans?	4	-
Is solar heater used instead of geyser?	10	-
Are clothes ironed outside the house?	7	-
Is the home an AEH one?	-	3
Is the per capita energy expenditure (electricity alone) less than 70 Rs/month ?	5	-
Use only devices having ISI approval	7	-
Frequently use high wattage devices?	-	9
Are the family members aware of the need to conserve energy?	10	-3

Scores:
If your score is 70 or more your home is a **GREEN** home
If your score is 55 -70 your home is an **ORANGE** home
If your score is less than 55, your home is a **RED** home

Tips for energy conservation:

Let us look at some of the measures that can be adopted to minimize energy consumption in our homes (based on the end use).

Lighting:

- Begin with switching off the lights and the fans in the rooms that are not occupied. Make sure that everyone in the family does the same.
- Use CFLs (compact fluorescent lamps) instead of ordinary incandescent lamps as these lamps are very energy efficient.
- Replace traditional chokes of tube lights with electronic chokes. They save two-third energy lost in chokes.
- Use light colours on the walls of your rooms; this helps reduce lighting requirements up to 40%.
- Keep lights and fixtures clean and dirt free. Dust and dirt reduce lighting levels by as much as 30%.
- Use solar lanterns wherever possible.

Heating:

- Plug on your iron only after you get all your clothes together.
- While cooking, use wide bottom vessels with lids. Allow food articles taken out of the refrigerators to attain room temperature before cooking them.
- Soak cereals and dals for some time before cooking them to reduce the cooking time as well as the fuel consumption. Use only the required quantity of water for cooking.
- Pressure cookers used with separators lead to substantial fuel saving. Reduce flame by bringing the burner knob to the simmer position (SIM) as soon as the water starts boiling.
- Try to eat together to avoid repeated warming of food. This not only saves fuel but also preserves the nutritional value of food.
- Light the flame only after all preparations have been made and the vessel is ready to be put on the stove .
- Use hot water from solar water heaters for cooking. Try to use a solar cooker if facility and time permit.
- Recommended the switch over to Nutan gas stove or Nutan wick stove developed by Indian Oil and aimed at fuel conservation.
- Reduce flame by bringing the burner knob to the simmer position as soon as the water starts boiling.
- In the rural sector, use of gobar gas plants, would be an excellent fuel conservation technique.
- If feasible, the use of electric hot plates could also be a fuel-saving tip.
- A switch-over to Nutan Hurricane Lanterns developed by Indian Oil both for better illumination & fuel conservation is recommended.

Washing and Drying:

- Use the washing machine at full loads, as the consumption of water will be the same whether you put in half a load of clothes or a full load.
- Try using the air conditioner an hour or two less every day. Switch on the air conditioner only when you go into the room and switch it off after a few hours as the room will remain cool for the next few hours. Keep the doors and the windows shut even after it is switched off. Clean the filter at least once a fortnight. A choked filter means improper cooling and more power consumption.
- Clean and lubricate your fans regularly and replace old regulators with electronic regulators. This helps reduce electricity consumption significantly at low speeds.
- Cool the food properly before storing in the fridge. Check on the gasket lining or the seal of the fridge. Avoid opening the door frequently. Defrost the fridge regularly, this reduces the power consumption.
- Buy only those appliances that are essential and try to get the maximum benefit from them.
- Ensure clothes are well spun before they are put in the dryer.
- Clean the lint filter in the clothes dryer each time you use it.
- Turn off the dryer as soon as the clothes are dry enough, don't over dry the clothes.
- Locate the dryer in a warm space. Dry heavy articles separately from light articles.

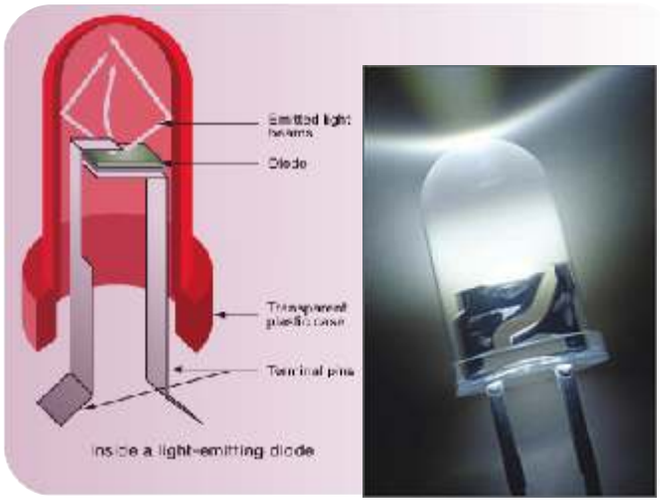
Commuting:

- Share a vehicle.
- Maintain your vehicle.
- As far as possible, travel by public transport.
- The easiest way to make your car more fuel-efficient is to keep it tuned. Well-tuned cars save 9% petrol.
- Keep fuel filters clean. Clogged filters use more petrol.
- Inflate your tires to the right pressure. It reduces fuel consumption by 5%.
- Drive gently. Don't race the engine; accelerate and slow down gradually. You can improve the mileage by 15%.
- Drive between 40 and 50 km/hr. The faster you go, the more wind resistance your vehicle will face. You can get 40% extra mileage at 40 km/hr as compared to 80 km/hr.
- Walk rather than drive wherever possible. Walking is one of the best exercises for your health.

Fast forward: a birds eye view of the energy efficient technologies of the future

Light emitting diodes:

Light emitting diodes, commonly called LEDs do dozens of different jobs in various kinds of devices. Among other things, they form the numbers on digital clocks, are part of traffic signals, transmit information from remote control, light up watches and tell you when your appliances are turned on. Collected together, they can form images on a huge television screen or illuminate a traffic light.



Basically, LEDs are just tiny light bulbs that fit easily into an electrical circuit. But unlike ordinary incandescent bulbs, they don't have a filament that will burn out, and they don't get especially hot. They are illuminated solely by the movement of electrons in a semiconductor material.Each diode is about 1/4" and consumes about ten milliamps (a tenth of a watt). Lamps come in various arrangements of diodes on a circuit board. Standard arrays are three, six, 12, or 18 diodes, or custom sizes. They are also available as screw-in lamps to replace incandescent. A 1.2 watt white LED light cluster is as bright as a 20-watt incandescent lamp (bright enough to read by).

The lighting quality is comparable to that of cool white compact fluorescent lamps, with color rendering indices near 85. LED lights don't flicker. The light is very directional in small arrays. LED strip lights can be installed under counters, in hallways, and in staircases. Concentrated arrays can be used for room lighting. Waterproof, outdoor fixtures are available, and they operate in temperatures from -20°C to 80°C. Manufacturers consider applications such as gardens, walkways, and decorative fixtures outside garage doors to be the most cost-efficient.

* LEDs use up to 90% less energy than an equivalent incandescent bulb. If many LEDs are used in place of other types of bulbs, incredible energy savings can result.
* LEDs last considerably longer than incandescent lighting, ranging from 50,000 to 100,000 hours of use. In addition, they can perform well in cold and can be made fro harsh weather conditions.

Things to remember while using Compact Fluorescent Lamps

Compact fluorescent lamps (CFLs) can now be used in many standard light sockets and fixtures. CFLs typically consume about 67 to 75 percent less energy than incandescent bulbs and last up to 10 times longer. This makes them ideal for use in fixtures that are not easily accessible, such as recessed luminaries and lights in stairwells. To gain the maximum economic benefits from compact fluorescent lamps, install them in fixtures that are used for three or more hours each day.

CFLs should not be used in closed fixtures indoors (such as globes) because the ballast may overheat.

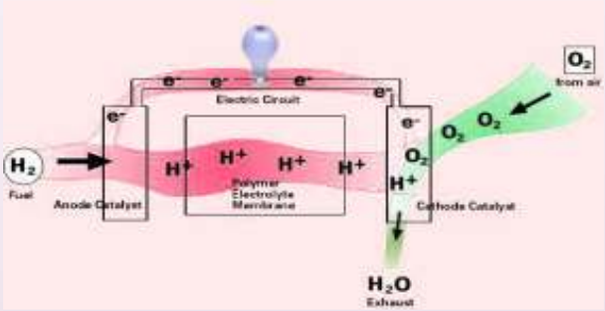
While it is often not possible to select lamp orientation, compact fluorescents work more efficiently when the lamp is oriented downwards, with the base up. This is because the efficiency of the bulb depends on the temperature of the coldest part of the lamp, which is the end furthest away from the ballast. Since heat rises, a base-up lamp will be coolest at the bottom, producing the greatest amount of light. Keep the lamp orientation in mind when comparing light output, which is actually rated for the base-up operation.

Compact fluorescent lamps work best when the lamp points downwards and the base is up. The variation in lamp color at start-up of the lamp is a result of phosphor activation. Phosphor is the coating on the inside of the bulb that glows when bulb has an electrical charge to give the lamp a "white" light effect. Different phosphor combinations produce different colors and may have slightly different response times. These differences are why the lamp sometimes looks pink or purple when you start it.

Battery banks:
A major problem with use of solar power is that sunlight is not available at night. Small machines like laptops can be powered by batteries that are recharged in daylight by photovoltaic cells. Large electric motors used to power lifts need large banks of batteries to operate at night or during cloudy days. When sun is hidden, the battery banks discharge power and when the sun shines, the batteries are recharged by photovoltaic cells.

Fuel cells:
Fuel cells produce electricity through the reaction of hydrogen and oxygen to form water. The hydrogen is extracted from sources such as methanol, propane, ethanol etc. The bi products of the reaction include electricity and water. A major advantage of the fuel cell is that it is portable and can provide power in remote areas of the country. The source of energy is a renewable one and relatively less pollution is generated when compared to contemporary technology. Fuel cells have a wide range of applications including stationary power generation (MW), portable power generation (kW) and transportation (kW). In a fuel cell, since the chemical energy of the fuel is directly converted to electricity, a fuel cell can operate at much higher efficiencies than internal combustion engines, extracting more electricity from the same amount of fuel. Fuel cells are capable of converting 40% of the available fuel to electricity. This can be raised to 80% with heat recovery. The fuel cell itself has no moving parts, offering a quiet and reliable source of power.

Working diagram of Fuel cell



In many countries, fuel cells are providing power for hospitals, military bases, schools etc. Now, efforts are also on to develop fuel cells which can provide power to meet domestic energy requirements. A US based multinational company has already revealed plans to launch fuel cells designed exclusively for domestic use. This cell, is about the size of a refrigerator and runs on natural gas or propane, with a fuel processor to extract the hydrogen. The system can provide a constant power output of 7kW, more than enough for domestic use, and the heat produced can also be harnessed, for example to provide hot water. The company claims that in the future customers will even be able to sell excess power to the power companies.

Going back to nature: One of the most efficient lighting systems in the world is bioluminescence of firefly where chemical energy is converted directly into light. Estimates are that its lighting efficiency is around 85-90%, compared to that of a light bulb which is 7-10%. R&D should be done in trying to duplicate this mechanism. Ultimate lighting system can be thought of as a solar powered unit producing luciferase enzyme and luciferin (the two chemicals used in bioluminescence of firefly) from a biomass resource and then using them at night to produce light. It may seem impossible now but the future will see this concept lighting up homes.

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