A STRATEGY
for
ENERGY EFFICIENCY
using
ENERGY MANAGEMENT TECHNIQUES
and
RENEWABLE ENERGY TECHNOLGIES

and

THE IDENTIFICATION
of
OPPORTUNITIES FOR ENERGY REDUCTION

at

ZAMORANO

Prepared by
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September – October 2006

Executive Summary

Part One of this report outlines a 4-year plan for the management of energy at Zamorano, and the implementation of renewable energy and energy management training into Zamorano's academic courses. This documents details very specifically the activities required to achieve an energy reduction of 30% in 3-10% steps. The plan includes a plan for, and the details of, renewable energy courses as well as the preliminary design of 4 on-campus solar systems. References to training programs and sample course outlines for Zamorano students and operating plant personnel training are detailed. Sample laboratory equipment lists, suggestions for the type of equipment to purchase, purchasing methods and methods for the development of laboratory space and experiments are detailed.

The plan is very ambitious but achievable. By February 28 2007, an Energy Manager will be in place, have the required training to implement Phase 2. 14 months later Zamorano will have an Energy Efficiency laboratory/classroom, have installed at least 2 commercially operating Solar Systems, presented the first two Energy Efficiency courses in Latin America, and have reduced its energy consumption by up to 10%. Phase 3 is a continuation of the Energy efficiency measures introduced in Phase 2, but with the expansion into the renewable technologies of Biodiesel, Biogas, and Micro Hydro. By May of 2010, it is anticipated that Zamorano's energy use will have decreased by 30%, and with the introduction of Biogas, Biodiesel, and Micro hydro there is a possibility of being self sufficient in electricity.

Part Two of the report examines eleven of Zamorano's production operations. Two of these, the Dairy Plant and the Kellogg Centre, are discussed in considerable detail. Efficiency opportunities within these two facilities have been identified and quantified. Although the low level "walk through" method was used to review the nine other facilities, opportunities and recommendations are presented. For each facility, when on site, the reason for my inspection was explained. Frequently the response of the plant manager was enthusiasm, but that they were hampered because utility monitoring was not in place. It is absolutely necessary that monitoring equipment and benchmarking be undertaken as the first technical step toward the management of energy.

Zamorano is in a unique position to implement the management of energy within each production unit. This is because within each facility students are already recording and examining various processes. Since the culture of recording, questioning and analyzing already exists it is a small step to include utility inputs to that list.

Of considerable importance is that Zamorano's standby generator when used at peak demand times is overloaded. Any additional load or even sustained operation will lead to shut down. Within this document are measures, which if taken now, will alleviate and possibly eliminate the need for the purchase and installation of a new and larger standby generator.

Finally, documents dealing with the management of energy tend to focus on the technical aspects of the subject. However, both technical and human aspects are mandatory for a successful outcome. This plan includes the social as well as the technical dimensions of energy efficiency

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Background

In March of 2006 CESO[1] signed a contract with Zamorano to provide an expert to investigate the potential for energy reduction using Energy Efficiency (EE) techniques and where feasible, renewable energy technology. From September 18 to October 27 2006, C.R. Price P.Eng executed this project on behalf of CESO.

Zamorano is a non-profit Agricultural University offering 4 full time programs: Agribusiness; Agricultural Science and Production, Agro-Industry, and Socio-Economic Development and Environment courses to 900 full time residential students.

Zamorano' motto is "Learn by Doing". This is exemplified by the course curriculum. A students time at Zamorano consists of classroom time and "on the job" time on a 50/50 basis. Theoretical and practical subjects are offered in each of the divisions noted above. Practical training is obtained by working in the many on site production facilities, such as the Meat Plant, the Diary plan, the Pig Farm and many other agricultural enterprises. It is these operations that have been the focus of attention for energy efficiency. While Zamorano exists for training, it also is an operating farm and approximately 25% of its revenues are a result of farm production. Energy costs are straining the budget; hence moving toward energy efficiency will reduce this strain. This project provided an opportunity to make recommendations toward energy efficiency as well as the opportunity to recommend specific renewable energy technologies that integrate with an energy efficiency program as well as provide training.

As is the case with all projects there are many people in the background. Without their help, it would have been impossible to execute this project. Some of these people and their role are listed below:

Dr. Mario Contreras	For initiating and providing direction and advice that allowed this project to be appropriate for Zamorano
Dr. Mily Cortés Posas.	For initiating and providing direction and advice that allowed this project to be appropriate for Zamorano
Helen Aguilar	For providing all of the day-to-day assistance that one need on a short term contact such as this.
CESO	For supporting this project
CIET[2]	For the use of the BC Hydro Course manual
The Canadian Government	For RETScreen®
SIEMP[3]	For excerpts of the CORE Training Program
Quail Engineering	For providing monitoring equipment
Ana Melissa Urquia	For taking me to all of the facilities and acting as an interpreter.
Students	For their effort in counting light fixtures

[1] Canadian Executive Services Organization – a Canadian non-profit organization that links retired and semi-retired professionals with Canadian aboriginal and International organizations. These professionals provide advice on a voluntary basis.

[2] Canadian Institute for Energy Training

[3] The SADC Industrial Energy Project – A CIDA project in Southern Africa 1995 to 2001.

Methodology

Upon arrival at, a tour of the campus was arranged for me in order that I become familiar with Zamorano's facilities. Various meetings were arranged with key personnel and over two days the project scope and purpose was refined.

Dr. Mario Contreras and Dr. Mily Cortés Posas reviewed previous Zamorano energy efficiency and renewable energy activities which included a conceptual plan by Lewis HMJ Consultants Inc, a 4th year thesis by two Zamorano students, and some time efficiency observations performed by second year students. Information was gathered by meetings with the Consejo Ejecutivo, the Energy Committee, and by conversations with the plant managers and students during visits to their operating facilities. Considerable information was obtained by osmosis – the result of living on campus for 6 weeks.

During the preparation of the report, energy efficiency presentations were made to the Consejo Ejecutivo, the Energy Committee and to the second year students. This is an important part of the implementation of an energy efficiency program as energy efficiency is about technical and behavioural changes. Because it may have considerable affect on some members of the organization, people need to be informed about and why changes are to be made. The following summary by Dr. M. Price explains the importance of the social aspects of an energy efficiency program.

Social Dimensions of Energy Management:

The fact that the majority of this document is about technical management exemplifies beliefs and practices underlying energy management. The social dimensions of energy management are often ignored until and even after the fate of the project is in jeopardy. There are some cases where the social structure of an organization prevented preliminary measurement to commence, and in other cases energy management reached less than optimum results because attitudes and social behavior was not taken into account.

Involvement of Members of the Organization

Social attitudes and behavior may impede change when people do not feel included in decisions and adjustments that affect their work area or specific job. Often people need to be motivated to make change, and have benefits because of that change. Energy management involves change, and organizations or parts of them may resist some of the initiatives toward change especially if they do not see the change as in their interests. It is important that all people in the organization, at all levels of the organization participate in decisions toward change, and that they are motivated to make change. If energy management diverts some people from their usual work, or adds extra duties or slows down processes during its start-up phase, some people become resistant to the entire change and may sabotage efforts to make energy management efficient.

Social Practices that Cause Energy Inefficiencies

Organizations are social entities. As such, they are vulnerable to members' social beliefs, as well as to human habits and practices. Energy is wasted because of habits such as leaving machinery in operating mode when not in use. While workers may believe it is more efficient to leave motors operating when not in use, or to leave lights on rather than switching them off and on several times a day, many of these beliefs have been submitted to scientific testing and found to be invalid. Because people have certain vested interests in knowing their job, it can become a difficult task to convince them toward new practices.

Because we are social beings, an important aspect of the workplace is social interaction. Social interaction uses both time and energy. Although some energy is lost during socializing and personal non-work interests, it is important to consider what level of inefficiency is acceptable for the organization and to make it the norm for all persons within the organization. It is important for the energy manager to understand these social norms and to make adjustments to account for them. Energy consultants and managers may create considerable conflict and resistance should they try to eradicate all organizational inefficiencies, especially those that concern pleasurable social practices. Rather than trying to eradicate these pleasurable social practices, training toward understanding the effect of loss of time and energy is certainly warranted. Another strategy would involve setting a firm time allowance to accommodate socializing with the condition that equipment and work processes are shut down. These are important organizational decisions than need to be discussed with the energy manager and workers at the outset.

The Problem of Structure

Most people in organizations do not study organizational behaviour, but they do create organizational structure and behaviour, i.e. work organizations are organized by humans. They build in an authority and status structure, and rules such as schedules, work plans and job descriptions. The introduction of energy management and an energy manager impose changes to the authority structure, schedules, work plans and job descriptions. It is important that these changes be promoted, endorsed and practiced throughout the organization. The failure to 'set the stage' for energy management, and/or to apply it differently for administration than for workers, reduces the credibility and the effectiveness of the program.

Motivation: The Place of Incentives for Energy Efficiency

Especially in the face of change, humans need to both understand and be motivated to successfully reach new goals. Although the logic that energy efficiency reduces costs and increases profits is compelling, it does not reduce costs and increase profits for all involved. Especially during its inception and through to its entrenchment within the organization, members of the organization may need to be reminded of 'why' these new practices are important and they will need to be motivated to attain these new goals.

Both tangible and intangible benefits can motivate people to change their practices toward energy efficiency. For some, recording savings on graphs that decorate their workspace can be sufficient, but for others it may be necessary to see some of those savings turned into improvements to their work area. It is important to learn and understand what the expectations are for all those involved. An energy efficiency goal may be initially met with enthusiasm, but the enthusiasm can be lost when benefits are not shared to some extent. Benefits that only accrue, or appear to only accrue to the organization, often leave managers and workers resentful of their efforts. The sharing of some benefits, and making that sharing visible, creates a sense of satisfaction and achievement.

While technical measures are the tools of energy efficiency, social management is the means to its success.

Purpose of the Project

1. To assist in the development of a strategy that will move Zamorano toward energy efficiency using energy management techniques and renewable energy where appropriate;
2. To identify opportunities which if implemented will reduce Zamorano's utility costs.

The Report

This report consists of two sections. Section 1 addresses the first purpose, and Section 2 addresses the second purpose.

Page 4 is a flow chart that provides a 4-year (2006 to 20010) overview of the proposed strategy. Page 5 is an expansion of the first 2 phases of the strategy. Section one of this report details the required activities for the first 18 months of the plan on a block-by-block basis. For clarity, these blocks have been labeled and have been used as headings. The details of the activities to be undertaken in Phase 3 are only shown on Chart 1. The blocks provide an overview of the required activities, however detailed information has not been provided as phase 3 occurs several years in the future and actual activities will depend upon progress during Phases 1 and 2.

SECTION 1 A STRATEGY FOR ENERGY EFFICIENCY

Phase 1

27 October 2006 to 28 February 2007

Blocks A and B The Committee and a Strategy

Most projects start with a group of people getting together to discuss an issue. A committee is formed and strategy on how to proceed is developed. For this project, an energy committee already existed at the time of arrival of the CESO volunteer. During the period 18 September 2006 to 27 October 2006, a presentation was made to this committee. Subsequent to that meeting, a strategy was developed and Charts 1 and 2 outline that strategy.

Block C The Energy Manager

To implement Energy Efficiency a full time champion is required. This person must be enthusiastic, be a leader, have a technical background, and the ability to manage people. Energy enters Zamorano in the form of fuel oil, vehicle gasoline, wood, propane, electricity and water[4], hence ideally this person will have a solid background in all technical fields, i.e. mechanical, electrical, biology, chemical, and instrumentation, plus, for Zamorano a person familiar with technical training. As this person will also be required to promote and implement the strategy,

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[4] While water is normally not considered to be an 'energy source', for the purposes of energy efficiency and this report it will be considered to be an energy form. The rationale for this is that in most cases it takes energy to pump water, hence the conservation of water results in the conservation of energy. Where water is piped from a water source elevated above the requirement, the conservation of water will result in the minimum water pipe size – hence ultimately an economic issue.

the management of personnel will also be a requirement. This person requires a vision and drive, and must be innovative. This is a rare person and will be hard to find.

Administratively the Energy Manager should be at a level that will allow him/her to direct operational changes in Zamorano's production plants and the educational programs. Making change will be the biggest challenge. This person must have the authority to implement change.

As it is unlikely that a person having all of these skills will be available, training will be required thus eventually developing the required skills. Zamorano may opt to:

- Hire a consultant for the position.
- Appoint from within and provide extensive training.
- A combination of appointment from within, training and the hiring of a consultant.
- Some other mechanism that has be used successfully in the past by Zamorano

Whatever method used the program must be ***sustainable***.

Block D Training

The energy manager will require expertise in both personnel relations and most technical areas. From a formal training point of view, this person ideally would be an Engineer with a specialty in energy issues and have an MBA. It is not likely a person with these qualifications will be easy to locate.

The energy manager will require expertise in the following technical areas:

- Energy management
- Renewable energy technologies
    - Solar (Thermal and Photovoltaic)
    - Biogas
    - Bio-diesel
    - Mini-hydro

There are several sources for this training:

The Canadian Institute for Energy Management (CIET) –. This Canadian organization specializes in Energy Management training. Both self-study and seminars are available. For more detailed information visit:

http://www.cietcanada.com/

In Canada, currently no College offers a formal renewable energy program. There is however, a self-study course offered by Seneca College in Toronto. This course was developed by the Canadian Solar Industries Association (CanSIA) and it is administered by Seneca College. For more information, visit the following site. Both thermal and photovoltaic courses are available.

http://www.cansia.ca/education.asp

Since I am one of the presenters of the Courses offered by CIET and that the CanSIA Photovoltaic course was developed by me, feel free to contact me at the following email address to discuss either of these courses.

crprice@quailcrossing.ca.

Phase 2

28 February 2008 to 30 April 2008

Block K **Develop Course Outlines**

Block K refers to the development of the energy management and renewable energy curriculum that is to be presented to Zamorano's students. Ultimately there will be two courses offered; the course for Zamorano's full time day students and the course to be presented in an outreach program. The strategy assumes that the material presented in both of these programs will be similar, however the depth may differ considerably. This decision must be made by the course developer

Appendix 1 provides suggested outlines for the energy efficiency training and also renewable energy subjects. The renewable energy subjects are limited to solar subjects, as other proposed renewable technologies do not appear in this phase. There also is a fourth section - minimum background. This section is intended to provide the person that is developing the courses some perspective on the technical background required to understand the proposed course material.

The outlines in Appendix 1 were developed assuming that upon completion of the material the graduate would be engaged full time in that occupation. I am fully aware that the intent of Zamorano is to provide *some* training in the renewable and energy efficiency, and not produce a fully qualified renewable energy technician. It is therefore imperative that the curriculum for Zamorano's courses be a sub-version of the Appendix 1 material.

The process used to select portions of suggested curriculum to be used, will consist of listing the required skills and the level of expertise required within that skill set for the course participants. This will then allow the course designer to choose subjects and determine the depth of the material of outlined in the suggested curriculum.

This point can be illustrated by the two following examples.

Example #1

Assumption: That a person is required upon graduation to have sufficient expertise to determine if a system is operating correctly, be able to correct minor faults (likely only electrical), but explain to a technician the problem. For this course the outline might be:

Course Outline for Photovoltaic Fault Finding
Total of 24 hours

Section 1	3 hours
Section 2	2 hours examining samples of the 3 types of modules and explain the application of each.
Section 3 &4	4 hours obtaining measurements on the system installed at Zamorano.
Section 5	3 hours in class examining each of section 5 components and their purpose.
Section 6	(8 hours) 2 Fault finding laboratories. Prior to the class the instructor will have introduced a fault on the operational system and using the check list of section 6, it will be the students responsibility to determine the fault and to recommend a solution to the fault
Section7 and 8	2 hours on each of these subjects.
Section 9	Not presented.

Example #2

Course Outline for Photovoltaic System Supervisor
Total of 56 hours

Assumption That a person is required upon graduation to work at a facility that has one of these systems installed. This person will be in charge of this system as well as other systems having similar complexities. This person is expected to have the ability to replace faulty equipment, but would not be expected to install a system.

Section 1	8 hours
Section 2	8 hours examining samples of the 3 types of modules and using the modules to performance some performance tests.
Section 3 &4	8 hours obtaining measurements on the system installed at Zamorano.
Section 5	8 hours in class examining each of section 5 components and their purpose, how to install and trouble shoot.
Section 6	(16 hours) - 2 Fault finding laboratories. Prior to the class the instructor will have introduced a fault on the operational system and using the check list of section 6, it will be the students responsibility to determine the fault and to recommend a solution to the fault
Section7 and 8	4 hours on each of these subjects.
Section 9	An assignment using this program

The course outlines for the Thermal Solar course and Energy efficiency courses can be developed using similar techniques.

Block L Laboratory Equipment, the Renewable Energy[5] and Energy Efficiency Laboratory

A classroom/laboratory will be required for the presentation of the theoretical concepts and for the students to perform experiments using renewable energy and energy efficient equipment similar to the demonstration[6] systems installed on the Zamorano campus. This classroom/laboratory will also be used for the presentation of energy management[7] techniques.

The equipment

Appendix 2 provides a list of equipment required for the presentation of the anticipated classes. Duplicates of some of this equipment will be required as it is important that each student has the opportunity to 'get their hands on' the equipment. The amount of duplication will depend upon the number of students to be trained at one time (i.e. the class size). It is my opinion that the ideal number of student per station is 2, but in no case should it be larger than 4. The concept of a 'station' refers to a specific location within the laboratory that contains a group of components such that the student/s performs experiments with that equipment. The student will connect components together thereby creating a 'system', upon which an experiment can be performed. Readings and observations will be taken and a report will be prepared thereby illustrating the amount of understanding of the system. This laboratory will have several stations, some stations will contain duplicates and other stations will be unique from all others. It is the task of the person developing the laboratory to determine the experiments to be performed and therefore the required equipment.

In all cases, the equipment listed is an absolute minimum. As the course is developed, it will become obvious what additional equipment and the quantity required. When determining the cost of the laboratory equipment, an initial estimate is made by making a 'best guess' based on the number of students present at one time and hence the amount of equipment. Actual costs will always be higher than the initial estimate and based on my experience, assume that the cost will be 2.5 to 3 times higher than the initial estimate

Purchasing Equipment

There are various options for purchasing equipment. Some organizations specialize in supplying equipment for education institutions. This is an attractive option as the equipment will come with a lab manual that contains experiments to be performed by the student on that equipment. The disadvantage to this route is that future flexibility is compromised. It is my experience that purchasing components that are currently being used in systems being marketed locally is a

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[5] It is intended that the proposed laboratory discussed in this section will have typical components that will be used to illustrate theoretical concepts of the particular subject being presented. Upon completion of the laboratory experiments, the student will then visit the on campus demonstration system to collect data on an operating system.

[6] While the term demonstration is used, it is intended that these systems are operating systems, however they shall have various ports and points installed such that operational readings can be taken by a student, so as to support/verify the theoretical aspects presented in the classroom/laboratory.

[7] Energy Management will not be demonstrated, it will be taught in this facility and then practiced at all of the production facilities during the work portion of the program.

better option. This results in components that can be configured in various ways to illustrate theoretical concepts, and these configurations can be changed over time for whatever reason.

For best results, the process is –

1. determine what concepts are to be illustrated
2. determine the equipment required to realize that concept
1. determine the monitoring components and points required
2. talk to equipment suppliers
3. make decisions
4. order equipment
5. develop the laboratory experiments[8]
6. the instructor performs the newly written laboratory experiment and
7. change the laboratory to make it illustrate the desired concepts

The Laboratory Space

The physical space requirement is determined via a process. The process is to gather all of the data that will have an impact on space. This data includes; the number of students at one time, the type and quantity of equipment used, other uses for the laboratory space, frequency of use, whether the equipment is to be permanently installed or can be stored in the store room when the laboratory space is being used for other subjects and or classes. A mock layout is then made for all of these possibilities. This will lead to the necessary compromises, and the 'must have' decisions being made. Once the building and the actual space and has been allocated the next task is to (on paper) locate the 'stations' and fit the equipment into that station location. Services (utilities) for each station must be then provided[9]

Blocks M and N Presentation of First Courses

Block K and L outline the procedures for developing the courses; the laboratory space; ordering equipment; and designing laboratory experiments. The goal of this activity is to present courses to both fulltime Zamorano and outreach students using the new classroom/laboratory facility. Do not expect total satisfaction during the first 2 or 3 classes presentations. It will take time to work out the details – 'Learn by doing' – the Zamorano motto! There will be mistakes. Learn from mistakes!

Block E Energy Efficiency Training for Production Plant Managers

Training for the production plant managers consists primarily of technical subjects. Appendix 3 contains the Table of Contents for a course that is presented on a regular basis to Energy Managers participating in BC Hydro's energy efficiency program. Participation in this course would provide the required information and allow any Zamorano production plant manager to introduce and operationalize energy management in a production plant. There are also several other options for training:

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[8] This is an iterative process. Start with # 5, proceed to 6 and 7, then back to 5. Repeat until the experiment achieves the required result.

[9] This will be determined by the station activity and the equipment located at that station. For the type of classes envisioned for this facility it likely will be: electricity, water, compressed air, and possibly piping to be used for biogas (to be introduced in phase 3).

Visit

http://www.cietcanada.com/

And click on "Workshops", "CEM Program", "TEMOL", and "International Training"

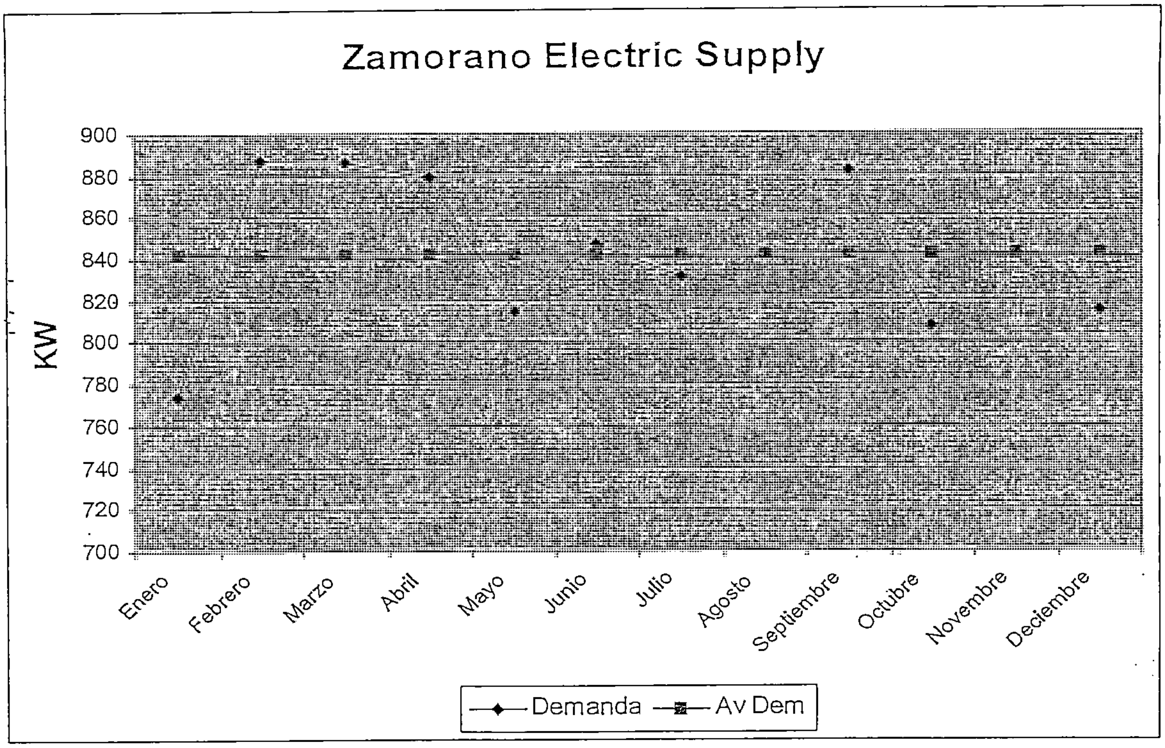
Blocks F,and G Install Monitoring Equipment and Initiate Benchmarking

Blocks F and G are two separate activities, however in this document they will be described under the same heading as the installation of monitoring equipment is essential for the introduction of benchmarking. The installation of monitoring equipment will provide the answer to the question "How much energy am I using per plant production unit". For a dairy plant the units might be kWHr per litre of milk, for a poultry plant it might be kWHr per egg. For the Kellogg Center, it might be kWHr per person night. Benchmarking asks the question "Why did I require and energy density of 0.068 kWHr per litre last month, but this month it is 075 kWHr this month".

Benchmarking is illustrated by the following graph. This is a plot of Zamorano's electrical demand for 2005[10]. Note that the maximum (840 KW) demand occurred in Febrero and the minimum (775 KW) in Enero. This begs the question – why such a difference? In this case, we know the answer for the minimum – the students are not on campus in Deciembre[11]. But why the discrepancy over the other months? Is it possible to reduce those peaks? If the demand was 845 KW in Junio, is possible to prevent the demand from rising above 845KW for each month? The horizontal line indicates the average of the 2005 monthly demand data points. Initially this might be the "benchmark" target demand goal. If the demand in 2005 had been held to no more than the Junio value of 845 KW Zamorano would have saved 35,293 Lps in electrical charges during 2005.

[10] This is a plot of the demand taken from the bills of the Hydro Supply Authority. Note that 3 of the months data is missing – Agosto, Novembre and Deciembre.

[11] Since this data was taken from the actual invoices – the values shown are for the previous month. The energy usage for Deciembre is invoiced in January.



Zamorano Electrical Demand for 2005

Benchmarking therefore is the process of examining energy usage and questioning the variations in usage over time. All variations are questioned i.e. – both highs and lows. Benchmarking requires data. Data can only be obtained if all energy inputs are monitored. Currently Zamorano's production plants do not have input monitoring on all energy inputs. All inputs must be measured – electricity, fuel, water, wood, propane, etc. Graphs can then be prepared and benchmarks established. Performance will be monitored against the somewhat arbitrarily assigned benchmarks. There will always be variation, but the goal is to reduce the variation towards the minimum target value (the benchmark). Appendix 4 includes the Table of Contents of an Energy Efficiency course offered by CIET. Note that sections 6, 7, 8, and 9 deal with demand, instrumentation, benchmarking and targeting.

Blocks H, I and J Benchmarking, Monitoring and Targeting

Block H, I and J describes a process. As described in the previous section the installation of monitoring equipment provides data which if analyzed will reveal fluctuations in energy use. The goal of energy management within a facility is to reduce those fluctuations to a minimum and towards a particular minimum – the target value. The process is an iterative one that consists of monitoring the input energy, studying the data (thereby revealing why there are fluctuations), then making changes to reduce the fluctuations toward that target value. The process then starts all over again and continues until some minimum acceptable target value has been reached. Once the target value has been reached, some fluctuations will remain – which still begs the question "Why". Energy management is a continuing process and will never be complete. For the vigilant, reduction opportunities will always exist.

Block O Coordination

Blocks O, P and Q pertain to the renewable energy portion of this strategy. It is intended that four solar systems be installed on campus. All of these systems are to be fully functional in the commercial sense, however each will also a second function, that is, the validation of the theoretical concepts presented in the Renewable Energy Laboratory/Classroom. Since these systems have this dual function, it is imperative that they be designed and installed with this dual function in mind. It is therefore very important that both the academic and operational personnel of Zāmorano coordinate closely on the design and installation of these systems otherwise the dual purpose envisioned for these systems will not be realized.

Blocks P and Q Design Solar Systems and Installation of Solar Systems

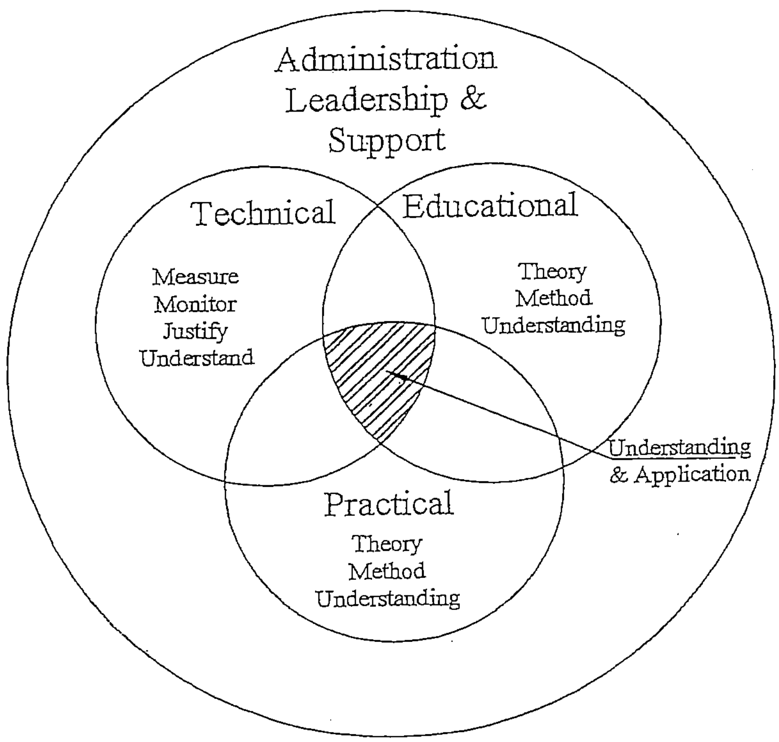
These two blocks refer to the design and construction of the on campus operating solar systems that will be used to illustrate the theoretical concepts learned in the renewable Energy Laboratory/classroom. This strategy recommends 4 solar systems, two thermal systems and two Photovoltaic (PV) systems. For details regarding the use and application of these systems, please refer to the section "On Campus Electric Transportation System" for the two PV systems, the section on the "Centro Kellogg" for the thermosyphon system, and the "Cafeteria" for the pumped system.

These systems must be designed in the normal commercial method of design, except that they shall have numerous monitoring points that the students can use during an inspection of each system. Because of this dual function, both the Facilities personnel and Academic personnel must be involved in their design and construction, because they must serve the purposes of both. Consideration must be given to both the fact they are used to provide energy and that they will be used for training purposes, as such when they are used for training purposes they shall not interfere with the commercial use. I have very carefully chosen the applications of the solar systems for this reason. In the case of the PV systems, one or two golf carts can be selected for testing by students by prearrangement. The grid tied system will not affect the stability of the main electrical system in any way as long as the testing is done during a non-peaking period. In any event, I expect that the grid tied system during student testing will not be disconnected, only monitored to observe (via voltmeters, ammeters and wattmeters) the operation of the system. Similarly, a thermosyphon system at Centro Kellogg can be inspected without interference if prearranged with the booking desk. The cafeteria pumped system if inspected during a non- dish washing period, will have no effect on the operation of the cafeteria. It is to be noted that the cafeteria system has a back up system installed hence if the pumped system is shut down temporarily it will not affect the kitchen in any way.

Block R Administration Activities

The role of administrations cannot be well defined. Administration starts the process and it is administrations responsibility to do whatever is necessary to insure that the process continues. Leadership, innovation and support will be important for all aspects and at all levels of the organization.

The following figure illustrates that administration surrounds the entire program. For Zamorano there are three very distinct spheres of influence. Zamorano is a teaching institution, and understanding is the goal of each sphere of influence. The administration must do whatever is necessary to cause those three spheres to overlap.



Spheres of Influence Impacting Energy Efficiency

SECTION 2 OPPORTUNITES FOR ENERGY REDUCTION

Planta Procesadora de Lácteos

At an initial meeting with Dr. M. Cortz, it was suggested that an energy audit be performed upon the Dairy Plant as it was deemed one of the larger energy users at Zamorano. This plant was therefore investigated more thoroughly than any other facility. The electrical input was monitored with a data logger and numerous pictures were taken to illustrate energy efficiency opportunities. It was not possible to determine water and diesel inputs, as no monitoring equipment exists for this purpose.

Recommendations:

This section discusses the Dairy Plant in considerable detail. As my time at Zamorano was very limited, my analysis has been limited to the technical aspects only of the operation. From an electrical viewpoint, the primary opportunities are with respect to the operating time of the compressors. Replacing the door seals on the cold rooms will reduce the compressor operating time resulting in 6745 kWHr less heat having to be removed from the cold rooms. The boiler and its associated piping and equipment provide several energy saving opportunities. Replacing/increasing the steam pipe insulation will reduce piping heat losses by 185 W/M. Several steam leaks exist which if repaired will reduce the steam required by 1.48 kg/h per leak. At the time that this report was being prepared technical changes were being made in the pasteurizing process, which the manufacturer has indicated will reduce the boiler heat required for that process by 10%. Considerable water is being used and this should be reviewed. Finally, from a technical perspective all utility inputs must be measured. Improvements cannot be tracked if the actual use is not known.

Included in this section are two documents produced by Zamorano students. These documents highlight operational behaviors, which if altered would result in considerable savings. It is my experience that behavioral changes can result in very low cost, high return savings. Those changes however, can be very difficult to implement and maintain. Some very careful (see Social Dimensions of Energy Management): consideration should be given to those recommended behavioral changes.

The data logger plot indicates that the plant load should be rebalanced, the overnight demand should be checked and the plant low power factor should be investigated.

Electrical Input

Electrical energy is supplied to the plant as 3 phase 120/208V. A SIEMENS 4300 Power Meter SEAbus Plus is installed in the main electrical panel. The typical plant load during full operation is 54 kW with a maximum demand of 77 kW. The plant Power Factor is approximately 75%. A data logger was installed on the input feeders, which resulted in the plot on page 22. This plot is a very typical plot of an operating plant. Note that there is 2.7 ratio between the maximum and minimum pant demand. This needs to be examined to determine if this is unavoidable. Two other points are to be noted. 1) That the minimum load is 18.5kW, which is the overnight demand. This demand should only be the compressors and 2) the line currents are unbalanced.

Unbalanced currents result in higher line losses than necessary, hence the plant loading should be rebalanced.

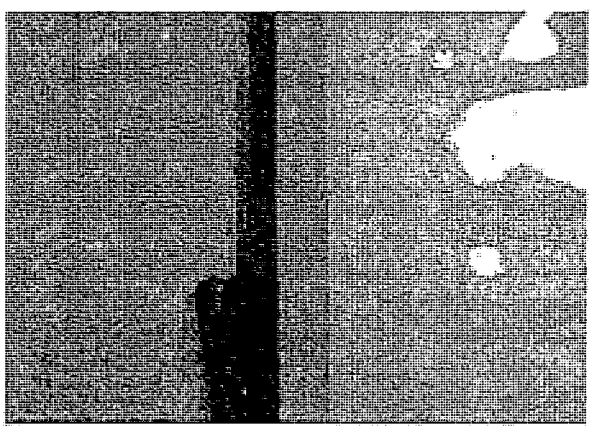
The staff at the Dairy plant were unaware that the Siemens meter was installed, hence the electrical input was not being recorded. The Siemens 4300 is a very versatile meter as it has front controls that allow the display of numerous electrical parameters. A poll of these parameters revealed that there is a problem with the meter or its connections as it displays one line voltage as considerably higher than the other two. A check on the actual line voltages with another meter reveals that the voltages are balanced, even though the phase loads currents are not. As an introduction to the management of energy the author developed an excel spreadsheet (see the end of this section), to be used for recording the daily electrical input kWHr. Five days data using this spreadsheet resulted in a calculated daily energy usage of 800 kWHr.

Individual equipment feeders were not monitored, however since all of the required process heat is obtained via the boiler, it is assumed that the majority of the electrical energy is used by the compressors.

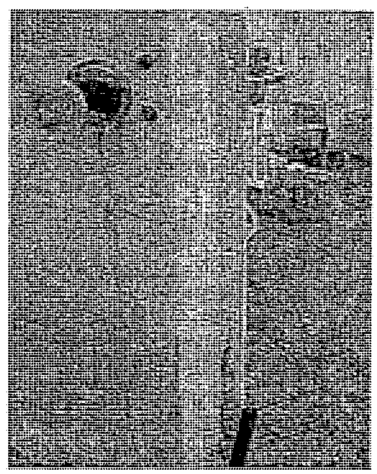
Electrical Energy Reduction Opportunities.

Compressors

Without detailed and extensive monitoring of each individual compressor feeder, it is not possible to quantify electrical waste. However, a visual inspection of the compressors, evaporators and cold room door seals and walls reveal energy reduction opportunities. In all cases, maintenance is required on door gaskets. The following two pictures are an illustration of this.



Door Gaskets Requiring Maintenance



Missing Door Gaskets

Sample Heat Loss Calculation

The equation for ventilation heat loss is given by

$$Q=1.232(\text{Flow rate})(T_1-T_2)$$

Where Flow rate is in L/s and T is in °C

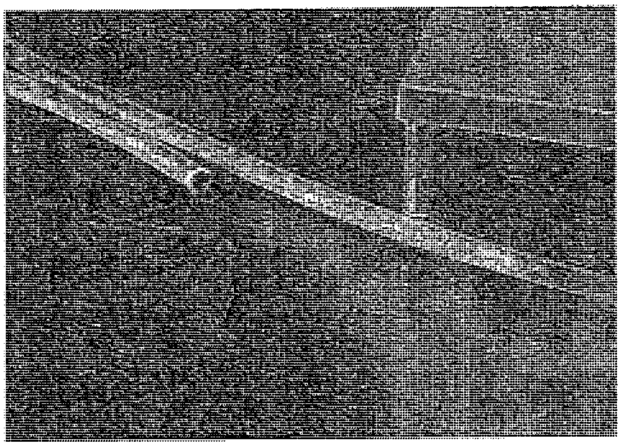
The amount of air exchange for a poorly sealed door will be approximately 1.5 air changes per hour. As the volume of each cold room is approximately 22.5 M^3, and the temperature differential is approximately 20 C^0, the energy loss per door is

$$Q=(22.5/3.6)(1.232)(20) = 154 \text{ W/door}$$

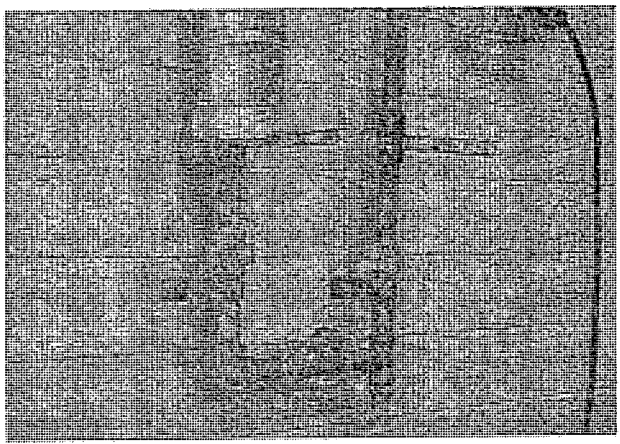
For 1 year this amounts to 1349 kWHr/year. There are 5 doors hence the approximate total energy loss per year would be 6745[12] kWHr.

Boiler Energy Reduction Opportunities

All of the process heat is obtained from steam that is generated by a fuel oil fired boiler. The boiler efficiency is not known, as there are no maintenance records. Inside the plant, some of the steam piping is not insulated and steam is escaping from several of the steam-heated appliances. It was also observed that steam was being exhausted to atmosphere by a pipe lying on the floor. The following two pictures illustrate this energy waste.



Steam Exhausting to Atmosphere



Un-insulated pipes

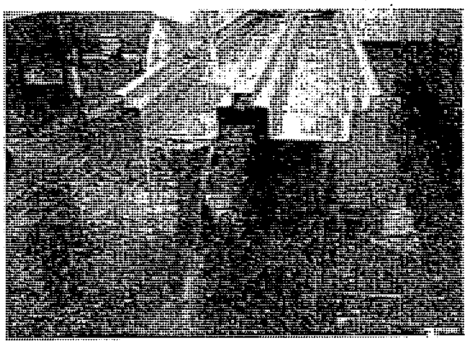
These losses can be calculated using the charts and graphs at the end of this section. The boiler is producing steam at 500 kPa at a temperature of 130^0 C hence pipe losses are 225W/M. By insulating the pipes, these losses will be reduced to 40W/M. Heat losses due to steam leaks can also be calculated. Leak diameters were not determined; however there are several leaks of at least 1mm and using Figure 14.13 this would amount to 1.7 kg/h per leak. Using various unit conversions this can be translated into litres of fuel and hence the cost.

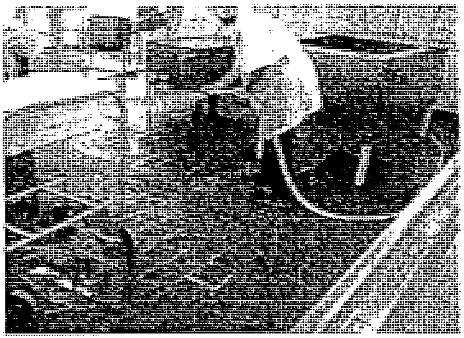
Water Reduction Opportunities

All diaries use copious amounts of water, hence water costs can be vary high. The study included with this section reports that the amount of water used by dairy processing plants varies between 0.9 and 5 litres of water per litre of milk (L/L). For Zamorano, whose milk processing is 8000 L/day, this would amount to between 7200 and 40000 L/day. Water is not metered in the

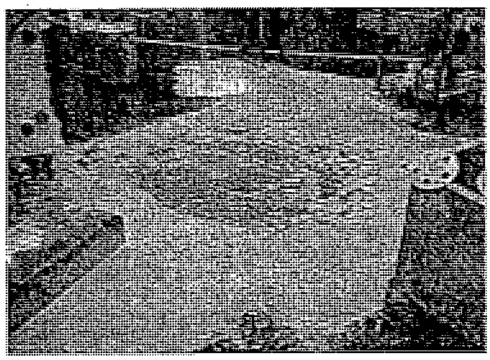
12 The actual amount of electricity saved will be less, depending upon the COP of the compressors. This could vary between 1.5 and 3 depending upon the condition and age of the equipment.

Dairy Plant hence consumption is unknown. A visual inspection reveals that there is considerable room for improvement. The following pictures illustrate this point of view.





Excess Wash Water



In the two pictures on the previous page water is being used for washing equipment or floors. High-pressure low volume washer nozzles might be a consideration. Rather than spilling warm soapy water on the floor, the collection and storage of this warm soapy water for some other lower level use (for example the floors via a high-pressure nozzle), should be considered.

Other Opportunities

Page 22 contains an excel spreadsheet that was prepared by several 2nd year students in environmental management as a learning by doing project to determine wasted energy in the Dairy. No attempt has been made to verify its accuracy, however, as this data indicates, process equipment may not be fully utilized. For this dairy plant, wasted energy has been calculated to be 11,190 kWHr. The management of energy consists of both technical changes and behavioral changes. The values tabulated on the next page are an indication of behavioral changes which if made would result in a no cost electrical savings. While these potential savings may be achieved at no cost, they may be very difficult to implement on a sustained basis.

Data

September 2004

Light

Switch	*Number of lamps*	*Power Kw*	*Wasted Time (Hours)*	*Wasted Kw*h*	*Wasted Kw.h.year*
Produccion Area Switchs	11	0.88	37.88	11.41	723.27
Office Switch	1	0.08	11.17	0.89	56.65
Stock Room Switch	1	0.08	2.93	0.23	14.86
TOTAL			*51.98*	*12.54*	*794.78*

Machines

Machine	*Power Kw*	*Wasted Time (Hours)*	*Wasted Kw*h*	*Wasted Kw.h.year*
Sealing Machine	0.0246	1.33	1.49	94.55
Reciver Tank	1.119	2.00	1.49	94.55
Chesse Presser	3.73	2.58	0.96	61.07
Ice Cream Maker	3.73	0.3	0.34	21.27
TOTAL		*6.22*	*4.28*	*271.45*

August 2005

Light

Switch	*Number of lamps*	*Power Kw*	*Hours used*	*Kwh*	*Kwh/year*
Produccion Area Switchs	38	3.04	9	27.36	8673.12

Machines

Machine	*Power Kw*	*Wasted Time (Hours)*	*Wasted Kwh*	*Wasted Kwh/year*
Pasteurizer	0.246	0.907	0.223	70.76
Sealing Machine	0.0246	0.397	0.010	3.10
Chesse Presser	3.73	0.122	0.454	143.86
Cheese Slicer	0.87	0.100	0.087	27.58
Ice Cream Maker	3.73	0.396	1.478	468.43
Mixer	0.373	0.128	0.048	15.10
Milk Skimmer	0.37	2.000	0.740	234.58
Homogenizer	1.298	0.544	0.706	223.77
Wash Machine for milk tanks	1.492	0.544	0.811	257.21
Wash Machine for milk containers	0.373	0.050	0.019	5.91
Total		*5.188*	*4.58*	*1450.29*

Total Potential Energy savings	11,190 kWhr/yr

Note this data was collected by Zamorano students on the dates shown above.

In 2005, Ana Carolina Paz Delgado and Miguel Ángel Estévez Moreira, studied several aspects of the dairy operation for their final thesis. They too, determined that considerable energy could be saved by behavioral changes. Their findings and recommendations follow.

1. CONCLUSIONES

- Las luces de la planta presentan desperdicios por no ser apagadas cuando no se está trabajando. Actualmente esto representa $ 41.39 /año.
- Las máquinas que pueden ser utilizadas con mayor eficiencia son: El pasteurizador, el tanque de almacenamiento y la empacadora en los procesos de leche chocolatada y semidescremada. De igual manera en el proceso de la mezcla previa del yogurt al pasteurizador de 200 lts, y la máquina envasadora. Actualmente esto representa $ 334.67 /año.
- Los puntos de ahorro de agua en los procesos son las mangueras al momento de lavado de las máquinas. Actualmente esto representa $ 9.38 /año.
- El agua residual de los pasteurizadotes, la manguera # 8 y de la máquina enfriadora puede ser reutilizada. Actualmente esto representa $ 2,862.9 /año.
- Los puntos y tipos de residuos que van al drenaje son: El suero producto del cuajado de la leche para queso y el proceso de moldeado del queso crema, la leche chocolatada y semidescremada al momento de empacarlas, yogurt al momento de envasado, detergentes, cuajada, y crema. De estos destacaron: El suero con 1,750 litros/día y el queso crema con 3.6 Kg. /semana reflejado en $ 18.30.
- En cuanto a las mangueras al iniciar el estudio dentro de la planta no había ninguna manguera con pistola, actualmente todas las mangueras de la planta cuentan con una, a excepción de la manguera #1 y #4 que utilizan vapor.
- De los tres procesos analizados el más eficiente es el yogurt, ya que presenta menos desperdicios en comparación a la leche chocolatada y la semidescremada. En la elaboración de yogurt se identificaron sólo dos puntos en el diagrama de flujo, donde se pueden obtener ahorros: Llenado de yogos con la mezcla previa de yogurt y el envasado. Actualmente esto representa $ 3,633.95 /año.
- Para la leche semidescremada y chocolatada se identificaron pérdidas en el proceso de empacado, ya que la mezcla, pasteurización, homogenización, enfriamiento, hasta el tanque de almacenamiento; es un ciclo cerrado y no se encuentran desperdicios. Actualmente esto representa $ 15,534.19 /año.
- En los procesos que se evaluaron, se pudieron definir puntos críticos al ser analizados por medio de los diagramas de flujos. Los puntos a mejorar son: En el proceso de yogurt el llenado de yogos con la mezcla y el envasado del producto final , el los procesos de leche chocolatada y semidescremada el empacado.
- En muchas ocasiones los trabajadores y estudiantes no siguen los pasos para el procesamiento de los productos de este estudio, como se muestra en los diagramas de flujo. Lo que representa descuidos al momento de empacar los productos, tener las máquinas prendidas por periodos mayores a los ideales, exceso de uso del agua para lavado de maquinaria o del área de proceso.

2. RECOMENDACIONES

6.1 Energía

- Sustituir la máquina obsoleta por la nueva, para hacer más eficiente el proceso de empaque ya que es la que refleja el mayor desperdicio energético de las máquinas analizadas. Ahorros $ 178.32/año. Cabe mencionar que aunque no este en uso, es importante que para el final de este estudio se cuente ya con una mueva máquina de empaque.
- En el área de pasteurizado reducir el uso en vació o tiempo muerto de la máquinas, realizando una programación diaria de los productos que necesitaran el uso de las mismas. Ahorros $ 32.57 /año.
- Las luces de la planta deberán ser apagadas en los tiempos de almuerzo y cuando no se este produciendo, por ejemplo: cuando se imparten charlas a los alumnos. Ahorros $ 41.39 /año.
- De igual manera haciendo una adecuada programación de actividades, evitar el trabajo en vano del tanque de almacenamiento y uso de mezcladora que por ambas se podrían obtener ahorros de $ 18.88 /año.
- Es recomendable realizar un estudio de vapor ya que no se hizo, porque no se contó con la información y la maquinaria necesaria para hacer las respectivas mediciones y determinar la eficiencia de la caldera. En este aspecto un punto clave es colocar un sistema de retorno de condensado, una pluma de 0.6 m de largo representa la pérdida de 70 ton/año de vapor.
- Realizar un estudio de toda la maquinaria de la planta ya que no se cuenta con datos como la potencia y vida útil de las mismas, y los eléctricos de la institución no cuentan con esos datos.

6.2 Agua

- Implementación de pistolas en las mangueras y reciclar el agua utilizada en los pasteurizadores incluida grifo con manguera # 8 para otros procesos como lavado de pisos. Ahorro $ 1,638.24 /año. Al final de este estudio la planta efectivamente instaló las pistolas.
- Almacenar el agua de la máquina enfriadora que puede ser reutilizada en procesos como lavado de máquinas o de pisos y así reducir el uso de agua para estos procesos. Ahorro. $ 1,234.04 /año.

- Capacitación a los operarios sobre el valor y manejo eficiente del agua e incentivarlos al ahorro de este recurso, por medio de sistemas de incentivos (Nombramiento del empleado del mes y reconocimientos económicos en el sueldo al final del año).

6.3 Procesos

- Actualmente la planta posee la nueva máquina empacadora de leche, pero no esta instalada por falta de capacitación técnica es recomendable instalarla lo antes posible ya que estas pérdidas se reflejan en leche y empaque de ambos procesos; leche chocolate y semidescremada. Ahorros $ 15,534.19 /año.
- Invertir en moldes y envases más eficientes, para mejorar las condiciones en el área de moldeo. Ahorros $ 951.66 /año.
- Con respecto al suero, este sería una fuente de ingreso al venderlo a los pequeños productores en las áreas aledañas a la entidad o se podría usar en las áreas de producción animal de la misma Universidad como alimento para cerdos o para terneros en el caso que sea un suero dulce. Posible ingresos $ 5,442.5 /año a $ 0.01 / lt de suero.
- Mejorar el proceso de llenado de yogos con la pre mezcla y envasado de yogurt dejando solo al trabajador encargado para que realice esta actividad, ya que ellos poseen más experiencia que los estudiantes y así evitar desperdicios y aumentar utilidades. Ahorros $ 3,633.95 /año.
- Para evitar las pérdidas de productos deben barrer los desperdicios presentes en el suelo y así evitar que estos vayan al drenaje. Con esto evitamos el aumento de la carga orgánica presente en las lagunas de estabilización reduciendo los parámetros de DBO y DQO que son los mayores contaminantes de las mismas. Reducción de pedazos de quesos, leche, material devuelto.
- Es recomendable para aumentar la eficiencia de los procesos que se realice un mantenimiento preventivo de la maquinaria, tuberías o mangueras, y así asegurar que no hayan problemas de fugas y lámparas quemadas que necesitan ser reemplazadas.

ZAMORANO MILK PROCESSING ENERGY DATA

Electrical									Boiler	Water	Milk
DATE	TIME	KWHR	Demand	Max	Vab	Vbc	Vca	PF	Fuel	Input	Production
		READING		Demand	Normal =			Should			
					a variance of 10%			be			
					or less			0.9			
2-Oct-06											
3-Oct-06											
4-Oct-06											
5-Oct-06											
6-Oct-06											
7-Oct-06											
8-Oct-06											
9-Oct-06											
10-Oct-06											
11-Oct-06											
12-Oct-06											
13-Oct-06											
14-Oct-06											
15-Oct-06											
16-Oct-06											
17-Oct-06											
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21-Oct-06											
22-Oct-06											
23-Oct-06											
24-Oct-06											
25-Oct-06											
26-Oct-06											
27-Oct-06											
28-Oct-06											
29-Oct-06											
30-Oct-06											
31-Oct-06											

Figure 8.7
HEAT LOSS FROM BARE STEEL PIPE

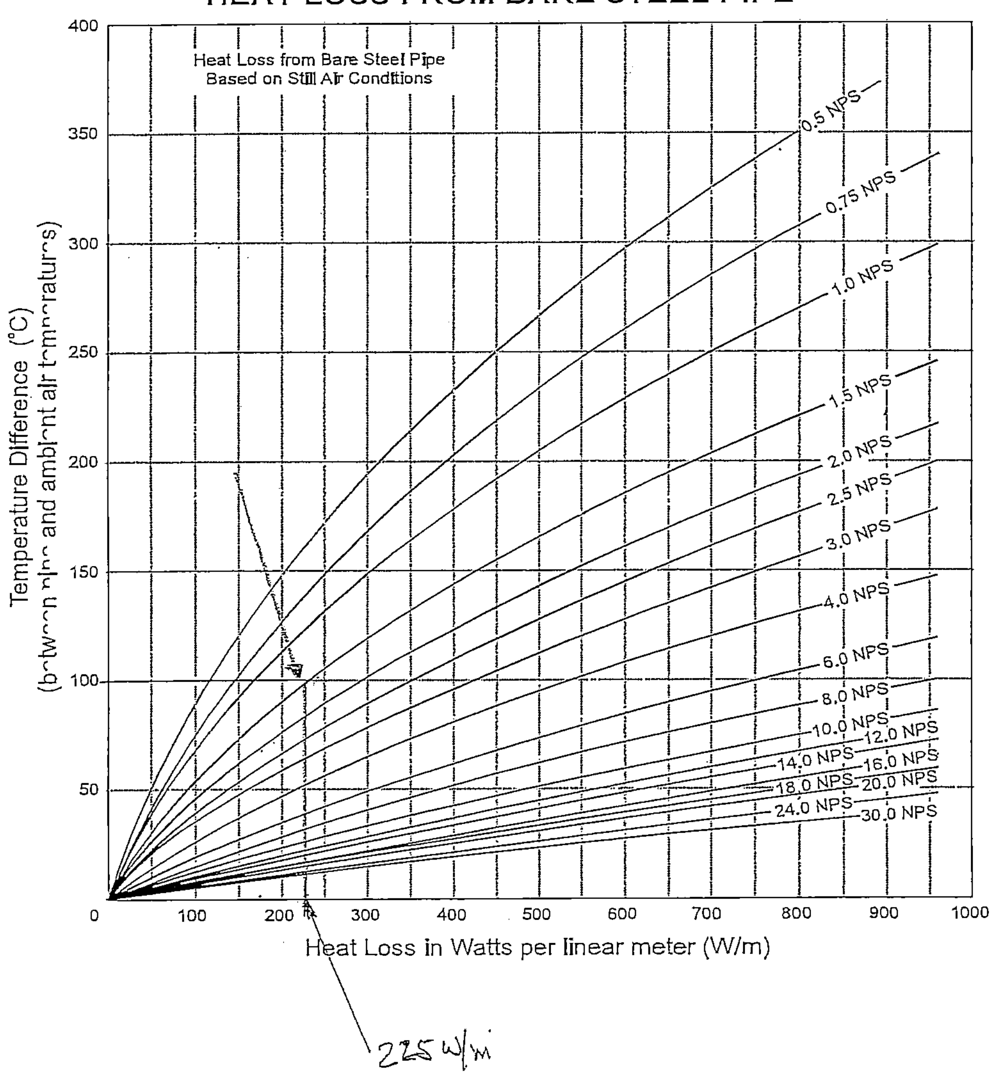

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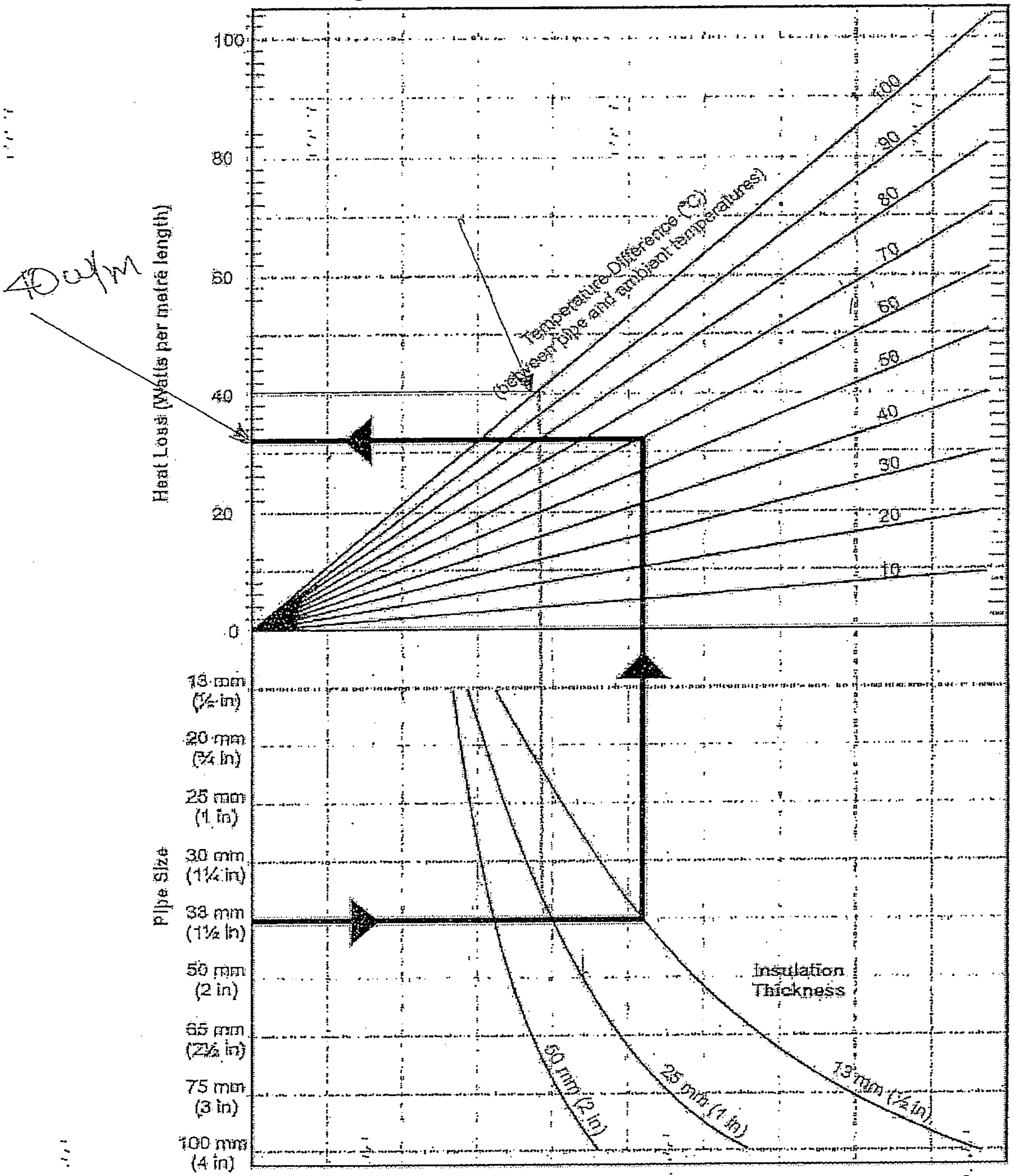
Figure 3.25: Heat Loss - Insulated Piping



24A

Infiltration by Air Change Method

With the air change method, the first step is to calculate the room volume, or the effective room volume if the room is more than 5 metres in depth. The next step is to select the appropriate air change value from Figure 3.xx, based on the room exposure. The infiltration air flow is then calculated as follows:

$$F_A \; ? \; \frac{V \; ? \; AC}{3.6}$$

where:
F_A = flow rate of infiltrated air (L/s)
V = room volume (m^3)
AC = air changes per hour (no units)

Figure 3.8: Typical Infiltration Rates (Air Change Method)

Room Exposure	Infiltration In Air Changes/Hour
One exterior wall, no windows or sealed, double-glazed windows	0.25
One exterior wall, with openable, weather-stripped windows	0.50
One exterior wall with openable non-weather-stripped windows or exterior doors	1.00
Two exterior walls with sealed, double-glazed windows	0.50
Two exterior walls with openable, weather-stripped windows	0.70
Two exterior walls with openable, non-weather-stripped windows or exterior doors	1.50
Entrance halls	2.0 (+)

Note: Room volumes to which the above rates are applied should be based on a room depth of no more than 5 metres from the exterior wall. For rooms having a greater depth, calculate the infiltration for the first 5 metres of depth only.

Worked Example

A room, 6 m long by 4 m wide (distance from exterior wall) by 2.7 m high, has one exterior wall with one door and openable, non-weather-stripped windows. Estimate the infiltration rate using the air change method.

$$V \; ? \; L \; ? \; W \; ? \; H \; ? \; 6.0 \; ? \; 4.0 \; ? \; 2.7 \; ? \; 64.8\, m^3$$

$$F_A \; ? \; \frac{V \; ? \; AC}{3.6} \; ? \; \frac{64.8 \; ? \; 1.0}{3.6} \; ? \; 18.0\; L/s$$

Figure 14.13
STEAM LOSS THROUGH ORIFICE DISCHARGING TO ATMOSPHERE

Orifice Diam (mm)	Steam Loss (kg/h) when steam gauge pressure (kPa) is:											
	15	30	60	100	150	300	500	700	900	1400	1700	1900
0.8	0.18	0.21	0.25	0.32	0.40	0.63	0.95	1.27	1.58	2.37	2.85	3.16
1.5 — 1	0.28	0.32	0.40	0.49	0.62	0.99	1.48	1.98	2.47	3.71	4.45	4.94
2	1.14	1.28	1.58	1.98	2.47	3.95	5.93	7.91	9.88	14.8	17.8	19.8
3	2.56	2.89	3.56	4.45	5.56	8.90	13.3	17.8	22.2	33.4	40.0	44.5
4	4.55	5.14	6.33	7.91	9.88	15.8	23.7	31.6	39.5	59.3	71.2	79.1 — 1.7 kg/h.
5	7.10	8.03	9.88	12.4	15.4	24.7	37.1	49.4	61.8	92.7	111	124
6	10.2	11.6	14.2	17.8	22.2	35.6	53.4	71.2	89.0	133	160	178
7	13.9	15.7	19.4	24.2	30.3	48.4	72.6	96.9	121	182	218	242
8	18.2	20.6	25.3	31.6	39.5	63.3	94.9	127	158	237	285	316
9	23.0	26.0	32.0	40.0	50.0	80.1	120	160	200	300	360	400
10	28.4	32.1	39.5	49.4	61.8	98.8	148	198	247	371	445	494
11	34.4	38.9	47.8	59.8	74.7	120	179	239	299	448	538	598
12	40.9	46.3	56.9	71.2	89.0	142	213	285	356	534	640	712
12.7	45.8	51.8	63.8	79.7	99.6	159	239	319	399	598	717	797

7.3 Shut Down Equipment (End-Use Equipment)

During the plant survey it was noted that a steam heater supplying hot air to a drying tunnel was operating even though the tunnel was not in use. Subsequent investigation established that the heater system ran for 8,760 hours per year, although the tunnel only operated 6,000 hours per year. Steam used for the heater was 689 kPa (gauge) dry and saturated. Steam flow to the unit was measured at 200 kg/h. The cost of steam was \$0.022 /kg.

The annual reduction in steam usage is:

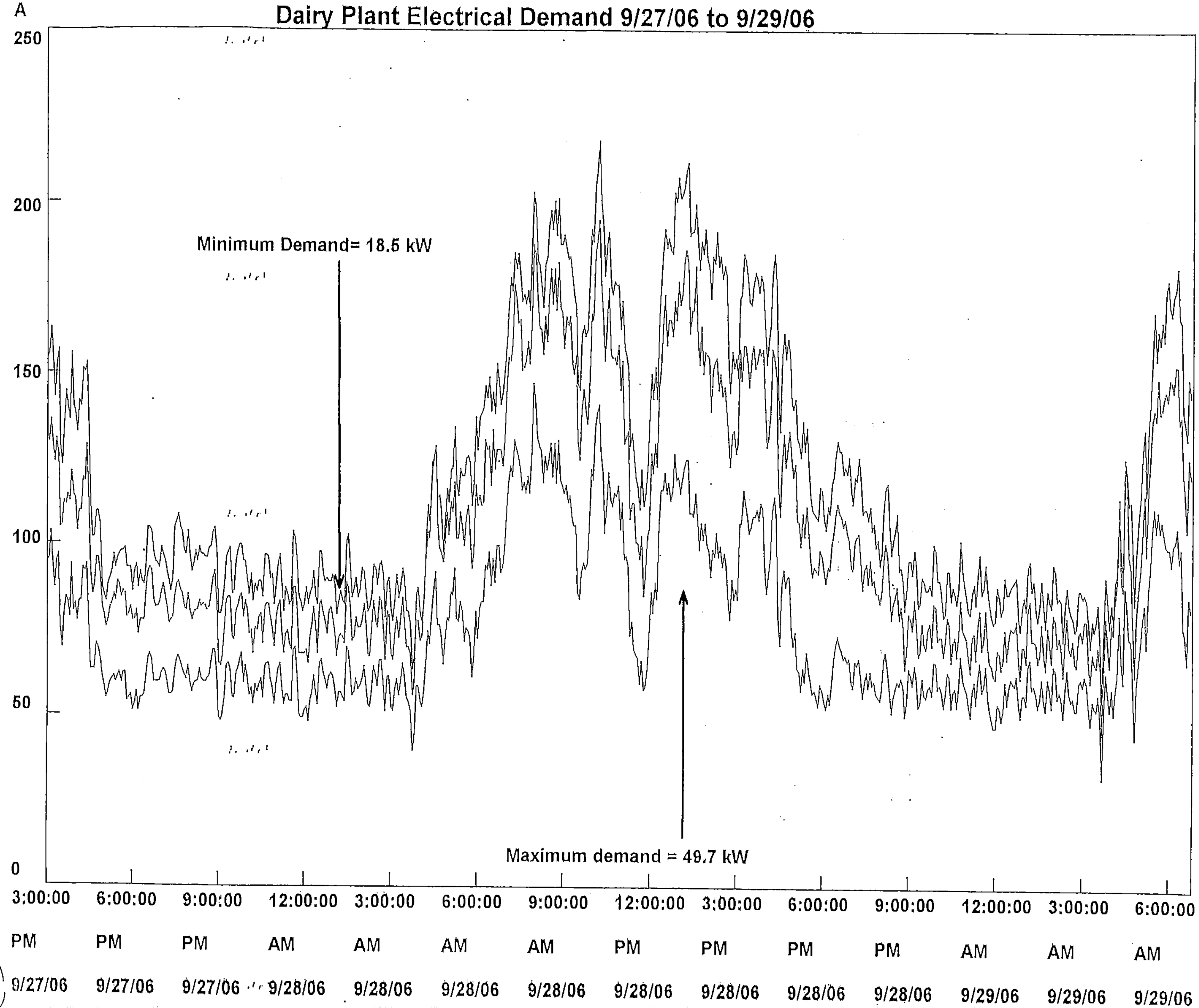
$$= (8{,}760 - 6{,}000)\ h/yr \times 200\ kg/h$$
$$= 552{,}000\ kg/yr$$

The annual cost saving is:

$$= 552{,}000\ kg/yr \times \$\,0.022\ /kg$$
$$= \$12{,}144\ /yr$$

It was decided to install a relay and solenoid valve to shut off the steam when the drying tunnel was not in operation. Estimated cost to supply and install the hardware was \$ 500. The simple payback period is:

$$SPB = \frac{\$500}{\$12{,}144} = 0.04\,years \quad (15\,days)$$


A
Dairy Plant Electrical Demand 9/27/06 to 9/29/06
250
200
150
100
50
0
Minimum Demand= 18.5 kW
Maximum demand = 49.7 kW
3:00:00 PM 9/27/06
6:00:00 PM 9/27/06
9:00:00 PM 9/27/06
12:00:00 AM 9/28/06
3:00:00 AM 9/28/06
6:00:00 AM 9/28/06
9:00:00 AM 9/28/06
12:00:00 PM 9/28/06
3:00:00 PM 9/28/06
6:00:00 PM 9/28/06
9:00:00 PM 9/28/06
12:00:00 AM 9/29/06
3:00:00 AM 9/29/06
6:00:00 AM 9/29/06

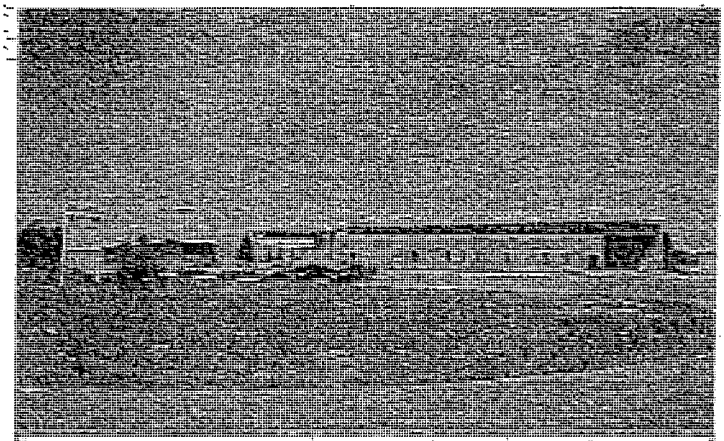
(22)

Cost Efficiencies in Cheese Processing

• Condensate Heat Recovery • Electrical Savings • Water Minimization

Highlights

- "Best in Class" energy and water conservation practices
- Top quartile performer in Canadian dairy industry
- 10% potential reduction in energy usage saving $13,800 per year
- annual reduction in GHG emissions of 130 tonnes



Pine River Cheese Ripley Operation

Sector Overview

The dairy industry is the fourth largest sector of the Canadian agri-food economy after grains, red meats and horticulture. It is the second largest employer in the Canadian food industry, with approximately 20,500 workers in 275 Canadian dairy plants. In 2001, sales from Canadian dairy processors were $9.8 billion, representing 14 per cent of total sales in the Canadian food and beverage industry.

Canadian milk and dairy products are recognized internationally for their superior quality. Canadian dairy product exports totalled $440 million in 2001, while dairy product imports totalled $545 million.

The dairy industry is comprised of two sub sectors. One processes farm gate milk into packaged fluid milk and cream products, and yogurt. The other, which used almost two-thirds of all milk produced in Canada during 2001, manufactures other dairy products such as cheese, butter, ice cream, and milk powders.

The dairy sector is relatively concentrated and has seen significant consolidation over the past few years. Today, the three leading processors own 36 per cent of plants that process 71 per cent of all milk produced in Canada. Ontario and Quebec account for more than 60 per cent of all Canadian plants and about 75 per cent of all industry output. Dairy cooperatives continue to form an important part of the dairy processing sector, handling more than a third of the milk processed.

Company Description

Pine River Cheese and Butter Co-operative (www.pineriverchees e.com) is a farmer-owned cooperative with a manufacturing facility and retail store located on the same site, near Ripley, Ontario. The company is owned by 35 local dairy producers and has been in operation since 1885.

Pine River enjoys a reliable customer base of over 800 retail locations across the province of Ontario. It has distribution points in western Canada, and product sales in Mexico, Cuba and Asia.

The 45 employee enterprise produces and sells more than 2.25 million pounds of various types of hard and soft cheeses annually.

e Situation

e cheese manufacturing eration at Pine River is a batch oduction process. The plant erates 18 hours a day, five days week.

al electrical and propane costs $120,900 per year. Electrical ergy is used for refrigeration, air mpressors and other processing ipment, at a cost of $63,900 ually. Electric motors constitute per cent of the power load. Peak nand charges can vary by 35 per t on a monthly basis, with atest demand in the summer. e plant is located at the end of a nsmission line and power quality major issue. The plant uses pane for plant and process ting at a cost of $57,000 ually.

ter is supplied by an on-site l, and is used in the cheese king process, for Clean In Place P) and other plant cleaning, for boiler make-up water, and for truck washing. Process wastewater is pumped to an aerated lagoon after passing through a solids interceptor. Solids collected in the interceptor are pumped out and trucked to the lagoon about four times per year. Lagoon wastewater is disposed of by irrigation onto fields adjacent to the plant from May to October. The company recently amended its Certificate of Approval to increase the irrigation area, and while it is generally satisfied with the current system, there could be an issue with storage capacity in the lagoon during wet years.

Bill Rutledge, general manager at Pine River, saw a need to upgrade its processes and equipment in order to increase efficiencies. Bill arranged to conduct an eco-efficiency audit of the plant in the summer of 2002. The audit was completed by XCG Consultants Ltd., with financial assistance from the Agricultural Adaptation Council and Natural Resources Canada. The objective was to identify opportunities to reduce energy and water usage, and minimize wastewater production. Pine River would use the audit results for future business planning and to establish a baseline against which to measure future improvements in energy and water efficiency.

Drivers for Change

- 3rd party review to benchmark operations
- Continuous improvement to remain low cost producer
- Poor power quality
- Reduce wastewater loadings to lagoon

udit Findings

e audit found that Pine River as a very energy efficient oducer. For example, electrical ergy consumption at the plant is 068 kWh/L of milk processed, mpared with an average for tario dairy processors of 0.14 Wh/L. Despite this, there were ll five energy saving portunities identified to reduce e plant's total annual energy sts by over 10 per cent (see ble 1). One area was ndensate heat recovery from the eam boiler (only 50 per cent of ndensate was being returned to e boiler feedwater from the pasteurizer). Not only could more condensate be recovered from the process, there is potential to recover heat from the flash steam of this condensate, and heat from boiler blowdown. This could lead to propane savings of $3,000 per year, as well as water and chemical savings of $1,500 per year, since the amount of make-up water in the boiler would be reduced.

Table 1: Energy Efficiency Opportunities

Energy Saving Opportunities	Capital Cost ($)	Cost Savings ($/yr)	Simple Payback (years)
Condensate heat recovery	9,000	4,500	2
Convert steam boilers to natural gas	5,000	2,500	2
Install high efficiency motors	4,000	3,100	1.3
Install controls to reduce peak demand	1,600	900	1.8
Install Plexiglass covers for retail store displays	3,000	2,800	1.1

Audit Findings (cont...)

Other energy efficiency opportunities included:

- conversion of steam boilers from propane to natural gas (if a natural gas line is extended to the plant);
- installation of high efficiency motors to increase efficiency from 85 to 92 per cent;
- installation of controls and setback thermostats to reduce peak electrical demand charges, especially during the summer months; and
- installation of Plexiglas covers for the display shelves in the retail store to reduce cooling losses in the refrigeration system.

Blocks of cheddar are cut into bricks, weighed, placed on a conveyor and packaged

The audit also found that the plant was very efficient in water usage. Water consumption is about 0.9 litres per litre of milk processed. This compares with a typical value of 2 to 5 litres for industrial milk processsing plants.

One opportunity was identified to reduce water usage. This involved collecting the start-up water in the CIP rinse tank for reuse as the CIP first rinse washer; however, this measure did not meet the company's payback criteria.

Due to cost-effective practices already carried out at the plant, there were limited cost-effective options for wastewater reduction and treatment. However, one interesting option involved converting lagoon water to snow ("snowfluent") during the winter months to increase lagoon storage capacity and minimize the amount of water used for irrigation.

Implementation Status

Pine River has completed the final design work, and plans to install the condensate heat recovery system in the spring of 2003. The company has plans to implement all the other energy savings on a prioritized basis.

Applications to the Food Sector

The process-focused approach used to identify and implement efficiency improvements at Pine River's plant is applicable to any food and beverage processor in Ontario. Studies of this nature typically identify total energy, water and sewer cost savings of 15 to 20 per cent. This approach is particularly relevant for companies dependent on municipal water supply and wastewater treatment.

"We were very satisfied with the findings of XCG Consultants - they were thorough and very knowledgeable in the needs of our sector. We were pleased with their findings and plan to put into place their suggestions for cost savings. XCG also validated our existing efficiencies in water and hydro usage. This program is well worth taking advantage of."

Bill Rutledge
General Manager

Support Services to Ontario's Food Industry

Food Industry Cost Reduction Program

This case study was prepared as part of an Ontario program specially designed for the food industry to help companies reduce their energy, water and sewer costs. **OCETA (Ontario Centre for Environmental Technology Advancement)** manages this program in partnership with the Agricultural Adaptation Council and OMAF.

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Ontario Ministry of Agriculture and Food (OMAF)

The Ontario Ministry of Agriculture and Food supports Ontario's food processing industry in several ways. The key strategies to support food business development include:

- attract new investment to grow the industry;
- retain the level of investment already in the industry;
- increase domestic and global market penetration of Ontario grown and processed foods; and
- minimize the risk to the public from food-borne illness.

OMAF has a network of sector officers to meet the everyday needs of food companies by:

- maintaining a proactive client account management system;
- researching and analysing sector challenges and opportunities;
- providing a "one-stop" access point to assist food companies in building their business and improving their competitive position; and
- providing information to influence investment and growth decisions.

For more information on OMAF services contact:

Dennis Flaming
Manager, Client Account Unit
Toll Free: 1.888.466.2372 ext. 6-4448
Email: dennis.flaming@omaf.gov.on.ca
www.gov.on.ca/omaf

Canada Ontario Agricultural Adaptation Council Agricultural Environmental Stewardship Initiative

Planta de Carnicos

Recommendations:

There are opportunities for energy reduction in the Meat Plant. A 1.5hr walk through inspection yielded two of these opportunities which if implanted would reduce the energy input by 20,650 kWHr. Further reductions would be achieved by wall insulation, better door seals, and some time spent on preventive maintenance.

It is imperative that a program of recording energy inputs be implemented as any energy efficiency efforts cannot be quantified without data.

The following report is based on a 11/2 hour walk around tour of the plant. As time does not permit detailed calculations to be made, the following comments are based on visual observations and discussion with our guide.

There are two major energy inputs to this plant; diesel for the boiler and electricity to operate the cold room compressors, for lighting. Some electrical process heating is used, however by far the majority of electrical energy is consumed by the compressors.

The Boiler;

This conventional diesel boiler produces steam. The steam transmission temperature is 125°C at a pressure of 1atmosphjere. It was noted that 10 meters of 50mm pipe between the boiler and the building was not insulated. A pipe of this size and temperature will dissipate 3 kW or approximately 7800[13] kWHr worth of diesel energy over one year. Boilers require servicing on a regular basis and it was reported that this is the case. Preventative maintenance for a boiler includes, as minimum, chimneystack temperature, excess air input and nozzle calibration.

Electrical Input

From an electrical point of view, the largest electrical load are the compressors for the cold rooms. It was noted that most of the access doors to the cold rooms have poor seals. Lights are on all the time in the cold rooms. The compressors looked in good operating condition and all of pipes leading to the evaporators appeared to be insulated. Another point to check is to see that the temperature within each cold room is the proper value as a lower set point than is necessary will result in excess energy being used. As time does not permit calculations, in Canada, as a rule of thumb, we say that a difference of 1 degree C will reduce the energy input to a room by about 1%. Further energy reductions would be obtained by insulating the walls of the cold rooms and where windows exist between a cold room and interior and exterior walls, both insulation and double paned windows would reduce the energy input considerably. It was noted that there are 4-1.5M x 1.5M (an area of $9M^2$) of single pane windows between the meat cutting room and a non cooled

[13] This assumes a typical boiler efficiency of 60%.

Figure 3.5 (continued)
Values of Thermal Resistance (R-value)
of Various Building Materials
($m^2 \cdot °C/W$)

Material Description	Per mm Thickness	For Listed Thickness
Structural Materials		
Cedar Logs/Timber	0.0092	
Other Softwood Logs/Timber	0.0087	
Concrete		
S 2400 kg/m³	0.00045	
S 1700 kg/m³	0.0013	
S 480 kg/m³	0.0069	
Concrete Block (3 Oval Core)		
S Sand/Gravel (or Cinder) Aggregate		
S 100 mm		0.125
S 200 mm		0.195
S 300 mm		0.225
S Lightweight Aggregate		
S 100 mm		0.264
S 200 mm		0.352
S 300 mm		0.400
Interior Finish Materials		
Gypsum Board, Gypsum Lath	0.0062	
Gypsum Plaster - Sand Aggregate	0.0014	
Gypsum Plaster - Lightweight Aggregate	0.0044	
Plywood	0.0087	
Hard-Pressed Fibreboard	0.0050	
Insulating Fibreboard	0.0165	
Mat-formed Particleboard	0.0165	
Carpet & Fibrous Underlay		0.366
Carpet & Rubber Underlay		0.226
Resilient Floor Coverings		0.014
Terrazzo - 25 mm		0.014
Hardwood Flooring - 9.5 mm		0.060
S 19 mm		0.060
Wood Fibre Tiles - 13 mm		0.209
Glass		
S 6 mm Plate		0.120
S Ordinary Window Glass		0.163
S Double Insulating Glass		0.303
S Triple Insulating Glass		0.455

area. For a difference in temperature of 10C° between these rooms over one year the energy flow through the windows would be 12,850 kWhr.

Planta de Concentrados

Recommendations

In addition to illumination, this facility uses electricity to operate motors that drive equipment for feed mixing. Efficiency measures are therefore limited to appropriate lighting, motor run time and equipment maintenance. As this mill is operated only during daytime the ceiling lights should not be used. If the workspace illumination is not sufficient under these conditions, high efficiency task lighting should be installed. The practice of pre-starting the motors should stop. A regular maintenance program should be initiated if it currently is not already in place.

Efficiency Opportunities

The lights are mounted either on the ceiling or very close to the ceiling. During the inspection, the light switch was turned off. This appeared to have little or no change in lighting levels on the work surface. Discussions with the guide revealed that it was common practice to turn the motors on before the mixing operation started to 'warm up the motors'. Indeed, this does warm up the motors, but it is not necessary. I suspect this is a practice initiated many years ago based on previous piston engine practices. This practice should be discouraged. As this facility is a feed mill, it is very dusty, hence, maintenance is very important. Bearing lubrication, gearbox maintenance, drive belts, chain drives and equipment ventilation should be checked and cleaned regularly. Inefficiencies in individual transmission components are multiplied by each other i.e. if the efficiency of two components in a drive train is reduced by 10% the overall efficiency is reduced to 81% of the former value.

Industria Hortofrutícola

Recommendations

High bay lighting is installed but appears unnecessary. The practice of not turning the lights on should continue. Motorized equipment should only be energized when needed. Steam traps should be installed strategically and well maintained. Consideration should be given to the installation of covered steam kettles. The boiler flue temperature and excess air volume should be checked to determine the boiler efficiency.

Efficiency Opportunities

Steam is required for process heat. The steam is produced by a wood fired boiler. Electricity is used for food mixing and for two compressors for the cold rooms. This facility was recently commissioned hence most of the equipment is new. Both the steam and refrigerator piping are well insulated. At the time of the inspection the high bay mercury vapor lights were not energized as the windows provided adequate lighting.

The guide reported that it was common practice in the plant to start motors prior to process to 'warm up the motors'. This practice should be discouraged. The guide also drew attention to a valve at the lowest point in the steam line and adjacent to one of the operating personnel. She indicated that the students were instructed to open this valve periodically but that it was not explained why they should do this. The students also complained about having to stand above the hot steam kettles while stirring the mixtures. Both opening the valve and stirring the mixture manually result in excess energy being required. Steam lines must be purged of air and water periodically (the reason for the valve opening practice), but the valve should be opened only long enough to expel the air and water. This is normally done automatically with a steam trap, and providing the steam trap is maintained it will always perform the function more efficiently than a manually un-informed periodic valve opening for an undetermined period. Covered steam heated mixing kettles while available may not perform the function that is required here, but they would be much more energy efficient than open kettles.

The wood boiler appears to be from the original installation and the efficiency was not known. Periodic maintenance is required on all boilers. An inefficient boiler results in additional labor and air pollutants.

Granja de Cerdos

Recommendations:

While the pig farm is a small user of energy compared to other operations at Zamorano, there are changes that will reduce energy use. One of these changes is an operational change – that of reviewing the use of lights at night in the pig houses. If the lights at night are used for security, then a more energy efficient strategy might be to use fewer lights at night. A large amount of water is used for cleaning each day. Pen alterations are under way to reduce the amount of water, however it appears that the improvement will not be quantified. It is therefore recommended that a water meter be installed so that any improvement will can be quantified. It is important that changes be monitored, analyzed and advertised,

Electrical Input

Electrical energy while important for the pig farm is very small. Electricity is used for lights, and for heat for the newborn piglets. It was reported that the lights are left on all night for security. If this is the case then consideration should be given to a minimal amount of lighting. A visual inspection revealed that the entire lamps were controlled by one switch. A more economical solution might be sectionalizing the lights such that ¼ of the lights are on over night.

Water

Of more concern from an energy point of view is the use of water. Water is used to clean the floor beneath the small pigpens and for washing down the pens of the larger pigs. While there is not a water meter on the incoming water main measurement reveal that approximately $14M^3$ per day is used for clean up. At the time of the visit, renovations were in progress to reduce the water requirement. This is a step in the right direction, however this conservation move should be monitored so as to quantity the improvement.

Ganado Lechero

Recommendations:

The installation of a solar system should be considered for this facility. The requirement matches the insulation almost perfectly. If installed it is anticipated that an annual electrical demand charge of 8317 Lps could be avoided, plus the electric energy required to heat the water. Water use could be reduced by using a high-pressure low volume system for cleaning the milking area. Energy and water meters should be installed so that energy efficiency measures can be quantified.

Electrical Input

Electrical energy is used to produce the vacuum for the milkers, for cooling the milk and for heating wash water. A cursory visual inspection indicated equipment was in average condition with no obvious maintenance being required. Electrical energy is used to produce hot water for washing via a 4.5kW 100-gallon water heater. As hot water is required at the end of the day and late in the morning, the installation of a solar system should be considered. Of particular advantage is that the water tank would not be energized during the day, which would reduce the peak input demand. If a solar installation were to result in the 4.5kW load never occurring during the peak daytime demand period, the demand savings would amount to 8317 Lps/year (4.5 kWx154 Lps/kWx12 months). Electrical energy charges would be in addition to this, however this cannot be quantified until the amount of water to be heated is known.

Water

Of more concern from an energy point of view is the use of water. It was reported that 9 M^2 of water is used to wash equipment at the end of the milling period and for washing the floor at the end of the day. A hose is used to flood the floor with water. A more efficient method would be to use a high-pressure low volume stream. As with other facilities on campus energy inputs are not measured, hence conservation measures when instituted cannot be quantified.

Zamorano Electric Substation/Standby Generator

Recommendations

The Zamorano back up generator is currently fully loaded, and additional load is expected to be connected in 2007. If measures are not taken immediately a new standby generator will have to be installed if a black out is to be avoided during an incoming mains failure.

It is recommended that Zamorano institute an energy management strategy immediately as a low cost first effort to avoid installing new plant. There is ample evidence that this can be achieved, however strategic monitoring must be implemented to identify these opportunities. A combination of demand control and a 10% overall load reduction (an achievable goal by mid 2007) would result in the generator being under loaded during a mains failure. Since the overloading problem is a peak demand problem, if peak demand can be reduced by 10% (89kW) this generator will be adequate in the short term. The cost of a new generator will be in excess of $133/kW.. It is normally less expensive to invest in Energy Efficiency measures than to install new plant. A non-critical peak demand load of 70 kW has been identified, which if disconnected during peak loading times (10 AM to 1 PM) will prevent a standby generator blackout. If the cost of implementing this 70 kW peak load reduction is less than $9310[14] ($133*70), then it should be considered.

Efficiency Opportunities

Electricity is supplied to Zamorano by Empressa Nacional De Energia Electrica. It is supplied via a high voltage line and circuit breaker to the Zamorano substation. Adjacent to the substation is a 750 kW Cummins Diesel Electric emergency generator. This generator is only used if the incoming supply fails for an extended period. In July 2006 the maximum demand was 840kW. This means that if the incoming supply fails during the peaking period and the load is shifted to the standby generator it will be overloaded by 12%.(90kW).

There are two energy meters at the substation, the utility meter and an energy meter connected such that it records the energy supplied by the standby generator. The standby generator also has ammeters and voltmeters on its control panel. From an energy efficiency point of view there is little that can be done to the facility itself, however it is the point at which Zamorano's demand can be monitored and controlled. Zamorano's demand varies between 774 kW (Enero 2005) and 890 kW (Febrero 2005). There will always be a demand charge, however considerable savings can be realized by monitoring and reducing demand. A permanent reduction in peak demand of 5% (44kW) will result

[14] The loads mentioned above have been specifically sited as they can be disconnected manually, hence at no cost (that is - send out a memo saying - do not iron, or connect the golf carts etc during the period 10am to 1 pm).

in annual savings of $1867. How could this be achieved? The following loads can be considered non-critical.

- There are 12 3000W water heaters in the Centro Kellogg Hotel
- There are 4 – 2500W water heaters for the Centro Kellogg Apartments
- There is a 4000W[15] water heater used for wash water for the milking operation
- There are 20[16] – Golf carts at 700W charging loads
- There are 9 –700 watt irons that are used in the Laundry

The above non-critical load totals 70 kW. If all of these loads were de-energized between 10 AM and 1 PM, a no-cost implementation annual savings of at least $1867 would be realized. There is an additional benefit in that if the standby generator is supplying the load during these hours it will not be overloaded, hence it will not shut down.

The above can only be achieved if metering is installed and monitored on a regular basis.

On Campus Electric Transportation System

Recommendations

The use of golf carts is an excellent choice for Zamorano as an on campus transportation system. It should continue and be encouraged. Further, the batteries should be charged using Photovoltaic modules. This will reduce both the peak demand and annual electrical energy purchased from the supply authority. It will also help reduce the possibility of a standby generator blackout during a mains supply failure.

Efficiency Opportunities

Zamorano has in place an efficient on campus transportation system – the Golf Carts. The cost to operate a golf cart is the cost electricity plus maintenance. One of the golf carts was monitored for 10 days during the study. The data gathered revealed that a golf cart required on average required 3 kWHr per working day. Zamorano's cost of electricity is approximately $0.11/kWhr. The fuel cost to operate a cart is therefore approximately $0.33/day, plus maintenance. This is much less than the cost of using a fossil fueled vehicle, hence the use of the golf carts should be encouraged.

Part 1 of this strategy recommends the installation of a Photovoltaic system as an operating system for Zamorano and for use by the students to reinforce the theoretical and practical aspects of their solar courses. An ideal application for Photovoltaics (PV) is the supply of electricity for the golf carts. A preliminary feasibility (see pages 38, 39 and 40) study was done using the RETScreen program, using the electricity requirement of

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15 A visit to the milking operation indicated that cleanup occurs earlier and later than the 10am to 1 pm period

16 This quantity is an estimate based on a 4 person poll.

3kWHr/day[17]. This analysis indicates that a grid tied system will yield 167.6 $kWh/M^2/year$; hence, $4.67M^2$ of PV modules will supply the electrical requirement of one golf cart.

Two configurations could be used. One is a direct[18] connected system and the other is a grid[19] tied system. Both are recommended. The area of a golf cart techo is 1.39M2, which coincidently is *exactly* the size and dimensions of a Kyocera 200W PV module. This would supply approximately 30% of the electrical requirement. The remainder of the electrical requirement would be supplied by a ground mounted grid tied system having 2 - 200W PV modules for each on campus golf cart. These two systems would provide an excellent and very visual demonstration of energy efficiency as well as provide students the opportunity to see the operation of two different systems.

There is an additional benefit to the installation of a PV system for the golf carts. A PV module connected to each golf cart will eliminate the need to charge the carts batteries during the day. This would reduce the peak demand by 700 watts/cart (for further elaboration of this concept see the section "Zamorano Electric Substation/Standby Generator", above).

Comedor Estudiantil

Recommendations

Insufficient time was spent at the kitchen to make other than general comments. This is s typical kitchen, and appears to be well run. Kitchen equipment maintenance and vigilance with respect to equipment shut downs will provide the best insurance of energy efficiency. Water, and electricity metering is necessary and the existing metering for the LPG and diesel tanks should be upgraded.

Of particular note is a discussion with Ligia Contrer at the end of the visit. She was very interested in conserving energy and this should be encouraged. She indicated that she was not able to monitor electrical or water inputs hence is not able to quantify any energy efficiency measures undertaken. The willingness to make the necessary changes to reduce waste is uncommon. With the installation of proper metering, and some benchmark training, I am positive significant reductions in kitchen energy use can be realized.

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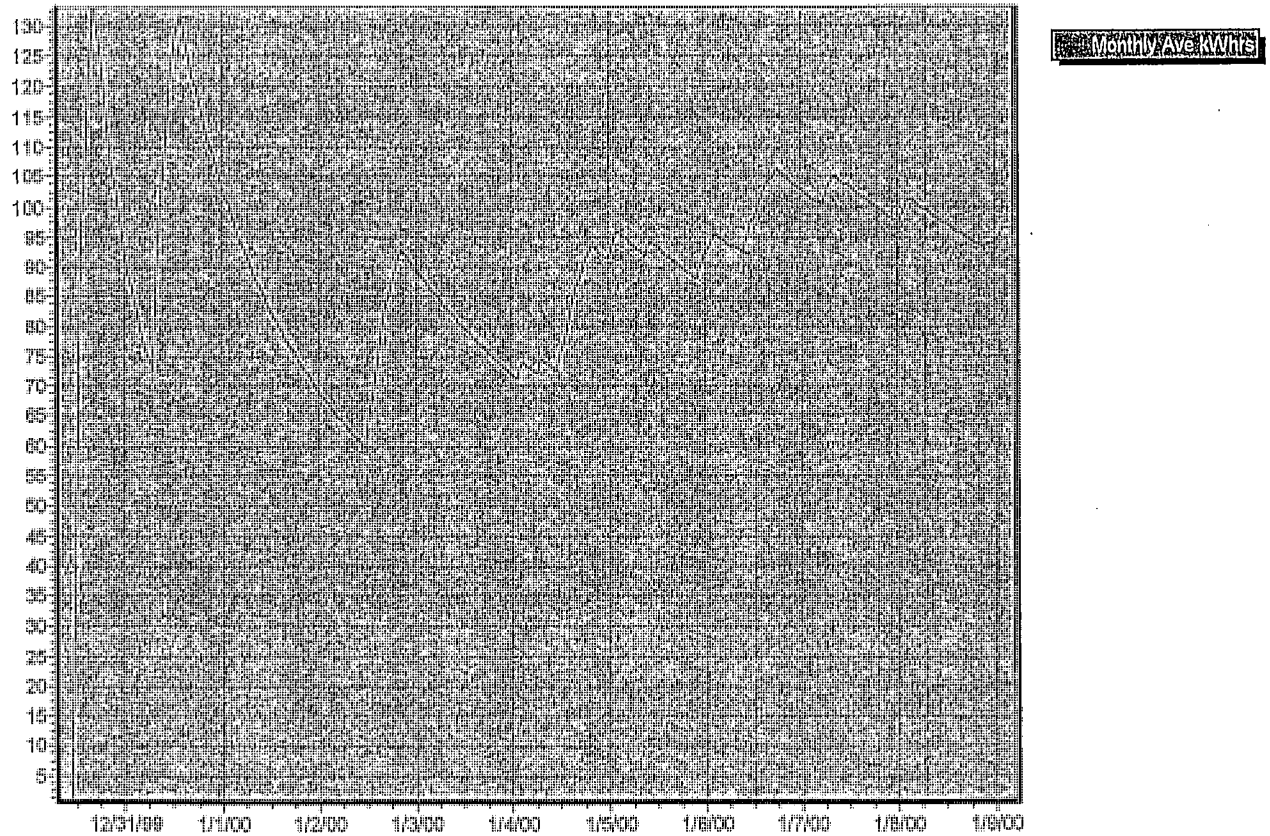
17 This is data obtained from monitoring only one golf cart. More reliable data is required if a PV system is to be considered. In the absence of more reliable data, this number will be used for this report. Further, it is assumed that these carts operate only 5 days per week but for 52 weeks/year. Each golf cart therefore requires 780 kWHr/yr.

18 A direct connected system is one that has the PV module connected directly to the golf cart batteries.

19 A grid tied system is one in which the output of the PV module is connected directly to the electrical grid via an inverter.

Watts Up Data For - Golf Cart.txt



OCT 2006 NOT

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ETScreen® Energy Model - Photovoltaic Project

Training & Support

ite Conditions		Estimate	Notes/Range
Project name		Tegucigalpa	*See Online Manual*
Project location		Golf Carts	
Nearest location for weather data	-	Tegucigalpa	*Complete SR&SL sheet*
Latitude of project location	°N	14.1	-90.0 to 90.0
Annual solar radiation (tilted surface)	MWh/m²	1.92	
Annual average temperature	°C	22.5	-20.0 to 30.0

ystem Characteristics		Estimate	Notes/Range
Application type	-	On-grid	
Grid type	-	Central-grid	
PV energy absorption rate	%	100.0%	
PV Array			
PV module type	-	poly-Si	
PV module manufacturer / model #		ABC Inc	*See Product Database*
Nominal PV module efficiency	%	11.0%	4.0% to 15.0%
NOCT	°C	45	40 to 55
PV temperature coefficient	% / °C	0.40%	0.10% to 0.50%
Miscellaneous PV array losses	%	5.0%	0.0% to 20.0%
Nominal PV array power	kWp	1.80	
PV array area	m²	16.4	
Power Conditioning			
Average inverter efficiency	%	90%	80% to 95%
Suggested inverter (DC to AC) capacity	kW (AC)	1.6	
Inverter capacity	kW (AC)	72.0	
Miscellaneous power conditioning losses	%	0%	0% to 10%

nnual Energy Production (12.00 months analysed)		Estimate	Notes/Range
Specific yield	kWh/m²	167.6	
Overall PV system efficiency	%	8.7%	
PV system capacity factor	%	17.4%	
Renewable energy collected	MWh	3.048	
Renewable energy delivered	MWh	2.743	
	kWh	2,743	
Excess RE available	MWh	0.000	
			Complete Cost Analysis sheet

ersion 3.2 NRCan/CETC - Varennes

RETScreen® Solar Resource and System Load Calculation - Photovoltaic Project

Site Latitude and PV Array Orientation		Estimate	Notes/Range
Nearest location for weather data		Tegucigalpa	*See Weather Database*
Latitude of project location	°N	14.1	-90.0 to 90.0
PV array tracking mode	-	Fixed	
Slope of PV array	°	10.0	0.0 to 90.0
Azimuth of PV array	°	0.0	0.0 to 180.0

Monthly Inputs

Month	Fraction of month used (0 - 1)	Monthly average daily radiation on horizontal surface (kWh/m²/d)	Monthly average temperature (°C)	Monthly average daily radiation in plane of PV array (kWh/m²/d)	Monthly solar fraction (%)
January	1.00	4.42	20.6	4.79	-
February	1.00	5.14	21.1	5.43	-
March	1.00	5.83	22.8	5.97	-
April	1.00	5.81	23.9	5.76	-
May	1.00	5.78	24.4	5.59	-
June	1.00	5.14	23.3	4.94	-
July	1.00	5.56	22.8	5.35	-
August	1.00	5.61	23.3	5.50	-
September	1.00	5.00	23.3	5.04	-
October	1.00	4.86	22.2	5.06	-
November	1.00	4.50	21.1	4.84	-
December	1.00	4.39	20.6	4.80	-

		Annual	Season of use
Solar radiation (horizontal)	MWh/m²	1.89	1.89
Solar radiation (tilted surface)	MWh/m²	1.92	1.92
Average temperature	°C	22.5	22.5

Load Characteristics		Estimate
Application type	-	On-grid

Return to Energy Model sheet

Version 3.2

NRCan/CETC - Varennes

41

Solar Electric Modules

The balance of this catalog lists and describes all of the equipment that you might need for a renewable energy system. We start with solar modules since they are your power producers and we progress through your system concluding with the loads your system will operate.

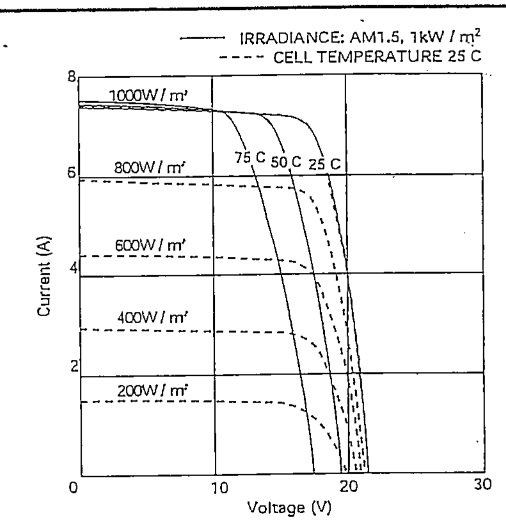
Solar Module Power Characteristics

The current and power output of photovoltaic modules are approximately proportional to sunlight intensity. At a given intensity, a module's output current and operating voltage are determined by the characteristics of the load. If that load is a battery, the battery's internal resistance will dictate the module's operating voltage.

A module which is rated at 17 volts will put out less than its rated power when used in a battery system. This is because the working voltage will be between 12 and 15 volts. As wattage (power) is the product of volts times amps, the module output will be reduced. For example: a 50 watt module working at 13.0 volts will produce 39.0 watts (13.0 volts x 3.0 amps = 39.0 watts). This is important to remember when sizing a PV system.

An I-V curve as illustrated to the right is simply all of a module's possible operating points, (voltage/current combinations) at a given cell temperature and light intensity. Increases in cell temperature increase current slightly, but drastically decrease voltage.

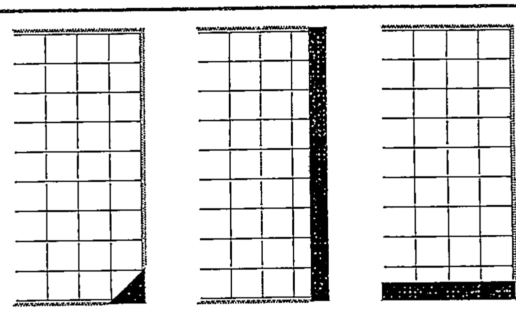
Maximum power is derived at the knee of the curve. Check the amperage generated by the solar array at your battery's present operating voltage to better calculate the actual power developed at your voltages and temperatures.



Shading

PV modules are very sensitive to shading. Unlike a solar thermal panel which can tolerate some shading, many brands of PV modules cannot even be shaded by the branch of a leafless tree.

Shading obstructions can be defined as soft or hard sources. If a tree branch, roof vent, chimney or other item is shading from a distance, the shadow is diffuse or dispersed. These soft sources significantly reduce the amount of light reaching the cell(s) of a module. Hard sources are defined as those that stop light from reaching the cell(s), such as a blanket, tree branch, bird dropping, or the like, sitting directly on top of the glass. If even one full cell is hard shaded the voltage of that module will drop to half of its unshaded value in order to protect itself. If enough cells are hard shaded, the module will not convert any energy and will, in fact, become a tiny drain of energy on the entire system.



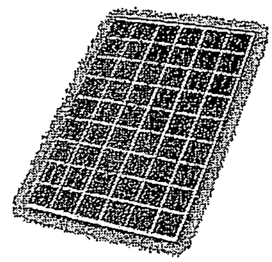
Examples of partial-cell shading that reduce PV module power by ½

Partial-shading even one cell of a 36-cell module, such as the KC130TM, will reduce its power output. Because all cells are connected in a series string, the weakest cell will bring the others down to its reduced power level. Therefore, whether ½ of one cell is shaded, or ½ a row of cells is shaded as shown above, the power decrease will be the same and proportional to the percentage of area shaded, in this case 50%.

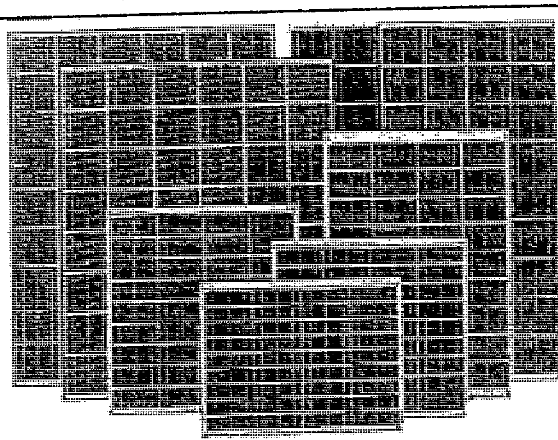
KYOCERA
KYOCERA SOLAR, INC.

Kyocera Solar Modules (KC)

Kyocera's advanced cell processing technology and automated production facilities have produced a multi-crystal solar cell with an efficiency of over 15%. All modules are constructed using a tempered glass front, EVA pottant and a PVF backing to provide maximum protection from the most severe environmental conditions. The entire laminate is framed in a heavy duty anodized aluminum frame to provide structural strength and ease of installation. Because Kyocera modules are so efficient less space is required than other solar modules of equal output. This translates to both more wattage per square foot and lower mounting structure cost.



KC200GT



KC Module Family

Features

- KC65T-KC200T modules have a +10/-5% power tolerance, KC40T-50T +15/-5%
- UL listed
- Low iron, tempered glass, EVA encapsulant and anodized aluminum frame construction
- 25 year output warranty on KC Series modules
- Weather resistant junction box (KC40T-KC130TM) or multi-contact connectors (KC130GT, 175GT, & 200GT)

Quality Assurance

Kyocera multi-crystal photovoltaic modules exceed government specifications for the following tests:

- Thermal cycling test
- Thermal shock test
- Thermal/Freezing and high humidity cycling test
- Electrical insolation test
- Hail impact test
- Mechanical, wind and twist loading test
- Salt mist test
- Light and water exposure test
- Field exposure test

Product Name and Description	KC 200GT	KC 175GT	KC 130GT	KC 130TM	KC85T	KC65T	KC50T	KC40T
Part Number	120002	117502	113002	113012	108511	106511	105011	104011
Rated Power (Watts)	200	175	130	130	87	65	54	43
Series Fusing (Amps)	15.0	15.0	15.0	15.0	7.0	6.0	6.0	6.0
Current at Max. Power (Amps)	7.61	7.42	7.39	7.39	5.02	3.75	3.11	2.48
Voltage at Max. Power (Volts)	26.3	23.6	17.6	17.6	17.4	17.4	17.4	17.4
Short Circuit Current (Amps)	8.21	8.09	8.02	8.02	5.34	3.99	3.31	2.65
Open Circuit Voltage (Volts)	32.9	29.2	21.9	21.9	21.7	21.7	21.7	21.7
Length (Inches)	56.2	50.8	56.0	56.0	39.6	29.6	25.2	20.7
Width (Inches)	39.0	39.0	25.7	25.7	25.7	25.7	25.7	25.7
Depth of frame (Inches)	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Depth including j-box	1.4	1.4	1.4	2.2	2.2	2.1	2.1	2.1
Shipping Weight (lbs.)	40.7	35.3	33.0	33.0	24.0	18.0	16.0	13.0

All specification at 25°C. cell temperature, 1.5 AM and 1000W/m^2. Wattage ratings are + 10% or – 5% (KC40T +/- 5%).
KC "T" and "TM" modules have a conduit ready junction box. "GT" modules have multi-contact connectors.
See Appendix A for module dimensions and shipping information.

Replacement bypass diodes for Kyocera J-Box equipped modules are sold in packs of 25; part number 1414100

Efficiency Opportunities

This kitchen prepares meals for approximately 900 on-campus students. It is a very large kitchen that has a diesel fired steam boiler, several LPG fired ranges and numerous electric cookers. There are numerous electrically operated mixers, grinders and other motor driven pieces of equipment. Fluorescent T12 fixtures are installed in the T bar ceiling. This kitchen, as is typical of all kitchens has a large makeup air fan that replaces the exhaust hood extraction system. There are several large cold/freezer rooms. A visit to a facility such as this normally includes a visual inspection of the make-up air and compressor systems. In this case, this was not possible as they are roof mounted and since it was during prime food preparation time, staff and ladders were not available.

Without a detailed study of this facility, only general comments can be made with respect to energy efficiency measures, and they all have to do with equipment maintenance. Routine maintenance will insure that all equipment operates at maximum efficiency. Of most importance are the high-energy users such as cold rooms, compressors and the make up air and exhaust systems. Cooking is achieved via LPG, electricity and steam from the diesel fueled boiler. Regular boiler maintenance is especially important to maintain top efficiency.

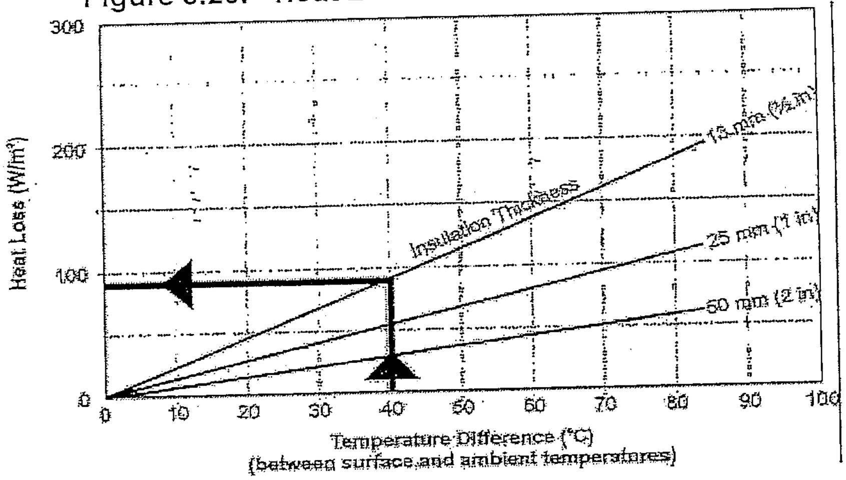
Suggestions for improvement include retrofitting the T12 lights with T8 fixtures, insulating the exterior boiler steam pipes and instituting a check list for shutdowns. The air make up and exhaust fans should be checked regularly to insure top efficiency. Water efficiency also needs to be addressed. It was noted that one sink had two faucets that were in the off postion but each had water streams of 3mm. Two streams of this size will result in a water waste of 630m^3/yr (see pagex). Of note was a comment made during the visit; that while some of the cooking appliances were dual fueled, without electricity the LPG could not be ignited. This is a serious consideration in light of a possible blackout (see Zamorano Electric Substation/Standby Generator above). Only crude monitoring is available on the LPG and diesel tanks. As a first measure it can be used, however measurement that is more precise will be required. Electrical and water is not measured.

Laundry

Recommendations

Wood energy is used by the laundry for steam heat. Water is also a large utility input. All of the equipment requires maintenance if less energy is to be used. Allan Sevilla, the, supervisor is keen on implementing energy efficient strategies, but is hampered in his efforts because he cannot quantify any changes that he might insititute. As with the student kitchens, if the inputs were monitored, here is an opportunity for an energy efficiencey program without the issue of oppostion becase of change.

Figure 3.26: Heat Loss - Insulated Flat Surface



3.7.3 Energy Management Opportunities

Reduce Waste

Inspect the SHW system for leaks on a regular basis. Encourage the building occupants to report drips and leaks to appropriate personnel.

Large quantities of hot water are often wasted due to dripping faucets and leaks around pipe joints. As shown in Figure 3.27, a leak of just 1 drop per second adds up to more than 6,000 litres per year. Hot water leaks waste both water and energy. In addition, leaking water may cause damage to the building structure, insulation, and other equipment.

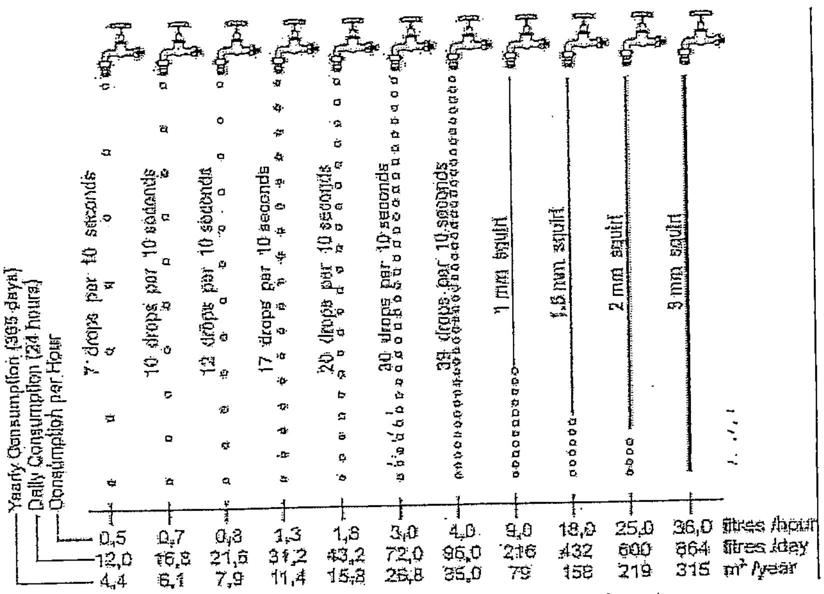


Figure 3.27: Loss from a Leak

Efficiency Opportunities

This facility provides laundry services for the 900 on-campus students. Input utilities include electricity, water and steam via a wood fired boiler. The equipment was installed a considerable number of years ago and is in need of maintenance. Of particular concern are the steam heated clothes dryers. Apparently because of incorrect installation, the paralleled steam dryers cannot all be used simultaneously. The major energy inputs are water and steam (wood). Neither is metered. Electricity (also not metered) is used for lights, ironing and to operate the washer and dryer motors.

In my opinion, this facility requires more maintenance than any of the facilities that I have seen at Zamorano. Allan Sevilla, who is in charge of the laundry, is very keen on doing whatever is necessary to reduce both wood and water inputs but is hampered by the lack of metering. He would like to use an alternate source of wood fuel, specifically the waste of some other process such as sawdust, slab waste from the sawmill or something from the recycling program. This would require the refitting of the boiler. In my opinion, this presents a philosophical issue. Wood is a renewable resource, however in this case wood that could be otherwise used more productively is being burned inefficiently thus causing unnecessary pollution. Should energy be spent to obtain metal resources and to manufacture new equipment so that less renewable energy (wood) will be used to operate the laundry?

In any case, eventually the equipment will have to be replaced and, I think, it is not too far in the future. This issue needs to be considered by Zamorano from a philosophical and economic point of view.

Electricity is used for ironing. There are nine 700-watt irons in use simultaneously. In view of the electrical demand problem, this represents part of a solution. If these irons were not used during the peak demand period, it would reduce the possibility of a standby generator blackout and it will reduce the peak demand charges levied by Empressa Nacional De Energia Electrica. For more details on this subject see Zamorano Electric Substation/Standby Generator above

Cafeteria

In section 1 Blocks P and G refer to the design and construction of a thermal Solar System. The cafeteria requires less hot water than the students kitchens hence it has been chosen for the installation of a solar system. Pages 47 to 50 provide preliminary design and the source for the hot water requirement. It is assumed that the cafeteria supplies approximately 200 meals per day and hence using Figure 3.21 the hot water requirement is approximately 9 litres per meal. Actual design will require monitoring of the hot water requirement. Using this data, RETScreen predicts that 80% of the hot water requirement will be supplied with 12 collectors having an area of 35.5M^2. A schematic has also been included to indicate the student monitoring points.

RETScreen® Energy Model - Solar Water Heating Project

Training & Support

Site Conditions		Estimate	Notes/Range
Project name		Zamorano Cafeteria	See Online Manual
Project location		Pan American Ag School	
Nearest location for weather data		Tegucigalpa	Complete SR&HL sheet
Annual solar radiation (tilted surface)	MWh/m²	1.92	
Annual average temperature	°C	22.5	-20.0 to 30.0
Annual average wind speed	m/s	4.1	
Desired load temperature	°C	50	
Hot water use	L/d	1,820	
Number of months analysed	month	12.00	
Energy demand for months analysed	MWh	21.35	

System Characteristics		Estimate	Notes/Range
Application type		Service hot water (with storage)	
Base Case Water Heating System			
Heating fuel type	-	Other	
Water heating system seasonal efficiency	%	50%	50% to 190%
Solar Collector			
Collector type	-	Glazed	See Technical Note 1
Solar water heating collector manufacturer		[illegible]	See Product Database
Solar water heating collector model		[illegible]	
Gross area of one collector	m²	[illegible]	1.00 to 5.00
Aperture area of one collector	m²	[illegible]	1.00 to 5.00
Fr (tau alpha) coefficient	-	[illegible]	0.50 to 0.90
Fr UL coefficient	(W/m²)/°C	[illegible]	1.50 to 8.00
Temperature coefficient for Fr UL	(W/(m·°C)²)	[illegible]	0.000 to 0.010
Suggested number of collectors		5	
Number of collectors		12	
Total gross collector area	m²	35.5	
Storage			
Ratio of storage capacity to coll. area	L/m²	23.0	37.5 to 100.0
Storage capacity	L	767	
Balance of System			
Heat exchanger/antifreeze protection	yes/no	No	
Suggested pipe diameter	mm	19	8 to 25 or PVC 35 to 50
Pipe diameter	mm	38	8 to 25 or PVC 35 to 50
Pumping power per collector area	W/m²	0	3 to 22, or 0
Piping and solar tank losses	%	1%	1% to 10%
Losses due to snow and/or dirt	%	3%	2% to 10%
Horz. dist. from mech. room to collector	m	5	5 to 20
# of floors from mech. room to collector	-	2	0 to 20

Annual Energy Production (12.00 months analysed)		Estimate	Notes/Range
SWH system capacity	kW_{th}	23	
	MW_{th}	0.023	
Pumping energy (electricity)	MWh	0.00	
Specific yield	kWh/m²	482	
System efficiency	%	25%	
Solar fraction	%	80%	
Renewable energy delivered	MWh	17.13	
	GJ	61.66	
			Complete Cost Analysis sheet

ETScreen® Solar Resource and Heating Load Calculation - Solar Water Heating Project

ite Latitude and Collector Orientation		Estimate	Notes/Range
Nearest location for weather data		Tegucigalpa	*See Weather Database*
Latitude of project location	°N	14.1	-90.0 to 90.0
Slope of solar collector	°	10.0	0.0 to 90.0
Azimuth of solar collector	°	0.0	0.0 to 180.0

lonthly Inputs

lote: 1. Cells in grey are not used for energy calculations; 2. Revisit this table to check that all required inputs are filled if you change system type or solar collector type or pool pe, or method for calculating cold water temperature).

Month	Fraction of month used (0 - 1)	Monthly average daily radiation on horizontal surface (kWh/m²/d)	Monthly average temperature (°C)	Monthly average relative humidity (%)	Monthly average wind speed (m/s)	Monthly average daily radiation in plane of solar collector (kWh/m²/d)
January	1.00	4.42	20.6	70.0	4.6	4.81
February	1.00	5.14	21.1	66.0	5.1	5.45
March	1.00	5.83	22.8	61.5	5.1	5.98
April	1.00	5.81	23.9	61.5	4.1	5.74
May	1.00	5.78	24.4	68.5	3.6	5.55
June	1.00	5.14	23.3	74.0	3.1	4.90
July	1.00	5.56	22.8	72.0	3.6	5.31
August	1.00	5.61	23.3	72.0	3.6	5.48
September	1.00	5.00	28.3	75.0	3.6	5.04
October	1.00	4.86	22.2	76.5	4.1	5.08
November	1.00	4.50	21.1	75.5	4.6	4.86
December	1.00	4.39	20.6	73.0	4.6	4.83

		Annual	Season of Use
Solar radiation (horizontal)	MWh/m²	1.89	1.89
Solar radiation (tilted surface)	MWh/m²	1.92	1.92
Average temperature	°C	22.5	22.5
Average wind speed	m/s	4.1	4.1

/ater Heating Load Calculation		Estimate	Notes/Range
Application type	-	Service hot water	
System configuration	-	With storage	
Building or load type	-	Restaurant	
Number of units	Meal/d	200	
Rate of occupancy	%	100%	50% to 100%
Estimated hot water use (at ~60 °C)	L/d	1,820	
Hot water use	L/d	1,820	
Desired water temperature	°C	50	
Days per week system is used	d	7	1 to 7
Cold water temperature	-	Auto	
Minimum	°C	21.8	1.0 to 10.0
Maximum	°C	23.1	5.0 to 15.0
Months SWH system in use	month	12.00	
Energy demand for months analysed	MWh	21.35	
	GJ	76.85	

Return to Energy Model sheet

ersion 3.1

NRCan/CETC - Varennes

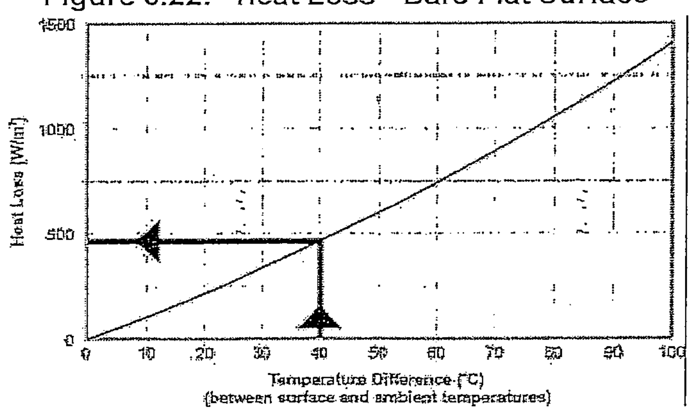
Figure 3.21
Typical Hot Water Utilization Factors

Office Buildings (without kitchen or cafeteria services)	4 - 8 litres/person/day
Department Stores/Shops (without kitchen or cafeteria services)	3 - 4 litres/customer/day
Hotels/Motels	
- < 20 rooms	75 - 90 litres/room/day
- 60 rooms	50 - 65 litres/room/day
- > 100 rooms	40 - 50 litres/room/day
Dormitories	50 litres/student/day
Apartments	
- < 20 units	160 litres/unit/day
- 50 units	150 litres/unit/day
- 100 units	140 litres/unit/day
- > 200 units	130 litres/unit/day
Restaurants	
- full-service restaurant/cafeteria	9 - 12 litres/meal/day
- quick-service food shops	3 - 4 litres/meal/day
Schools	
- Elementary School	3 - 5 litres/student/day
- Junior/High School	7 - 11 litres/student/day
- Boarding School	60 - 90 litres/student/day
Medical Facilities	
- Nursing Homes	70 litres/patient/day
- Hospitals	70 - 150 litres/patient/day

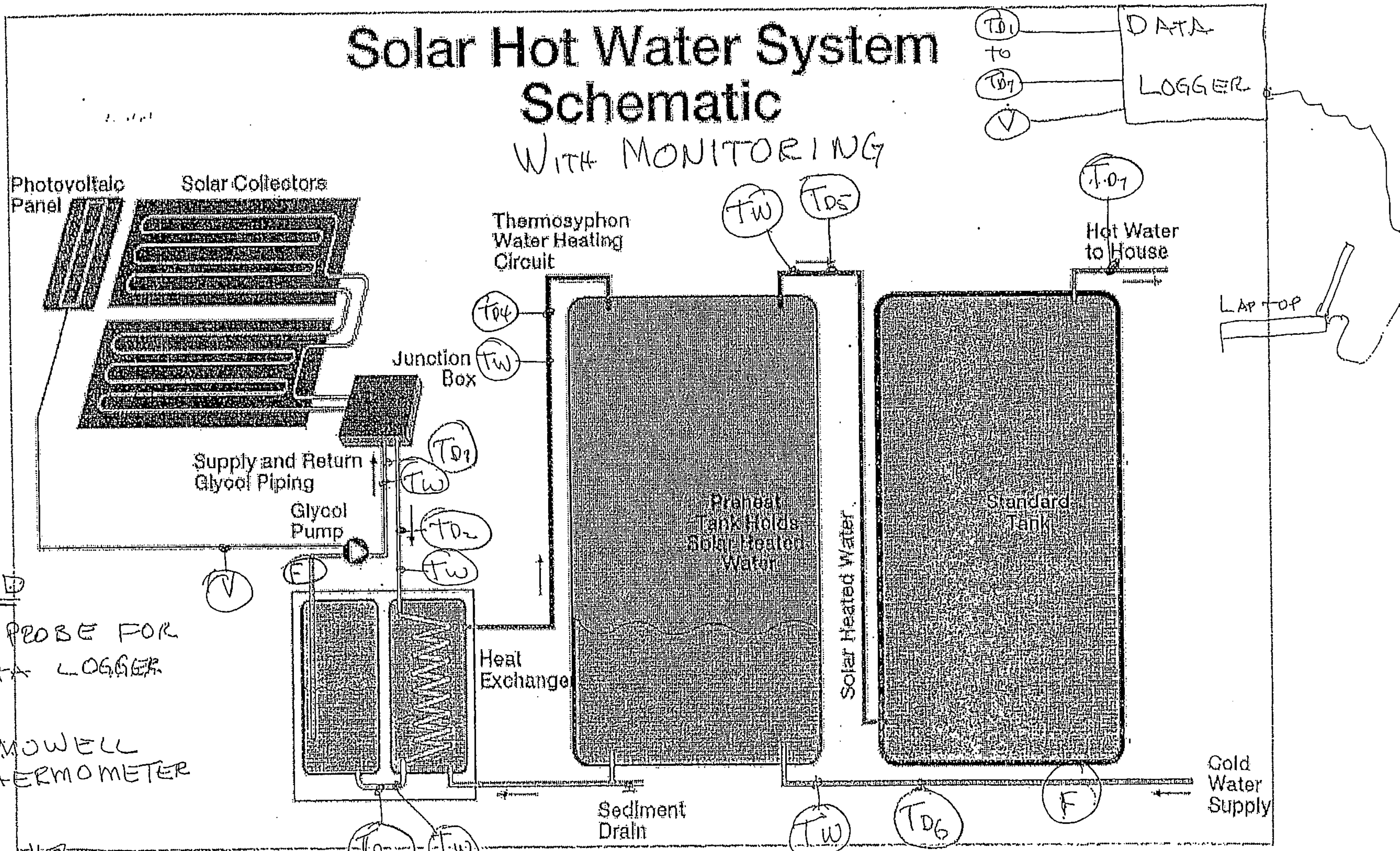
Energy to Offset Heat Loss

The energy required to maintain the hot water temperature is a function of the heat loss from the storage and distribution system. Methods for estimating this heat loss energy are discussed in detail in Module 8 of the CTP manual. Figures 3.22 to 3.26 provide charts for estimating heat loss from bare and insulated pipes and flat surfaces.

Figure 3.22: Heat Loss - Bare Flat Surface



Components of SWH Systems



LEGEND

TD TEMP PROBE FOR DATA LOGGER

TW THERMOWELL FOR THERMOMETER

V PV PANEL VOLTAGE

F FLO METER

Photo Credit: NRCan

Centro Kellog

Recommendations

Several opportunities exist for reducing the energy used by Centro Kellogg. It is recommended that the T12 fixtures be revamped using T8 bulbs and ballasts. This will save approximately 20,552 kWHr/year. If the wash water was heated with solar it would supply between 79 and 94% of the hot water requirement. This would reduce the annual electrical consumption, but more importantly would reduce the peak daytime load. Weather stripping the windows and doors in the two air-conditioned conference rooms will reduce operating times of the two very large air-conditioned units. Consideration should be given to installing "vend misers" or/and disconnecting one of the pop machines in the reception area of the hotel.

Efficiency Opportunities

Centro Kellog is a full service hotel. There are sleeping and meeting rooms, a computer centre and laundry facilities. The major energy loads are water and electricity. Electrical loads consist of 12 – 3.8kW 80 US gallon water tanks for the main hotel and 3 – 3kW 60 US gallon water heaters for the apartments, 2- 6.5 kW air conditioners, fluorescent and incandescent lights, pop coolers, computers, washers and dryers.

As time was limited, only the lights, water heaters, compressors and pop coolers have been considered, hence the discussion will be limited to those items. Two 4th year students, Lizeth L. Aliaga Orellana y Cindy G. Irusta Tórrez, volunteered to evaluate the building lighting with respect to replacing the outdated T12 and incandescent bulbs with the newer more efficient T8 and compact fluorescents bulbs. This consisted of determining the number and type of fixtures, entering this into an excel spreadsheet along with the reduced load and on[20] times. The spreadsheet then displays the estimated current lighting load, the estimated load using energy efficient lamps and hence the annual kWHr savings. This spreadsheet has been including at the end of this section. This analysis shows that a lamp retrofit will reduce the lighting demand load by 13.4kW, and reduce the annual energy consumption by 20,552 kWHr. One of the most significant opportunities is the total connected 54 kW, water heater load. As this load is totally uncontrolled, it may be contributing significantly to the peak day time load. If this load were disconnected during the daytime peaking period, it would reduce the monthly demand charge and significantly reduce the possibility of standby generator shut down (for a more detailed discussion of this, see the standby generator section on page 36). The strategy of part 1 recommends the installation of a thermal solar system. The hotel is

[20] The determination of on times is a difficult. The annual on time depends primarily upon occupancy rate, as the room lights will be on each evening if the room is occupied. Lizeth and Cindy attempted to determine the occupancy rate. While the data was promised it was not forthcoming. Finally, the request had to be abandoned because of time constraints. The students also assumed that with some awareness training and signage actual on times will be reduced. The spreadsheet contains comments in each time cell regarding time determination.

the obvious choice for this system. Two preliminary designs are attached to this section. One system is for the South wing, rooms 9 to 18, 27 to 36, and one for the suites. The analysis indicates that an array of 17.8 M^2 will provide 79% of the hot water (76L/room/per day) requirement for the South wing and 3 M^2 will provide 94% of the hot water requirement for two apartments. In both cases, a thermosyphon system is recommended (see attached picture). Two other opportunities are the air conditioners and the pop coolers. The air conditioners are used to cool the sala de conferercia #'s 1 and 2. These units appear to be used infrequently however a each of the rooms have large air gaps in all windows and doors, which if sealed would reduce operating time considerably. It is common practice to install vend-misers on all pop machines in Canadian Universities, which results in savings of about $100/yr per pop cooler. While this should be considered, it is also noted that much of the time one of the machines is empty. Possibly three machines would be adequate. A brochure is attached to this section

I would like to thank Lizeth and Cindy for their assistance in my efforts to identify opportunities for energy reduction at Centro Kellogg. Counting fixtures is a time consuming job, for which I did not have to do. Without their help, I would not have been able to quantify the opportunities. As a former teacher, I feel that it is important that when students assist in a project, they be fully involved and that they learn something – the "Learn by doing" philosophy. To that end I asked the students to write a paragraph about their portion of the work, as I indicated that when a report is prepared one must be prepared to explain the reasoning and assumption behind the conclusion. The following is that paragraph.

El conteo de focos de cada lugar (habitaciones, pasillos, suites, apartamentos, etc) del hotel Kellogg de Zamorano se realizó minuciosamente, la estimación del tiempo de horas de uso real y el tiempo de uso ideal de dichas luces fueron efectuados por las estudiantes de cuarto año Lizeth L. Aliaga Orellana y Cindy G. Irusta Tórrez.

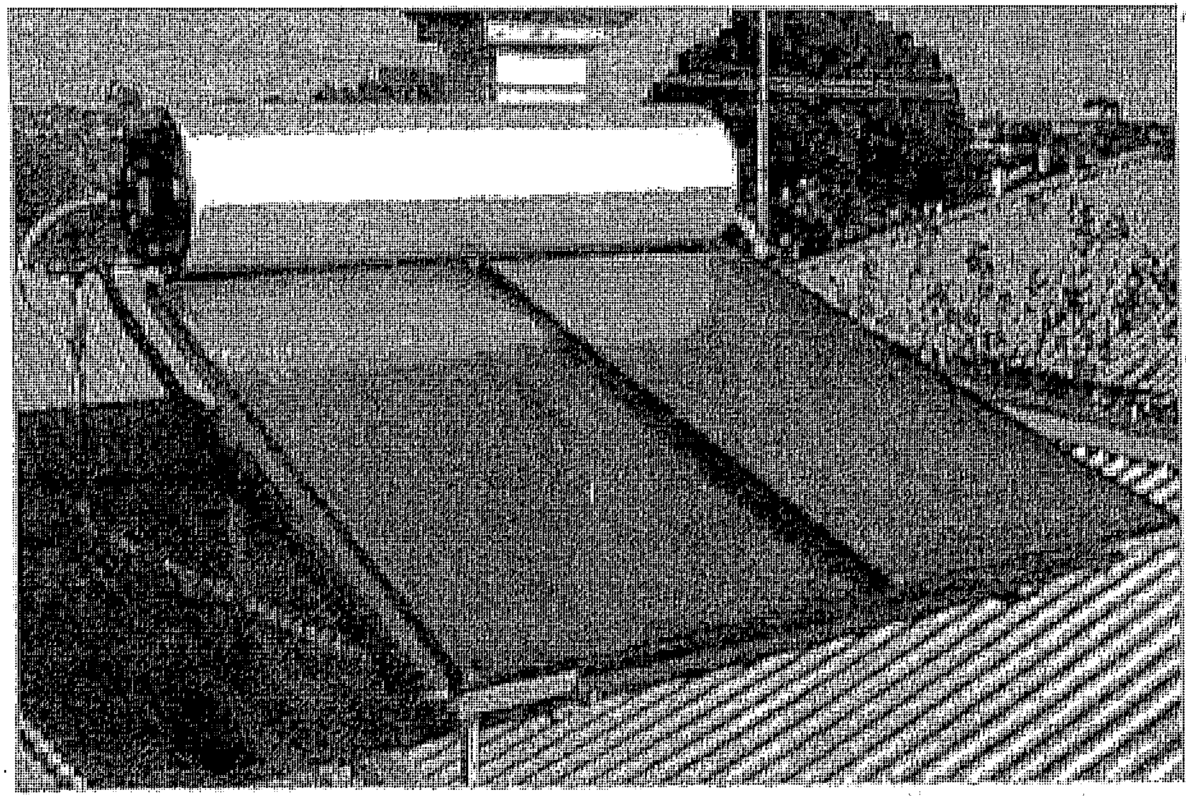
Power Smart
Product Incentive Program
Calculator

Enter Your Project Name: Genlro Kellogg Lamp Refit

Item Number	Location	Existing Installation	Retrofit	Quantity	Average Operating Hours	Adjsuted Operating Hours	Existing Watts/Unit ***	Revised Watts/Unit ***	Existing Total Energy Cost**	Revised Total Energy Cost**	Existing Demand	Revised Demand	Total Kwh Savings
		Retrofit Details							Benefits: Annual O				
1	Room of conferences	1.2M-2 lamp T12	1.2M-2 lamp T8	53	480	480	85	65	$76.98	$58.87	4,505	3,445	509
2	Rooms	Incandescent	CFL screw in	140	231	184.8	60	23	$69.08	$21.18	8,400	3,220	1,345
3	Suites	Incandescent	CFL screw in	37	1050	1050	60	23	$82.98	$31.81	2,220	851	1,437
4	Suites	1.2M-2 lamp T12	1.2M-2 lamp T8	2	1050	1050	85	65	$6.35	$4.86	170	130	42
5	Apartments	Incandescent	CFL screw in	42	1050	1050	60	23	$94.20	$36.11	2,520	966	1,632
6	Apartments	0.7M-2 lamp T12	0.7M-2 lamp T8	6	1050	1050	50	38	$11.21	$8.52	300	228	76
7	Reception	0.7M-2 lamp T12	0.7M-2 lamp T8	2	5241.6	2839.2	50	38	$18.66	$7.68	100	76	308
8	Reception	1.2M-2 lamp T12	1.2M-2 lamp T8	1	5241.6	2839.2	85	65	$15.86	$6.57	85	65	261
9	Reception stairs	0.7M-2 lamp T12	0.7M-2 lamp T8	2	5241.6	2839.2	50	38	$18.66	$7.68	100	76	308
10	Billiards room	1.2M-2 lamp T12	1.2M-2 lamp T8	3	840	840	85	65	$7.63	$5.83	255	195	50
11	Corridors	1.2M-2 lamp T12	1.2M-2 lamp T8	50	5250	4550	85	65	$794.33	$526.44	4,250	3,250	7,525
12	Corridors	0.7M-2 lamp T12	0.7M-2 lamp T8	7	5250	4550	50	38	$65.42	$43.09	350	266	627
13	Apartment corridors	Incandescent	CFL screw in	6	420	420	60	23	$5.38	$2.06	360	138	93
14	Offices	1.2M-2 lamp T12	1.2M-2 lamp T8	38	1936	1232	85	65	$222.62	$108.33	3,230	2,470	3,210
15	Offices	0.7M-2 lamp T12	0.7M-2 lamp T8	4	1936	1232	50	38	$13.78	$6.67	200	152	200
16	Second floor hall	1.2M-2 lamp T12	1.2M-2 lamp T8	7	8400	4550	85	65	$177.93	$73.70	595	455	2,928
17	Warehouse	0.7M-2 lamp T12	0.7M-2 lamp T8	2	1820	910	85	65	$11.01	$4.21	170	130	191
18	Kitchen	1.2M-2 lamp T12	1.2M-2 lamp T8	1	700	700	85	65	$2.12	$1.62	85	65	14
19	Laundry room	1.2M-2 lamp T12	1.2M-2 lamp T8	3	1400	1400	85	65	$12.71	$9.72	255	195	84
20	Room Heaters	1.2M-2 lamp T12	1.2M-2 lamp T8	4	78	78	85	65	$0.94	$0.72	340	260	6
21	Bathrooms	1.2M-2 lamp T12	1.2M-2 lamp T8	10	3150	840	85	65	$95.32	$19.44	850	650	2,132
TOTALS									$1,803.17	$986.11	29,340	15,983	20,552

10/24/2006

Thermosyphon System



Courtesy Quail Engineering

Vending Machines

UTILITY SAVINGS INITIATIVE (USI) – FACT SHEET

Delamp Vending Machines

Typical Energy Use. Vending Machines can often be overlooked when considering your business' energy consumption, but they are in fact one of the largest energy consumers in the office environment. A typical refrigerated vending machine consumes 400 Watts, which at a rate of 6.39¢ per kWh, can translate into an annual operating cost of $225.[1]

Delamping Savings: One easy way to reduce your vending machine cost is to ask your vending machine company to de-lamp the advertising lights inside the machine. The lights and ballasts in a typical refrigerated vending machine use about 180 Watts. At a rate of 6.39¢ per kWh, delamping vending machines can save $100 every year!

Delamping Issues: Some facility managers feel that removing the illumination of vending machines could reduce vending sales (and revenues) in areas where machines are remotely located. Other managers have made vending machine de-lamping a universal policy. When delamping, always educate vending machine users that de-lamped machines save energy. A decal can be conspicuously placed on the machine stating, "This Machine Is Operational. Lights Turned Off to Save Energy." Vending machine reps may discourage de-lamping, so do your homework and have your requests thought through.

Successful Application of Vending Machine Sensors

Wake County School System. In 2000, the Wake County Schools System incorporated the use of VendingMiser power controllers in an exclusive vending machine contract with Pepsi Cola. Energy and cost savings from the vending machines exceeded expectations. To inform users about the energy saving measures, every vending machine displays a decal explaining the use of the VendingMiser controller and its beneficial savings. Most vending machines were also permanently delamped as part of the initiative, especially in highly visible locations. No decrease in vending sales revenues have been experienced since the energy saving initiatives. Pepsi Cola worked with Researchers at NCSU to independently verify the energy saving achieved through the use of VendingMiser power controllers. Pepsi is considering establishing a nationwide policy to incorporate occupancy sensor technology in all their vending machines. For more information on Pepsi's energy saving initiatives, contact Tom Spencer, Corporate MEM, Pepsi Bottling Ventures , (919) 863-8530.

Energy Saving Sensors

Consider the use of occupancy sensors and controllers that will reduce a vending machine's power requirements during long periods of non-use, such as overnight and weekends. This occupancy controller option should be considered when de-lamping a vending machine is not advisable (i.e., when a vending machine does not have a captive audience or when de-lamping resulted in reduced vending sales revenues.)

VendingMiser, a Bayview Technology product, saves between 30—50 percent of the annual electricity costs of a refrigerated vending machine, depending on the application and occupancy of the location.[2,3,4] VendingMiser uses an infrared sensor to power down the vending machine after 15 minutes of vacancy, constantly monitoring the room's temperature while powered off to maintain the temperature of the product. Some new vending machines have built in occupancy sensors and power controllers. Energy saving sensors also reduce maintenance costs and increase the life of fluorescent lamps in the front panels.[2]

Applications and Suggestions

The VendingMiser technology has been employed in many governmental and school settings. The following suggestions are provided to ensure a successful application:

- Make sure everyone is aware of and

Calculate Your Potential Savings*

Typical Savings from Delamping your Vending Machines

________# vending machines x $100 = $ ________/ year

Typical Savings from Occupancy Controllers/VendingMiser

________# vending machines x $225 x 0.4 = $ ________/ year

Typical Savings from SnackMiser

________# snack vending machines x $56 x 0.4 = $ ________/ year

Payback Periods

Delamping Vending Machines:	Immediate
Occupancy/VendingMiser Controllers:	1.4—2.4 years
A VendingMiser controller costs	~$170

*Savings based on NC average commercial electrical rate of $0.0639/kWh and 40 percent saving using VendingMiser.

educated about the installation and use of these units, including local drink vendors, building managers, and users. Even though Coke and Pepsi corporate management have approved the use of the VendingMiser, local reps may not be informed.[6]

- Coordinate any moves of vending machines. The units use a photo sensor that is permanently mounted to the wall or ceiling over the vending machines.
- Be careful not to overload a circuit, where multiple vending machines are plugged into one circuit. Repeaters are available that stagger the starts of multiple machines on one circuit.
- Some facility managers suggest that VendingMiser not be used with machines that dispense dairy products.

Vending Contracts & New Options

Efforts should be made to incorporate the use of vending machine power sensors (built-in or add-on devices) in all future contracts with beverage and snack machine vendors. VendingMiser (add-on) products are now available on state contract for NC agencies.

New refrigerated vending machines are making advances in energy efficiency, through improvements in compressors, insulation, lighting, use sensors, and programmable logic controllers. Request the highest energy efficient machines in new contracts. Request that existing machines be upgraded.

Other Applications

Organizations can also substantially reduce the energy costs of non-refrigerated vending machines by de-lamping or using occupancy controllers. A typical snack machine can draw almost 100 Watts, costing $55.98 per year. See "Typical Savings" above.

References & Resources:

1. A Roadmap for Simultaneously Developing Supply and Demand for Energy Efficiency Beverage Vending Machines, Horowitz, et al. USDOE, EPA, ACEEE, and Natural Resources Defense.
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5. Vending Machine Power Consumption Comparisons, Milwaukee School of Engineering, 1/2004, www.msoe.edu/orgs/focus/vending-/htm
6. Tuff Climate Initiative: Vending Miser: Fact & Issues. www.tuffs.edu/tie/tci/vendingmiserhandout.pdf

Sponsored by the State Energy Office, N.C. Department of Administration and the U.S. Department of Energy, with State Energy Program funds, in cooperation with the Land-of-Sky Regional Council (Waste Reduction Partners) and the NCDPPEA. However, any opinion, findings, conclusions, or recommendations expressed herein are those of the author(s) and do not necessarily reflect the views of either the N.C. Department of Administration or the U.S. Department of Energy. An online version of this fact sheet is available at www.landofsky.org/wrp.

State Energy Office

RETScreen® Energy Model - Solar Water Heating Project

Training & Support

Site Conditions		Estimate	Notes/Range
Project name		Centro Kellogg	See Online Manual
Project location		Pan American Ag School	
Nearest location for weather data		Tegucigalpa	Complete SR&HL sheet
Annual solar radiation (tilted surface)	MWh/m²	1.92	
Annual average temperature	°C	22.5	-20.0 to 30.0
Annual average wind speed	m/s	4.1	
Desired load temperature	°C	40	
Hot water use	L/d	152	
Number of months analysed	month	12.00	
Energy demand for months analysed	MWh	1.14	

APARTMENTS

System Characteristics		Estimate	Notes/Range
Application type		Service hot water (with storage)	
Base Case Water Heating System			
Heating fuel type	-	Other	
Water heating system seasonal efficiency	%	50%	50% to 190%
Solar Collector			
Collector type	-	Glazed	See Technical Note 1
Solar water heating collector manufacturer		[illegible]	See Product Database
Solar water heating collector model		[illegible]	
Gross area of one collector	m²	[illegible]	1.00 to 5.00
Aperture area of one collector	m²	[illegible]	1.00 to 5.00
Fr (tau alpha) coefficient	-	[illegible]	0.50 to 0.90
Fr UL coefficient	(W/m²)/°C	[illegible]	1.50 to 8.00
Temperature coefficient for Fr UL	(W/(m·°C)²)	[illegible]	0.000 to 0.010
Suggested number of collectors		1	
Number of collectors		1	
Total gross collector area	m²	3.0	
Storage			
Ratio of storage capacity to coll. area	L/m²	23.0	37.5 to 100.0
Storage capacity	L	64	
Balance of System			
Heat exchanger/antifreeze protection	yes/no	No	
Suggested pipe diameter	mm	10	8 to 25 or PVC 35 to 50
Pipe diameter	mm	38	8 to 25 or PVC 35 to 50
Pumping power per collector area	W/m²	0	3 to 22, or 0
Piping and solar tank losses	%	1%	1% to 10%
Losses due to snow and/or dirt	%	3%	2% to 10%
Horz. dist. from mech. room to collector	m	5	5 to 20
# of floors from mech. room to collector	-	2	0 to 20

Annual Energy Production (12.00 months analysed)		Estimate	Notes/Range
SWH system capacity	kW_{th}	2	
	MWth	0.002	
Pumping energy (electricity)	MWh	0.00	
Specific yield	kWh/m²	360	
System efficiency	%	19%	
Solar fraction	%	94%	
Renewable energy delivered	MWh	1.07	
	GJ	3.84	
			Complete Cost Analysis sheet

Version 3.1

NRCan/CETC - Varennes

RETScreen® Solar Resource and Heating Load Calculation - Solar Water Heating Project

Site Latitude and Collector Orientation		Estimate		Notes/Range
Nearest location for weather data		Tegucigalpa		See Weather Database
Latitude of project location	°N	14.1	APARTMENTS	-90.0 to 90.0
Slope of solar collector	°	10.0		0.0 to 90.0
Azimuth of solar collector	°	0.0		0.0 to 180.0

Monthly Inputs

(Note: 1. Cells in grey are not used for energy calculations; 2. Revisit this table to check that all required inputs are filled if you change system type or solar collector type or pool type, or method for calculating cold water temperature).

Month	Fraction of month used (0 - 1)	Monthly average daily radiation on horizontal surface (kWh/m²/d)	Monthly average temperature (°C)	Monthly average relative humidity (%)	Monthly average wind speed (m/s)	Monthly average daily radiation in plane of solar collector (kWh/m²/d)
January	1.00	4.42	20.6	70.0	4.6	4.81
February	1.00	5.14	21.1	66.0	5.1	5.45
March	1.00	5.83	22.8	61.5	5.1	5.98
April	1.00	5.81	23.9	61.5	4.1	5.74
May	1.00	5.78	24.4	68.5	3.6	5.55
June	1.00	5.14	23.3	74.0	3.1	4.90
July	1.00	5.56	22.8	72.0	3.6	5.31
August	1.00	5.61	23.3	72.0	3.6	5.48
September	1.00	5.00	23.3	75.0	3.6	5.04
October	1.00	4.86	22.2	76.5	4.1	5.08
November	1.00	4.50	21.1	75.5	4.6	4.86
December	1.00	4.39	20.6	73.0	4.6	4.83

		Annual	Season of Use
Solar radiation (horizontal)	MWh/m²	1.89	1.89
Solar radiation (tilted surface)	MWh/m²	1.92	1.92
Average temperature	°C	22.5	22.5
Average wind speed	m/s	4.1	4.1

Water Heating Load Calculation		Estimate	Notes/Range
Application type	-	Service hot water	
System configuration	-	With storage	
Building or load type	-	Hotel/Motel	
Number of units	Room	2	
Rate of occupancy	%	100%	50% to 100%
Estimated hot water use (at ~60 °C)	L/d	152	
Hot water use	L/d	152	
Desired water temperature	°C	40	
Days per week system is used	d	7	1 to 7
Cold water temperature	-	Auto	
Minimum	°C	21.8	1.0 to 10.0
Maximum	°C	23.1	5.0 to 15.0
Months SWH system in use	month	12.00	
Energy demand for months analysed	MWh	1.14	
	GJ	4.08	

Return to Energy Model sheet

RETScreen® Solar Resource and Heating Load Calculation - Solar Water Heating Project

Site Latitude and Collector Orientation		Estimate		Notes/Range
Nearest location for weather data		Tegucigalpa	Rooms	*See Weather Database*
Latitude of project location	°N	[illegible]		-90.0 to 90.0
Slope of solar collector	°	10.0	9-18 & 27-36	0.0 to 90.0
Azimuth of solar collector	°	0.0		0.0 to 180.0

Monthly Inputs

(Note: 1. Cells in grey are not used for energy calculations; 2. Revisit this table to check that all required inputs are filled if you change system type or solar collector type or pool type, or method for calculating cold water temperature).

Month	Fraction of month used (0 - 1)	Monthly average daily radiation on horizontal surface (kWh/m²/d)	Monthly average temperature (°C)	Monthly average relative humidity (%)	Monthly average wind speed (m/s)	Monthly average daily radiation in plane of solar collector (kWh/m²/d)
January	1.00	[illegible]	[illegible]	[illegible]	[illegible]	4.81
February	1.00	[illegible]	[illegible]	[illegible]	[illegible]	5.45
March	1.00	[illegible]	[illegible]	[illegible]	[illegible]	5.98
April	1.00	[illegible]	[illegible]	[illegible]	[illegible]	5.74
May	1.00	[illegible]	[illegible]	[illegible]	[illegible]	5.55
June	1.00	[illegible]	[illegible]	[illegible]	[illegible]	4.90
July	1.00	[illegible]	[illegible]	[illegible]	[illegible]	5.31
August	1.00	[illegible]	[illegible]	[illegible]	[illegible]	5.48
September	1.00	[illegible]	[illegible]	[illegible]	[illegible]	5.04
October	1.00	[illegible]	[illegible]	[illegible]	[illegible]	5.08
November	1.00	[illegible]	[illegible]	[illegible]	[illegible]	4.86
December	1.00	[illegible]	[illegible]	[illegible]	[illegible]	4.83

		Annual	Season of Use
Solar radiation (horizontal)	MWh/m²	1.89	1.89
Solar radiation (tilted surface)	MWh/m²	1.92	1.92
Average temperature	°C	22.5	22.5
Average wind speed	m/s	4.1	4.1

Water Heating Load Calculation		Estimate	Notes/Range
Application type	-	Service hot water	
System configuration	-	With storage	
Building or load type	-	Hotel/Motel	
Number of units	Room	20	
Rate of occupancy	%	100%	50% to 100%
Estimated hot water use (at ~60 °C)	L/d	1,516	
Hot water use	L/d	1,516	
Desired water temperature	°C	45	
Days per week system is used	d	7	1 to 7
Cold water temperature	-	Auto	
Minimum	°C	21.8	1.0 to 10.0
Maximum	°C	23.1	5.0 to 15.0
Months SWH system in use	month	12.00	
Energy demand for months analysed	MWh	14.56	
	GJ	52.40	

Return to Energy Model sheet

RETScreen® Energy Model - Solar Water Heating Project

Training & Support

Site Conditions		Estimate	Notes/Range
Project name		Centro Kellogg Rooms 9-18, 27-36	See Online Manual
Project location		Pan American Ag School	
Nearest location for weather data		Tegucigalpa	Complete SR&HL sheet
Annual solar radiation (tilted surface)	MWh/m²	1.92	
Annual average temperature	°C	22.5	-20.0 to 30.0
Annual average wind speed	m/s	4.1	
Desired load temperature	°C	45	
Hot water use	L/d	1,516	
Number of months analysed	month	12.00	
Energy demand for months analysed	MWh	14.56	

Rooms
9-18 & 27-36

System Characteristics		Estimate	Notes/Range
Application type		Service hot water (with storage)	
Base Case Water Heating System			
Heating fuel type	-	Electricity	
Water heating system seasonal efficiency	%	50%	50% to 190%
Solar Collector			
Collector type	-	Glazed	See Technical Note 1
Solar water heating collector manufacturer		Thermo Dynamics	See Product Database
Solar water heating collector model		G32	
Gross area of one collector	m²	2.96	1.00 to 5.00
Aperture area of one collector	m²	[illegible]	1.00 to 5.00
Fr (tau alpha) coefficient	-	[illegible]	0.50 to 0.90
Fr UL coefficient	(W/m²)/°C	[illegible]	1.50 to 8.00
Temperature coefficient for Fr UL	(W/(m·°C)²)	[illegible]	0.000 to 0.010
Suggested number of collectors		4	
Number of collectors		6	
Total gross collector area	m²	17.8	
Storage			
Ratio of storage capacity to coll. area	L/m²	70.0	37.5 to 100.0
Storage capacity	L	1,168	
Balance of System			
Heat exchanger/antifreeze protection	yes/no	No	
Suggested pipe diameter	mm	13	8 to 25 or PVC 35 to 50
Pipe diameter	mm	38	8 to 25 or PVC 35 to 50
Pumping power per collector area	W/m²	0	3 to 22, or 0
Piping and solar tank losses	%	1%	1% to 10%
Losses due to snow and/or dirt	%	3%	2% to 10%
Horz. dist. from mech. room to collector	m	5	5 to 20
# of floors from mech. room to collector	-	2	0 to 20

Annual Energy Production (12.00 months analysed)		Estimate	Notes/Range
SWH system capacity	kW_{th}	12	
	MW_{th}	0.012	
Pumping energy (electricity)	MWh	0.00	
Specific yield	kWh/m²	646	
System efficiency	%	34%	
Solar fraction	%	79%	
Renewable energy delivered	MWh	11.48	
	GJ	41.33	

Complete Cost Analysis sheet

LIST OF APPENDICES

APPENDIX 1

Course Outlines

and
required background training
for the

Energy Management
and
Solar Renewable Energy (Thermal and Photovoltaic) Courses

Course Outlines

The following are suggested course outlines. The development of the actual material will depend upon the background of the students and the time that has been allocated to the study of the subject.

Thermal Solar Course Outline

1. Solar Radiation
   - Effect of time, the day and latitude
   - Measuring, tables, using insolation data, and adjusting for tilted surfaces, penalty charts,
2. The Solar Module
   - glazed
   - unglazed
   - evacuated tube
   - efficiency curve and calculations using this curve
   - cold weather operation – the consequences of freezing
3. Thermosyphon Systems
   - theory of operation
4. Pumped Systems
   - theory of operation
5. Balance of System Components
   - heat exchangers
   - piping
   - pumps
   - controls
   - insulation
   - instrumentation
   - data loggers
6. Solar maintenance and operation checklists
7. Safety
8. Codes and Standards
9. The use of RETScreen™ computer program

PV Course Outline

1. Solar Radiation
   - Effect of time, the day and latitude
   - Measuring, tables, using insolation data, and adjusting for tilted surfaces, penalty charts,
2. Solar cells and modules
   - characteristic curve and calculations
3. Designing an array
4. Batteries

- types
- characteristics
- specifying batteries

5. Safety
6. Balance of system components
   - wiring, controllers, fuses, switches
   - instrumentation
   - data loggers
7. Types of Systems
   - direct coupled
   - basic dc system
   - standalone
8. Inverters
9. Grid connected systems
10. The use of RETScreen™ computer program

EM Course Outline

1. Energy basics
2. Understanding energy costs
3. A systematic approach to EM
4. Benchmarking
5. Monitoring and targeting and reporting
6. Instrumentation
7. Electrical demand
8. Understanding when
9. Understanding where
   - electrical
   - thermal
10. Waste loss analysis
11. Identification of electrical, thermal and waste losses
12. Optimization
13. Economics of EM
14. The human factor

Technical Level Required prior to Course Commencement

1. High School (grade 12)

   - <u>Plus</u>

2. Electrical Theory
   - DC circuits
   - AC circuits (single phase only)
   - Electrical devices (motors, fuses and breakers, lighting, etc)

3. Mechanical Theory
    - heat transfer
    - heat units
    - piping and pipe friction
    - types of piping; copper, pvc
    - piping components – valves, connections

APPENDIX 2

Equipment

for the

Renewable Energy Laboratory

Renewable Energy Laboratory Equipment

Thermal Equipment

1. Thermal solar panels
   a. Glazed
   b. Unglazed
2. Differential Temperature Controllers
   a. (2) - representing different types
3. Storage tanks
   a. Uninsulated
   b. Insulated
4. Heat exchanger
   a. Suitable for use with pumped solar system
5. Complete solar systems
   a. Thermosyhon
   b. Pumped
6. Instrumentation
   a. Thermometers stem type
   b. Petes plugs
   c. Flowmeters suitable for testing solar systems
   d. Thermal data logger
   e. Suitable test equipment for calibrating differential controllers

Photovoltaic Equipment

1. Photovoltaic Modules
   a. Amorphorous -50W and 10 W
   b. Wafer - 50W and 10 W
2. Batteries
3. Charge Controllers
4. Inverters
5. Instrumentation
   a. Voltmeters
   b. Ammeters - DC clip on and insertion type
   c. Watt-hour meters
   d. Data loggers