Technews

National Dairy Development Board

For Efficient Dairy Plant Operation

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ELECTRICAL ENERGY CONSERVATION IN DAIRY PLANTS

This bulletin includes technical information based on latest developments on products, systems, techniques etc. reported in journals, companies' leaflets and books and based on studies and experience. The technical information in different issues is on different areas of plant operation. It is hoped that the information contained herein will be useful to readers.

The theme of information in this issue is **Electrical Energy Conservation in Dairy Plants**. It may be understood that the information given here is by no means complete.

In this issue:

1. INTRODUCTION

- In a Dutch brewery[1], the pumping station had six pumps connected in parallel. An electronic variable speed system (frequency inverter) was connected to two of the six pumps and yielded an energy saving of 25 to 30%. The pay back period was 1.8 years.
- In a whey plant in The Netherlands[1], the throttle valve in the centrifugal transport pump unit was replaced by a frequency inverter which decreased the power from 5.1 kW to 3 kW. The pay back period of the initial investment was 2.1 years. However, considering the reduced number of production stops due to lower pumping wear the investment recovery period was only 4 months.
- In a sludge treatment plant[1], a 77.6 kW fan system with an electronic speed control instead of a throttle valve reduced the electricity consumption by an average of 30 kW, amounting to a 45% energy saving. Thus the investment paid back itself in 1.7 years.

These are some examples of electrical energy saving in industry.

Energy costs are high and it is certain that they will continue to rise thereby resulting in increased production costs in dairy plants. In the era of globalization and free competition it is important that the cooperative dairy sector reduces processing costs and effects energy savings to enable it to compete successfully with the private and multinational dairy organizations. Improvements in technology have offered opportunities for increasing the energy efficiency of dairy plants and thereby resulting in real cost savings.

To realize energy savings, dairy plants should give the responsibility for energy usage and savings to a person with the authority to implement changes. The energy manager should find answer to the questions: where and when is the energy used in the plant; why is energy used in this way; can energy be used more effectively/efficiently; do more efficient alternative methods exist ? The judicious use of energy will increase dairy plants profits and assist in the environment conservation.

An approach to energy management was suggested in November-December 1999 issue of *Technews*. Some other issues of the bulletin (November-December 1996; March-April 1998; and November-December 2004) had outlined measures for energy - mostly heat energy - conservation in dairy plants.

This issue of the *Technews* highlights some measures for conservation of electrical energy in dairy plants.

2. MEASURES FOR ELECTRICAL ENERGY CONSERVATION

Very often the electrical energy is wasted due to the negligence of and lack of awareness in the work force. Other times more energy is used then required due to low power factor, use of sub-standard equipment, use of low energy efficiency equipment and such other factors. An efficient energy management programme would include an energy audit as its essential first step. Electrical energy conservation programme can only be initiated after an energy audit. Audits must continue on a routine basis to maintain savings achieved. The ratio of throughput to each unit of electricity should be determined, and the efforts should be to continually improve this. An efficient electrical energy conservation programme should consider the following:

i) Using commonsense
ii) Power factor management
iii) Use of standard equipment
iv) Using energy efficient equipment/system
v) Using controllers and timers
vi) Efficient lighting management

The specific measures required to be taken in each of the above are outlined in the subsequent sections.

3. USE OF COMMONSENSE

Considerable amount of electrical energy is wasted due to negligence and lack of awareness of persons working in an organization. It is, therefore, necessary that different means of effective communication are employed to educate persons working in the organization on saving of energy. Some of the commonsense measures for reducing electrical energy consumption are given below:

i) Turn off equipment, fans, and lights when not in use.
ii) If motor operating efficiency is below 70%, investigate further.
iii) If a motor is damaged and needs rewinding, consider replacing it with higher efficiency motor.
iv) In comparison with fixed capacitor bank, the automatic switchable capacitor bank is more energy efficient.
v) More electricity is used initially to bring 'cold' plant to its maximum efficiency point. Power can be saved by spreading the load. For instance, cream separation may be left until later in the morning by which time the large electric demand of the

main milk pasteurizing plant will have reached its maximum operating efficiency. The separators would then be requiring less power.

vi) An ice bank system enabling the refrigeration plant to run for longer periods can save energy costs compared with conventional systems.

vii) Consider integration of daylight with electric lighting.

4. POWER FACTOR MANAGEMENT [2-3]

AC equipment containing coils of wire (such as motors, fluorescent lamps and welding machines) cause electric current to be out-of-phase with the voltage. 'Useful' power is produced by the position of the current and voltage which are in-phase.

The ratio of useful power (kW) to total power drawn (kVA) is called the power factor (p.f.) of the item of equipment. A motor might run at a p.f. of 0.9 (slightly out-of-phase) while a welder might operate at a p.f. of 0.5. Power factor can be monitored with a suitable motor. Inductive loads such as motors, chokes, transformers and welding machines work at a low power factor. Low power factor decreases the capacity and increases the magnetizing losses in end use equipment such as motors, transformer and welding machines, thereby reducing its efficiency. It is therefore necessary to take corrective action to improve the power factor.

It should be noted that wiring **must** carry **all** the current, in-phase or not. Hence, with a low p.f., the wiring needs to be heavier than is strictly required to do the job.

The power factor of the individual equipment or the system network can be improved by the following methods:

- Use of capacitors connected parallel to the main supply: A capacitor absorbs the power during the first quarter of the cycle while an inductor emits the power. This sequence reverses during every quarter of the cycle. Thus, capacitor compensates the reactive component of power. This method is very commonly used for improving the industrial power factor.

  Location of power factor improvement devices is important. For large sized equipment, for example above 50 kVA, it is advisable to install capacitor bank at individual equipment, which will reduce the network losses. On the other hand, if the factory is having a large number of small equipment, it would be better to install automatic switchable capacitor bank at incoming panel on LT side. If the automatic switchable capacitor bank is installed on HT side, the losses can be reduced, but the cost of installation would increase.

- Use of synchronous condensers (synchronous motor working on no load) improves the power factor of transmission lines where the bulk quantity of power is required to be improved at sub-stations. Normally for improving the power factor of transmission lines, synchronous condensers are located at sub-stations. There are 3 options in factories: First, directly parallel to the equipment; second, at the incoming panel board at HT side; and third, at the incoming panel board of LT side.

- Using devices which are pre-designed for high power factor such as electronic ballast and operation of equipment, like induction motors, transformers etc., at near full load.

5. USE OF STANDARD EQUIPMENT

For all the requirements, only the standard equipment conforming to BIS standards should be used. Sub-standard equipment, which are still being manufactured, consume more power than the standard equipment. Although such sub-standard equipment are cheaper in initial cost, they prove to be very expensive in terms of power consumption and maintenance requirements.

6. EFFICIENT EQUIPMENT AND SYSTEMS

In a dairy plant motors and drives account for the bulk of the electrical energy consumption. They drive different mechanical equipment like compressors, blowers, pumps and fan blades. Clearly, using efficient motor and drive systems would effect considerable savings in electrical energy.

Motors

Different types of electrical motors are used for different applications in dairy plants. Many a time the systems are observed to be highly inefficient: Motors are sub-standard, and are overrated; spurious materials are used when they are repaired. All these result in inefficient operation and wastage of electrical energy. For energy efficient operation of motors, following points are worth considering:

Proper rating of motors: For avoiding wastage of electrical energy, it is essential that motors are selected of ratings that match the required load. Most industrial motors (1 to 15 kw) are probably 75% to 90% efficient at full load. However, many motors do not operate near full load. An overrated motor for a smaller load has low efficiency as shown in Figure 1.

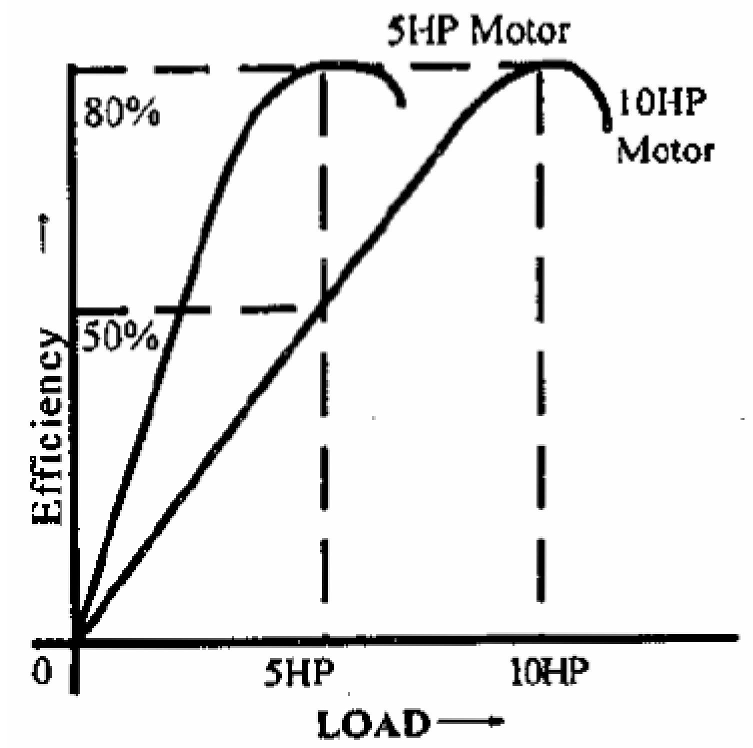

Fig.1: Motor efficiency at different loads for different capacity motors[4]

A simple method of making a rough check on the operation of a motor is to measure current drawn under load using a clip-on ammeter. If it is less than ¾ of the nameplate rating, it is possible that a smaller motor can be used[2]. High rating motors with low loads have high losses and low efficiency. Normal rating motors with normal load have normal losses and therefore the efficiency is high. It may also be noted that idle running of the system and lightly loaded conditions result in unnecessary consumption of electric power.

Standards: Motors which have ISI marks and proper name plates which include the details of the driven members also, only should be considered. It is also important to consider that the motor as well as the driven member are manufactured by a single manufacturer. Sub-standard motors are being manufactured in the country, which should be avoided. Such motors are of poor quality and have poor efficiency.

Higher efficiency motors: An important consideration in purchasing motor should be its high efficiency and not the cost, because high efficiency motors would consume less electrical energy which in long term would prove more economic than purchasing low efficiency motor at cheaper prices. It may be noted that smaller size, less copper, less iron and lesser insulation would result in excessive heating, lesser efficiency and reduced life.

In-built motor losses may be due to friction, windage, hysteresis, magnetic leakage and copper losses. Compared with standard motors, higher efficiency motors (HEMs) are manufactured by including several features as follows[(2)]:

- increasing the amount of copper used in windings
- using a longer rotor
- using high quality, thinner silicon steel laminations
- using an airgap calculated for optimal performance
- using a smaller fan because of lower heat loss
- using higher temperature insulation to allow motors to run hotter and increase the kW rating while using the same size standard efficiency motor frame.

The difference in efficiency [(Input power - Losses) x 100/Input Power] between HEMs and standard motors are[(5)]:

- HEMs are 4-7% higher in efficiency for motor sizes below 5.5 kW.

- HEMs are 2-4% higher in efficiency for larger motor sizes.

HEMs are ideal where:

- Motor running time exceeds its idle time.
- The load is constant and close to the motor's full load rating.

Efficiency: While considering motors, their energy efficiency must be considered rather than the commercial efficiency or watt efficiency. The energy efficiency is the real efficiency factor of a motor and should be high. The energy efficiency is the output power divided by apparent input power. Therefore, the motor should have not only the high commercial efficiency but also should have high power factor which is a function of rating and load. At low loads, the power factor is less and at high loads the power factor is high. These must be kept in mind while selecting a motor.

Unbalanced operation[4]**:** In a plant, the LT distribution system is often in an unbalanced condition. Unbalanced voltage operation in motors causes the motor to operate at lesser efficiency. Further, when the motor is subjected to non-sinusoidal wave from voltage, the power factor becomes low and the efficiency is reduced. Both over voltage or fall in voltage give reduced efficiency operation. If the unbalance is a result of internal plant loads, then possibility of rearranging these loads should be explored to correct the problem and save money.

It is often noted that the system frequency becomes low due to the heavy loads and it requires reduction in supply voltage. For variable speed operations with inverters, constant voltage-frequency ratio input leads to a high efficient operation. Measures should be taken to avoid any nature of voltage unbalance.

Variable Speed Drives[1]

In a dairy plant, the requirement of compressed air does not remain constant through out the operation. Therefore, in any normal system of operations of air compressors, the energy is wasted when the compressor runs at full speed with the requirement of compressed air low, which is met by throttle valves or by-passes. The variable speed drive (VSD) system offers the ability to tune the capacity precisely to the compressed air demand. This system relies on an advanced electric frequency converter, which varies and governs the high efficiency induction motor to run at the required compressor speed. This system eliminates the need for a belt or gear transmission between motor and compressor and also replaces the conventional throttling or basic load/no-load control system. This system makes it possible to achieve whatever rotational speed is required across the given capacity range with a narrow pressure band with a maximum effective working pressure as desired. The motor speed is controlled at the desired level with a corresponding power demand depending on the speed.

The inverter provides soft starting and stopping with controlled acceleration and deceleration. This results in much lower stress to the electrical and mechanical components, resulting in increasing the life of compressor unit. Peak currents are limited to 15-40% of those required for conventional regulation systems.

These units are fully capable of performing continuously at maximum speed. However, full capacity is only needed during peak load periods. Normally compressor operation averages 50-75% of the maximum capacity. As the VSD system continuously controls speed, the compressor readily adapts to any load without incurring unnecessary energy losses due to throttling or load/no-load regulating. This represents significant energy savings during the times when the compressor is running at part load. Considering a VSD unit runs at an average load factor of 60% (150 l/s at 7 bar), an energy saving of 13 kW/h is realized compared to a conventional 90 kW unit with a load/no-load regulatory system. Over a running time of 4,500 hours per year, an electricity saving of 58,500 kWh is obtained.

Compared with a throttled controlled system, the VSD unit even have higher energy saving: 18 kW/hour at the same load factor giving savings of 81,000 kWh/year. The system offers energy saving in the range of 10-15%.

The ability for continuous regulation between 15 and 100% of capacity with negligible energy losses makes the VSD unit very suitable in a multi-compressor installation where each type of compressor is running at its best performance. The base load is covered by a conventional load/no-load unit whereas the remaining variable demand for compressed air is met by a variable speed drive compressor. Variable speed drives can be used effectively in other applications using variable load demand thereby saving electrical energy considerably.

7. CONTROLLERS AND TIMERS[2]

Controls provide a means of automatically and precisely controlling the equipment operation. They provide energy savings, labour savings and also improvement in product quality. However, for correct operation of meters and controls, they need to be calibrated regularly.

Automatic control methods are more reliable than manual methods. Controllers are available for different requirements.

Optimal start and stop of equipment: Optimal start can be used to switch on equipment like air conditioning plant so that the required conditions are reached at a predetermined time. The control system continually monitors plant response and adjusts for a minimum start-up time.

Time-of-Day (TOD) scheduling: TOD scheduling means that loads (e.g. lighting systems, air conditioning system etc.) are automatically turned on and off at set times according to a pre-determined programme.

Load shedding: This involves switching off non-essential loads when it is anticipated that a pre-set Maximum Demand is about to be exceeded. System load is normally sensed via pulses generated by the energy authority's meter. Loads are shed and restored according to a pre-determined schedule based on priorities.

Duty cycling: This can be used when there is some thermal inertia in a system so that equipment can be switched off for a set period during a specified time interval. For example, a chiller might be switched off for five minutes in each half-hour interval.

8. EFFICIENT LIGHTING MANAGEMENT

One of the important forms of electrical energy consumption is electrical lighting. While electrical energy is converted into light energy some of the former is converted into heat energy which is not useful. Therefore, electrical lighting efficiency would depend upon proper selection of light sources, use of improved lighting systems and efficient management in lighting. Any lighting system should consider using natural daylight as much as possible. Some of the important approaches for reducing the use of electric energy in lighting are as follows:

Using the Most Efficient and Suitable Lighting Source

The first important consideration in designing lighting for a dairy plant is the actual requirement of illumination level per unit area for different applications/areas.The lighting system should be designed to obtain the required illumination levels (see Table 1) and should be maintained at that level.

Table 1: Minimum level of illumination required in different dairy sections

Area / section	Minimum illumination lumen/sq. m
Receiving room	530
Exterior areas, loading and unloading platforms	220
Weigh scales	750
Can washing	330
Cooling equipment	330
Processing	1080
Pasteurizers and separators	540
Gauges, on faces; thermometers	540
Instruments panels with switch boards	540
Casing and active storage room	220
Dead storage	60
Boiler room	330
Refrigeration (compressor) room	330
Cold storage room	330
Bottle washing	1080
Bottle sorting	540
Bottle filling	1080
Inspection	1080
Bottle storage	330
Engines, generators, air compressors & blowers	220
Laboratory	1080
Office	
filling and mail sorting	800
accounting, auditing, tabulating & machine operations	1620
Corridor and stairway	220
Toilet and washroom	330

For the required illumination level, different types of lamps can be selected. The basic principle is to select the lamp size to give the maximum amount of light for each watt of electrical energy consumption. Table 2 provides the information on the illumination

Table 2: Efficiency of various light sources

Type of lamp	Wattage range	Initial lumens per watt including ballast losses	Average rated life (hours)
Low-pressure sodium	18-180	62-150	12,000-18,000
High-pressure sodium	35-2,000	51-130	7,500-24,000
Metal halide	32-2,000	69-115	7,500-20,000
Fluorescent	20-215	63-95	9,000-20,000
Mercury vapour	40-1,000	24-50	12,000-24,000
Incandescent	60-1,500	13-24	750-3,500

levels for different types of lighting source[1] and Table 3 the percent of electrical power saved[6].

Table 3: Electrical energy saving in using more efficient light sources

Light source in use	Alternative	% Power saved
GLS 60 W Incandescent Lamp	Compact Fluorescent 9W	78
GLS 100 W Incandescent Lamp	Bowl Reflector 60 W	40
GLS 150/200/300W Incandescent Lamp	Reflector Lamp 75/100/150 W	50
GLS 200 W Incandescent Lamp	160 W Blended Lamp	20
160 W Blended Lamp	80 W Mercury Vapour Lamp	42
125 W Mercury Vapour Lamp	70 W Sodium Vapour Lamp	78
250 W Mercury Vapour Lamp	150 W Sodium Vapour Lamp	40
400 W Mercury Vapour Lamp	250 W Sodium Vapour Lamp	35
GLS 1000 W Incandescent Lamp	Halogen 1000 W Lamp	18

The common incandescent lamps have low initial unit and installation cost, but their light efficiency is very poor and, therefore, for a particular level of illumination required, they consume high amount of electrical energy. Compared with them the low watt high pressure mercury or sodium vapor lamps are very energy efficient. For the same level of illumination required, they use lower wattage. Similarly, high pressure sodium vapor lamps have high luminous efficiency, have longer life and excellent lumen maintenance, and therefore make them preferred choice. These lamps are now commonly used for street light.

In recent years, compact fluorescent lamps using high frequency electronic ballast have come to be used. These provide considerable energy saving. These lamps are highly energy effective and have more than 8 times the average life of incandescent lamp(6). Although their initial costs are high, their very low operational cost due to very low consumption of electrical power makes them highly economical in long term.

Another category of lamps available are 160 W blended light lamps which account for around 20% savings in energy consumption compared with incandescent lamp(6). These lamps are used extensively by small plants.

Control Gears and Luminaires

The contribution of proper luminaires like light reflectors and diffusers in lighting system in energy conservation cannot be overstated. Where acceptable, efficient light reflectors and concentrators would reduce the consumption of electrical energy to provide the same level of illumination. For example, in place of ordinary painted reflector use of luminaire with mirror optics design would give higher illumination on the desired surface with the same electrical energy consumption. Consequently, not only the number of luminaires can be reduced for maintaining the desired level of illumination, the electrical power also could be reduced.

Certain types of light sources like the discharge type, for example fluorescent lamps, high intensity discharge lamps, mercury vapour lamps, compact fluorescent lamps, need control gear, mainly the ballast, for their operation. These ballasts consume substantial amount of electrical energy during operation, dissipated as heat. Use of efficient ballasts, such as electronic ballasts, results in the reduction in energy consumption(7).

Effective Lighting Control System

Proper lighting control system, depending upon the requirement of a particular situation, would result in considerable saving in electrical energy. There are several specific lighting control systems. The various types of controls can be used in isolation or in combination, depending on the building occupancy pattern. Whatever the arrangement, it is important that the occupants are aware of the system as well as that they can operate it effectively. Otherwise the best performance cannot be achieved from the system, energy savings will then be reduced and the occupants may become dissatisfied with the system. The wide variety of lighting control systems can be categorized as follows(8):

Time switching: Time controlled systems switch lighting on or off to a pre-set schedule. With these types of control systems maximum savings are achieved when they are set to turn lights off only. A typical schedule would for example, switch lights off at lunch time and at the end of the working day. Occupants would need to switch lights on when coming in an area in the morning and after lunch. Time control systems are suitable for areas with multiple occupancy.

However, a minimum level of lighting would be required to be maintained at some places at all times. Therefore, it may be necessary to ensure that certain light sources remain independent of automatic systems, for example in areas such as corridors, stairwells and exits. These light sources should work on a manual switching circuit.

Occupancy-linked control: Occupancy-linked control systems are strongly recommended for areas where no day light is available, for example, underground plant rooms, and which are only occupied intermittently. These systems employ presence detection devices based on infra-red, ultrasonic or microwave technology. They may control one or more light sources.

When some one comes into the area, a sensor senses the presence upon which the systems switch on the relevant lights. After a pre-set time, the control will cut off if no further presence is detected. Additional benefits can be obtained by combining occupancy detectors to daylight-linked controls and other equipment, such as fans and urinal flushing systems in toilets. Lights and fans will turn off and the urinals flush at a set time after the rooms have been vacated.

Day light-linked control systems: Based on photocell technologies, these control systems can switch on or dim light sources in relation to daylight-linked systems. Dimming controls can vary the light output of the luminaires between a pre-set minimum and 100% of full load to balance the available daylight as measured by the photocell. When enough daylight is available, these controls save energy by reducing the power drawn by the fittings.

These controls can be used in conjunction with both time and occupancy controls. The simple on-off switching type is relatively inexpensive.

Localized switching: Localized switching is useful where only one part of a large space requires the lighting to be on, whereas the other parts are occupied or enjoy adequate daylight. In general, any area controlled by a simple switch should have a similar level of daylight.

Maintenance

- Incandescent lamps should be replaced on complete failure.
- Fluorescent or discharge type lamps should be replaced according to a planned maintenance schedule.
- Lamps, diffusers, reflectors and reflecting wall surfaces should be kept clean.

9. CONCLUSION

Considerable savings, higher than 30-40%, in electrical energy consumption can be realized by implementing an efficient electrical energy conservation programme. Avoidance of negligence and awareness are very important in avoiding the wastage and reducing the consumption of electrical energy. By implementing the measures suggested here, a dairy plant can reduce electrical energy consumption substantially, and increase its profits.

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NEWS SECTION

Indian Food laws

Notification GSR 368 (E) of 22 May 2007 of the Ministry of Health and Family Welfare: The draft notification specifies the dose of irradiation for different food products including '*dried foods of animal origin and their products*' for the purpose of insect disinfection, control of molds and elimination of pathogenic microorganisms.

Codex Alimentarius Commission

The month of September 2007 features 17th meeting of the Codex Committee on Residues of Veterinary Drugs in Foods during 3-7 September at Breckenridge, Colorado, USA.

International Dairy Federation (IDF)

1. The IDF World Dairy Summit 2007 would be held during 29 September - 4 October 2007 in Dublin, Ireland.

The Summit would hold 3 parallel symposia daily during 1-4 October. These would have the following themes:

- **Dairy policies and economics:** Future trends and developments; Dairy policy changes and their economics; Economics of environmental changes.
- **Functional foods:** Market developments; Developments in biotechnology; Regulatory environment; etc.
- **Developments in dairy science and technology:** Casein micelle (structure, functioning and practical aspects).
- **Nutrition and health:** Health benefits dairy foods; Regulation and labelling issues for dairy health claims and functional foods.
- **Marketing including nutrimarketing:** Nutritional profiling and health claims.
- **Milk production and farm management:** Dairy farming in future; Managing change to survive; etc.
- **Environment:** Environmental and food quality issues at farm level.

More details of the Summit are available on the website http://www.wds2007.com

2. The IDF has published the following Bulletins recently:

- IDF Bulletin No.414/2007: World Dairy Production and Trade: Trade Policy and Development for Asia; and
- IDF Bulletin No.415/2007: Asian Indigenous Dairy Products.

For purchasing the IDF publications, contact Mr. Oscar Chavez, Office Manager, IDF, Brussels, Belgium (Email: OChavez@fil-idf.org).

ELECTRICAL ENERGY CONSERVATION IN DAIRY PLANTS

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Useful	☐	Informative	☐
Only entertaining	☐	Boring	☐

I think the format of this bulletin needs/does not need change.

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