ENGINEERING A NOVEL AUTOMATED PUMP
CONTROL SYSTEM FOR THE MINING
ENVIRONMENT

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Abstract

South Africa is experiencing serious electricity supply problems. A major concern is the high peak electricity demands between 18:00 and 20:00. This peak is primarily caused by the growing residential sector. Unfortunately, changing people’s behaviour to reduce the evening energy peak is difficult. An easier approach will be to focus on other sectors such as the industrial and mining sectors.

South African mines contribute 18% of the country’s electricity consumption. Of the total mining electricity bill 40% is consumed by water pumping systems. Manual load shifting is attempted on approximately 15% of these pumping systems. The results are not sustainable due to maintenance problems and system complexities.

By automating, simulating, optimising and controlling the pumping systems of deep level mines, sustainable load shift can be achieved. This will also reduce the running cost of mine water pumping system due to time based electricity pricing.

With this research a novel solution is presented. This unique automated tool simulates, optimises, schedules and controls any pumping configuration in a unique integrated fashion. The new system was tested in 13 case studies, involving a wide variety in terms of layout, size, and equipment types. More than 39 MW of load was consistently shifted out of the evening peak. This resulted in cost savings of more than R 5.7 million per year for the mines involved in the case studies.

This system also has other benefits. Automated systems require fewer personnel such as pump attendants, leading to more savings. The system also provides better safeguard against the risk of flooding, and faster training of new control room personnel. The benefits for ESCOs are fast and accurate predictions on the savings potential of specific pump configurations.

These and other benefits indicate that the new control system should be rolled out on all large pumping systems.
**Opsomming**

Diep myne in Suid-Afrika dra 18% by tot die nasionale energieverbruik. ’n Studie in ’n tipiese diep myn toon dat die piek aanvraag tot 27% gesny kan word met die gebruik van ’n geoptimeerde energiebeheerstelsel. Dit kan lei tot ’n potensiële jaarlike besparing van R 135 miljoen in die Suid-Afrikaanse mynbedryf.

Tydgebaseerde elektrisiteitstariewe maak hierdie elektriese kostebesparings moontlik. Die energielas word daagliks verskuif van hoëkoste na laekoste tye. Deur hierdie beginsel toe te pas kan die hoogste kostebesparing op mynwaterpompstelsels geneereer word.

’n Literatuurstudie en gesprekke met mynbeamptes het aangedui dat daar nog nie ’n stelsel op ’n Suid-Afrikaanse myn geïnstalleer is om die potensiële kostebesparings te benut nie. Die rede hiervoor is ’n gebrek aan geautomatiseerde pompbeheerstelsels en die moeilikheidsgraad van geoptimeerde beheer.

Hierdie tesis bied die ontwikkeling van ’n nuwe oplossing aan. Dit is ’n unieke geautomatiseerde stelsel wat simuleer, optimeer, skeduleer en beheer. Hierdie stelsel is ontwikkel om enige industriële pompstelsel te beheer. Die stelsel is op 13 myne in verskillende omstandighede getoets. Meer as 39 MW las is volhoubaar uit die aandpiek geskuif met ’n volhoubare kostebesparing van R 5,7 miljoen per jaar.

Die stelsel het ook ander voordele. As gevolg van die automatiese beheer benodig myne minder operateurs wat tot verdere besparings lei. Die stelsel kan ook aangewend word om myn personeel vinniger op te lei. Die voordeel vir ESCOs is vinnige, akkurate projekpotensiaalvoorspellings.

Hierdie en verdere voordele van die nuwe stelsel wys dat die installering van hierdie nuwe oplossing op alle groot myn pompstelsels voordelig sal wees.
Acknowledgements

I would like to express my thanks and gratitude to Prof. M. Kleingeld on the way he, in more than one way, guided and motivated me throughout this study. He gave me the opportunity to undertake this study. I would also like to thank him for making all the case studies possible, as he opened the doors to the mines where the system was implemented, tested, and verified.

A special thank goes to Prof. E. H. Mathews and HVAC International. Without Prof. Mathews’ invitation to study at HVAC International this study never would have happened. His guidance and persistence taught me how to mould concepts and put them on paper.

I would like to mention and greatly thank Dr. D T Claassen who taught me the basics of system development and Delphi coding. The system I present in this thesis was coded in Delphi. I would also like to thank him for the basis for my literature review found in chapter 1.

Nico de Kock drove the implementation of REMS for my case studies. He helped with the performance calculations and reports of the case studies.

Everything possible was done to acknowledge sources of information and references to published works. However, should the reader notice any omission, please inform me so that this can be rectified.

Most important, I would like to thank my parents, family and friends. Your ongoing support and encouragement made this so much easier.

Praise God the Almighty Father in heaven, for You are my ability, knowledge, determination, peace and salvation. Thank You.
## Nomenclature

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>C/kWh</td>
<td>Cent per kilowatt-hour</td>
</tr>
<tr>
<td>CO₂</td>
<td>Carbon Dioxide</td>
</tr>
<tr>
<td>DDE</td>
<td>Dynamic Data Exchange</td>
</tr>
<tr>
<td>DSM</td>
<td>Demand Side Management</td>
</tr>
<tr>
<td>EE</td>
<td>Energy Efficiency</td>
</tr>
<tr>
<td>ESCO</td>
<td>Energy Services Company</td>
</tr>
<tr>
<td>GUI</td>
<td>Graphical User Interface</td>
</tr>
<tr>
<td>GW</td>
<td>Gigawatt</td>
</tr>
<tr>
<td>GWh</td>
<td>Gigawatt-hour</td>
</tr>
<tr>
<td>HVAC</td>
<td>Heating Ventilation and Air-Conditioning</td>
</tr>
<tr>
<td>MW</td>
<td>Megawatt</td>
</tr>
<tr>
<td>NER</td>
<td>National Energy Regulator</td>
</tr>
<tr>
<td>OLE</td>
<td>Object Linking and Embedding</td>
</tr>
<tr>
<td>OPC</td>
<td>OLE for Process Control</td>
</tr>
<tr>
<td>PBMR</td>
<td>Pebble Bed Modular Reactor</td>
</tr>
<tr>
<td>PLC</td>
<td>Programmable Logic Controller</td>
</tr>
<tr>
<td>RTP</td>
<td>Real Time Pricing</td>
</tr>
<tr>
<td>REMS</td>
<td>Remote Energy Management System</td>
</tr>
<tr>
<td>SA</td>
<td>South Africa</td>
</tr>
<tr>
<td>SCADA</td>
<td>Supervisory Control and Data Acquisition</td>
</tr>
<tr>
<td>SMS</td>
<td>Short Message Service</td>
</tr>
<tr>
<td>SO₂</td>
<td>Sulphur Dioxide</td>
</tr>
<tr>
<td>UK</td>
<td>United Kingdom</td>
</tr>
<tr>
<td>USA</td>
<td>United States of America</td>
</tr>
<tr>
<td>WEP</td>
<td>Wholesale Electricity Pricing</td>
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