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Evaluation report LECO Energy Management System

LECO

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Abstract

This report provides a reflection of the research done on the comparison between the Lankan Electricity Companies (LECO) current Energy Management System (EnMS) and the system as described by the ISO 50001 standard on energy management. It was found that LECO is running a well functioning management system to monitor and control electricity losses in their distribution network, although the system has some shortcomings. The company is furthermore aware of these shortcomings and is working to fix them. Key difference with the ISO 50001 standard was the lack of central organization within the system and the absence of a general company policy on energy efficiency. It is suggested that fixing these 2 issues would provide the starting point from which the company could then adjust a number of smaller issues to make their EnMS ISO 50001 certifiable. A key question that is raised and left open is if the company would wish to expand the scope and boundaries of their EnMS to include other aspects of company operations.

Keywords: Energy Management System - ISO 50001 – Electricity Distribution Network – Loss control

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1. Introducing the problem

1.1. Problem introduction

The Sri Lanka electricity market consists of two major companies and a number of privately owned small scale electricity producers. The first big company is the Ceylon Electricity Board (CEB). This company has control over approximately 60% of the electrical production capacity, producing 6500 GWh and covering most of the country with its distribution network. 40% of the power is produced by private parties who sell their power directly to CEB. The second large company is the Lanka Electricity Company (LECO). LECO is a distribution utility, operating in the south western coastal region of Sri Lanka. LECO has a customer base of 484.000 accounts. Annually LECO procures approximately 1300GWh from CEB through 33kV/11kV primary substations. (1)

The main business of LECO is buying electricity from CEB and selling it to their customers. LECO reports a difference of about 5 % between the amount of kWh of electricity they buy from CEB and the amount they sell to their customers. In absolute numbers this amounts to an annual loss of 65 GWh in the transmission system. Considering that LECO pays an average of Rs. 12 per kWh, this amounts to a financial loss of Rs. 780 million or approximately 4,64 million euro each year (2).

Technical loss during transmission of electricity is unavoidable, but every possible action should be taken to keep this loss to a minimum. To this end the company has a loss management system in place using an extensive measurement and monitoring system. The current system has been in place since 1993.

In 2011 the International Organization for Standardization (ISO) published a new standard, ISO 50001. This standard pertains specifically to implementing and maintaining an Energy Management System (EnMS) for companies. LECO has asked me to evaluate their current EnMS and compare it to the system as described by the ISO 50001 standard. Result of the study should include a report on the gaps between the current EnMS system and the ISO 50001 requirements. This report should also include recommendations on how to close these gaps, in order to attain ISO certification.

1.2. Problem approach

The first step in the process is to determine the current workings of LECO, along with a description of the distribution network. This will be done by making a study of company documents, manuals and records. This investigation will be supplemented with discussions with LECO personnel and visits to different company offices. Once the company organization has been understood, a description of the current Energy Management System will be given.

The second part of the process will focus on an evaluation of the strong points and weaknesses in the current EnMS system. An analysis of the merits of the system will be based on a comparison between the system in place and current best-practice guides on energy management, as well as study materials provided by the United Nations Industrial Development Organization (UNIDO) on energy loss management. This strength and weakness analysis will be concluded with a gap analysis between the current EnMS and the system as described by the ISO 50001 standard.

The final part of the process will focus attention on action plans to close the gap between the EnMS and the ISO 50001. Focus will be on the general approach to closing the gaps, leaving the drafting of detailed action plans to the company itself.

1.3. Report structure

Chapter 2 will give a general introduction to the concept of energy management and introduce the International Organization of Standardization (ISO) and the ISO 50001 standard. LECO’s Energy Management System (EnMS) will be described in chapter 3 of the report. Chapter 4 will present the gap analysis between LECO’s EnMS and the system as described by ISO 50001. Furthermore, this chapter will provide a number of steps to close the gap between the two systems and ensure that LECO’s EnMS conforms to the requirements as stated by the standard. At the end of this report the main points of the research will be summarized and a number of recommendations will be given for future projects and areas of research for the company.

2. ISO 50001 and Energy management systems

2.1. An introduction to energy management

Throughout history energy has always been one of the driving forces for human progress and development. Sources of energy have included human and animal labor, wind and water power and the burning of bio-fuels for heating and lighting. In recent centuries, energy production has become an increasingly specialized field requiring technical training, especially with the introduction of electricity and the development of all manner of high efficiency turbines and engines (3).

Due to the increasingly complicated nature of energy acquisition and application, the cost of energy within companies is often regarded as a fixed cost, necessary in order to execute the actual business of the company. Efficient use of energy is therefore considered as beyond the scope of company policies. Whenever control of energy consumption is practiced this is usually delegated to the engineering department and not executed as part of the company business. Energy control therefore happens on an “Ad hoc” basis leading to suboptimal results.

Recent years have shown a rapidly changing attitude towards this subject. Climate change has taken up an increasingly important position on the global agenda. Another development is the increasing cost of energy. These factors have influenced companies to rethink there approach to energy management. It is slowly being realized that a systematic approach to energy management within a company could significantly reduce energy consumption and therefore decrease company costs. Companies implementing systematic energy control have achieved annual savings ranging from a couple of 100 dollars, up to savings of well over a million dollars (4).

Plan-Do-Check-Act

Most energy management schemes are based on the plan-do-check-act quality management system as introduced by Dr. W. Eduards Deming around 1950 (5). This system describes an iterative cycle, aimed at continual improvement of a process or a product. Results of the first walkthrough of the cycle are used to formulate new plans for the next cycle, while results of each action are constantly verified. This leads to a systematic approach for product or process development.

Figure 1 - The Deming cycle

Plan
In this phase targets and objectives are established. Furthermore action plans are drafted to accomplish these goals. Results of the planning phase are all documented in order to verify results in later stages.

Do
The action plans are carried out and results are measured and collected. Data collection in this phase is important for the Check and Act steps.

Check
Results from the Do phase are analyzed and compared to the expected results, as formulated in the plan phase. It should also be checked if execution of the action plans was done in accordance to the way in which the activity was planned.

Act
Deviations to the expected results should be analyzed and the causes underlying these differences should be identified. Result of this step should be recommendations and data that can be used as input for the next planning step, when the cycle starts over.

These four steps seem fairly obvious. In practice however correct execution of these four steps is rarer then one might suspect. Entrepreneurs are often men of action focusing on planning and execution of action plans. Experience has shown that in some cases, company activities are mainly focused on these two steps, and fail to follow through on the checking of results and taking actions to prevent derivations between actual and expected results.

Other scenarios include companies that start an energy management program due to high energy loss. After a number of successfully executed action plans that bring down energy consumption, the company thinks that it is done with energy management. Without continued monitoring however energy consumption soon increases again, giving cause for a new set action plans. This is illustrated in Figure 2.

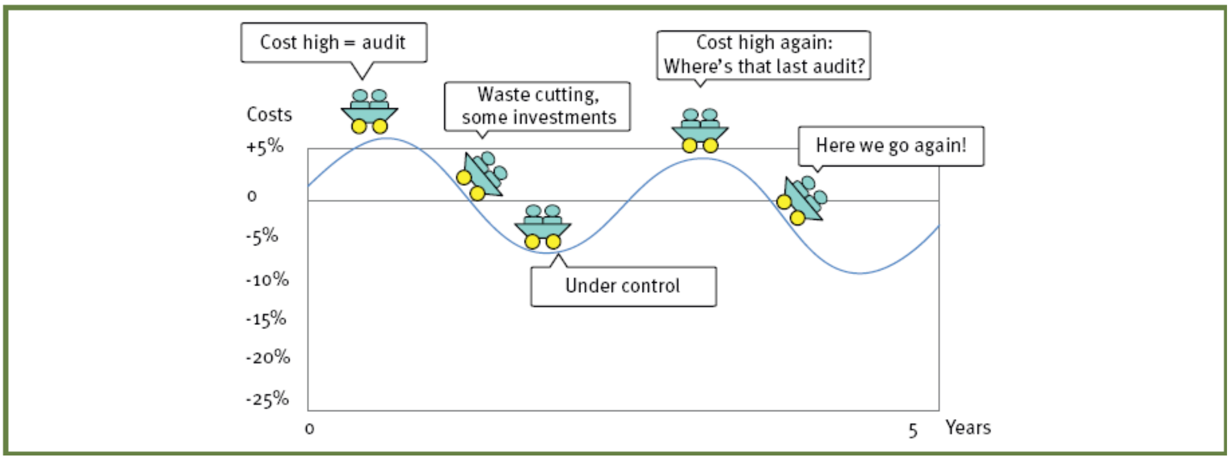

FIGURE 2 - RESULTS OF AD-HOC ENERGY MANAGEMENT

Adopting a systematic approach to energy management and repeatedly following the cycle will lead to continued improvement in energy performance. By being constantly vigilant on the topic of energy, permanent energy savings can be achieved. This structural approach is the core idea behind a sound energy management system.

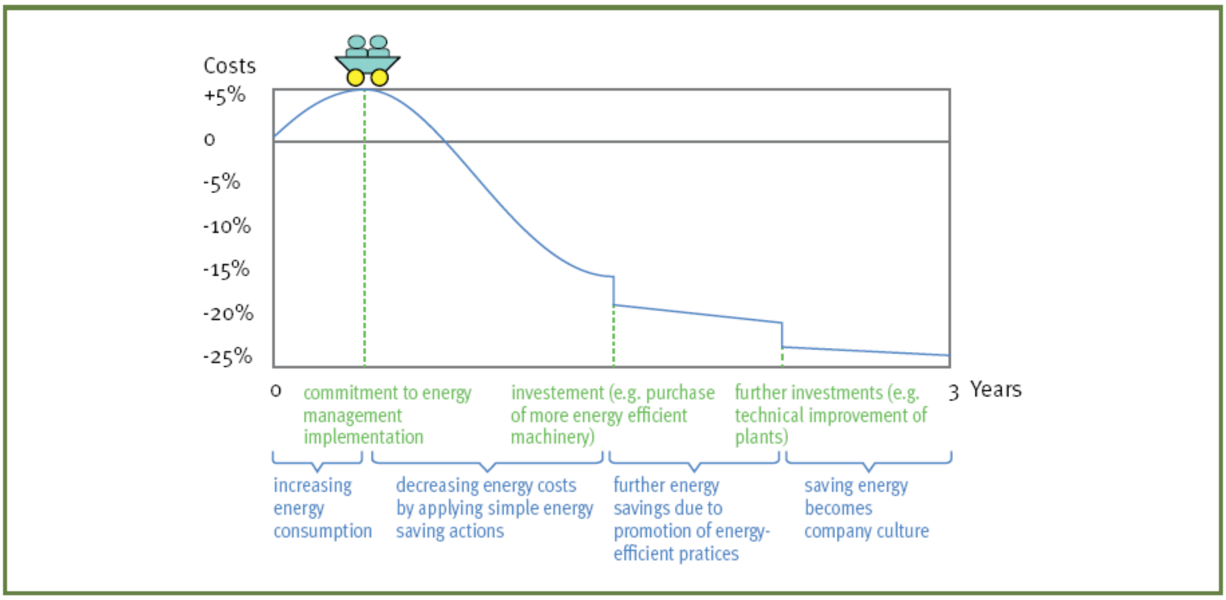

FIGURE 3 - RESULTS OF A STRUCTURAL APPROACH TO ENERGY MANAGEMENT

2.2. Short introduction to ISO

The international organization of standardization finds it origin in London in 1946 (6). Representatives of 25 countries decide to set up the organization in order to; “facilitate the international coordination and unification of industrial standards”. In February 1947 the new organization, ISO, officially began operations.

An ISO standard is defined as followed; ” A standard is a document that provides requirements, specifications, guidelines or characteristics that can be used consistently to ensure that materials, products, processes and services are fit for their purpose.”

Currently ISO has a portfolio of over 18.600 standards, in topics ranging from management to food safety regulations to quality control for any number of products (3). ISO standards can ensure that products and services are safe, reliable and of good quality. Furthermore, ISO standards may supply businesses with the proper toolset to create a smooth running company, cutting down on cost and waste, by providing best-practice guides for any number of industries.

ISO standards can be used in two ways. The fist method is by using ISO standards as a means to operate a healthy company. This is done by applying the standards as a best practice guide on for instance, quality control or management practices. The second way in which an ISO standard may be applied is by getting a product or company officially certified. By obtaining an official certification, companies can prove to their clients and other interested parties that they provide quality products, or act in an environmentally responsible way.

The ISO organization is only responsible for the development of the standards. Official certification for a product or process is performed by external certification bodies, mostly private companies. When obtaining official certification it is therefore also important to hire a reputable certification body. The ISO certificate may be only as valuable as the reputation of the company that provided it.

2.3. ISO 50001

2.3.1. General

The ISO 50001 standard was written in order to enable organizations to establish an energy management system to improve energy performance in areas including energy efficiency and consumption (7). The standard was launched in 2011, after a growing market trend showed that more and more companies had a need for good energy management policies. The standard was written using common elements from existing ISO standards, mainly ISO 9001 on quality management and ISO 14001 on environmental management systems. The implementation of the standard is intended to lead to reduction in greenhouse gas emissions and related environmental impacts, and to minimize energy cost for a company.

Although the ISO 50001 standard consists of a large number of requirements, the standard does not set down quantifiable targets that need to be achieved on energy performance. Rather, the standard states that these targets should be set by the companies that decide to implement the standard for themselves. In this way, the standard focuses more on the process of energy management and not on the end result. It provides a good way to achieve targets without forcing specific targets on companies. In this way, companies can themselves decide what kinds of targets are appropriate, making the standard accessible for any kind of industry.

2.3.2. A BREAKDOWN OF THE STANDARD

The standard consists of a number of chapters explaining the different aspects of the standard. The actual requirements, by which a company's EnMS is checked on compliance, are confined to chapter 4 of the standard. The requirements are divided into 7 paragraphs, each describing a specific part of the standard. The first three paragraphs focus on the boundary conditions that are necessary for a well functioning EnMS. The final four sections correlate to the four steps of the Deming cycle; Plan – Do – Check – Act.

GENERAL REQUIREMENTS

This part simply sets the stage for the companies EnMS. The company must decide where the focus of the EnMS will come to lie. Will the entire company be involved or will the company focus on energy use in a specific area, a production line for instance? This section provides the organization with flexibility on how an EnMS might best suit the company's needs.

MANAGEMENT RESPONSIBILITY

This section focuses on management commitment and organization. If top management is not committed to energy savings, then the EnMS will most likely fail. In terms of commitment, top management is required to make visual statements to their ambition. In terms of organization, requirements are made on how the responsibility of energy management is organized within a company.

ENERGY POLICY

The standard requires that the company shall state its commitment to achieving energy performance improvements in an official energy policy. This section describes the requirements that this policy should adhere to.

ENERGY PLANNING

This section covers the first step of the Deming cycle, the planning phase. The section covers the acquisition of relevant data to energy management, such as legal requirements and consumption patterns, as well as setting out targets and action plans based on this data. If consumption data is not available, one of the first action plans might include methods by which this data might be obtained, for instance by installing new meters. The section also describes how all the performed actions in this phase should be documented and recorded.

IMPLEMENTATION AND OPERATION

This section sets requirements for the execution of the action plans. The first sections pertain to in-house communication and adequate training of personnel performing tasks related to energy management. This is done to insure that the quality of work is maintained. The largest part of the section pertains to documentation of the processes and action plans that are (to be) carried out. This is done to make sure that achieved results are verifiable. This section has a large overlap with for instance ISO 9001 on control of quality management processes.

CHECKING

This section requires that the organizations shall implement processes by which results may be verified. This section overlaps the Check and Act phase of the Deming cycle since the paragraph also sets our requirements for responding to non-conformities as discovered in the Check phase.

Management review

This phase covers the Act phase in the Deming cycle and creates a loop back to the planning cycle by means of the EnMS audit. By this process all results of the previous sections may be used as inputs, in order to amend the energy policy, alter the EnMS or draft up new action plans. Thus the cycle is closed, ensuring that an Energy Management System is created that is continually improved upon. The complete cycle on which the standard is based can be seen in Figure 4.

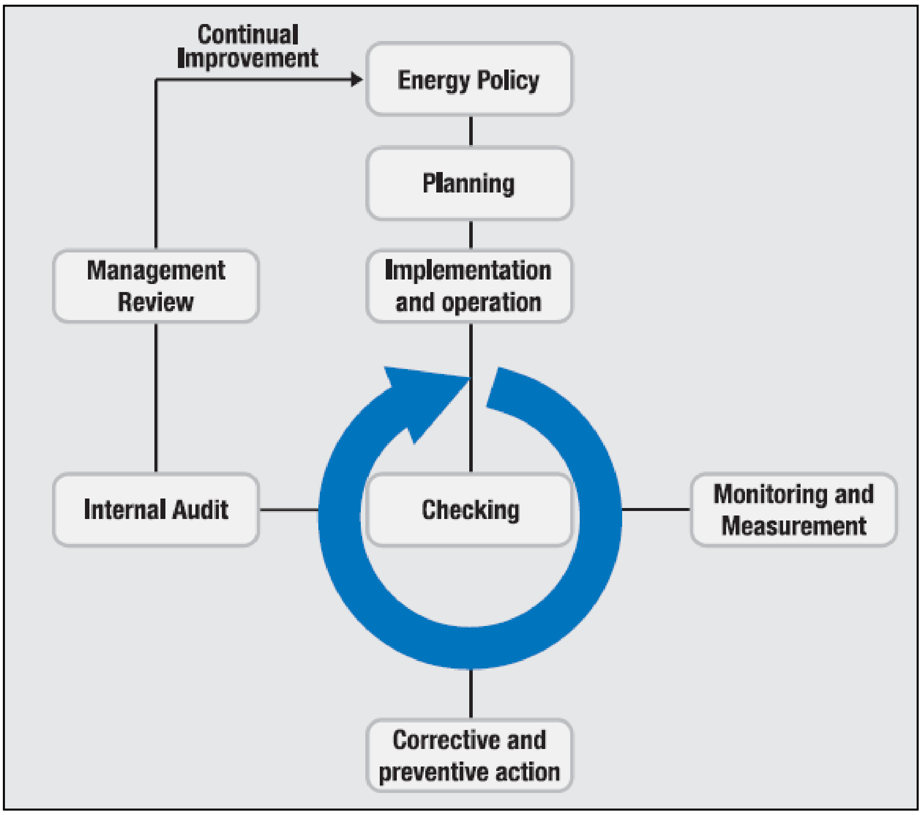

Figure 4 - Energy management system model for the ISO 50001 standard

3. LECO'S ENERGY MANAGEMENT SYSTEM

3.1. ORGANIZATION OF THE LANKA ELECTRICITY COMPANY

The Lanka Electricity Company (LECO) was first incorporated in 1983, by acquiring and combining local assets for electrical power distribution. The goal was to set up competing distribution companies to stimulate higher efficiency within the distribution market. The incorporation of LECO was part of the long term goal to privatize the entire electricity market. This objective has of yet not been achieved, leaving LECO and CEB as the only companies operating distribution networks in Sri Lanka at the moment.

LECO provides electricity to seven geographical areas along the southwest coast of Sri Lanka. Some of these areas are adjacent to each other while other areas are surrounded by areas where CEB provides power. LECO receives electricity from CEB through a number of primary substations at 11kV. These 11kV lines transport the power throughout a specific area. Individual consumers in each area are connected to 230 V power lines. Groups of consumers are all attached to distribution substations which in turn are fed by the aforementioned 11 kV lines.

LECO has 7 branch offices, each in charge of administering to their own geographical area. Each area is then further divided into sections, each section with its own customer service center. Customer Service Centers (CSC) are in charge of maintenance of the grid in their section and responsible for collecting monthly metering data from their customers. The collected data is sent to the branch office where the data is processed and recorded. CSC's only perform infield activities and have no administrative department of their own.

Each branch office is staffed with a financial department, administration department and an engineering department. Branch offices run fully independent and are responsible for running the company business and maintaining the company assets in their respective areas. Branch offices send monthly reports to the LECO head office.

The head office is responsible for creating and upholding of company policies and setting out guidelines on how to operate the company. The head office has its own financial department, administrative department and engineering facilities. Engineering facilities include a research and development department for continued improvement of the distribution network. Design and control of the power grid is also run from the head office, delegating visual inspection and maintenance to the branch offices and customer service centers. Company policy, targets, objectives and action plans are also set out by the head office.

3.2. SCOPE AND BOUNDARY OF THE ENMS

A loss of 65GWh is an enormous amount of electricity. For comparison, LECO's own electricity consumption, of all its buildings and facilities combined, is estimated to be between 2 and 3 GWh. LECO has therefore specifically designed its energy management system to manage the power loss in its distribution system. The boundaries of the system are defined as starting at the point where power is bought from CEB and ends at the point from where power is billed to the customers.

The distribution network of LECO is equipped with a large number of electricity meters and control switches. In order to get a complete overview of the electricity consumption and losses, it is important to obtain meter readings and interpret the data in a correct way. The Energy Management System is therefore a combination of available hardware and an adequate organization, to obtain and process the data. Losses within the distribution system are defined as kWh that are bought from CEB but cannot be billed to a customer.

3.3. Distribution network hardware

Power is provide to the LECO network by CEB at 11 kV through a number of Primary Substations (PSS). The 11kV network is interconnected, so that if a single PSS fails, power flow can be rerouted through another PSS. Multiple distribution transformers are attached to the 11kV lines. These distribution transformers convert 11kV to 230 V for individual households. Each distribution transformer services approximately 200 to 300 individual customers. The transformer furthermore provides a line out for street lighting in that area.

Power flow meters can be found at a number of locations. PSS's are all equipped with power flow meters. The amount of power bought from CEB is based on these meter readings. Individual distribution substations are also equipped with meters. Whenever power flow crosses the boundary between the territories of CSC's, this is also metered. Each account (household) has their own power flow meter. Street lighting lines do not have a separate meter. Assuming a perfect no-loss system, the distribution transformer readings should equal the household meter readings plus the amount of power consumed by street lighting. There is however no meter to verify this.

3.4. EnMS methods for data collection

All the meters built into the system lack the option of remote metering and thus have to be checked manually. This requires a well thought out organization and a fairly large amount of data processing capacity. Reading of the meters is mostly delegated to the CSC's while all data processing happens in the branch offices. One of the biggest problems concerning loss analysis, is that it is impossible to obtain all meter readings simultaneously, or even in a single week. Total loss figures are therefore always based on extrapolation of obtained readings and never on the precise figures.

Street light data

As mentioned, there is no separate meter to measure power consumption of street lighting. The amount of power consumed by street lighting is currently estimated as follows. Streetlights are grouped according to which distribution transformer they are connected to. The wattage for each individual streetlight is registered and this register is updated regularly. It has been agreed with the operators of the streetlights, the municipalities, that they shall be switched on from 6 PM to 6 AM. Based on the agreed upon burning time and lamp wattage, the amount of power theoretically consumed is calculated.

Single distribution transformer losses

Customer meters have to be checked monthly in order to insure proper billing of consumption. This process is referred to as the monthly billing cycle. Customers are grouped according to the distribution transformer that they are connected to. A billing officer can check a single group of customers within 3 days. On one of these days the officer will also check the distribution transformer meter. The meter data is sent to the branch office for processing, along with the dates on which individual customers and transformers were checked. The branch office can then produce a report on the losses that occur between the distribution transformers and the customers. Streetlight data is also included in these calculations. The monthly results are combined into a distribution transformer loss report, containing data for every transformer in the branch area.

CSC area losses

Measuring the losses that occur in the 11kV network of a single CSC is somewhat less accurate. The primary substation meters are measured monthly by CEB and reported to LECO. The meters measuring power flow between different CSC areas are also checked monthly. As has been described above, power flow through individual distribution transformers is measured throughout the entire month. This implies that a large amount of data extrapolation is needed to obtain the loss figures over the 11kV network. These extrapolations and other data processing activities are done by branch office personnel. The amount of required data extrapolation activities lead to overall loss figures that are more an indication than precise results. As a consequence, it may happen that sales in a certain month will be higher than the amount of electricity bought from CEB, leading to positive loss figures.

Loss data reporting
Branch offices publish a monthly energy management report on the activities within their district. These reports include the individual transformer loss data, the most recent streetlight data and overall loss measurements. Overall loss is reported to head office, while the transformer loss report is used by the branch office and CSC's to plan loss control activities.

3.5. Losses in the distribution system

The company has determined that measured losses can be ascribed to a number of factors. Different loss reduction activities have been designed to target one or more of these loss factors. It should be noted again that actual losses are defined as the difference between the amount of power coming in to the system at the Primary Substations and what is billed to the customers. Taking this into account, any measured losses in the system can be divided into two categories. Some losses represent an actual difference between the amount of power bought and sold. Other measured losses only contribute to an incomplete overview of the actual losses, thus making effective and targeted loss control more difficult. This category will be called apparent loss.

Technical losses

Technical losses are unavoidable in an electrical system. Excessive technical losses are kept low by keeping the entire distribution network in a well maintained condition and quickly replacing faulty and high loss equipment when detected. These losses contribute exclusively to the actual power loss. The following loss categories in the distribution network have been identified by LECO:

1. Load losses (I^2r) in feeders, and transformers
2. Magnetic and core losses in transformers
3. Corona losses due to high voltage stresses on overhead lines
4. Losses at joints due to poor workmanship
5. Cable sheath losses
6. Leakage currents
7. Unbalanced loading of the 3 phases in feeders (losses are minimum when the 3 phases are balanced).

Streetlight losses

These losses are very hard to estimate, due to the current measurement system. The first problem is that LECO does not control the on and off switch of the lighting. This means that lights could be turned on/off earlier or later then the agreed upon time. This immediately leads to deviations in estimated and actual power consumption. Secondly, lights might break and be replaced by lamps of a different wattage. This also leads to deviations between estimated and actual consumption. This category exclusively influences actual loss.

Faulty metering

Faulty metering mostly occurs at individual customer level and at distribution transformer levels. At distribution transformer level this leads to incomplete loss data and thus an apparent power loss. At customer level this leads to actual power loss, since consumed power cannot be accounted, and thus billed for.

THEFT

Individuals may install illegal connections to the system to obtain free electricity. Other means of theft is by tampering with the consumer meters. This category falls under actual power loss.

INCORRECT GROUPING

High losses from a single distribution transformer may occur when certain houses are registered as being attached to a certain transformer, while they receive power through a different transformer. This does not lead to an overall loss, since the power still gets billed to the customer. It does however lead to incorrect loss data, since it will seem as if one transformer is performing at a high efficiency while a higher loss is measured for the adjacent transformer. This factor contributes exclusively to apparent power loss.

EXTRAPOLATION ERRORS

As mentioned in the previous paragraph, a large amount of the loss data is acquired by means of data extrapolation. This process does not lead to actual power loss, because this process does not influence the amount of power bought from CEB versus the amount of power that is sold to individual consumers. The extrapolation process does however heavily influence the loss data, making it harder to detect actual losses in the system. This factor contributes exclusively to apparent power loss.

3.6. EnMS LOSS CONTROL ACTIVITIES

The previous paragraph divides losses, in to apparent losses and actual system losses. Company policy should be heavily focused on reducing actual losses within the system since these losses lead to a decrease in profitability. Efficiently targeting these losses is difficult however, if appropriate loss data is not available. Considerable effort is therefore also invested in decreasing the apparent losses in the system, thus making actual losses more visible. Reduction of apparent losses is therefore the same as improvement of loss data. The company has a number of regular procedures in place to keep losses under control. The company has furthermore launched a number of (pilot) projects specifically targeting certain loss factors within the distribution system. Past projects include the introduction of the EnMS and other design activities to keep the network modern and well maintained. The current project is focused on improving street light data.

3.6.1. EnMS LOSS CONTROL REGULAR PROCEDURES

Regular procedures within the company are well documented and explained. These documents can be found in the various company procedure manuals. This section will cover the procedures that have been specifically linked to loss management activities. References will be made to the accompanying company procedure documents and manuals.

REVENUE MANAGEMENT PROCESS – BILLING

As mentioned earlier, collecting metering data is an important part of the loss measurement activities. However, the billing procedure covers a lot more than just reading customer meters. The procedure involves checking streetlight data, performing visual inspection of the distribution lines and reporting on any problems found in the system. This process thus influences a whole range of loss categories. Technical losses are kept down by routine inspection of the distribution system, making maintenance work more effective. Street light consumption and loss data is more accurate due to regular update of the streetlight data. Theft might be discouraged by observing illegal connections. Faulty metering is reported immediately when observed. And finally, correct metering procedures insure that the acquired data can be better processed, leading to a better overview of consumption and losses. Observing the right metering moments leads to better results when extrapolating data.

Process Manual		Contributes to	
DOC. NO.	LECO-PM-01	**Loss data collection**	**X**
SEC. NO.	KP1/CSC/03	**Improvement on loss data**	**X**
		Reduction of actual loss	indirect

Bulk Revenue Billing process

This process does not have a big influence on loss control, but is nevertheless relevant because it provides additional consumption data, necessary to analyze the entire system. The process describes the operations to collect meter readings from LECO's bulk customers, like factories.

Process Manual		Contributes to	
DOC. NO.	LECO-PM-01	**Loss data collection**	**X**
SEC. NO.	KP2/BR/ENG/01	**Improvement on loss data**	
		Reduction of actual loss	

Routine maintenance process

CSC's draft new maintenance schedules each month to fix all reported system discrepancies and keep the distribution network well maintained. In terms of loss management these activities lead to a decrease in actual losses, by maintaining an efficient distribution system with low technical losses. By replacing defective metering in distribution transformers regular maintenance also contributes to better and more complete loss data.

Process Manual		Contributes to	
DOC. NO.	LECO-PM-01	**Loss data collection**	
SEC. NO.	KP1/CSC/01	**Improvement on loss data**	**X**
		Reduction of actual loss	**X**

Loss Reduction Activity Process (Branch office level)

Staff at the branch offices collect the meter readings and compile the monthly consumption and loss reports. Reports are written for both the CSC's and the head office. Correct execution of this process ensures a correct representation of the loss data. This process only influences the apparent loss and has no influence on actual losses. Correct data is however very important in order to effectively target actual losses.

Process Manual		Contributes to	
DOC. NO.	LECO-PM-01	**Loss data collection**	**X**
SEC. NO.	SP2/BR/ENG/02	**Improvement on loss data**	**X**
		Reduction of actual loss	

Loss Reduction Activity Process (CSC level)

The loss reports from the branch office form the basis for this final loss reduction process. The branch office publishes a monthly list of losses per distribution transformer. Each month each CSC picks a single high-loss transformer to perform a complete audit on. Audits include checking if metering is correct, and close inspection of the distribution system and individual meters to check for tampering, Streetlight data is completely updated and grouping of the system is checked. This process is designed to target all the loss possibilities and to bring the transformer loss back to acceptable levels. Systematically targeting high loss transformers insures that the overall loss average of the distribution network is kept to a minimum.

Process Manual		Contributes to	
DOC. NO.	LECO-PM-01	**Loss data collection**	**X**
SEC. NO.	SP1/CSC/01	**Improvement on loss data**	**X**
		Reduction of actual loss	**X**

3.6.2. Loss control, targeted activities

LECO has a number of current projects specifically designed to target losses. Although the company does not officially describe these projects within the framework of the EnMS, these projects are nevertheless relevant.

Streetlight project

LECO is currently working on a pilot project to explore the possibilities of bringing street lighting under LECO control. This is however only happening in specific municipality areas as a general governmental policy on this issue is lacking. Bringing street lighting under control would significantly improve loss reporting and reduce actual losses.

Contributes to	
Loss data collection	
Improvement on loss data	**X**
Reduction of actual loss	**X**

4. Gap analysis EnMS

This chapter will provide an analysis of the gaps between the current EnMS as operated by LECO and the standard as provided by ISO 50001. The first paragraph will provide some general remarks regarding the application of the ISO standard to a company like LECO. The second paragraph will give a short summary of the gaps between the ISO standard and the LECO EnMS. An extensive comparison between the two systems has been enclosed in Appendix I. The final paragraph will provide an approach to closing the gaps between the current EnMS and the ISO 50001 system.

A point of importance is that LECO is currently going through the process of becoming ISO 9001-2008 certified. Due to this, the company has recently invested a huge amount of effort on updating all their instruction manuals and procedure descriptions. ISO 50001 has been modeled after the 9001 standard and follows similar guidelines where it comes to documentation and recordkeeping. This will be of great advantage to the company when they will go for ISO 50001 certification and is indeed part of the reason that compliance to the standard is already at a very high level.

4.1. Applying ISO 50001 to a utility company

Applying the ISO 50001 standard to a utility company poses some interesting dilemmas. Originally the standard was created for industries that use energy to produce other products or provide other services. For those companies, energy is always a means to an end and might therefore be of less importance then the end product. A typical approach to energy efficiency for these companies would be to firstly measure how much energy is needed to produce a certain amount of products. The second step would then be to keep the amount of energy needed per produced product as low as possible. A simple representation of energy efficiency would be kWh/Product.

In the case of a utility company, the situation becomes a bit different since the main product of the company is electricity. Translating the previous scenario to LECO, one would try to minimize the amount of electricity needed by LECO, to distribute a certain amount of electricity. An overly simple example would be to calculate how much energy all the LECO offices and holdings would consume, and divide this by the amount of electricity the company sells, this being their product. A simple representation of energy efficiency for LECO could then be expressed as kWh consumed by LECO per GWh sold to customers.

In practice this turns out to be a rather useless figure for a number of reasons. The first reason is that benchmarking of this figure is extremely difficult. There is no comparative data on how much energy it should take to organize the logistics of distributing energy. It would make more sense to compare LECO offices to regular offices and try to achieve high efficiency in this well documented area. The second reason that this exertion is not of much interest is due to the quantity of electricity that is involved. It has been estimated that LECO consumes between 2-3 GWh annually, while distributing 1300 GWh. The reported losses on the distribution lines, of 65GWh, are several times larger than the entire electricity consumption of LECO. This makes focusing the EnMS on the distribution network the far more logical scenario.

It has been suggested that LECO might adopt an EnMS for the entire company, approaching the operation as a regular office building would. In this way LECO might set an example towards the customers it provides electricity to and the public in general.

4.2. Gap analysis EnMS versus the ISO 50001 standard

The only part on which a company can be audited for compliance to the ISO 50001 standard is described in chapter 4 of the standard. The certification company DQS UL provides a practitioners guide to implementing the standard in a company (3). Chapter 11 of their guide provides a list of actions that should be taken in order to comply by the standard. This complete list of actions can be found Appendix I. This list has been used as a check list for LECO and the results have been added in the table. In case of compliance, an explanation has been given and a reference to proof of compliance has been provided. A summary of the gap analysis will be presented in this paragraph, making use of the form in which the ISO standard has been written.

General requirements (ISO section 4.1)

LECO is close to fulfilling the general requirements. The current EnMS is working well. Expanding this system to close the last remaining gaps with the ISO 50001 standard will ensure complete compliance with the stated requirements.

Management responsibility (ISO section 4.2)

In terms of commitment LECO complies with the standard. In terms of organization some changes will have to be made. Two main gaps have been identified in this section. The first main gap is that the company lacks an official energy policy, stating the commitment of the company to energy savings and defining responsibilities in this area. The second gap is that although energy saving activities are organized, the ISO standard demands a more concentrated and focused approach towards energy management. LECO’s EnMS is currently completely integrated into the company but lacks a central point of control. Appointing an official energy manger and reorganizing the way in which the EnMS is managed should close this gap.

Energy policy (ISO section 4.3)

As stated in the previous section, the company lacks an official energy policy. This gap is the most obvious one in the entire system but also the one that is the most easily remedied.

Energy planning (ISO section 4.4)

Since LECO is a utility company, planning for energy efficiency is part of the main business of the company. Since the scope and boundaries of the EnMS have been limited to the distribution network, nearly all company planning activities are aimed at distributing energy as efficiently as possible.

A slight gap might be that that action plans are not reviewed on a regular basis. Furthermore, action plans should be consistent with the energy policy. The policy does however not exist.

Implementation and operation (ISO section 4.5)

General operations and procedures are well documented and implemented. However, there exist no procedures on how the current EnMS could be changed or updated. This is due to a lack of a general description of the EnMS. Energy management is so ingrained in the company that it is not viewed as an EnMS, it is just part of day to day operations. By drafting an energy policy and making a description of the EnMS, the company may also introduce ways in which to change procedures within the EnMS when necessary.

On a separate note, the company should decide whether or not to communicate their EnMS externally.

Checking (ISO section 4.6)

This section has overlap with the section “Implementation and operation. The process to control losses within the distribution network all well developed and documented. There is however a large gap when it comes to evaluation of the EnMS itself. Although projects are regularly initiated to improve loss control, procedures to evaluate the core EnMS structure are not in existence.

Due to the recent effort to become ISO 9001-2008 certified, any procedures that currently exist are well documented and results are recorded.

Management review (ISO section 4.7)

In the same way that there is no official energy policy or means of evaluating the EnMS, there is also no method for conducting a management review of energy management operations.

4.3. Suggested plan for obtaining conformity to the ISO standard

Based on the checklist that can be found in Appendix I, a number of actions are required before LECO's EnMS becomes eligible for ISO certification. This paragraph will attempt to set out a number of steps by which conformation to the standard may be achieved. It is suggested that the steps are executed in the order by which they are presented here, although deviations to the order should not provide any difficulty and a number of steps can be taken simultaneously. The five main actions that need to be done are:

1. Draft an Energy Policy;
2. Appoint an energy manager and create an energy management team to centralize efforts;
3. Create an EnMS description and implement EnMS core documents;
4. Develop standard procedures for auditing/improvement of the EnMS
5. Develop standard procedures for management reviews;

4.3.1. Drafting an energy policy

The first step that the company should do is draft an official energy policy. Doing so will cover an enormous amount of the gaps still existent between the ISO standard and the current EnMS. More than that, the official energy policy will provide a good foundation, a starting point, from where the other gaps may be closed. There are a number of best practice guides describing the development of a policy (8). Using a guide as template, for instance the one referred to in the bibliography, will ensure that all the requirements of the ISO standard are met. The specific requirements in the ISO standard referring to an energy policy are listed below.

Management responsibility (section 4.2.1 of the ISO standard)

Top management shall demonstrate its commitment to support the EnMS and to continually improve its effectiveness by:

a. Defining, establishing, implementing an maintaining an energy policy;
b. Appointing management representative and approving the formation of an energy management team;
c. Providing the resources needed to establish, implement maintain and improve the EnMS and the resulting energy performance;
d. Identify the scope and boundaries to be addressed by the EnMS;
e. Communicating the importance of energy management within the organization;
f. Ensuring that energy objectives and targets are established;

g. Ensuring that EnPI’s are appropriate to the organization; considering energy performance in long-term planning;
h. ensuring that results are measured and reported at determined intervals;
i. conducting management reviews;

Energy policy (Section 4.3 of the ISO standard)

The energy policy shall state the organizations commitment to achieving energy performance improvement. Top management shall define the energy policy and ensure that it:

a. is appropriate to the nature and scale of the organizations energy use and consumption;
b. includes commitment to continual improvement in energy performance;
c. includes a commitment to ensure the availability of information and of necessary resources to achieve objectives and targets;
d. includes a commitment to comply with applicable legal requirements and other requirements to which the organization subscribes related to its energy use, consumption and efficiency;
e. provides the framework for setting and reviewing energy objectives and targets;
f. Supports the purchase of energy efficient products and services. And design for energy performance improvement;
g. is documented and communicated at all levels within the organization;
h. Is regularly reviewed and updates as necessary;

4.3.2. Appoint an energy manager and create an energy management team

Although energy management and control is well delegated to the branch offices and customer service centers, the company currently lacks a central person or committee responsible for energy management. Rather, the responsibility is now divided among a number of managers at the head office. The head of Engineering and the operations manager are both responsible for certain aspects of the EnMS but someone chiefly responsible for the EnMS as a whole has not been identified.

Along with the drafting of the policy a management representative, chiefly responsible for the EnMS, should be appointed. This energy manager should be supported by a number of staff members at the head office. The requirements for the energy management representative according to the ISO standard are as followed;

Management representative (Section 4.4.2 of the ISO standard)

Top management shall appoint a management representative(s) with appropriate skills and competence, who, irrespective of other responsibilities, has the responsibility and authority to:

a. Ensure the EnMS is established, implemented, maintained, and continually improved in accordance with this International Standard;
b. Identify person(s), authorized by an appropriate level of management, to work with the management representative in support of energy management activities;
c. Report to top management on energy performance;
d. Report to top management on the performance of the EnMS;
e. Ensure that the planning of energy management activities is designed to support the organization's energy policy;
f. Define and communicate responsibilities and authorities in order to facilitate effective energy management;
g. Determine criteria and methods needed to ensure that both the operation and control of the EnMS are effective;

h. Promote awareness of the energy policy and objectives at all levels of the organization;

4.3.3. Creating an EnMS description and Core documents

The implemented policy can form the basis on which the rest of the EnMS can be built. As already mentioned repeatedly, day to day energy management operations are well established within the company. However the entire operation lacks an overarching document or description, a backbone, so to say. The first thing that the newly appointed energy management team should focus on is creating this overall description of the EnMS. This document should contain a complete overview of all activities that might be related to energy management. Chapter 3 of this report may be used as a first reference to all the processes that might be included. The to be created document or collection of documents should contain at the least the items listed below and cover a number of the actions as described in Appendix I.

Content of EnMS core documents

1. Energy Policy;
2. Complete EnMS overview/summary;
3. Energy targets and objectives, consistent with the energy policy;
4. Methods and procedures for evaluating and updating the core documents of the EnMS;
5. Methods for communicating EnMS operations/results internally and externally;

These documents should provide the basis on which procedures can be designed to perform internal audits of the EnMS as per section 4.6.3 of the ISO standard.

These documents should provide the basis on which procedures can be designed to perform management reviews, as per section 4.7.3 of the ISO standard.

4.3.4. Develop standard procedures for auditing/improvement of the EnMS

With the energy team firmly in place and the core documents well established, the team may now venture to make systematic improvements upon the EnMS. Improving the EnMS may be done in two ways. The first method is to make sure that the current EnMS is functioning as designed. To this end CSC's and Branch offices may be audited, to check that procedures are carried out in a correct and intended way. A standard audit procedure should be developed and documented, so that audits may be performed as efficiently as possible. These documented procedures should be added to the core documents of the EnMS.

The second method by which the energy team might improve the EnMS is by constantly looking for opportunities to improve upon the system and to propose or initiate projects to specifically target these opportunities. Examples of such projects in the current EnMS are the remote metering and streetlight projects. Although such projects may be initiated from any department within the company, it is the job of the energy team to document such projects within the context of the EnMS. Ensuring that such projects are taken within the context of the EnMS will ensure that the system conforms to the requirement for continual improvement.

4.3.5. Develop standard procedures for management reviews

Assuming that all the previous steps are carried out correctly, LECO's updated EnMS should now be functioning according to specifications as set out by ISO 50001. Top management should develop a method by which the Energy manager, his team and the EnMS should be reviewed. This may be done either by an independent and impartial committee from within the company or by an external consultancy firm. How often a management review is to take place, should be included within the core documents of the EnMS. Further specifications as to the extent of the review may be found in section 4.7 of the ISO standard.

4.4. Extending the scope and the boundaries of the EnMS

The contents of this report so far, have been written assuming the scope and the boundaries of the EnMS to be specifically aimed at the LECO distribution network, and the losses occurring therein. During the course of the research another interesting point of discussion was brought up that is extremely relevant for the company. Because the question was posed rather late into the research, the question has not received the central position that is should deserve. Since the problem is however an interesting and extremely relevant one, a separate paragraph has been dedicated to the introduction of the problem and how this might relate to LECO's EnMS.

4.4.1. Introduction

As mentioned earlier in the report, electricity in Sri Lanka is heavily subsidized. The Sri Lanka electricity market works with a tariff structure by which the first set amount of kWh is the cheapest per kWh. As the consumer uses more electricity, prices per kWh increase. Figure 5 depicts the current tariff structure for domestic users.

Customer Category and consumption per month	Energy Charge (LKR/kWh)	Fixed Charge (LKR/month)
Domestic (D-1)		
0-30	3.00	30
31-60	4.70	60
61-90	7.50	90
91-120	21.00	315
121-180	24.00	315
>180	36.00	315

Figure 5 - Cost structure of electricy for a domestic user

Statistics from the Ceylon Electricity Board (1) show that the current average cost of generation electricity by means of fuel burning costs approximately 14 LKR per kWh, while private producers of renewable energy receive up to 16 LKR per kWh. This implicates that a large amount of electricity is being sold below cost price. Contrary to "normal" utility companies, where increased consumption of electricity leads to larger turnover and bigger profits, LECO would actually benefit from reducing consumer consumption of electricity. It might therefore seem relevant to include customer consumption within the scope and boundary of LECO's EnMS.

4.4.2. An ISO 50001 approach to the problem

If the company should decide that it wishes to include their customers within the boundaries of the EnMS, the procedure for implementation of the standard would still not differ much from the steps presented in the previous paragraph of the report. LECO would have to start by building a strong foundation, a platform, from which their energy management efforts would be launched and monitored. This foundation would include an extensive energy policy defining the scope and boundaries of the EnMS. Using the policy as a starting point, the newly appointed Energy Management Team could then launch initiatives to better assess electricity consumption patterns and suggest and implement schemes that might lead to a reduction of the overall electricity consumption.

Taking a systematic approach to the problem, the company should be able to identify and monitor the consumption patterns of their customers. Indeed, the required data is already being collected and is available throughout the company. Using the already available data, it should be possible to set our consumption trends over the course of a number days, months and years. In this way any actions that might be taken to decrease consumption levels of certain customers can be easily checked for effectiveness. The monitoring of this consumption data is the first important step to controlling the consumption.

With the data monitoring in place, it would be possible for the company to start influencing consumer consumption patterns through action plans. The easiest way to influence consumption patterns is by adjusting electricity prices. Prices are however controlled by the PUCSL and are therefore beyond the influence of LECO. Other schemes could include awareness programs to educate their customers on energy efficiency.

There are assumedly many other methods by which the company could influence electricity consumption patterns. The key message is that these schemes should be founded on a coherent vision of the targets and objectives, to be the most effective. It is for the company to state this vision and create an organization in which these initiatives can be thought our and implemented.

4.4.3. Discussion

The issue remains that ISO 50001 is generally intended to help improve a company's own energy effectiveness. If LECO has the ambition to influence their customer's behavioral patterns, it might be best to lead by example. This would imply firstly to implement ISO 50001 not just for the distribution network, but for all of the company's operations.

The second point that needs to be made is that this problem is not actually an organizational problem. The current pricing scheme is a progressive one, based on the idea that even the poorest people in Sri Lanka should have access to electricity for basic lighting. Richer people, who need more electricity for appliances like air-conditioning, computers and televisions, are charged more per KWh. Charging to much here however may stifle economic growth, since production processes also require large amounts of electricity. Seen in this light, the problem of losing money on electricity sales is not only a problem for LECO, but a country wide social-economic dilemma. In this way the ISO 50001 standard is a tool that is far to insufficient to apply to this case.

CONCLUSIONS

This report shows that LECO has an extensive and well working EnMS in place. The main issue with the system is that it lacks centralized control and feedback on the efficiency of the system. Furthermore, the company does not have a clear policy on energy management, other than the general impression that it is important to keep losses low.

The first step that LECO should do is draft an official energy policy, clearly stating the vision and the objectives of the company, concerning energy management. Doing so would provide focus to individual energy efficiency programs tying them together and yielding better results for all plans involved. The second step would be to appoint an Energy Management Team, to centralize the organization of the companies EnMS. Centralizing the organization and focusing effort will lead to better results in the long run. Establishing this basis will have the further advantage of being able to react faster to changing circumstances in the energy market. As a final advantage, creating this strong basis for energy management activities may be especially useful if the company decides to expand the scope and the boundaries of their EnMS to include their own operations and not to limit themselves to the distribution network.

With a strong organizational foundation in place, the company should have no trouble to close the remaining identified gaps, as have been presented in appendix I of this report.

Recommendations

There are a number of interesting studies that might be conducted in correlation to this report and the ISO 50001 standard. The foremost question that springs to mind is to research the saving potential if LECO were to apply ISO 50001 to the operations of the entire company and not just the distribution network. This point has been mentioned a number of times in this report already but is of such relevance that it deserves to be brought up here again. Although saving potential might be small in comparison to distribution network losses, investment in this area and any initiatives that follow, might have a payback period of less than 5 years. Besides the benefit of energy savings, taking these measures would set a clear example to the general public and instill a sense of energy awareness in all LECO personnel. This awareness might well lead to higher energy efficiency in the workplace and might even be conferred to LECO customers.

The second question that was briefly touched upon in this report concerned the situation that LECO was selling a large amount of electricity at a loss, due to the Sri Lankan tariff structure. The simple solution to this is to raise the price of electricity. However, as explained in this report, this goes against national policy to make electricity available for even the poorest people of the country. There seems to be no simple solution to this problem. This situation will therefore provide ample fields of research for both technicians and especially policy makers and economists.

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APPENDIXES

I. EXTENSIVE GAP LIST BETWEEN LECO ENMS AND ISO 50001

ISO paragraph		**Prescribed action**	**LECO Compliance**				
			YES	**Half (pass)**	**Half (fail)**	**NO**	
4.1	General requirements	Define and document the Scope and boundaries of the EnMS			**X**		The scope and boundaries of the EnMS are defined as starting at the primary substations of CEB and ending when Electricity is sold to the customers. Half marks because this has not been officially documented.
		Determine how you will meet the requirements of the standard.	**X**				Standards will be fulfilled by closing the gaps between the current EnMS and the ISO 50001 as proposed by this report.
		Establish your EnMS			**X**		Half marks because the EnMS is established but does not yet completely conform to the ISO 50001 standard
4.2	Management Responsibility						
4.2.1	Management Responsibility	A demonstration of Top Management's commitment to EnMS (see also 4.2)			**X**		Management is committed but should show this by implementing an official energy policy.
		Define, establish, implement and maintain an energy policy (see also 4.3)				**X**	

	Appoint a management representative and approve the formation of an energy management team (see also 4.2.2)			X	
	Providing the resources needed to establish, implement, maintain and improve the EnMS and resulting energy performance. (see also 4.2.1 and 4.3)		X		Ample resources are provided for the current EnMS. Providing for the upgrade of the EnMS to ISO 50001 should close the gap.
	Identify the scope and boundaries addressed by the EnMS (see also 4.1)	X			The scope and boundaries of the EnMS are defined at starting at the primary substations of CEB and ending when Electricity is sold to the customers.
	Communicate the importance of energy management to the organization. (see also 4.5.3)		X		This happens on a need to know basis towards personnel directly involved in the EnMS.
	Ensure energy objectives and targets are established. (see also 4.4.6)	X			The current objective is to keep distribution network losses below 4.8% as can be found in the loss reduction activities CSC process manual.
	Ensure EnPIs are appropriate to the organization. (see also 4.4.5)		X		The single EnPI in use is the distribution loss percentage. It might be useful to discuss additional EnPI's.
	Consider energy performance in long-term planning. (see also 4.2.1)	X			Energy planning is the single most important activity in a utility company.
	Ensure results are measured and reported at determined intervals. (see also 4.6.1)	X			The current EnMS has well maintained reporting procedures. Branch offices produce monthly reports that include reports on loss management activities and total electricity consumption and loss. The head office uses these reports to compile a company summary report on energy losses (MIS 3 / MIS 31).
	Conduct management reviews. (see also 4.7)			X	

4.2.2	Roles, Responsibilities and authorities	Top Management has to appoint a Management Representative or Energy Team, with the responsibilities and activities noted in the ISO Requirements section.			**X**	
4.3	Energy Policy	Define and implement an energy policy as described by the standard			**X**	
4.4	Energy Planning					
4.4.1	General	Have a process in place to aid in planning activities that continually improve energy performance.	**X**			The drive towards continual improvement is there, as is demonstrated by project concerning remote metering and streetlight improvement. Improvement in this area might be achieved by basing these plans on the to be drafted energy policy.
4.4.2	Legal and other requirements	Identify and have access to your legal and other energy related requirements.	**X**			Requirements are known and documented.
4.4.3	Energy review	Set up a process for energy reviews	**X**			A description of the system is presented in chapter 3 of the report.
		Opportunities may relate to potential sources of energy, use of renewable energy, or other alternative energy sources such as waste energy. The energy review shall be updated at defined intervals and in response to major changes in facilities, equipment, systems, or processes.		**X**		This does not completely apply to LECO since the companies only option is to buy electricity from CEB. LECO should however keep track of new technologies pertaining to distribution electronics, especially considering the potential for solar panels for their customers.
		What are your methods for energy reviews?	**X**			See chapter 3 of the report
		What are your current energy sources (including any energy generated on-site)?	**X**			Electricity bought from CEB
		What is your past and present energy use and consumption?	**X**			See past MIS- and monthly branch office reports.

		What are your areas of significant energy use?	**X**		See MIS-, branch office- and transformer loss reports.
		How do you identify the facilities, equipment, systems, processes and personnel working for or on behalf of the organization that significantly affect energy use and consumption?	**X**		See process manuals and chapter 3 of the report.
		How do you identify other relevant variables affecting significant energy uses?	**X**		See chapter 3 of the report
		How do you determine the current energy performance of facilities, equipment, systems, and processes related to identified significant energy uses?	**X**		See process manuals and chapter 3 of the report.
		How do you estimate future energy use and what are those values?	**X**		See the long term planning of the company
		How do you identify, prioritize, and record opportunities for improving energy performance?	**X**		See the long term planning of the company, as wel as MIS, branch office and transformer loss reports
4.4.4	Energy Baseline	Identify, document and maintain your energy baseline		**X**	Current loss percentage as energy baseline. It might be useful to discuss other possibilities for an energy baseline.
		Use your Energy Review	**X**		
		Identify and document your data period	**X**		See MIS-, branch office- and transformer loss reports.
		Are there processes to identify changes to measure against the baseline?	**X**		Continued use of MIS-, branch office- and transformer loss reports.
		What are the trigger limits for EnPIs requiring change to the baseline?		**X**	The permittable loss percentage is lowered each year.
		Is there a predetermined method to address major changes to the process, operational patterns, and energy systems?	**X**		

		What currently influences changes to your Energy baseline?	**X**		Improved efficiency of the system lowers the baseline.
4.4.5	Energy performance indicators	Identify and document your EnPI's	**X**		The loss percentage is the EnPI.
		What is the methodology for determining and updating, recording and regularly review the EnPI's?	**X**		See chapter 3 of the report.
		What is the frequency for EnPI's to be reviewed and compared to the energy baseline as appropriate?	**X**		Monthly
4.4.6	Energy Objectives, Energy Targets and Energy Management Action Plans	What are your documented energy objectives and targets within the organization?	**X**		The main target is to keep distribution losses as low as possible. Sub targets include action plans to introduce remote metering and remote streetlight switching.
		What is the time frame to achieve the objectives and targets?	**X**		Differs per action plan. See individual plans for details.
		Are the objectives and targets consistent with the energy policy?		**X**	
		Are the targets consistent with the objective?	**X**		Archiving the targets will help towards fulfilling the objective of low distribution losses.

		When establishing and reviewing objectives and targets, how do you take into account legal requirements and other requirements, significant energy uses, and opportunities to improve energy performance as identified in the energy review and include consider its financial, operational and business conditions, technological options, and the views of interested parties?	X			Targets and action plans are completely based on reducing the total energy loss, making use of the monthly data provided by the energy review process. The PUCSL sets (legal) requirements for energy efficiency.
		How are Action Plans established, implemented, and maintained for achieving its objectives and targets, including: designation of responsibility; means and time frame by which individual targets are to be achieved; and statement of the method by which an improvement in energy performance shall be verified?		X		Action plans and loss control processes are initiated according to ISO 9001-2008 standard. These are therefore also of enough quality to satisfy ISO 50001 requirements.
		What is the method to verify results?				Constant (monthly) energy reviews.
		What is the frequency to review and update documented action plans?			X	There is no process in place to update documents and action plans. The last major update of all documents and processes was done just this year, before applying for ISO 9001-2008 certification.
4.5	Implementation and operation					
4.5.2	Competence training and awareness	Identify how you will train employees, communicate awareness and define competence and how records of the training will be kept.	X			LECO has a well up to date personnel archive keeping track of all trainings that personnel receive.
4.5.3	Communication	What are your methods for communication?			X	Internal communication lines are clear. It needs to be discussed if external communication is desired.

		Will you communicate externally your energy policy, system and performance? If so, how?			X	
4.5.4.1	Documentation requirements	What is the method (or methods) to establish, implement and maintain information to describe the core elements of the EnMS and their interaction?		X		Process manuals are established and well written, according to ISO 9001-2008 specification. The organization lacks an official policy and framework from which to launch action plans.
		Is there a need to define the media (paper, electronic, or any other medium)?		X		This has been done for regular processes. Decisions have to be made on how the overarching paperwork, the core documents concerning the EnMS should be recorded.
4.5.4.2	Control of documents	Determine the methods or processes to control, approve, review and distribute documents		X		A process for document review should be established.
		Identify the current revision status of your applicable documents	X			The current set of documents have just been revised according to ISO 9001-2008 specifications.
		Determine how obsolete documents are controlled		X		A process for document review should be established.
		Determine how documents of external origin are identified and controlled		X		A process for document review should be established.
4.5.5	Operational control	How are operations and maintenance activities which are related to its significant energy uses identified?	X			Operations for maintenance are well documented in a number of process manuals.
		Are they consistent with the energy policy, objectives, targets and action plans?	X			
		How do you establish and set criteria for effective operation and maintenance of significant energy uses?	X			Records of all maintenance work are being kept.
		How are operating and maintaining facilities, processes, systems and equipment, in accordance with established operational criteria?	X			All operations are focused on keeping the distribution network as smooth and efficient as possible.

		How are communications of the operational controls to personnel working for, or on behalf of, the organization conducted?	**X**		Communication of results is done through CSC-Branch- and head office (MIS) reports.
		How do you plan for contingency, emergency situations or potential disasters, including procuring equipment, to include energy performance in determining how you will react to these situations?	**X**		Entire protocols are in place to deal with power outages and other emergencies etc…
4.5.6	Design	How are energy performance improvement opportunities and operational control in the design of new, modified and renovated facilities, equipment, systems and processes that can have a significant impact on its energy performance considered or implemented?	**X**		Design of the distribution system is done, while constantly keeping minimizing losses in mind.
		How are the results of the energy performance evaluation incorporated (where appropriate) into the specification, design and procurement activities of the relevant project(s)?	**X**		Design and procurement of equipment is done keeping best practice within the utility industry in mind.
		How are these activities recorded?	**X**		All design activities are carefully archived. System design plans are meticulously kept up to date.
4.5.7	Procurement of Energy Services, Products, Equipment and Energy	How are suppliers informed that procurement is partly evaluated on the basis of energy performance?	**X**		In the case of procuring power electronics, high efficiency and low loss is always a priority.
		What are the criteria for assessing energy use, consumption, and efficiency over the planned or expected operating lifetime when procuring energy using products, equipment and services which are expected to have a significant impact on energy performance?	**X**		Again, In the case of procuring power electronics, high efficiency and low loss is always a priority.

		How do you define and document energy purchasing specifications as applicable for effective energy use?		X		This is not of influence to LECO since the only supplier of electricity is CEB.
		What are the procurement methods of your energy?	X			This is not of influence to LECO since the only supplier of electricity is CEB.
4.6	Checking					
4.6.1	Monitoring, Measurement and Analysis	What items are being tracked, monitored, measured or analyzed?	X			Electricity consumption and loss is being monitored monthly. Loss due to different aspects of the system are measured or estimated as accurately as possible. See also chapter 3.
		What are your key characteristics?	X			Key characteristics are the consumption and loss data of the distribution network.
		How are the results recorded?	X			Results are recorded in MIS- Branch office- and CSC reports.
		What is your energy measurement plan and is it defined and implemented?	X			The entire process is described in chapter 3 of this report.
4.6.2	Evaluation of Legal Requirements and Other Requirements	What are the results of your legal and other requirement evaluations?	X			The PUCSL sets requirements for maximum allowable loss each year. Other requirements include maximum outage, and general law as applied to industry in Sri Lanka.
		What is the defined frequency of the evaluations?		X		
4.6.3	Internal audit of the EnMS	When and how are internal audits conducted?			X	
		Are all areas of the facility and all clauses of the standard covered?			X	
		Is there a procedure to describe the internal audit process?			X	

		Does the audit plan taking into consideration the status and importance of the processes and areas to be audited as well as the results of previous audits?		**X**	
		How are internal auditors selected and are they competent (see 4.5.2)?		**X**	
		How are records of the internal audit kept?		**X**	
		How are results reported to management?		**X**	
4.6.4	Nonconformities, correction, corrective, and preventive action	How are nonconformities identified and introduced into your system?	**X**		Within the current EnMS system, non-conformities are tracked down using the monthly energy review and applying correct maintenance procedures and the transformer loss audits. An audit of the EnMS itself is however not yet part of the procedures and will have to be implemented. See also section 4.6.3 of the ISO standard on EnMS internal audits.
		How is correction implemented?	**X**		
		How is a non-conformity determined to require corrective or preventive action?	**X**		
		How are records kept?	**X**		
		How is the effectiveness of corrective or preventive actions reviewed?	**X**		
		How are changes to documentation, resulting from corrective or preventive action made?	**X**		
4.6.5	Control of Records	How are records identified, with controls for the identification, retrieval and retention of records?	**X**		Records of the current EnMS are well maintained. Procedures and record keeping of new additions to the EnMS will have to be implemented.
		How are records kept legible, identifiable and traceable to the relevant activity?	**X**		

4.7	Management review		
4.7.3	Output of management review	What are the inputs and outputs of your management reviews?	**X**
		Does management evaluate and state the EnMS' state of suitability, adequacy and effectiveness?	**X**
		How are outputs from previous management reviews noted as inputs to the next one?	**X**
		How are changes to the EnMS implemented, resulting from Management Review?	**X**
		How are records of the Management Review kept?	**X**

II. Notes on the methodology used for this research

Prior to the start of the internship, the student already had sound background knowledge of the ISO 50001 standard, due to previous work experience. In terms of research methodology, this prior knowledge has taken the place of a preliminary literature study into the relevant material. This prior knowledge, along with a short brush-up on relevant materials during the first two weeks of the assignment have resulted in the material used to write chapter 2 of the report, giving a general overview of energy management practices and the ISO 50001 standard.

The first month of the assignment was spent getting to know the organization of the company. This was done in three ways. Firstly, time was spent on studying company reports and manuals. Especially the company process manuals proved to be valuable as they accurately explained the organizational workings of the company. These process manuals proved to be very accessible as they were drafted conform ISO 9001-2008 requirements. The company’s monthly reports are the end result of these processes and served to further increase the understanding of company workings.

The second source of information was through discussion with co-workers. These discussions served to further explain certain organizational processes, along with examples of how these procedures were executed in practice. Finally, a number of visits were made to branch offices and customer service centers of the company to add practical experience to the theoretical knowledge obtained so far. Knowledge acquired through these three activities has been reported in chapter 3 of the report, on the company’s own EnMS.

It was found that especially technical knowledge about the distribution network set-up was hard to come by in documentation. This information, concerning everything from electric circuitry to meter placement to redundancy in the wiring, was obtained through explanations and sketches from members of the technical staff.

After the preliminary research, in the beginning of the second month, it was decided that the scope and boundary of the research should focus on the EnMS for the distribution network. It was then also decided how ISO 50001 might be applied to a utility company. The results of this can be found in chapter 4.1 of the report.

During the preliminary research of the first month, a number of manuals on applying ISO 50001 were obtained. The consulting company UL DQS INC provided the most extensive and yet practical hands-on guide for the purpose of evaluating the current EnMS. During the course of the second month, the information in this guide was distilled into a simple to use checklist. This checklist was then applied to LECO’s current EnMS system. The completed checklist can be found in appendice I of this report.

In the second half of month 2, the results of this checklist where used to create a summary, providing a more comprehendible overview of the current gaps between the ISO 50001 standard and the current EnMS. This summary has been added to chapter 4 of the report.

The ISO 50001 standard provides a rough approach to implementing the EnMS in to a company. This approach was compared to the summarized gap analysis to identify the required steps needed to lift the LECO EnMS to ISO 50001 certifiable level. These steps are described in 4.3 of the report. This concluded the actual research on the assignment and was fished by the end of the second month. The final two weeks of the project where spent drawing up the report on the work done.

III. REFLECTION ON THE INTERNSHIP

PRACTICAL PREPARATIONS

The LECO internship was arranged on relatively short notice. As a consequence, I had only four weeks to prepare for departure to Sri Lanka. Furthermore, there was not a lot of time to read up on the subject and do preparatory research. As an added challenge, the research problem description was still a bit vague, which meant that the definite research question would still have to be formulated in the first weeks of the internship.

On the other hand, I already possessed quite a lot of knowledge on the general subject of ISO 50001 due to previous work experience. This meant that an extensive preparatory literature study in to the subject was not necessary. Due to this prior experience, I was well prepared to start work on the internship.

The lack of a concrete research question proved to be a challenge in the first month. The host organization was unfamiliar with the exact competencies of a student Sustainable Energy Technology, as they are unfamiliar with the curriculum of the study. Because of this lack of knowledge, the host organization left the research question rather vague on purpose, letting the student formulate his own questions in accordance with his own training and teaching. This required a high level of initiative from my side, with the host organization providing only a small amount of feedback. This was tough in the beginning, since it was hard to judge what exactly was expected of me from the host organization. During the course of the internship it became increasingly clear that the area of research, and the questions I had formulated where indeed being appreciated. This ensured that I could finalize my research with confidence.

Like the assignment itself, all other preparations were completed in a bit of a rush. The suddenness of the whole process made it seem like vital preparations were being forgotten. However upon arriving in Sri Lanka everything was well in order. After the initial week to settle in and find a place to stay, I could fully concentrate on the assignment. This indicates that the preparations from both the company and myself were more than adequate.

INTERACTION WITH THE HOST ORGANIZATION

As mentioned above, the host organization did not have a full understanding of my capabilities, other than my knowledge of ISO 500001. The organization therefore chose to give me a lot of freedom with regard to the research. As part of the evaluation the host mentor and I discussed if this was a good idea or that it was seen more as lack of guidance. Both parties agreed that in my specific case, this approach resulted in excellent results and was therefore the right course of action. It was however also decided that more structural guidance should be given to future interns.

Interacting with my direct colleagues on a daily basis went fine as these colleagues speak reasonable English. Making a connection on a more personnel level was very hard though since upbringing, mentality and world outlook are so much apart. As an example of this completely different world view: The second question in any conversation with new people is often if I was married. Responding in the negative often got me a surprised look. Conversations with my colleagues therefor always seemed a bit superficial, sticking to the pleasantries. Most of the friends I made were people from outside the office, who had travelled some themselves and had a far broader worldview. Contact with other staff members was a lot harder since their English was a lot less good. Social interaction in the office was therefore mostly restricted to polite and kind greetings and smiles with very few actual conversations.

Interaction with tutor

I think that the interaction with the tutor can be described as adequate. The same as with my local supervisor, I often needed to rely on my own judgment about the work I was doing, with only minimal guidance from the tutor. In the end, I think that this has yielded excellent results, in terms of the final report and the work produced. Furthermore, the learning experience for me was much greater because of the low amount of feedback. The question remains if the tutor also agrees if I sent her enough information or that I should have sent more regular updates.

Working in a different culture

One of the things that surprised me most was how efficient everything seemed to be running in the company. I was fully prepared for inefficiency and a lot of time-wasting. LECO however operates quite a smooth running operation, with personnel all working on their own projects and assignments. In comparison, I heard stories from other interns in Colombo who work at offices where people do not reach their deadlines, are constantly checking Facebook and the like and lack a sense of responsibility for the work that they should be doing.

This being said, it was sometimes quite tough to get a hold of a supervisor as meetings always seemed to be planned on an ad-hoc basis. Setting appointments by email did not guarantee that the meeting would actually happen, as any of a number of other things could come in between.

Because of the independence I had in running my project I was however not that heavily dependent on my colleagues and the company, and could quite easily work at my own pace and efficiency. It was not so much working, as was living in another culture, which made the whole experience so interesting and challenging. Outside of work you had the choice of staying home at your apartment, reading a book and working or playing on the computer, or throwing yourselves well out of your comfort zone and into hectic city life in Colombo. Noise, smell, the oppressive heat and the press of humanity seemed overwhelming at times. It was being immersed in all of this however that has greatly increased my own confidence and has learned me a lot about both myself and the world in general.

Skills, strengths and weaknesses

My biggest assets during my internship were my strong independent working attitude and being an easy going person. Since the company kept the assignment description a bit vague on purpose, I had to find out a lot by myself and use my own judgment in formulating research questions and deciding on courses of action. LECO only provided small amounts of feedback to guide me in the right direction. In order to actually function properly in a country like Sri Lanka, I had to be able to take things the way they came up. In Colombo, things were not always that well organized. The only way to deal with the unexpected is to take it with a smile and deal with it, instead of complaining about it. Thus working in this kind of environment was quite compatible with my skill set.

This laid-back attitude might have been a slight weakness as well. When trying to plan meetings with my supervisor the meeting often fell through, meaning that I just gave a sigh and went back to working on other lines of research where I did not have any questions about. In hindsight I should have set up a standard weekly meeting, and I should have been insistent on my supervisor sticking to this meeting schedule. Instead, I chose to go for the route of least resistance, trying not to bother my supervisor no more than absolutely necessary and only insisting on seeing him when there was no other way to continue work.

Learning experience from the internship

My theoretical knowledge of ISO 50001 and EnMS was already quite decent. What I found extremely interesting about this internship was that I could apply this theoretical knowledge to a real word case. I have thus gained a huge amount of practical experience in the applications and use of Energy Management Systems in general and specifically in ISO 50001.

My great personal improvement because of the internship is that my confidence has greatly increased. Living in Colombo has provided me with an enormous amount of world experience. This has also inspired me to start looking for job opportunities far outside of the Netherlands when I graduate, since I have found out that I will have no problem whatsoever settling down in a new country in building up a life there.

Doing this assignment has also confirmed for me that I would like to continue my career in the field of sustainable building and the built environment either as a PhD or as a consultant. I think that giving me a clear idea of what I would like to do in the future was one of the most important contributions of doing this internship.