CHAPTER 6 CONCLUSIONS AND RECOMMENDATIONS

6.1. INTRODUCTION

In chapter 1, the main and specific objectives of this dissertation were listed; these objectives were addressed during the course of this dissertation and will now be properly concluded through referring to the relevant sections. Lastly, recommendations with regard to certain aspects of the energy management system presented in this dissertation will be made followed by a closing remark.

6.2. CONCLUSIONS ON THE OBJECTIVES

The main objective of this dissertation was to present a framework that would enable effective management of energy cost and efficiency in cryogenic air separation plants, as stated in section 1.2.

In this dissertation, a model has been defined which serves as the framework for the energy management program at cryogenic air separation plants. Within this framework, various functions have been defined and the energy management effort is realized through performing the activities surrounding each of the respective functions.

6.2.1. Conclusion on the energy management model

The energy management model was introduced in chapter 3. The model is depicted in figure 3.5 and entails the transformation process, its inputs and outputs and the external environment as well as the interaction between all of these. Inputs are resources like capital, skills, people and facilities; outputs are the accomplished energy management objectives like improved preventive maintenance strategies, optimized production schedules, reduced energy cost and improved plant design.

The external environment accounts for the higher order systems to which the energy management system belongs. The transformation process involves the managerial functions of organizing, planning, leading and controlling, which are the core managerial functions the energy manager has to perform.

6.2.2. Conclusion on the energy policy

Theory behind the energy policy was presented in section 4.3. The energy policy normally consists out of three components: the declaration of commitment, mission statement and specific objectives. The energy policy guides or channels thinking, it is an expression of the commitment plant management has towards a continuous and effective energy management program and sets the scope for energy management effort at plant level.

6.2.3. Conclusion on the energy policy strategy

The energy policy strategy is the means for accomplishing the vision expressed by the energy policy and was introduced in section 4.4. The energy policy strategy thus encapsulates the plan for changing current reality into future vision. This plan is composed of five activities, and they have been identified as the following:

- deployment of human resources,
- current situation evaluation,
- energy systems maintenance,
- energy management planning,
- establishment of measurement and control indicators.

Deployment of human resources entails the appointment of a dedicated person, in charge of the plant's energy management program, as well as enabling this person to utilize other relevant human resources.

Energy systems maintenance refers to maintenance actions regarding the energy efficiency of equipment that use or affect the use of energy.

The energy management plan is a structured and well-formulated set of plans and tactics that should be followed in order to ultimately achieve the primary objectives as stipulated in the energy policy.

Key performance indicators were presented in section 4.4.5 and these indicators enable the energy manager to assess the plant's energy efficiency and also to perform the control function of the energy management program.

6.2.4. Conclusion on the energy audit process

The energy audit process was discussed in section 4.4.2, and consists out of the energy audit policy and the energy audit strategy. The energy audit policy sets the scope for what to audit whereas the energy audit policy strategy states how this would be done.

Auditing is done through assessing relevant plant efficiencies, as listed in section 4.4.2.1 and, for the holistic approach to energy auditing, assessment of all these plant efficiencies should be enabled; this assessment is done by means of the audit strategy as detailed in section 4.4.2.4.

6.2.5. Conclusion on the mathematical model

Model building blocks, with regard to all the major systems, were derived in section 4.4.2.4. The energy conversion model is a very important auditing tool and most of the building blocks derived in this section also find their application in the control function of the energy management program (section 5.2).

Model accuracy is greatly enhanced through empirical modeling of critical plant elements, and as stated in chapter 4, it becomes obvious that availability of relevant data is critical in model building.

6.2.6. Conclusion on the performance indicators

KPI's (key performance indicators) were derived in section 4.4.5 and consist of global indicators as well as lower level indicators. Global indicators quantify the performance of the plant as a whole and include the energy cost per product produced (R/Nm^3) and energy consumption per cumulative product produced (kWh/Nm^3). The lower level indicators enable the energy manager to monitor the energy efficiency of critical components such as the compressor motors, compressors and the distillation columns and are also utilized in the control function of the energy management program.

Each KPI is defined as the ratio between actual and theoretical performance. The theoretical performance effectively defines the energy standard of a particular system, which enables the energy manager to identify system inefficiencies when comparing this to the actual system performance.

6.2.7. Conclusion on energy systems maintenance

Energy systems maintenance with regard to cryogenic air separation plants was introduced in section 4.4.3. Energy systems maintenance is the energy manager's contribution to the overall maintenance effort on the plant and is conducted by means of an energy maintenance life plan.

The state of each of the respective critical systems is monitored in terms of their energy efficiency and deviations are acted upon so as to minimize resulting energy losses. The critical systems are the compressors, distillation columns and compressor motors and a maintenance plan for these systems were presented in section 4.4.3.5.

A cryogenic air separation plant normally utilizes a large number of induction motors for driving loads such as blowers, pumps and compressors and these motors consequently have a significant impact on the energy efficiency of the plant. As stated in section 4.4.3.3 energy systems maintenance on large induction motors driving these loads may not be so simple and in this section a tool that facilitates decision-making between induction motor replacement and renewal was presented as well.

6.3. RECOMMENDATIONS

This section contains recommendations with regard to certain aspects of the energy management system at cryogenic air separation plants.

6.3.1. Recommendations on setting up the energy management program

First and foremost, it is the responsibility of the appointed energy manager to ensure that there is a formal and well-defined energy policy in place at plant level, for the whole energy management program will be as a direct consequence of this policy and is therefore the foundation from which all energy management efforts will outflow. This policy should be agreed upon by the relevant stakeholders and approved by top management.

For the energy management system to be fully integrated into the plant's organizational structure and to ensure that top management continually gives it the commitment it needs, it is recommended that the outcomes of this program be accounted for in the overall performance of the plant in order for it to ultimately have an impact on the merits of plant performance.

As a direct consequence of the energy policy, capital will be made available for the energy management program in the form of a financial budget. The energy manager is responsible for formulating the energy management budget for the next financial year and this budget should then serve as the cost goal for the energy management program. This is a critical resource input to the program and the energy manager should make sure that optimum use of this resource is exercised through proper planning and allocation (see section 4.4.4).

When implementing the energy management program it is important that the appointed person should first organize a workshop session in which all the relevant departments in the plant's organization are informed about what the proposed energy management effort entails, what is expected of them and how they can benefit from it. This is also a good opportunity for the energy manager to highlight the importance of effective energy management on these energy intensive plants and to aspire fellow personnel in contributing positively towards energy management objectives.

6.3.2. Recommendations regarding existing energy management programs

In the case where there already is an existing energy management program in place, the contents of this dissertation may be used to supplement or adjust current efforts. The model presented in this dissertation aims to foster an effective and value-adding energy management program without compromising production output streams and will add to the success of existing energy management efforts.

6.3.3. Recommendations regarding energy modeling

In section 4.4.2.4 it becomes obvious that in building the energy conversion model the energy manager requires a large amount of data of different types, ranging from process variables like temperature, pressure and flow to capacity limits on equipment. To avoid spending too much time in model building and ensuring good accuracy, the energy manager must enable easy access to relevant data.

Building the energy conversion model may take a relatively long time, especially in plants incorporating multiple trains, and most of the time will be consumed by processing relevant data, it is therefore recommended that appropriate computer software be used. Spreadsheets will undoubtedly proof to be most efficient in data processing and it is also recommended that software capable of multiple variable regression be utilized in modeling certain subsystems.

Lastly, some model building blocks are utilized in the control function of the energy management system, and it would be advisable to link the relevant model outputs to the respective KPI's in which they are utilized; in this manner, KPI's are automatically evaluated whenever plant performance needs to be determined.

6.3.4. Recommendations regarding the energy manager

Although it is recommended that the energy management system should form part of the plant's organization, it doesn't necessarily mean that the person appointed to drive this program should be stationed at the plant. This person may form part of an organization external to the plant's organization like for example an energy management task team that is charged with managing energy cost on a company-wide level, a technical hub or even an outside company (outsourcing).

It is required that the appointed person should be experienced in general management and competent in applying financial tools. This person should also be technically orientated, typically operating from the base of mechanical, electrical or process engineering.

6.3.5. Recommendations regarding energy management at Sasol Secunda

It is a fact that certain plants within the Sasol complex are generally energy intensive and, in optimizing the energy cost per output product more efficiently, it is recommended that intentional consideration should be given to energy management at plant level. Realizing this energy management effort lies in adopting an efficient managerial structure, such as the one presented in this dissertation, and allocating resources to fuel this energy management effort.

Driving this managerial effort would be the responsibility of a dedicated energy manager appointed by the company. Lastly, Janse van Rensburg [17], also suggested that an energy manager should be appointed by each of the major energy consumers within the factory and that a specific plant's performance, with regard to energy management, should have an impact on the overall performance merit of the plant, thereby motivating relevant personnel in achieving energy management objectives.

6.4. FUTURE WORK

Although there are key commonalities between various cryogenic air separation plants they may still be diverse in design and it is up to the energy manager to derive an energy model specific to his/her plant; this may be done by employing the basic modeling theory presented in chapter 4.

Another point worth mentioning is that of extending the application of the energy model. Utilization of the energy model is basically limited to that of the energy manager, but by modifying the model such that it is able to receive real-time data in order to produce specific predefined outputs in real-time, the proactive element of the energy management effort is greatly enhanced. The model may be added as an extension to the control operator's workstation. The control operator is directly responsible for the process control of the plant and is able to see (in real time) on how certain of his/her actions impact on the energy cost and efficiency of the plant.

Lastly, this study was aimed at presenting a generic framework for energy management at cryogenic air separation plants, however, it was also the intent of the author to introduce an energy management framework that may be applied to plants of any nature. In the quest for deriving an energy management program, future studies may thus apply the basic philosophy presented in this study to other types of plants as well.

6.5. CLOSING REMARKS

This dissertation presents a framework for energy management at cryogenic air separation plants. It addresses all the critical managerial aspects required in conducting a successful energy management program and may be used as a reference or tool in managing electrical cost and energy efficiency at these energy intensive plants.

Because these plants are so energy intensive, a relatively small improvement in energy efficiency may lead to significant energy cost savings. Cost savings are not the only benefits resulting from the energy management effort, indirect benefits resulting from this include reduced CO_2 emissions and conservation of the earth's energy resources.

From the above it can be seen that energy management at plant level not only makes business sense but is also the answer to environmental concerns and the ever-increasing energy price.