

Utilities optimization in a wax process plant

O.A Babalola B Eng

**Dissertation submitted in partial fulfilment of the requirements
for the Master of Engineering at the Potchefstroom Campus of
the North-West University South Africa**

Supervisor: Prof PW Stoker

November 2007

DEDICATION

I wish to dedicate this dissertation to the all-sufficient God, who gave me the grace to commence my study and has also given me the ability to bring it to a good conclusion.

ACKNOWLEDGEMENT

Most thanks goes to God the author of life for giving me strength to see this work to an end.

I cannot but appreciate a group of people who have been my source of inspiration from “way back” until now.

I appreciate my parents, Col, Dr (M.B.B.S.) and Mrs (M.Sc) Babalola for giving me education as a legacy and for being wonderful mentors to me.

My love and thanks goes to my bride in due time, my princess and jewel of inestimable value, Opeyemi Adejumo-Adu, you have been my source of motivation while doing this work, your loving and soothing words of encouragement in times of discouragement helped me follow through.

Great thanks goes to my siblings, Olabisi, Olayemi, Oluwagbenga, Adeola and Oluwatosin, you all have been my friends and companions over the years, your respect for me and my sense of responsibility to you motivated me to carry on with this study.

I refuse to forget my “friends that stick closer than a brother”; Kolade Duduyemi, Oluwole Ehinmowo and Banji Akande, I thank you all for not being mediocre, your ambitiousness and advises spurred me to forge ahead with this work, I guess I owe you guys.

To my project supervisor, Professor Piet Stoker, I want to say a very big thank you. Your patience, diligence, thoroughness and contributions towards this work are priceless.

To Oluwasegun Agboola and Oluwagbenga Akintokun, I want to say thank you guys for being my friends, your focus and discreteness has been my motivation and your companionship helped sustain my confidence throughout the duration of this work.

My sincere thanks goes to Sannelie Van Der Westhuizen, who despite her tight schedule helped me prove read the introductory chapter of this work, I wish you success in your research.

I want to appreciate my colleagues- Greg Ogunli, Joan Ogunyowa, Jeffery Okon, Wallace Iyonsi, Kunle Adenuga, Jonathan Nwankwo, Olusola Agbabiaka and others too numerous to mention, your friendship and understanding with me enhanced my drive to succeed with this work.

Cheers

ABSTRACT

In this dissertation, the extent of utilities optimization, conservation and management is investigated in a case study plant (Sasol Wax plant).

At the outset, the particular types of utilities in the case study plant were identified and they were found to be similar to utilities common to the chemical process industries. Also, reasons to optimize utilities such as continuous rise in utilities cost and maximizing profit while cutting back on cost of production were established.

There was an indication to explore the influence of the human element comprising personnel perception, orientation and attitude towards utilities optimization

The collected literature revealed the reasons why utilities optimization, conservation and management should be handled seriously. Such reasons included economic, environment and quality/social concerns. The literature survey covered the Chemical Process Industries' approach to utilities optimization, conservation and management which includes;

- Technological Development;
- Process Integration; and
- Changing to less expensive energy or reduced consumption of energy/utilities by employing energy conservation procedures.

Preliminary investigation revealed that the three approaches did not solve the problem of energy under-utilization and utilities wastage, and it did not enhance cost savings on utilities consumed in the case study plant. Hence, the influence of the human element (personnel perception, orientation and attitude towards

utilities optimization) in utilities optimization, conservation and management was investigated.

This investigation, led to an extensive discussion of several utilities management systems which formed the crux of chapter two of this work.

Furthermore, several methods of investigation which included, interviews, questionnaires and observations were employed to reveal the case study plant's management and personnel's attitude (human element) towards the subject of utilities optimization, conservation and management.

Findings from the investigation were put in proper perspective by employing the grounded theory approach which helped to simplify into themes the factors that influence utility optimization, conservation and management.

In the concluding chapter, a management system that will minimize utilities underutilization and utilities wastage as well as recommendations that will improve the utility optimizing potential of the case study plant was developed for the case study plant that is adaptable to other chemical process plants with similar processes and recommendations for practise to boost the utility efficiency as well as recommendation for further research on optimization of utilities were suggested.

LIST OF FIGURES

FIGURE	TITLE
4.1	UTILITY FLOW DIAGRAM OF CASE STUDY PLANT

LIST OF TABLES

TABLE	TITLE
3.1	TABLE SHOWING TIME SPENT ON INTERVIEW SESSIONS WITH EACH INTERVIEWEE

TABLE OF CONTENT

DEDICATION.....	ii
ACKNOWLEDGEMENT	iii
ABSTRACT.....	v
LIST OF FIGURES	vii
LIST OF TABLES	vii
TABLE OF CONTENT	viii
CHAPTER 1.....	1
INTRODUCTION.....	1
1.1 PROBLEM STATEMENT AND SUBSTANTIATION	2
1.2 AIMS.....	4
1.3 SIGNIFICANCE	4
1.4 WORK SCOPE	5
CHAPTER 2.....	7
LITERATURE SURVEY.....	7
2.1 ENERGY CONSERVATION IN EXISTING PLANTS.....	14
2.1.1 CONCLUSION.....	18
2.2 INDUSTRIAL ENERGY CONSERVATION	19
2.2.1 ENERGY AUDIT CONSIDERATIONS.....	25
2.2.2 EVALUATING ENERGY AUDIT DATA.....	26
2.2.3 IDENTIFYING AND IMPLEMENTING FEASIBLE ENERGY CONSERVATION OPPORTUNITIES.....	27
2.2.4 REPORT ON ENERGY AUDIT	28
2.3 ENERGY STAR ENERGY MANAGEMENT GUIDELINE.....	28
CHAPTER 3.....	44
EMPIRICAL INVESTIGATION	44
3.1 QUESTIONNAIRE:	45
3.1.1 TARGET POPULATION:	45
3.1.2 QUESTIONNAIRE OBJECTIVES AND REVIEW:.....	47
3.1.3 QUESTIONNAIRE VALIDATION.....	48
3.2 INTERVIEWS	50
3.2.1 INTERVIEW OBJECTIVES.....	51
3.3 OBSERVATIONS	52
3.4 SUMMARY	54
CHAPTER 4.....	56
FINDINGS AND DISCUSSION.....	56
4.1 QUESTIONNAIRE.....	56
4.1.1 CONCLUSIONS	60
4.2 INTERVIEWS	60
4.2.1 UTILITIES.....	61
4.2.2 UTILITY WASTAGES	61
4.2.3 MONITORING.....	62

4.2.4 MANAGEMENT SYSTEM	63
4.2.5 OPTIMIZATION	64
4.2.6 PREFERENCES	65
4.2.7 IMPROVEMENTS	65
4.2.8 SAFETY HEALTH AND ENVIRONMENT	66
4.2.9 CONCLUSION	67
4.3 OBSERVATIONS	67
4.3.1 CONCLUSIONS	69
4.4 UTILITY FLOW DIAGRAM	69
4.5 DISCUSSION	71
4.5.1 MANAGEMENT SYSTEM	73
4.5.2 UTILITY OBJECTIVE	74
4.5.3 MONITORING	74
4.5.4 PEOPLE	75
4.5.5 CONTROL	75
4.5.6 MAINTENANCE	76
4.5.7 COST AND PRODUCTION	76
4.5.8 SAFETY HEALTH AND ENVIRONMENT	77
4.6 PLEMINARY CONCLUSION	77
CHAPTER 5	79
RECOMMENDATION AND CONCLUSION	79
5.1 INTRODUCTION	79
5.2 MANAGEMENT SYSTEM STRUCTURE	80
5.3 RECOMMENDATIONS FOR PRACTICE	83
5.4 VALIDATION	86
5.5 RECOMMENDATIONS FOR FURTHER RESEARCH	87
5.6 CONCLUSION	87
REFERENCES	89
APPENDIX 1	94
APPENDIX 2	99
APPENDIX 3	103

CHAPTER 1

INTRODUCTION

Growing concerns have risen about energy management and conservation in energy consuming industries. The concerns revolve around energy consumption, its cost and its adverse environmental impact. (Davis Yih-Liang Chan, et al, Dec. 2005).

Energy saving has been a crucial issue for sustainable development. During the past 3000 years, economic development all over the world has relied on increasingly depleting fossil fuels. Therefore before new and substitute fuels become available, energy saving is a must in order to make economic growth possible. (Li Hu & Hung Ka, Jan. 2006).

The importance of energy has led several groups to call for large commitments (Schock et al, 1999; Davis & Owens, 2003; Kammen & Nemet, 2005) as concerns about the environment and macroeconomic impact of energy production and use are intensifying (Neme & Kammen, Feb. 2006).

In the chemical process industry, the issue of energy conservation and management and alternative energy sources has been a major concern over the years (Richard Green, et al, 1982) and even till date. The growing concern of energy optimization, conservation and management has led to the emergence of the energy management solutions industry. This industry comprises several companies with unique methods/approaches of tackling energy issues (www.copernic.com).

The need to conserve energy, particularly in the process industry is strongly felt as the cost of energy has not stopped increasing since 1973 (Richard Green, et

al, 1982). The effect of this continuous increase has its resultant effect on the overall cost of production.

Conservation will lead to improvements in industrial energy efficiency, and will reduce utilities wastage and environmental emissions.

It is almost impossible to discuss energy matters without mentioning themes such as;

- Energy consumption;
- Environmental impact;
- Sustainable development and
- Economy.

Energy in industries, comprise utilities that are utilized to run processes.

This dissertation focuses on the chemical process industry which is a major energy consuming industry. The Sasol Wax Slurry bed process plant is considered as case study.

1.1 PROBLEM STATEMENT AND SUBSTANTIATION

Preliminary evaluation of the case study plant revealed the various forms of energy/utilities used for the production processes. These forms of energy/utilities include;

- Steam;
- Instruments Air;
- Plant Air;
- Cooling Water;
- Boiler Feed Water;

- Nitrogen Gas;
- Hydrogen Gas; and
- Electricity.

Instances of utility/energy underutilization, utility wastage amongst other deviations were also observed during the preliminary investigation. These necessitated the need to identify such deviations, their causes and strategies of mitigating or eliminating them in order to use these utilities more efficiently.

This work is expected to better inform and benefit the management and entire stakeholders of the wax process plant or any other process plant by helping them optimize utilities use in the plant by exposing areas of deviation from best practices, exploring non technical factors such as the human element that may influence utilities optimization and recommending possible actions that will enhance utilities optimization.

It was revealed that there has been a continuous rise in the cost of utilities used for process control in the case study plant. (Interview, April 31st, 2007).

The case study plant management is currently focused on maximizing profit while cutting back on cost of production, (interview, April 9th, 2007).

Upon assessment of the costs that make up the plant production cost, labour cost, utility cost, laboratory cost and raw material cost were prominent. Hence, the potential of cutting cost of production largely depends on the potential of cutting back on any of these costs.

The potential of reducing utility cost for the case study plant can be explored by investigating its utility optimization, conservation and management potential.

If the utilities employed in the case study plant are well optimized, conserved and managed, it will lead to reduction in cost expended on utility, which will reflect a resultant reduction in production cost.

1.2 AIMS

The purpose of this work is to go beyond the conventional approaches that Chemical Process Industries have employed to optimize, conserve and manage utilities by exploring the role and influence of the human element.

This dissertation will also investigate how personnel perception, orientation and attitude towards utilities optimization can influence/affect utilities optimization, conservation and management to achieve the combination of the following benefits;

- Reduced specific energy consumption;
- Minimizing or possible elimination of energy wastage;
- Reduction in total operating costs; and
- Savings in cost of utilities consumption.

1.3 SIGNIFICANCE

The goal of management is to look for ways in which their profit can be optimized and also meet global standards in terms of safety health and environmental issues.

“The concentration of greenhouse gases (GHG) resulting from anthropogenic action such as emissions from factories and mobile motors has increased markedly since the industrial revolution. To minimize the environmental impact of GHG (such as global climate change and global warming), the United Nations

Framework Convention on Climate Change (UNFCCC) initiated efforts in Rio de Janeiro in 1992 to consider strategies for reducing GHG emissions. In December 1997, the third conference of parties (COP-3) of the UNFCCC was held in Kyoto in Japan and resulted in the so-called Kyoto Protocol. In Kyoto, the developed countries committed themselves to reducing emissions of carbon dioxide (CO₂), methane (CH₄) and nitrous oxide (N₂O) by 6–8% compared with 1990 emission levels in the period 2008–2012 (Kramer et al., 1999)” (Yi-Liang Chan, et al, Dec, 20, 2005).

“Energy research organizations and governments are actively engaged in developing methods of assessing energy efficiency”. (Yi-Liang Chan et al, Dec, 20, 2005).

This work becomes important as it intends to identify and recommend ways of using plant utilities more efficiently, which will in turn be a commendable milestone in the process of achieving utility consumption efficiency.

The knowledge gained from this work will help to optimize the use of all forms of energy utilized in the plant thereby saving cost expended on energy.

1.4 WORK SCOPE

In this work, the case study plant will be the main focus and research will cover;

- Identifying the particular utilities used in the plant;
- Conduct energy audits/investigation of these utilities;
- Identify under-utilization and wastage of utilities;
- Define the areas where energy savings may be possible;
- Consider alternative means for reducing energy consumption by;
 - Eliminating waste; and

- Improving maintenance.
- Recommend practices for immediate implementation and for further research;
- Propose a management system, applicable to the Chemical Process Industry that will help optimize the use of utilities and sustain the optimization.

In the process of elaborating on the highlighted scope of this work, the human element will be explored.

When considering the human element, personnel's perception and disposition towards utilities optimization conservation and management will be considered.

CHAPTER 2

LITERATURE SURVEY

Energy is the prime source of value, because other factors of production such as labour and capital cannot do without energy. (Ghali & El-Sekka, 2004).

Energy (utilities) optimization in process plants is of paramount importance. There are many reasons why organizations should take energy-efficiency seriously, from improving the operating cost of the organization to helping to reduce damage to the environment.

“The principal objective for energy policy makers is the implementation of sustainable energy systems. Sustainability in energy system has been interpreted in various ways that include an on-going discussion of a possible ranking of “three pillars” - “environmental, economic & Social/Quality” (Santer & Awerbuch, July 2005).

ECONOMIC

Minimizing energy waste means saving money through lower energy bills. Lowering energy bills will result in reduced operating cost since energy costs is a part of operating cost. This means improved profits, and can help enable the organization to price products and services more competitively. Controlling energy costs through energy efficiency now will help to mitigate the impact of increases in energy prices. “Organizations that have not looked seriously at energy efficiency can typically save 20% on their energy consumption, and consequent emissions of greenhouse gases, through no-cost and relatively low-cost measures, yielding significant reductions in their energy bills.” (Elf Business Energy, energy efficiency advice report, March 2003).

ENVIRONMENTAL

Wasting energy not only wastes money, it results in unnecessary pollution, particularly through emissions of the main greenhouse gases and carbon dioxide which cause global warming.

Global warming, with the consequent changes to sea levels, patterns of weather and of disease, is widely considered to be the single most important environmental issue facing us all.

By using fuel and electricity more efficiently, organizations will be able to reduce their impact on the environment.

QUALITY/SOCIAL

Energy efficiency is an important factor in accreditation to environmental management systems such as ISO14001 and EMAS. Many organizations now require their suppliers to operate under such systems; good energy management can help supply chain obligations to be met.

In addition, good performance can be publicized, thereby establishing green credentials for the organization. An image of responsibility for the organization is increasingly important to customers and shareholders alike.

Many energy efficiency measures can also bring substantial benefits in terms of employee comfort through improved heating, insulation and the avoidance of cold spots. This can reduce staff turnover and improve productivity. Attention to energy efficiency often highlights deficiencies in other areas such as maintenance, process yield and quality, and so can bring significant additional productivity benefits.

There are other advantages that will be revealed in the course of this dissertation. (Elf Business Energy, energy efficiency advice report, March 2003)

Literatures relating to energy management methods and processes will be reviewed and deductions will be made from them in order to develop a suitable energy management system that would be most suitable for the case study plant.

In an attempt to unveil what the chemical process industries have been doing to optimize, conserve and manage energy, three major approaches were identified, namely;

- Technology Development;
- Integration of Process; and
- Change to less expensive energy or reduced consumption of energy/utility by employing energy conservation procedures.

Adopting technology/equipment modification and/or replacement to optimize and conserve utility for the case study plant may be considered.

The equipments to be considered in this case will include;

Electrical motors of Condensate Pump

Utility optimization and conservation can be achieved by upgrading electrical motors to become more energy efficient. The energy efficient motor is more efficient in converting electrical energy to mechanical energy than comparable standard models (Philip M. Kohn, Feb 1980).

The efficiency is achieved primarily in two areas: Speed controllers and power factor controllers.

Employing variable speed drives can also cut pumping cost. "When operated at less than design flow rates, conventional single-speed-pumps and throttling-valve systems waste energy. Pumps powered by AC variable speed drives can handle operating at less than design flow rates without the energy penalty incurred by the conventional arrangement of a single-speed centrifugal pump and throttling valve" (James D. Johnson, Aug. 1981).

The energy efficient motor referred to earlier has been employed in the past with the compressor in the case study plant, but the result recorded was not satisfactory to the management. (Interview, 30TH MAY 2007).

Heat Exchangers

Heat exchangers can be instrumental to better optimization of steam in chemical process industries (CPI). "CPI's development work is advancing along several fronts: enhanced tube surfaces (rough textured) for use mainly within the boiling and condensation ranges; ceramic heat transfer surfaces for high temperature heat exchange and recovery and for new heat exchanger designs e.g. the rod baffle configuration.

Tube fabricators have also found ways to make enhanced-surface tubes from diverse materials, such as carbon steel, stainless steel, titanium and tantalum" (Philip M. Kohn, Feb 1980).

The pinching technique used in heat exchanger design is another approach that may be considered for enhancing heat exchanger efficiency (Questionnaire, May 2007). The pinch technology is applied in order to achieve the goal of heat recovery and utility allocation of the plant (energy conservation, vol.53; No.1; PAGE.84-92, 2001).

“Apart from technological and equipment modification, process integration has also been considered and it has proved to be a reliable approach to energy optimization.” (Philip M. Kohn, November 1977).

The idea is to add processes equipments to efficiently consume the surplus energy/steam from another process. Another alternative may be to sell the excess steam produced as a by-product of another process to make profit.

Process integration therefore, may also be considered for the Slurry bed plant as it guarantees aggregate energy cost reduction.

The technology/equipment modification and process integration approach for the case study plant seem to be worthwhile approaches.

In as much as modifying or replacing the existing technology/equipment will boost the case study plant's efficiency and in effect conserve energy, the cost of such modification or replacement might be too overbearing and hence, discourage management from pursuing energy optimization, conservation and management.

As regards process integration, the current situation of the case study plant reveals instances where processes have been integrated such as;

- The steam released from the boiler feed water used to cool the reactor, the reactor is used to heat up the cooling water and converts the cooling water to 12 Bar and 2.4 Bar steam for steam tracing the wax and hot condensate lines respectively; and
- The steam condensate from some of the steam traps in the plant which could have flown to the drain as waste is stored in a vessel and then is pumped through several heat exchangers to cool down the relatively high temperature process products.

Irrespective of these process integration steps, it was observed that a considerable amount of steam condensate end up in the drain, hence, there is a need to investigate the reason for this wastage and to propose a way of eliminating the waste.

The third approach of making use of alternative fuel may not be readily applicable to case study plant since all the utilities used in the plant are imported and hence, to use an alternative fuel may require approaching new utilities vendor and/or acquiring new technology and equipment to support the alternative fuel.

The three approaches of CPI's discussed may be described as technical energy saving measures.

These measures have not yielded any outstanding energy optimization and conservation result in the case study plant so far (Interview, May 2007).

To save on wastage of utilities and use such resources optimally and conservatively in the case study plant requires more than technology, process integration and using alternatives energy sources. It requires the human element to buy into the need for utilizing these scarce energy resources in a responsible way.

The extent to which the human element is a factor in the overall utilities optimization process is not well understood, hence, this research investigates the human element in utilities optimization, using the Sasol wax plant as a case study.

"Fundamental to the effective implementation of energy efficiency is good management. Like any other resource that an organization employs, utilities/energy will only be used efficiently if it is managed properly. Good energy

management saves energy in itself, but is also necessary for getting the most out of technical energy saving measures (technology, process integration and using alternatives energy sources). Energy management can be broken down into a number of key areas;

Policy

A formal statement of the organizations objective demonstrating senior management's commitment to continuous improvement in the efficient use of energy;

Planning and Organizing

A clear and formalized responsibilities, plans and procedures put in place in the organization to foster energy efficiency;

Monitoring and Control

This involves physical energy survey and ongoing monitoring and analysis of energy consumption information;

People

People are crucial to effective energy management and can steer the energy efficiency measures to yield outstanding results if they have awareness, motivation and empowerment;

Reporting and Review

This requires providing management reports on energy use and management and reviewing such reports to give the opportunity to consider whether the energy management system being employed remains appropriate and decide whether modifications are required”.

(Elf Business Energy, energy efficiency advice report, March 2003).

The key areas highlighted above form a generic overview of the human element in an effort to optimize, conserve and manage utilities.

This human element may also be termed “management approach to utilities optimization”, since “management facilitates the effort of humans and arises when they seek to achieve goals” (The History of Management Thought, 5th edition, Daniel A. Wren, pg. 12, 2005).

Therefore, the option of using energy more efficiently by employing energy conservation/management measures is probable and awakens curiosity. Hence, there is need to discuss various energy conservation management methods.

2.1 ENERGY CONSERVATION IN EXISTING PLANTS

The first energy management method to be considered is drawn from a paper by J.C. Robertson, published in the Chemical Engineering magazine in 1982 by McGraw-Hill Publication Company.

This method is an expression of what had been done and what was being done at Dow Chemicals USA at that time to achieve energy optimization results. The processes employed are still very relevant today as some similarities will be seen even in more recent methods that will be discussed later.

The method includes the following processes;

1. Management Support: This in other words refers to top management endorsement. Once management can be convinced to commit to the energy conservation/management goal, then it becomes the interest of the whole organization. Line supervisors therefore become the midwives for the proper birth

of the effort. They see to it that actions are taken to accomplish energy conservation.

Management in essence provides the motivation that will drive the entire organization to achieve energy conservation.

2. Energy Conservation Team: Once the management has given necessary support for the vision, there is need to form an energy conservation team that will be responsible to formulate and coordinate an energy conservation program.

This team is supposed to comprise of representatives from all sectors of the organization, so that every interest will be represented and recommendations will be made from a holistic assessment.

The team will serve just like a project team, and would meet regularly so that they will come up with an executable action plan that would yield results. They will also come up with a method of evaluating progress.

3. Industrial Power and Steam Generating Cycles: The idea here is to trace out the energy streams in order to locate areas where energy losses could be reduced or eliminated. The result is therefore to modify the industrial power and steam generation by addition or removal of equipments such as gas turbines and waste heat recovery boilers that will increase generating capacity while consuming less fuel than usual.

4. Chemical Process Design Innovation: To achieve plant energy reduction requirements, process design innovations need to be explored and implemented. This was the case for Richard C. Bennet, the division manger of Swenson division of Whiting Corporation, when his company replaced their conventional cylindrical vapour evaporator head with a special compression evaporator design to achieve a remarkable 5-20 % capital cost saving. (Richard Green Et Al, 1982)

5. By-product Recovery: Opportunities to recover raw materials from by-products should be explored, so that the returns of such materials will add to the aggregate returns for the plant's products.

The aim is to achieve more returns per cost of energy used for production.

6. Efficient Use of Steam: Better utilization of steam is still a great avenue for potential energy saving. More saving is achieved with high pressure steam since when it is used to heat up a product or material, its temperature only drops and it most likely becomes low pressure steam which can be used for heating up other lower temperature processes. But whenever low pressure steam is condensed by cooling water or air, which is usually the case, about 1000 BTU per pound of steam is wasted. (Richard Green Et Al, 1982)

The challenge therefore, is how to ensure that a very large percentage of the energy inherent in the low pressure steam is utilized effectively. For this to be achieved, again process integration needs to be the focus.

For example, in the Dow Chemical plant, the electric motor driven mechanical refrigeration units was replaced with absorption refrigeration units which use 10 to 1 psi g steam as the driving force. Previously, the steam was condensed from 15-30 psi g steam and returned to the power plant as condensate. However, the condensate from the absorption units is still returnable to the power plant. They actually achieved some savings by using the energy in the low pressure steam thereby saving electrical power. (Richard Green Et Al, 1982)

They claimed one of their plants in the Texas division saved an equivalent of 20 million BTU/hr. in this manner while several others saved 2 to 5 million BTU/hr. (Richard Green Et Al, 1982)

The dowtherm SR-1 (ethylene glycol) is also recommended to replace steam tracing since it freezes at -37°F and only requires a heat exchanger that heats

the SR-1 solution in a tank before it is pumped through the traces and a steam trap. Having fewer steam traps will result in steam savings and lower maintenance expenses.

7. Condensate Recovery: The steam condensate is high purity water and possesses heat content, hence, if it is not recovered, this amounts to waste.

Sometimes the condensate may be polluted with products, thereby making it useless for plant use. Efforts should be made to minimize the flow of condensate to the drains and filters may be installed to remove impurities or pollutants from the polluted condensate.

8. Minimizing Combustion Losses: The idea is to operate plant boilers efficiently such that stack gas temperature is minimal.

Economizers and combustion air pre-heaters to reduce flue gas heat loss may be incorporated in the power plant boilers.

9. Electricity Saving: The electrical department should strive for the most economical overall design consistent with good performance, reliability, maintenance and power costs. To achieve this, details such as;

- Size of cables;
- Capacitors for power factor correction;
- Motor ratings;
- Generators;
- Transformers; and
- Rectifier loss, need to be considered.

Steps also need to be taken to make better use of energy required for lighting. Lighting within the plant should be used responsibly.

Among the approaches Dow Chemicals used to address this issue are;

- Separate metering for lighting in the plant;
- Use of high intensity discharge lamps to obtain higher efficiency;
- Ensuring plant lighting meets applicable industrial standards;
- Conducting light level survey and making field changes to correct deficiencies;
- Employing photocell control on outdoor lights rather than entrusting the responsibility of switching them off to personnel, thereby guaranteeing that the lights are off when not needed; and
- Instituting a “Turn off Lights” campaign.

2.1.1 CONCLUSION

The method discussed above requires;

- Management endorsement;
- Line supervision attention to monitor and implement energy saving actions and projects;
- An energy conservation team conducting a continuous program to focus interest in energy conservation and to communicate ideas, techniques and progress regarding energy savings;
- Innovative designs from the process engineering department; and
- Utility conservation measures.

2.2 INDUSTRIAL ENERGY CONSERVATION

This energy management method was developed by Charles M. Gottschalk and published in the UNESCO Energy Engineering Series 1996.

The aim of the method is to guarantee immediate energy conservation results as well as to ensure cost effectiveness.

It involves the following processes discussed below;

1. Management Support: Apart from management fully committing to the energy conservation goal, they are also required to;

- Emphasize the economic reasons to conserve energy as well as employees' responsibility for suggesting and /or implementing energy saving ideas, proposals and measures within the area of their concern;
- Create an energy conservative task force with the guidelines to look into the energy saving potential in various segments of operations or divisions and to initiate a continuous program of activities to stimulate interest and encourage participation in the energy conservative efforts.

2. Establish Energy Database: There is need to have a complete and orderly energy data record as this will help management understand the urgency of undertaking an energy conservation program. The database may focus more on activities that will explore potential energy saving areas. It may also help to justify actions for a productive use of limited manpower and capital resources.

Such energy database will assist the energy manager function effectively by helping him take well informed decisions.

The database should contain information such as;

- Types of energy and their uses;
- Normalized cost of each form of energy;
- Rate of consumption of energy;
- Overall production output etc.

The database will indicate what percentage of energy used comes from the various sources and what percentage of energy is consumed in production, non production, power generation etc.

The ratio of energy use against production output is a rough indicator of energy intensity i.e. the specific energy used expressed in energy per unit of production.

From all these information, the energy manager will be able to;

- Assess the effectiveness of the energy conservation program;
- Determine the cost effectiveness of the energy measures;
- Quantify the net effects of energy saving measures;
- Quantify cost of production for a given production mix;
- Justify replacement of obsolete machinery;
- Propose dropping of non-profitable products;
- Improve maintenance programs;
- Suggest modifications to lessen repeated heating and cooling operations;
and
- Incorporate better temperature control systems.

Measuring all the energy that enters and leave the plant during a given period is necessary for proper energy conservation.

The measurements may be approximations initially but should improve with experience and with acquisition of additional measuring and monitoring equipments.

3. Conduct Energy Audit: Energy audit refers to an in-depth examination of an energy consuming system or facility for the purpose of;

- Determining the forms of energy used;
- Examine historical energy use and cost data;
- Verify current energy data and investigate operating practices and procedures;
- Relate energy consumption to production (specific energy consumption);
- Identify potential areas where energy waste can occur;
- Develop possible measures to reduce energy consumption;
- Establish energy efficiency in major equipments; and
- Develop a medium to long term energy program for better allocation of capital resources. (Charles M. Gottschalk, November 1996)

Energy audit according to Charles M. Gottschalk is usually categorized into three levels of activities. Each level of activity requires different magnitude of resources.

1. **Primary or Preliminary Audit:** It involves recording and analysing energy use by cost centre/activity over a fixed period of time. This is usually performed by a quick walk through of the facilities and by analysing utility bills. The visual inspection is made to determine broad energy saving opportunities and to establish the need for a more detailed analysis.
2. **Detailed or Maxi-Audit:** It consists in recording complete energy use data for every cost centre/activity over a fixed period of time and calculating

energy balances and efficiencies. This level requires measuring/monitoring instruments.

3. **Plant Surveys or Mini-Audits:** This involves identifying obvious energy wastage situations and recommending measures through improved maintenance and operating practices. It usually requires tests and measurements to quantify energy uses and losses. It also involves recommending and analysing energy conservation opportunities which require minor expenses or major capital investments.

The energy survey is aimed at identifying and correcting energy losses such as;

- Fuel oil leaks;
- Steam leaks;
- Bare hot surfaces needing insulation;
- Burners out of adjustment;
- High exit gas temperature;
- Equipment idling when not needed;
- Compressed air leaks; gas leaks;
- Product rejects;
- Unnecessary handling of materials;
- Frequent production interruption/shut-downs;
- Unnecessary pressure reducing stations;
- Defective control instruments;
- Defective steam traps; faulty installation of steam traps;
- Plug-up filters of blowers/compressors;
- Dirty working environment;
- Condensate leaks;
- Water leaks;

- Excessive lighting; and
- Excessive air conditioning/heating.

The scope of energy audit covers aspects of;

- Material flow; and
- Energy flow.

The material flow refers to the actual process or production flow from raw material stage to end product stage.

The energy flow refers to the utilities flow from the point of entry into the plant through its points of usage to its point of exhaustion. (Charles M. Gottschalk, November 1996)

The energy audit focuses on specific systems and major equipments such as;

1. Steam system: generation, distribution, use, and condensate recovery;
2. Compressed air system: generation, distribution, use;
3. Pump system: motors, pumps, operating requirements, constraints;
4. Heat generator: furnaces, re-boilers;
5. Heat recovery system;
6. Air conditioning system: chillers, instrumentation, load requirements;
7. System modification: batch operation to continuous operation; and
8. Integration of several process streams.

In preparing an energy audit the following steps must be followed;

1. **Set Objectives:** Objectives should be specific taking into account the limited resources available.

- 2. Organize the Energy Audit Team:** This team will be subject to the energy conservation task force. Members should have the required technical know-how and expertise in specific system, equipment and unit operations under study. The team executes the audit.
- 3. Establish the Urgency of the Task and Support Manpower needed:** Schedule the audit work according to the magnitude of opportunities to conserve energy.
- 4. Initiate a Quick Review and Evaluation:** This review and evaluation should be for existing information, current activities and operating practices which may include;
 - Record keeping, reporting, energy accounting;
 - Plant operating data (present and historical);
 - Overall process operations: specific energy consumption, material and energy flows, process flow diagram, auxiliary services, operating and maintenance practices;
 - Instrumentation: locations, conditions of various indicating and controlling instruments;
 - Equipment: list, operating conditions, design conditions, efficiency, capacity utilization;
 - Production scheduling: product mixes;
 - Material inputs; utilities;
 - Organizational structure (responsibilities in terms of operating cost centres); and
 - Government requirements and incentives, if any.
- 5. Prepare Plant Facilities:** This is for the purpose of data collection and test runs.

6. Establish Proper Timing and Duration: Proper timing and duration of the audit exercise must be determined to ensure desired test conditions.

7. Ensure the following;

- All necessary field and panel board instruments are properly calibrated;
- Portable instruments for comparative checking are calibrated;
- Standard reference gases and recalibrating devices are available;
- Maintenance and instrument staffs are present for back-up service.

8. Prepare all necessary Documents: This will include worksheets, survey forms, operating log sheets and reference drawings such as P and IDs.
(Charles M. Gottschalk, November 1996)

2.2.1 ENERGY AUDIT CONSIDERATIONS

During the energy audit, one should note the overriding principles applicable to all forms of energy conservation as follows;

1. The manner and extent of all energy use, including process methods, system balance, size of equipment, size of plant, instrumentation control systems, etc., should be investigated. Incidental benefits should be carefully evaluated.
2. For each stage of temperature and pressure rise/drop, useful work as well as extent of inefficiencies must be determined, if possible.
3. Waste heat must be usable and an end use must be identified. The quantity and quality of waste heat, timing of use, and distance from source

must be known. Moreover, net savings must exceed the cost of recovery and investment criteria.

4. Apparent energy savings must be carefully studied to ensure they have not caused increased costs elsewhere.
5. All forms of product reject waste energy must be kept at a low rate.
6. Reliable instruments should be used and test reference be clearly defined. (Charles M. Gottschalk, November 1996).

2.2.2 EVALUATING ENERGY AUDIT DATA

Using all available operating data taken from portable test instruments as well as historical data, assess and evaluate whether information;

- is fairly accurate
- is doubtful and needs retesting
- should be scrapped and disregarded

Analyse all process energy balances in depth:

- Can the equipment be rehabilitated to increase thermal efficiency?
- Can a process step be simplified to reduce energy use?
- Can the system balance be improved to optimize energy use?
- Can waste heat be recovered for suitable end use (i.e. to generate steam, hot water or preheat raw materials)?
- Can capacity utilization be improved?
- Can product rejects be minimized?
- Can better instrumentation reduce turnaround?

- Is it justified to replace old or oversized equipment with new equipment which requires less energy downtime or maintenance repair?

Analyse and summarize data, as applicable:

- Energy input in raw materials and utilities;
- Net energy charged to the main product;
- Energy credit for by-product;
- Energy dissipated or wasted;
- Energy consumed in waste disposal;
- Energy per unit output (to be compared with theoretical or designed specific energy). (Charles M. Gottschalk, November 1996).

2.2.3 IDENTIFYING AND IMPLEMENTING FEASIBLE ENERGY CONSERVATION OPPORTUNITIES

1. List down and classify energy saving opportunities into:

- Procedural and maintenance requiring small expenditures of money;
- Modifications requiring modest expenditures of money; and
- Modifications requiring extensive capital investment.

2. Describe briefly the engineering concept or scheme to implement proposed energy conservation measures.

3. Prepare a financial evaluation showing savings, funding requirement, return on investment or payback, risks etc.

4. Review past project proposals which were not considered for implementation or for further study. (Charles M. Gottschalk, November 1996)

2.2.4 REPORT ON ENERGY AUDIT

To conclude the energy audit, there is need for a comprehensive report to be submitted to management. It should contain the following;

- What actually transpired;
- The revisions for the proposed work plans; and
- Follow-up actions required.

(Charles M. Gottschalk, November 1996)

2.3 ENERGY STAR ENERGY MANAGEMENT GUIDELINE

Energy Star is a joint program of the US Environmental protection agency and the US department of Energy enhancing cost savings and protecting the environment through energy efficient products and practices.

They claim to have helped save Americans enough energy in 2005 alone to avoid greenhouse gas emissions equivalent to those from 23 million cars, while also saving \$14 billion on their utility bills (www.energystar.gov/index.cfm).

In order to assist CPI's in proper energy management, so as to achieve energy cost savings, low emissions etc. Energy Star published guidelines for energy management which will be discussed below.

Energy Star claims that their partners have employed the guideline with suitable results; hence they believe it can assist any CPI in improving its energy and financial performance while distinguishing the CPI as an environmental leader.

The guideline proposes the following steps:

1. **Commit to Continuous Improvement:** This involves regularly assessing energy performance and implementing steps to increase energy efficiency. Irrespective of the size and type of industry, the common element of successful energy management is commitment. The commitment is expressed by allocating staff and funding to achieve continuous improvement.

The following are actions that enhance commitment;

A. Appoint Energy Director: The energy director helps an organization achieve its goals by establishing energy performance as a core value. He must possess an understanding of how energy management helps the organization achieve its financial and environmental goals and objectives, his key duties include;

- Coordinating and directing the overall energy program;
- Acting as the point of contact for senior management;
- Increasing the visibility of energy management within the organization;
- Drafting an energy policy;
- Assessing the potential value of improved energy management;
- Creating and leading the energy team;
- Securing sufficient resources to implement strategic energy management;
- Assuring accountability and commitment from core parts of the organization;
- Identifying opportunities for improvement and ensuring implementation including staff training;
- Measuring, tracking and communicating results; and
- Obtaining recognition for achievements.

B. Establish an Energy Team: The team plans and implements specific energy improvements, the team also measures and tracks energy performance and communicates with management, employees and other stakeholders. The size of the team should depend on the size of the organization.

C. Institute an Energy Policy: Such policy provides the foundation for successful energy management. It formalizes senior management's support and articulates the organizations commitment to energy efficiency. The policy will state the objective, establish accountability, ensure continuous improvement and promote goals. (www.energystar.gov/index.cfm).

2. Assess Performance: This is a periodic process of evaluating energy use for all major facilities and functions in the organization and establishing a baseline for measuring future results of efficiency efforts. This approach helps the organization to;

- Categorize current energy use by fuel type;
- Identify high performance facilities for recognition and replicable practices;
- Prioritize poor performing facilities for immediate improvement;
- Understand the contribution of energy expenditures to operating costs;
- Develop a historical perspective and context for future actions and decisions; and
- Establish reference points for measuring and rewarding good performance.

Performance assessment involves the following key aspects;

A. Gathering and Tracking Data: This can be done by employing several data tracking process instruments or better still it could be outsourced. The point to note is that the data must be complete and accurate since it will be used for analysis and goal setting.

The following should be considered when collecting energy data;

- Determine the appropriate level of detail;
- Account for all energy sources;
- Document all energy uses;
- Collect facility and operational data;
- Establish tracking system; and
- Determine normalization factors and normalize data.

B. Establish Baselines: This can be achieved by measuring energy performance at a specific time. It will provide a starting point for setting goals and evaluating future efforts and overall performance. The steps involve using the data collected to;

- Establish base year;
- Identify metrics; and
- Publish results.

C. Benchmarks: Benchmarking can be used to develop relative measures of energy performance, track change over time and identify best energy management practices. It enables you to compare the energy performance of similar facilities or an established level of performance.

Facility or organizational performance may be benchmarked to;

- Past performance;
- Industry average;
- Best in class; and
- Best in practice.

D. Analyse data: This involves critical evaluation of the gathered data. It helps the organization gain a better understanding of the factors that affect energy performance and identify steps for reducing energy consumption. Depending on the need of the organization, data can be in the following ways;

Quantitative reviews;

- Develop and use profiles;
- Compare performance;
- Assess financial impacts; and
- Identify data gaps.

Qualitative reviews;

- Conduct interviews; and
- Review policies and procedures.

E. Conduct Technical Assessment and Audits: The periodic assessment of the performance of equipment processes and systems will help to identify opportunities for improvement.

Energy audits as discussed earlier are comprehensive reviews conducted by energy professionals that evaluate the actual performance of a facility's systems and equipments against their designed performance level or against best

available technology, thereby revealing the potential for possible energy savings. The main step for conducting technical assessments and audits are;

- Assemble audit team;
- Plan and develop audit strategy; and
- Create audit report. (www.energystar.gov/index.cfm).

3. Set Goals: The setting of clear and measurable goals is critical for understanding intended results, developing effective strategies and reaping financial gains. Well stated goals guide daily decision making and are the basis for tracking and measuring progress, they also drive energy management activities and promote continuous improvements.

Such goals should be communicated to staff in order to motivate their support for energy management in the organization. The energy director with the energy team develop the goals, this will help them;

- Set the tone for improvement throughout the organization;
- Measure the success of the energy management program;
- Help the energy team identify progress and setbacks at a facility level;
- Foster ownership of energy management, create a sense of purpose and motivate the staff;
- Demonstrate commitment to reducing environmental impacts; and
- Create schedules for upgrade activities and identify milestones.

To develop effective performance goals, the following process may be employed;

A. Determine Scope: The scope of performance goals may include multiple levels of the organization as well as various time periods for completion of specific goals.

Organizational levels include; organizational wide, facility, process or equipment.
Time periods include; short term and long term.

B. Estimate Potential for Improvement: It is necessary to have an informed idea of what level of performance is achievable and the amount of resources needed. The method that will be employed to determine potential will depend on several factors such as; available resources, time, nature of energy used at facilities and how the energy program is organized.

The methods used include;

- Reviewing performance data;
- Benchmarking;
- Evaluating past projects and best practices;
- Reviewing technical assessments and audit;
- Comparing goals of similar organizations; and
- Linking to organization wide strategic goals.

C. Establish Goals: Energy performance goals should be formally established and recognized by senior management at appropriate organizational levels as a mission for the whole organization once the potential for improvement has been estimated.

Goals could be expressed in the following ways;

- Defined reduction;
- Best in class;
- Efficiency improvement;
- Environmental improvement;
- Threshold goals; and
- Stretch goals. (www.energystar.gov/index.cfm).

- 4. Create Action Plan:** Once the goals are in place, the organization should develop a detailed roadmap to ensure a systematic process to implement energy performance improvement measures. The action plan should be updated regularly in order to reflect recent achievements, changes in performance and shifting priorities.

The basic steps for creating such action plan include;

A. Define Technical Steps and Targets: Technical steps involve;

- Evaluating technical assessments and audits results;
- Determining technical steps.

Defining targets involve;

- Creating performance targets;
- Setting time lines; and
- Establishing tracking system.

B. Determine Roles and Resources: This includes;

- Identifying internal roles, i.e. employees' responsibility;
- Identifying external roles, i.e. consultants, contractors etc. responsibilities;
- Define needed resources; and
- Secure resources. (www.energystar.gov/index.cfm).

- 5. Implement Action Plan:** To implement action plan successfully requires the support and cooperation of key people at different levels within the organization. Achieving success depends on the awareness, commitment and capability of the people who will implement the projects.

To implement the action plan, the following steps should be taken;

A. Creating a Communication plan: For effective communication it is required to identify key employees, customers and stakeholders, determine the information they need and adapt the messages appropriately for each one.

B. Raise Awareness: Every stakeholder should be made aware of his or her responsibilities and benefits regarding the energy performance goals. This awareness can be enhanced by initiating;

- New employee orientation programs;
- Poster campaigns;
- Energy performance seminars;
- Intra and Internet sites;
- Fairs and summits;
- Summary statistics; and
- Score cards.

C. Build Capacity: This involves enlarging the organizations context for energy management performance.

Investing in training and systems to share successful practices helps ensure the success of the action plan by building the overall organizational capacity. Capacity can be built with staff trainings such as;

- Operational and procedural training;
- Administrative training;
- Specialized training;
- Management information system also enhances capacity building by providing means for sharing information on best practices, technologies and operational procedures.

D. Motivate: Offering incentives is a way of creating interest in energy initiatives and foster a sense of ownership among employees, but care should be taken so that the focus does not lie on the incentives rather than energy saving performance. Motivation can be in various forms which include;

- Internal competition;
- Recognition;
- Financial bonus and prizes;
- Environmental responsibility;
- Financial responsibility; and
- Performance standards.

E. Track and Monitor: The tracking and monitoring system is a means by which an energy program's activities are monitored, it enables the organization to assess necessary steps, corrective actions and identify successes.

The system should be centralized and available for all to use in gauging progress towards established targets, milestones and deadlines.

The tracking system can be used to advance energy management goals in the following ways;

- Perform regular updates;
- Conduct periodic reviews; and
- Identify necessary corrective actions. (www.energystar.gov/index.cfm).

6. Evaluate Progress: This includes formal review of both energy use data and the activities carried out as part of the action plan as compared to the established performance goals. The results from the evaluation help to create new action plans; identify best practices and set new performance goals.

Regular evaluation of energy performance and the effectiveness of energy management initiatives allow the energy manager to;

- Measure effectiveness of projects and programs implemented;
- Make informed decisions about the future energy projects;
- Reward individuals and teams for accomplishments; and
- Document additional saving opportunities as well as non-quantifiable benefits that can be leveraged for future initiatives.

This requires the following key steps;

- Measure results: This requires gathering energy use data and comparing results to goals to determine accomplishments.
- Review action plan: The reviewing of performance data should look at the effectiveness of the established action plan. Then the next will be to understand factors affecting the results of the action plan as well as the additional benefits of the improved energy performance. Where activities and project are successful, best practices should be documented for sharing throughout the organization and when goals are not met, the cause should be determined and decision should be made on what corrective or preventive actions should be taken.

The steps in reviewing action plan include;

- i. Get feedback.
- ii. Gauge awareness.
- iii. Identify critical factors
- iv. Quantify side benefits

Action plan review requires a commitment of resources, but also has several merits such as;

- Creates insight for new actions (technology, practices, program);
- Avoids repetition of failures by identifying activities that were not as effective as expected;
- Assesses the usefulness of the tracking system and other administrative tools to ensure better management and evaluation;
- Provides staff the opportunity to contribute to and understand the process of energy management; and
- Provide specific success stories and financial results for communication to stakeholders inside and outside the organization.

(www.energystar.gov/index.cfm).

7. Recognize Achievements: This has a two way approach, i.e. providing and seeking recognition for energy management and achievements. Providing recognition for those who helped the organization achieve results motivates staffs and brings positive exposure to the energy management program within the organization.

Receiving recognition from outside sources validates the importance of the energy management program to both internal and external stakeholders and provides positive exposure for the organization as a whole.

The steps required in providing and gaining recognition include;

A. Providing Internal Recognition: This involves recognizing the accomplishment of individuals and teams which in turn will help sustain support and momentum for energy management initiatives.

It involves the following;

- Determining recognition levels which include individuals, teams, facilities etc.;
- Establish recognition criteria which will state the threshold of achievement for recognition;
- Determining recognition type; this can range from formal acknowledgements and certificates to salary increases and cash bonuses, to simple forms of appreciation such as souvenirs.

The purpose of the recognition and the organizational structure will go a long way in determining the type of recognition to be used.

B. Receiving External Recognition: Recognition from a third party can help provide;

- Validation for the organizations energy management program;
- Enhance the organizations public image; and
- Provide satisfaction and motivation to those involved in earning the recognition.

The avenues to pursue in order to gain recognition from external agencies include;

- Partnership programs with government agencies, trade associations, etc.
- Meet performance standards set by energy standard organizations;
- Win achievement awards that identify superior energy management programs;
- Public reporting: Report progress publicly and to targeted stakeholders that monitor and critique energy performance in order to gain their support and/or goodwill. (www.energystar.gov/index.cfm).

After evaluating the three methods on energy conservation management discussed, several similarities can be identified while dissimilarities can only be seen on where each method laid its emphasis.

Comparing these methods with several other methods only revealed that in energy conservation management certain steps or processes are always necessary and these steps include;

- Management support;
- Establishing energy database;
- Energy conservation team;
- Energy audit and survey;
- Continuous performance assessment;
- Goal setting; and
- Create action plan.

The differences in these methods can also be found in the way and manner each method was implemented.

The above listed generic steps will be employed in designing a management system for the case study plant. Nonetheless, the management system will be applicable to other chemical process plants.

In addition, other tested and proven energy management tools were also discovered in the process of this survey and they are also highlighted below;

1. Energy Management Matrix: This tool enables the organization's energy management profile to be found. The matrix will deal with organizational issues as it relates to the steps of the chosen or developed energy management method.

Once the matrix has been completed, areas that need further attention will be seen. Hence, energy management can thus be developed in a balanced way by addressing the areas requiring further attention. Energy star claims several of their clients have used it with positive results. (www.energystar.gov/index.cfm)

2. Strategic Asset Management: This is ensuring that assets are contributing to the operational efficiency of an organization, i.e. cost incurred in acquiring, maintaining and disposing (life cycle cost) of assets are balanced with the benefits they bring to reducing the output costs of a business.

A better way of expressing is in terms of “energy intensity” which is the amount of energy consumed per unit output of product/service.

Hence, by reducing energy intensity, an organization can reduce its unit output costs and hence increase its competitiveness. (Government of South Australia, department of Transport, Energy and Infrastructure, Energy Division Advisory, November 2006)

3. Environmental Management and Reporting: The purpose of this tool is to minimize resources consumption and waste output while still maintaining a successful business.

The organization will make it their responsibility to be fairly accountable to stakeholders on energy consumption and management issues. This will encourage the organization to always take actions that will portray it as environmentally friendly and on the long run help it manage energy more efficiently. (Government of South Australia, department of Transport, Energy and Infrastructure, Energy Division Advisory, November 2006)

4. Energy performance contracts: This approach allows potential contractors to provide innovative ideas for improving plant operation and energy costs. The

successful contractor then guarantees the level of energy saving that will be achieved.

Common wealth governments have invested in developing standard contracts to use within their own operations.

“The NSW health commission has used energy performance contracts (EPC) as a mechanism to upgrade many of their boiler plants and building services and some of these projects are successfully realizing their second year of savings.

The merits of using EPC as a tool includes;

- Reduced risk;
- Innovation; and
- Third party financing.

A guide to the steps involved in implementing EPC can be found on the energy performance contracting association’s website and the SEDA website” (Government of South Australia, department of Transport, Energy and Infrastructure, Energy Division Advisory, November 2006)

The tools discussed no doubt are effective for energy management (Government of South Australia, department of Transport, Energy and Infrastructure, Energy Division Advisory, November 2006), but not all of them will be considered as priority because they may not be applicable in the approach to be proposed considering the case study plant.

The strategic asset management and EPC tools are usually applicable with capital project where there is need to procure equipments or involve contractors in the enhancement of the plants production capacity.

CHAPTER 3

EMPIRICAL INVESTIGATION

In the previous chapters, the topic, “utilities optimization was introduced. Several opportunities and merits that accompany utilities optimization were highlighted.

The human element in managing utilities has aroused curiosity; hence various utility management techniques and approaches were discussed.

The possibility of optimizing utilities in the case study has been suggested. Hence, there is need to investigate the case study plant, while focusing more on the human element (managers, operators and shift supervisors) to identify differences in perception and levels of involvement by attempting to peruse the following;

- To determine if utilities in the plant are utilized with minimum wastage;
- To determine if there is a utilities management system being employed in the plant at the moment; and
- To investigate the need for utilities optimization in the case study plant.

This chapter discusses the approach employed in performing the field work for this research work. The approaches are listed below;

- Questionnaire;
- Interviews; and
- Observations.

3.1 QUESTIONNAIRE:

Questionnaires were developed in order to gather true, unbiased and reliable information about utilities management in the case study plant. In developing the questionnaire, a target population was considered.

The questionnaire was presented in three versions to cater for the different responsibilities/official positions of the people within the target population.

3.1.1 TARGET POPULATION:

The target population for the questionnaire was carefully selected based on factors such as:

- Population size that can give responses that may represent an acceptable view of the organization;
- The relevance of the job specification of each of the respondents to the subject;
- Perceived ability of the respondent to understand and appreciate the purpose of the questionnaire.

These factors were considered so that answers that will be given to the questions will be sufficient and reliable.

When considering the fact that the target population comprised three different work groups in the case study plant, it is certain that they will most likely view the subject of utility optimization, conservation and management differently.

The job specification and level of each work group also suggested that they were all privy to different levels or details of information relating to utility optimization,

conservation and management. Hence the need to develop three different questionnaires that will suit each of the work groups that make up the target population.

The people that make up the target population all have reckonable experiences with plant equipments, utilities and systems. Their positions include managers, shift supervisors and process controllers.

The questionnaires were presented in three different categories to suit the three positions.

The designing of three different questionnaire ensured that each work group received questions within their capacity to answer.

The differences in questionnaire design were also informed by the “social desirability effect”. (Johann Mouton, 2001, 107).

The social desirability effect makes a respondent answer questions based on what he feels is ideal rather than on the actual situation.

Assuming only one type of questionnaire was given to all three positions, the process controller may want to give a model answer to a question relating to his responsibility if he feels the correct answer may threaten his job, hence, such question is restricted to the questionnaire that would be answered by his shift supervisor.

3.1.2 QUESTIONNAIRE OBJECTIVES AND REVIEW:

The objectives of designing the questionnaire include;

TIME CONSTRAINT: It is usually not possible to have enough time to interview every person with relevant information, hence in order to make up for the insufficient time required for interview, introducing the use of questionnaire will enable more persons to answer more questions in minimum time.

FOCUS RESEARCH EFFORT: The questions contained in the questionnaire were designed to focus the person answering within the area covered by the study. Although allowance is created for diversions and additions by way of creating space for explanations and discussions on the questionnaire as long as they are relevant to the study.

COMPLIMENT OTHER DATA SOURCES: In order to validate the inferences from which analysis and discussions will be based, it is usual scientific practice to consider as many relevant scientific data as possible, hence the designing of a questionnaire as one of the three scientific data sources used for this research. This would in effect boost the confidence level of the data set.

In reviewing the questions, answers are expected to;

- Familiarize readers with the kinds of utilities used in the case study plant
- Establish the impact of utilities on production budget of the plant;
- Draw attention to possible sources of utilities wastage in the plant;
- Give hints on how management relates utilities consumption to the subject of utilities conservation;
- Enlighten readers on management's current or future effort to optimize utilities in the plant;

- Inform on the types of solutions that can be postulated for optimizing utilities in the plant;
- Expound on how process controllers relate utilities consumption in the facility to the subject of utilities optimization.

3.1.3 QUESTIONNAIRE VALIDATION

In conducting a research, care should be taken to ensure that data gathered are reliable and as scientific as possible.

Since a questionnaire has been adopted in this research it therefore becomes important that it should give a valid result that would be both reliable and scientific. Hence steps were taken to validate the questionnaire before introducing it to the target population.

Initially, a sample questionnaire was drafted and submitted to the academic project sponsor for perusal. His observations and recommendations informed the designing of a second draft. The major features introduced into the second draft were;

- Proper focusing of research effort; and
- Questionnaire presentation in three different categories.

Afterwards, the second draft was validated based on the concerns raised in “How to succeed in your masters and doctoral studies, sources of error in questionnaire/scale construction” (Johann Mouton, 2001:103) as follows;

Ambiguous words and sentences: To address this concern, questions were designed to be short and simple.

Double barrelled questions: Each question was designed not to be a combination of two or more question.

Item order effect: The questions were sequenced such that response would be accurate.

Fictitious construction: The questions were designed within the scope of responsibility and exposure of the respondents.

Leading questions: The questions were not designed to lead the respondents to answer in a particular way but rather to answer based on their knowledge. This is a reason for presenting the questionnaire in three categories.

Sensitive or threatening questions: None of the questions was designed to suggest to the respondents that their job was in any way being threatened or would be affected by their answers.

In concluding the validation, a pre-testing was carried out. In the pre-testing stage, the sample size considered was a sub-set of the target population which included a manger, a shift supervisor and a process controller.

The appropriate questionnaire was given to each one of them to complete after which a short interview was conducted with each one of them to find out what their concerns were regarding the questions.

The questions asked included but were not limited to the following;

- Do you understand the question?
- Do you think the questions relate to the subject “utilities management?”
- Do the questions intrude plant operations proprietary?

- Do the answers required undermine your responsibilities to your company?
- What questions do you think will further enhance the success of the research if asked?
- What question do you think are not relevant to the subject “utilities management?”

The conclusion of the pre-testing stage brought about the final draft of the questionnaire. The major additions in the final draft were;

- Correction of tenses;
- Reconstruction of some questions;
- Removal of some questions; and
- Introduction of some new questions.

The final draft is included in appendix 1 to appendix 3.

3.2.0 INTERVIEWS

Interviews were conducted in order to derive information expected to reveal facts that are relevant to the topic, “utilities management.”

Two groups of people were interviewed. The 1st group of people interviewed was in their capacity competent to give information concerning the case study plant’s utility management system, which is why they were considered for the interview sessions.

The 2nd group comprised people not working in the case study plant, but who work in different CPIs with similar processes as the case study plant.

The questions asked during the various interview sessions actually have their origin from the questions in the questionnaire. The reason was to ensure that the scope of research was properly streamlined and not unnecessarily broadened to such an extent where it would be characterized by ambiguity.

The interviews were conducted at various times in both formal and informal settings. A particular respondent was interviewed via email. Some of the interviewees were interviewed on more than one occasion, whereas, opportunity to interview some only came once, while some requests for interviews were turned down.

3.2.1 INTERVIEW OBJECTIVES

The objective of the interview is to know;

- The current perception within the facility as regards utility consumption;
- To highlight the measures put in place to optimally manage utilities in the plant;
- To identify if there is any workable energy management system or tool employed within the facility;
- To identify management's preferences as regards utility optimization;
- To identify operational practices employed in the facility that will not enhance utilities optimization;
- What kind of measures the target population suggests would be the best to optimize utilities in the plant.

The interview itinerary is shown in the table below

Table 3.1: Table showing time spent on interview sessions with each interviewee.

DATE	NAME	TOTAL TIME SPENT (MINS)
31 ST APRIL 2007	DEVEN GOVENDER	60
16 TH APRIL 2007	MELISHA RAMROOP	60
12 TH JANUARY 2007	GEOFFREY YARNOLD	60
9 TH FEBRUARY 2007	ROLIE PRETORIUS	30
30 TH MAY 2007	DOUGLAS ESPLIN	30
07 TH JUNE 2007	JAYAN PERUMAL	30
8 th JULY 2007	RIAAN WELGEMOED	E-mail Interview
15 TH AUGUST 2007	JACQUES ROSSOUW	30

From the table above, considering the total time spent column, a total of 300 minutes was spent on interviews. This length of time was enough to gather information required to support or rather add to information gathered from other methods of research employed in this work.

3.3.0 OBSERVATIONS

Observation of phenomena, actions or events and reasoning the knowledge gathered from such observation with previously acquired knowledge from abstract thought and everyday experience was carried out in the facility. It involved the primary method of collecting data employing human perception skills.

This method of data collection was adopted to support other methods of research employed for this work. By this it was intended that certain conditions and

processes as well as personnel attitude towards utilities management in the plant would be identified. These observations may either support or counter the data gotten from other methods of data collection employed in this work.

Observation was carried out in the case study plant under the following themes;

Operating culture: The operating status quo that obtains in the plant would have a way of affecting the management of utilities in the plant;

Plant Maintenance Strategy: The particular maintenance strategy adopted in the plant should have its resultant effect on the consumption of utilities in the plant;

Utility Management System: The management system in place in the plant determines the trend of utilities consumption in the plant; and

Plant Utility Surveys: This form of visual inspection would reveal on-site evidences of utilities wastage in the plant.

It involved activities such as;

- Physical inspection of the plant process lines and their associated utilities, with the intent of identifying best practices;
- Physical inspection of each utility system in the plant for the purpose of identifying deviations and potentials for better optimization;
- Holistic assessment of the facility's system and comparing it with best practices; and
- Observing operating practices of plant personnel within the plant.

Observation was a continuous activity throughout the period of writing this dissertation and hence, no specific period of time could be said to have been set apart for it.

3.4.0 SUMMARY

The above discussed methods of investigation were the tools used to gather data from and for the case study plant for this research work.

The data gathered from each method was analyzed independently so as to avoid biasness. The data from all the methods were also analyzed interdependently so that a common inference may be deduced from them.

The interdependent analysis was considered because the data collected was all about the same case study plant, hence the possibility of all the methods emphasizing on particular utility management issues. This would make it easy for problem areas to be quickly identified. It was also expected, though not compulsorily that the information derived from each method should tend towards the same conclusion.

In the event of the data giving contradictory information, the process observation method data would be used to benchmark the other two methods. This is because the researcher would not want to undermine his work by altering his observations. Hence, data from this method would most probably represent the actual state of utilities in the plant.

The other two, i.e. questionnaire and interviews are accepted only in “utmost good faith” hence, their integrity is only subject to the sincerity of the respondent.

The process of gathering data was characterized with various challenges. Not everybody contacted initially for data was willing to share them, but after some formal and informal meetings where issues of confidentiality and proprietary were discussed and agreed upon, some of them came around and became of tremendous help.

CHAPTER 4

FINDINGS AND DISCUSSION

The data gathered for this work was a result of in-depth observation, structured questionnaires and interviews.

This chapter will interpret the data collated in the process of the empirical investigation.

Each of the methods will be analysed and summarized separately after which the findings from all the methods will be discussed together to arrive at certain conclusions as would be found.

4.1 QUESTIONNAIRE

The questionnaire was designed to reveal information relating to trends, use, preferences, cost, attitude, system, plant key performance areas, optimization, opportunities etc. on the subject of utilities optimization/management in the case study plant.

As explained in the previous chapter, the questionnaire was shared among managers, shift supervisors and operators. In analysing the questionnaires, shift supervisors and managers would be referred to as management in some instances because after assessing their responses, there were similarities that could not be ignored while operators are referred to as operators or personnel.

The following were the findings from the questionnaire;

- The utility cost trend is also commensurate with the utilities consumption trend. This means if utility consumption is reduced by employing good optimization tools, cost spent on utilities will be reduced and hence, production cost;
- There seemed to be varying views among management regarding whether the amount and cost of utilities consumed within the plant is a concern. This is probably due to the difference in perspective of the respondents, which evidently suggests that there is no management focal point on the subject;
- The facility does not export steam to other plants under normal operation but rather it re-uses the steam produced. This is a good optimization practice as it is in line with best practices;
- There seems to be varying views on whether there are evidences of wastage of utilities in the plant. This further suggests that management has not put in place a system that monitors the plant utility system effectively e.g. inspections and reports that would reveal the exact state of utilities;
- Management is of the opinion that operators have a complacent attitude towards utilities optimization. This raises the question whether operators have been sensitized or whether operators have relevant training on the subject;
- Actions have been taken in the past with the intent of enhancing utilities optimization, but minimum results have been achieved from such action in the area of cost of electricity. Such action involved changing of electrical motors (technological development);
- At present, there are various utility optimization measures in place, but there are no indications that these measures are convergent. Some respondents were also quick to point, that the non-convergence can lead to lack of focus and loss of unique opportunities.

- There was a unanimous stand that the utilities optimization potential of the plant is not being fully exploited. The aspect of control and management should be looked at since monitoring is being carried out, though not very effectively;
- Incentives are not given to personnel for exceptional utility optimization results; this may also be a reason for their perceived mediocre attitude to utilities optimization. Moreover no major considerable utility optimization in recent past can be identified;
- Possible utilities optimization incentives are captured in incentives for economic results; this means that in the past, incentive that may have accrued due to utilities cost savings added up with incentives that accrued due to better production/financial year profits;
- The Management's preferences as regards utility optimization include safety health and environment, cost and production throughput; hence if the utility optimization conservation and management measure that may be suggested to the management does not affect these preferences positively, it may not be a welcome suggestion.
- There are various stances among management on whether personnel show knowledge and understanding of the impact of utilities consumption on production. Some claim that regular meetings among management, shift and suggestion scheme and context of such meetings indicate considerable knowledge and understanding of the impact of utilities consumption on production, while others are of a contrary opinion. The variance in opinion suggests a poor utilities management feedback structure;
- Utilities management as claimed falls within the plant's KPA (key Performance Area), but the extent to which it does is questionable if records of utility consumption are kept only for the purpose of payment of bills as management respondents stated;
- There was also a variance of opinion on whether there is an established utility management system in place within the plant. Some respondents

made mention of “SAP” as the utility management system, while some denied the existence of any utility management system. From investigation the “SAP” system in place in the plant is used to monitor utilities consumption in the plant as well as other phenomena, but it does not control and manage utilities consumption. Moreover, “SAP” is not a dedicated system for monitoring utilities in the plant;

- Operators however, are of the opinion that the plant utilities management can be improved upon. This view is shared with all other respondents including management;
- None of the operators have suggested any measure that may improve utilities management in the plant. This may be due to lack of avenue for such suggestions or due to inadequate training to enable them give such suggestions;
- Operators’ idea as regards management preferences with respect to utilities optimization is basically production throughput. This further suggests that the ideology within the plant is focused mainly on production. This also suggests that the company may not have an established generally known and accepted utility optimization objective;
- Upon perusal of the questionnaire responses, it was deduced that the monitoring of utilities consumption is the responsibility of one person rather than a department or a team. This is opposed to best practices as highlighted in the literature survey;
- The operators’ response to the purpose of keeping record of utilities consumption for the facility can be termed as assumed rather than informed as it differs from management response. The managers’ response is presumably correct since their job responsibility puts them in the position to be better acquitted with utility matters in the plant.

4.1.1 CONCLUSIONS

- There still exists a great opportunity for utility optimization/management in the plant if management can establish a standard utility optimization/management objective;
- There is much emphasis on utility monitoring while little or nothing is done on control and management;
- The plant requires a dedicated utility optimization/management tool that monitors, control and manage utilities consumption since “SAP” may not fulfil these three objectives; the management’s ability to monitor, control and manage utilities with this management tool will help management to align utility performance to suit their preferences
- There is need for plant personnel to be sensitized on utility optimization/management as well as its advantages to operations cost;
- The optimization/management of utilities should be handled by a utility team rather than an individual; this will enhance the management’s capacity to optimize, conserve and manage utilities consumption.

4.2 INTERVIEWS

The interviews were conducted interpersonally and by e-mail (questions were e-mailed to some respondents and they sent their responses back by e-mail).

Interviews were not limited to people working in the case study plant but it included people working in the chemical process industry (CPI).

The common qualifier for all the interviewees was that they worked in a CPI with similar processes that utilize similar utilities.

Rather than analysing each interview, attempt was made to analyse the responses of all the people interviewed under particular themes and present it as a report.

4.2.1 UTILITIES

The utilities that respondents agree are used on their plants are either a combination of some or all of the ones listed below;

- Steam; the particular pressure of steam used at different plants varied;
- Electricity; the voltage rating of electricity used varied at different plants depending on the particular equipment it was used to power;
- Hydrogen;
- Instrument air;
- Fuel gas;
- Nitrogen; it included high and low pressure nitrogen; and
- Water.

The utilities listed above are the basic utilities that can be found in most CPI's.

4.2.2 UTILITY WASTAGES

While some respondents agreed that there are forms of utilities wastage in their plants, some were of the opinion that there was no utility wastage in their plant.

From further enquiries it was discovered that there were forms of wastage in all the plants, but the extent of such wastage varied in each plant. While some wastage was apparent some were termed negligible by the respondents (reason why they said there was no wastage in their plant).

On the subject of utilities optimization/management, world best practices advocates zero tolerance to utilities wastage, (Government of South Australia, Department for Transport, Energy and Infrastructure , Energy Division Advisory, November 2006), hence, any form of utility loss or waste can not be termed as negligible, but relevant.

4.2.3 MONITORING

From the interviews, it was apparent that a lot had been invested in the monitoring of utilities consumption by installing several flow meters. Despite the amount of installed flow meters, many respondents still noted that there still exist some monitoring instruments that are yet to be installed into their utility systems in order to monitor their utilities consumption more effectively.

“We don’t measure all our utilities, for example instruments air, but we plan to commence its measurement by installing flow meters on the instruments air line” (interview, May 30, 2007). “Sometimes utilities management is a concern to us because we don’t have metering equipment on all our utility lines” (interview, April 16, 2007).

It was also discovered that the utilities monitoring claimed by respondents referred only to the amount of utility imported into the factory and not on the actual utility supplied to the equipments that utilized the utility.

Energy losses occur along the utility supply and distribution system due to equipment inefficiencies and mechanical and thermal limitations (ITP Industrial Energy Systems, Understanding energy footprints, Aug, 13, 2004).

The amount of loss that occur from “battery limit” (point of utility import to plant) to equipments are not measured. This is a shortcoming in monitoring as the

actual utility believed to be used for production actually consists of utility/energy used by equipment plus utility/energy lost along the lines.

This energy lost along the lines is expressed in equation 4.1 below;

$$U1 + U2 = Ut..... \text{eqn. 4.1}$$

Where;

U1 is utility/energy used by equipment;

U2 is utility/energy lost along the lines;

Ut is the total utility imported into the plant.

4.2.4 MANAGEMENT SYSTEM

None of the respondents could state a particular utility management system in use in their plant. One stated “we are currently not running any specific energy management system. The optimization of operation is still done in the old fashioned way via mass/energy balances from the process engineers” (interview, July 8, 2007).

The mass/energy balance helps to determine the quantity of energy that can be gotten from a given mass to deliver or maintain the energy flows and service requirement of the plant process. In practice the mass/energy balance should be a part of a utility management system.

“A utility management system ensures the efficient use of energy by eliminating wastage in an organizations operation” (Government of South Australia, Department for Transport, Energy and Infrastructure, Energy Division Advisory, November 2006)

The mass/energy balance may be used as a tool to enhance proper utility management by using it to determine the mass of energy required to deliver the energy flows that will meet the optimized target proposed by the management system.

4.2.5 OPTIMIZATION

While most respondents agreed that utility optimization was necessary for their plants, they were quick to infer that the purpose of such optimization was to enhance production or rather reduce production cost; “since our production cost comprises of labour, laboratory expenses and utilities cost, optimization of utilities consumption will lead to reduced cost of utilities and in effect will lead to reduced production cost; the better for us” (interview, May 14, 2007).

A particular respondent stated that the plant will experience full utility optimization after it has reached its optimal operating point.

“From a utility integration perspective, the plant has already been designed to achieve its optimal point when running at full load. We still have to get to this point; therefore, our focus is not necessarily related to plant energy efficiency but rather stable, reliable operation. Therefore, we will only start looking at optimizing utilities cost once the plant is in a more stable, higher load operating condition” (interview, July 8, 2007).

The above statement by the respondent suggests that the possibility of operating the plant optimally in any given operational situation apart from “when running at full load” has not been explored. It also gives the impression that production optimization receives most attention in the plant.

4.2.6 PREFERENCES

The preferences with respect to utility optimization stated by respondents include;

- Cost;
- Production;
- Safety, Health and Environment.

These are similar to those stated by the questionnaire respondents; hence, this suggests that any optimization method to be suggested must address these themes.

4.2.7 IMPROVEMENTS

The interviews also gave opportunity for the respondents to suggest possible ways of improving utility optimization/management within their plants and their suggestions included;

- Installation of metering equipments;
- Installation or upgrading of their current condensate system to a more efficient condensate system;
- Optimal design for compressor electrical motor; and
- Employing pinching techniques used in heat exchanger design.

On further enquiry, respondents also noted that whatever improvement that would be implemented must not be too cost implicative especially in the case of a “running plant” (a plant that is already in operation). This suggests that improvement methods that would be suggested must not be too costly.

It was also noted that none of the respondents suggested any energy management system/practice. Their focus was on equipments and processes. A good utility management system combines the human factor/element with equipments and processes.

4.2.8 SAFETY HEALTH AND ENVIRONMENT

A good utility optimization management approach should reduce the organization's negative environmental impact caused by the organization's energy use. This was the position of all the respondents.

They also noted that such approach must not in any way undermine the safety and health of the personnel that would be involved in its implementation and sustenance. That is to say the structural and operational design of such a system should not pose any threat to the safety and health of the personnel.

Whatever risk that may be associated with such approach must be properly assessed and proper mitigation actions should be put in place to minimize or/and eliminate it.

It was a general opinion that irrespective of the advantages of any utility optimization/management system or solution, if it endangers the environment or the safety and health of personnel, it is not worth it.

The government also put in place measures (penalties and incentives) e.g. the OSH ACT (occupational safety and health ACT) to ensure that organizations don't indulge in practices that will endanger safety and health of the personnel and environment.

4.2.9 CONCLUSION

- Since there are evidences of wastages in plants, there exists opportunities for optimization by curbing/eliminating the wastages;
- Good utility management involves monitoring, control and management, hence, there is need to improve on utility monitoring and implement utility control and management;
- It is apparent that there is no utility management system in place. Implementing a good management system will give opportunity for remarkable optimization of utilities since it will ensure proper monitoring, control and management of utilities;
- Plant management still need to see the possibility of using their utilities optimally under any operating condition, they need to explore several “energy optimization and management systems” (EOMS) available in the market to achieve continual optimization;
- Cost, production, safety, health and environment must be the focus of any management system to be introduced to the plant management;
- There is need for a proactive utilities optimization culture in the plant; and
- Safety Health and environment is vital to utilities optimization/management.

4.3 OBSERVATIONS

Observation of processes, systems and operations culture was carried out in the case study plant after which the following were discovered;

- Most of the electrical lighting was left “ON” throughout the day and night (24hours). This outrightly eliminates the opportunity of saving electricity during the day when natural lighting can be exploited for visibility around the plant;

- There exists bare steam tracing lines in the plant without insulation. This minimizes the efficiency of the steam tracing because the hot steam tracing lines experience natural cooling due to their exposure to the atmosphere. This necessitates the use of more steam to give proper steam tracing effect on the product lines;
- There are steam leaks from broken steam pipes in several areas within the plant. This is an evidence of steam waste;
- Steam pipes leaking are left for a long period of time before being repaired. Steam leaks are not treated as top priority in the plant's defect priority list;
- There are leaking steam traps at several places within the plant. This is another evidence of steam waste;
- The attitude of personnel within the plant depicted much emphasis on production and safety, utilities optimization/management is scarcely mentioned. This attitude does not enhance good utility optimization culture in the plant;
- Some steam traps are installed to expel steam condensate to the drain, whereas, there are better uses of the steam condensate like using it as part of another process (cooling) rather than expelling it to drain;
- Access to plant air within the plant is not restricted; anyone can locate the valve and open it. It was observed that some operators use it to blow off dust from their PPE (personal protective equipment). This attitude is not in line with best practices; moreover, some of them don't close the valves completely, so it eventually results to waste as the instrument air leaks to the atmosphere;
- There is no physical log sheet for logging utilities consumption values like in the case of process values, hence deviations may not be noticed on time.

4.3.1 CONCLUSIONS

- There exists great potential to save cost expended on electricity in the plant if natural lighting is employed;
- There also exists great potential to save cost expended on steam, if all the avenues of wastages and inefficiency stated earlier are properly addressed;
- There exists potential to save cost of instrument air if access to its use is properly controlled;
- There is need to create a proactive utilities optimization management culture in the plant like in the case of production and safety. This will create a good environment for enhancing utilities optimization/management;
- Instituting regular logging of utilities and inspection of utilities and inspection of utility systems is necessary to enhance the proactive utilities optimization/management culture;
- Several evidences of steam waste from leaking pipes and traps exist in the plant.

4.4 UTILITY FLOW DIAGRAM

The utility flow diagram shown in figure 4.1 shows all utilities imported into the plant. It also shows all the utilities that are produced within the plant as by-products of processes.

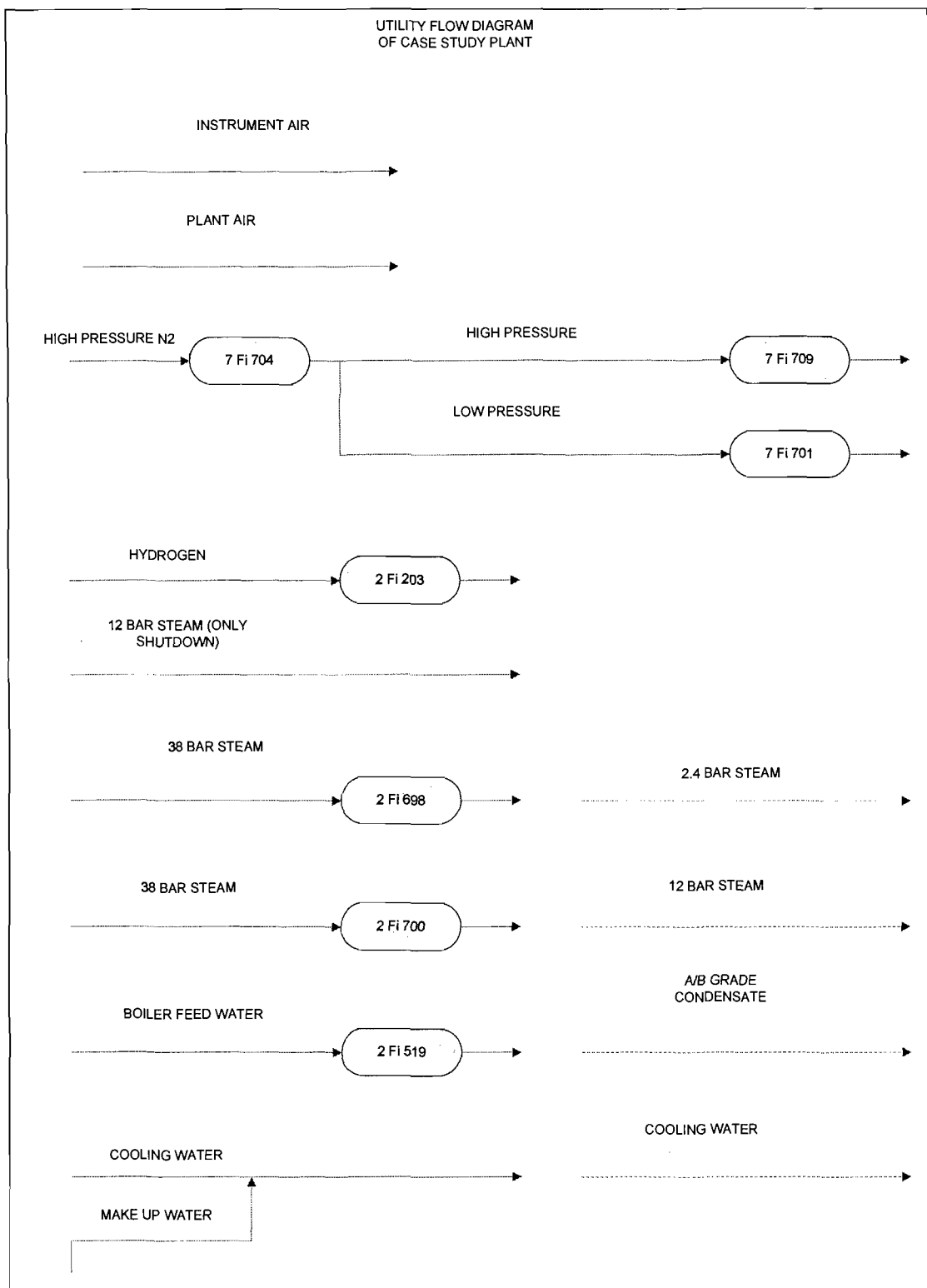


Figure 4.1 Utility Flow diagram of Case Study Plant.

The 2.4 Bar and 12 Bar steam, A/B grade condensate and cooling water are by-products of processes within the plant. They are all reused within the plant for other processes; this is a good example of process reintegration discussed in chapter two.

Not all the utilities that make up the process by-products are utilized for other processes and also the processes they are used for still produce utilities like 2.4 Bar steam, steam condensate as by products, hence, the question arises, what happens to the utility leftovers?

Some are vented to the atmosphere while others find their way to the drains. This creates an avenue for pollution as the steam vented to the atmosphere and the condensate released to the drains sometimes contains traces of hydrocarbons which can pollute the environment and atmosphere. This negates the safety health and environment efforts of the company and also amounts to wastage.

There is therefore need for finding a way of getting optimum value from the utility used and produced in the facility. This may be in the form of improved process integration or/and selling of utilities to other facilities.

Another observation while studying the utility flow diagram is that all the imported utilities are only measured at the point of entry into the facility, but the actual amount of utility consumed by equipments is not known. There is need for proper monitoring of utilities consumption.

4.5 DISCUSSION

Upon perusal of the findings so far, certain properties and their theoretical sensitivity (interrelationship) from the textual data base were deduced.

The grounded theory approach (Glaser & Strauss, 1967) was employed to arrive at these deductions. The grounded theory is a general research method that would enable the establishment/development of a theory or case with respect to the case study plant from the available data on the phenomenon "utility conservation and management". This case that will be developed is emergent, in other words, it emerges from the findings.

By employing this approach, the findings highlighted earlier will be grounded into nine themes listed below;

- People;
- Management system;
- Maintenance;
- Monitoring;
- Control;
- Utility objective;
- Safety health and environment;
- Cost; and
- Production.

The selective coding method of grounded theory that involves choosing a theme to be the core category and relating all other categories to it is used to further simplify the discussion. "The essential idea is to develop a single storyline around which everything else is draped" (Steve Borgatti, introduction to grounded theory, 25th Aug, 2007).

At the core of all the themes is the concept of management system and utility objective. This core category emerged strongly because every other theme can be related to it.

The measure of influence or relevance of each theme to utility optimization, conservation and management is dependent on the objective of the organization with respect to the themes.

The objective of the organization will in effect determine the organizations management system strategy.

4.5.1 MANAGEMENT SYSTEM

The purpose of management is to achieve organizational objectives. As discussed in the questionnaire findings, utility optimization falls within the case study plant's key performance area, hence making efficient utility optimization conservation and management one of the management's objectives.

The management system should determine how responsibilities are assigned and how resources are managed. This system will enhance ease in;

- Establishing, prioritizing and reaching objectives;
- Communicating targets and results within the organization;
- Establishing a framework for communication and pattern of work within areas of the organization;
- Sensitizing employees towards achieving set objectives; and
- Creating resource and performance monitoring for all the elements of the set objective.

Of key importance to the management system is the management of resources which include;

- People;
- Finance;

- Materials;
- Machinery, equipments and systems; and
- Information.

4.5.2 UTILITY OBJECTIVE

As already discussed in the findings, it could not be established that the case study plant's management have a stated utility objective.

The aim of any management is to achieve its objective, hence if any of the management's objectives is not met, much effort is made to ensure the achievement of that objective and necessary actions are taken.

Hence, if the case study plant has a utility objective, the management system will of necessity be in place and will be such that it operates to achieve that objective.

4.5.3 MONITORING

A management system designed to achieve an objective needs to have a means of monitoring the performance of all the elements of the objective.

It should be able to monitor the progress made with respect to the actions prescribed for achieving the objective and at the same time allow the management respond to the divergences with precise actions and also ensure that accurate feedback is received.

Proper monitoring increases capacity for proper measurement of the condition of utility performance.

To get the full result of monitoring, details of what is to be monitored should be considered.

4.5.4 PEOPLE

The proper management of people within an organization determines to a large extent the organizations ability to reach its objective.

The management system should focus on the human resources in the aspects of;

- **Training:** This training should be such that it empowers and enlightens the people to work towards achieving the organization set objectives.
- **Responsibility:** Every personnel in the organization should be assigned a job specification that addresses different elements of the objective. The result of this is that it will develop a sense of personal ownership of the objective by each personnel since they will see themselves as a vital tool and responsible for achieving the organization's objectives.

People are organization's most valuable assets; hence, the management system should be such that it manages them well.

4.5.5 CONTROL

For any objective that is set, certain actions are required to be taken in order to achieve the objective. Hence, control becomes necessary in order to ensure that such actions are taken rightly and at the right time. "Power without control is disastrous" (anonymous).

In order to ensure proper control, there is need for a system that manages the actions so that the objectives are met to specification.

A good management system must be efficient and have a good control mechanism.

4.5.6 MAINTENANCE

An important aspect of any management system is the management of resources. The resources here are machinery, equipment and systems.

To achieve management objective, it is necessary to use the most appropriate machinery and equipment and at the same time make sure that it is maintained, replaced and updated where necessary. The maintenance should be timely as well.

There are several methods of maintenance and the management system should accommodate the best maintenance method that will enhance its objective.

4.5.7 COST AND PRODUCTION

Organizations set objectives that will enable them to maximize cost and optimize production.

Since the organization's objective determines the management system, the management system will enable them to maximize cost and optimize production by;

- Using financial resources, such that it is in line with profit and sales target;
- Using material/resources in the most productive way with minimum waste.

4.5.8 SAFETY HEALTH AND ENVIRONMENT

It is a known fact that safety, health and environment are a vital consideration in every organization since it finds relevance in the social and environmental governance.

A good management system should put in place a structure that ensures safety health and environment requirements are met and maintained.

4.6 PLEMINARY CONCLUSION

Going by the findings, there have been shortfalls in the current state on the case study plant regarding some of the discussed themes with respect to utility optimization, conservation and management. The themes include;

- **People:** There are no formal trainings to sensitize them on the subject of utility conservation and management that would in turn create in them a utility optimizing attitude.
- **Monitoring:** Utilities are measured only at the point of entry into the plant and not also at the point of usage by the equipments; hence the exact amount consumed for production purpose is unknown.
- **Control**
- **Maintenance:** Steam leaks are not repaired quickly enough.

Emphases are laid on certain aspects of operation such as;

- Cost;
- Production; and

- Safety health and environment.

Whereas, the avenues through which utility conservation and management can enhance these aspects have not been well explored.

It is my opinion that if any utility objective is set for the case study plant and a management system that will pursue that objective is put in place, then utilities in the case study plant will be better optimized, conserved and managed. This is so because once there is a good management objective in place, driven by the right management system, other elements like people, monitoring, control etc. will be properly addressed and hence, utility will be well optimized.

Since management is a human skill, the right management system in place will be the human skill in place (human element).

In the next chapter a workable management system will be described for the case study plant.

Although developed with reference to the case study plant, the proposed management system constitutes best practices for the CPI, and can be applied as such.

In addition, recommendations for immediate implementation and further research on the subject of utility optimization, conservation and management for the case study plant will be outlined.

CHAPTER 5

RECOMMENDATION AND CONCLUSION

5.1 INTRODUCTION

Utility/Energy optimization conservation and management is a great global concern today.

This concern has been expressed in various industries such as Oil and Gas industries, Chemical industries, Production industries, etc. and the concerns include safety health environment, pollution, cost and wastages.

This work centres on the chemical process industry using a wax plant as a case study.

The current situation on the wax plant on the subject of utility optimization conservation and management as well as its potential for utility conservation and management was investigated.

After perusal of the information gained through questionnaires, interviews, and observation, some themes emerged. These themes were found to be factors that influence utility optimization, conservation and management performance of the case study plant.

From the discussion in chapter 4, the need for a utility objective driven by a management system to enhance the utility optimization, conservation and management of the case study plant was established.

In this chapter, a workable management system for the case study plant that will also be applicable to similar plants in the chemical process industry will be

described and recommendations will be made for practice and also for further research.

5.2 MANAGEMENT SYSTEM STRUCTURE

The management system structure was developed to address the shortcomings highlighted in chapter 4 of this work such as; lack of management focal point/objective on the subject of utility optimization; inadequate monitoring, control and management of utility consumption; inadequate training/sensitization of personnel on the subject of utility optimization; non-convergence of utility optimization measures; non-specification of incentives due to remarkable utilities optimization; avoidable utilities wastage; etc.

The management system is as follows;

A. CREATE UTILITY OBJECTIVE

This involves publishing a documented statement stating the management's intention to optimize, conserve and manage utilities. This statement may include the steps to be taken to optimize utility and the expected benefits of optimizing utilities in the organization.

The utility objective statement should be understood by every personnel in the organization. By creating the utility objective, the management will be declaring its commitment and support to utility optimization, conservation and management, hence passing the message to all other organizational stakeholders.

B. ESTABLISH UTILITY OPTIMIZATION, CONSERVATION, AND MANAGEMENT TEAM

This requires top management to create a team comprising mainly of personnel within the organization. This team is saddled with the responsibility of steering the organization towards the utility objective of the organization.

The team should be made up of Managers, shift supervisors, operators, service providers and if possible, energy organizations and association. The reason for this composition is to ensure best performance from the team. All the members of the team will be able to view the subject from varying perspective but with the same goal in mind, hence guaranteeing best results.

C. ASSIGN GOALS TO UTILITY TEAM

This requires setting clear and measurable goals towards achieving the intended results. The assigned goals will guide the utility team in making decisions and will also form the basis for tracking and measuring progress.

These goals should be communicated to staff in order to motivate their support for the utility team as well as the utility objective.

The set goals could centre on;

- Cost reduction;
- Elimination of wastages; and
- Environmental improvement.

It is necessary to assign a time frame for every set goal.

D. OPTIMISATION, CONSERVATION AND MANAGEMENT ROADMAP

Once the goals have been set, the team needs to develop a roadmap or action plan to ensure a progressive approach to attaining the expected goals.

This phase will require that the responsibilities of all stakeholders be spelt out.

The strategy that will best enhance the goals will need to be outlined. This will involve;

EVALUATE CURRENT UTILITY STATUS OF PLANT: This involves performing energy audits and study utility database for consumption trend.

CREATION OF A COMMUNICATION PLAN: There must be an effective communication of roles and responsibilities to stakeholders.

RAISE AWARENESS: The stakeholders must be aware of the requirements and benefits of the utility goals, by way of orientations, seminars, training, poster campaigns, etc.

MAINTENANCE: Upgrade maintenance strategy to increase priority of utility related defects.

ENERGY PERFORMANCE CONTRACTS (EPC): This approach commits contractors and service providers to enhance utility optimization, conservation and management.

The EPC will enable the management to approach the utility goal, employing third party efforts.

E. CREATE FEEDBACK STRUCTURE

A feedback structure should be in place in order for the utility team's performance to be monitored. The structure should enable continuous performance assessment of the utility road map's action plan, corrective actions and also recognition of success.

The feedback structure will motivate the utility team to keep working towards the set goals if the goals have not been reached since it will serve as a measuring tool, measuring current achievement against set goals.

F. RECOGNIZE ACHIEVEMENT

This will require that a criteria that will state the benchmark of achievement for recognition to be created.

The purpose of recognition of achievements is to further motivate the commitment of stakeholders to the utility objective,

The process of recognition should be clearly stated such as the levels, which include individuals, teams, service providers etc. and types which include bonuses, certificates, souvenirs, etc.

5.3 RECOMMENDATIONS FOR PRACTICE

Better knowledge and understanding of the benefits tied to utility optimization, conservation and management will encourage the management of chemical process industries to employ a suitable utility management system for their plants.

The case study plant management tends to focus more on the process, production, and safety. They always almost overlook utilities consumption except when it affects production directly.

In my opinion, management focus has been too biased towards production and safety; hence they are unable to reap the benefits of a utility system that is well optimized, conserved and managed.

In order for the case study plant as well as other chemical process industries to begin to experience the economic, quality, and environmental benefits of a well managed utility system, the following recommendations need to be permitted by the management system structure.

- Employ photocell switches for plant lightings. This will ensure that natural lighting is well exploited;
- Ensure all steam tracing lines are lagged. This helps increase steam tracing efficiency;
- Improve on process integration by creating a vessel to store all condensate from steam traps for other uses;
- Positively isolate plant air valves and necessary permits to use the plant air should be given only when there is need for it;
- Log sheets for utilities should be introduced to ensure continuous monitoring of utilities consumption in the plant. This will help track deviations immediately;
- The possibility of using steam for office heating during winter should be explored. This would reduce cost expended on electrical heating, since low pressure steam is a process by-product;
- Variable speed motors and variable speed drives should replace all the single speed motors within the facility. This will help to reduce the cost of electricity, since the motors will only run at the speed required for any particular process flow;

- Utilities consumption monitoring should be improved upon by introducing more measuring instruments into the process. The process equipments can be grouped into modules and each module will have a measuring instrument measuring the amount of utilities that is supplied to it. The “difference” U_2 (equation 4) will determine the plant performance with respect to utility conservation;
- A strategy should be put in place to control the consumption of utility. This is only possible if utility consumption per time is closely monitored. If monitoring is properly done, then deviations from optimal operation will be noticed on time, and the process will be controlled to correct the deviations;
- There is need for a management system within the facility that includes personnel, process, equipments, etc. This management system will integrate all the discussed factors, thereby ensuring better optimization, conservation and management within the facility;
- Good utility conservation results should attract incentives that may be added or tied to the already existing safety bonus. This will ensure that personnel pay attention also to utility conservation;
- A utility conservation suggestion scheme as well as feedback structure should be put in place to ensure continuous improvement on utility matters within the facility;
- Energy performance contracts should be encouraged.

The above listed recommendations will definitely help reduce cost expended on utilities. By implementing the recommendations, plants will be tending towards proper utility optimization, conservation and management.

These recommendations will further enhance the effect of the utility management system already discussed.

5.4 VALIDATION

Going by the findings from the literature survey, best practices in using utilities/energy efficiency suggests that an effective energy management system structure should be in place in a chemical process plant. (Government of South Australia, department of Transport, Energy and Infrastructure, Energy Division Advisory, November 2006)

Such management system was not found after investigating the case study plant as revealed in chapter 4. This made it necessary to develop a utility management system structure that would compare to best practices and at the same time be adaptable to the case study plant and other similar chemical process plants.

The steps that make up the discussed utility management system structure correlates with the steps described in chapter two as always necessary for any energy conservation management method.

These steps are:

- Management support;
- Energy conservation team;
- Goal setting;
- Creating action plan;
- Continuous performance assessment; and
- Energy audit.

The utility management system also allows for proper monitoring, control and management of utilities.

This therefore assures stakeholders of guaranteed better utility efficiency in the case study plant or similar plant if the system is implemented.

5.5 RECOMMENDATIONS FOR FURTHER RESEARCH

Utility optimization conservation and management is a very wide subject. In this work, there has been more focus on conservation and management. Avenues of utility wastage, personnel attitude, management disposition and strategy towards utility optimization, conservation, and management have been of major concern. All these are contained in the human element (management).

Much could not be done on optimization because the utility system was not operating at capacity, hence the measure or possible opportunities could not be accurately ascertained. Moreover, optimization would have required apart from process integration already suggested, other approaches such as process redesign, equipment redesign and modification, design calculations, etc. Time restriction as well as shortage of resources limited the research in this area.

Researchers are expected to delve further into the area of utility optimization, considering approaches such as process redesign and technological improvement, redesign and modification. Their findings and recommendations will prove useful in new plants or proposed plants and it will go a long way in conserving and managing utility.

5.6 CONCLUSION

This work set out to evaluate the state of the case study plant with respect to utility optimization, conservation and management.

The findings that emerged from this work have been an eye opener to the utility optimization potential of the case study plant and the effect that enhanced human efforts to optimize utilities would have on utility efficiency in the chemical process

industry. It has also served as a major platform for further research into the subject of utilities optimization for the case study plant.

Although quantifying/measuring the economic benefit of optimizing, conserving and managing utilities in the case study plant was not done to detail, research from other literature asserts the possibility and certainty of reaping economic benefits from utility conservative measures.

Once proper monitoring can be introduced into the utility system as recommended in this work, quantifying the economic benefit will be more visible.

The awareness of utility optimization, conservation and management that this work has brought to the case study plant management has created a stir that would enhance management approach to utility management.

This research work has provided me with an opportunity to be enlightened on the impact and necessity of proper management in the engineering field and it has also served as a platform for me to make known my contribution to utility management in the case study plant and the chemical process industry.

REFERENCES

1. A.L. Davidson, Grounded Theory, 2002.
([Http://Az.Essortment.Com/Groundedtheory_Rmnf.Htm](http://Az.Essortment.Com/Groundedtheory_Rmnf.Htm)) (Date Accessed July 2007).
2. Al-Hinti, A. Al-Ghandoor, B. Akash And E. Abu-Nada, Energy Saving And Co₂ Mitigation Through Restructuring Jordan's Transportation Sector: The Diesel Passenger Cars Scenario, Energy Policy Volume 35, Issue 10, (October 2007), Pages 5003-5011.
3. Best Practices In Process Plant Management, Kuala Lumpur Convention Centre, Malaysia 21-22 June 2006,
([Http://Www.Cepp.Utm.My/Files/Brochure_Local.Pdf](http://Www.Cepp.Utm.My/Files/Brochure_Local.Pdf)). (Date Accessed, January 2007)
4. Bob Dick, Grounded Theory: A Thumbnail Sketch, (June 2005).
5. Co Energy Commission, Co generation Optimization, (November 2000).
6. Charles M. Gottschalk, Industrial Energy Conservation, Unesco Energy Engineering Series, John Wiley & Sons Ltd., Chichester, West Sussex, U.K., (1996)
7. Chemical Engineering Journal, 1982 Edition, Process Energy Conservation Edited By Richard Green Et Al, McGraw-Hill Publications Co., New York, N.Y.
8. Christopher Russell, Don't Lose Steam, Paper (September 2006).
9. Craig B. Smith And Rocco A. Fazzolare, Energy Use Management—An Appropriate Technology, Energy Conversion Volume 19, Issue 4, (1979), Pages 181-233.
10. David Yih-Liang Chan, Kuang-Han Yang, Chung-Hsuan Hsu, Min-Hsien Chien And Gui-Bing Hong, Current Situation Of Energy Conservation In High Energy-Consuming Industries In Taiwan, Energy Policy Volume 35, Issue 1, (January 2007), Pages 202-209.
11. Doug V. Bloss, Energy Optimization Strategies Paper (December 2003).

12. Duoplan Oy, Energy Optimization Ekono's Power House Management System "Eham", March 2006).
13. Electric Power Research Institute, Energy Audit Manual For Water/Waste water Facilities, Report. Cr-104300, (July 1994).
14. Elf Business Energy, Energy Efficiency Advice Report (March 2003).
15. Energy Conservation Management, Charles M. Gottschalk: *Industrial Energy Conservation, UNESCO Energy Engineering Series*, John Wiley & Sons Ltd., Chichester, West Sussex, UK, 1996, ([Http://Powerlab.Fsb.Hr/Osnoveenergetike/1999/Oe6p.Html](http://Powerlab.Fsb.Hr/Osnoveenergetike/1999/Oe6p.Html)). (Date Accessed, November 2006).
16. Energy Efficiency Advice For Non-Domestic Customers British Energy Code Of Practicemarch2003, ([Http://Www.Britishenergydirect.Com/Documentstore/Ee_Cop_Mar03_Final.Pdf](http://Www.Britishenergydirect.Com/Documentstore/Ee_Cop_Mar03_Final.Pdf)) (Date Accessed September 2006).
17. Energy Efficiency Improvement In Indian Cement Industry, Mr. Shiban Ji Raina, Director General, Nccbm, lipec Program On 22nd September 2002 At M/S Shree Cement, Beawar, ([Http://Www.Energymanagertraining.Com/Cement/Pdf/lipec_Nccbm-2.Pdf](http://Www.Energymanagertraining.Com/Cement/Pdf/lipec_Nccbm-2.Pdf)) Date Accessed, November, 2006).
18. Energy Focus Website, ([Http://Www.Energy-Focus.Com/Pdfs/Power/Spirax121.Pdf](http://Www.Energy-Focus.Com/Pdfs/Power/Spirax121.Pdf)) (Date Accessed, July 2006).
19. Energy on the Web, A Guide To Online Resources, Infonic Ltd, Financial Times Energy Publishers.
20. Energy Optimization Strategies, Doug V. Bloss, Corporate Vice President Sales & Marketing Armstrong International, Inc. (Www.Ase.Org/Files/1150_File_Blosspaper.Pdf).
21. Energy Star, U.S. Environmental Protection Agency, Guidelines For Energy Management Overview, (Www.Energystar.Gov/Index.Cfm) (Date Accessed, November 2006).
22. Excerpts from the Second Pacific Chemical Engineering Congress (Aug.28-31, 1971), Denver, Colorado.

23. Experimental Methods For Engineers, J.P. Holman, Seventh Edition, Page 605- 635.
24. Forbes Marshall, Energy Audits Paper, (2003).
([Http://Www.Forbesmarshall-inc.Com/Services.Asp?Serviceid=4](http://www.Forbesmarshall-inc.com/Services.Asp?Serviceid=4)) (Date Accessed November 2006)
25. Gary Faagau, Valero Energy Corporation, Valero Case Study: Refinery-Wide Energy Optimization Model. (March 2003).
26. George Allan, A Critique Of Using Grounded Theory As A Research Method, (August 2003).
27. Government of South Australia's Department Of Transport And Infrastructure Energy Management Website.
([Http://Www.Sustainable.Energy.Sa.Gov.Au/Pages/Advisory/Industry/Energy_Management/Energy_Management.Htm:Sectid=16&Tempid=49](http://www.Sustainable.Energy.Sa.Gov.Au/Pages/Advisory/Industry/Energy_Management/Energy_Management.Htm:Sectid=16&Tempid=49)) Date Accessed (June 2006)
28. Gregory F. Nemet And Daniel M. Kammen, U.S. Energy Research And Development: Declining Investment, Increasing Need, And The Feasibility Of Expansion, Energy Policy Volume 35, Issue 1, (January 2007) Pages 746-755.
29. Hina Zia And V. Devadas, Energy Management In Lucknow City, Energy Policy Volume 35, Issue 10, (October 2007), Pages 4847-4868.
30. How to Succeed In Your Masters And Doctoral Studies, A South African Guide And Resource Book, Johann, M. (2001).
31. International Site For Spirax Sarco,
([Http://Www.Spiraxsarco.Com/Learn/Block.Asp?Id=11](http://www.Spiraxsarco.Com/Learn/Block.Asp?Id=11)) (Date Accessed, March 2007).
32. Itp Industrial Energy Systems: Understanding Energy Footprints (August 2004).
33. James B. Ang, Co₂ Emissions, Energy Consumption, And Output In France, Energy Policy Volume 35, Issue 10, (October 2007), Pages 4772-4778.

34. Jin-Li Hu And Chih-Hung Kao, Efficient Energy-Saving Targets For Apec Economies, Energy Policy Volume 35, Issue 1, (January 2007), Pages 373-382.
35. Jonas Nässén And John Holmberg, Energy Efficiency—A Forgotten Goal In The Swedish Building Sector? Energy Policy Volume 33, Issue 8, (May 2005), Pages 1037-1051.
36. Malcolm Pirnie, Energy Optimization, November 2006.
37. Mr. Shiban Ji Raina, Energy Efficiency Improvement In Indian Cement Industry, (April 2004).
38. Peter Watt And Marie Telepneff, Energy Optimization And Management Solution For Bp Texas City Complex, September 2003.
39. Plant Services.Com, The Digital Resource Of Plant Services Magazine, ([Http://Www.Plantservices.Com/](http://www.plantservices.com/)) (Date Accessed, September 2006).
40. Process Energy Conservation, Chemical Engineering Magazine, McGraw-Hill Publications Co., New York. Page 77-89, 135-147, 297-299.
41. Processonline.Com.Au, September 2006, [Http://Www.Processonline.Com.Au/Process/Feature Article/Item_052006a.Asp](http://www.processonline.com.au/Process/Feature_Article/Item_052006a.Asp) (Date Accessed, November 2006).
42. R. Chedid M. Kobrosly And R. Ghajar, The Potential Of Gas-To-Liquid Technology In The Energy Market: The Case Of Qatar, Energy Policy Volume 35, Issue 10, (October 2007) Pages 4799-4811.
43. Raphael Sauter And Shimon Awerbuch, Achieving A Sustainable Global Energy System, Edward Elgar, Cheltenham (2004). Energy Policy Volume 35, Issue 1, (January 2007), Pages 756-757.
44. Sophie Meritet, French Perspectives In The Emerging European Union Energy Policy, Energy Policy Volume 35, Issue 10, (October 2007), Pages 4767-4771.
45. Steve Borgatti, Introduction To Grounded Theory, 1998.
46. Tony Dafft, Texas Technology 2003 Showcase, Plant Energy Optimization (April 2003).

47. U.S. Department Of Energy, Plant-Wide Energy Savings Identified At Ford Motor Plant (May 2006).
48. U.S. Department Of Energy, Pumping System Improvements Save Energy At Texas Power Plant (May 2006).
49. Valentinas Klevas, Dalia Streimikiene And Ramute Grikstaite, Sustainable Energy In Baltic States, Energy Policy Volume 35, Issue 1, (January 2007), Pages 76-90.
50. Washington State Energy Office, Improving The Energy Efficiency Of Waste water Treatment Facilities, Wseo 93-192, (June 1993).
51. Wolfram Krewitt, Sonja Simon, Wina Graus, Sven Teske, Arthouros Zervos And Oliver Schäfer, The 2 °C Scenario—A Sustainable World Energy Perspective, Energy Policy Volume 35, Issue 10, (October 2007), Pages 4969-4980.

APPENDIX 1

QUESTIONNAIRE ON THE UTILITIES AND ITS CONCERN IN A CHEMICAL PROCESS PLANT 1

OCCUPATION:

POSITION:

DATE:

The following questions are for the purpose of furthering research on utilities optimization in a typical wax plant and not for any other purpose.

Please any questions that infringe on the plants patent right or that tends to threaten the plants utility's security may be discussed with the questioner.

1. List the types of utilities used in the plant.

.....
.....
.....
.....
.....

2. With reference to the list above can you state the trend of consumption of each utility in your facility? Please indicate whether upward, downward, stable or irregular.

.....
.....
.....
.....
.....

3. With reference to the list above can you state the cost trend of each utility in your facility? Please indicate whether upward, downward, stable or irregular.

.....
.....

.....
.....
.....

4. What percentage of production cost does utilities cost consume in your plant.

1- 20%	21-40%	41-60%	61-80%
☐	☐	☐	☐

5. Is the amount of utilities consumed in your plant a concern? ☐ Yes ☐ No

6. If yes please indicate which utilities.

.....
.....

7. Is the cost of utilities paid for in your plant a concern? ☐ Yes ☐ No

8. If yes, please indicate which utilities.

.....
.....

9. Are all utilities imported into your facility consumed for production purposes only?

☐ Yes ☐ No

10. If "No" what other purposes are they utilized for.

.....
.....

11. Does your facility export utilities to other facilities outside your plant?

☐ Yes ☐ No

12. If yes, are these exports for profit purposes? ☐ Yes ☐ No

13. Are there evidences of wastage of utilities in your plant? ☐ Yes ☐ No

14. If yes, please list such wastages below.

.....
.....
.....

15. What is the attitude of your personnel/operators to utilities optimization?

Proactive Complacent Other (please Specify)
☐ ☐

16. What actions have been taken in the past to address utilities optimization?

.....
.....
.....
.....

17. What was the overall effect of such action?

.....
.....

18. What measures are currently in place in your facility to manage utility costs?

.....
.....
.....
.....

19. With respect to the current measures to manage utility in your facility, would you say the utility optimization potential of your plant has been fully exploited?

☐ Yes ☐ No

20. If yes, in what areas? E.g. process, control, management etc.

.....

21. If no, what are you doing presently to fully optimize it?

.....
.....
.....

22. What design changes aimed at optimizing utilities would you propose for the next generation wax plant?

.....
.....
.....

23. What operations, control system, etc. changes would you propose for the next generation wax plant?

.....
.....
.....

24. Does your system attach incentives for exceptional utility optimization results?

☐ Yes ☐ No

25. If yes, what are the effects of such incentives?

.....
.....
.....

26. If no, why are incentives not employed?

.....
.....
.....

27. What are your company's preferences as regards utility optimization? Please list.

.....
.....
.....
.....

28. What is your facility's utility consumption performance strategy?

.....
.....

29. Does your personnel show knowledge and understanding of the utility consumption performance strategy? ☐ Yes ☐ No

30. If yes, how do you measure such knowledge?

.....
.....
.....

31. If no, what measures are you taking to correct such knowledge lapse?

.....
.....
.....

32. Does utility management fall within your facility's key performance area?

☐ Yes ☐ No

33. Is there any established utility/energy management system or tool in place within your facility? ☐ Yes ☐ No

34. If yes which one?

.....
.....

35. What are the characteristics/features of this energy management system?

.....
.....
.....

36. Is there a department that monitors utilities in your facility? ☐ Yes ☐ No

37. Is there any provision for proper records of data of imported and exported utilities with respect to your facility? ☐ Yes ☐ No

38. For what purpose does your facility keep such records?

.....
.....
.....
.....

APPENDIX 2

QUESTIONNAIRE ON THE UTILITIES AND ITS CONCERN IN A CHEMICAL PROCESS PLANT 2

OCCUPATION:

POSITION:

DATE:

The following questions are for the purpose of furthering research on utilities optimization in a typical wax plant and not for any other purpose.

Please any questions that infringe on the plants patent right or that tends to threaten the plants utility's security may be discussed with the questioner.

1. List the types of utilities used in the plant.

.....
.....
.....
.....
.....

2. With reference to the list above can you state the trend of consumption of each utility in your facility? Please indicate whether upward, downward, stable or irregular.

.....
.....
.....
.....
.....

3. Is the amount of utilities consumed in your plant a concern? ☐ Yes ☐ No

4. If yes please indicate which utilities.

.....
.....

5. Are all utilities imported into your facility consumed for production purposes only?

☐ Yes ☐ No

6. If "No" what other purposes are they utilized for.

.....
.....

7. Does your facility export utilities to other facilities outside your plant?

☐ Yes ☐ No

8. If yes, are these exports for profit purposes? ☐ Yes ☐ No

9. Are there evidences of wastage of utilities in your plant? ☐ Yes ☐ No

10. If yes, please list such wastages below.

.....
.....
.....

11. What is the attitude of your operators to utilities optimization?

Proactive	Complacent	Other (please Specify)
☐	☐	☐

12. What is the attitude of management to utilities optimization?

Proactive	Complacent	Other (please Specify)
☐	☐	☐

13. Do you have any official responsibility as regards utility optimization?

☐ Yes ☐ No

14. If yes, please list them.

.....
.....
.....
.....

15. What other responsibility do you think will help you optimize utility better if you are given? Please state.

.....
.....

16. Have you suggested such to management? ☐ Yes ☐ No

17. What action has been taken in the past to address utilities optimization?

.....
.....
.....
.....

18. What was the overall effect of such action?

.....
.....

19. What measures are currently in place in your facility to manage utility costs?

.....
.....
.....
.....

20. What other measures do you think should be taken to further enhance utility optimization?

.....
.....
.....

21. Have you suggested them to the management? ☐ Yes ☐ No

22. Is there any established utility/energy management system or tool in place within your facility? ☐ Yes ☐ No

23. If yes which one?

.....
.....

24. What are your company's preferences as regards utility optimization? Please list.

.....

.....

.....

.....

25. Is there a department that monitors utilities in your facility? ☐ Yes ☐ No

26. Is there any provision for proper records of data of imported and exported utilities with respect to your facility? ☐ Yes ☐ No

27. For what purpose does your facility keep such records?

APPENDIX 3

QUESTIONNAIRE ON THE UTILITIES AND ITS CONCERN IN A CHEMICAL PROCESS PLANT 3

OCCUPATION:

POSITION:

DATE:

The following questions are for the purpose of furthering research on utilities optimization in a typical wax plant and not for any other purpose.

Please any questions that infringe on the plants patent right or that tends to threaten the plants utility's security may be discussed with the questioner.

1. List the types of utilities used in the plant.

.....
.....
.....
.....
.....

2. With reference to the list above can you state the trend of consumption of each utility in your facility? Please indicate whether upward, downward, stable or irregular.

.....
.....
.....
.....
.....

3. Is the amount of utilities consumed in your plant a concern? ☐ Yes ☐ No

4. If yes please indicate which utilities.

.....
.....

5. Are all utilities imported into your facility consumed for production purposes only?

☐ Yes ☐ No

6. If "No" what other purposes are they utilized for.

.....
.....
.....

7. Does your facility export utilities to other facilities outside your plant?

☐ Yes ☐ No

8. Are there evidences of wastage of utilities in your plant? ☐ Yes ☐ No

9. If yes, please list such wastages below.

.....
.....
.....

10. What is the attitude of your management to utilities optimization?

Proactive Complacent Other (please Specify)
☐ ☐ ☐

11. What action has been taken in the past to address utilities optimization?

.....
.....
.....
.....

12. What was the overall effect of such action?

.....
.....
.....

13. What measures are currently in place in your facility to manage utility consumption?

.....
.....
.....

.....
14. Do you think there are measures that can be introduced to improve utility consumption in your facility? ☐ Yes ☐ No

15. If yes, have you suggested them to management?

16. Can you please list such measures?

.....
.....
.....
17. What are your company's preferences as regards utility optimization? Please list.

.....
.....
.....
.....
18. Is there a department that monitors utilities in your facility? ☐ Yes ☐ No

19. Is there any provision for proper records of data of imported and exported utilities with respect to your facility? ☐ Yes ☐ No

20. For what purpose does your facility keep such records?