Optimization of Electrical Installations Management

At Imtech Industrial Services BV

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June 2009
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Imtech Industrial Services BV

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Foreword

The dissertation you hold in your hands is the result of a research by Imtech Industrial Services in Botlek, Rotterdam (The Netherlands).

The main task of this study has consisted in the definition, development and introduction to the marketing aspects of an optimization plan for the electrical installations management. During this period I have been studying the technical aspects to optimize the management of electrical installations and also the marketing aspects involved in the development of a new service or product.

Through this internship I have had the opportunity to know how Imtech works. I have also travelled to other sections in Den Haag and Kerkrade where I got more knowledge and useful information for my research. Besides, in the Industrial Maintenance fair I had the opportunity to contact and interview possible customers to have an idea of their interests on Imtech and this optimization of electrical installations management service.

I would like to thank a number of persons important for the success of this project. They are:

Pieter Dominicus, my supervisor in Imtech, for giving me the opportunity of start my workplace in a well-known organization as Imtech and for all his support since the beginning of the internship till the end.

My supervisor in HZ, Wim Korevaar, for all his help and my supervisor in EUITIZ, Antonio Usón, for the interest he showed since the proposal of the project.

My fellow co-workers in Imtech Industrial Services: Wieke, Wouter, Huugh and Muamer for all their help.
Summary

An electrical installation is a group of materials and equipment of a workplace that allow generating, transforming and distributing the electricity. By optimizing the performance of it, the current common objective of being sustainable will be achieved. This means that a balance between environment and industry can be achieved by implementing several improvements in the installation management.

This report focuses not only in the physical installation, but also on the external factors that have influence on it. These factors are: the organization involved in its performance, the rules and regulations established by different organizations, the energy efficiency and the technical conditions of the equipment. All of them are influenced at the same time by the new technologies that are a key to achieve a more efficient performance.

The main goal of this assignment is the definition, development and introduction into the market of a technical service that optimizes the management of the electrical installations in the industry sector. Imtech aims to implement this service as a tool to achieve a better position in the energy and environmental market as a technical services provider.

After compiling all the information and analyzing it, an integrated concept has been designed to implement this optimization plan. In this concept, the basic regulations for an electrical installation are NEN 3140 and NEN 3840 for the management of electrical installations. The energy consumption determines the actions a company has to take into account to reduce the energy expenses. The technical inspections of the installation and equipment determine the correct performance of the installation. The organization has to promote the participation and motivation of the workers in the modification for the improvement.

With the application of the inspection of the plant, the elaboration of a working plan and a report with the failures and improvement to solve them and with the monitoring of all these changes, the current situation of the electrical installation should be improved.

Imtech, with the optimization of electrical installations management, aims to achieve a better position in the market of the technical services. Changing the weaknesses into opportunities and strengths is the correct strategy to improve its position in the technical field.
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1. Introduction

In this introduction there is an overview about the project and its definition. This will help to understand what this project is about and why it has been carried out.

1.1. Background

An electrical installation is an assembly of associated electrical equipment to fulfil a specific purpose and having coordinated characteristics. Its main goal is to supply the electricity to the equipments in a safe and efficient way, looking for the correct operation of all machines and equipments.

Currently, there is an increasing demand of sustainable technology. Because of that, the government demands several requirements that industries have to obey. In these requirements energy is one of the aspects that influences them. These aspects have motivated Imtech, a potential service provider in the technical market, to define this project: The optimization of the electrical installations management. Based on Knelman F.H. (1975), optimization is synonymous of minimum costs and maximum throughput in order to achieve a better performance. In an electrical installation, optimization involves several aspects. These aspects are:

A) The Organization involved  
B) The Rules and Regulations required  
C) The Energy aspects  
D) The Technical Conditions of the equipment

By making an integrated concept with these four aspects, Imtech aims to achieve a better position in the technical market at the same time it helps industries to be more sustainable.

1.2. Problem definition

In this section there is a more detailed description of the project. Next, the description and the main question of the project are given in order to clarify the assignment.

1.2.1. Assignment Description

The project consists of the research of the optimization of the electrical installations management and the specific applications within the market of Imtech Industrial Services (Imtech IS). As this project has been developed in the maintenance department, it is important to know what are the main activities. They are:

- Maintenance management  
- Maintenance contract management  
- Maintenance engineering  
- Implementation  
- Technical services  
- Facility services
The assignment of this project is to define, develop and explain how to introduce into the market an optimization plan for the installations management. It shall focus on electrical installations and shall not be process related, like heat balances of chemical processes. Just electrical and mechanical aspects will be mentioned.

Imtech wants to offer to its customers a service for optimizing the management of the electrical installations. This optimization is focused on the organization, energy, rules and regulations and technical conditions of the installation. By the definition of all of them and the analysis of the technological development, an integrated concept to improve the installations is obtained.

1.2.2. Research question

There is a main question that summarizes the aim of this report. Other subquestions related to this one complement this definition, providing all the necessary information for a better understanding of the service.

The main question is:

**How can Imtech help its customers to improve their electrical installations management?**

And in order to support this question to be solved, there are sub-questions that summarizes the whole research:

- What is an electrical installation?
- How does an electrical installation work?
- What are the main problems in an electrical installation?
- How can these problems be solved?
- What methods are used to improve the situation?
- What rules and regulations are applicable to electrical installations?
- What parts of the organization are involved in this service?
- What are the advantages and disadvantages?
- How can this service be introduced in the market?

1.3. Structure of the report

On the first part some background information, restrictions and basic questions needed for a correct definition of the problem will be analyzed. After the specification of the project, the ideas will be generated. Once they are discussed, the concept will be elaborated.

The process described above is also the order of discussion for this report. In chapter 2 there is the company information. Chapter 3 contains all the research information. Through chapter 4 the most possible solution will be elaborated and when this is made, the conclusions and recommendations are shown in chapter 5.


2. Imtech

Imtech N.V. is a European technical services provider in the fields of electrical engineering, ICT (Information and Communication Technology) and mechanical engineering. It is a financially powerful, reliable and brand independent company which provides customers with added-value by offering high-value technical total solutions. Imtech strives for continuity for the customer based on long-term partnership relationships. It covers the entire chain from consultancy and design to implementation, maintenance and management. Currently, it has an annual revenue over 3.8 billion euro, and in its 200 offices through the whole Europe there are approximately 22,500 employees who are distributed in the buildings, industry, infrastructure, marine and telecom markets in Belgium, Germany, Luxembourg, the Netherlands, Spain and the UK. The market that is focused in this project is the Dutch market. (Imtech, 2008)

This research has been created at Imtech Industrial Services in Botlek as a new service to implement into the industry sector. Inside the Imtech Industrial Services section, there are several departments. An illustration is given in figure 1. The Competence Centre Industrial Maintenance is the department where this project is developed. But also other departments have been important on the development of it, such as the marketing and safety department. The marketing department has been necessary to know all the marketing techniques Imtech uses to implement into its services, supplying information about the organization structure, competitors and potential clients. The safety department has given the information necessary to know all the risks and certifications that an electrical installation requires.

![Imtech Industrial Services organization chart](image)

Figure 1: Imtech Industrial Services organization chart (Imtech IS, 2009)
3. Research

This chapter gives a summary of the research executed and it is divided into two parts: the definition of the research, with information about the goals and restrictions of the project and the development of the research, in which the applicable information will be explained.

3.1. Research Definition

In this section there is a definition of the goal of the research, the project scope, the restrictions of it and what has been the research method to get the information.

3.1.1. Goal of the research

Imtech Industrial Services is a company with a mission to be a world-class partner for industrial companies to define, optimize and realize System Support Management on all organizational levels (Imtech, 2008). Therefore, structured methods such as maintenance engineering, maintenance management, lean maintenance, Life Cycle Cost (LCC) and Reliability, Availability and Maintainability (RAM) engineering are applied for the realization of projects. Due to the increasing demand of a sustainable technology in the industries, Imtech wants to take advantage of it by means of the development of this service.

The main goal of this research is to define, develop and establish how to introduce into the market an optimization service for the electrical installations. There are other goals that are involved in this one:

- Make a service to be used as a tool to reduce expenses
- Achieve a better and more efficient performance of the installation
- Define the requirements industries have to carry out to be more sustainable

3.1.2. Project scope

Currently, several aspects such as the government regulations, the economical situation, and the environmental problems are motivating industries to change several aspects in their working.

In the industry sector, the government is trying to reduce the emissions of greenhouse gases in order to reach the objectives named in the Kyoto Protocol. In this protocol the emissions of six types of greenhouse gases have to be reduced between 2008 and 2012 by an average of over 6% as compared to 1990 levels. (United Nations, 1997).

Nowadays, the economy is in crisis. Numerous companies have to take strict solutions in order to continue actively in the market. One of them is reduce the expenses they have. In the industry, the energy is one of the most important expenses. This can be reduced by making
and optimization plan to reduce the expenses by improving the critical aspect of the plant that causes important risks for it.

Besides, the environmental conditions are not the same as several years ago. This is due to several factors, but one of them is the pollution the industries cause. As it has been mentioned before, by reducing the emissions, an organization will get benefits. The contribution to the conservation of the environment is the most important, but also, this will make the organization more sustainable and consequently, more competitive.

Based on Schneider Electric (2008), an electrical installation is an assembly of associated electrical equipment to fulfil a specific purpose and having coordinated characteristics. Its main goal is to supply the electricity to the equipments in a safe, efficient and effective way, looking for the correct operation of all machines and equipments. It is important to clarify the difference between efficient and effective installation. An efficient installation aims to reduce the resources used (time or energy) and an effective installation wants to achieve a correct performance. To optimize an installation efficiency and effectiveness have to be together in order to achieve a good and productive performance.

As a first approach, there is a conceptual model for the research (see figure 2). There are four main aspects that influence in the performance of an electrical installation:

A) The Organization involved  
B) The Rules and Regulations required  
C) The Energy aspects  
D) The Technical Conditions of the equipment

The organization has to know the technical standards applicable to the installation (1). Depending on the energy consumption the government establishes different requirements (2). These requirements sometimes imply modifications in the technical equipment of the installation (3). The complete organization has to be aware of these modifications (4) and tries to select the correct personal to implement them. If some aspects are improved, such as the energy reduction or the technical conditions, the company will get benefits such a better company image (5) at the same time it will be under the legal conditions. Besides, the technological development is an important aspect that can influence several actions.

Figure 2: Conceptual model
3.1.3. Project restrictions

To clarify the definition and the limits of this research, several restrictions are defined:

- Because this is for Imtech IS, it has to be applicable just to industries.

- It has to be connected with maintenance engineering, which is one of the core products of Imtech IS. If maintenance is not good organized, all the system will be working in a non-efficient way.

- This optimization plan is applicable only for electrical installations.

- This service has to be introduced into the market. It can be promoted not only in the internal market of Imtech, but also to all the external customers.

- This report has to be useful for Imtech IS as a service of them to their customers. The customer’s demand and the imminent competition force this report to be finished in time and in the properly conditions to start implementing it as soon as possible.

- It has not only to focus on the energy aspects of consumption. The energy consumption is not everything in a plant; there are other aspects that affect in its performance and costs. They are the organization, the requirements and the technical conditions of the installation.

3.1.4. Research Methodology

Before start writing this final report, a research was made to collect all the information of several fields in order to have an extended view of all terms involved in it (see figure 3).

1. First, a preliminary study from books and documents on the internet was performed. In this phase, information about energy, such as energy efficiency, energy optimization, energy conservation and energy management was studied. A research of the applicable rules and regulations was made by governmental, institutional and European commissions information. Moreover, a research of all the actions to be taken to improve its performance are analyzed, such as reparation of the equipment, solutions for saving costs, reduction of the bad practices into the installation or corrective and preventive maintenance.

2. Then, terms like maintenance engineering and management, RAM engineering, asset management, lean maintenance, LCM and Life Cycle Cost (LCC), were used to know the intermediate steps to implement this plan. Methods and tools like thermography, Sankey diagrams, Pipe and Instrumentation diagrams (P&ID) were also studied (see appendix G). And to market it, terms such as (Strengths, Weaknesses, Opportunities and Threats) SWOT and trend analysis were also analyzed in order to know how to apply them to this project into Imtech IS.

3. Finally, with the combination of all this knowledge in a structured program, the optimization plan can be performed.
To sum up, in the optimization of the electrical installations, several disciplines of engineering and management, tools and analyses are required. These are needed for the implementation and understanding of the different aspects involved in the installation.

- The engineering and management disciplines are a necessary part for the organization and rules and regulations development.

- Several tools are required for implementing the energy programs and for modifying the technical conditions of the installation.

- To detect the current trends in the market and the new technologies that can be applied, some analyses can be performed.
3.2. Research Development

In this section, the main question and the subquestions are answered by using all the knowledge acquired in the research. Here all the information collected is explained in order to select the applicable and most important for the development of the project.

3.2.1. How can Imtech help its customers to improve their management situation in the electrical installations?

Imtech, with the development of this service, wants to improve the situation of the management in the electrical installations of the industry sector. This is possible by making an integrated concept in which all the parts that are related to an electrical installation management are connected and depending of each other. Imtech aims to achieve several objectives for its customers. These objectives are:

- Make an efficient and safe electrical installation
- Optimize the performance of the equipment of the installation
- Reduce the energy consumption and costs
- Certify the installation according to the European standards and regulations
- Achieve the whole organization’s participation and motivation

The service consists of a first approach and collection of all the data regarding the electrical distribution system, by which it is possible to find the possible failures and bad practices that do not allow the installation to work properly. Then, the optimization is made with the analysis of all the information available. In order to make profitable analysis maintenance techniques are applied.

3.2.2. Performance of an electrical installation

What is an electrical installation?

According to Schneider Electric (2008), an electrical installation is an assembly of associated electrical equipment to fulfil a specific purpose and having coordinated characteristics. By the whole group of materials and equipments the electricity is generated, converted, transported and used. Its main goal is to supply the electricity to the equipments in a safe and efficient way, looking for the correct operation of all machines and equipments.

How does an electrical installation work?

An electrical installation must be reliable, efficient, that is to say, the energy must be transferred in the most efficient way, economic, because its final cost must be adequate to the necessities, flexible and safe, they have to guarantee the safety of the personnel and properties. The main components of an electrical installation are divided into:
• Process
• Heating
• Lighting

All of them have to work together by ensuring safety conditions for the operation of the installation. (Imtech IS, 2009).

**What are the main problems in an electrical installation?**

In order to ensure a correct economic and safe operation of the installation, a system for protecting the electric network has to be designed properly. There are also several problems such as maintenance problems or the overheating of the equipment that can appear in an installation. Based on Imtech IS (2009), the main problem is that the distribution of the electricity can break off and the plant can stop working. If this happens, several consequences can appear in the plant. Inside the plant, nothing will work and the production will stop causing losses for the plant. Outside the plant, this failure can cause environmental problems due to the emissions of gases and chemical products that can be produced at that moment. Consequently, the company have to pay a penalty to the government; there can be loss of customers, a degradation of the image of the company, etc.

**How can these problems be solved?**

To solve this problem, the organization of the plant can adopt several solutions, which will depend on the situation, the severity of the risk or the amount of money of the organization. The best solution is to work on an emergency system that can work when a failure happens. Before this happens in the distribution, the best solution is to make a parallel connection in the transformers that supply the electricity. With this solution, the main risk of an electrical installation is solved. By the same way, this connection is also used for all the equipments that could have the risk of break down. Besides, by adopting the parallel connection of the equipments of an installation, the capacity of the system can be increased. This is because you can select the equipment or equipments that are the most suitable to work in a determinate moment. Another solution that can be adopted to assure a continuous supply to the process is the called “Ring Supply”. This method allows the distribution to put more transformers and to increase the capacity. However, it is more expensive and more extra cable is needed. (Imtech IS, 2009).

### 3.2.3. Organization

The organization consists of all the sections of the company that are responsible for the execution of a service. Its main goal is to coordinate all the sections and departments to develop a correct plan and management of the service. It tries to improve the company’s situation in terms of economic, quality, safety and effectiveness by establishing a balance between them.
There are several functions and departments that can be involved in the performance of an electrical installation. Later on the further chapters it will be discussed which of them are applicable to the organization of the optimization of the electrical installations management and which of them are applicable to Imtech and to the customer who demands the service. They are:

- The *manager* has to be involved in all actions that will be taken in the whole installation and to give the approval of the decisions.

- The *process manager* establishes the responsibilities, process performance and administrative activities to define a process.

- The *project manager* is responsible for the development of a project plan and the definition of the goals, tasks, and resources needed in a project.

- *The account manager* is the responsible of the contact with the clients.

- The *maintenance department*, based on Hawkins B., Smith R., (2004) is the responsible to provide timely, quality and cost-effective services and technical guidance to an organization.

- The *Quality, Safety, Health and Environment (QSHE) department* is responsible to coordinate the quality, safety, health and environmental assets that are present in an organization. It objective is to implement these characteristics into the organization.

- The *marketing department* is responsible of the promotion and advertisement of a product or service, the definition of the marketing goals and strategy and the customer needs.

- The *technicians* are the bases of the installation. They perform the technical work implemented.

The organization has to know if the implementation of a new service or product will be feasible or not. One action that can be taken into account is the calculation of the life cycle cost of the service of product.

**Life Cycle Cost (LCC)**

Based on Blanchard B.S. (2004), Life Cycle Cost is a technique to establish the total costs of a product or service. These costs can be divided into four categories (see figure 4).

1. *Design and development cost.* It contains the cost of feasibility studies, system analyses, detail design and development, fabrication, assembly, test of engineering models, initial system test and evaluation and associated documentation.

2. *Production and construction cost.* It contains the cost of fabrication, assembly, test of operation systems, production capability and the cost of associated logistic support requirements.
3. *Operation and maintenance cost*. The costs of personnel and maintenance support, spare and repair parts and equipment maintenance are some of the costs included.

4. *System retirement and phase-out cost*. It includes the cost of phasing the system out of the inventory due to the wear out and equipment item recycling and disposal.

![Life Cycle Cost Diagram](image)

**Figure 4: Main categories of LCC (Blanchard B.S., 2004)**

### 3.2.4. Rules and Regulations

Rules and regulations are all the requirements for a product or a process that guarantee its validity, quality and effectiveness. These requirements can be from the government, whose no fulfilment can result in a penalty, and national and international standardizations. Their goal is to establish limits into the performance of a product or service in order to reduce or solve one common problem of several businesses.

*What requirements are applicable to electrical installations?*

There are several technical standards an electrical installation has to comply to in order to know which machines and equipment should be designed, manufactured and tested. By carrying out all these standards, the efficiency and the safety of the installation will be assured. For an electrical installation, the main NEN-EN\(^1\) standards are shown in table 1.

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\(^1\) Dutch NEN (Nederlands Normalisatie Instituut) – EN (European Normative).
<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EN 50110-1</td>
<td>Management of electrical installations. General provisions</td>
</tr>
<tr>
<td>EN 50110-2</td>
<td>Management of electrical installations. National annexes</td>
</tr>
<tr>
<td>NEN 3140</td>
<td>Management of electrical installations. Additional Dutch provisions for low-voltage installations</td>
</tr>
<tr>
<td>NEN 3840</td>
<td>Management of electrical installations. Additional Dutch provisions for high-voltage installations</td>
</tr>
<tr>
<td>NEN 1010</td>
<td>Safety provisions for low-voltage installations</td>
</tr>
</tbody>
</table>

Table 1: Basic NEN-EN standards for electrical installations

Besides, there are two ISO\(^2\) standards that every company has to take into account (see table 2).

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISO 9001</td>
<td>Quality Management Standard-Requirements</td>
</tr>
<tr>
<td>ISO 14001</td>
<td>Environmental Management Standard-Requirements</td>
</tr>
</tbody>
</table>

Table 2: Basic ISO standards for electrical installations

A list that gives in more detail several standards required for an electrical installation is given in the appendix D.

**Legal requirements**

Regarding to the legal requirements, the Ministry of Economy of The Netherlands, refers to the law about “Environmental Protection” in the article 8.11 and define the *Alara* concept: *As Low As Reasonably Achievable*. It establishes that the authorities will give companies a licence to operate only if environmental consequences are kept as low as possible, but also as low as reasonably achievable. (Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer, Ministerie van Economische Zaken, 1999).

In order to get a licence to operate the Ministry of Economy of The Netherlands establish several limits, according to the energy consumption of the plant. A flow chart from the Dutch Ministry of Economy that represents all the conditions and actions to take into account depending on the energy consumption is given in the appendix C. Based on Ministerie van

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\(^2\) ISO (International Organization for Standardization) is a non-governmental organization network of the national standards institutes of 161 countries (ISO 2009).
Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer, Ministerie van Economische Zaken (1999) it is established that:

- If the energy costs are higher than €7,000, it is necessary to make an analysis of the energy use with an inventory of all the equipment that consumes energy.

- If the energy costs are less than €45,000 a Limited Energy Scan is required.

- If the energy costs are higher than €45,000, it is required to implement an Energy Scan.

- There is another action to take, a Feasibility Study, when the Return on Investment is unknown.

- If the Return on Investment is known and less than five years it is necessary the generation of energy prescriptions and the specification of the requirements for the measures that have to be taken in order to save energy.

All these solutions and actions mentioned above will be explained in further chapters.

**Energy Investment Allowance (EIA)**

Based on Senternovem (2009), one requirement the government establishes is that all the plants whose energy consumption is higher than 50,000 kWh have to apply for a service to reduce and optimize the energy consumption. The Ministry of Finance and the Ministry of Economic Affairs of The Netherlands have made the Energy Investment Allowance (EIA). It is a fiscal scheme that promotes the investment in energy-saving company assets and sustainable energy. Besides the usual depreciation rate, 44% of the investment costs are deductible from the fiscal profit. The government uses the EIA scheme to promote the investment of the Dutch industry in energy-saving techniques.

**Deltalinqs**

Depending on the area where the plant is located, different labels will be required. For instance, in the area of Botlek (The Netherlands), the label of Deltalinqs is required. It is an organization that represents the common interests of all the logistical and industrial companies in the Rotterdam port and industrial area. Its mission is: “to promote the collective interests of the affiliated companies and associations” and it is focused on infrastructure and accessibility, space, handling goods flows, EU policy, costs and rates, promotion, benchmark, labour market and industrial ecology among other terms. (Deltalinqs, 2009).
3.2.5. Energy

In this section the terms that are associated to a correct use and consumption of the energy will be described. The goal is to optimize the energy use and consumption, with the consequence of the reduction of the costs.

Optimization can be defined such as all the actions that are focused in the achievement of a better performance. Energy in an installation is associated to the terms: efficiency, optimization and conservation.

Energy conservation

The conservation of the energy is necessary because the current natural resources are limited. If we want them to be available in the future we have to conserve the energy by using renewable energy sources, because it contributes to reduce the impacts that the non-renewable sources make to the environment. Based on McVeigh J.C., Mordue J.G. (1999) with this practice, there is a decrease in the quantity of the use of energy and also an increase of the financial capital, the environmental value, the national security and the human comfort.

Energy efficiency

Based on Rajan G.G. (2003) an efficient energy use is achieved by maintaining the same level of energy services. This can be done with the combination of the environmental conservation and the use of the current resources. It is important to improve the energy efficiency because several causes such as the reduction of the cost in energy, the increase of the competence in the EU and the protection and conservation of the environment.

Energy optimization

Based on McVeigh J.C., Mordue J.G. (1999) energy optimization is the meeting of the energy demand at the minimum cost without loss of the production of the system. For optimizing the energy consumption several questions must be answered, such as:

- Is the system performance okay?
- Where is the problem?
- Which parameters are responsible?
- What is the best alternative to improve the performance?

But all these terms need to be controlled in an installation by specialized personnel. That is the reason why it is necessary to define a responsible person or department (depending on the size of the company) to manage the energy use.
Energy Management

Based on Jones T. (2008), energy management is a systematic way of planning, organizing, implementing, monitoring and controlling energy use in an enterprise, with the aim of efficient utilization of energy inputs. In fact, the term energy management refers to the management of energy consumption focusing on energy savings. This notably means improving the efficiency of powered devices such as electrical equipment and the development of renewable energies. Besides, the energy management has to control if the company fulfils the requirements established in terms of energy. As it has been named before, depending on the energy costs a company has, the government (see appendix C) establishes several solutions can to adopt (see figure 5).

<table>
<thead>
<tr>
<th>Energy QuickScan</th>
<th>Performance Advices</th>
<th>Limited Energy Investigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>It is a simple investigation where no specific quality standards are applied. This doesn’t require high qualified personnel to do it. It is easy, basic and cheap.</td>
<td>This is an advice service focused mainly in HVAC and in taking measures for buildings.</td>
<td>In this service there is a description of the energy balance, in order to determine a estimation of the savings potential for standards systems that have an annual energy cost lower than €45,000.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Standard Energy Investigation</th>
<th>Energy Potential Scan</th>
<th>Feasibility Energy Study</th>
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<tbody>
<tr>
<td>A Taylor made package of measures is given. This is applied for more complex companies and industries.</td>
<td>This is a standard energy investigation, but with the involvement of all the personnel at all levels.</td>
<td>It is made in order to detect if the specific measures taken are feasible or not.</td>
</tr>
</tbody>
</table>

Figure 5: An estimation of energy services (Imtech Buildings, 2009)

Currently, Imtech Buildings is working on this topic, by developing several services. They depend on the annual consumption of the company. Although they are focused to buildings, some of them are also applicable to the industry area. Depending on the consumption of every plant, the service to apply would be different and the steps would be the same: measuring things, collect the data, investigate the critical points, the bad aspects and give and implement advices and corrective measurements. (Imtech Buildings, 2009).

The energy services are necessary in the optimization of an electrical installation because most of the losses of the installation are due to the energy consumption. Implementing them into the company has several advantages. Based on Imtech Buildings (2009), these advantages are the following:
• Reduction of energy
• Improvement of the energy efficiency
• Savings on investments
• Reduction of CO₂ and other emissions to be under the legal requirements
• The image of a sustainable company

**Demand Side Management (DSM)**

Demand Side Management are all the activities, which involve actions on the demand- or customer-side of the electric meter, either directly caused or indirectly stimulated by the utility. The use of DSM is limited to those activities such as strategic conservation and load management of peak clipping which result in reductions in usage in at least some periods. DSM is an integral part of the broader concept of integrated resource planning in which a utility attempts to develop a set of resources which minimize future costs, while achieving other goals such as maintaining reliability (Chamberlin J.H., Gellings C.W., 1993). Some of the benefits of DSM are:

• Allow the most productive and least cost use of both capital and fuel resources.
• Maintain or enhance the quality, reliability and predictability of service.
• Build improved relationships with customers based upon better understanding of customer needs and values, and improved, lower cost, service.

**3.2.6. Technical Conditions**

The technical conditions are all the conditions that determine the state of the installation in terms of design, safety, healthy and quality. Their objective is to make an installation efficient and with a correct operation. It is made by means of the modification of the equipment, the replacement of them, if it is the case, and the establishment of some corrective and preventive actions. In the technical conditions of the installation the application of RAM strategies, asset management and maintenance strategies have an important role.

**RAM engineering**

To have an effectiveness system it is important to understand both reliability and maintainability along with traditional information about availability (see figure 6). The Reliability, Availability and Maintainability influence the capability and the life cycle costs and they are an important part in the design or evaluation of the equipment and systems.
Reliability

Reliability can be defined simply as the probability that a system or product will perform in a satisfactory manner for a given period of time when used under specified operating conditions (Blanchard B.S., 2004). Reliability engineering involved the redesign, modification, improvement and replacement of the components in a system. There are four elements important in the reliability concept. They are:

- Probability. It is the relationship between the number of times an event occurs and the total number of trials.
- Satisfactory performance indicates that specific criteria must be established that describe what is considered to be satisfactory system operation.
- Time. It represents a measure against which the degree of system performance can be related.
- Specified operation conditions, such as environmental factors.

Reliability is a characteristic of design that must be considered at program inception and be addressed throughout the system life cycle. (Blanchard B.S., Hawkins B., Smith R., 2004).

Availability

Availability is the probability a system has to be ready or available when is required for the use. It must be applied at any time in the overall mission profile representing a point estimate or may be more appropriately related to a specific segment of the mission in which the requirements are different from other segments (Blanchard B.S., 2004).

Maintainability

Maintainability is an inherent characteristic of system design that can be expressed in terms of maintenance frequency factors, maintenance times and maintenance cost. It may be defined as a characteristic of design and installation expressed as the probability that:
• An item sill be retained in or restored to a specified condition within a given period of time, when maintenance is performed in accordance with prescribed procedures and resources.

• Maintenance will not be required more than a certain number of times in a given period, when the system is operated in accordance with prescribed procedures.

• The maintenance cost for a system will not exceed an amount of money per designated period of time, when the system is operated and maintained in accordance with prescribed procedures.

Summing up, maintainability is a design characteristic that must be considered in the early phases of the system development. (Blanchard B.S., 2004).

**Asset management**

Based on Vesel, R., DuBay, J. (2008), asset management is an improvement approach for optimizing all technical and operational aspects by lowering lifecycle costs that are in an installation, such as the maintenance costs. That is the reason why it can be defined like an application of advanced maintenance. Its main advantage is the capacity to detect the failures before they had happened. By implementing a strategic asset management into an organization, several goals can be achieved, such as the following:

• Development of models to predict asset failure and to identify and concentrate investment on critical assets.
• Improve the management of systems.
• Utilization of advanced maintenance techniques.

This allows reducing the time between the identification of the failure and the solution. So, it can be said that the asset management strategy is concentrated on four main points:

1. Installation performance
2. Reduction of operational and maintenance costs
3. Reliability and availability improvements
4. Maintenance strategies

**Maintenance Engineering**

They are required for the optimization of the equipment, to achieve procedures and departmental budgets in order to get better reliability, availability and maintainability of the equipment. In order to have a qualified maintenance program, based on Hawkins B., Smith R., (2004), there are several factors to take into account (see figure 7).
What methods and tools are used to improve the situation of the electrical installation?

There are some techniques used to measure the technical conditions in an electrical installation that will be discussed after. In this research some of them have been studied. They are:

- Actions and advices for a correct use of the installation
- Thermography inspections
- NEN Inspections
- Assurance of a correct Payback Period
- Benchmark analysis

Actions and advices for a correct use of the installation

A list with advices and actions to take into account for the different aspects that involve an installation is included in the appendix E. They are classified into:

- General aspects of an electrical installation
- Lighting system
- Electrical engines
- Transformers
- Pump system
- Cooling and air conditioning system
- Compensation on the reactive energy
**Thermograph inspections**

Failures or malfunctions in these installations are a major factor in starting fires and may also lead to dangerous electric shocks. Companies need to assess their electrical risk and analyze the condition of the electrical installation.

Based on FLIR Systems (2008), thermograph inspections allow visualizing an object by the infrared rays that it radiates. The amount of radiation emitted by an object increases with temperature. It shows a visual picture so temperatures over a large area can be compared. It is capable of catching moving targets in real time, to find deteriorating (i.e. at higher temperature) components prior to their failure, to be used to measure or observe in areas inaccessible or hazardous for other methods. Next, there is an example of a picture taken with a thermographic camera (see figure 8). The different colours show the different temperatures (as it is indicated on the right side of the picture) that determine an industrial electrical fuse block. This is a first step for the detection of potential failures. It has to be analyzed to obtain the reason of the failure.

![Thermographic Camera](image)

**Figure 8: Failure in an electrical fuse detected by a thermographic camera (FLIR systems, 2008)**

**NEN/ISO Inspections**

The NEN and ISO inspections are all the tests performed on the electrical systems in order to get the different NEN or ISO certifications. As named before, the most important standards that require an inspection are:

- NEN 3140: Management of electrical (low-voltage) installations
- NEN 3840: Management of electrical (high-voltage) installations
- ISO 9001: Quality management requirements
- ISO 14001: Environmental management requirements

The company, by carrying out these inspections, will get some benefits:

- The reduction of the cost and time by managing compliance with multiple standards and regulations with one system in a systematic and uniform way.

- They ensure the company get tangible business value out of quality, environmental and electrical installations projects by integrating related processes with performance management to drive continuous improvement.
✓ They integrate the management of quality, care for the environment and electrical installations with the processes of the company by providing the employees with a system that makes it part of their daily tasks.

Assurance of a correct Payback Period (PBP)

Based on accountingformanagement.com (2008), the payback period is defined as the time taken to recover the initial investment. It is a method for analysis that represents the estimated period of time that passes since the realization of the investment till the return of it. This return to the investment can continue after the payback period. It is the period of time passed till the cost saved in equipment equals the costs spent. In order to calculate the PBP, it is necessary to apply the next formula:

\[
PBP = \frac{\text{Invested required}}{\text{Net annual cash inflow}}
\]

The payback method is not a true measure of the profitability of an investment. However, it is sometimes used as a way of comparing alternative investments with respect to risk. An investment with a short payback period is considered less risky.

Benchmark analysis of the equipment

This is a process of comparing the cost, time or quality of the equipment available in the installation and in the market. This is made in order to make improvements and to change the equipment that doesn’t work efficiently. In order to implement it, there are several steps to follow:

1. Identification of the equipment which has a problem
2. Identification of other similar equipment/machines in the market
3. Identification of the best equipment available
4. Implement changes if it is necessary and replace the equipment

3.2.7. Technological Development

In the technological development, the measurements and techniques involved evolve quickly in time and are used to repair all the faulty equipment. The goal of the technological development is to select the correct solutions and the technical conditions according to the new technologies, to repair the equipment that doesn’t work efficiently and that is affecting to the whole operation of the installation. In the conceptual model given in figure 2 the technological development covers all the aspects of an electrical installation management. The influence on the four main aspects is:

- **Organization.** New technology sometimes implies modifications of the whole organization. If, for example, new equipment is introduced into the installation it is necessary to know the performance of it. Sometimes training of the personnel can be needed, in order for them to know how the new machinery works. Besides, when a company buys new equipment or uses new technologies, this is an expense for it. New technologies, in most of

---

3 If new equipment is replacing old equipment, this becomes incremental net annual cash inflow.
the cases, mean high investment at the beginning. Sometimes, the organization requires new technologies in order to be more efficient.

- **Rules and regulations.** Nowadays, new equipment is designed, among other objectives, in order to become sustainable. Governments support these technologies applied into the industry and because of that they promote these investment with subsidiaries. Some requirements need the application of new technologies to be fulfilled.

- **Energy.** In energy terms, technology development is linked with the energy development. It is achieved by providing sustainable energy equipment. New equipment is more sustainable, in part, because of the reduction of the energy use they have. In order to achieve the energy conditions to be sustainable, sometimes is required the use of new technologies. Besides, new technologies are required in order to obtain energy savings.

- **Technical conditions.** In the technical conditions, new technology can be applied by new equipment. New equipment can need less maintenance than old equipment. Besides, by implementing new equipment in the installation the performance will be better and less expensive, because of the reduction of the maintenance costs.

### 3.2.8. Marketing

In this section all the information collected of the marketing aspects is explained (see figure 9). There is a SWOT analysis of Imtech in order to detect inconvenients and try to improve them. Besides, there is a benchmarking analysis of the most significant competitors of Imtech, a study of the potential customers opinion and a study of the trends in this field.

<table>
<thead>
<tr>
<th>MARKETING INFORMATION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Trend Analysis</strong></td>
</tr>
<tr>
<td>To predict future outcome and useful to know if the service will be applicable or not</td>
</tr>
<tr>
<td><strong>SWOT Analysis</strong></td>
</tr>
<tr>
<td>This is the process to detect the: strengths, weaknesses, opportunities and threats of the company</td>
</tr>
<tr>
<td><strong>Potential Customers</strong></td>
</tr>
<tr>
<td>Make a questionnaire in order to know what is their opinion</td>
</tr>
<tr>
<td><strong>Important Competitors</strong></td>
</tr>
<tr>
<td>Determine who are the main competitors and what services do they make.</td>
</tr>
</tbody>
</table>

**Figure 9: Marketing analyses**
Trend Analysis

Based on Imtech IS (2009), a trend analysis is a quality control tool that determines whether the performance strengths are improving or deteriorating. In this case, the analysis is focused on the feasibility of this assignment. It will allow seeing what is the current situation on the four factors defined in this research for an electrical installations management (organization, rules and regulations, energy and technical conditions) and what will be their future trends. In this research several trends have been selected to apply them to the four factors, in the following way:

- **Organization.** Related to this factor, the social trends that can affect to the organization of a company will be discussed in order to determine the future actions Imtech and the customers will take.

- **Rules and Regulations.** The trends that have been considered more relevant to this field in this research are the environment trends because some of the requirements are focused on the environment. One example is the implication of the Dutch government in the achievement of the objectives determined in the Kyoto protocol.

- **Energy.** The evolution of the energy through a more efficient use of it will be discussed, as so as the factors that influence it, such as the use of new technologies.

- **Technical Conditions.** One important aspect in the evolution of the technical conditions of an installation is the technology factor. Currently, it is a wide field that evolves quickly in time. This evolution can affect the technical conditions of an installation.

In further chapters, the results obtained from this trend analysis will be discussed.

SWOT Analysis

It is used within organizations in the early stages of strategic and marketing planning and in problem solving, decision making, or for making staff aware of the need for change. Next, based on Imtech (2008) there is the analysis with all the strengths, weaknesses, opportunities and threats that Imtech has (see appendix A). The aim of a SWOT analysis is to improve the company situation by studying not only the good aspects, but also the bad aspects. That is to say, the goal of this analysis is to reduce all the weaknesses and threats by trying to convert them into positive points for the company and to use all the opportunities the company has.

Based on Imtech (2008), if we link the strengths with the opportunities Imtech has, there are several conclusions and actions to take into account. They are:

- **Internationalization:** several locations in Europe can help Imtech to expand itself and to collaborate between them in order to have a better communication and quality in the services.

- **Increase of high value of ICT through a further strengthening of partnerships with world market leaders.**
Imtech can give more value to the customers by using services such as project management, asset management, project financing, risk management and energy contracting integrating in one service.

Imtech has several very good strengths. Moreover, if the threats are critically analyzed, they can be converted into new strengths, such as:

- Imtech’s reputation, independency are used to adopt new technologies and more qualified people.
- Sustainable technology for low price during the Life Cycle, what gives specific knowledge about contracts.
- By risk management they are able to comply with the legislation.

Finally, in order to reduce to the minimum all the incorrect practices and points that don’t allow the company to improve, the weaknesses can be turned into strengths by:

- Improving the collaboration between departments of Imtech, helping organizations to focus on its core competence.
- Developing potential knowledge and management skills in relation to the speed because there has to be a balance.

**Potential Customers**

In order to know what is the opinion about this topic of the potential customers, a questionnaire was made. The aim of it is to determine who are these customers, their current situation into the energy and environment aspects and what things can be improved for a correct performance.

By means of a simple and short questionnaire several companies where interviewed on 21st, 22nd and 23rd of April during the *Industrial Maintenance trade fair* in Rotterdam. This was an opportunity to view and contact with new and known customers in order to introduce this project and get some information about their working. The questionnaire consisted of 13 questions that were about:

- The environment awareness
- The certifications of the company
- The quality, safety and improvement activities
- The maintenance concept
- The external factors that affect the company
- The expectations from Imtech

The complete questionnaire is in the appendix H. The conclusions and results of it will be explained in further chapters. A frequency distribution of the questionnaire is shown in appendix I.
Main Competitors

A study about the competitors of Imtech and the services and products they made is important to make in order to know what they do, what differences between them and Imtech are and what exists on the market. The main competitors of Imtech are Croon, GTI suez, SPIE, Cegelec and Stork, among others (see figure 10).

Figure 10: Imtech’s competitors

All of them work in the field of industry and the services they implement are similar. Most of them work in the same fields (among others):

- Energy management
- Installations management
- Maintenance management
- Tests and inspections
- Consultancy

In relation to the topic of this report, some of them have proposed several solutions. Next, some of them are explained:

SPIE is specialized in performing NEN inspections in electrical installations, with the documentation and the training of the personnel. They also promote the Cryornest®. This is a tool for cleaning the electrical systems without interrupting the work of it. This method makes the installation safer. (SPIE, 2009). Another solution Croon proposes is the use of remotely readable meters. (Croon, 2009). This is a solution similar to the one Imtech Measurement Solutions is using. IMS proposes the Certified Energy Measurements. By performing energy measurements it provides a better understanding of the energy usage and a control on the energy costs.
4. Results

This chapter contains the results obtained from the research. The information that is considered relevant and applicable to the optimization of the electrical installations management will be discussed.

4.1. Characteristics of the model

In order to make an integrated concept of this research, the main aspects that influence an electrical installation performance should be connected between them. The conceptual model given in the figure 11, shows six connection points that link all the aspects involved in the electrical installation management.

Figure 11: Optimization of the electrical installations model

Next, an explanation about the relationship between the six connection points of organization, rules and regulations, energy and technical conditions is made:

1. Organization - Rules and Regulations

The organization has to know the basic requirements and programs that the government offers. It has to be critical and decide which standards and regulations are going to be applied, because not all of them are mandatory. The participation of the top management is essential in order to decide what programs they are going to apply.

In the other part, the rules and regulations establish some guidelines and actions that should be taken into account by the organization. In the research chapter some of the applicable standards were mentioned and in this section, some of the specifications referred to the organization are explained.

ISO 14001: Environmental Management Systems

This standard is a mandatory standard which specifies a set of environmental management requirements for environmental management systems. Its main purpose is to help all kind of organizations to prevent pollution, protect the environment and improve their environmental
performance. In order to fulfil the ISO standards for a better performance of a company, based on the annex A of the ISO 14001 (2004) standard, there are some specifications that an organization has to take into account:

The organization needs to identify the legal requirements that are applicable to its environmental aspects. These may include:

a) national and international legal requirements  
b) state/provincial/departmental legal requirements  
c) local governmental legal requirements

In relation with the tasks an organization has to implement in order to get this certification this international standard requires an organization to:

a) establish an appropriate environmental policy,  
b) identify the environmental aspects arising from the organization’s past, existing or planned activities, products and services, in order to determine the environmental impacts of significance,  
c) identify applicable legal requirements and other requirements to which the organization subscribes,  
d) identify priorities and set appropriate environmental objectives and targets,  
e) establish a structure and a program(s) to implement the policy and achieve objectives and meet targets,  
f) facilitate planning, control, monitoring, preventive and corrective actions, auditing and review activities to ensure both that the policy is complied with and that the environmental management system remains appropriate, and  
g) be capable of adapting to changing circumstances.”

Besides, every company has to define the environmental policy that reflects the commitment of top management to comply with all the legal requirements. And this policy “should be communicated to all persons who work for, or on behalf of, the organization, including contractors working at an organization’s facility” (ISO 14001, 2004).

ISO 9001: Quality Management Systems

This standard is voluntary for the companies. It is focused in all types of organizations and it can help both products and service-oriented organizations achieve standards of quality recognized through the world. The comments mentioned before are also applicable to this standard, by changing some terminology. In the appendix E there is a table with the correspondence between these two ISO standards. (ISO 9001, 2000).

NEN 3140/EN 50110-1: Management of (low voltage) Electrical Installations

This standard provides the information and general requirements for safety and maintenance of the (low voltage) electrical installations and electrical tools. Regarding to the organization’s role, it establishes all the conditions they have to obey and implement. Among other specifications, this standard requires the availability and update of all the existing documents in the installation.

Some of the specifications are about the tasks and responsibilities of the personnel:
• One person of the organization has to be the responsible for an electrical installation.
• The personnel who work in an electrical installation have to get an adequate technical knowledge and training.
• The responsibilities regarding to safety of the personnel working with electrical installations must be in step with the national legislation.
• The personnel have to comply and execute all these prescriptions. One example of these prescriptions is the obligatory use of the safe clothing of the personnel on the electrical installations.

Based on this normative, the communication within the organization has to be promoted. By this way, everybody has a better understanding of everything that happens in the installation, because:

• All tasks and responsibilities of all the personnel must be defined in a clear way.
• All the personnel must be informed frequently about safety and corporate prescriptions.

NEN 3840/EN 50110-2: Management of (high voltage) Electrical Installations

The scope of the standard NEN 3840/EN 50110-2 differs with the standard NEN 3140/EN 50110-1 on the voltage used. This is applicable to installations with a voltage higher than 1000V. All the requirements and specifications are similar to the previous one but with more restrictions due to the high voltage of the installation.

2. Rules and Regulations – Energy

The Dutch government, through the Ministry of Economy, establishes the criteria for implementing different actions depending on the energy consumption of a company in order to get a licence to operate a flowchart with the requirements given in the appendix C. Based on Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer, Ministerie van Economische Zaken (1999) it is established that:

• If the energy costs are higher than €7,000, it is necessary to make an analysis of the energy use with an inventory of all the equipment that consumes energy.

• If the energy costs are less than €45,000 a Limited Energy Scan is required.

• If the energy costs are higher than €45,000, it is required to implement an Energy Scan.

• There is another action to take, a Feasibility Study, when the Return on Investment is unknown.

• If the Return on Investment is known and the Payback Period is less than five years it is necessary to generate energy prescriptions and the specification of the requirements for the measures that have to be taken in order to save energy.
The rules and regulations focused on energy are written in order to achieve energy savings. In the other hand, the high demand and consumption of energy has made the governments to look for programs to create an economy that is both efficient and sustainable in terms of its energy use.

The Dutch Ministry of Economy, through Senternovem agency, offers several products and services regarding the energy sustainability, such as:

- Energy Investment Allowance
- BESS: Benchmarking and energy management schemes in the Small- and Medium-sized Enterprises (SME’s)
- Long Term Agreements (LTA)

3. Energy – Technical conditions

In order to be an energy efficient and sustainable company, the Dutch government, through the flowchart given in the appendix C, establishes the criteria to implement the different energy solutions to reduce the consumption. The guidelines have been explained in previous chapters. Depending on the annual consumption of energy, the services to apply are different. Figure 12 gives the relation between the energy consumption and the solution applicable in some cases.

![Figure 12: Solutions depending on the energy consumption](image)

For the other cases of consumption, there are other solutions:

- Energy QuickScan
- Performance Advices
- Energy Potential Scan
- Feasibility Energy Study

With these services, not only the bills, but also the technical conditions of the equipment and the whole installation are inspected and evaluated in order to detect the critical points that don’t allow the installation to work under the legal requirements and in an efficient way.
The energy consumption of an installation depends on the performance of the equipment. If the equipment doesn’t work efficiently, with continuous failures and wasting energy, the consumption will be higher. That is the reason why all the technical equipment of the installation has to be checked periodically and improved in order to get an efficient performance. In this improvement the RAM engineering and Asset management techniques have an important role because they allow optimizing the technical and operational aspects. At the same time they give reliability and availability improvements. By making periodical revisions where the failures are detected and the solutions are defined, the reduction of the energy consumption can be achieved.

4. Technical Conditions – Organization

One of the objectives is to achieve a correct performance of all the equipment of the installation. The equipment has to work in a reliable, available and maintainable way; and because of that, the maintenance department is one of the most important parts in this stage. Defining a good maintenance and asset strategy is a crucial fact to achieve this objective. Based on Thomson N. (2002), in order to have a good strategy for a safe and effective installation, the tasks of the people involved in the maintenance process have to be defined clearly. These tasks are (among others):

- Analysis of repetitive failure of the equipment
- Forecasting of spare parts
- Assessing required maintenance tools and skills for efficient maintenance
- Assessing and repairing safety hazards associated with the maintenance of equipment
- Estimation of maintenance costs and evaluation alternatives
- Assessing the needs for equipment replacements and establish replacement programs
- Assessing required skills and knowledge for maintenance personnel

By implementing these tasks in the organization, the technical conditions of the equipment will be improved. Thanks to a good strategy, a safer and more efficient operation of the equipment can be achieved.

And for the managers to control the organization is important to consider the standard NEN-EN 15341: Maintenance-Maintenance Key Performance Indicators. This standard, explained in further sections, provides the indicators to achieve a maintenance excellence.

5. Organization – Energy

The energy aspects of an electrical installation are in relation with the organization. The whole organization has to be involved in all the changes that are related to them. One step for a plant to be energy efficient is to adopt an energy management system.

Every company should have an energy function to control all the aspects related to it, like energy reduction, energy efficiency or energy bills. If the company is small sized, it is not necessary to create a big department. In this case, one person will be responsible of the energy management. However, in bigger companies, the implication of more personnel of the company will be necessary. Besides, all the improvements made in the energy field are improvements for the organization, such as:
• Energy savings
• Cost savings
• Improvement in the efficiency of the equipment
• Development of renewable energies

The implication of the whole organization is important for the improvement of the energy situation of the company. Not only the personnel responsible for the energy management is required, but also all the personnel of the company have to be involved in the changes. This implication can be achieved by giving brochures to the workers, making meetings with the explanation of the benefits of the energy savings, by inspecting their behaviour with the machineries and the installation, etc.


The requirements and legislation an electrical installation management has to comply with can be achieved by the improvement of the technical conditions of the equipment. For example old equipment will consume more energy and consequently costs will be higher.

Based on the regulations that have been named previously, here there are the requirements they specify related to the technical conditions and equipment of the installation.

*NEN 3140/EN 50110-1: Management of Electrical Installations*

The Management of Electrical Installation rule establishes several specifications, such as:

• The establishment of maintenance procedures in the equipment.
• The development and implementation of standard procedures such as inspections and tests.
• General rules for safety equipment.
• Rules for the labelling and the lay out of a workshop of the electrical installations.
• The execution of a risk assessment before the maintenance operations.

*NEN-EN 15341: Maintenance-Maintenance Key Performance Indicators*

This is a European standard that provides the key performance indicators to support management in achieving maintenance excellence and utilize technical assets in a competitive manner (NEN-EN 15341, 2007). The maintenance has an important role in this connection between the technical conditions and the rules and regulations because, in some cases, by implementing a good maintenance on the equipment the requirements can be achieved.

According to this rule there is a relationship between the total maintenance costs of the equipment and the energy costs. This relationship comes from the technical conditions of the equipment and is considered as an economic factor that can be influenced by the laws and regulations.
4.2. Description of the optimization process

The outcome of this research is a plan for the optimization of the electrical installation. This plan aims for savings in consumption and costs and for optimizing the current resources. The process is divided into four steps (see figure 13). Every step is related to the aspects of the electrical installation management in order to achieve a complete optimization plan.

![Figure 13: Steps of the optimization process](image)

1\textsuperscript{st} Step: Inspection

First of all, the scope is defined in order to establish which parts of the installation are going to be inspected and what will be ruled out of the inspection. During the inspection several aspects will be analyzed:

<table>
<thead>
<tr>
<th>Inspection</th>
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</thead>
<tbody>
<tr>
<td><strong>Organization</strong></td>
</tr>
<tr>
<td>• Organigram of the organization</td>
</tr>
<tr>
<td>• Check the personnel tasks</td>
</tr>
<tr>
<td>• Safety conditions of the workers</td>
</tr>
<tr>
<td><strong>Rules and Regulations</strong></td>
</tr>
<tr>
<td>• Define the required certifications applicable to the installation</td>
</tr>
<tr>
<td>• Check the certifications the installation already has</td>
</tr>
<tr>
<td><strong>Energy</strong></td>
</tr>
<tr>
<td>• Inspect electrical contracts and budgets</td>
</tr>
<tr>
<td>• Check of the last years bills</td>
</tr>
<tr>
<td>• Sankey diagram of the installation to see the energy flow</td>
</tr>
<tr>
<td><strong>Technical Conditions</strong></td>
</tr>
<tr>
<td>• Technical conditions of the equipment, such as the calibration of the grounded connections, schemes of the installation, documentation, etc.</td>
</tr>
<tr>
<td>• Safety conditions, such as the protection devices, the existence and calibration of protection devices, etc.</td>
</tr>
</tbody>
</table>

Table 3: Inspection of the optimization process
Once the inspection has finished, the failures and problems identified in the installation have to be evaluated. Based on Hawkins B., Smith R., (2004), it can be evaluated by a Critically Assessment. It indicates how important equipment or system function is relative to the production, environment or safety. Appendix F provides a method with ten categories of criticality, from none to hazard effect on the installation. The hazard they have will influence the next steps of the process. This table can be used as a tool to calculate the dangerousness of the equipment failure into the maintenance program.

2\textsuperscript{nd} Step: Working plan

All the faults and possible problems detected are analyzed and studied in order to solve them. Then, a plan to solve these aspects has to be designed and proposed to the manager of the company. If the company accepts the working plan, it should be implemented. This working plan is

<table>
<thead>
<tr>
<th>Working Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Organization</strong></td>
</tr>
<tr>
<td>• Selection of the parts of the organization that need to be improved</td>
</tr>
<tr>
<td>• Redefine tasks of personnel to become an optimized organization</td>
</tr>
<tr>
<td><strong>Rules and Regulations</strong></td>
</tr>
<tr>
<td>• Selection of the applicable requirements for the installation</td>
</tr>
<tr>
<td>• Define the costs and consequences of the implementation of the requirements</td>
</tr>
<tr>
<td><strong>Energy</strong></td>
</tr>
<tr>
<td>• Thermography study to identify the points of the installation where there are leaks of energy or false contacts.</td>
</tr>
<tr>
<td>• Select the energy saving program applicable depending on the energy consumption</td>
</tr>
<tr>
<td><strong>Technical Conditions</strong></td>
</tr>
<tr>
<td>• Revision of the one-line diagram or P&amp;ID of the installation in order to detect the location of the possible faults</td>
</tr>
<tr>
<td>• Benchmarking of the faulty equipment</td>
</tr>
<tr>
<td>• Redefining the maintenance plan</td>
</tr>
</tbody>
</table>

Table 4: Working Plan
3rd Step: Report

With all the information collected in the previous stages, a report has to be written. It has to contain for every section:

- Date of the inspection
- Name of the person who has made the process
- All the elements and sections that have been analyzed
- Parameters and results that have been obtained
- Evaluation of the results
- Improvements that should be implemented. Depending on the seriousness of the faults detected they should be implemented in the short or long-term.
- Proposal of monitoring: a plan for monitoring and checking all the measurements that have been made in order to continue with the improvements established is required to obtain continuous improvement.

4th Step: Implementation and Monitoring

All the measurements and improvements have to be implemented. After that, they have to be monitored in order to check that these improvements are working and the modifications become a positive result for the installation.

One content of the report is a proposal of monitoring. The definition of a correct monitoring plan is very important for the last step in the optimization of the electrical installations management. By making periodical inspections the monitoring will be made possible. In these inspections all the modifications and measurements established before are analyzed and checked. Besides, the training of the personnel is a very important aspect to take into account and work on it. If the personnel have the adequate knowledge and skills, the performance of the installation will be improved.
4.3. Communication process

After discussing how the process of optimization of electrical installations management should be performed, an explanation of the process of communication between Imtech and the customer is developed. The flowchart of the communication process is given in the appendix B. It consists of three stages that cover the first contact between Imtech and the customer to the end, obtaining of the optimization of the process. The steps are:

1\textsuperscript{st} Stage: Approach

The customer asks for information about the service Imtech is promoting. In this stage the relevant information about the optimization of electrical installations management (utility, methodology, parts involved, requirements, advantages, disadvantages, etc.) is shared with the client.

<table>
<thead>
<tr>
<th>Imtech</th>
<th>Account manager</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Marketing department</td>
</tr>
</tbody>
</table>

| Customer | Top/middle manager |

Table 5: Functions and departments involved in the 1\textsuperscript{st} stage of the communication process

The account managers from Imtech are in contact with the top or middle manager of the customer in order to share the information about the service. If Imtech goes to the client, the marketing department of Imtech also participates in this process by promoting the service and introducing it into the market (see table 5).

2\textsuperscript{nd} Stage: Approval

Imtech starts with a preliminary inspection of the plant, in which all the systems, equipments, machinery, practices are analyzed in order to detect if there is any anomaly in the performance. If the inspection is positive, the plant works efficiently, the process has finished, but if not, if there is any failure that doesn’t allow the plant to work properly, the service has to be applied.

<table>
<thead>
<tr>
<th>Imtech</th>
<th>Maintenance engineering department</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>QSHE department</td>
</tr>
</tbody>
</table>

| Customer                | Maintenance engineering department |
|                         | Production/Operation department    |

Table 6: Functions and departments involved in the 2\textsuperscript{nd} stage of the communication process
The maintenance engineering department and the production and operation department of the customer provide all the relevant data and information from the equipment and installation to the maintenance department of Imtech. Also, the QSHE department and the maintenance engineering department of Imtech can participate in the inspection in order to detect bad practices or some safety failures that can affect the performance of the installation. As a result, they determine the efficiency of the installation and if it needs to be improved (see table 6).

3rd Stage: Optimization process

Imtech starts by changing all the bad performance, repairing all the non-effective equipment, taking the appropriate corrective actions and also training the personnel in order to change their behaviour. Then, Imtech or the customer has to monitor if all the changes are useful. If the electrical installation has been optimized the process is finished. But if the installation still doesn’t work efficiently, Imtech has to study the application of new technologies in the equipment, remake the inventory of the installation and look for new solutions to the problem.

<table>
<thead>
<tr>
<th>Imtech</th>
<th>Maintenance engineering department</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>QSHE department</td>
</tr>
<tr>
<td>Customer</td>
<td>Manager</td>
</tr>
<tr>
<td></td>
<td>Maintenance engineering department</td>
</tr>
<tr>
<td></td>
<td>QSHE department</td>
</tr>
<tr>
<td></td>
<td>Production/Operation department</td>
</tr>
<tr>
<td></td>
<td>Technicians</td>
</tr>
</tbody>
</table>

Table 7: Functions and departments involved in the 3rd stage of the communication process

If the installation has to be optimized, the manager of the installation has to give the approval. Then, the maintenance, safety and quality department of Imtech work together with the departments of the customer. The production department works with the technicians in order to explain them the saving solutions, the practices to change and all the reparations that have to be made. Here also all the energy aspects have to be solved. Then, it is advisable to have a person or department (depending on the size of the company) responsible for the energy management (see table 7).
4.4. Introduction into the market

In this section, the results obtained from the research about the marketing aspects will be described:

- The results from the trend analysis.
- The results from the SWOT analysis.
- Results related to the potential customers.
- Ways to introduce and promote this service into the market.

4.4.1. Trend analysis

In the research chapter, a relationship between the organization, rules and regulations, energy and technical conditions with several trends has been established. Next, there are the results obtained:

Social trends and Organization

There are several social trends from potential customers that affect Imtech. Based on Imtech (2008), more and more customers are specifying their desired output. This means that Imtech, as a technical service provider, must specify how they can help customers to achieve these outputs. Imtech must take them into account in order to define future actions and strategies. These trends are:

- An increase in the demand for energy saving, alternative energy and fuels and solutions that contribute towards a better environment and reduced CO$_2$ emissions.
- An increase in the demand for safe and reliable technology.
- An increase in the demand for security from the authorities, the business world and consumers.
- An increased trend in the outsourcing of the responsibility for technology services.

Due to all these trends, Imtech must increase its added value in this respect. This means that Imtech has to invest in the development of technical services such as project management, asset management, project financing, risk management and energy contracting as an integral component of the total services package. Because of that, it can be said that the future evolution of this services will be positive for the development of Imtech as a technical service provider.

Environmental trends and rules and regulations

Based on Schäfer O., Teske S., Zervos A. (2007), from 1990 to 2005 the global energy use has increased 23%, with an increase of 25% of the CO$_2$ emissions. In the current market there are several barriers and failures that don’t allow the energy use to be improved. The low priority of energy issues and the inaccurate information about this aspect are two of these problems.

In spite of this, more and more, companies are trying to change the situation and to convert them more sustainable. The government has an important role in this awareness. It demands
new requirements the companies should comply with. Addressing climate changes and rapidly increasing supply-demand gap is one of the most important activities of the electric utilities management worldwide. The industry has undergone progressive restructuring over the last decade along with significant regulatory changes to accommodate the associated change. So, if companies continue as so far, implementing environmental friendly techniques and activities the CO₂ emissions and the environmental situation will be improved and reduced with approximately 80% (see figure 14).

![Figure 14: Global CO₂ emissions evolution until 2100 (Schäfer O., Teske S., Zervos A., 2007)](image)

The Dutch Ministry of Economic Affairs, through Senternovem, promotes sustainable development and innovation to achieve positive results in the environment and economy. They offer several programs, such as:

- Environment & technology
- Green funds scheme
- Greenhouse gas emissions and monitoring
- ROB international: reducing non-CO₂ emissions
- Energy Investment Allowance (EIA)

All these programs are for the industry sector in relation with the environment and aim for the objective to be more sustainable with the environment.

**Technology trends and technical conditions**

Currently, there is an increasing demand for technology. Technological services demand and total technical solutions are increasing. It is playing a role in solving social issues more often. Without technology comfort the lifetime of equipment is short. Technology keeps business processes running and improves them, because of the better performance the new technologies imply.

In the future, technology is increasing. More and more there are new better products and new better solutions to make more efficient equipment. By improving the quality of the equipment with new technologies, the performance of the installations will be better.


Energy trends

The savings in the energy aspects are more and more important. Based on International Energy Agency (IEA) (2008), with the application of new technologies and by implementing energy advices as energy efficiency, the consumption of it will be reduced.

There is an evolution on the energy activities since the application of the efficiency (see figure 15). Continuing these activities based on efficient energy, the savings in the long term will be improved.

![Energy savings due to energy efficiency improvements](image)

**Figure 15: Long term energy savings from improvements in energy efficiency (IEA, 2008)**

Accelerating energy efficiency improvements is a crucial challenge for energy and climate policies. A large potential remains for further improvements in energy efficiency across all sectors. For instance, the application of proven technologies and best practices on a global scale in industry could save between 25 EJ\(^4\) and 37 EJ per year (1.9 Gt CO\(_2\) to 3.2 Gt of CO\(_2\) emissions per year). Because of this, Imtech should focus on the promotion of the optimization of electrical installations management (regarding to the energy aspects) as a way to achieve energy savings and reductions. (IEA, 2008).

4.4.2. SWOT Results

As a result from all the strengths, weaknesses, opportunities and threats named in the SWOT analysis based on Imtech (2008), Imtech has to adopt a strategy in order to improve the current situation. Imtech has to focus on the current opportunities trying to convert them into strengths. Besides, the threats and weaknesses have to be converted into strengths and opportunities. Because of that, several aspects have to be taken into account:

- As Imtech wants to be one of the most important services providers in the technical market, it has to detect what is the current most important demand from the market.
- In this case, the communication between Imtech and the customer can be improved by the implementation of technology applications.

\(^4\) 1 EJ = \(10^{18}\) J = \(278\times10^9\) GWh = \(278\) TWh = \(34.1\) Mt
✓ To achieve a good position in the market, Imtech should take advantage of the current increasing demand for technology and related services.

✓ There is also an increasing demand in the energy and environment. So, currently, this is the moment to start promoting this service to the customers.

✓ The training programs can also be an important action in order to face the technological developments that evolve fast.

4.4.3. Potential customers

As mentioned before, Imtech is a service provider in several sectors, but not all of them are applicable to this optimization of electrical installations management service. The first step to take into account is to identify the sector in which this service will be implemented. Next, a list with the sectors that Imtech IS works on is given. However, not all sectors are applicable to this service of optimization. Table 8 shows the sectors of the usual customers of Imtech and which of them are target markets to the optimization of electrical installations management.

### Customer’s Sectors of Imtech Industrial Services applicable to the Optimization of Electrical Installations Management

<table>
<thead>
<tr>
<th>Sector</th>
<th>Applicable to this project?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automotive industry</td>
<td>✗</td>
</tr>
<tr>
<td>Building materials</td>
<td>✗</td>
</tr>
<tr>
<td>(Petro-) chemical industry</td>
<td>✓</td>
</tr>
<tr>
<td>Drinking water</td>
<td>✓</td>
</tr>
<tr>
<td>Energy &amp; Environment</td>
<td>✓</td>
</tr>
<tr>
<td>Food &amp; Feed</td>
<td>✗</td>
</tr>
<tr>
<td>Machine</td>
<td>✓</td>
</tr>
<tr>
<td>Metal &amp; Electrical Industry</td>
<td>✓</td>
</tr>
<tr>
<td>Oil &amp; Gas</td>
<td>✓</td>
</tr>
<tr>
<td>Paper &amp; Cardboard</td>
<td>✗</td>
</tr>
<tr>
<td>Pharmacy</td>
<td>✗</td>
</tr>
</tbody>
</table>

Table 8: Target Markets for the Optimization plan (Imtech IS, 2009)
As a result of the interviews performed (see appendix H) among potential customers at the Industrial Maintenance trade fair in Rotterdam, an overview of their way of thinking has been obtained:

- In relation to the legal requirements and environmental aspects 80% of the people who answered the questionnaire are aware of the environmental aspects that affect a company. Most of them have the ISO certification of Quality and Environmental management standards.

- All of them implement maintenance for the improvement, quality programmes and new technologies, but about the strategic outsourcing, only half of them rely on the services made by other companies, which means that Imtech has to take this into account in order to make an intensive promotion of it in several companies.

- The aspects that are more important for the companies are the requirements from the government, the quality, the internal costs and the environmental management, while the energy management, the competence and the necessity of modernization are less important for them. This indicates what are the most important aspects to mention when the service will be explained to the customer.

- About the internal practices the companies implement, the safety and quality activities are the most applied. However, the flexibility of the plant and competence benchmarking are not implemented at all. Because of that Imtech has to comply with these points as improvements.

To sum up, most of them want to improve their current situation, because the main problems they have detected are the finalizing of the optimization and the qualification and education of the personnel. Because of that, the training of the personnel has to be mentioned in the approach to the customer. In turn, the customers surveyed expect a good service from Imtech with very good qualified personnel.

4.4.4. How can this service be introduced into the market?

Based on Imtech IS (2009), the way to introduce a service into the market can vary depending on the customer. The customer can be a new customer or a regular customer of Imtech. Depending on this, there are two ways to introduce a new service into the market:

a) Direct: this is made when the customer is new. There has been no contact with Imtech before and Imtech is not implementing any service to it. It is called direct because the service is introduced directly to the customer. Imtech goes to the customer, or vice versa and the service is explained and promoted.

b) Indirect: this is applied when the customer is a current customer of Imtech. For example, if this customer is implementing a service from Imtech, this optimization for the electrical installations management service can be explained and promoted as a solution or complement to the current service it has.
Imtech IS works on services to the customer. There are several methods to promote one service that Imtech IS always uses. One service can be promoted to the new customers, but also inside Imtech. In order to do it, several methods are usually used:

- Mail or Email
- Internet
- Brochures
- Present it directly to the customers
- Make seminars

Applied to the optimization of electrical installations management service, all of them are applicable. However, making a seminar can be a challenge to Imtech to show and share the knowledge of the future service to the customers. In these seminars Imtech can invite the potential customers that could be interested in the application of the service. After a seminar has been made, Imtech can make an appointment with the customers individually. This will allow a direct contact with the client in order to improve the relationship. Besides, the service can be explained in more detail and customized to the client. During this appointment, the use of brochures is required. These brochures should contain the most important information, supported with pictures, in order to make easier the understanding of the service to the client. Internet and email promotion are useful but it doesn’t allow having a direct contact with the client. They can also be used as an approach or as a first contact with some new customers.
5. Conclusions and Recommendations

After the information showed in this report, the report is finished. Several conclusions and recommendations obtained from the whole report are described.

5.1. Conclusions

In this section there is the outcome of the research. The conclusions obtained contain the answers to the main question and subquestions.

What are the advantages and disadvantages?

Before the main conclusions, it is important to know what are the advantages and disadvantages of the optimization of the electrical installations management. The advantages are classified into the four aspects of the installation management. They are:

- **Organization**
  - Reduction of the costs
  - Better and more sustainable image of the company
  - Professional development of the personnel

- **Rules and Regulations**
  - Standard method to comply with the rules and regulations
  - Reduction of CO$_2$ and other hazard substances emissions
  - Licence to operate
  - Key to achieve the Kyoto Protocol requirements
  - Key to get subsidies from the government

- **Energy**
  - Savings in energy consumption
  - Better understanding of the energy flows

- **Technical conditions**
  - Increase of the equipment efficiency
  - Better effectiveness of the performance of the installation
  - Safer conditions of the installation
  - Guarantee of the sustainability of the equipment in its whole life cycle

Regarding the disadvantages of this method, there is no important disadvantage applied to every aspect. In general we can consider as disadvantage that:
This method supposes an expense for the company. This is because it uses external knowledge and personnel to develop and implement the whole process.

If the plan is not continued and monitored, it is only an inspection that does not give any benefit to the company.

By taking these advantages and disadvantages into account and the results obtained from the research, Imtech can offer the industries the possibility to achieve sustainability in the electrical installations management. By implementing an integrated concept in which the organization, the rules and regulations, the energy aspects and the technical conditions are in relation and influenced by the new technologies, the management of an electrical installation can be optimized if:

1. The whole organization is involved and motivated in the process.

2. The mandatory requirements established by the government and certifications are achieved.

3. The energy is used in an efficient way by reducing unnecessary consumption.

4. All the technical equipment is in a correct state by means of a correct maintenance program.
5.2. Recommendations

Imtech IS wants to implement the service for the optimization of the electrical installations management. Before implementing it, there are several advices Imtech has to take into account. These advices come from the results obtained from the different analyses made in this report and they establish the guidelines to focus the strategy to start working on this optimization plan. Imtech, as a potential technical service provider should:

- Improve the collaboration between departments of Imtech with the common objective of helping organizations to focus on their core competence.
- Take the opportunity of the strong position in the energy and environment market that Imtech currently has.
- Invest in energy management, control, health and safety for the companies, because of the increasing demand of them.
- Focus on cost-reducing services to support companies in the optimization of their installations.
- Promote sustainable technology for a competitive price during the whole life cycle of the installation.

Once Imtech and the customer are in contact and working on the optimization of the electrical installations management, as a result of the whole document, there are several recommendations that support the process performance. They are focused on the organization, rules and regulations, energy and technical conditions of the installation.

In the organization the communication is a very important aspect for improvement. Besides to communicate all the modifications to the employees, it is important to guide, train and motivate them in the implementation of this service.

Regarding the rules and regulations, it is recommendable to update all the requirements and subsidies from the Dutch government and EU as well as to get the certifications of the different applicable standards.

The energy consumption in most of the cases needs to be reduced. By controlling the electricity bills and implementing thermographic inspections the leaks of energy and critical points can be defined in order to implement energy savings services.

The technical conditions of the installation are improved by a correct maintenance strategy. Due to implementing periodical revisions and inspections to the equipment, by qualified and trained personnel, the performance of the installation will be efficient.

This report has shown the guidelines to start implementing an optimization plan for electrical installations management. Despite of the duration of the internship (four months) this research has been adapted to it successfully. However, this document means a first step to continue with a more detailed investigation.
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• SPIE, [www.amecspie.nl](http://www.amecspie.nl), 2009.
Abbreviations List

Alara: As Low As ReasonAble
CC: Competence Centre
DSM: Demand Side Management
EIA: Energy Investment Allowance
EN: European Normative
EPA: Energy Performance Advices
ICT: Information and Communication Technology
IEA: International Energy Agency
IEC: International Electrotechnical Commission
Imtech IS: Imtech Industrial Services
ISO: International Organization for Standardization
LCC: Life Cycle Cost
LCM: Life Cycle Management
NEN: Nederlands Normalisatie Instituut
PBP: PayBack Period
P&ID: Pipe and Instrumentation Diagram
QSHE: Quality, Safety, Health and Environment
RAM: Reliability, Availability and Maintainability
SWOT: Strengths, Weaknesses, Opportunities and Threats
Appendices

Appendix A: Imtech’s SWOT

Based on Imtech (2008) the strengths, weaknesses, opportunities and threats that Imtech IS has are given in this section.

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge of services such as project management, facility management, asset management, project financiering, risk management and energy management.</td>
<td>The development of the knowledge potential and the management skills fast enough to keep pace with technological developments</td>
</tr>
<tr>
<td>Numerous references for every technology solution</td>
<td>The decentralised business model makes harder to share the knowledge and work together with other sections because every section is financial independent.</td>
</tr>
<tr>
<td>Solutions as technology that works for innovation, best practises, corrective and improvement actions…</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Opportunities</th>
<th>Threats</th>
</tr>
</thead>
<tbody>
<tr>
<td>A strong position in the “Energy and Environmental” market.</td>
<td>More competitors</td>
</tr>
<tr>
<td>Customers can focus on its core competence</td>
<td>Competition from international suppliers</td>
</tr>
<tr>
<td>Customers want sustainable technical solutions and good image for the society</td>
<td>Increase of risks because projects are too difficult and bigger. Also there are more regulations</td>
</tr>
<tr>
<td>The covering of the entire services provision column through the entire life cycle of the services</td>
<td>Increasing dependence on large suppliers, co-makers and subcontractors</td>
</tr>
<tr>
<td>Initiative in managing a new project/service</td>
<td>Price competitiveness of Imtech</td>
</tr>
<tr>
<td>Increasing demand for energy management, control, health, care and safety</td>
<td></td>
</tr>
<tr>
<td>Increasing demand for cost-reducing services</td>
<td></td>
</tr>
</tbody>
</table>
Appendix B: Communication process flowchart

In this section there is the approach of Imtech and the customer from the first contact to the implementation of the optimization service. It is a graphic explanation of how the interaction process should be.

1st Stage

Customer

Information about the service

Does the customer want the service?

YES

NO

2nd Stage

Inspection of the installation

Is the service applicable?

YES

NO

3rd Stage

Savings, solutions, repairing, practices, advices, training…

Monitoring

Installation optimized?

YES

NO

Technological development, readjust of the machinery, list of possible better equipment and improvement of the technical conditions

END
Appendix C: Licence to operate flowchart

Based on Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer, Ministerie van Economische Zaken (1999), the Dutch Ministry of Economy establishes the next criteria and actions to take into account depending the energy costs.

1. **Analyses of Energy use**
   - If energy costs are less than €7,000:
     - **YES**: End
     - **NO**: Inventarisation of commonly used and modern technique
   - If energy costs are higher than €45,000:
     - **YES**: Standard Energy Scan
     - **NO**: Limited Energy Scan

2. **Inventarisation of commonly used and modern technique**
   - If the information is completed:
     - **YES**: The use is enough?
       - If the use is enough:
         - **YES**: Generation of energy prescriptions, specification of requirements for the measures to be taken to save energy
         - **NO**: Feasibility study
       - **NO**: ROI is known?
         - If ROI is known:
           - **YES**: Standard Energy Scan
           - **NO**: Limited Energy Scan
         - **NO**: ROI less than 5 years?
           - If ROI less than 5 years:
             - **YES**: Generation of energy prescriptions, specification of requirements for the measures to be taken to save energy
             - **NO**: Feasibility study
           - **NO**: No measures
         - **YES**: Standard Energy Scan
         - **NO**: Limited Energy Scan

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June 2009
Appendix D: List of applicable standards

The rules and regulations selected and applicable to the electrical installations management are divided into European and Dutch standards, ISO standards, European Directives, International Electrotechnical Commission (IEC) standards and other interest legal documents.

**European Standards**


**Dutch Standards**

- NEN-EN 15341: Maintenance-Maintenance Key Performance Indicators.

**ISO standards**

- ISO 14001: Environmental management standards.

**EU directives**

- EU Directive 2001/80/CE: Limitation of emissions of certain pollutants into the air from large combustion plants.
• EU Directive 2001/77/EC: Promotion of electricity produced from renewable energy sources in the internal electricity market.


• IEC 60027: Letter symbols to be used in electrical technology.
• IEC 60034: Rotating electrical machines.
• IEC 60038: Standard voltages.
• IEC 60076: Power transformers.
• IEC 60146: Semiconductor converters – General requirements and line-commutated converters.
• IEC 60255: Electrical relays.
• IEC 60265: High-voltage switches.
• IEC 60269: Low-voltage fuses.
• IEC 60282: High-voltage fuses.
• IEC 60287: Electric cables – Calculation of the current rating.
• IEC 60309: Plugs, socket-outlets and couplers for industrial purposes.
• IEC 60427: High-voltage alternating current circuit breakers.
• IEC 60439: Low-voltage switchgear and controlgear assemblies.
• IEC 60446: Basic and safety principles for man – machine interface, marking and identification – identification of conductors by colours or numerals.
• IEC 60479: Effects of current on human beings and livestock..
• IEC 60529: Degrees of protection provided by enclosures (IP code).
• IEC/TR 60616: Terminal and tapping markings for power transformers.
• IEC 60617: Graphical symbols for diagrams.
• IEC 60644: Specification for high-voltage fuse-links for motor circuit applications.
• IEC 60664: Insulation coordination for equipment within low-voltage systems.
• IEC 60724: Short-circuit temperature limits of electric cables with rated voltages fuses for transformer circuit application.
• IEC 60755: General requirements for residual current operated protective devices.
• IEC 60781: Application guide for calculation of short-circuit currents in low-voltage radial systems.

• IEC 60787: Application guide for selection of fuse-links of high-voltage fuses for transformer circuit application.

• IEC 60831: Shunt power capacitors for the self-heating type for AC systems having a rated voltage up to and including 1000V – General – Performance, testing and rating – Safety requirements – Guide for installation and operation.

• IEC 60865: Short circuit currents: Calculation of effects.

• IEC 60909: Short circuit currents in three-phase A.C. systems.

• IEC 60947: Low-voltage switchgear and controlgear.

• IEC/TR 61000: Electromagnetic compatibility (EMC).

• IEC 61032: Protection of persons and equipment by enclosures.

• IEC 61082: Preparation of documents used in electrotechnology.

• IEC 61140: Protection against electric shocks – Common aspects for installation and equipment.

• IEC 61557: Electrical safety in low-voltage distribution systems up to 1000 C AC and 1500 V DC.

• IEC 61558: Safety of power transformers, power supply units and similars.

• IEC 62271: Common specifications for high-voltage switchgear and controlgear standards.

Other Documents

• Decision num. 1230/2003/EC: Multiannual programme for action in the field of energy: “Intelligent Energy-Europe”.

• Regulation (EC) num 1980/200: Revised community eco-label award scheme.

• Kyoto Protocol.
Appendix E: General advises to save energy

Based on Enertec Solar (2005), Kornelis, B. (2004), Kreith, F. (2007), Thumann, A. (2002), Younger, W.J (2003), here there are several actions and tips to save energy and to have a good use of the equipment.

Electrical installations

- The overload conductors have higher temperatures than the normal. This causes leak because of the warming and also the risk of short circuit. Because of that, the temperature of operation of the conductors must be checked frequently.

- The slack or unsuitable joints increase the loss of energy. Because of that it is important to carry out a periodically adjustment of the joints and a cleaning of the contacts, joints, and terminals.

Lighting System

- Clean frequently the luminaries because the dirtiness decreases the lighting level of a bulb till a 20%.

- Turn off the lights that are no necessaries, for example when the personnel are working in another area.

- Evaluate the possibility of the use of natural light.

- Use bright colours in the walls and roofs, because the dark colours absorb a great amount of light and they force to use more bulbs.

- Make independent the lighting circuits. This will help to light the necessary places.

- Install reflecting surfaces because it addresses and increases the lighting and it makes the decreasing of bulbs in the luminaries possible.

- Use electronic ballasts because they allow you to save energy till a 10%, it improves the power factor and it increases the lifetime of the fluorescents.

- Evaluate the possibility of installing presence sensors, timers and dimmers for controlling the lighting systems.

Electrical Engines

- Avoid the start and the simultaneous operation of engines, above all the engines of medium and big capacity, in order to decrease the maximum demand.

- Avoid the no load operation of the engines.
Check frequently the alignment of the engine with the driven load. A defective alignment can increase the friction loss and it can cause damage in the engine and the load.

Improve the electrical voltage dropping in the power suppliers. A reduced voltage in the terminals of the engine generates an increasing of the current, an overheating and a decreasing of its efficiency. The regulations allow an electrical voltage dropping of 5%. Because of that, use correctly dimensioning conductors.

Evaluate the voltage in the AC three-phase engines. The imbalance between phases cannot exceed the 5%, but the fewer imbalances, the more efficiency engines are.

Keep the start switch of the single-phase engines in perfect conditions. If it doesn’t work properly, there is an overheating in the conductors causing leaks of energy.

In the engines that make a lot of starts, use starters at a reduced voltage. With this, it will be avoided an excessive heating in the conductors and a decreasing of lacks during the acceleration.

Install control equipments of the temperature of the lubricating oil in the great capacity engines, in order to minimize the leak because of the fiction and in order to increase the efficiency.

Don’t rewind more than two times the engines, because it can vary the design features of the engine. And this would increase the lacks of energy.

**Transformers**

Know the load associated to the transformer in order to not overload it and in order to reduce the leak in the copper.

Avoid operating with the transformers at a low load and if it’s possible reallocate the loads.

Check the level and the electrical rigidity of the oil every six months in order to control the insulating and refrigerating capacity of it.

Make a periodically cleaning of the transformer (surface, terminals…).

Measure frequently the surface temperature of the transformer. It cannot be higher than 55ºC.

**Pump Systems**

Check the filters of the pump. Clean it frequently in order to avoid that the obstructions cause overloads which increase their energy consumption.

Verify periodically the no existence of lacks, because they can cause loss of energy.
Check all the pipe installation in order to verify that there are no leaks, especially in the joints of the pipes. The slack joints can cause leaks that will get a greater electrical consumption.

The nominal power supplied by the engine must be equal to the one of the pump in order to work at the maximum efficiency. If it’s higher there is a wasting of energy.

The engine must be perfectly aligned with the pump and it must be over a surface that increases the vibrations.

It’s important to install automatic controls to start and stop the engine of the pump. So, the engine of the pump will not consume electrical energy when the pump stops working.

Cooling and air conditioning systems

The doors of the cooling systems must allow the hermetic lock in order to avoid the entrance of the warm air into the cooled space.

Clean frequently the filters and condensers of the cooling equipments.

In the air conditioning environments with air conditioning or heating, make sure the temperature control, by adjusting the thermostat.

When you turn on the air conditioning you have to wait some minutes to notice its effects. Because if you select a lower temperature it will not get cold and it will consume a lot of energy.

Compensation of the reactive energy

The transformers, engines and reactors consume reactive energy, which can be compensated by the installation of a group of condensers or generators in order to improve the power factor. With an optimal location of these capacitors, the energy losses will be compensated.

The compensation of the reactive energy has several benefits: the elimination of the reactive energy invoicing, the improvement of the electrical network, the reduction of the voltage droppings, the Joule effect and it protect the lifetime of the installations.

---

5 Reactive energy it is necessary to create an electromagnetic field that allows motors and transformers working.
Appendix F: Critically Assessment

Based on Hawkins B., Smiths R. (2004), by means of a critically assessment it is possible to quantify the importance of the function of one equipment or system related to its production, environmental or safety aspects. Next table gives ten levels of severity, but it can be expanded or reduced to produce a site-specific listing.

<table>
<thead>
<tr>
<th>Description of Failure Effect</th>
<th>Effect</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>No reason to expect failure to have any effect on Safety, Health, Environment or Mission.</td>
<td>None</td>
<td>1</td>
</tr>
<tr>
<td>Minor disruption of production. Repair of failure can be accomplished during trouble call.</td>
<td>Very Low</td>
<td>2</td>
</tr>
<tr>
<td>Minor disruption of production. Repair of failure may be longer than trouble call but does not delay Mission.</td>
<td>Low</td>
<td>3</td>
</tr>
<tr>
<td>Moderate disruption of production. Some portion of the production process may be delayed.</td>
<td>Low to Moderate</td>
<td>4</td>
</tr>
<tr>
<td>Moderate disruption of production. The production process will be delayed.</td>
<td>Moderate</td>
<td>5</td>
</tr>
<tr>
<td>Moderate disruption of production. Some portion of production function is lost. Moderate delay in restoring function.</td>
<td>Moderate to High</td>
<td>6</td>
</tr>
<tr>
<td>High disruption of production. Some portion of production function is lost. Significant delay in restoring function.</td>
<td>High</td>
<td>7</td>
</tr>
<tr>
<td>High disruption of production. All of production function is lost. Significant delay in restoring function.</td>
<td>Very High</td>
<td>8</td>
</tr>
<tr>
<td>Potential Safety, Health or Environmental issue. Failure will occur with warning.</td>
<td>Hazard</td>
<td>9</td>
</tr>
<tr>
<td>Potential Safety, Health or Environmental issue. Failure will occur without warning.</td>
<td>Hazard</td>
<td>10</td>
</tr>
</tbody>
</table>
Appendix G: Types of Diagrams

Next, three types of diagrams are mentioned. They are used for a better visualization of several aspects of the plant and in order to detect the location of the problem.

► Sankey Diagram

Based on Sankeydiagrams.com (2009), a Sankey diagram is a directional flow chart where the width of the streams is proportional to the quantity of flow, and where the flows can be combined, split and traced through a series of events or stages.

It is particularly appropriate for representing flow through a system in that it gives an immediate visualization of the weight of the flows and thus enables priority areas to be identified and tackled. Applied to this project, it can be use to visualize the energy flows in the plant.

Next figure represents an example of Sankey diagram that shows the power flow in a typical data centre.

An one-line diagram is a simplified notation for representing the electrical elements of an installation by standardized schematic symbols. Electrical elements such as circuit breakers, transformers, capacitor, bus bars and conductors are shown in this type of diagram.

The elements that appear on the diagram do not represent the physical location or size of the electrical equipment, but it is a common convention to organize the diagram for an installation. (McAvinew, T., Mulley, R., 2004).

As an example, next figure shows a typical one-line diagram of an electrical substation.

**Piping & Instrumentation Diagram (P&ID)**

Based on engineeringtoolbox.com (2009), a Piping and Instrumentation Diagram is a diagram that shows the interconnection of process equipment and the instrumentation used to control the process. It plays a significant role in the maintenance and modification of the process that it describes. It demonstrates the sequence of equipment and systems and how are they connected. A P&ID provides the basis for the development of system control schemes allowing for safety and operational investigations. Next figure gives an example of a P&ID.

Appendix H: Questionnaire to potential customers

Company Information

<table>
<thead>
<tr>
<th>Name of the company</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sector</td>
<td></td>
</tr>
<tr>
<td>Contact person</td>
<td></td>
</tr>
<tr>
<td>Position</td>
<td></td>
</tr>
</tbody>
</table>

1. Do you have any program to detect the impacts of the plant on the environment?

   - Yes
   - No

2. Is there a commitment to comply with all appropriate environmental laws and regulations?

   - Yes
   - No

3. Do you have the certification ISO 9001: Quality Management Standard?

   - Yes
   - No

4. Do you have the certification ISO 14001: Environmental Management Standard?

   - Yes
   - No

5. Do you have any program to reduce the energy consumption?

   - Yes
   - No
6. Are you implementing some continuing improvement measures?

- Yes
- No

7. Has the organization developed procedures and operational criteria including maintenance that address operations for improvement of the conditions?

- Yes
- No

8. Do you implement any of these practices? (Select them if it is the case)

- Optimization in the maintenance of the equipment
- Technology development (new technologies) in the process or equipment
- Systems for planning the production
- Strategic outsourcing
- Programs of quality

9. Determine the level of influence of the following factors in the success of the performance of the plant: (1: Low influence 2: Medium influence 3: High influence)

<table>
<thead>
<tr>
<th>Factors/Level of Influence</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>External Competence</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Excess of governmental requirements</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Necessity of modernization</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy management</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environmental “image”</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quality</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internal costs</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
10. Which of the following activities are implemented into your plant?

- Practices to improve the flexibility of the plant
- Preventive or predictive maintenance of the machinery and equipment
- Total quality management
- Competitive benchmarking
- Safety-improvement programs

11. Do you think the situation of the electrical installations in your plant could be improved?

- Yes
- No

12. What do you think are the main problems concerning the electrical installations?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

13. What do you expect from the application of this service by a provider of services, like Imtech, into your plant?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
Appendix I: Frequency Distribution of the questionnaire

I made the questionnaire by myself to the customers. I asked to several people to do the questionnaire, but only five of them were the applicable persons for the questionnaire. So, the response rate was five.

The frequency distribution from every question is:

| 1. Do you have any program to detect the impacts of the plant on the environment? |
|---|---|
| **Answer** | **Number** |
| Yes | 4 |
| No | 1 |

| 2. Is there a commitment to comply with all appropriate environmental laws and regulations? |
|---|---|
| **Answer** | **Number** |
| Yes | 5 |
| No | 0 |

| 3. Do you have the certification ISO 9001: Quality Management Standard? |
|---|---|
| **Answer** | **Number** |
| Yes | 4 |
| No | 1 |

| 4. Do you have the certification ISO 14001: Environmental Management Standard? |
|---|---|
| **Answer** | **Number** |
| Yes | 4 |
| No | 1 |

| 5. Do you have any program to reduce the energy consumption? |
|---|---|
| **Answer** | **Number** |
| Yes | 4 |
| No | 1 |
6. Are you implementing some continuing improvement measures?

<table>
<thead>
<tr>
<th>Answer</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>4</td>
</tr>
<tr>
<td>No</td>
<td>1</td>
</tr>
</tbody>
</table>

7. Has the organization developed procedures and operational criteria including maintenance that address operations for improvement of the conditions?

<table>
<thead>
<tr>
<th>Answer</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>5</td>
</tr>
<tr>
<td>No</td>
<td>0</td>
</tr>
</tbody>
</table>

8. Do you implement any of these practices?

<table>
<thead>
<tr>
<th>Practices</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimization in the maintenance of the equipment</td>
<td>Yes 5</td>
</tr>
<tr>
<td></td>
<td>No 0</td>
</tr>
<tr>
<td>Technology development (new technologies) in the</td>
<td>Yes 4</td>
</tr>
<tr>
<td>process or equipment</td>
<td>No 1</td>
</tr>
<tr>
<td>Systems for planning the production</td>
<td>Yes 4</td>
</tr>
<tr>
<td></td>
<td>No 1</td>
</tr>
<tr>
<td>Strategic outsourcing</td>
<td>Yes 3</td>
</tr>
<tr>
<td></td>
<td>No 2</td>
</tr>
<tr>
<td>Programs of quality</td>
<td>Yes 4</td>
</tr>
<tr>
<td></td>
<td>No 1</td>
</tr>
</tbody>
</table>

9. Determine the level of influence of the following factors in the success of the performance of the plant.

<table>
<thead>
<tr>
<th>External Competence</th>
<th>Level of Influence</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>2</td>
</tr>
</tbody>
</table>
### Excess of governmental requirements

<table>
<thead>
<tr>
<th>Level of Influence</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>0</td>
</tr>
<tr>
<td>Medium</td>
<td>2</td>
</tr>
<tr>
<td>High</td>
<td>3</td>
</tr>
</tbody>
</table>

### Necessity of modernization

<table>
<thead>
<tr>
<th>Level of Influence</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>0</td>
</tr>
<tr>
<td>Medium</td>
<td>5</td>
</tr>
<tr>
<td>High</td>
<td>0</td>
</tr>
</tbody>
</table>

### Energy Management

<table>
<thead>
<tr>
<th>Level of Influence</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>1</td>
</tr>
<tr>
<td>Medium</td>
<td>2</td>
</tr>
<tr>
<td>High</td>
<td>2</td>
</tr>
</tbody>
</table>

### Environmental “image”

<table>
<thead>
<tr>
<th>Level of Influence</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>0</td>
</tr>
<tr>
<td>Medium</td>
<td>1</td>
</tr>
<tr>
<td>High</td>
<td>4</td>
</tr>
</tbody>
</table>

### Quality

<table>
<thead>
<tr>
<th>Level of Influence</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>0</td>
</tr>
<tr>
<td>Medium</td>
<td>2</td>
</tr>
<tr>
<td>High</td>
<td>3</td>
</tr>
</tbody>
</table>
### Internal Costs

<table>
<thead>
<tr>
<th>Level of Influence</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>1</td>
</tr>
<tr>
<td>Medium</td>
<td>1</td>
</tr>
<tr>
<td>High</td>
<td>3</td>
</tr>
</tbody>
</table>

### 10. Which of the following activities are implemented into your plant?

<table>
<thead>
<tr>
<th>Activities</th>
<th>Answer</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Practices to improve the flexibility of the plant</td>
<td></td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Preventive or predictive maintenance of the machinery and equipment</td>
<td></td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Total quality management</td>
<td></td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Competitive benchmarking</td>
<td></td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Safety-improvement programs</td>
<td></td>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>

### 11. Do you think the situation of the electrical installations in your plant could be improved?

<table>
<thead>
<tr>
<th>Answer</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>3</td>
</tr>
<tr>
<td>No</td>
<td>1</td>
</tr>
</tbody>
</table>