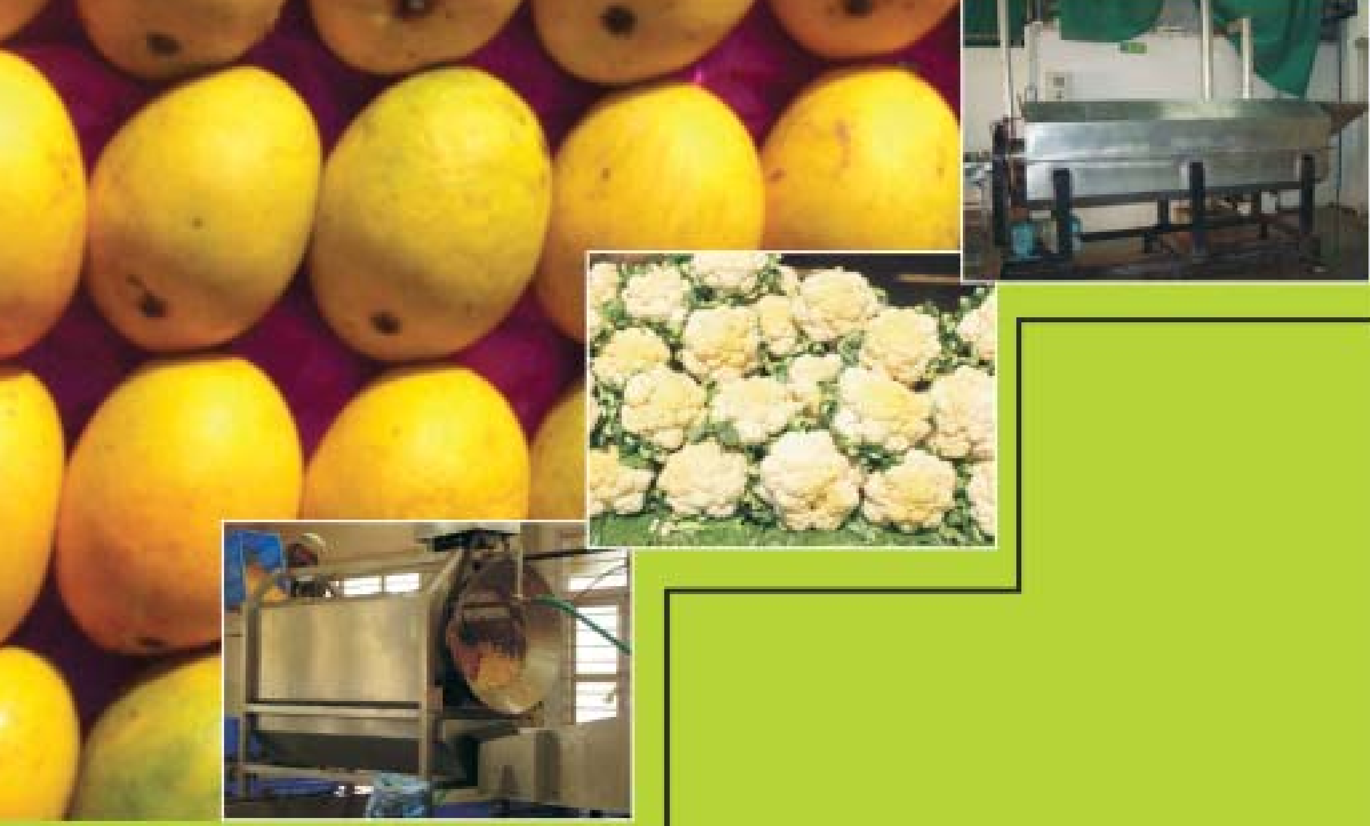

Energy conservation measures in the fruit and vegetable processing sector

SIDBI
भारतीय लघु उद्योग विकास बैंक
SMALL INDUSTRIES DEVELOPMENT BANK OF INDIA

teri

DFID Department for International Development

Disclaimer

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DINESH RAI I.A.S.
Secretary to the Government of India

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MESSAGE

India has adopted a conscious policy for the promotion and development of MSMEs in view of their vital role in generation of employment, dispersal of economy and better utilisation of resources. The number of MSMEs in India is estimated to be over 13 million, while the estimated employment provided by this sector is over 42 million. The sector contributes about 40 per cent of India's exports and 45 per cent of the manufacturing output.

The MSME sector has been facing some inherent challenges, which are getting expanded along with the horizons of globalization. Sustaining revenues, improving margins and being competitive are some of those challenges. "Savings from improved efficiency/cost reduction/waste minimization" is a superior alternative to "additional revenue" for improving profitability of MSMEs.

"Energy Efficiency" means use of less energy for achieving the same or better output through improved technologies. However, at the same time, it involves ensuring the expected financial benefits (i.e., energy savings expressed in monetary terms) over a reasonable time-period to be adequate to justify such investments.

I congratulate SIDBI for bringing out this booklet to serve the needs of MSMEs in fruit and vegetable processing sector for saving energy through simple housekeeping methods, which would ultimately help the MSMEs in becoming competitive.

(Dinesh Rai)

Place: New Delhi
Date: August 28, 2008

जवाहर सरकार
अपर सचिव एवम्
विकास आयुक्त

JAWHAR SIRCAR
Additional Secretary &
Development Commissioner

भारत सरकार
सूक्ष्म, लघु एवं मध्यम उद्यम मन्त्रालय

GOVERNMENT OF INDIA
MINISTRY OF MICRO, SMALL AND MEDIUM ENTERPRISES

'A' WING, 7TH FLOOR, NIRMAN BHAVAN,
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Phones : 23061176, Fax : 23062315

MESSAGE

Worldwide, the micro and small enterprises (MSEs) have been accepted as the engine of economic growth and for promoting equitable development. The MSEs constitute over 90% of total enterprises in most of the economies and are credited with generating the highest rates of employment growth and account for a major share of manufacturing output and exports.

The energy consumption in MSE sector is high and there is considerable scope of energy conservation in this sector. Energy efficiency is widely regarded as the first step in making the transition to a low carbon economy. While renewable energy and other measures are vital, energy efficiency ensures that valuable energy is not wasted.

There are numerous energy efficiency technologies available in the market, which remain out of the reach of the MSEs either due to cost factors or due to lack of awareness. The Ministry of MSME has been taking various initiatives for the energy efficiency in the MSE sector including implementation of a scheme, namely, Credit Linked Capital Subsidy Scheme (CLCSS) for promoting energy efficient technologies.

I compliment SIDBI for bringing out this booklet on simple housekeeping measures for saving energy in Fruit and Vegetable Processing sector. I am hopeful that the booklet would succeed in sensitizing the MSE sector about the importance of energy conservation and in encouraging them to adopt energy saving techniques.

(Jawhar Sircar)

Foreword

The MSME sector has played a very important role in the socio-economic development of the country during the past 50 years. It has significantly contributed to the overall growth in terms of the Gross Domestic Product (GDP), employment generation and exports. The performance of the sector, therefore, has a direct impact on the growth of the overall economy. SIDBI is proud to be associated with the promotion & development of this vibrant sector.

SIDBI is implementing a multi agency / multi activity Project on Financing and Development of Micro, Small & Medium Scale Enterprises. The Project is aimed at making lending to the sector, an attractive and viable financing option as also facilitating increased turnover and employment in the sector. The project has 3 major Components viz. Credit facility from the World Bank (WB) and KfW , Risk Sharing Facility, and Technical Assistance (TA) from Department for International Development (DFID). A dedicated Project Management Division (PMD) has been setup by SIDBI to implement this project.

"Business Development Services" (BDS) in MSME Clusters is the cornerstone of the DFID TA. BDS refers to the wide range of services used by entrepreneurs to help them operate efficiently and grow their businesses. SIDBI has started the BDS interventions in 3 clusters namely Alleppey (Coir), Kanpur (Leather) & Pune (Fruit & Vegetable processing).

The Fruit &Vegetable processing cluster uses a substantial amount of energy in the manufacturing process. It has been found that the profitability of the MSME units can be improved through simple energy saving initiatives / house-keeping measures. However, most of the MSME units do not have ready access to these measures and thus there is a need to raise the level of awareness on the simple, cost-effective solutions that would reduce the energy consumption of this sector and improve its competitiveness. PMD, SIDBI has therefore commissioned The Energy and Resources Institute (TERI) to undertake a study of the cluster and prepare a simple Do's and Don'ts booklet for the purpose.

The booklet prepared by TERI offers simple & useful tips on saving energy. It is expeced that this booklet would be helpful not only to the Fruit & Vegetable Processing sector in Pune but also to many such units all over the country.

R M Malla
Chairman and Managing Director
SIDBI

Preface

Acknowledgement

TERI places on record its sincere thanks to SIDBI (Small Industrial Development Bank of India) for entrusting it with the assignment of preparing a booklet on 'increasing energy efficiency of units located in Pune fruit and vegetable processing cluster'.

It also thanks Apex Cluster Development Services Pvt. Ltd for helping the TERI team and providing them with the necessary support during the study.

The support and cooperation received from all the plants visited in the Pune food processing cluster for completion of the study is also acknowledged. The names of these plants are mentioned hereunder.

- M/s PKM Foods Pvt. Ltd
- M/s Monsoon Agro Bio Ltd
- M/s Adinath Agro Processed Foods Pvt. Ltd
- M/s Gits Food Products Pvt. Ltd
- M/s Gomukh Frozen Foods
- M/s Vaish Vik Foods Pvt. Ltd (S V Foods)

Introduction

The cost of energy is a significant controllable factor in the food-processing sector. Typically, it depends on the processes and the product types, and accounts for up to 10%–15% of the manufacturing cost. Significant saving can be made in the energy bill by implementing simple energy conservation measures outlined in this booklet.

High energy-consuming areas in various types of food-processing industries are highlighted in the table below.

Type of products	*Critical areas*
Frozen fruits and vegetables	Boiler, refrigeration, cold storage, blast freezing, motors, power factor, cooling tower
Tomato ketchup/puree/ juice, sauces, canned fruits and vegetables, fruit pulps, juices	Boiler, steam heating, steam traps, motors, power factor.
Ready-to-cook, ready-to-eat, instant mixes, soup mixes and pickle, spices, chutneys	Grinder and pulverizer, motors, air compressor, lighting, power factor
Candies and jellies	Boiler, steam usage, motors, power factor

Steam generation and distribution system

Steam – in the fruit and vegetable, and food processing industry – is generally used for blanching, peeling, heat sterilization, evaporation, pasteurization, hot water generation, indirect heating, and so on. Energy can be saved both in steam generation and distribution through some simple measures.

- Adopt biomass-based boiler, wherever possible. It is environment friendly and does not contribute to GHG (greenhouse gas) emissions.
- Arrest fuel oil leakage. Even a small oil leakage of one drop per second can result in wastage of 4000 litres per year of fuel oil.

Excess air and flue gas temperature are two important parameters on which the boiler efficiency depends

A 22 °C reduction in the flue gas temperature reduces the fuel consumption by 1%

Every 6 °C rise in feed water temperature by heat recovery or condensate recovery corresponds to a 1% saving in fuel consumption in the boiler

- Provide gauges for steam pressure and temperature on boilers and temperature gauge in the flue gas outlet and monitor the data regularly.
- Analyse flue gas regularly by using portable flue gas analyser. The parameters to be checked are O_2 (oxygen), CO (carbon monoxide), and temperature.
- Optimize excess air in the boiler. Excess air is the quantity of air in addition to the theoretical quantity required for 100% fuel combustion. Recommended excess air and O_2 levels for various fuels are mentioned in Table 1.
- Observe colour of the smoke coming out of the boiler. Brown hazy smoke indicates proper combustion; black colour indicates incomplete combustion; and colourless or white smoke shows high excess air quantity as shown in Figure 1.
- 5 % reduction in excess air quantity (above the recommended excess air percentage) increases the boiler efficiency by 1%. Similarly, 1% reduction of residual oxygen in the flue gas reduces fuel consumption by 1%.

Table 1 Recommended O_2 and excess air levels

Fuel	*Recommended O_2 level in flue gas (%)*	*Excess air (%)*
Diesel	2–3	10–15
Bagasse	5–7	25–35
Wood/biomass	4–5	20–25

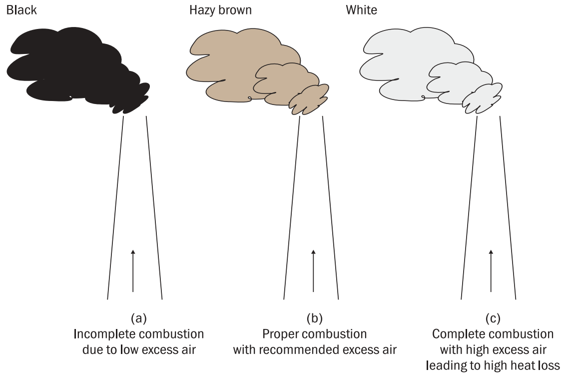


Figure 1 Colour of smoke from boiler chimney

- Recover the sensible heat from the hot flue gas for heating the boiler water (via economizer) or preheating the combustion air (via air-preheater).
- The boiler tubes should be cleaned regularly to avoid deposition of scales. A 1-mm thick scale (deposit) on the water side of boiler tubes could increase fuel consumption by 5%–8%.
- The boiler should be checked for any soot and fly ash deposition on the fire side of boiler tubes. If the flue gas temperature rises about 40 °C above the design specification, it is time to remove the soot deposits. A 3-mm thick soot deposition on the heat transfer surface can increase the fuel consumption by 2.5%.
- Recover and return condensate to the boiler, as it still carries about 15%–20% of the total steam energy.
- Insulate all steam/condensate pipes, condensate/hot water tanks with proper insulation as indicated in Table 2. The heat loss from 100 feet of a bare 2-inch pipe carrying saturated steam at 10 kg/cm^2 is equivalent to a fuel loss of about 1100 litres of fuel oil per month.
- Insulate all flanges by using pre-moulded sections because heat loss from a pair of bare flanges is equivalent to the loss from 1 foot of non-insulated pipe of same diameter.
- Use air vents to remove the trapped air from the jacketed vessel as air acts as insulator and reduces the heat transfer. A 0.25-mm thick air film offers the same resistance to heat transfer as a 330-mm thick copper wall.
- For all indirect steam uses, use steam at a lowest acceptable pressure, since the latent heat of steam at lower pressure is higher.
- Fix all steam leakages as soon as they are identified. A 3-mm diameter hole on a pipeline carrying steam at 7 kg/cm^2 would waste 33 000 litres of fuel oil per year. Figure 2 shows the steam wastages from various leakage sizes at different pressures.
- Install temperature gauges in all steam heating equipments and avoid overheating of material.
- The condensate should flow to the trap using the gravity force.

Table 2 Indicative for mineral wool insulation thickness (in mm) for various steam pipe sizes

Temperature (°C)	*1-inch diameter*	*2-inch diameter*	*4-inch diameter*
Up to 100	25	40	65
100–150	40	50	75
150–200	50	65	100
200–250	65	75	125

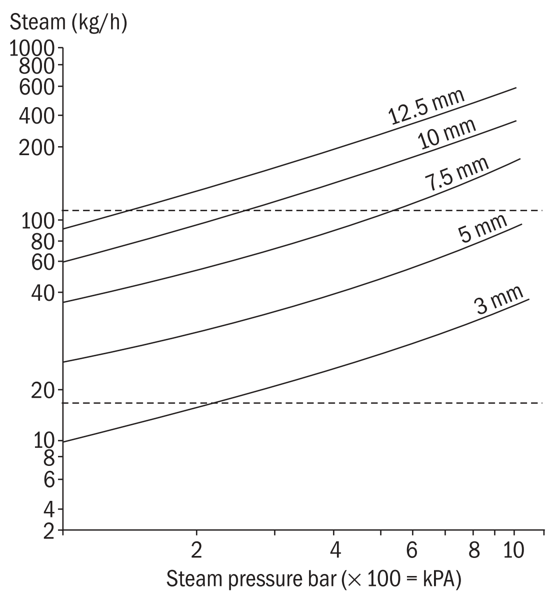


Figure 2 Steam losses from various leakage sizes and pressure

- Keep the trap bypass line closed always except during start up. If the trap is faulty, replace the trap rather than opening the bypass valve.
- Make use of Table 3 for efficient trap management in the plant.

Compressed air system

Compressed air is generally used in all food processing industry for machine operations, pneumatic controls, and other simlar applications. Following recommendations should be followed for an efficient compressed air system.

- The air intake to the compressor should be clean, cool (certainly not from the air-conditioned area) and drawn from a place, which is away from the heat sources.

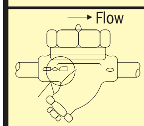
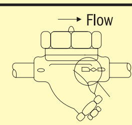
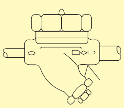
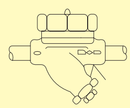
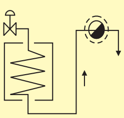
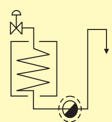
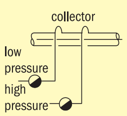
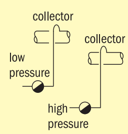
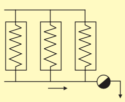
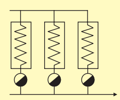
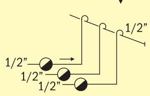
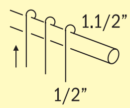
Since the efficiency of the compressed air system, from generation to end-use, is less than 10% (Figure 2), it must be used judicially in the plant

All compressed air usage for cleaning the floor/ equipment/personal cleaning must be avoided. Air blowers are well suited for such applications as they generate large volume of air at lower pressure with lower energy consumption

Every 5 °C rise in suction air temperature will increase power consumption by 2%

- Compressor discharge pressure should be kept at minimum acceptable levels. Increase of 1 kg/cm^2 air discharge pressure (above the desired) from the

Table 3 Tips for efficient use of steam traps

Wrong installation	*Description*	*Correct installation*
	Steam traps should be fitted in the direction of flow. All steam traps have the mark showing the flow direction.	
	Never use an inlet pipe smaller than the trap size.	
	Never install steam trap at a higher level than the drainage point to avoid back pressure	
	Condensate discharge from traps operating at different pressures should not be collected to a common collector.	
	Each steam-using unit should always have an individual steam trap.	
	Condensate main should have a cross sectional area more than the sum of all the traps connected to it.	

compressor would result in about 4%–5% increase in input power. This will also increase compressed air leakage rates roughly by 10%.

- If compressed air is required at two different pressures, it is better to have two compressors catering to air requirement at different pressures rather than having one large compressor generating compressed air at higher pressure.
- Air intake filters should be cleaned at regular intervals to facilitate clean air intake of compressor and low pressure drop across it.
- Compressed air should be cooled up to the ambient temperature by using after coolers/air dryers before it enters the system. This will help in removing the moisture from the system.
- Provide separators to get rid of any moisture in the system before the compressed air reaches the pneumatic equipment.
- Change the oil filter regularly.
- All the compressed air piping should be laid out in such a way that it minimizes pressure drops during transmission. The pressure drops in a smaller compressed air system should not be more than 0.3 bar.
- Use a properly sized compressed air storage receiver. It dampens the pulsation from the reciprocating compressor and makes the flow of air smooth. It also acts as a reservoir to meet short time excess demand in the system, condenses moisture, and removes the oil traces (through drain trap) from the compressed air. The size of the receiver should be at least 6–10 seconds capacity of the compressor. It is always beneficial to over design the air receiver. The receiver should be fitted with a pressure gauge, safety valve, and a moisture drain valve.
- Compressed air generation is a costly affair. Therefore, always debate the addition of a new compressed air based application. Consider alternatives to compressed air such as blowers for low-pressure high-quantity applications, hydraulic rather than air cylinders, electric rather than air actuators, and electronic rather than pneumatic controls.
- It is very difficult to eliminate air leakages from a compressed air network. Although, large leakages are identified by their sound, small leakages generally go unnoticed. Leakages can be identified by their hissing sound, during the non-operational time. Air leakages depend on the air pressure and the size. Leakages through various orifice sizes (at 7 kg/cm^2) are mentioned in Table 4. Common sources of leakages are coupling, hoses, fittings, pressure regulators, valves, pipe joints, and drain traps.

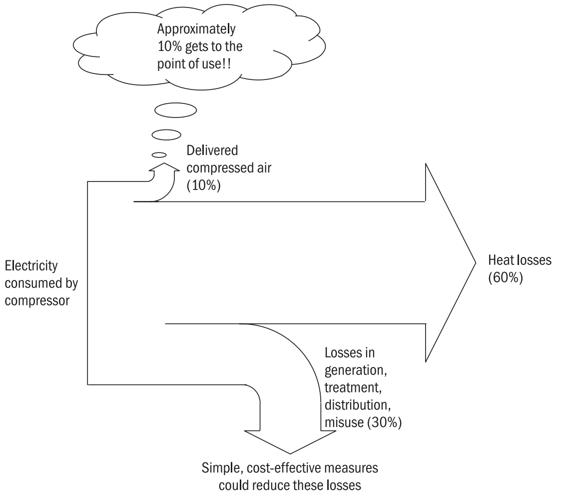


Figure 3 Typical sankey diagram for a compressed air system

Table 4 Power wasted due to air leakages

Orifice size (inch)	*Air leakage* (Nm^3/hour)	*Power wasted* (kW)
1/32	2.9	0.3
1/16	11.5	1.3
1/8	46.2	5.0
1/4	184.8	20.2

Electrical distribution system

Electrical system is an integral part of all food processing industry. An efficient electrical distribution system and demand management can reduce the electricity bill significantly. Box 1 shows a typical electricity bill along with possible areas of energy savings. This section provides some of the opportunities to improve efficiency of the distribution network.

- Stagger the non-critical load according to the electricity tariff to reduce your bill. The benefit due to this is shown in Box 2.
- The benefits of higher power factor are reduced demand (as shown in the Box 3), better voltage, high system efficiency and rebate from the electricity supplying company. Power factor can be improved by installing capacitors in the electrical system. Table 5 provides the values of capacitance required per unit kilowatt, to improve power factor from 0.85 to any desired level up to 1.
- Provide capacitor at the load (motor) end to have the benefit of reduced distribution loss (for example, line losses, and cable loading). Any shortfall from the desired power factor can be met by connecting the capacitors at the main panel. It should always be less or equal to unity

Maximum efficiency of a transformer is at 32% –35% load of its full load capacity

Maintain the power factor at the main feeder greater than 0.9 to avoid penalty and further improve it to above 0.95

Control the maximum demand by tripping the non-critical loads through a demand controller. This will avoid the penalty due to excess demand usage than the sanctioned

Box 2 Benefits of load staggering

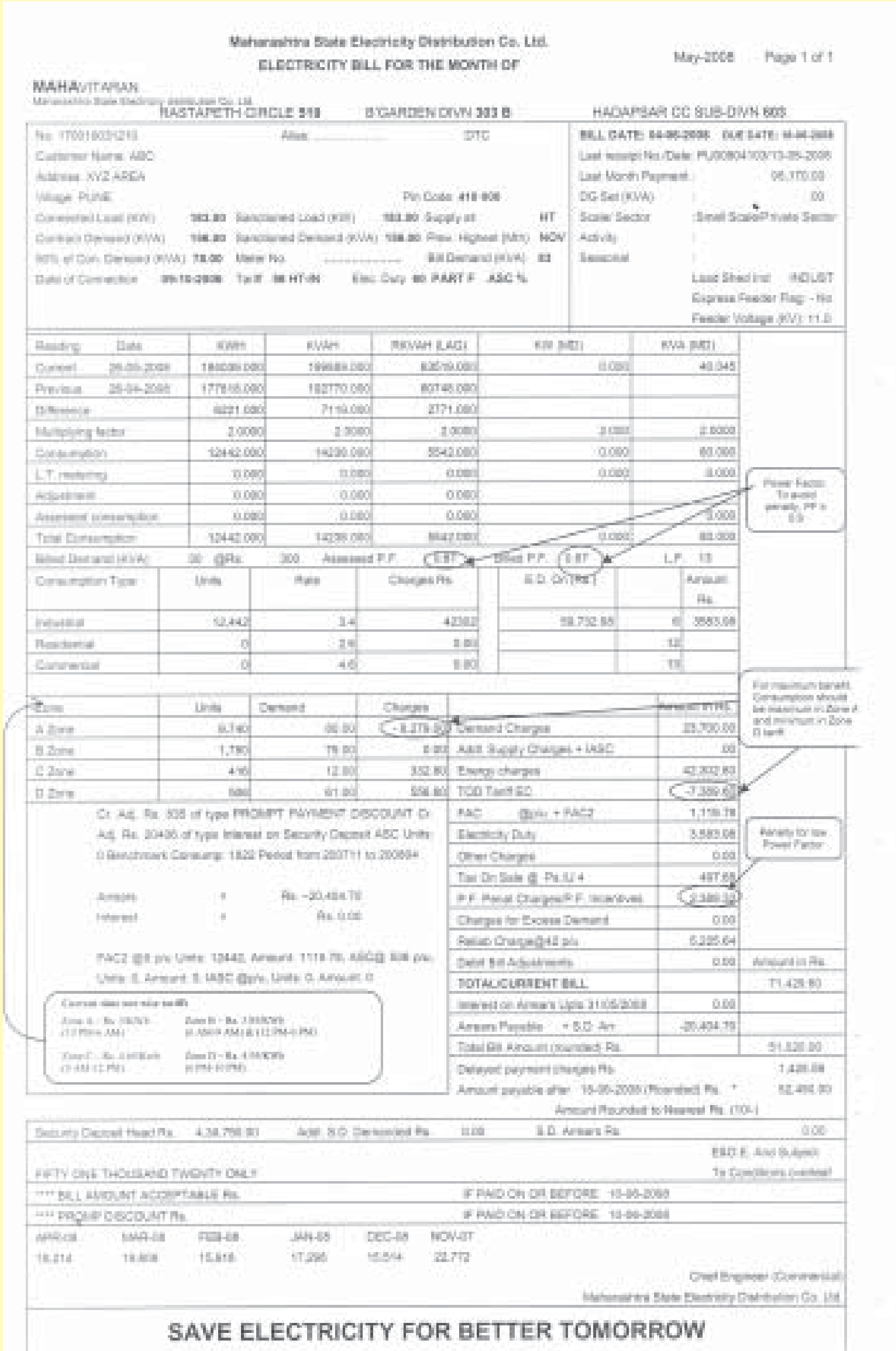
Load to be shifted to night shift (10 p.m.–6 a.m.) from the general shift (9 a.m.–5:30 p.m.)	= 10 kW
Assumed working hours per shift	= 6
Monthly power consumption(kWh)	= 1200
(Assuming 20 days operation per month)	
Electrical cost for night shift operation	= Rs 3600
(@ Rs 3/kWh during 10 p.m.–6 a.m.)	
Electrical cost for general shift operation	= Rs 5100
(@ Rs 4.65/kWh during 9 a.m.–12 p.m. and	
(@ Rs 3.85/kWh during 12 p.m.–6 p.m.)	
Savings per months	= Rs 1500
Annual savings	= Rs 18 000

Box 3 Savings in demand due to high power factor

Existing load of the unit (kW)	=	100
Existing power factor	=	0.90
Existing maximum demand of the unit (kVA)	=	111
Desired power factor	=	0.98
Capacitor required (kVAR)	=	~30
New demand of the unit (kVA)	=	102
Reduction in maximum demand (kVA)	=	9
Monthly savings in demand charges@ Rs 300/kVA	=	2700
Savings per annum	=	32 400
Cost of capacitors @ Rs 250/kVAR	=	7 500
Simple payback period	=	less than 3 months

This calculation does not include the rebate in the monthly electricity bill due to maintaining a power factor of 0.98

Box 1 Typical electricity bill showing some possible areas of saving



Maharashtra State Electricity Distribution Co. Ltd.
ELECTRICITY BILL FOR THE MONTH OF May-2008 Page 1 of 1

MAHAVITARAN

RASTAPETH CIRCLE 518 B'GARDEN DIVN 333 B HADAPSAR CC SUB-DIVN 603

Reading	Date	KWH	KVAH	RKVAH (LAG)	KW (MD)	KVA (MD)
Current	28-05-2008	180089.000	199689.000	83519.000	0.000	40.345
Previous	28-04-2008	177818.000	192770.000	80748.000		
Difference		6221.000	7119.000	2771.000		
Multiplying factor		2.0000	2.0000	2.0000	2.000	2.0000
Consumption		12442.000	14238.000	5542.000	0.000	80.000
L.T. metering		0.000	0.000	0.000	0.000	0.000
Adjustment		0.000	0.000	0.000		
Assessed consumption		0.000	0.000	0.000		0.000
Total Consumption		12442.000	14238.000	5542.000	0.000	80.000

Zone	Units	Demand	Charges
A Zone	9,740	66.00	-8,279.00
B Zone	1,790	78.00	0.00
C Zone	416	12.00	332.80
D Zone	496	61.00	396.80

	Amount in Rs.
Demand Charges	23,700.00
Addl. Supply Charges + IASC	.00
Energy charges	42,302.80
TOD Tariff EC	-7,389.60
FAC	1,119.78
Electricity Duty	3,583.08
Other Charges	0.00
Tax On Sale	497.68
P.F. Penal Charges/P.F. Incentives	-2,389.32
Charges for Excess Demand	0.00
Reliab Charge	6,225.64
Debit Bill Adjustments	0.00
TOTAL CURRENT BILL	71,428.80
Interest on Arrears	0.00
Arrears Payable	-20,404.79
Total Bill Amount (rounded) Rs.	51,020.00

Power Factor: To avoid penalty, PF is 0.9

For maximum benefit Consumption should be maximum in Zone A and minimum in Zone D tariff

Penalty for low Power Factor

FIFTY ONE THOUSAND TWENTY ONLY

APR-08	MAR-08	FEB-08	JAN-08	DEC-08	NOV-07
18,214	19,808	15,818	17,296	15,514	22,772

Chief Engineer (Commercial)
Maharashtra State Electricity Distribution Co. Ltd.

SAVE ELECTRICITY FOR BETTER TOMORROW

Table 5 Multipliers to determine capacitor KVAR required for power factor correction

Original Power Factor	*Desired Power Factor*															
	0.85	*0.86*	*0.87*	*0.88*	*0.89*	*0.90*	*0.91*	*0.92*	*0.93*	*0.94*	*0.95*	*0.96*	*0.97*	*0.98*	*0.99*	*1.0*
0.85	0.00	0.03	0.05	0.08	0.11	0.14	0.16	0.19	0.23	0.26	0.29	0.33	0.37	0.42	0.48	0.62
0.86		0.00	0.26	0.53	0.08	0.11	0.14	0.17	0.20	0.23	0.26	0.30	0.34	0.39	0.45	0.59
0.87			0.00	0.03	0.06	0.08	0.11	0.14	0.17	0.20	0.24	0.28	0.32	0.36	0.42	0.57
0.88				0.00	0.03	0.06	0.08	0.11	0.15	0.18	0.21	0.25	0.29	0.34	0.40	0.54
0.89					0.00	0.03	0.06	0.09	0.12	0.15	0.18	0.22	0.26	0.31	0.37	0.51
0.90						0.00	0.03	0.06	0.09	0.12	0.16	0.19	0.23	0.28	0.34	0.48
0.91							0.00	0.03	0.06	0.09	0.13	0.16	0.21	0.25	0.31	0.46
0.92								0.00	0.03	0.06	0.10	0.13	0.18	0.22	0.28	0.43
0.93									0.00	0.03	0.07	0.10	0.14	0.19	0.25	0.40
0.94										0.00	0.03	0.07	0.11	0.16	0.22	0.36
0.95											0.00	0.04	0.08	0.13	0.19	0.33
0.96												0.00	0.04	0.09	0.15	0.29
0.97													0.00	0.05	0.11	0.25
0.98														0.00	0.06	0.20
0.99															0.00	0.14
																0.00

Required capacitor rating (kVAR)= Load (kW) × muliplication factor

and never be leading, which may lead to motor burning. Use automatic power factor relay for effective power factor management.

- Transformers are, normally, designed to operate at maximum efficiency between loadings of 32% and 35% of its full load capacity. If the load on transformer increases beyond 80% of the designed capacity, it is better to go for a new or bigger transformer to avoid the sharp rise in transformer losses.

Lighting

Energy savings in lighting can be realized by adopting the following tips.

- Make the maximum use of daylight by providing translucent roof sheets, glass window, etc., as it is freely available.
- Replace all the incandescent bulbs with CFL (compact fluorescent lamp). A case study for such replacement is shown in Box 4.

Develop the habit of switching off the lights whenever not required

Clean the lamp and fixture regularly for better lighting efficiency

Immediately replace the fused tube light to avoid choke losses in tube light fitting without any useful lighting

Box 4 Replacement of incandescent lamp (100 W) with CFL

Lamp wattage	=	100
Wattage of CFL (for equivalent lighting)(W)	=	23
Savings in lighting load per lamp (W)	=	77
Annual energy savings (kWh)	=	138
(Based on 6 hours/day for 300 days)		
Monetary savings (rupees)	=	690
(@average of Rs 5/kWh, inclusive of all charges)		
Cost of CFL (rupees)	=	160
Simple payback period (years)	=	0.2

This calculation doesn't include the savings due to reduction in demand.

- Replace all 40 W conventional tube lights with more efficient T5 lights (28 W). A case study for this is mentioned in Box 5.
- Replacement of mercury vapour lamps with 70 W low pressure sodium vapour (LPSV) lamp, for street lighting or the area where colour rendering is not important, will result in 40%–50% electricity savings.
- Consider painting the inner walls with a lighter colour. This will require less number of lighting fixtures.

Box 5 Replacement of conventional tube light with energy-efficient 28-W T5 lighting system

Wattage of lamp and ballast (40+15)	=	55
Wattage of T-5 Lamp and ballast (28+2)	=	30
Reduction in wattage	=	25
Total Reduction in kW	=	.025
Annual electricity saving in kWh	=	60
(Based on 8 hours/day for 300 days)		
Annual monetary savings (rupees)	=	300
(@average of Rs 5/kWh, inclusive of all charges)		
Cost of T5 lighting system (rupees)	=	800
Simple payback period in years	=	2.7

This calculation doesn't include the savings due to reduction in demand.

Motors

Motors are used throughout a typical food-processing unit for various processes (such as mixing, grinding, peeling, cutting, pulping, filling, and packaging) and utility (such as ventilation fans, compressors, and pumps) equipment. Some energy conservation opportunities for small food processing units are given below.

- Always use properly sized motors as per the load application. Oversized motors can result in unnecessary energy wastage due to decrease in efficiency and power factor (Figure 3). A case study is shown in Box 6.

A 20% reduction in motor speed will result into almost 50% power savings

All new replacements should be done with energy-efficient motors having 3%–5% higher efficiency. This results into significant energy savings and simple payback period in most of the cases is less than three years

It is better to replace the old motor which has undergone rewinding 3 times. Motor efficiency goes down by 3% – 5% after each rewinding

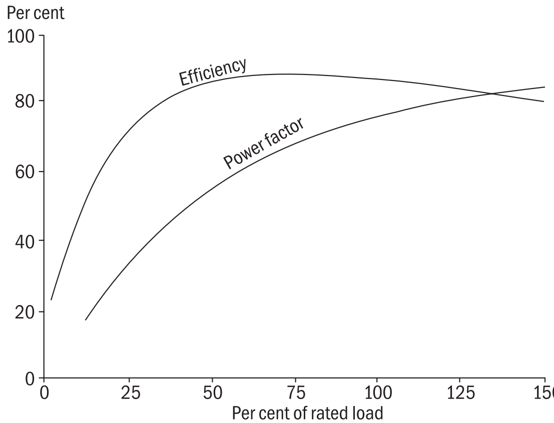


Figure 3 Variation in efficiency and power factor with load on the motor

Box 6 Replacement of an oversized motor with an appropriate one

Parameters	Existing case	Proposed case
Rating (kW)	15	11
Shaft load (kW)	8.3	8.3
Percentage loading on the motor	55.3	75.5
Power factor	0.75	0.88
Motor efficiency (%)	84	86
Motor input power (kW)	9.88	9.65
Reduction in input power (kW)	–	0.23
Working hours per year	6000	6000
Annual electricity savings (kWh)	–	1380
Monetary savings (rupees)	–	6900
(@ Rs 5/kWh)	–	20 000
Cost of new motors (rupees)		
Simple pay back period (years)	–	2.9

- The motor should be rewound by a qualified person. This will ensure to minimize the losses of the rewound motors.
- If a motor is continuously running below 45% of its design load, it is better to operate in star mode by changing to star connection or by installing auto del-star converter. This will give a handsome saving.
- It is appropriate to use VSD (variable speed drive) with the motor, if the load is of variable nature such as that for pumps, fans, and mixers. VSD matches the motor speed as per the load and results in savings.

Refrigeration system

Refrigeration systems consume a significant amount of electricity in the frozen fruits and vegetable-processing units. These are required for generating chilled water for various cooling applications and also to generate cold air for cold storage, and freezing of fruits and vegetables. The following suggestions will help in reducing the energy bill and also in improving the performance of refrigeration system.

- Maintain the suction and discharge parameters of the refrigerant as recommended by the manufacturer for efficient chilling/refrigeration operation.
- Switch off the chiller compressor as soon as the required temperature is achieved. It is better to automate the compressor controls to have superior matching of cooling/ refrigeration demand and compressor load. Use of VSD can further reduce the energy consumption in a system having variable cooling demand.

Condenser coils should regularly be cleaned. A scale build-up of 1 mm on condenser tubes can increase energy consumption by 40%

All the lights in the cold storage/refrigeration chamber should be kept off, if there is no movement, to avoid unnecessary heat load. Heat due to lighting can add up to 5%–10% of the refrigeration load

Always examine new low-temperature cooling requirements and the temperature required to be attained by the product. Additional cooling by every 1 °C will increase the compressor power consumption by 3%–5%

- All different cooling applications should be segregated. A chiller compressor catering to low-temperature application (that is, freezing or cold storage) must not be used for generating chilled water for cooling purposes.
- It is important to keep the surfaces of condenser and evaporator clean for better heat transfer. Fouling or deposits on condensing/evaporating coils can lead to high condenser gas pressure and temperature, and low evaporation temperature and pressure. In both the cases, compressor power consumption will increase.
- Plug the refrigerant leakages as soon as they are identified.
- Regularly check the pipe insulation. Any damage or removal should immediately be attended to.
- All the doors of cold storage/refrigeration chamber should be tightly closed to avoid the infiltration of outside air. They should not be opened too frequently and the duration of opening should be as short as possible. All unnecessary movement in it should be curtailed to avoid heat ingress, even from the human body. The energy loss due to improper door management can be as high as 10%–20%.
- Remove all the excess surface water from the fruit/ vegetable/corn before refrigeration (blast freezing) as it will lead to extra energy consumption by the refrigeration compressor.

- For the chilled water requirement during the day, it would be cheaper to operate chiller plant during the night, when the electricity charges are less, and form ice in the tank. The ice can be used for generating chilled water during the day. For ice bank operation, insulation of the ice/chilled water tank has to be in good condition. A case study for such operation is mentioned in Box 7.
- Avoid frost formation on the evaporation coils in the blast freezer and cold storage by regular defrosting. Frost acts as an insulator and slows down the heat transfer between the cooling air and coils thereby leading to the lower suction temperature at the compressor. A reduction in refrigerant evaporation temperature by 1 °C will increase the compressor power consumption by about 3%.

Box 7 Savings due to switching to ice formation during night

Chiller capacity (TR)	= 15
Motor size (kW)	= 15
Load on motor (@80%) in kW	= 12
Power consumption (kWh) (Assuming 6 hours/day and 300 days operation per year)	= 21 600
Electrical cost for night shift operation (@ Rs 3/kWh during 10 p.m.–6 a.m.)	= Rs 64 800
Electrical cost for general shift operation (@ Rs 4.65/kWh during 9 a.m.–12 p.m. and (@ Rs 3.85/kWh during 12 p.m.–6 p.m.)	= Rs 91 800
Savings per year	= Rs 27 000

Cooling towers

Cooling tower is a sub-system of a refrigeration system and its performance can significantly affect the performance of a refrigeration system. By following the measures given below, energy savings and better cooling tower performance can be achieved.

- Cooling towers are designed based on the worst condition in the region. Therefore, control the operation of the cooling tower fan based on leaving water temperatures. Switch off the cooling tower fan when loads are reduced or during night/colder months. This can be automated by installing a basin water temperature based controller for fan operation.
- Clean the distribution nozzles in the cooling tower regularly to have uniform distribution of water.
- Consider installation of energy-efficient FRP blades since they consume 15%–20% less energy compared to cast iron/aluminium blades with the same airflow.
- Avoid idle operation of cooling tower and circulation of cooling water to an application that is not operating.
- Avoid buying an oversized cooling tower.

Aerodynamic FRP (fibre reinforced plastic) fan blades can reduce the fan energy consumption by 15%–20% in cooling towers

Replace splash bars with PVC cellular-film fill for efficient cooling tower operation

Keep water in the cooling tower basin free of algal growth

Diesel generating sets

DG sets in the food processing industry are generally used to provide back up power during power cuts or when there is no power. Adopting measures given below will keep the DG sets in good condition.

- The performance of the DG set can be evaluated in terms of SEGR (specific energy generation ratio) in kWh/litre, which provides combined efficiency including the engine and alternator.
- Conduct regular SEGR trials to monitor the performance of DG sets. If the operating value of SEGR is less than 80% of the design value, at optimum load and with all other parameters within limit, it is time to contact the manufacturer for overhauling.
- Consider the use of fuel oil additives in the DG set after carefully evaluating the results.
- In case of a base load operation, explore the possibility of waste heat recovery for hot water generation from the DG set's exhaust.

The fuel consumption per unit of power generation is lowest if the DG set is loaded in a range of 60%–80% of the design capacity, without fluctuation

Air intake to the DG set should be cool and free from dust, preferably outside the generator room

Clean the air filters regularly to reduce the pressure drop across it

Process

Energy consumption in the processing of fruits and vegetables can also be reduced by inducting more efficient process equipment or by adopting the latest technologies as mentioned below.

- Whenever new process equipment is bought it should have better efficiency even if the cost is higher. The life cycle cost (purchase and operating cost) of a more efficient equipment is less compared to one with lesser efficiency.
- All new steam using equipment (vets, blanchers, indirect heaters, and so on) should have proper steam seals to stop steam leakage, proper insulation to minimize heat loss through surface and process controller (with temperature indicators) to regulate steam flow based on the product.
- Infrared heating could be a more efficient option. In conventional heating, substantial heat quantity is used to heat the product and surroundings, whereas in infrared drying, infrared radiation heats only the material that needs to be heated—not the surrounding air—and thus saves energy compared to conventional methods.
- Solar energy is available in plenty in the country and should be explored for possible use in food industry. Sunlight in India varies from 2300 to 3200 hours per year, with an average radiation of 4–5 kWh/m^2/day. Solar collectors for applications using 90—95 °C temperature, namely flat plate and evacuated collectors, are readily available in India. This temperature is enough to cater to many applications such as hot water/air generation in the food-processing cluster.
- Waste generated from the fruits and vegetables based industry can be used for biogas generation, which could be used for heat generation. The biogas generated can be used in the boiler to replace fossil fuel for example, LPG/oil. The techno-economic feasibility of plants of various capacities is given in Table 6.

Table 6 Techno-economic feasibility for installing a biogas generation plant

Quantity of the waste (kg/day)	100 kg/day	150 kg/day	250 kg/day
Quantity of the biogas to be generated (m^3/day)	6	9	15
LPG equivalent (kg/day)	3	4.5	7.5
Savings due to replacement of LPG (Rs/day) (@ Rs 80/kg LPG)	240	360	600
Manure generation (kg/day) (@10% of the waste)	10	15	25
Savings due to manure (Rs/day) (@ Rs 3/kg)	30	45	75
Net revenue (Rs/day)	270	405	675
Net annual recovery (Rs/year) (@300 days operation per year)	81 000	121 500	202 500
Cost of plant (rupees)	430 000	450 000	480 000
Pay back period (year)	5.2	3.7	2.4

Conclusion

Energy is an important basic input in the manufacturing process and its saving will have direct impact on the profitability of the manufacturers. It is expected that by implementing the suggestions mentioned in this booklet, plants can save about 5%–10% of their energy costs.

Some general guidelines for energy conservation, which are applicable to a wide spectrum of plants in Pune's fruit and vegetable processing cluster, are summarized below.

- Regularly undertake energy audit
- Meter your energy consumption
- Optimize the equipment usage
- Switch off lights, motors, equipments, and so on when not in use
- Replace old/inefficient equipments with the new and more efficient ones
- Optimize water usage and reduce water wastages
- Make maximum use of day-lighting by using translucent sheets on roof and glass windows
- Replace exhaust fans with air circulators wherever possible
- Avoid leakages of fuel oil
- Insulate the bare surfaces in the steam and chilled water system
- Avoid compressed air for floor/personal cleaning
- Avoid power factor penalty by maintaining power factor above 0.9
- Replace all fused tubes at the earliest to avoid choke losses
- Whenever buying a new motor always opt for high efficiency motors
- Keep all lights off in cold storage to avoid additional load on refrigeration system due to extra heat load of lighting fixture, if there is no movement

SOME GENERAL GUIDELINES FOR IMPROVING ENERGY EFFICIENCY

Dos	Don'ts
Undertake regular energy audits to identify energy saving potential	Do not work in isolation
Sensitize plant personnel on the benefits of energy conservation	Do not be stagnant
Encourage people to provide ideas for energy savings and reward them	Do not always believe in what you hear
Promote group activities for information sharing at cluster level	Do not look for only short-term benefits
Search constantly for energy-efficient technological solutions	Do not be afraid of adopting new technologies
Avail external expertise to develop and undertake technological upgradation	Do not always depend on in-house technical capacity
Participate in workshops and training programs on energy efficiency improvements	Do not think low-cost solutions are always economical
Share success stories and discuss energy efficiency improvement strategies with co-entrepreneurs	Do not be apprehensive to approach banks for loans to invest in energy-efficient technologies

ENERGY AUDIT

What is an energy audit?

Energy audits indicate the ways in which different forms of energy are being used and quantify energy use according to discrete functions. Energy audits do not provide the final answer to the problem. They identify where the potential for improvement lies, and therefore, where energy management efforts must be directed.

Energy audits are broadly classified as: preliminary energy audits and detailed energy audits. Brief explanatory notes are provided below.

Preliminary energy audit

In a preliminary energy audit, the entire audit exercise can be divided into three steps. Step 1 identifies the quantity and cost of the various energy forms used in the plant. Step 2 identifies energy consumption at the department/process level. Step 3 relates energy input to production (output), thereby highlighting energy wastage in major equipment/processes. The typical outputs from a preliminary audit assignment are as given below.

- A set of recommendations for immediate low-cost action
- Identification of major areas/projects which require a more in-depth analysis

In a preliminary energy audit study, one basically relies on the data supplied by the unit or personal readings from meters installed in the industry.

Detailed energy audit

A detailed energy audit goes much beyond the quantitative estimates of cost and savings. It is generally preceded by a plant visit, which is also called a scoping study or preliminary energy audit, wherein the scope of the audit assignment is discussed in detail with the plant personnel. The study involves detailed mass and energy balance of major energy-consuming equipment. The system efficiencies are evaluated and measures are identified for improving the end-use energy efficiency. The study proposes specific projects/feasibility studies for major retrofitting/replacement proposals, providing a cost-benefit analysis of the recommended measure. The duration of the audit is a function of the size and complexity of the plant, the areas to be covered under the study, and so on.

INCENTIVE SCHEMES FOR USING RENEWABLE ENERGY

MNRE (Ministry of New and Renewable Energy), IREDA (Indian Renewable Energy Development Agency), and SNAs (state nodal agencies) responsible for development of renewable energy projects in their respective states. MNRE provides financial assistance to SNAs and private sector for development of such projects. Schemes for renewable energy system development from these agencies are as follows.

MNRE provides support for development renewable energy projects. The schemes that are applicable for fruits and vegetable processing industries are given below.

1. Schemes for solar energy devices and systems

Under this scheme financial assistance are provided by MNRE for promotion of solar water heating systems, solar azir heating systems, solar buildings, solar photovoltaic devices, and products such as street lights. There are different levels of incentives for the different devices. Please contact IREDA and MEDA for further details.

2. Solar power projects

Support for maximum of 50-MW grid interactive solar power project (this includes both solar photovoltaic and solar thermal power projects). MNRE provides generation based incentives through IREDA of a maximum of Rs. 12 per kWh to the eligible projects, which are commissioned by 31 December, 2009, after taking in account the power purchase rate (per kWh) provided by the State Electricity Regulatory Commission or utility for that project.

3. Solar air heating systems and steam generators for industrial applications

To promote solar air heating/steam generating systems, financial support in the form of 35% of the cost of system, subject to a maximum of Rs 3500 per square metre of dish area for solar concentrating systems, and Rs 1750 per square metre of collector area for FPC-based solar air heating systems/ dryers will be provided to commercial/industrial organizations.

4. Biogas plants

The ministry has started a scheme 'Biogas based power generation program'. The central financial assistance for such projects will be limited to a maximum of Rs 30 000 to 40000 per kW depending upon capacity of the power generating projects or 40% of the plant cost, whichever is lower, in the range of 3 kW to 250 kW.

5. Small wind hybrid systems

Small wind energy systems namely, water pumping windmills, aero-generators and wind–solar hybrid systems are useful for meeting water pumping and small power requirements. The ministry provides financial assistance up to 50% of the ex-works cost of water pumping windmills, (except for un-electrified inlands for which up to 90% of the ex-works cost) and 50% to 75% of the cost of hybrid system.

Above details given are the brief of the various schemes of MNRE, for more detail please visit the MNRE website www.mnre.gov.in

IREDA Ltd.

IREDA is a Public Limited Government Company established in 1987, under the administrative control of MNRE to promote, develop and extend financial assistance for renewable energy and energy efficiency/conservation projects. The details of these financial supports can be found in IREDA's website www.ireda.in. Contact details of IREDA is as follows

Indian Renewable Energy Development Agency Limited
(A Government of India Enterprise)
India Habitat Centre Complex,
Core-4A, East Court, 1st Floor,
Lodi Road, New Delhi – 110 003
Tel: +91 11 2468 2214–21 Fax +91 11 2468 2202
E-mail cmd@ireda.in

Maharashtra Energy Development Agency

MEDA was established in July 1985 and functions as the SNA the promotion and development of Non-conventional and renewable energy sources of energy in Maharashtra. The contact details of MEDA is as given below.

Maharashtra Energy Development Agency
MHADA Commercial Complex, II floor,
Opp: Tridal Nagar, Yerwada
Pune – 411 006 (Maharashtra), INDIA
Tel. – 91 020 2661 4393/4403 Fax 91 020 2661 5031
E-mail - meda@vsnl.com, pg1@mahaurja.com
Web www.mahaurja.com

About DFID

The Department for International Development (DFID) is the British government department responsible for Britain's contribution towards international efforts to eliminate poverty. DFID works in partnership with developing country governments towards poverty alleviation. DFID supports long-term programmes to help tackle the underlying causes of poverty. DFID recognises that the development of small and medium enterprises (MSMEs) is key to creating the jobs and income needed to reduce India's poverty. DFID is supporting the development of the MSME sector in India through MSME Financing & Development project (SMEFDP) being implemented by SIDBI. SMEFDP aims to enhance MSMEs' access to institutional finance and to market oriented Business Development Services. The Technical Assistance part of the project is funded by DFID.

About TERI

TERI (The Energy and Resources Institute), a dynamic and flexible organization with a global vision and a local focus, was established in 1974. Initially the focus was on documentation and information dissemination. Research activities in the fields of energy, environment, and sustainable development were initiated towards the end of 1982. All these activities were rooted in TERI's firm conviction that efficient utilization of energy, sustainable use of natural resources, large-scale adoption of renewable energy technologies, and reduction of all forms of waste would move the process of development towards the goal of sustainability.

A unique developing-country institution, TERI is deeply committed to every aspect of sustainable development. From providing environment-friendly solutions to rural energy requirements to helping shape the development of the Indian oil and gas sector; from tackling global climate change issues across continents to helping conserve forests; from advancing solutions to the growing urban transport and air pollution to promoting energy efficiency in the Indian industry, the emphasis has always been on finding innovative solutions to make the world a better place to live in. Although TERI's vision is global, its roots are firmly entrenched in the Indian soil. All activities in TERI move from formulating local- and national-level strategies to shaping global solutions to critical energy and environment-related issues. To this end, TERI has established regional centres in Bangalore, Goa, Guwahati, Kolkata, and Mumbai. It has set up affiliate institutes: TERI–NA (The Energy and Resources Institute, North America) in Washington, DC, USA and TERI–Europe, London, UK; and it also has a presence in Japan and Malaysia.

Small Industries Development Bank of India

SIDBI was established on April 2, 1990 under an Act passed by Indian Parliament as the Principal Financial Institution for Financing, Promotion and Development of industries in the small scale sector and to coordinate the functions of other institutions engaged in similar activities.

Mission

"To empower the Micro, Small and Medium Enterprises (MSME) sector with a view to contributing to the process of economic growth, employment generation and balanced regional development."

SIDBI has been supporting the MSME sector with various innovative schemes and has brought special products for addressing the requirements in the areas of cleaner production measures and also energy efficiency with the support of various multilateral agencies, brief details of which are as under :-

SIDBI - Japan Bank for International Cooperation (JBIC) partnership:-

SIDBI and JBIC have collaborated with an objective to promote energy saving projects in MSME sector by providing financial assistance through direct finance and refinance through select PLIs/NBFCs thereby contributing to environmental improvement and economic development in the country. Assistance under the scheme will be provided on softer terms to install equipments, changing the processes and directly associated activities with the installation as per the approved Equipment / Activity List. MSMEs may also avail the benefits of carbon credit due to reduced emission of CO_2.

SIDBI - KfW partnership:-

A new scheme namely "SIDBI-KfW Scheme for Cleaner Production Measures for SSI/CETPs" was introduced in collaboration with KfW, Germany, in order to encourage select industrial sectors in the MSME sector and Common Effluent Treatment Plants (CETPs) to adopt cleaner production measures, so as to reduce the severe pollution loads, as well as to improve the profitability of the beneficiary units in the long run. Assistance is provided on softer terms for medium & long term investments in integrated measures-machinery & equipment- to reduce the emission of hazardous substances.
Besides, SIDBI has been endeavouring to meet the diverse needs of the MSMEs through various tailor - made schemes.

Direct finance schemes of SIDBI

- *Term Loan Assistance* – For setting up of new projects & for technology upgradation, diversification, expansion etc. of existing MSMEs, for Service sector entities & infrastructure development & upgradation.
- Various other schemes e.g. working capital, Inland Letter of Credit, Guarantee Scheme , Equity Support, Vendor Development Scheme & bill discounting facility etc.

SIDBI has country-wide network of 73 branches to service the MSME sector efficiently:-

Agartala
Agra
Alwar
Agartala
Ahmedabad
Aizawl
Aligarh
Ambattur
Andheri
Aurangabad
Baddi
Bangalore
Baroda
Bhopal
Bhubaneswar
Chandigarh
Chinchwad
Chennai
Coimbatore
Dehradun
Dimapur
Dhanbad
Kolkata
Erode
Faridabad
Ganktok
Gandhidam
Gurgaon
Guwahati
Hosur
Hubli
Hyderabad
Imphal
Indore
Itanagar
Jaipur
Jalandhar
Jammu
Jamnagar
Jamshedpur
Jodhpur
Kanpur
Kozikode
Kochi
Kundli
Lucknow
Ludhiana
Mumbai
Nagpur
Nashik
New Delhi
Noida
Okhla
Panaji
Patna
Pune
Puducherry
Rae Bareilly
Raipur
Rajkot
Ranchi
Rourkela
Rudrapur
Shiliong
Surat
Thane
Tirupur
Trichy
Up
Vapi
Varanasi
Visakhapatnam
Vijaywada

For further details please contact nearest SIDBI branch
Toll free number: 1800226753
Website: www.smefdp.net, www.sidbi.in

SIDBI has also setup following **Associate Organisations** to cater to specific needs of MSME sector:-

SIDBI Venture Capital Ltd. (SVCL)
Website:- www.sidbiventure.co.in

Credit Guarantee Fund Trust For Small Industries (CGTSI)
Website:- www.cgtsi.org.in

SME Rating Agency Of India Ltd. (SMERA)
Website:- www.smera.in

India SME Technology Services Ltd. (ISTSL)
Website:- www.techsmall.com