

https://dspace.org/

Analysis of energy consumption, economics and management at New Denmark Colliery

Mogodi, Phillip

2013-08-28
http://hdl.handle.net/10539/13079

Downloaded from a DSpace repository. https://dspace.org/

DECLARATION

I declare that this dissertation is my own, unaided work. It is being submitted for the Degree of Master of Science to the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination to any other University.

_____

_____day of _____2012

ABSTRACT

Sufficient energy availability and utilization lie at the core of not only the mining industry but also the economic growth of South Africa. The mining industry is one of the major consumers of electricity in South Africa; accounting for approximately 17.4 percent. The focal point of the research project was on New Denmark Colliery; an Anglo American Thermal Coal operation located in the Mpumalanga Province. The main objective of the research project was to analyse energy consumption, economics and management at the mine. The study provides a framework for understanding significant energy uses in a mining operation; electricity costs and some of the mechanisms, tools and initiatives that can be used to manage energy optimally. This provides the mining industry with a platform to become part of the energy solution in South Africa.

The author conducted comparative time series studies to determine energy consumption as a function of production, specific activities at the mine, carbon dioxide emissions, electricity costs; from which the forecasts were made to determine the amount of electricity consumption and costs in the future. It can be submitted from the monthly comparative studies that more electricity is consumed during high demand season (June, July and August); as a result the costs are also very high. It was concluded that mining, ventilation and coal transportation consume relatively more electricity compared to other activities at the mine. It was further submitted that the higher the level of production the higher the quantity of electricity consumption and vice versa.

It was further concluded that although the amount of electricity consumption has been fluctuating over the years, electricity costs have been escalating at an alarming rate due to change in tariff rate, inflation and the structure of the tariff. The cost of power will increase drastically over the next five years, due to uncertainty regarding the magnitude of the pending Eskom tariff increases. It was recommended that mining operations must create energy management models for their mining operations in order to reduce the amount of electricity consumption, minimize the electricity costs and secure long term electricity supply. Models created must be aligned to company vision, organizational structure and also operational practice at the mine.

DEDICATION

This research report is dedicated to my family, Wits School of Mining Engineering and the Mandela Rhodes Foundation; they frequently inspire and empower me to do things I never thought I could.

ACKNOWLEDGEMENT

I wish to express my appreciation to the following organisation and persons who made this project report possible:

1. Dr Hudson Mtegha, my project supervisor for his guidance, encouragement and support.

2. The following company divisions/organizations are gratefully acknowledged for their assistance and provision of data during the course of the study.

a) Anglo American Energy Department (Global)

b) Anglo American Global Shared Service

c) Anglo American Library

d) Anglo American Thermal Coal Project Services

e) Anglo Thermal Technical Service

f) Eskom

g) New Denmark Colliery (Mining, Finance and Engineering Department)

h) Goedehoop Colliery (Engineering and Finance Department)

3. My family and friends for encouragement and support during the study.

TABLE OF CONTENTS

DECLARATION i

ABSTRACT ii

DEDICATION iii

ACKNOWLEDGEMENT iv

LIST OF FIGURES x

LIST OF TABLES xiii

LIST OF APPENDICES xiii

LIST OF ACRONYMS/SYMBOLS xiv

1. INTRODUCTION 1

1.1 Problem Statement 2

1.2 Objectives 3

1.3 Methodology and Scope of Study 4

1.4 Plan of Action (Research Procedure) 5

2. LITERATURE REVIEW 6

2.1 ENERGY OVERVIEW 6

2.2 SOUTH AFRICAN ENERGY SECTOR 9

2.2.1 Introduction 9

2.2.2 South African Power Mix 9

2.2.3 Energy Policies and Strategy 11

2.2.4 Energy Efficiency 12

2.2.5 South African Sectoral Energy Consumption 13

2.2.6 South African Energy Supply Challenge 14

2.2.7 Energy Crisis Introduced a Paradigm Shift 15

2.2.8 Outlook of the Energy Landscape 16

2.3 ESKOM 18

2.3.1 Introduction 18

2.3.2 Generation, Transmission and Distribution of Electricity 21

2.3.3 Structure of the Electricity Supply Industry 22

2.3.4 Challenges Encountered by Eskom 23

2.4 SECURITY OF COAL SUPPLY 25

2.4.1 Coal Producers in South Africa 26

2.4.2 Dependence on Coal 27

2.4.3 Strategic Analysis of South Africa's Coal Mining Industry 28

2.5 ENVIRONMENTAL ECONOMICS 30

2.5.1 Introduction 30

2.5.2 How Energy Generation Causes Environmental Change in SA 30

2.5.3 Climate Change Strategy 32

2.6 ENERGY AND THE MINING INDUSTRY 33

2.6.1 Introduction 33

2.6.2 Mining Industry as part of the Energy Solution 35

2.7 Summary 35

3. AREA OF STUDY 37

3.1 Anglo American Thermal Coal 37

3.1.1 Energy Consumption of Anglo American Thermal Coal 39

3.1.2 Anglo American Thermal Coal Energy Strategy 41

3.2 New Denmark Colliery 44

3.2.1 Mine Background and General Information 44

3.2.2 Structure of the Mine 45

3.2.3 New Denmark Colliery and Tutuka Power Station 47

3.2.4 Supply, Transmission and Distribution of Electricity to the Mine 48

3.2.5 Type of Energy Account 50

3.2.6 Electricity Demand Load Profile of New Denmark Colliery 52

3.2.7 Electricity Management at New Denmark Colliery 54

3.3 Summary 55

4. ENERGY CONSUMPTION 56

4.1 Introduction 56

4.2 Use of Energy 56

4.3 Factors Influencing and Affecting Electricity Consumption 58

4.4 Electricity Consumption per Geographical Area 60

4.5 Year Electricity Consumption versus Production Rate 61

4.6 Monthly Electricity Consumption 62

4.7 Carbon Dioxide Emissions 64

4.8 Future Studies - Electricity Consumption 66

4.9 Summary 67

5. FINANCIAL ECONOMICS OF ENERGY 68

5.1 Introduction 68

5.2 Cost of Energy 68

5.3 Energy Cost Break Down 70

5.4 Yearly Electricity Cost versus Production and Electricity Consumption 71

5.5 Monthly Electricity Cost versus Production and Electricity Consumption 72

5.6 Monthly Electricity Cost Distribution 74

5.7 Tariff 75

5.8 Electricity Cost Forecast 78

5.8.1 Electricity Tariff Forecast for New Denmark Colliery 80

5.8.2 Electricity Cost Forecast for New Denmark Colliery 81

5.9 Summary 81

6. SUMMARY OF DISCUSSIONS AND RECOMMENDATIONS (ENERGY MANAGEMENT) 82

6.1 Summary of Discussions 82

6.1.1 Literature Review 82

6.1.2 Area of Study 83

6.1.3 Energy Consumption at New Denmark Colliery 85

6.1.4 Financial Economics of Energy at New Denmark Colliery 86

6.2 Recommendations (Energy Management) 89

6.2.1 Energy Management Standards 90

6.2.2 Management Capacity and Organizational Structure for Energy Management 91

6.2.3 Energy Accounting and Auditing 92

6.2.4 Energy Management Mechanisms 94

6.2.4.1 Metering Energy Consumption and Data Collection 95

6.2.4.2 Finding and Quantifying Opportunities to Save Energy 96

6.2.4.3 Targeting the Opportunities to Save Energy 96

6.2.4.4 Tracking your progress at saving energy 96

6.2.5 Energy Security 97

6.2.6 Educational Programs, Communication and Training 98

6.2.7 Energy Efficient Technology 99

6.2.8 Other Tools (Information System and Investment 99

6.2.9 Energy Policy 100

6.2.10 Benefits of Energy Management 100

7. CONCLUSION 101

8. APPENDICES 104

LIST OF FIGURES

Figure 1: Flow of energy chart 7

Figure 2: Primary energy supply 8

Figure 3: Power mix in South Africa 11

Figure 4: Electricity consumption per sector of the economy 14

Figure 5: Energy gap and capacity reserve of South Africa 15

Figure 6: Short to medium term solutions of the energy crisis 16

Figure 7: Generating capacity of utility companies across the world 18

Figure 8: Relative position of power stations and their ownership in South Africa 19

Figure 9: Electricity generation, transmission and distribution 22

Figure 10: Energy flow through the electricity supply industry 23

Figure 11: Coal production and consumption trends 25

Figure 12: Largest coal producers in South Africa 26

Figure 13: Mining companies supply coal to Eskom 27

Figure 14: Particulate emissions due to power generation at Eskom 31

Figure 15: Electrical energy consumption per sector 33

Figure 16: Electricity consumption in the South African mining industry 34

Figure 17: Production of Anglo American Thermal Coal 38

Figure 18: Energy usage by type at Anglo American Thermal Coal 39

Figure 19: Annual energy consumption of Anglo American Thermal Coal 40

Figure 20: Average energy consumption at Anglo American Themal Coal 41

Figure 21: Electricity cost of Anglo American Thermal Coal 43

Figure 22: Relative position of Tutuka power station and New Denmark Colliery 43

Figure 23: Location of New Denmark Colliery 45

Figure 24: Shafts and sections of New Denmark Colliery 46

Figure 25: Relative position of Tutuka Power Station and New Denmark Colliery 47

Figure 26: Relationship between New Denmark Colliery and Tutuka Power Station 49

Figure 27: Transmission and distribution of energy at New Denmark Colliery 50

Figure 28: Time of Use (TOU) ratings for Megaflex 52

Figure 29: Monthly electricity demand profiles of NDC for the year 2009 and 2010 53

Figure 30: Different forms of energy and their application at New Denmark Colliery. 57

Figure 31: Electricity consumption of Anglo American Thermal Coal collieries 59

Figure 32: Estimated electricity consumption per geographical area 61

Figure 33: Monthly electricity consumption 63

Figure 34: Production versus electricity consumed for the year 2010 64

Figure 35: Anglo American Thermal Coal carbon footprint per operation 65

Figure 36: Electricity consumption projection for New Denmark Colliery 67

Figure 37: Anglo American Thermal Coal electricity cost per operation 69

Figure 38: Electrical energy costs per Anglo American Thermal Coal operation 69

Figure 39: 2010 energy costs breakdown for New Denmark Colliery 70

Figure 40: Yearly average electricity cost for New Denmark Colliery 72

Figure 42: NDC monthly electricity increase between the year 2009 and 2010 73

Figure 41: NDC Electrical power versus cost for the year 2010 74

Figure 43: Cost distribution of average monthly electricity charge rates 75

Figure 44: Algorithm of deriving or calculating the electricity cost 76

Figure 45: NDC hourly electricity charges profile for different season in the year 2010 78

Figure 46: Anglo American Thermal Coal electrical energy cost forecast 79

Figure 47: Anglo American Thermal Coal electricity cost and average cost forecast 79

Figure 48: Energy management tools that can be used by New Denmark Colliery 90

Figure 49: Organisational structure that can be used by NDC 92

Figure 50: Different aspects of energy accounting 93

Figure 51: Types of energy audits 94

Figure 52: Energy management mechanisms that can be used by NDC 95

Figure 53: Demand Side Management (DSM) options 97

LIST OF TABLES

Table 1: Energy statistics of Sub-Saharan countries 10

Table 2: Eskom power stations 20

Table 3: Energy sector carbon dioxide emissions, various measures and time frames 32

Table 4: Coal production data of Anglo American Thermal Coal 38

Table 5: Technical details of Tutuka power station 48

Table 6: Eskom contractual range qualities 48

Table 7: Electricity account of New Denmark Colliery 54

Table 8: Forms of energy and quantity used at New Denmark Colliery in the year 2010 58

Table 9: Production data of Anglo American Thermal Coal 60

Table 10: NDC's production and electricity consumption 62

Table 11: Electricity consumed versus CO2 emission for the year 2007 – 2010 66

Table 12: Yearly electricity cost versus power 71

Table 13: NDC electricity monthly charge rate for the year 2008/2009 and 2009/2010 77

Table 14: Electricity tariff forecast 85

LIST OF APPENDICES

Appendix A: South African energy gap and capacity reserve statistics 104

Appendix B: Electricity Demand, Consumption and Cost for the year 2009 and 2010 104

Appendix C: Predicted Eskom tariffs increase for the next five years 105

Appendix D: Electricity Cost Forecast for New Denmark Colliery 106

Appendix E: Financial benefit (savings) of electricity management (reduction) forecasts 107

LIST OF ACRONYMS/SYMBOLS

AATC	: ANGLO American Thermal Coal
c/kWh	: cents per Kilo watt hours
CO_2	: Carbon Dioxide
CV	: Calorific Value
DE	: Department of Energy
DME	: Depart of Minerals and Energy
DSM	: Demand Side Management
ECS	: Energy Conservation Scheme
EE	: Energy Efficiency
GHG	: Green House Gases
GW	: Gigawatt
IEP	: Integrated Energy Plan
EIA	: Energy Information Administration
GDP	: Gross Domestic Product
GJ	: Giga Joules
J	: Joules
Kg	: Kilogram
km	: Kilometre
Kt	: Kilotonnes
KV	: Kilo Volts
kW	: Kilo Watt
kWh	: Kilo Watt Hour
kWh/t	: Kilo Watt hours per tone
MD	: Maximum Demand
m	: Metre

m^3	: Meter cube
Mtpa	: Million tonnes per annum
MVA	: Mega Volts Amperes
MW	: Mega Watts
NDC	: New Denmark Colliery
NER	: National Electricity Regulator
NERSA	: National Energy Regulator of South Africa
PCP	: Power Conservation Programme
PV	: Present Value
R	: Rand
R/kWh	: Rand per kilowatt hour
Rmil	: Million Rands
R & D	: Research and Development
RTS	: Return to Service
SA	: South Africa
SAPIA	: South African Petroleum Industry Association
SAPP	: Southern African Power Pool
SO_2	: Sulphur Dioxide
t	: tones
TWh	: Tera Watt Hour
UNFCCC	: United Nations Framework Convention on Climate Change)
USA	: United States of America
V	: Volts
WEC	: World Energy Council
YTD	: Year to Date