

**AN INDUSTRIAL ENGINEERING APPROACH TO POWER
MANAGEMENT LOGIC**

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Final Project Report

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Executive Summary

After ESKOM introduced load shedding in 2008, MTN decided to make use of alternative energy sources for primary power sources. On 2 September 2010 MTN opened and connected their Tri-Generation¹ natural Gas Generators, using it as their primary power supply. During December of 2010 failures of the Tri-Generation plant resulted in unexpected demands added to the ESKOM supply. With the added demand needed from ESKOM, the power supplier decided to install maximum demand meters that calculates the maximum power demand needed. The costs of maximum demand become an eyesore for the engineers of the Tri-Generation plant and alternative methods of managing the power flow during a failure were developed.

A simulation model was built to be able to experiment with the system and the new power management logic without causing disruptions in the system.

With the simulation model, the ability to plan for future expansion in the complex became a reality: The construction of Phase 3 in the complex started in 2011, and the building is planned to be finished by the end of 2012. As with all the buildings in the complex, Phase 3 will also be in need of a backup power supply. With the installed backup capacity already at 12MW for a 6MW complex, management is investigating the possibility of using the current backup power supplies for Phase 3. The simulation model will be able to give management insight into making a final decision.

¹ Tri-Generation: Also called Combined Cooling Heating and Power, refers to the generation of power through mechanical process with the combined ability to use waste heat either as heating or cooling purposes.

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List of Acronyms

A/C	Air Conditioner
ESCOM	Electricity Supply Commission
EVKOM	Elektrisiteitsvoorsieningskommissie
MTN	Mobile Telecoms Network
UPS	Uninterruptable Power Supply

Chapter 1

1. Introduction

1.1. Background

MTN South Africa's headquarters is located at 14th avenue in Roodepoort, Johannesburg. The complex is composed of 5 key buildings: Phase 1, Phase 2, Test Switch, Data Centre and the Service Yard. Each building is connected to a ring power network that is supplied with grid power from ESKOM² as well as 2 natural Gas Generators. Each building (except the data centre) is also equipped with diesel generators for backup power in case of a failure in the ring network. With the power ring network, an air conditioning water network is connected to each building, providing each building with chilled water. The chilled water is used in heat exchangers to provide cooling to heat sensitive equipment as well as cooling the working environment for MTN employees.

In the power ring network the primary power source is the natural Gas Generators (capacity 2MW). ESKOM (Capacity 6MW) supplements the Gas Generators to provide additional power to the network. The exhaust gas of the Gas Generators is used in Absorption Chillers (capacity 1.7MW) to create cool water which is added to the water network. This supplies additional chilled water to the air conditioning water network. With the added chilled water there is less demand from electric Chillers needed and can be switched off in turn decreasing the demand needed from ESKOM.

In the case of an ESKOM power failure, all the buildings are removed from the power ring network. Each building's backup generator is started; the Gas Generators are used as the backup generators for the data centre. MTN uses an N+1 policy for the required number of generators per building (Number of generators needed for full capacity + 1). For example, Phase 1 has a demand of 1.5MW, the backup generator used is a W16, turbocharged, 1.5MW

² ESKOM is a combination of the two acronyms, EVKOM and ESCOM

diesel generator, and thus the number of generators installed in Phase 1 is calculated at: $1.5/1.5 + 1 = 2$. Making the backup generator capacity for Phase 1: $2 \times 1.5\text{MW} = 3\text{MW}$. The backup generator capacity for the entire 6MW complex is 10MW of diesel generator capacity as well as the 2MW capacity of the Gas Generators.

In the case that the Gas Generators fail an interesting problem occurs. Not only does the ESKOM demand increase with the 2MW that the natural Gas Generators supplied but the ESKOM demand also increases additionally by 1.7MW that the Absorption Chillers added to the cool water network because of electric Chillers that are needed to supply chilled water to the air conditioning water network. In 2010 ESKOM installed maximum demand meters that measure the average power consumption over any 30 minute period. If the Gas Generators have a failure the maximum demand needed from ESKOM will increase until it reaches ESKOM's capacity of 6MW. The maximum demand is calculated biannually, and the cost for a 6MW maximum demand can range from R200k to R300k per month for a 6 month period.

MTN is currently building Phase 3 of the complex; an investigation into the backup power demand was made. This investigation concluded that the backup generators' capacity currently in the system will be sufficient for the expansion of Phase 3 and additional backup generators would not be necessary if certain infrastructure changes are made.

1.2. Map of the complex

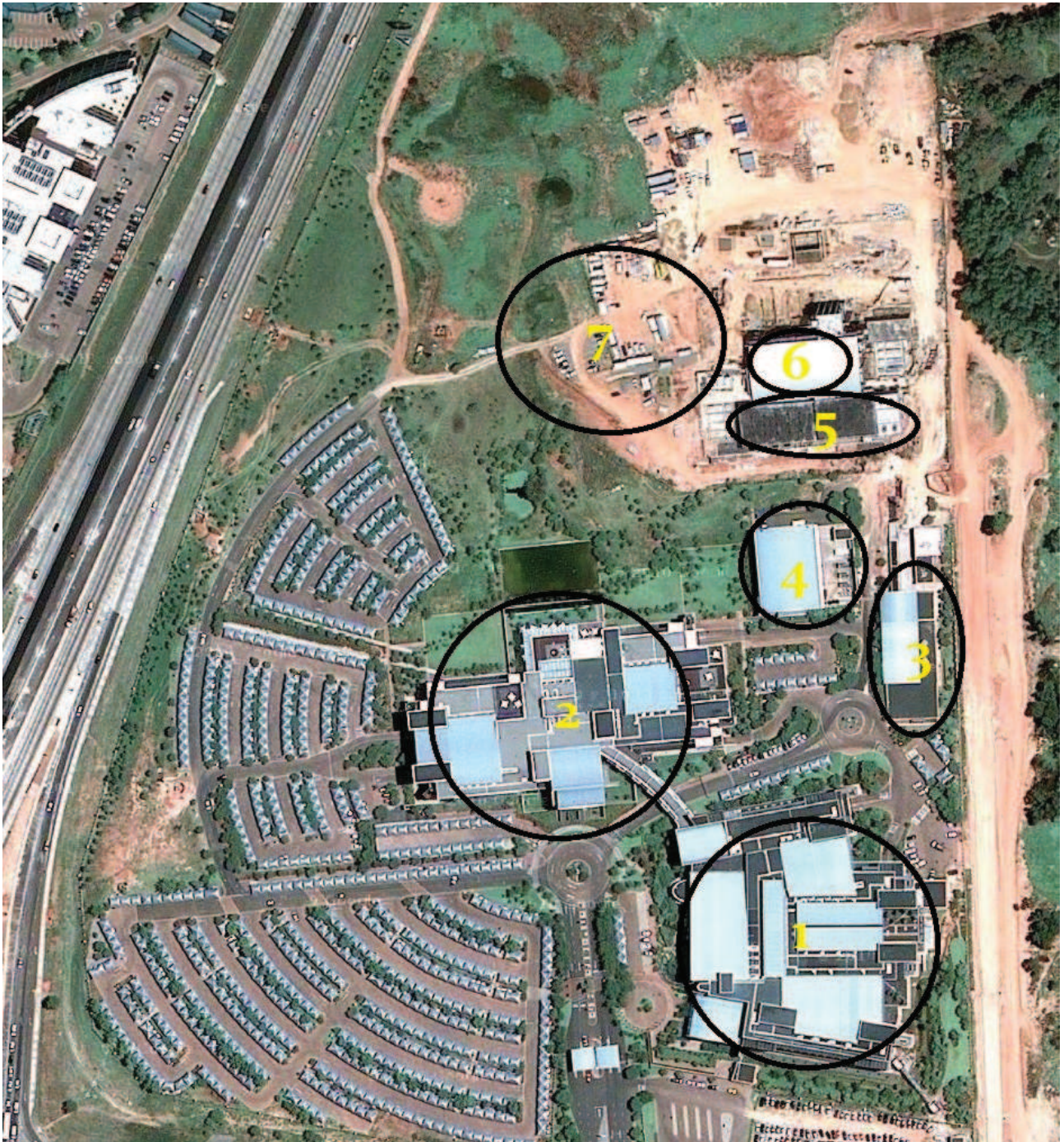


Figure 1 - Overview of the MTN 14th Avenue Complex

1. Phase 1
2. Phase 2

3. Phase 1&2 back up diesel generators
4. Test Switch
5. Service Yard with Gas Generators and Absorption Chillers
6. Data Centre
7. Planned site for Phase 3

1.3. Primary Electrical Layout of the Complex

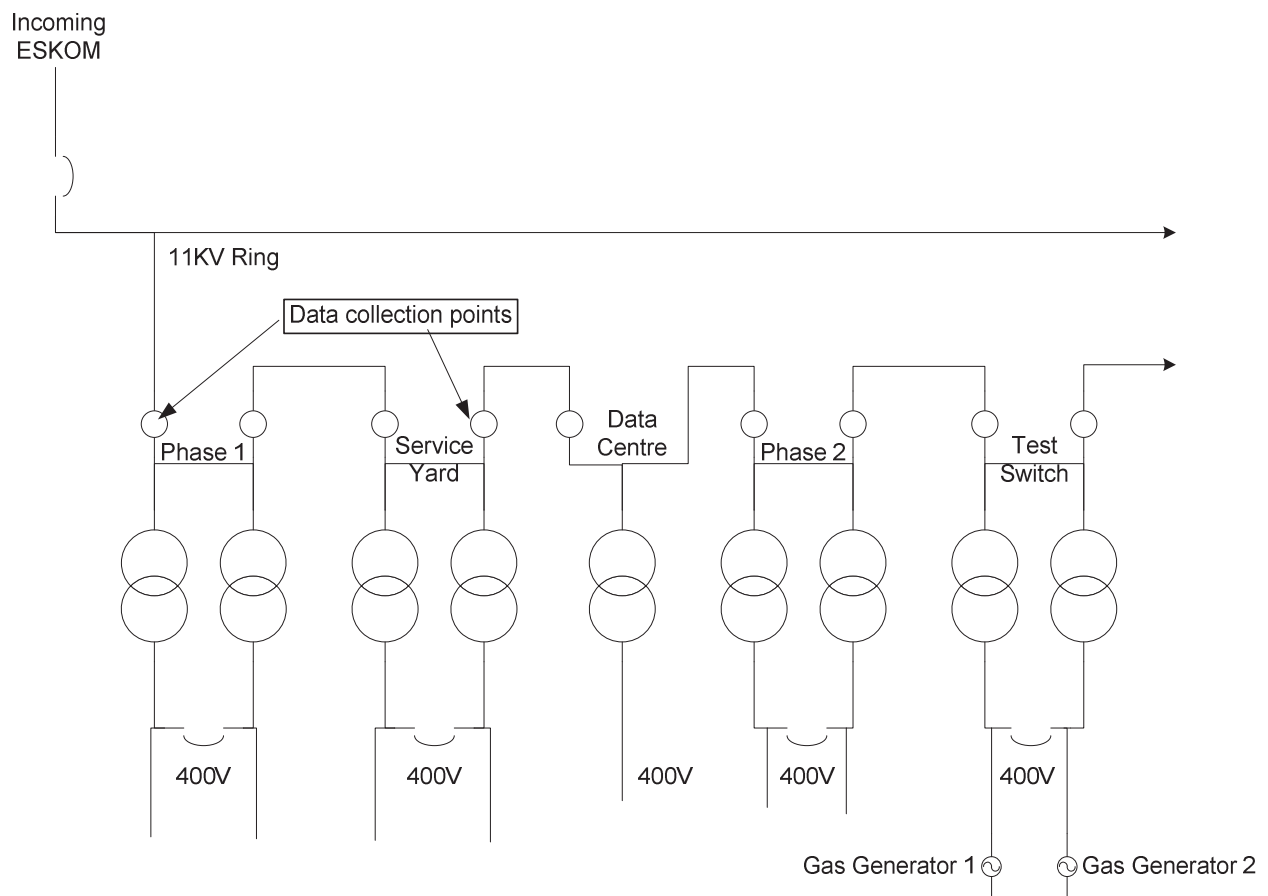


Figure 2 - Electrical layout

1.4. Research Design and Methodology

The focus of this project will be the development of a simulation model of the current system to identify problem areas in the power management system. The simulation will be able to simulate current working conditions as well as failures that have happened in the past. The

main failure to be investigated is the case where the Gas Generators fail, increasing the demand required from ESKOM. Results of the simulation will be verified with real data to ensure that the simulation is valid for the actual system. Failure data will also be verified in the simulation. After validation of the simulation, the simulation will then be modified to develop new logic for the power management system in the case of a failure. With the improved simulation power demand will also be increased to investigate the possibility of adding an extra phase to the system without the need of increasing the backup capacity of the diesel generators.

Chapter 2

2. Literature Review

2.1. Why Simulation?³

According to Oxford Dictionary [7], to simulate is to imitate the appearance or character. Simulation in computing is defined as the construction of a mathematical model of a process to estimate characteristics or solve problems in terms of the model (Dictionary.com [2]).

Why simulation?

To gain additional insight and knowledge of a system one can either experiment with the actual system or one can experiment with a model of the system (see: Figure 3 - Ways to find insight). A rarely feasible solution will be to experiment with the actual system, and this can provide a definitive answer and immediate results. But most of the time this can be too disruptive for operations and costly if the experiment is a failure (Carson [1]). The experimentation of a model of the system becomes an attractive solution. Experimenting with physical models will provide an answer that can be extrapolated to find an approximation of the answer. But most models built for experimentation are mathematical representations of the actual system, if the model is valid. When the mathematical model is built, it can be solved again using two methods, by analytical solution or by creating a simulation. If the model is simple enough then solving it by using analytical methods will be easiest. But once again most of mathematical models built are too complex and thus the mathematics become complex not even to mention if there is an analytical solution to the model. (Law & Kelton [4])

³ **Simulation** - noun, [sim-yuh-ley-shuh n], to imitate the appearance or character

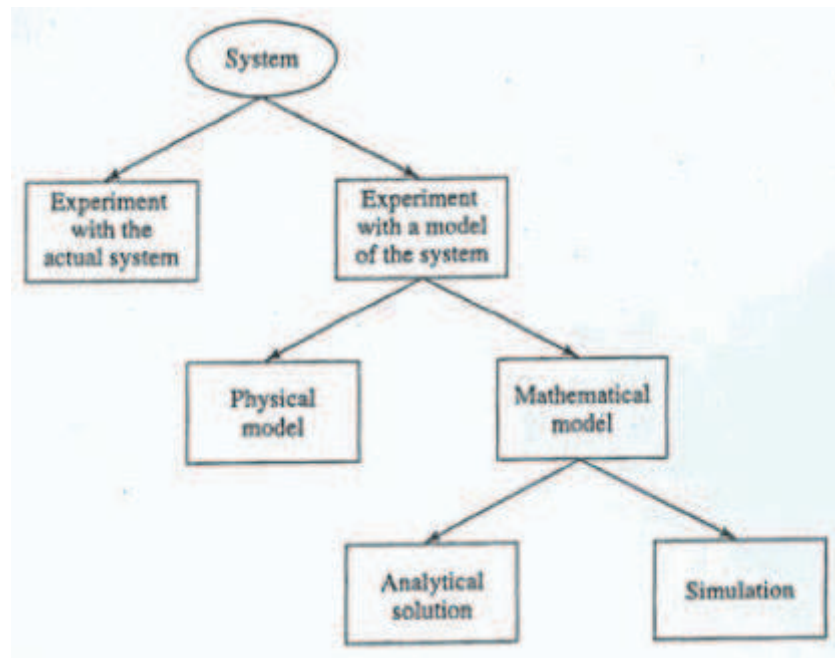


Figure 3 - Ways to find insight in a project

Why simulation?

To summarize the above mentioned paragraph: Simulation is a cost effective way to study a system without using complex mathematics or causing disruptions in the actual system.

2.2. Discrete⁴- vs. Continuous-Simulation Models

The decision to choose between a discrete or continuous model depends on the particular system and what is to be investigated in the model. For example, a discrete system will be the study of movements of cars during a traffic-jam on the freeway. A continuous system will be the study of the aggregate⁵ flow of cars on a freeway during a traffic-jam (Law & Kelton [4]).

⁴ **Discrete – adjective**, [dih-skreet], apart or detached from others; separate; distinct

⁵ **Aggregate, adjective**, [ag-ri-git, geyt], formed by the conjunction or collection of particulars into a whole mass or sum; set

2.3. Continuous to Discrete

When looking at a discrete system, two aspects can be discrete, the system state and the system time. Consider a continuous function $x(t)$, if the function is reduced into discrete points then the two types of discretizations⁶ can occur. Discrete time approximation is to take the value of the function at equal predetermined times. Discrete state approximation is to sample the function at equal predetermined state values (Nutaro [6]).

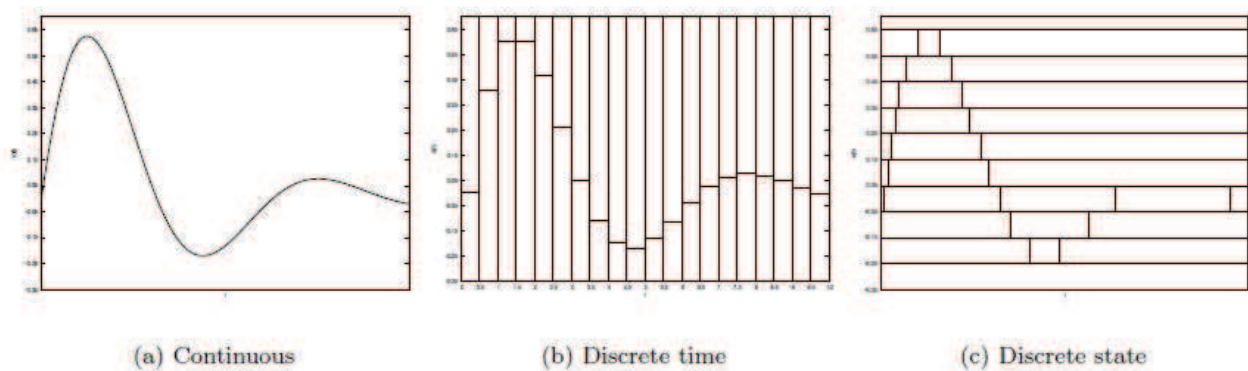


Figure 4 - Time and state discretizations of a system (Nutaro n.d.)

Consider a function $f(a)$, the function $f(a)$ will be continuous at a if $f(a)$ approaches $f(x)$ as a approaches x (Steward [8]), with a few assumptions. Thus if the time between sampling in the discrete time and discrete state approximations is to approach zero then both the discrete time and discrete state approximations will be continuous.

2.4. Hybrid⁷ models

According to Law & Kelton [4], some world problems have characteristics of discrete and continuous systems. Such a system is called a hybrid⁸ model. Some discrete modelling

⁶ **Discretizations, noun**, [dih-skree-tuh-zey-shuh n]. The act or process of making mathematically discrete. The process of dividing a geometry into finite elements to prepare for analysis.

⁷ **Hybrid, noun**, [hahy-brid], composite; formed or composed of heterogeneous elements.

software has the capability to accommodate both discrete and continuous characteristics in the same model (Law & Kelton [4]).

2.5. Advantages and Disadvantages of Simulation

Table 1 – Advantages and Disadvantages of simulation (Carson [1])

Advantages	Disadvantages
• Ability to conduct an experiment without causing expensive disruptions	• Time consuming
• Allow evaluations to take place before final decisions are made to resource allocation and investments	• Data is difficult and costly to get hold of
• Detect problems before modification of current system	• Can become a “check list” for the project and not a decision tool
• Allows for different solutions to be easily compared	• Can provide misleading information to decision makers
• Show how the system changes over time	

A good simulation will provide understanding as well as numerical measures of the system in terms of performance (Carson [1])

2.6. Simulation Study Guidelines

According to Carson [1], there are 4 major guidelines to creating a successful simulation modelling project:

1. Project initiation

1.1. Problem Formulation and Setting of Objectives

Important factors to consider:

- **Model boundary and scope**

This will state everything that is included in the model and the areas to be investigated.

- **Level of detail**

The level of detail specifies to what extent every module will be investigated and modelled.

- **Project scope**

The scope of the project will determine how the simulation will be used in the experiment and during validation phases.

1.2. Overall Project Plan

- Time and cost estimates are made for the various parts of the project

1.3. Conceptual Model and Assumptions Document

- The set of arguments is the conceptual model
- The assumptions should be written in a way that no programming jargon is used

2. Project work

2.1. Model Development

The model development consists of 2 aspects:

- Development of the data structures to be used within the simulation
- Translation of the assumptions into the simulation software

2.2. Data Collection, Cleansing, and Analysis

- Data collection

The data used in the simulation is usually collected by the customer, or is estimates of the actual data. If estimates are used then the data should be verified by people with knowledge of the actual process.

- Cleansing

Databases seldom represent the actual process data. According to Carson [1] the most accurate data is the data that has a direct relationship with revenue. As a simulation is a representation of what happens within a process the actual data can provide a more accurate answer than the data stored in databases.

- Analysis

The analyst can use the actual data in the simulation; this is sometimes easier to accomplish than creating a statistical distribution of the data.

3. Model Verification and Validation

3.1. Model Verification

3.2. Model Validation

4. Experimentation, Analysis, and Reporting

4.1. Experimental Design

In the experimental design the analyst must decide a number of parameters:

- Replication length
- Number of replications
- Parameters to be changed and studied
- Steady state analysis, warm-up period

4.2. Experimentation

In each experiment the model changes should be guided by an experimental design that lays out the characteristics of each parameter.

4.3. Analysis

It rarely occurs that the first initial experiment pinpoints the actual cause of the problem in the system. Many additional measures of performance must be added to the simulation so that the cause of the problem can be isolated and identified.

Additionally Carson [1] and Musselman [5] refer to some downfalls to avoid when managing a simulation project.

- Have clear and achievable goals throughout the project
- Do not make assumptions
- Over designing the simulation
- Scope Creep

2.7. Model Verification and Validation

Model verification and validation is part of the guidelines set out by Carson [1] for creating a successful simulation model.

Verification

Four steps to model verification may include:

1. Good programming practice, such as modular programming techniques
2. Checking of modules by statistically testing the outputs of the modules
3. Comparing the actual results with the simulation results
4. Animation, by following entities to see that corresponds with the actual system

(Kleijnen [3])

Validation

Four steps to model validation may include:

1. Collection of real-world data and verifying with simulation outputs
2. Statistical test to compare simulated outputs to real world data
3. Sensitivity and risk analysis
4. Regression analysis and linear programming.

(Kleijnen [3])

Chapter 3

3. Simulation Model

3.1. Project Initiation

3.1.1. Problem Formulation and Setting of Objectives

3.1.1.1. Model boundary and scope

The following modules of the system will be investigated:

- Demand of the system
- Absorption Chillers
- Gas Generator
- ESKOM
- Backup generators

3.1.1.2. Level of detail

- **Demand of the system**

The demand of the system is separated into electrical and A/C power. This is classified as critical and non-critical power demand. The critical A/C and electrical power is supplied to server and data centre computers. The non-critical electrical power is supplied to the lighting and the employee's computers and the non-critical A/C is used for the employee's comfort.

- **Absorption Chillers**

The Absorption Chillers utilize the exhaust gas of the Gas Generators thus the Absorption Chillers can only be used if the Gas Generators are operational. Each absorption chiller will be modelled independent of the other; this will allow failures to be simulated at one absorption chiller regardless of what happens to the other.

- **Gas Generator**

The gas generator is the primary power supply of the system. As with the Absorption Chillers, the Gas Generators will be modelled independently from one another. If one gas generator fails then the exhaust gas of only one gas generator can be used at the Absorption Chillers.

- **ESKOM**

ESKOM is used to supplement the gas generator but the majority of the power is supplied by it. If ESKOM fails then the demand of each building will be satisfied by their respective backup generators.

- **Backup generators**

Each of the backup generators will be present in the system to investigate the maximum demand that can be satisfied during a failure if the demand is increased. A generic UPS will be simulated but with minimal detail.

3.1.2. Overall Project Plan

The overall project plan should include cost and time estimates. As there were no direct costs to the project, only time estimates were included in the form of a Gantt chart (See Appendix A for a bigger version).

#	Activity	July	August					September				October				
		25-Jul	01-Aug	08-Aug	15-Aug	22-Aug	29-Aug	05-Sep	12-Sep	19-Sep	26-Sep	03-Oct	10-Oct	17-Oct	24-Oct	31-Oct
1	Draft Project Proposal															
2	Finalize Project Proposal															
3	Modelling of Current System															
4	Additional Modelling															
5	Interim Project Draft															
6	Interim Project															
7	Final modelling of alternative systems															
8	Final Project Draft															
9	Finalize Project															
10	Prepare Final Project															
11	Project Oral Preparation															

Figure 5 - Gantt chart of the Project

3.1.3. Conceptual Model and Assumptions

The model was built using Rockwell Software's Arena Version 12. The model was built by adding more complex logic to a simple model until the logic of the model was similar to the logic of the system. The first module built was very crude and simple but more complex modules were added until the final result was a model that simulates the actual system.

Rather than simulating the physical system, the simulation is the process of demand and supply.

Physical system:

Power provider → Building utilizes power → Discard

Process of the system:

Demand for power created → Power provider satisfies demand → Discard

Assumptions:

1. The modelling of a continuous system with discrete entities

To be able to simulate a power system as a discrete system the travelling time between blocks has been removed. The time between arrivals of entities can be reduced until the model is of a required sensitivity. This time that elapses between arrivals will be named the "system cycle".

2. In the model there are blocks named "Dispose Nothing"

This is to validate that all possible logic combinations have been identified and are present in the decide blocks

3. 1MW in the actual system is equal to 10 entities in the simulation model

Because the student version of Arena is used for the simulation modelling, there is a limitation on the number of entities in the system. The number of entities, 120 (limitation of entities = 150) was divided by the backup power capacity 12MW, this equals 10. Thus in the simulation model each 1MW is represented by 10 entities.

3.2. Project Work

3.2.1. Model Development

3.2.1.1. Entire model (See bigger figure in Appendix)

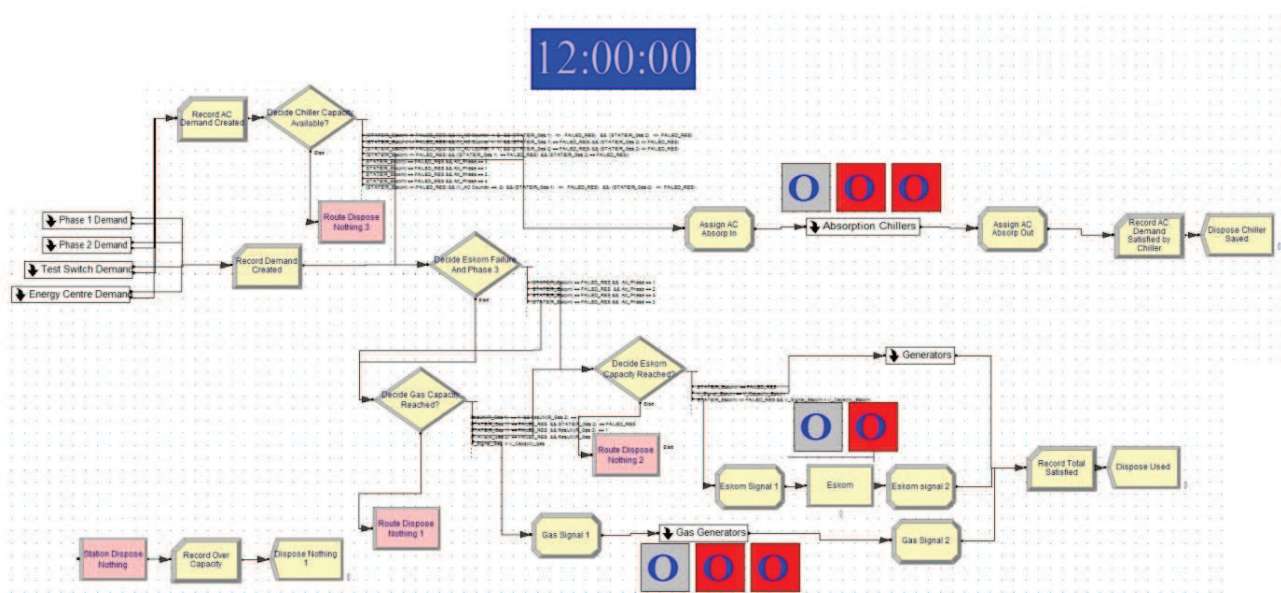


Figure 6 – Overview of Entire Simulation Model

3.2.1.2. Demand

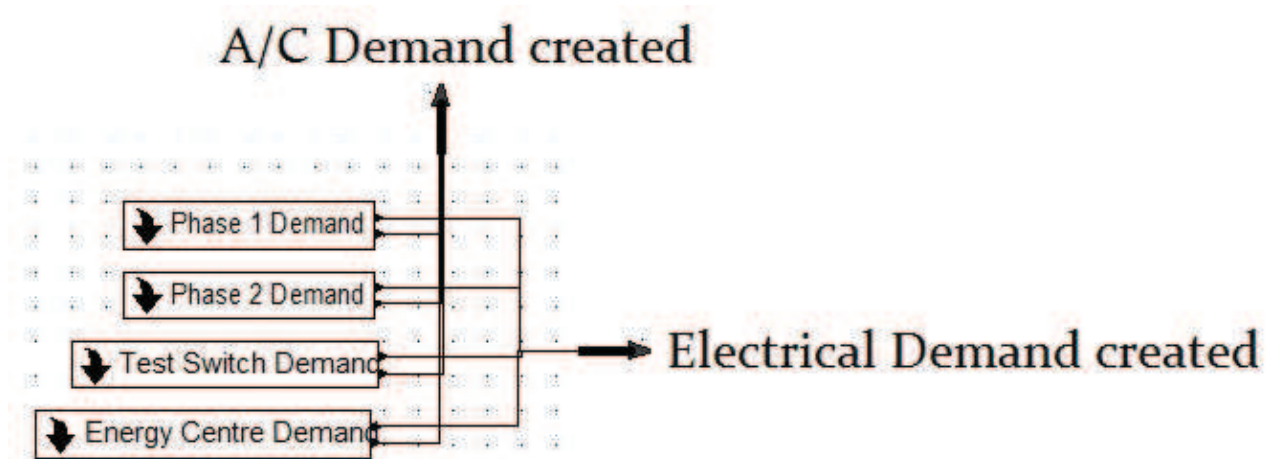


Figure 7 – Demand, Simulation Model

Each building is represented by a sub model; this allows the demand to be separated at the generator sub model and to see where each entity originates.

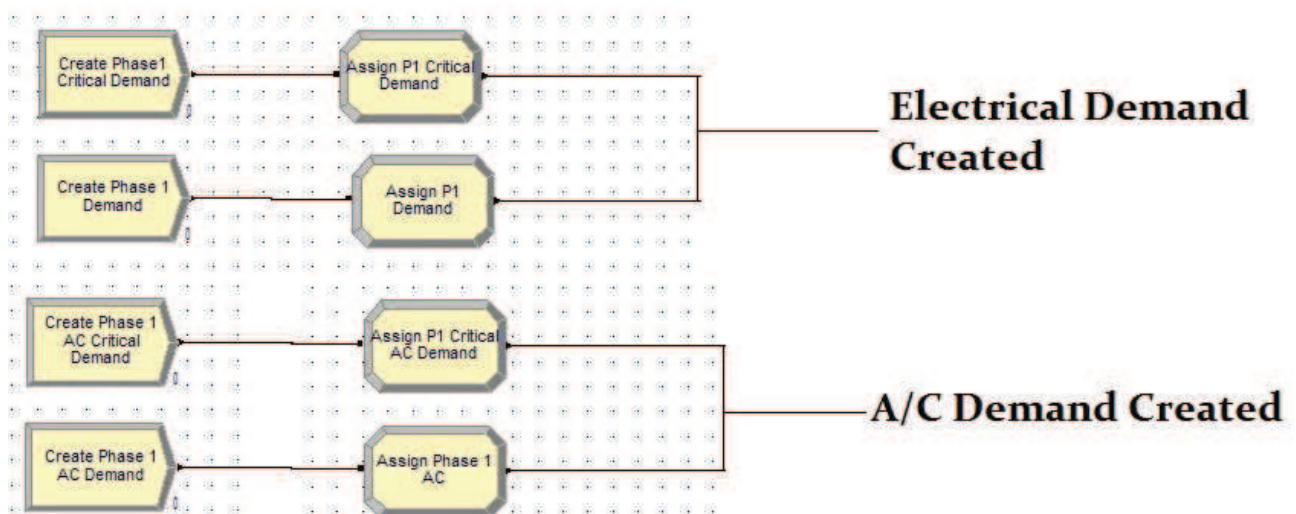


Figure 8 – Demand, Simulation Model, Sub-Model

Each demand sub-model is similar. The demand of each phase is separated into four create blocks to allow the model to separate the four types of demand needed. The assign blocks for each create assigns the priority and an entity picture to each demand entity.

3.2.1.3. Absorption Chillers

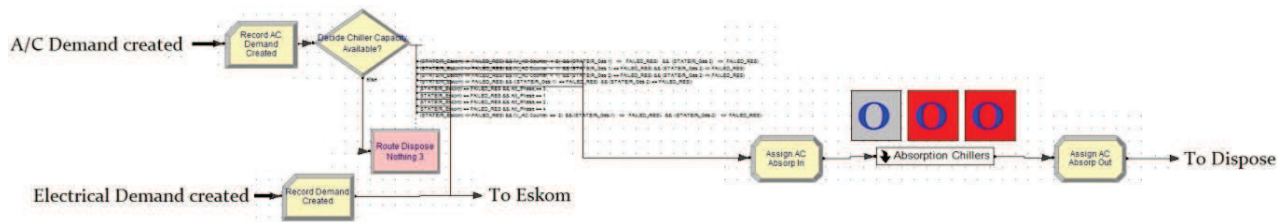
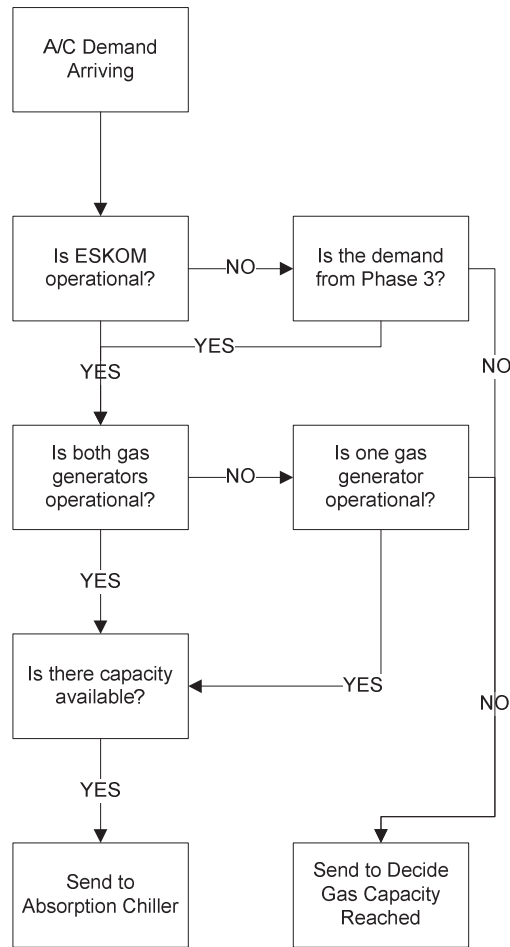


Figure 9 – Absorption Chillers, Simulation Model

The absorption chiller is not a power source but rather a power saver. If there is spare capacity at the absorption chiller then electrical A/C Chillers can be switched off. Only A/C power demand will be allowed to be satisfied by the Absorption Chillers. First the total is recorded in a record block. The capacity is managed by a variable named A/C Counter, x is the capacity of 1 absorption chiller.

The logic of the decide block is (True will allow the entity to the Absorption Chillers):

- $No\ ESKOM\ failure \times (A/C\ Counter < 2x) \times No\ failure\ on\ gas\ generator = True$
- $No\ ESKOM\ failure \times (A/C\ Counter < x) \times Only\ 1\ failure\ on\ the\ gas\ generator = True$
- $ESKOM\ failure \times (A/C\ Counter < 2x) \times (Entity\ Phase == 3) = True$
- $No\ ESKOM\ failure \times Gas\ failure = False$
- $No\ ESKOM\ failure \times (A/C\ Counter == 2x) = False$
- $ESKOM\ Failure \times (Entity\ Phase == (1 + 2 + 4)) = False$



Flow Chart 1 – Absorption Chillers Logic

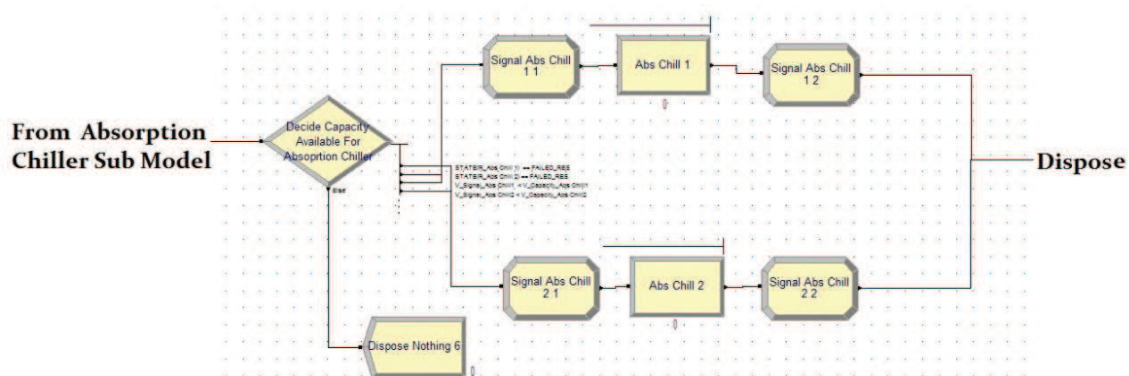
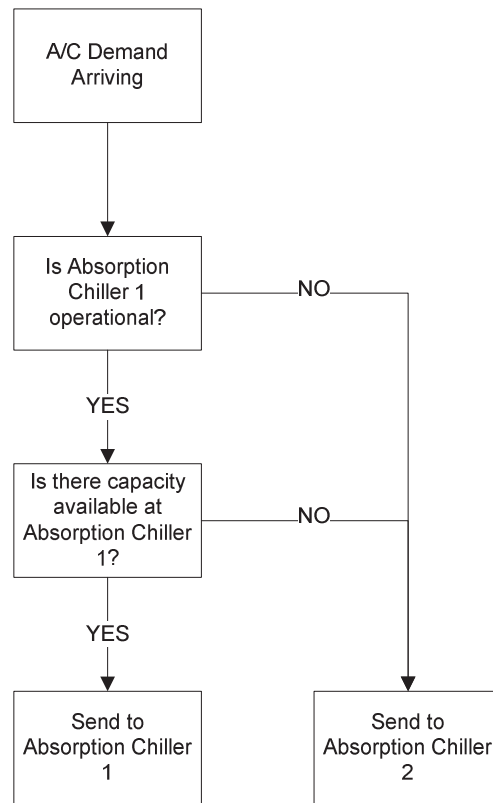


Figure 10 - Absorption Chiller, Simulation Model, Sub-Model

The logic for the Decide Capacity Available for Absorption Chillers in the Absorption Chillers sub model (True will route the entity to Absorption Chiller 1 (Abs Chill 1)):

- *Absorption Chiller 2 failed = True*
- *Absorption Chiller 1 failed = False*
- *Absorption Chiller 2 no capacity = True*
- *Absorption Chiller 1 no capacity = False*



Flow Chart 2 - Absorption Chiller Sub Model

3.2.1.4. Gas Generator

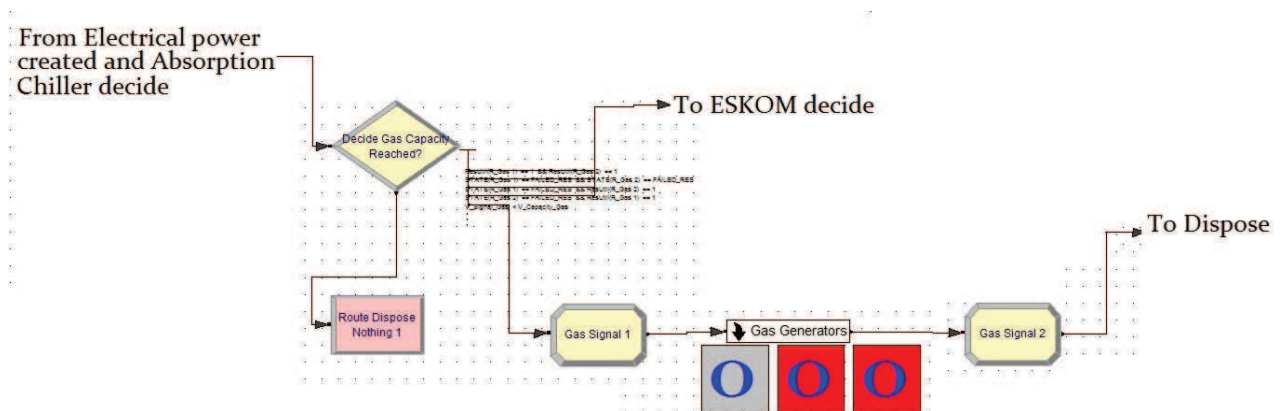
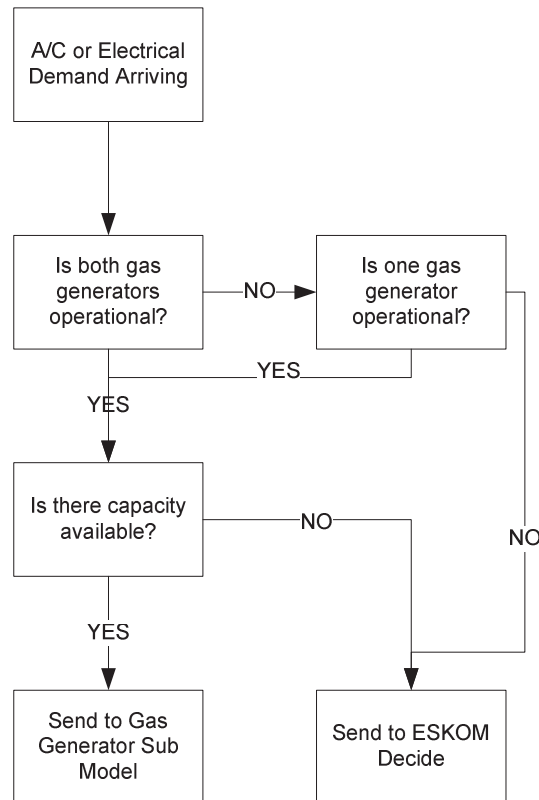


Figure 11 - Gas Generator, Simulation Model

The gas generator cannot work with variable loads; this is why it is the first power supply in the system and should always be operating at 100% capacity. Two variables are used in the decide block. $V_Signal_Gas1/2$ and $V_Capacity_Gas_1/2$, $V_Signal_Gas1/2$ is a counter used gas signal 1 and 2. When an entity enters block Gas Signal 1 the variable will increase and when the entity exits Block Gas Signal 2 the variable will be decremented. $V_Signal_Gas1/2$ is a variable to easily change to capacity of the gas generator.

The logic for the Decide Gas Capacity Reached (True will route the entity to the Gas Generator Sub model):

- $(Utilisation\ Gas\ generator\ 1 == 1) \text{ and } (Utilisation\ Gas\ generator\ 2 == 1) = False$
- $(Gas\ Generator\ 1\ failed\ and\ Gas\ Generator\ 2\ failed) = False$
- $(Utilisation\ Gas\ generator\ 1 == 1) \text{ and } (Gas\ generator\ 2\ failed) = False$
- $(Utilisation\ Gas\ generator\ 2 == 1) \text{ and } (Gas\ generator\ 1\ failed) = False$
- $(Utilisation\ Gas\ generator\ 1 == 1) \text{ and } (Gas\ generator\ 2\ failed) = False$
- $Signalcapacity < Gascapacity = True$



Flow Chart 3 - Gas Generator Logic

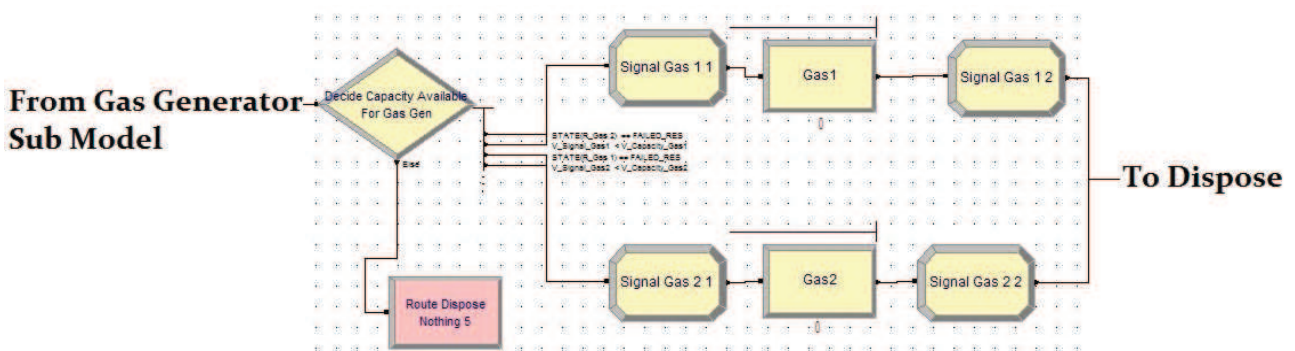
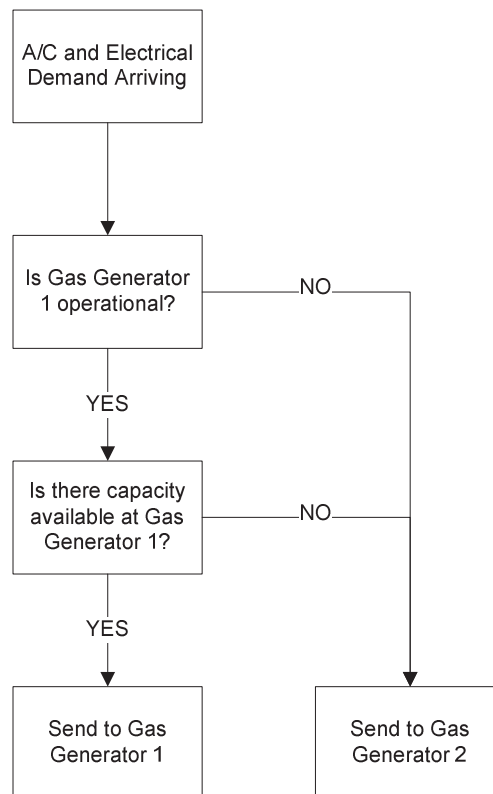


Figure 12 - Gas Generator, Simulation Model

The logic for the Decide Capacity Available for Gas Generator in the Gas Generator sub model (True will route the entity to Gas 1):

- *Gas 2 failed = True*
- *Gas 1 failed = False*

- *Gas 2 no capacity = True*
- *Gas 1 no capacity = False*



Flow Chart 4 - Gas Generator Sub Model Logic

3.2.1.5. ESKOM

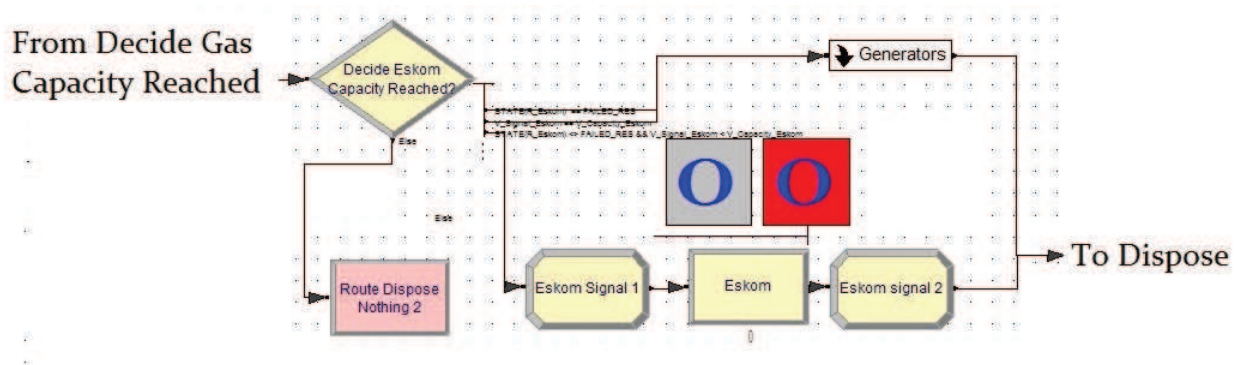


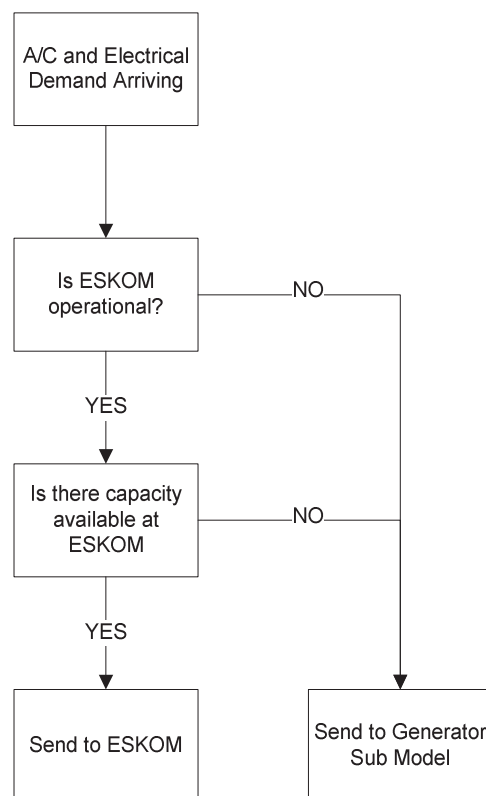
Figure 13 - ESKOM, Simulation Model

ESKOM is used as the supplementary power supply to the Gas Generators. But this is also where the problem occurs when the Gas Generators have a failure. When a problem occurs at

the Gas Generators, all entities will be routed to the ESKOM decide block. Two variables were used in the decide block V_Signal_ESKOM and $V_Capacity_ESKOM$. V_Signal_ESKOM will be incremented if an entity enters the block ESKOM signal 1 and will decrement it if an entity exits ESKOM Signal 2. $V_Capacity_ESKOM$ is used to be able to easily change the capacity of ESKOM.

The logic for the ESKOM block (True will route the entity to ESKOM):

- $ESKOM \text{ not failed and } V_Signal_Eskom < V_Capacity_Eskom = True$
- $V_Signal_Eskom == V_Capacity_Eskom = False$
- $ESKOM \text{ failed} = False$



Flow Chart 5 - ESKOM Logic

3.2.1.6. Generator (See bigger figure in Appendix)

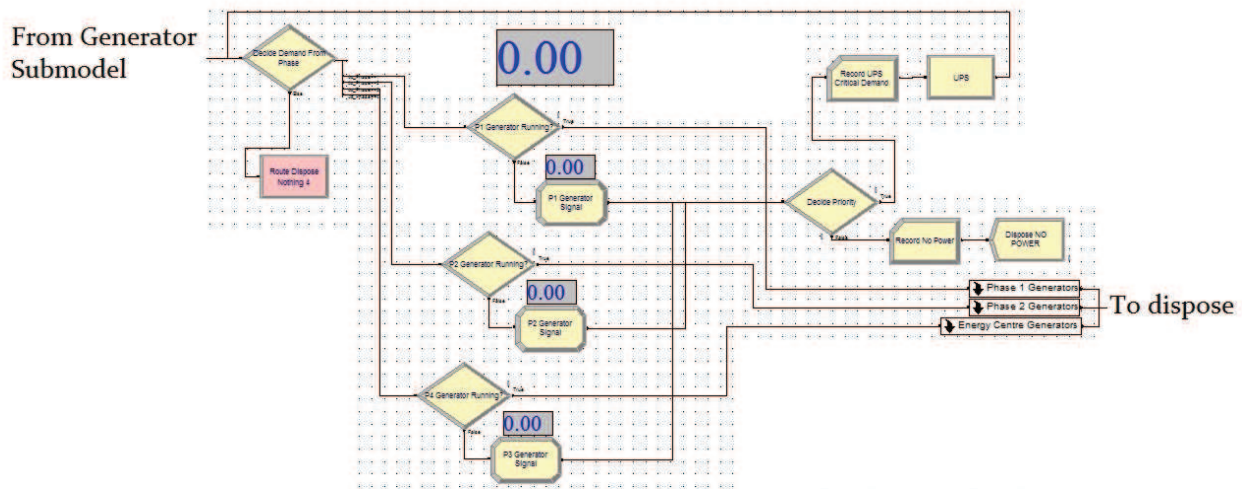


Figure 14 - Overview of Generator, Simulation Model, Sub-model

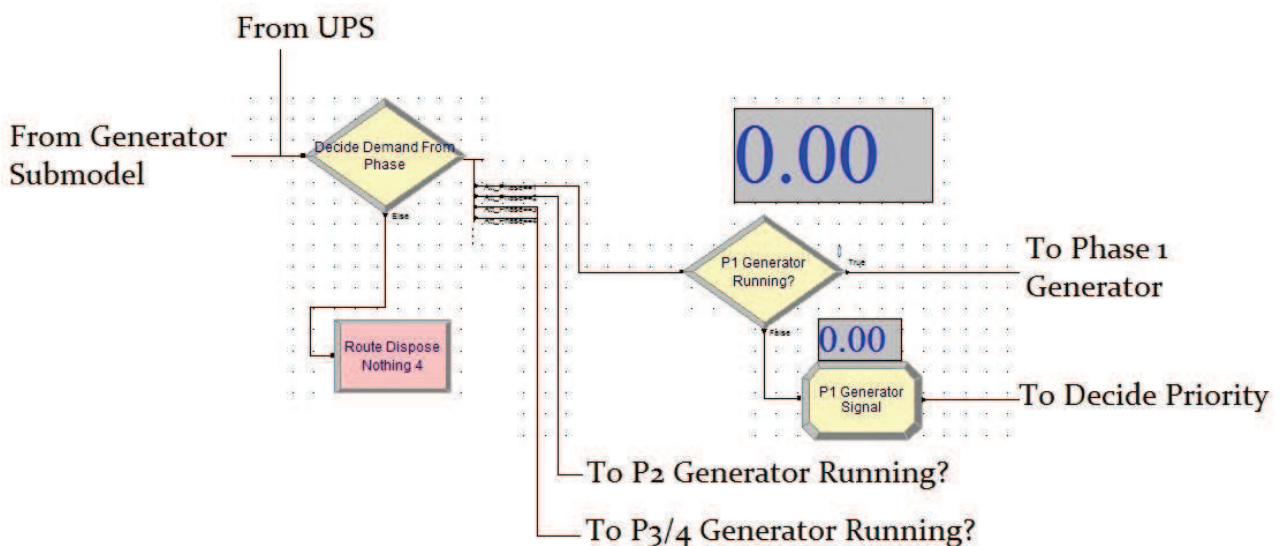


Figure 15 – Generator 1, Simulation Model

The decide block for the generator only separates the entities by phase. The generators have a warm up period; currently this warm up is 20 seconds long. For example: When an entity enters “P1 Generator Running?” a timer is started, all entities arriving at the generator will be routed towards the “Decide Priority” block. After 20 seconds have elapsed, the entities will be routed toward the phase generator sub-model.

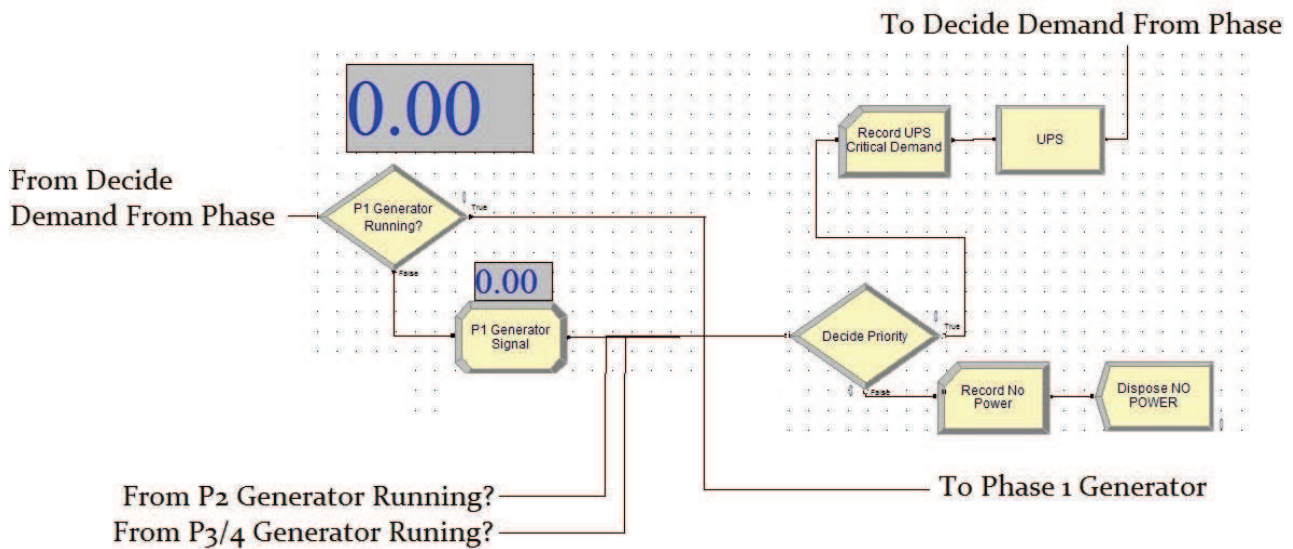
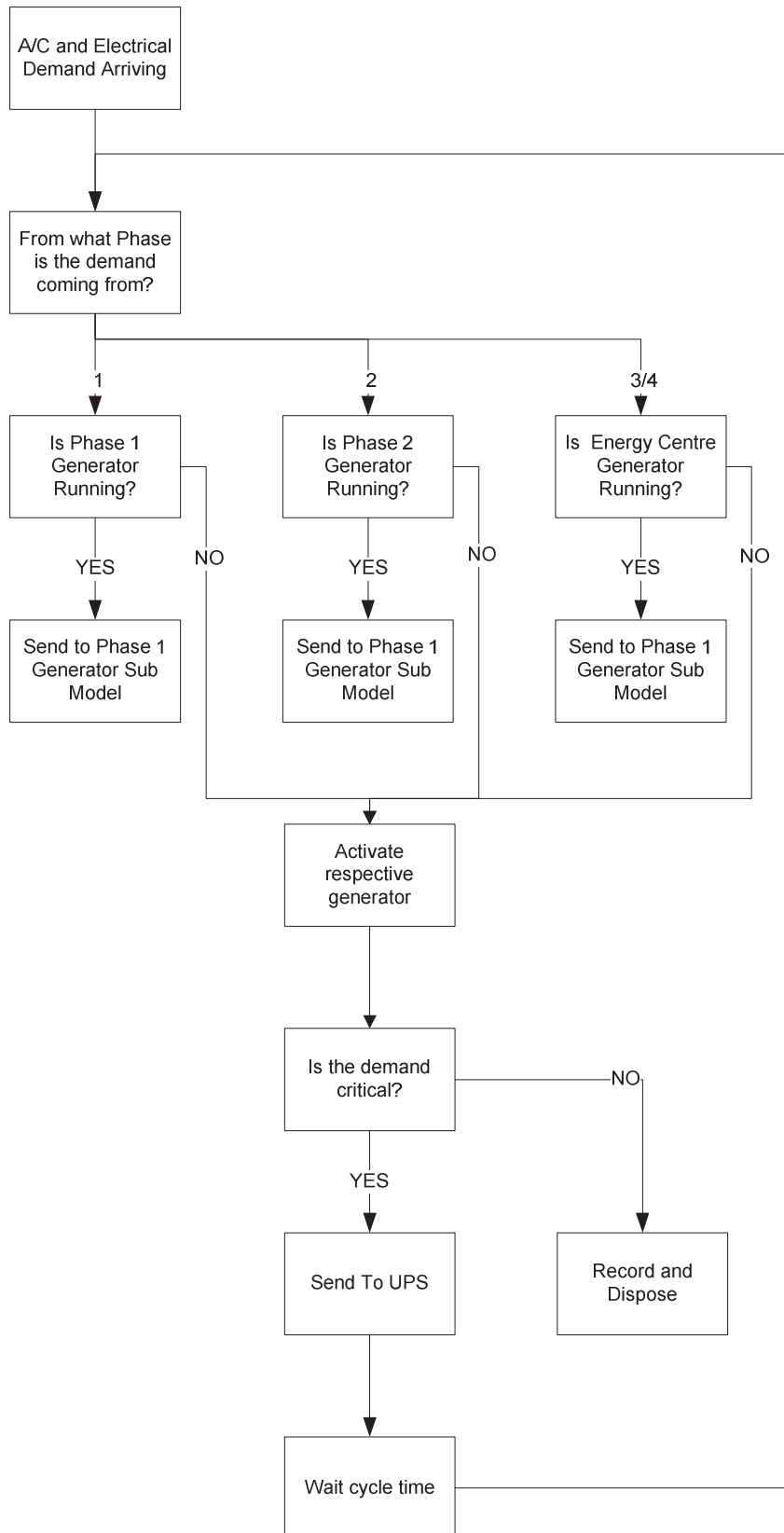


Figure 16 – Generator 2, Simulation Model

In the warm up period of the generator, entities with a critical priority will by-pass the generator and enter a UPS. This was a very difficult process to model. The characteristics of the UPS are simple; it acts as a rechargeable battery for critical components until the other power supply has been activated. The UPS will also require a recharge once the power has stabilised. First the entity will be recorded, then pass through a process block named “UPS” this is only to delay the entity until the next system cycle. This creates a bottleneck at the generators once the warm up period has passed. This is only a simple demonstration of the UPS. If the warm up period is too long then the bottle neck will be too large for the generators and the model will behave differently from the real world system. Entities without critical demand will be routed towards the block “Dispose NO POWER”.



Flow Chart 6 - Generator Logic

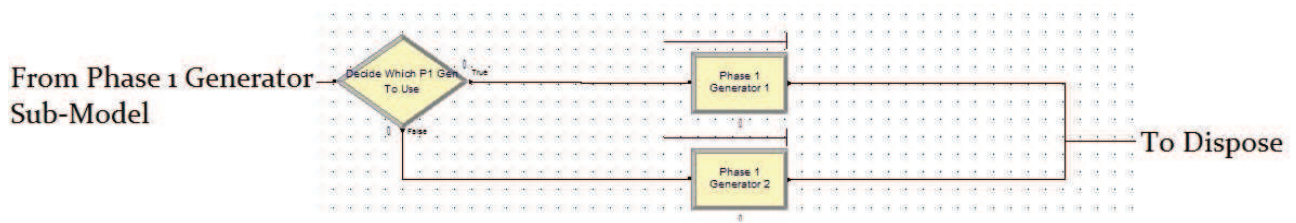


Figure 17 - Phase 1 Generator, Simulation Model, Sub-Model

The Sub-Model for the generator sub-models of Phase 1 and Phase 3/4 is the identical, in the event of a power failure and the generators are used; both generators will start and run until the system stabilizes. Then one of the generators will switch off and will serve as a backup for the other generator. The Phase 2 generator is slightly different, instead of switching off one generator when the system stabilizes, both of the Phase 2 generators will continue to provide power. No apparent reason was found for this.

3.2.2. Data Collection, Cleansing, and Analysis

The data collected from the system is the system demand for a single day for all of the buildings. The data is captured at 10 minute intervals. The data available weren't classified into A/C en electrical demand or critical and non-critical⁹. Thus the data for each building is divided equally across the four classifications (critical, non-critical, A/C, electrical) in the simulation model.

For simplification of the model not all the data is used in the simulation, only the data for the busiest time of day (11:00 to 14:00) is used. From the data it is visible that Phase 1 (Figure 18 - Phase 1 Demand Data) and Phase 2 (Figure 19 - Phase 2 Demand Data) have a cyclic demand every day. The test switch's demand (Figure 20 - Test Switch Demand Data) only increases when new equipment is being tested and the energy centre (Figure 21 - Energy Centre) that includes the data centre has a constant demand throughout the day.

⁹ A request to MTN was made for more detail into the specific demand data for each building.

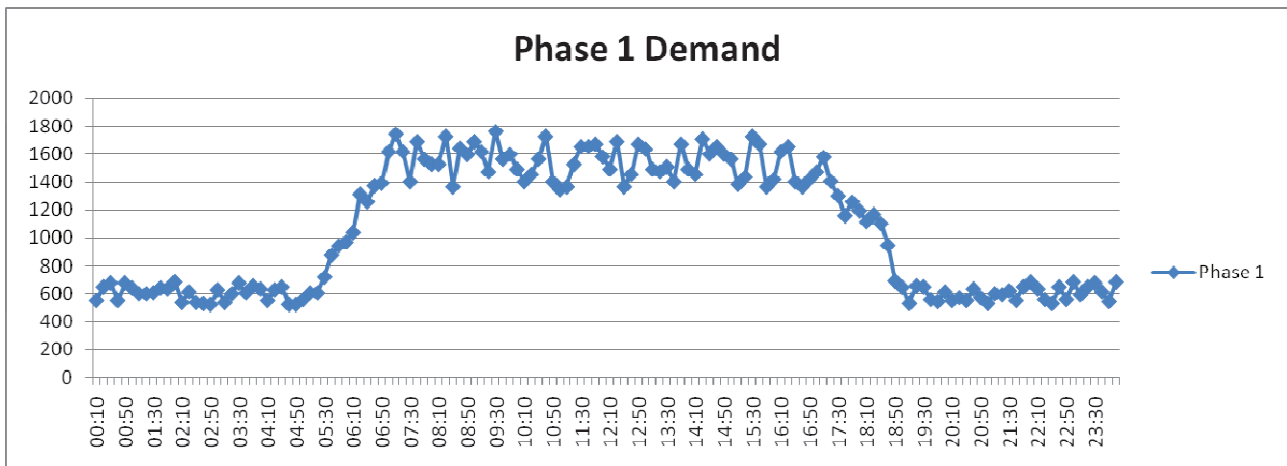


Figure 18 - Phase 1 Demand Data

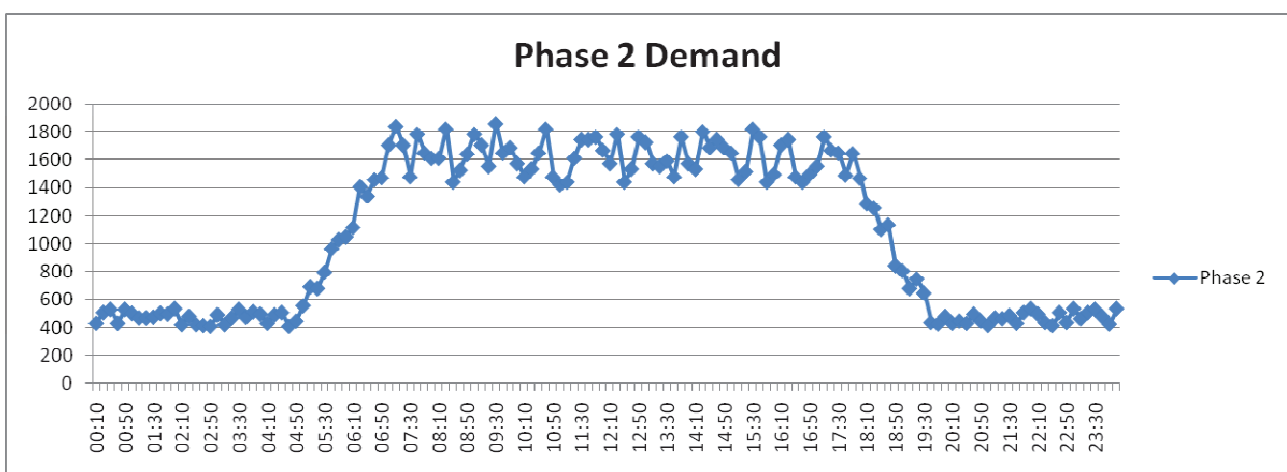


Figure 19 - Phase 2 Demand Data

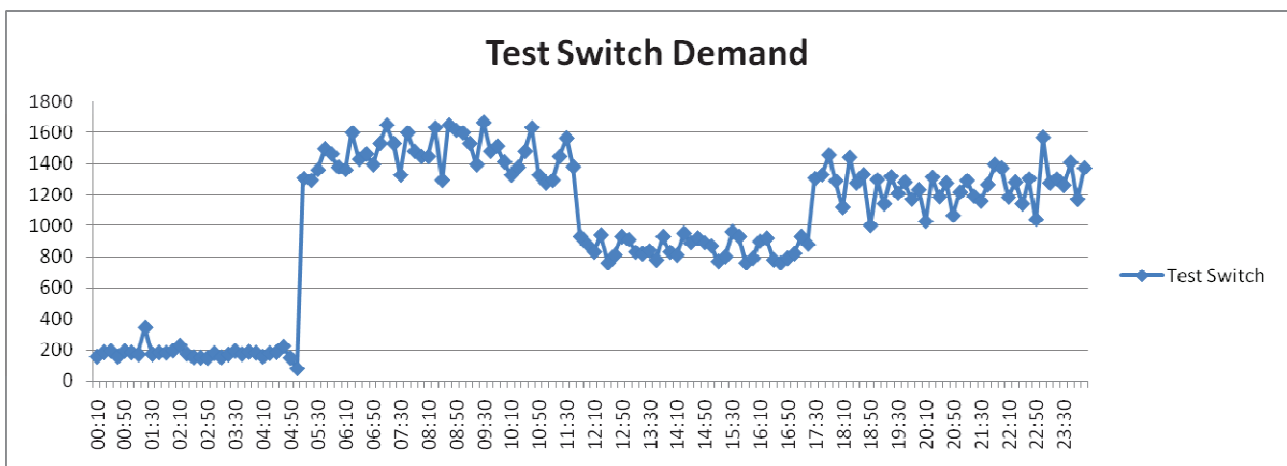


Figure 20 - Test Switch Demand Data

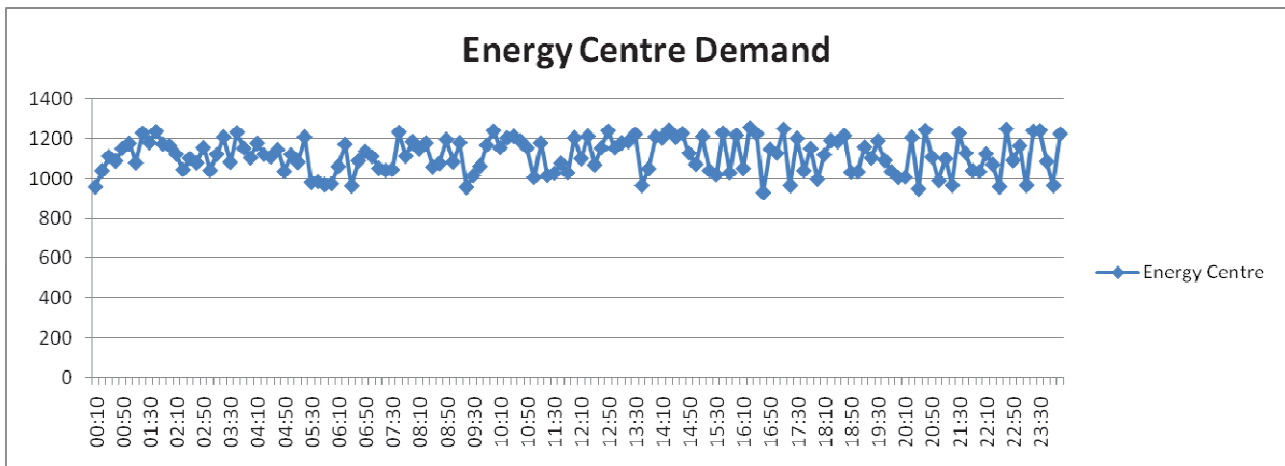


Figure 21 - Energy Centre Demand Data

3.3. Model Verification and Validation

3.3.1. Model Verification

The model was tested with the original data but limitations of the ARENA student version were found (maximum of 150 entities in the system). The entities in the simulation are grouped together to work around this limitation. 12MW maximum in the model, 120^{10} divided by 12 equals 10. 1MW = 1000KW, 1000 divided by 10 equals 100. Thus 100KW in the data is represented by 1 entity in the simulation model. This is divided by 4 for each demand per building (critical, non-critical, A/C, electrical).

3.3.2. Model Validation

For the simulation model to be an accurate representation of the actual system, the simulation model must adhere to a few specifications. The failure simulated is an uptime of 120 minutes with a down time of 60 minutes.

3.3.2.1. There must be no queuing times for the entities, if there are queuing times then in the actual system the demand will not be satisfied and it will result in a power failure.

¹⁰ 120 was used to allow the additional demand needed from proposed Phase 3.

Queue				
Time				
Waiting Time	Average	Half Width	Minimum Value	Maximum Value
Abs Chill 1.Queue	0.00	0.000000000	0.00	0.00
Abs Chill 2.Queue	0.00	0.000000000	0.00	0.00
Eskom.Queue	0.00	0.000000000	0.00	0.00
Gas1.Queue	0.00	0.000000000	0.00	0.00
Gas2.Queue	0.00	0.000000000	0.00	0.00

Figure 22 - Simulation Model Queuing Time

3.3.2.2. The simulation model must show that the ESKOM demand is a supplementary to the Gas Generators. Thus the gas generator must have a utilization of 1 if no failures are present.

Resource				
Usage				
Instantaneous Utilization	Average	Half Width	Minimum Value	Maximum Value
R_Abs Chill 1	1.0000	(Insufficient)	0.00	1.0000
R_Abs Chill 2	1.0000	(Insufficient)	0.00	1.0000
R_EC_Gen 1	0.00	(Insufficient)	0.00	0.00
R_EC_Gen 2	0.00	(Insufficient)	0.00	0.00
R_Eskom	0.1944	(Insufficient)	0.00	0.3333
R_Gas 1	1.0000	(Insufficient)	0.00	1.0000
R_Gas 2	1.0000	(Insufficient)	0.00	1.0000
R_P1_Gen 1	0.00	(Insufficient)	0.00	0.00
R_P1_Gen 2	0.00	(Insufficient)	0.00	0.00
R_P2_Gen 1	0.00	(Insufficient)	0.00	0.00
R_P2_Gen 2	0.00	(Insufficient)	0.00	0.00

Figure 23 - Simulation Model Resource Utilization (fraction of capacity utilized)

3.3.2.3. Counters such as “No Power” and “Over Capacity” must be zero if no failures are present.

User Specified	
Counter	
Count	Value
Record AC Demand Created	501.00
Record AC Demand Satisfied by Chiller	360.00
Record Demand Created	502.00
Record No Power	0.00
Record Over Capacity	0.00
Record Total Satisfied	570.00
Record UPS Critical Demand	0.00

Figure 24 - Simulation Model Counters (number of entities)

From the above figures a conclusion can be made, with the logic of the simulation model the same as the actual system, that the simulation model is an accurate representation of the actual system if no failures are present.

3.3.2.4. If an ESKOM failure does occur the demand from the various buildings must be satisfied by the respective building’s backup generator.

- R_EC_Gen 1: Energy Centre’s backup generator
- R_P1_Gen 1: Phase 1’s backup generator
- R_P2_Gen 1 & 2: Phase 2’s backup generator
- R_Gas 1 & 2: Test switch’s backup generator

Resource				
Usage				
Instantaneous Utilization	Average	Half Width	Minimum Value	Maximum Value
R_Abs Chill 1	0.8444	(Insufficient)	0.00	1.0000
R_Abs Chill 2	0.7222	(Insufficient)	0.00	1.0000
R_EC_Gen 1	0.1583	(Insufficient)	0.00	0.6500
R_EC_Gen 2	0.00	(Insufficient)	0.00	0.00
R_Eskom	0.1343	(Insufficient)	0.00	0.3167
R_Gas 1	0.8444	(Insufficient)	0.00	1.0000
R_Gas 2	0.7222	(Insufficient)	0.00	1.0000
R_P1_Gen 1	0.2000	(Insufficient)	0.00	1.0000
R_P1_Gen 2	0.00	(Insufficient)	0.00	0.00
R_P2_Gen 1	0.1111	(Insufficient)	0.00	0.4000
R_P2_Gen 2	0.1111	(Insufficient)	0.00	0.4500

Figure 25 - Simulation Model, ESKOM Failure, Resource Utilization (fraction of capacity utilized)

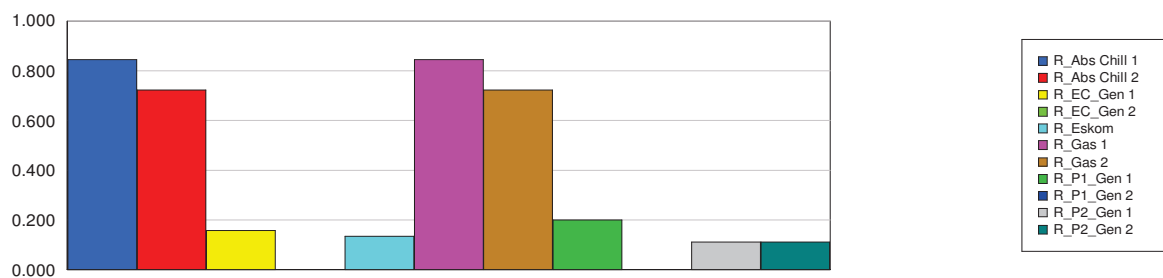


Figure 26 - Simulation Model, ESKOM Failure, Resource Utilization Graph (fraction of capacity utilized)

3.3.2.5. If an ESKOM failure occurs, the non-critical demand must have no power and the UPS must have satisfied the critical demand.

User Specified	
Counter	
Count	Value
Record AC Demand Created	498.00
Record AC Demand Satisfied by Chiller	282.00
Record Demand Created	500.00
Record No Power	8.0000
Record Over Capacity	0.00
Record Total Satisfied	636.00
Record UPS Critical Demand	10.0000

Figure 27 - Simulation Model, ESKOM Failure, Counters (number of entities)

3.3.2.6. If a gas failure occurs then ESKOM should carry the entire demand of the complex.

- Maximum Value of R_ESKOM = 1, 100% utilization during the gas failure.

Resource				
Usage				
Instantaneous Utilization	Average	Half Width	Minimum Value	Maximum Value
R_Abs Chill 1	0.7222	(Insufficient)	0.00	1.0000
R_Abs Chill 2	0.7222	(Insufficient)	0.00	1.0000
R_EC_Gen 1	0.00	(Insufficient)	0.00	0.00
R_EC_Gen 2	0.00	(Insufficient)	0.00	0.00
R_Eskom	0.3778	(Insufficient)	0.00	0.9333
R_Gas 1	0.7222	(Insufficient)	0.00	1.0000
R_Gas 2	0.7222	(Insufficient)	0.00	1.0000
R_P1_Gen 1	0.00	(Insufficient)	0.00	0.00
R_P1_Gen 2	0.00	(Insufficient)	0.00	0.00
R_P2_Gen 1	0.00	(Insufficient)	0.00	0.00
R_P2_Gen 2	0.00	(Insufficient)	0.00	0.00

Figure 28 - Simulation Model Gas Failure Resource Utilization (fraction of capacity utilized)

3.4. Experimentation, Analysis, and Reporting

Experiment 1

Backup power capacity during ESKOM failure with additional phase

Experimental Design

Replication length

Data of the 3 busiest hours of the day is used in this simulation. If a failure is to happen during this time of day, it is a worst case scenario.

Number of replications

The simulation contains no probabilities thus only 1 replication is needed.

Parameters to be changed and studied

Parameters changed include:

- ESKOM removed from the simulation due to failure
- Backup generators placed in parallel
- Backup generators being the supplement of the Gas Generators
- Added extra phase named NP Phase (Maximum demand = ± 2 MW)
- Peak demand
- Failure of 180 minutes (entire duration of the simulation)

Steady state analysis, warm-up period

The data used is from an excerpt from the total data collected. The process is already in a steady state when the excerpt was taken. Thus no warm-up period is necessary.

Experimentation

The experiment was to investigate if it is possible to add an extra phase without having to add additional backup generators. The Gas Generators and the Backup Generators are placed in parallel.

Analysis

With only ESKOM failing a hypothesis can be drawn that there would be ample of backup power available.

Resource				
Usage				
Instantaneous Utilization	Average	Half Width	Minimum Value	Maximum Value
BU_Gen 1	1.0000	(Insufficient)	0.00	1.0000
BU_Gen 2	0.3917	(Insufficient)	0.00	0.6000
BU_Gen 3	0.00	(Insufficient)	0.00	0.00
BU_Gen 4	0.00	(Insufficient)	0.00	0.00
BU_Gen 5	0.00	(Insufficient)	0.00	0.00
BU_Gen 6	0.00	(Insufficient)	0.00	0.00
R_Abs Chill 1	1.0000	(Insufficient)	0.00	1.0000
R_Abs Chill 2	1.0000	(Insufficient)	0.00	1.0000
R_Gas 1	1.0000	(Insufficient)	0.00	1.0000
R_Gas 2	1.0000	(Insufficient)	0.00	1.0000

Figure 29 - Resource Utilization, ESKOM failure (fraction of capacity utilized)

Keeping in mind that the Absorption Chillers and the Gas Generators have a capacity of 1MW respectively and the backup Generators have a capacity of 2MW each, there is still backup capacity of 8.8MW at the maximum. The average available backup capacity is 9.21MW.

Resource				
Usage				
Instantaneous Utilization	Average	Half Width	Minimum Value	Maximum Value
BU_Gen 1	1.0000	(Insufficient)	0.00	1.0000
BU_Gen 2	1.0000	(Insufficient)	0.00	1.0000
BU_Gen 3	1.0000	(Insufficient)	0.00	1.0000
BU_Gen 4	0.4278	(Insufficient)	0.00	0.8000
BU_Gen 5	0.00	(Insufficient)	0.00	0.00
BU_Gen 6	0.00	(Insufficient)	0.00	0.00
R_Abs Chill 1	0.00	(Insufficient)	0.00	0.00
R_Abs Chill 2	0.00	(Insufficient)	0.00	0.00
R_Gas 1	0.00	(Insufficient)	0.00	0.00
R_Gas 2	0.00	(Insufficient)	0.00	0.00

Figure 30-Resource Utilization, ESKOM and Gas failure (fraction of capacity utilized)

With the ESKOM and the Gas Generators failed there is 4.4MW backup capacity available at the maximum. Notice that the Absorption Chillers also have no utilization; this is because the Absorption Chillers is dependent on the Gas Generators to operate. The average capacity available is 5.1MW.

Experiment Conclusion

By making a simple probability calculation it is possible to see that this arrangement can be beneficial. Assume the probability of failing is = 0.001

Original system:

For a phase to have no power during an ESKOM power failure both backup generators must fail.

$$P(Fail) = 0.001 * 0.001$$

$$P(Fail) = 1 \times 10^{-6}$$

Proposed system:

For a phase to have no power during an ESKOM power failure at least 5 generators should fail.

$$P(Fail) = 0.001^5$$

$$P(Fail) = 1 \times 10^{-15}$$

Even if the Gas Generators and the Absorption Chillers fail the probability is still better by placing the backup generators in parallel. For a phase to have no power during an ESKOM and Gas Generator power failure at least 3 generators should fail.

$$P(Fail) = 0.001^3$$

$$P(Fail) = 1 \times 10^{-9}$$

With MTN's policy of N + 1 generator required per building, by having the backup generators in a parallel configuration for the whole system, an extra phase can be added without additional backup power requirements.

Simulation Model

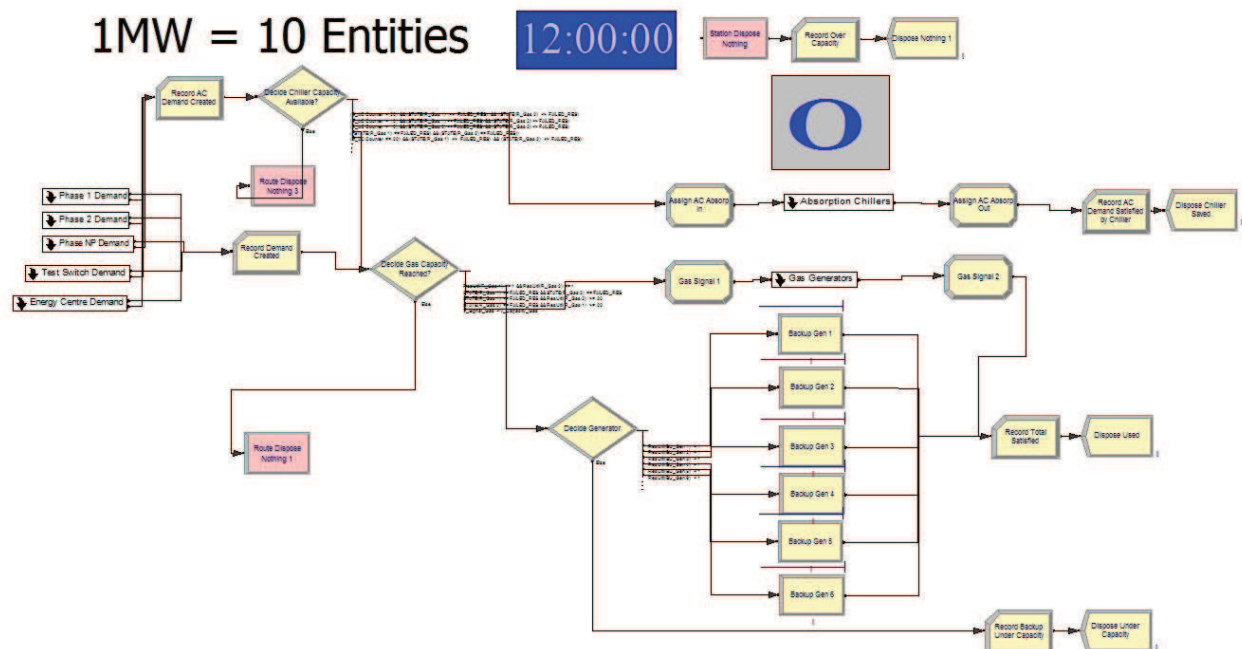


Figure 31 - Entire Experiment 1 Model

Experiment 2

Proposed design with Gas Generator failure

Experimental Design

Replication length

Data of the 3 busiest hours of the day is used in this simulation. If a failure is to happen during this time of day, it is a worst case scenario.

Number of replications

The simulation contains no probabilities thus only 1 replication is needed.

Parameters to be changed and studied

Parameters changed include:

- Decide ESKOM and Phase 3 decide block removed

This was used to separate the entities during an ESKOM failure. In the proposed design the Gas Generators can provide power to all building during an EKSOM failure.

- Backup Generators added in Generator sub-model

All the backup generators are added in the generator sub-model instead of a sub-model for each building. All the generators are now in parallel.

Steady state analysis, warm-up period

The data used is from an excerpt from the total data collected. The process is already in a steady state when the excerpt was taken. Thus no warm-up period is necessary.

Experimentation

Initially the plan was to redesign the simulation model so that during a Gas Generator failure there would not be an increase in the demand needed from ESKOM. After inspection it was

found that all the necessary logic was already in the model and only minor parameter changes needed to be made.

By adding a virtual capacity limit on ESKOM the maximum demand issue can be solved. This limitation is set at the maximum of the ESKOM load in the actual system simulation (2MW). During a Gas Generator failure the load on ESKOM will not exceed this virtual capacity.

Instead of each building having 2 backup generators; all the backup generators are placed in parallel on the ring network as well as the Gas Generators. In the case of an ESKOM failure then the Gas Generators are still the primary power source and the backup generators can be used as supplementary power source to avoid the maximum demand on ESKOM.

A sensitivity analysis must also be performed to see when it will be more profitable to put the added demand on ESKOM and pay the maximum demand charges.

Analysis

During normal operation the demand is satisfied by the Gas Generators, Absorption Chillers and EKSOM. Note that due to the virtual capacity, ESKOM now have a capacity of 2MW. Thus according to the figure below, during normal operation ESKOM have a maximum load of 1.8MW. This means the virtual capacity can be made even smaller to reduce costs. But for the sake of simplicity for the simulation it will be kept at 2MW.

Resource				
Usage				
Instantaneous Utilization	Average	Half Width	Minimum Value	Maximum Value
BU_Gen 1	0.00	(Insufficient)	0.00	0.00
BU_Gen 2	0.00	(Insufficient)	0.00	0.00
BU_Gen 3	0.00	(Insufficient)	0.00	0.00
BU_Gen 4	0.00	(Insufficient)	0.00	0.00
BU_Gen 5	0.00	(Insufficient)	0.00	0.00
BU_Gen 6	0.00	(Insufficient)	0.00	0.00
R_Abs Chill 1	1.0000	(Insufficient)	0.00	1.0000
R_Abs Chill 2	1.0000	(Insufficient)	0.00	1.0000
R_Eskom	0.6167	(Insufficient)	0.00	0.9000
R_Gas 1	1.0000	(Insufficient)	0.00	1.0000
R_Gas 2	1.0000	(Insufficient)	0.00	1.0000

Figure 32 - Proposed System Resource Utilization, No failure (fraction of capacity utilized)

Here the issue of maximum demand is investigated. With the Gas Generators and the Absorption Chillers in failure, ESKOM takes the load until the virtual capacity is reached. The rest of the demand is satisfied by the backup generators acting as a supplementary power source for ESKOM.

Resource				
Usage				
Instantaneous Utilization	Average	Half Width	Minimum Value	Maximum Value
BU_Gen 1	1.0000	(Insufficient)	0.00	1.0000
BU_Gen 2	0.6306	(Insufficient)	0.00	0.9000
BU_Gen 3	0.00	(Insufficient)	0.00	0.00
BU_Gen 4	0.00	(Insufficient)	0.00	0.00
BU_Gen 5	0.00	(Insufficient)	0.00	0.00
BU_Gen 6	0.00	(Insufficient)	0.00	0.00
R_Abs Chill 1	0.00	(Insufficient)	0.00	0.00
R_Abs Chill 2	0.00	(Insufficient)	0.00	0.00
R_Eskom	1.0000	(Insufficient)	0.00	1.0000
R_Gas 1	0.00	(Insufficient)	0.00	0.00
R_Gas 2	0.00	(Insufficient)	0.00	0.00

Figure 33 - Proposed System Resource Utilization, Gas Generator Failure (fraction of capacity utilized)

Another aspect of this problem is for how long the generators can run until it is cheaper to pay the maximum demand and let the whole demand be satisfied by ESKOM during a Gas Generator failure.

Firstly the operating costs for each generator must be calculated. MTN uses the benchmark of 300 grams of diesel per generated KWh to calculate the running cost per hour.

- 300 grams of diesel per generated KWh
- From the figures above the Backup Generators must generated 3200KW
- Density of diesel = 0.832kg/L
- Price of 0.05% sulphur diesel = R9.65 per liter (according to Engen on 2011/10/05)
- Maximum Demand Cost = R230000 per month for 6 months
- 10% of running cost added for maintenance cost

$$\text{Grams of diesel used per hour} = 300 \times 3200 = 960000g$$

$$\text{Kilograms of diesel used per hour} = 960000 \div 1000 = 960Kg$$

$$\text{Liters of diesel used per hour} = 960 \div 0.832 = 1154L$$

$$\text{Running cost per 3200KWh} = 1154 \times 9.65 = R11134$$

$$\text{Running and maintenance cost per 3200KWh} = 11134 \times 1.1 = R12248$$

Thus the equivalent of the maximum demand charge in terms of the running time for the Backup Generators is:

$$\text{Equivalent cost} = 230000 \div 12248 = 18.7 \text{ hours per month}$$

Experiment Conclusion

From the graph below the experiment can be concluded that if the Backup Generators are supplementing ESKOM less than 19 hours per month then it will be more profitable to add the demand to the Backup Generators rather than letting ESKOM satisfy the full demand of the system.

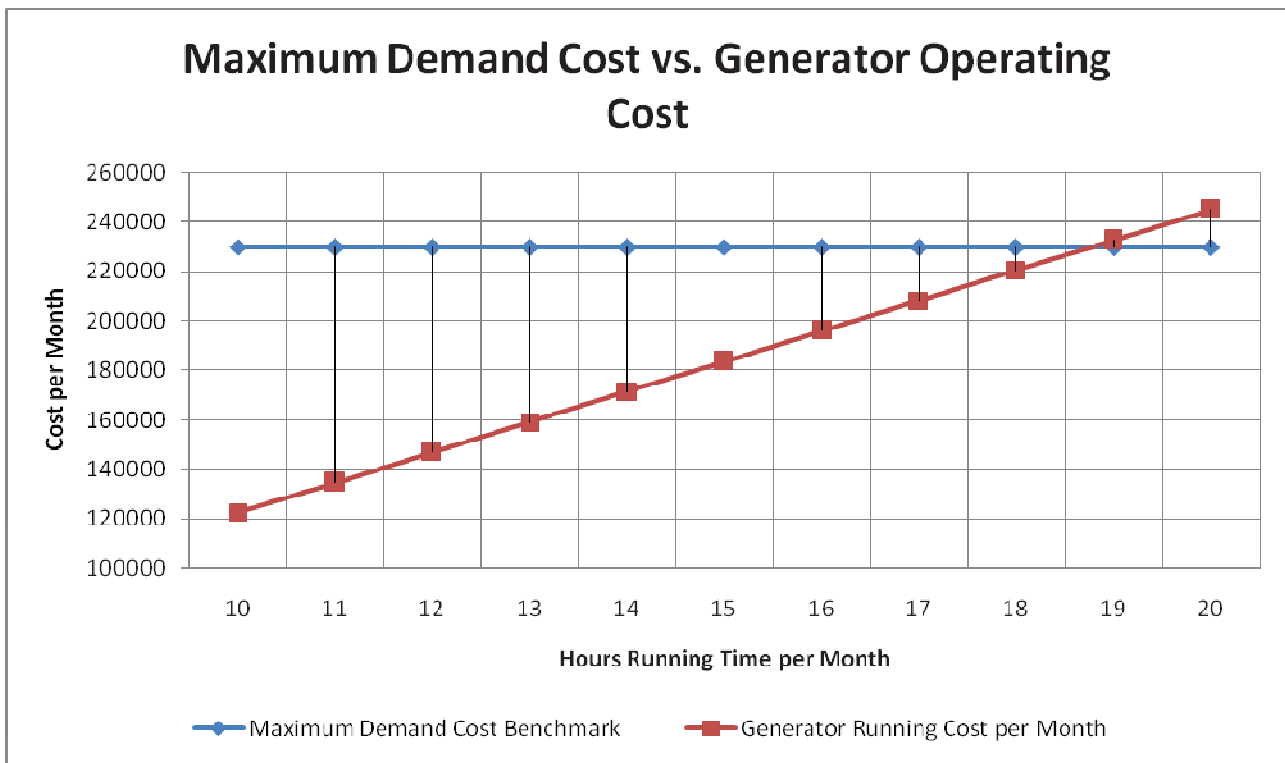


Figure 34 - Maximum Demand Cost vs. Generator Operating Cost

The operating costs of the Backup Generators are dependent on the cost of the diesel as well as maintenance and logistical costs. It is recommended to calculate the running cost frequently to ensure that the hours running time per month is optimized.

Another possibility would be that during times that the Gas Generators are maintained the Backup Generators also supplement ESKOM even if it is more than 19 hours for that month, because for months that the Gas Generators aren't being maintained there is the possibility that the Backup Generators will not run the 19 hours, making up for the months that the Backup Generators did run for more than 19 hours.

1MW = 10 Entities 12:00:00



Chapter 4

4. Conclusion

The aim of this project was to build a model of the actual system that can be used for experimentation without causing any major disruptions in the system. The model built in ARENA is a discrete and accurate representation of the power flow within the complex. The experiments performed on the simulation gave insight to the maximum demand problem and future expansion of the system.

The complex's modular design was to decrease costs and complexity during the building stages of each building. With the addition of the Gas Generators new possibilities to reduce overheads have emerged. From experiment 1 of the simulation it has been proven that it is possible to build an extra phase in the complex without adding extra backup capacity. But this can only be achieved if all the backup generators are placed in parallel and connected directly to the power ring network. From experiment 2 of the simulation the maximum demand problem can be solved by allowing the Backup Generators to satisfy the increase in demand in the case that the Gas Generators fails instead of ESKOM. This however can only be done for a certain amount of hours per month depending on the operational costs of the Backup Generators. Further analysis of the operating cost of each power source will provide further insight of the system and more comprehensive simulations can be built.

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Appendix A

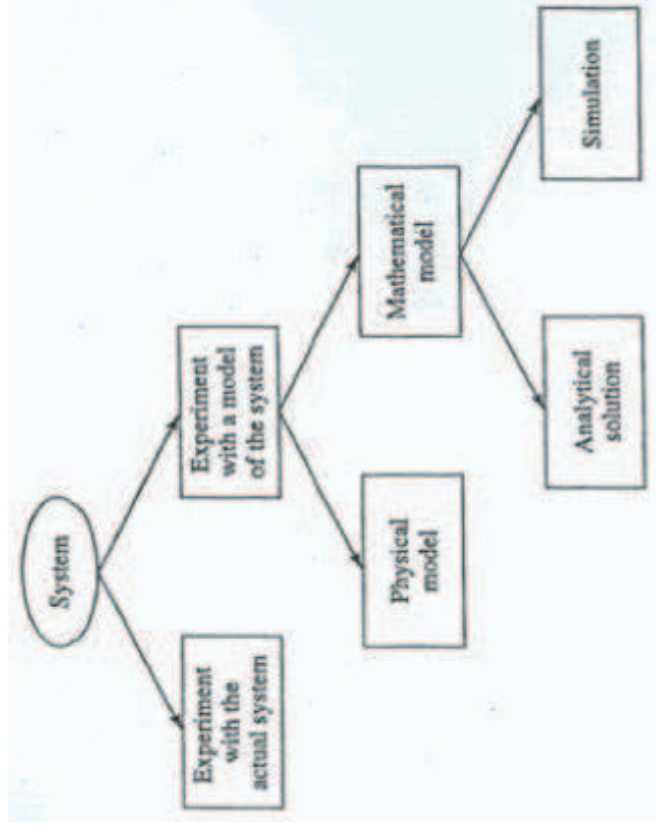


Figure 37 - Ways to study a system (Law & Kelton [4])

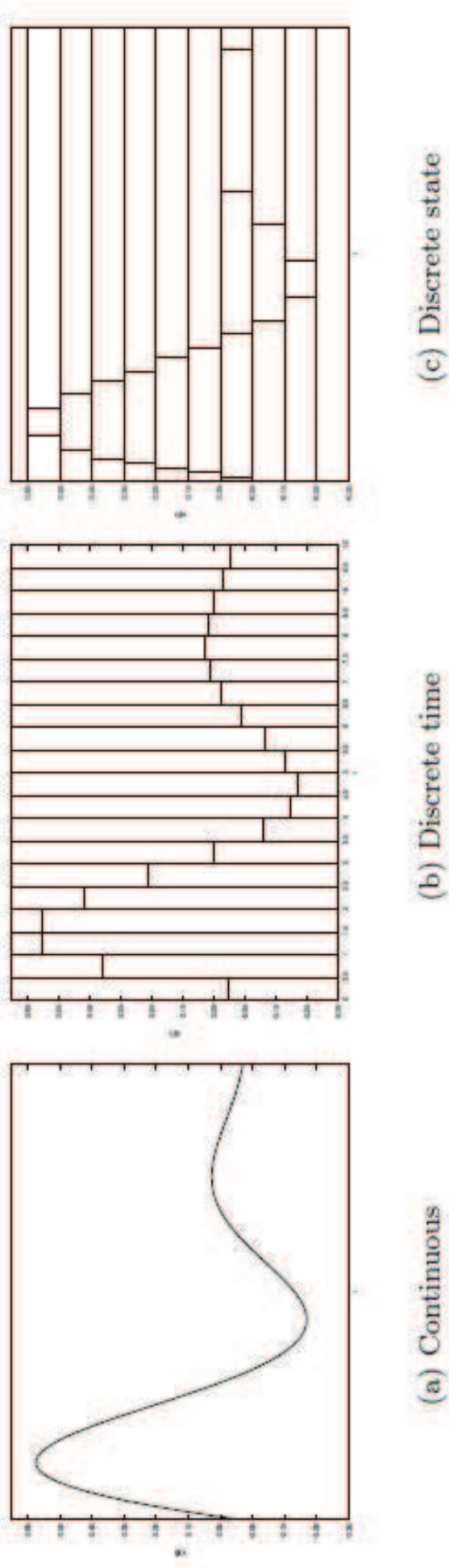


Figure 38 - Time and state discretizations of a system (Nutaro n.d.).

#	Activity	July	August				September				October					
		25-Jul	01-Aug	08-Aug	15-Aug	22-Aug	29-Aug	05-Sep	12-Sep	19-Sep	26-Sep	03-Oct	10-Oct	17-Oct	24-Oct	31-Oct
1	Draft Project Proposal															
2	Finalize Project Proposal															
3	Modelling of Current System															
4	Additional Modelling															
5	Interim Project Draft															
6	Interim Project															
7	Final modelling of alternative systems															
8	Final Project Draft															
9	Finalize Project															
10	Prepare Final Project															
11	Project Oral Preparation															

Figure 39 - Gantt chart of the Project

12:00:00

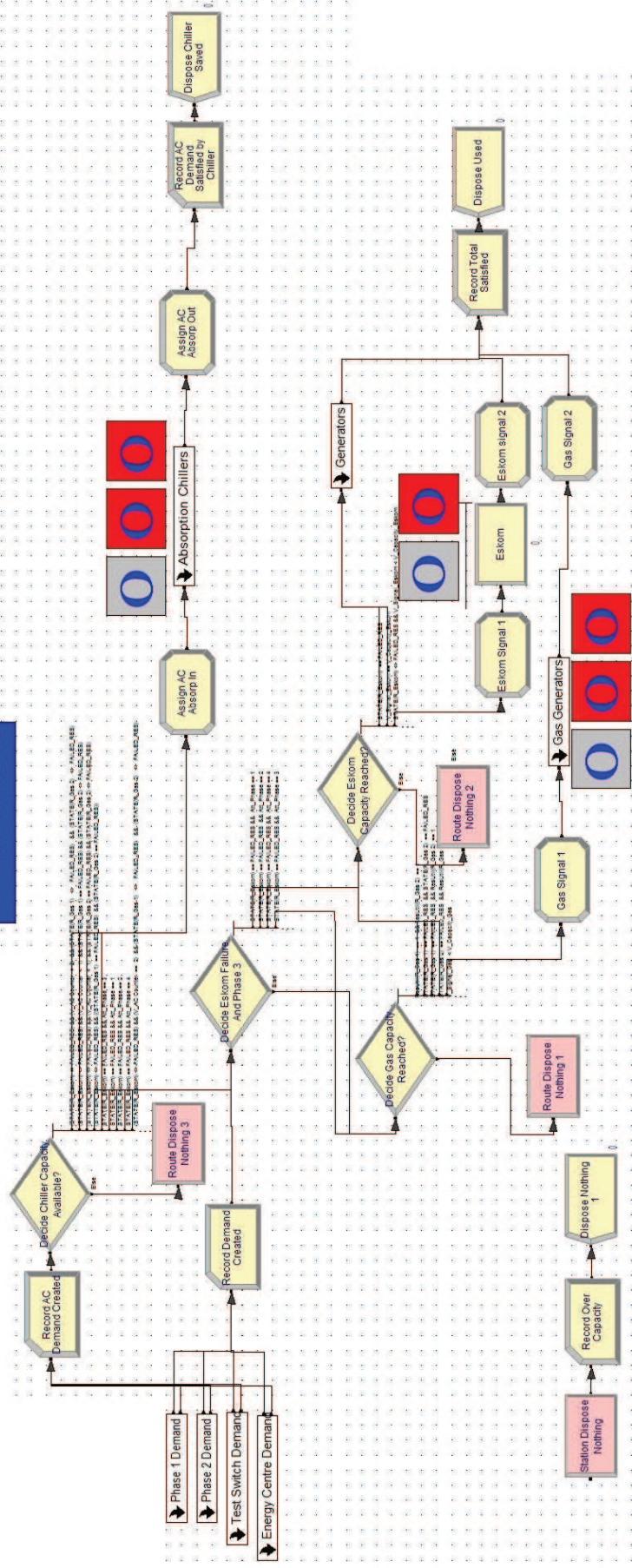


Figure 40 – Entire Current Model

The flowchart illustrates the process of power distribution and disposal. It begins with a decision diamond 'Choose Demand From Phase'. If the demand is from Phase 1, it proceeds to 'P1 Generator Running' (a yellow diamond). If the demand is from Phase 2, it proceeds to 'P2 Generator Running' (a yellow diamond). If the demand is from Phase 3, it proceeds to 'P3 Generator Running' (a yellow diamond). If the demand is from Phase 4, it proceeds to 'Route Disposal Nothing 4' (a pink rectangle). Each 'Generator Running' diamond is connected to a 'Generator Signal' (a yellow rectangle) and a '0.00' value box. The 'Generator Signal' boxes are connected to a 'Decide Priority' diamond. The 'Decide Priority' diamond is connected to a 'Record UPS Critical Centre' box, which is then connected to a 'UPS' box. The 'Decide Priority' diamond is also connected to a 'Record No Power' box, which is then connected to a 'Dispose NO POWER' box. The 'Dispose NO POWER' box is connected to a 'To dispose' box, which is then connected to a 'Phase 1 Generators' box, a 'Phase 2 Generators' box, and an 'Energy Centre Generators' box.

Figure 41 - Generator Sub-model

1MW = 10 Entities

12:00:00

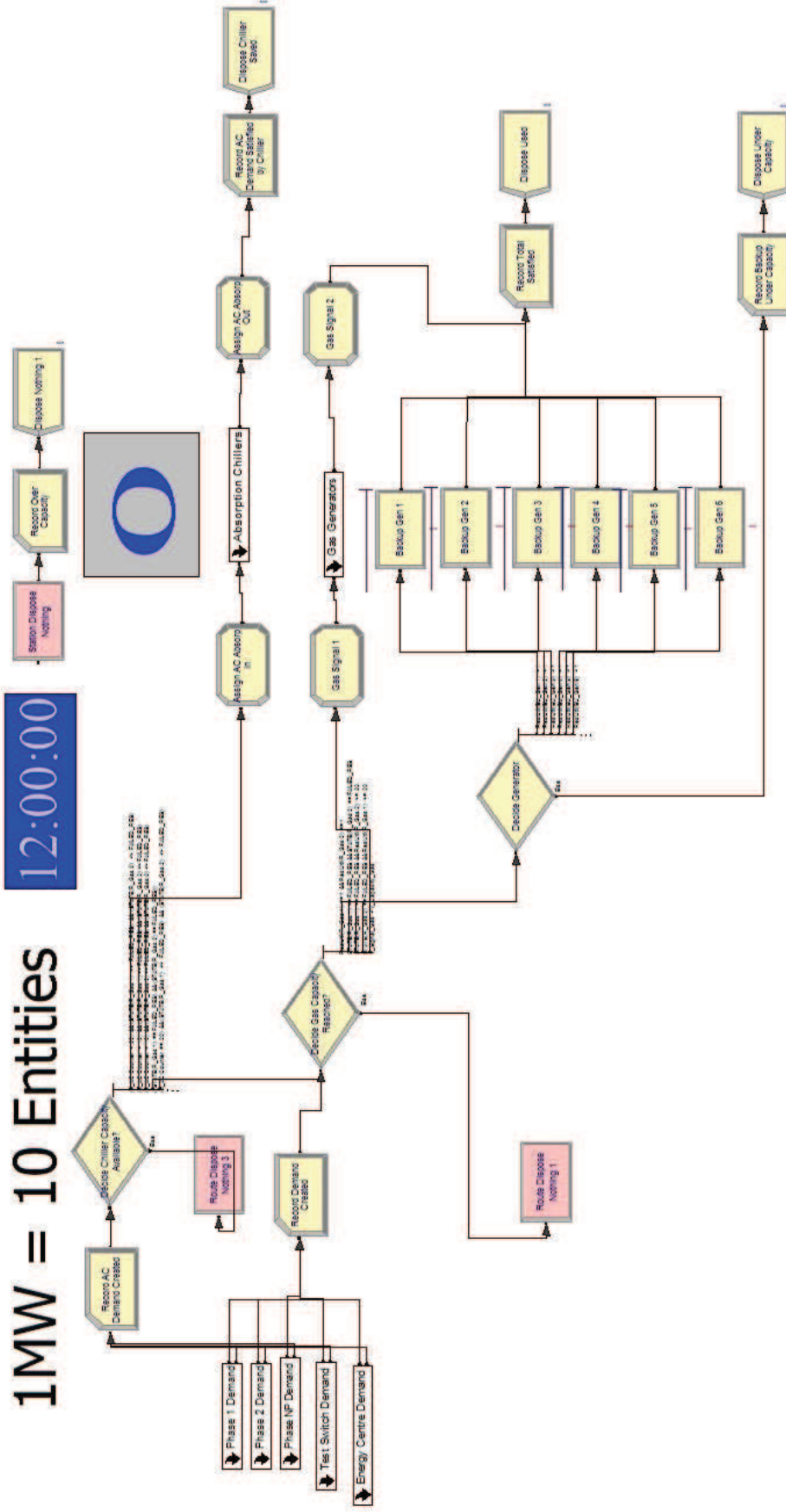


Figure 42 - Experiment 1 Model

1MW = 10 Entities

12:00:00

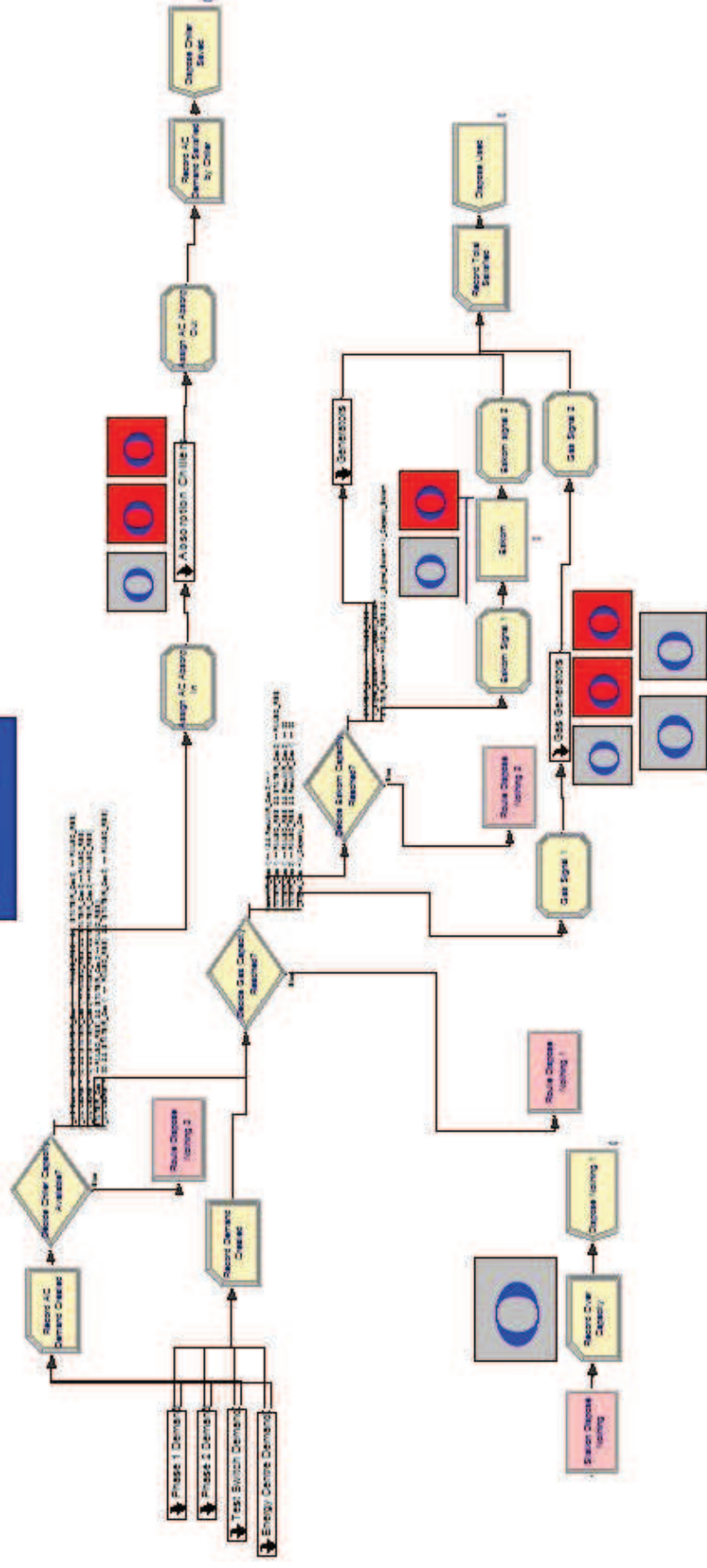


Figure 43 - Experiment 2 Model

Appendix B

Physical Data

	Phase 1	Phase 2	Test Switch	Data Centre	Service Yard	Energy Centre	Total
11:00	1350	1425	1275	780	225	1005	5055
11:10	1368	1444	1292	950	228	1178	5282
11:20	1530	1615	1445	760	255	1015	5605
11:30	1656	1748	1564	750	276	1026	5994
11:40	1656	1748	1380	800	276	1076	5860
11:50	1674	1767	930	750	279	1029	5400
12:00	1584	1672	880	940	264	1204	5340
12:10	1494	1577	830	850	249	1099	5000
12:20	1692	1786	940	930	282	1212	5630
12:30	1368	1444	760	840	228	1068	4640
12:40	1458	1539	810	910	243	1153	4960
12:50	1674	1767	930	960	279	1239	5610
13:00	1638	1729	910	880	273	1153	5430
13:10	1494	1577	830	930	249	1179	5080
13:20	1476	1558	820	940	246	1186	5040
13:30	1512	1596	840	970	252	1222	5170
13:40	1404	1482	780	730	234	964	4630
13:50	1674	1767	930	770	279	1049	5420

Figure 44 - Actual Data

Appendix C

Simulation model reports

- No Failure Current System
- Eskom Failure Current System
- Gas Failure Current System
- Experiment 1 – ESKOM Proposed Backup with Phase added
- Experiment 1 – ESKOM and Gas Failure Proposed Backup with Phase added
- Experiment 2 – Gas Failure Proposed System

Category Overview

Unnamed Project

Replications: 1 Time Units: Seconds

Key Performance Indicators

System
Number Out
Average
950

Category Overview

Unnamed Project

Replications: 1 Time Units: Seconds

Entity

Time

VA Time	Average	Half Width	Minimum Value	Maximum Value
E_Demand	454.74	(Correlated)	0.00	600.00
NVA Time	Average	Half Width	Minimum Value	Maximum Value
E_Demand	132.63	(Correlated)	0.00	600.00
Wait Time	Average	Half Width	Minimum Value	Maximum Value
E_Demand	0.00	0.000000000	0.00	0.00
Transfer Time	Average	Half Width	Minimum Value	Maximum Value
E_Demand	0.00	0.000000000	0.00	0.00
Other Time	Average	Half Width	Minimum Value	Maximum Value
E_Demand	0.00	0.000000000	0.00	0.00
Total Time	Average	Half Width	Minimum Value	Maximum Value
E_Demand	587.37	14.89708	0.00	600.00

Other

Number In	Value			
E_Demand	1003.00			
Number Out	Value			
E_Demand	950.00			
WIP	Average	Half Width	Minimum Value	Maximum Value
E_Demand	51.6667	(Insufficient)	0.00	60.0000

Unnamed Project

Replications: 1 Time Units: Seconds

Queue

Time

Waiting Time	Average	Half Width	Minimum Value	Maximum Value
Abs Chill 1.Queue	0.00	(Insufficient)	0.00	0.00
Abs Chill 2.Queue	0.00	(Insufficient)	0.00	0.00
Eskom.Queue	0.00	(Insufficient)	0.00	0.00
Gas1.Queue	0.00	(Insufficient)	0.00	0.00
Gas2.Queue	0.00	(Insufficient)	0.00	0.00

Other

Number Waiting	Average	Half Width	Minimum Value	Maximum Value
Abs Chill 1.Queue	0.00	(Insufficient)	0.00	0.00
Abs Chill 2.Queue	0.00	(Insufficient)	0.00	0.00
Absorption Chillers.Queue	0.00	(Insufficient)	0.00	0.00
Energy Centre Generator 1.Queue	0.00	(Insufficient)	0.00	0.00
Energy Centre Generator 2.Queue	0.00	(Insufficient)	0.00	0.00
Eskom.Queue	0.00	(Insufficient)	0.00	0.00
Gas.Queue	0.00	(Insufficient)	0.00	0.00
Gas1.Queue	0.00	(Insufficient)	0.00	0.00
Gas2.Queue	0.00	(Insufficient)	0.00	0.00
Phase 1 Generator 1.Queue	0.00	(Insufficient)	0.00	0.00
Phase 1 Generator 2.Queue	0.00	(Insufficient)	0.00	0.00
Phase 2 Generator 1.Queue	0.00	(Insufficient)	0.00	0.00
Phase 2 Generator 2.Queue	0.00	(Insufficient)	0.00	0.00

09:02:05 PM

Category Overview

October 3, 2011

Unnamed Project

Replications: 1 Time Units: Seconds

Resource				
Usage				
Instantaneous Utilization	Average	Half Width	Minimum Value	Maximum Value
R_Abs Chill 1	1.0000	(Insufficient)	0.00	1.0000
R_Abs Chill 2	1.0000	(Insufficient)	0.00	1.0000
R_EC_Gen 1	0.00	(Insufficient)	0.00	0.00
R_EC_Gen 2	0.00	(Insufficient)	0.00	0.00
R_Eskom	0.1944	(Insufficient)	0.00	0.3333
R_Gas 1	1.0000	(Insufficient)	0.00	1.0000
R_Gas 2	1.0000	(Insufficient)	0.00	1.0000
R_P1_Gen 1	0.00	(Insufficient)	0.00	0.00
R_P1_Gen 2	0.00	(Insufficient)	0.00	0.00

R_P2_Gen 1	0.00	(Insufficient)	0.00	0.00
R_P2_Gen 2	0.00	(Insufficient)	0.00	0.00

Number Busy	Average	Half Width	Minimum Value	Maximum Value
R_Abs Chill 1	10.0000	(Insufficient)	0.00	10.0000
R_Abs Chill 2	10.0000	(Insufficient)	0.00	10.0000
R_EC_Gen 1	0.00	(Insufficient)	0.00	0.00
R_EC_Gen 2	0.00	(Insufficient)	0.00	0.00
R_Eskom	11.6667	(Insufficient)	0.00	20.0000
R_Gas 1	10.0000	(Insufficient)	0.00	10.0000
R_Gas 2	10.0000	(Insufficient)	0.00	10.0000
R_P1_Gen 1	0.00	(Insufficient)	0.00	0.00
R_P1_Gen 2	0.00	(Insufficient)	0.00	0.00
R_P2_Gen 1	0.00	(Insufficient)	0.00	0.00
R_P2_Gen 2	0.00	(Insufficient)	0.00	0.00

Number Scheduled	Average	Half Width	Minimum Value	Maximum Value
R_Abs Chill 1	10.0000	(Insufficient)	10.0000	10.0000
R_Abs Chill 2	10.0000	(Insufficient)	10.0000	10.0000
R_EC_Gen 1	20.0000	(Insufficient)	20.0000	20.0000
R_EC_Gen 2	20.0000	(Insufficient)	20.0000	20.0000
R_Eskom	60.0000	(Insufficient)	60.0000	60.0000
R_Gas 1	10.0000	(Insufficient)	10.0000	10.0000
R_Gas 2	10.0000	(Insufficient)	10.0000	10.0000
R_P1_Gen 1	20.0000	(Insufficient)	20.0000	20.0000
R_P1_Gen 2	20.0000	(Insufficient)	20.0000	20.0000
R_P2_Gen 1	20.0000	(Insufficient)	20.0000	20.0000
R_P2_Gen 2	20.0000	(Insufficient)	20.0000	20.0000

09:02:05 PM

Category Overview

October 3, 2011

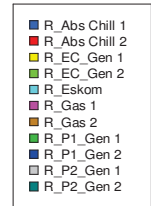
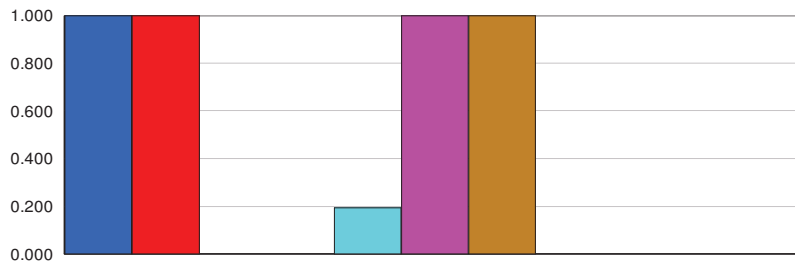
Unnamed Project

Replications: 1 Time Units: Seconds

Resource

Usage

Scheduled Utilization	Value
R_Abs Chill 1	1.0000
R_Abs Chill 2	1.0000
R_EC_Gen 1	0.00
R_EC_Gen 2	0.00
R_Eskom	0.1944
R_Gas 1	1.0000
R_Gas 2	1.0000
R_P1_Gen 1	0.00
R_P1_Gen 2	0.00
R_P2_Gen 1	0.00
R_P2_Gen 2	0.00



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Category Overview

October 3, 2011

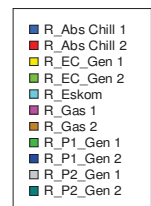
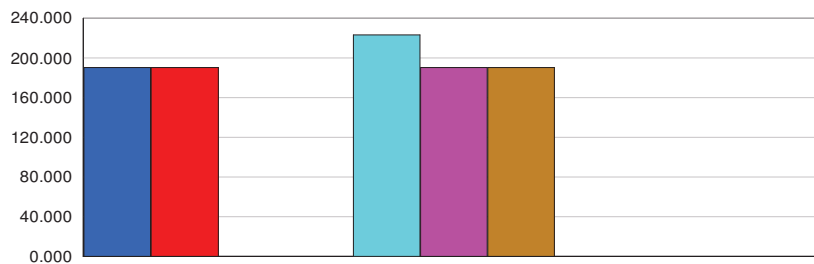
Unnamed Project

Replications: 1 Time Units: Seconds

Resource

Usage

Total Number Seized	Value
R_Abs Chill 1	190.00
R_Abs Chill 2	190.00
R_EC_Gen 1	0.00
R_EC_Gen 2	0.00
R_Eskom	223.00
R_Gas 1	190.00
R_Gas 2	190.00
R_P1_Gen 1	0.00
R_P1_Gen 2	0.00
R_P2_Gen 1	0.00
R_P2_Gen 2	0.00



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Category Overview

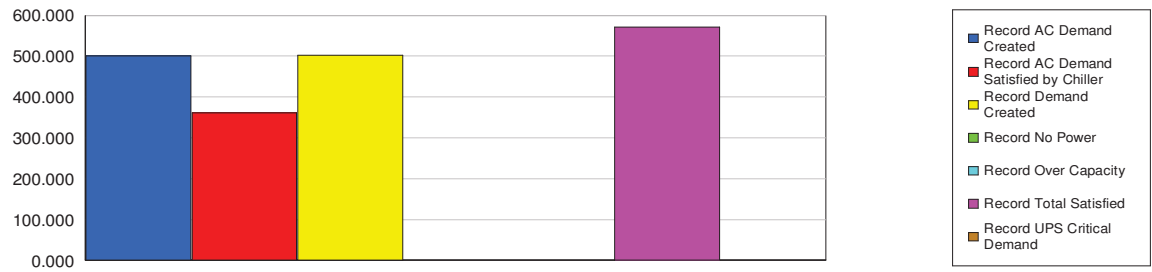
October 3, 2011

Unnamed Project

Replications: 1 Time Units: Seconds

User Specified	
Counter	
Count	...

	Value
Record AC Demand Created	501.00
Record AC Demand Satisfied by Chiller	360.00
Record Demand Created	502.00
Record No Power	0.00
Record Over Capacity	0.00
Record Total Satisfied	570.00
Record UPS Critical Demand	0.00



09:05:18 PM

ESKOM Failure Current System

Category Overview

October 3, 2011

Unnamed Project

Replications: 1 Time Units: Seconds

Key Performance Indicators

System

Average

Number Out

946

09:05:18 PM

Category Overview

October 3, 2011

Unnamed Project

Replications: 1 Time Units: Seconds

Entity

Time

VA Time	Average	Half Width	Minimum Value	Maximum Value
E_Demand	490.27	36.63239	0.00	600.00
NVA Time	Average	Half Width	Minimum Value	Maximum Value
E_Demand	91.9662	32.62136	0.00	600.00
Wait Time	Average	Half Width	Minimum Value	Maximum Value
E_Demand	2.5370	5.29655	0.00	600.00
Transfer Time	Average	Half Width	Minimum Value	Maximum Value
E_Demand	0.00	0.000000000	0.00	0.00
Other Time	Average	Half Width	Minimum Value	Maximum Value
E_Demand	6.3425	(Correlated)	0.00	600.00
Total Time	Average	Half Width	Minimum Value	Maximum Value
E_Demand	591.12	21.69728	0.00	1200.00

Other

Number In				
	Value			
E_Demand	998.00			
Number Out				
	Value			
E_Demand	946.00			
WIP				
	Average	Half Width	Minimum Value	Maximum Value
E_Demand	51.7778	(Insufficient)	0.00	62.0000

Unnamed Project

Replications: 1 Time Units: Seconds

Queue

Time

Waiting Time	Average	Half Width	Minimum Value	Maximum Value
Abs Chill 1.Queue	0.00	(Insufficient)	0.00	0.00
Abs Chill 2.Queue	0.00	(Insufficient)	0.00	0.00
Energy Centre Generator 1.Queue	0.00	(Insufficient)	0.00	0.00
Eskom.Queue	0.00	(Insufficient)	0.00	0.00
Gas1.Queue	0.00	(Insufficient)	0.00	0.00
Gas2.Queue	0.00	(Insufficient)	0.00	0.00
Phase 1 Generator 1.Queue	33.3333	(Insufficient)	0.00	600.00
Phase 2 Generator 1.Queue	0.00	(Insufficient)	0.00	0.00
Phase 2 Generator 2.Queue	0.00	(Insufficient)	0.00	0.00

Other

Number Waiting	Average	Half Width	Minimum Value	Maximum Value
Abs Chill 1.Queue	0.00	(Insufficient)	0.00	0.00
Abs Chill 2.Queue	0.00	(Insufficient)	0.00	0.00
Absorption Chillers.Queue	0.00	(Insufficient)	0.00	0.00
Energy Centre Generator 1.Queue	0.00	(Insufficient)	0.00	0.00
Energy Centre Generator 2.Queue	0.00	(Insufficient)	0.00	0.00
Eskom.Queue	0.00	(Insufficient)	0.00	0.00
Gas.Queue	0.00	(Insufficient)	0.00	0.00
Gas1.Queue	0.00	(Insufficient)	0.00	0.00
Gas2.Queue	0.00	(Insufficient)	0.00	0.00
Phase 1 Generator 1.Queue	0.2222	(Insufficient)	0.00	4.0000
Phase 1 Generator 2.Queue	0.00	(Insufficient)	0.00	0.00
Phase 2 Generator 1.Queue	0.00	(Insufficient)	0.00	0.00
Phase 2 Generator 2.Queue	0.00	(Insufficient)	0.00	0.00

Unnamed Project

Replications: 1 Time Units: Seconds

Resource				
Usage				
Instantaneous Utilization	Average	Half Width	Minimum Value	Maximum Value
R_Abs Chill 1	0.8444	(Insufficient)	0.00	1.0000
R_Abs Chill 2	0.7222	(Insufficient)	0.00	1.0000
R_EC_Gen 1	0.1583	(Insufficient)	0.00	0.6500

R_EC_Gen 2	0.00	(Insufficient)	0.00	0.00
R_Eskom	0.1343	(Insufficient)	0.00	0.3167
R_Gas 1	0.8444	(Insufficient)	0.00	1.0000
R_Gas 2	0.7222	(Insufficient)	0.00	1.0000
R_P1_Gen 1	0.2000	(Insufficient)	0.00	1.0000
R_P1_Gen 2	0.00	(Insufficient)	0.00	0.00
R_P2_Gen 1	0.1111	(Insufficient)	0.00	0.4000
R_P2_Gen 2	0.1111	(Insufficient)	0.00	0.4500

Number Busy	Average	Half Width	Minimum Value	Maximum Value
R_Abs Chill 1	8.4444	(Insufficient)	0.00	10.0000
R_Abs Chill 2	7.2222	(Insufficient)	0.00	10.0000
R_EC_Gen 1	3.1667	(Insufficient)	0.00	13.0000
R_EC_Gen 2	0.00	(Insufficient)	0.00	0.00
R_Eskom	8.0556	(Insufficient)	0.00	19.0000
R_Gas 1	8.4444	(Insufficient)	0.00	10.0000
R_Gas 2	7.2222	(Insufficient)	0.00	10.0000
R_P1_Gen 1	4.0000	(Insufficient)	0.00	20.0000
R_P1_Gen 2	0.00	(Insufficient)	0.00	0.00
R_P2_Gen 1	2.2222	(Insufficient)	0.00	8.0000
R_P2_Gen 2	2.2222	(Insufficient)	0.00	9.0000

Number Scheduled	Average	Half Width	Minimum Value	Maximum Value
R_Abs Chill 1	10.0000	(Insufficient)	10.0000	10.0000
R_Abs Chill 2	10.0000	(Insufficient)	10.0000	10.0000
R_EC_Gen 1	20.0000	(Insufficient)	20.0000	20.0000
R_EC_Gen 2	20.0000	(Insufficient)	20.0000	20.0000
R_Eskom	60.0000	(Insufficient)	60.0000	60.0000
R_Gas 1	10.0000	(Insufficient)	10.0000	10.0000
R_Gas 2	10.0000	(Insufficient)	10.0000	10.0000
R_P1_Gen 1	20.0000	(Insufficient)	20.0000	20.0000
R_P1_Gen 2	20.0000	(Insufficient)	20.0000	20.0000
R_P2_Gen 1	20.0000	(Insufficient)	20.0000	20.0000
R_P2_Gen 2	20.0000	(Insufficient)	20.0000	20.0000

09:05:18 PM

Category Overview

October 3, 2011

Unnamed Project

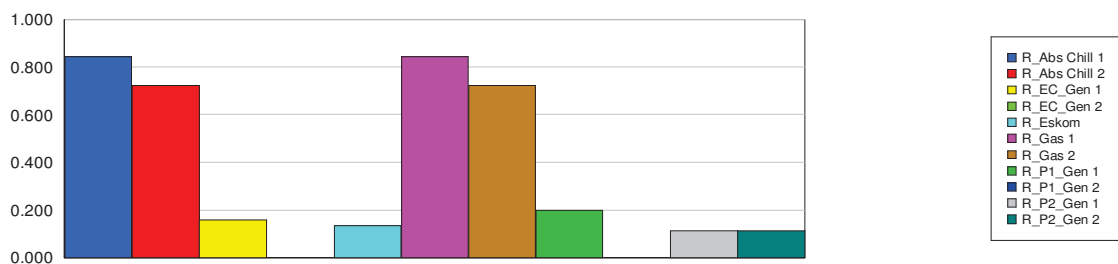
Replications: 1 Time Units: Seconds

Resource

Usage

Scheduled Utilization	Value
R_Abs Chill 1	0.8444
R_Abs Chill 2	0.7222
R_EC_Gen 1	0.1583
R_EC_Gen 2	0.00
R_Eskom	0.1343
R_Gas 1	0.8444
R_Gas 2	0.7222
R_P1_Gen 1	0.2000

R_P1_Gen 2	0.00
R_P2_Gen 1	0.1111
R_P2_Gen 2	0.1111



09:05:18 PM

Category Overview

October 3, 2011

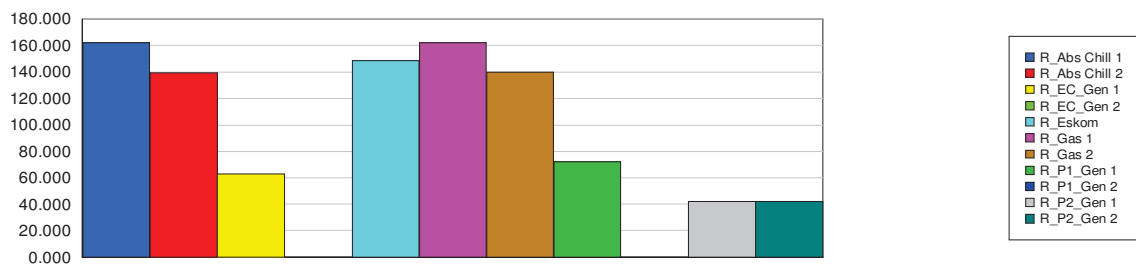
Unnamed Project

Replications: 1 Time Units: Seconds

Resource

Usage

Total Number Seized	Value
R_Abs Chill 1	162.00
R_Abs Chill 2	139.00
R_EC_Gen 1	63.0000
R_EC_Gen 2	0.00
R_Eskom	148.00
R_Gas 1	162.00
R_Gas 2	140.00
R_P1_Gen 1	72.0000
R_P1_Gen 2	0.00
R_P2_Gen 1	42.0000
R_P2_Gen 2	42.0000



09:05:18 PM

Category Overview

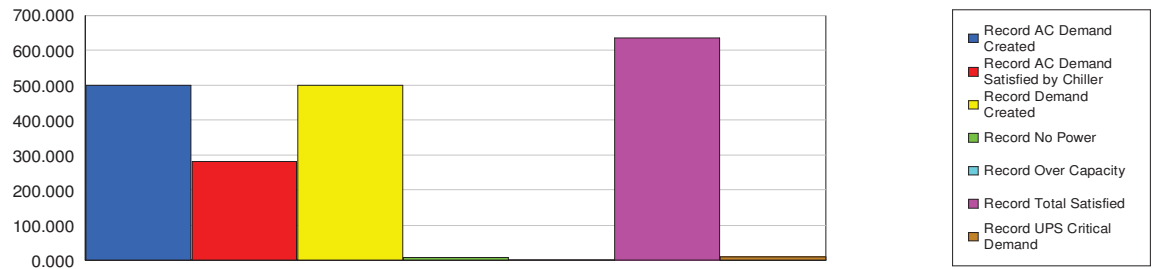
October 3, 2011

Unnamed Project

Replications: 1 Time Units: Seconds

User Specified

Counter	
Count	Value
Record AC Demand Created	498.00
Record AC Demand Satisfied by Chiller	282.00
Record Demand Created	500.00
Record No Power	8.0000
Record Over Capacity	0.00
Record Total Satisfied	636.00
Record UPS Critical Demand	10.0000



Unnamed Project

Replications: 1 Time Units: Seconds

Key Performance Indicators

System	Average
Number Out	948

Unnamed Project

Replications: 1 Time Units: Seconds

Entity

Time				
VA Time	Average	Half Width	Minimum Value	Maximum Value
E_Demand	329.11	(Correlated)	0.00	600.00
NVA Time	Average	Half Width	Minimum Value	Maximum Value
E_Demand	258.23	(Correlated)	0.00	600.00
Wait Time	Average	Half Width	Minimum Value	Maximum Value
E_Demand	0.00	0.000000000	0.00	0.00
Transfer Time	Average	Half Width	Minimum Value	Maximum Value
E_Demand	0.00	0.000000000	0.00	0.00
Other Time	Average	Half Width	Minimum Value	Maximum Value
E_Demand	0.00	0.000000000	0.00	0.00
Total Time	Average	Half Width	Minimum Value	Maximum Value
E_Demand	587.34	14.89708	0.00	600.00
Other				
Number In	Value			
E_Demand	1001.00			
Number Out	Value			
E_Demand	948.00			
WIP	Average	Half Width	Minimum Value	Maximum Value
E_Demand	51.5556	(Insufficient)	0.00	59.0000

09:08:22 PM

Category Overview

October 3, 2011

Unnamed Project

Replications: 1 Time Units: Seconds

Queue

Time

Waiting Time	Average	Half Width	Minimum Value	Maximum Value
Abs Chill 1.Queue	0.00	(Insufficient)	0.00	0.00
Abs Chill 2.Queue	0.00	(Insufficient)	0.00	0.00
Eskom.Queue	0.00	0.000000000	0.00	0.00
Gas1.Queue	0.00	(Insufficient)	0.00	0.00
Gas2.Queue	0.00	(Insufficient)	0.00	0.00

Other

Number Waiting	Average	Half Width	Minimum Value	Maximum Value
Abs Chill 1.Queue	0.00	(Insufficient)	0.00	0.00
Abs Chill 2.Queue	0.00	(Insufficient)	0.00	0.00
Absorption Chillers.Queue	0.00	(Insufficient)	0.00	0.00
Energy Centre Generator 1.Queue	0.00	(Insufficient)	0.00	0.00
Energy Centre Generator 2.Queue	0.00	(Insufficient)	0.00	0.00
Eskom.Queue	0.00	(Insufficient)	0.00	0.00
Gas.Queue	0.00	(Insufficient)	0.00	0.00
Gas1.Queue	0.00	(Insufficient)	0.00	0.00
Gas2.Queue	0.00	(Insufficient)	0.00	0.00
Phase 1 Generator 1.Queue	0.00	(Insufficient)	0.00	0.00
Phase 1 Generator 2.Queue	0.00	(Insufficient)	0.00	0.00
Phase 2 Generator 1.Queue	0.00	(Insufficient)	0.00	0.00
Phase 2 Generator 2.Queue	0.00	(Insufficient)	0.00	0.00

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Category Overview

October 3, 2011

Unnamed Project

Replications: 1 Time Units: Seconds

Resource				
Usage				
Instantaneous Utilization	Average	Half Width	Minimum Value	Maximum Value
R_Abs Chill 1	0.7222	(Insufficient)	0.00	1.0000
R_Abs Chill 2	0.7222	(Insufficient)	0.00	1.0000
R_EC_Gen 1	0.00	(Insufficient)	0.00	0.00
R_EC_Gen 2	0.00	(Insufficient)	0.00	0.00
R_Eskom	0.3778	(Insufficient)	0.00	0.9333
R_Gas 1	0.7222	(Insufficient)	0.00	1.0000
R_Gas 2	0.7222	(Insufficient)	0.00	1.0000
R_P1_Gen 1	0.00	(Insufficient)	0.00	0.00

R_P1_Gen 2	0.00	(Insufficient)	0.00	0.00
R_P2_Gen 1	0.00	(Insufficient)	0.00	0.00
R_P2_Gen 2	0.00	(Insufficient)	0.00	0.00

Number Busy	Average	Half Width	Minimum Value	Maximum Value
R_Abs Chill 1	7.2222	(Insufficient)	0.00	10.0000
R_Abs Chill 2	7.2222	(Insufficient)	0.00	10.0000
R_EC_Gen 1	0.00	(Insufficient)	0.00	0.00
R_EC_Gen 2	0.00	(Insufficient)	0.00	0.00
R_Eskom	22.6667	(Insufficient)	0.00	56.0000
R_Gas 1	7.2222	(Insufficient)	0.00	10.0000
R_Gas 2	7.2222	(Insufficient)	0.00	10.0000
R_P1_Gen 1	0.00	(Insufficient)	0.00	0.00
R_P1_Gen 2	0.00	(Insufficient)	0.00	0.00
R_P2_Gen 1	0.00	(Insufficient)	0.00	0.00
R_P2_Gen 2	0.00	(Insufficient)	0.00	0.00

Number Scheduled	Average	Half Width	Minimum Value	Maximum Value
R_Abs Chill 1	10.0000	(Insufficient)	10.0000	10.0000
R_Abs Chill 2	10.0000	(Insufficient)	10.0000	10.0000
R_EC_Gen 1	20.0000	(Insufficient)	20.0000	20.0000
R_EC_Gen 2	20.0000	(Insufficient)	20.0000	20.0000
R_Eskom	60.0000	(Insufficient)	60.0000	60.0000
R_Gas 1	10.0000	(Insufficient)	10.0000	10.0000
R_Gas 2	10.0000	(Insufficient)	10.0000	10.0000
R_P1_Gen 1	20.0000	(Insufficient)	20.0000	20.0000
R_P1_Gen 2	20.0000	(Insufficient)	20.0000	20.0000
R_P2_Gen 1	20.0000	(Insufficient)	20.0000	20.0000
R_P2_Gen 2	20.0000	(Insufficient)	20.0000	20.0000

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Category Overview

October 3, 2011

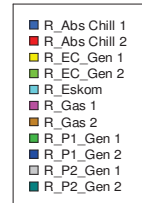
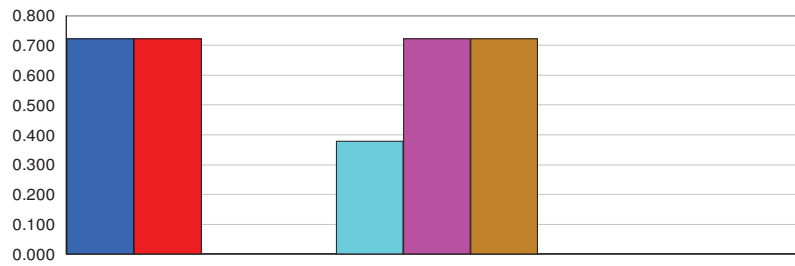
Unnamed Project

Replications: 1 Time Units: Seconds

Resource

Usage

Scheduled Utilization	Value
R_Abs Chill 1	0.7222
R_Abs Chill 2	0.7222
R_EC_Gen 1	0.00
R_EC_Gen 2	0.00
R_Eskom	0.3778
R_Gas 1	0.7222
R_Gas 2	0.7222
R_P1_Gen 1	0.00
R_P1_Gen 2	0.00
R_P2_Gen 1	0.00
R_P2_Gen 2	0.00



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Category Overview

October 3, 2011

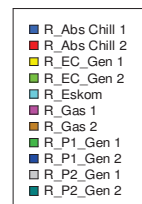
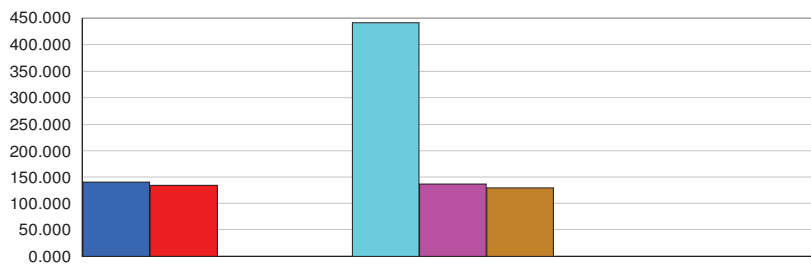
Unnamed Project

Replications: 1 Time Units: Seconds

Resource

Usage

Total Number Seized	Value
R_Abs Chill 1	140.00
R_Abs Chill 2	134.00
R_EC_Gen 1	0.00
R_EC_Gen 2	0.00
R_Eskom	441.00
R_Gas 1	136.00
R_Gas 2	130.00
R_P1_Gen 1	0.00
R_P1_Gen 2	0.00
R_P2_Gen 1	0.00
R_P2_Gen 2	0.00



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Category Overview

October 3, 2011

Unnamed Project

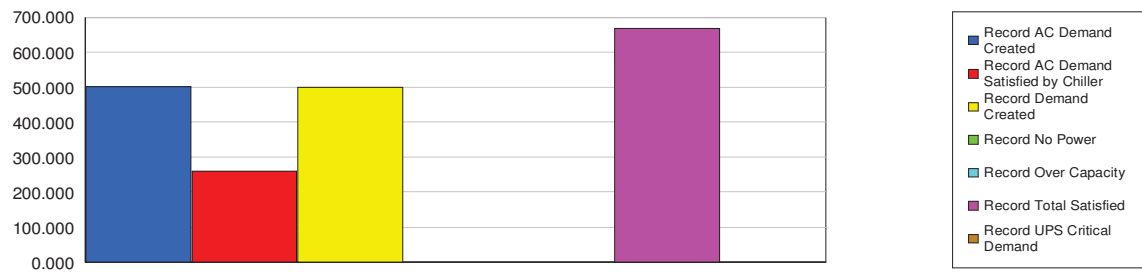
Replications: 1 Time Units: Seconds

User Specified

Counter

Count ...

	Value
Record AC Demand Created	501.00
Record AC Demand Satisfied by Chiller	260.00
Record Demand Created	500.00
Record No Power	0.00
Record Over Capacity	0.00
Record Total Satisfied	668.00
Record UPS Critical Demand	0.00



Unnamed Project

Replications: 1 Time Units: Seconds

Key Performance Indicators

System

Average

Number Out

1 221

Unnamed Project

Replications: 1 Time Units: Seconds

Entity

Time

VA Time	Average	Half Width	Minimum Value	Maximum Value
E_Demand	600.00	(Correlated)	600.00	600.00
NVA Time	Average	Half Width	Minimum Value	Maximum Value
E_Demand	0.00	0.000000000	0.00	0.00
Wait Time	Average	Half Width	Minimum Value	Maximum Value
E_Demand	0.00	0.000000000	0.00	0.00
Transfer Time	Average	Half Width	Minimum Value	Maximum Value
E_Demand	0.00	0.000000000	0.00	0.00
Other Time	Average	Half Width	Minimum Value	Maximum Value
E_Demand	0.00	0.000000000	0.00	0.00
Total Time	Average	Half Width	Minimum Value	Maximum Value
E_Demand	600.00	(Correlated)	600.00	600.00

Other

Number In				
	Value			
E_Demand	1291.00			
Number Out				
	Value			
E_Demand	1221.00			
WIP				
	Average	Half Width	Minimum Value	Maximum Value
E_Demand	67.8333	(Insufficient)	0.00	72.0000

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Category Overview

October 3, 2011

Unnamed Project

Replications: 1 Time Units: Seconds

Queue

Time

Waiting Time	Average	Half Width	Minimum Value	Maximum Value
Abs Chill 1.Queue	0.00	(Insufficient)	0.00	0.00
Abs Chill 2.Queue	0.00	(Insufficient)	0.00	0.00
Backup Gen 1.Queue	0.00	0.000000000	0.00	0.00
Backup Gen 2.Queue	0.00	(Insufficient)	0.00	0.00
Gas1.Queue	0.00	(Insufficient)	0.00	0.00
Gas2.Queue	0.00	(Insufficient)	0.00	0.00

Other

Number Waiting	Average	Half Width	Minimum Value	Maximum Value
Abs Chill 1.Queue	0.00	(Insufficient)	0.00	0.00
Abs Chill 2.Queue	0.00	(Insufficient)	0.00	0.00
Absorption Chillers.Queue	0.00	(Insufficient)	0.00	0.00
Backup Gen 1.Queue	0.00	(Insufficient)	0.00	0.00
Backup Gen 2.Queue	0.00	(Insufficient)	0.00	0.00
Backup Gen 3.Queue	0.00	(Insufficient)	0.00	0.00
Backup Gen 4.Queue	0.00	(Insufficient)	0.00	0.00
Backup Gen 5.Queue	0.00	(Insufficient)	0.00	0.00
Backup Gen 6.Queue	0.00	(Insufficient)	0.00	0.00
Eskom.Queue	0.00	(Insufficient)	0.00	0.00
Gas.Queue	0.00	(Insufficient)	0.00	0.00
Gas1.Queue	0.00	(Insufficient)	0.00	0.00
Gas2.Queue	0.00	(Insufficient)	0.00	0.00
Phase 1 Generator 1.Queue	0.00	(Insufficient)	0.00	0.00
Phase 1 Generator 2.Queue	0.00	(Insufficient)	0.00	0.00
Phase 2 Generator 1.Queue	0.00	(Insufficient)	0.00	0.00
Phase 2 Generator 2.Queue	0.00	(Insufficient)	0.00	0.00

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Category Overview

October 3, 2011

Unnamed Project

Replications: 1 Time Units: Seconds

Resource				
Usage				
Instantaneous Utilization	Average	Half Width	Minimum Value	Maximum Value
BU_Gen 1	1.0000	(Insufficient)	0.00	1.0000
BU_Gen 2	0.3917	(Insufficient)	0.00	0.6000
BU_Gen 3	0.00	(Insufficient)	0.00	0.00
BU_Gen 4	0.00	(Insufficient)	0.00	0.00

BU_Gen 5	0.00	(Insufficient)	0.00	0.00
BU_Gen 6	0.00	(Insufficient)	0.00	0.00
R_Abs Chill 1	1.0000	(Insufficient)	0.00	1.0000
R_Abs Chill 2	1.0000	(Insufficient)	0.00	1.0000
R_Gas 1	1.0000	(Insufficient)	0.00	1.0000
R_Gas 2	1.0000	(Insufficient)	0.00	1.0000

Number Busy	Average	Half Width	Minimum Value	Maximum Value
BU_Gen 1	20.0000	(Insufficient)	0.00	20.0000
BU_Gen 2	7.8333	(Insufficient)	0.00	12.0000
BU_Gen 3	0.00	(Insufficient)	0.00	0.00
BU_Gen 4	0.00	(Insufficient)	0.00	0.00
BU_Gen 5	0.00	(Insufficient)	0.00	0.00
BU_Gen 6	0.00	(Insufficient)	0.00	0.00
R_Abs Chill 1	10.0000	(Insufficient)	0.00	10.0000
R_Abs Chill 2	10.0000	(Insufficient)	0.00	10.0000
R_Gas 1	10.0000	(Insufficient)	0.00	10.0000
R_Gas 2	10.0000	(Insufficient)	0.00	10.0000

Number Scheduled	Average	Half Width	Minimum Value	Maximum Value
BU_Gen 1	20.0000	(Insufficient)	20.0000	20.0000
BU_Gen 2	20.0000	(Insufficient)	20.0000	20.0000
BU_Gen 3	20.0000	(Insufficient)	20.0000	20.0000
BU_Gen 4	20.0000	(Insufficient)	20.0000	20.0000
BU_Gen 5	20.0000	(Insufficient)	20.0000	20.0000
BU_Gen 6	20.0000	(Insufficient)	20.0000	20.0000
R_Abs Chill 1	10.0000	(Insufficient)	10.0000	10.0000
R_Abs Chill 2	10.0000	(Insufficient)	10.0000	10.0000
R_Gas 1	10.0000	(Insufficient)	10.0000	10.0000
R_Gas 2	10.0000	(Insufficient)	10.0000	10.0000

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Category Overview

October 3, 2011

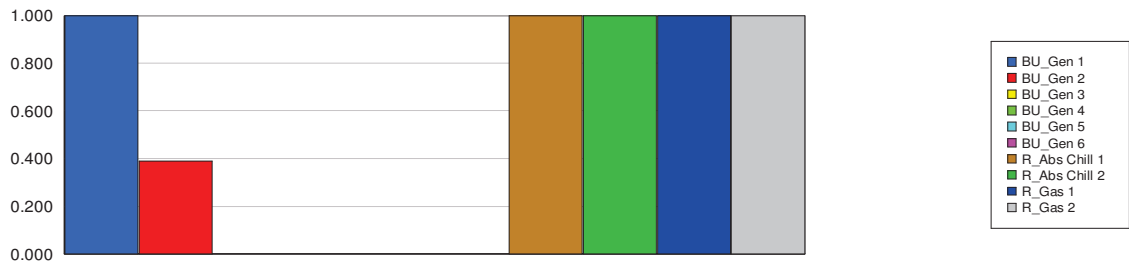
Unnamed Project

Replications: 1 Time Units: Seconds

Resource

Usage

Scheduled Utilization	Value
BU_Gen 1	1.0000
BU_Gen 2	0.3917
BU_Gen 3	0.00
BU_Gen 4	0.00
BU_Gen 5	0.00
BU_Gen 6	0.00
R_Abs Chill 1	1.0000
R_Abs Chill 2	1.0000
R_Gas 1	1.0000
R_Gas 2	1.0000



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Category Overview

October 3, 2011

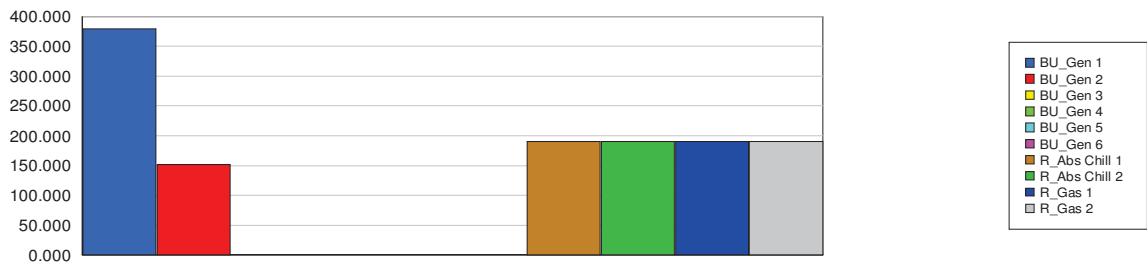
Unnamed Project

Replications: 1 Time Units: Seconds

Resource

Usage

Total Number Seized	Value
BU_Gen 1	380.00
BU_Gen 2	151.00
BU_Gen 3	0.00
BU_Gen 4	0.00
BU_Gen 5	0.00
BU_Gen 6	0.00
R_Abs Chill 1	190.00
R_Abs Chill 2	190.00
R_Gas 1	190.00
R_Gas 2	190.00



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Category Overview

October 3, 2011

Unnamed Project

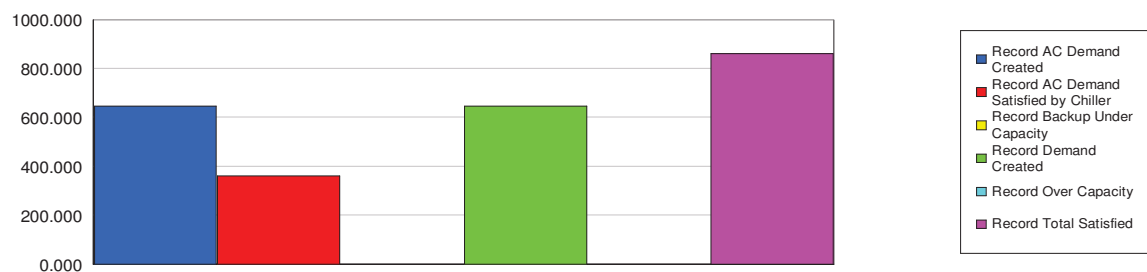
Replications: 1 Time Units: Seconds

User Specified

Counter

Count	Value
-------	-------

Record AC Demand Created	646.00
Record AC Demand Satisfied by Chiller	360.00
Record Backup Under Capacity	0.00
Record Demand Created	645.00
Record Over Capacity	0.00
Record Total Satisfied	861.00



Category Overview

Unnamed Project

Replications: 1 Time Units: Seconds

Key Performance Indicators

System

Average

Number Out

1 234

Category Overview

Unnamed Project

Replications: 1 Time Units: Seconds

Entity

Time

VA Time	Average	Half Width	Minimum Value	Maximum Value
E_Demand	600.00	(Correlated)	600.00	600.00
NVA Time	Average	Half Width	Minimum Value	Maximum Value
E_Demand	0.00	0.000000000	0.00	0.00
Wait Time	Average	Half Width	Minimum Value	Maximum Value
E_Demand	0.00	0.000000000	0.00	0.00
Transfer Time	Average	Half Width	Minimum Value	Maximum Value
E_Demand	0.00	0.000000000	0.00	0.00
Other Time	Average	Half Width	Minimum Value	Maximum Value
E_Demand	0.00	0.000000000	0.00	0.00
Total Time	Average	Half Width	Minimum Value	Maximum Value
E_Demand	600.00	(Correlated)	600.00	600.00

Other

Number In	Value			
E_Demand	1303.00			
Number Out	Value			
E_Demand	1234.00			
WIP	Average	Half Width	Minimum Value	Maximum Value
E_Demand	68.5556	(Insufficient)	0.00	76.0000

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Category Overview

October 3, 2011

Unnamed Project

Replications: 1 Time Units: Seconds

Queue

Time

Waiting Time	Average	Half Width	Minimum Value	Maximum Value
Backup Gen 1.Queue	0.00	0.000000000	0.00	0.00
Backup Gen 2.Queue	0.00	0.000000000	0.00	0.00
Backup Gen 3.Queue	0.00	0.000000000	0.00	0.00
Backup Gen 4.Queue	0.00	(Insufficient)	0.00	0.00

Other

Number Waiting	Average	Half Width	Minimum Value	Maximum Value
Abs Chill 1.Queue	0.00	(Insufficient)	0.00	0.00
Abs Chill 2.Queue	0.00	(Insufficient)	0.00	0.00
Absorption Chillers.Queue	0.00	(Insufficient)	0.00	0.00
Backup Gen 1.Queue	0.00	(Insufficient)	0.00	0.00
Backup Gen 2.Queue	0.00	(Insufficient)	0.00	0.00
Backup Gen 3.Queue	0.00	(Insufficient)	0.00	0.00
Backup Gen 4.Queue	0.00	(Insufficient)	0.00	0.00
Backup Gen 5.Queue	0.00	(Insufficient)	0.00	0.00
Backup Gen 6.Queue	0.00	(Insufficient)	0.00	0.00
Eskom.Queue	0.00	(Insufficient)	0.00	0.00
Gas.Queue	0.00	(Insufficient)	0.00	0.00
Gas1.Queue	0.00	(Insufficient)	0.00	0.00
Gas2.Queue	0.00	(Insufficient)	0.00	0.00
Phase 1 Generator 1.Queue	0.00	(Insufficient)	0.00	0.00
Phase 1 Generator 2.Queue	0.00	(Insufficient)	0.00	0.00
Phase 2 Generator 1.Queue	0.00	(Insufficient)	0.00	0.00
Phase 2 Generator 2.Queue	0.00	(Insufficient)	0.00	0.00

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Category Overview

October 3, 2011

Unnamed Project

Replications: 1 Time Units: Seconds

Resource				
Usage				
Instantaneous Utilization	Average	Half Width	Minimum Value	Maximum Value
BU_Gen 1	1.0000	(Insufficient)	0.00	1.0000
BU_Gen 2	1.0000	(Insufficient)	0.00	1.0000
BU_Gen 3	1.0000	(Insufficient)	0.00	1.0000
BU_Gen 4	0.4278	(Insufficient)	0.00	0.8000
BU_Gen 5	0.00	(Insufficient)	0.00	0.00
BU_Gen 6	0.00	(Insufficient)	0.00	0.00

R_Abs Chill 1	0.00	(Insufficient)	0.00	0.00
R_Abs Chill 2	0.00	(Insufficient)	0.00	0.00
R_Gas 1	0.00	(Insufficient)	0.00	0.00
R_Gas 2	0.00	(Insufficient)	0.00	0.00

Number Busy	Average	Half Width	Minimum Value	Maximum Value
BU_Gen 1	20.0000	(Insufficient)	0.00	20.0000
BU_Gen 2	20.0000	(Insufficient)	0.00	20.0000
BU_Gen 3	20.0000	(Insufficient)	0.00	20.0000
BU_Gen 4	8.5556	(Insufficient)	0.00	16.0000
BU_Gen 5	0.00	(Insufficient)	0.00	0.00
BU_Gen 6	0.00	(Insufficient)	0.00	0.00
R_Abs Chill 1	0.00	(Insufficient)	0.00	0.00
R_Abs Chill 2	0.00	(Insufficient)	0.00	0.00
R_Gas 1	0.00	(Insufficient)	0.00	0.00
R_Gas 2	0.00	(Insufficient)	0.00	0.00

Number Scheduled	Average	Half Width	Minimum Value	Maximum Value
BU_Gen 1	20.0000	(Insufficient)	20.0000	20.0000
BU_Gen 2	20.0000	(Insufficient)	20.0000	20.0000
BU_Gen 3	20.0000	(Insufficient)	20.0000	20.0000
BU_Gen 4	20.0000	(Insufficient)	20.0000	20.0000
BU_Gen 5	20.0000	(Insufficient)	20.0000	20.0000
BU_Gen 6	20.0000	(Insufficient)	20.0000	20.0000
R_Abs Chill 1	10.0000	(Insufficient)	10.0000	10.0000
R_Abs Chill 2	10.0000	(Insufficient)	10.0000	10.0000
R_Gas 1	10.0000	(Insufficient)	10.0000	10.0000
R_Gas 2	10.0000	(Insufficient)	10.0000	10.0000

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Category Overview

October 3, 2011

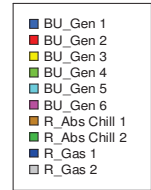
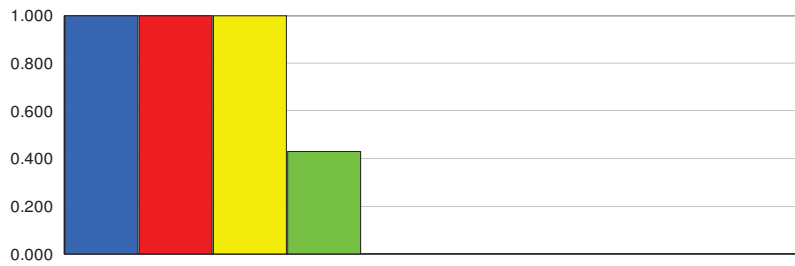
Unnamed Project

Replications: 1 Time Units: Seconds

Resource

Usage

Scheduled Utilization	Value
BU_Gen 1	1.0000
BU_Gen 2	1.0000
BU_Gen 3	1.0000
BU_Gen 4	0.4278
BU_Gen 5	0.00
BU_Gen 6	0.00
R_Abs Chill 1	0.00
R_Abs Chill 2	0.00
R_Gas 1	0.00
R_Gas 2	0.00



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Category Overview

October 3, 2011

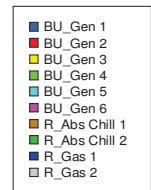
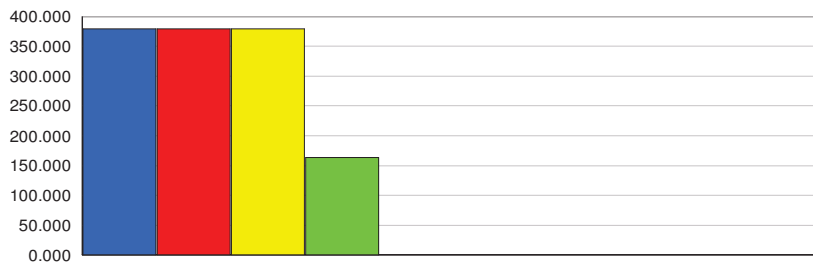
Unnamed Project

Replications: 1 Time Units: Seconds

Resource

Usage

Total Number Seized	Value
BU_Gen 1	380.00
BU_Gen 2	380.00
BU_Gen 3	380.00
BU_Gen 4	163.00
BU_Gen 5	0.00
BU_Gen 6	0.00
R_Abs Chill 1	0.00
R_Abs Chill 2	0.00
R_Gas 1	0.00
R_Gas 2	0.00



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Category Overview

October 3, 2011

Unnamed Project

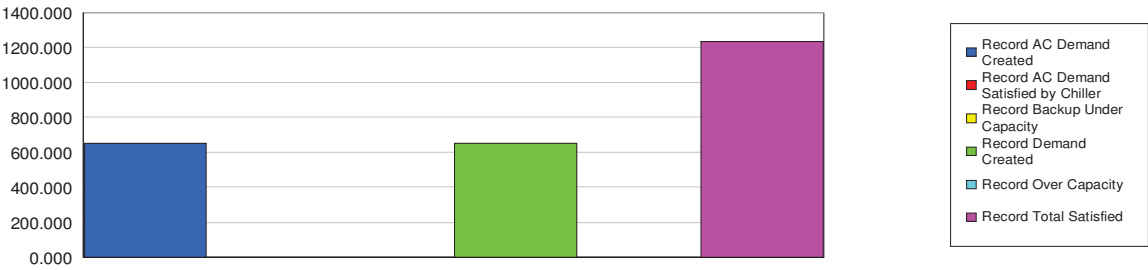
Replications: 1 Time Units: Seconds

User Specified

Counter

Count	Value
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Record AC Demand Created	651.00
Record AC Demand Satisfied by Chiller	0.00
Record Backup Under Capacity	0.00
Record Demand Created	652.00
Record Over Capacity	0.00
Record Total Satisfied	1234.00



Unnamed Project

Replications: 1 Time Units: Seconds

Key Performance Indicators

System	Average
Number Out	947

Unnamed Project

Replications: 1 Time Units: Seconds

Entity

Time				
VA Time	Average	Half Width	Minimum Value	Maximum Value
E_Demand	371.91	(Correlated)	0.00	600.00
NVA Time	Average	Half Width	Minimum Value	Maximum Value
E_Demand	228.09	(Correlated)	0.00	600.00
Wait Time	Average	Half Width	Minimum Value	Maximum Value
E_Demand	0.00	0.000000000	0.00	0.00
Transfer Time	Average	Half Width	Minimum Value	Maximum Value
E_Demand	0.00	0.000000000	0.00	0.00
Other Time	Average	Half Width	Minimum Value	Maximum Value
E_Demand	0.00	0.000000000	0.00	0.00
Total Time	Average	Half Width	Minimum Value	Maximum Value
E_Demand	600.00	(Correlated)	600.00	600.00
Other				
Number In	Value			
E_Demand	1000.00			
Number Out	Value			
E_Demand	947.00			
WIP	Average	Half Width	Minimum Value	Maximum Value
E_Demand	52.6111	(Insufficient)	0.00	58.0000

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Category Overview

October 4, 2011

Unnamed Project

Replications: 1 Time Units: Seconds

Queue

Time

Waiting Time	Average	Half Width	Minimum Value	Maximum Value
Backup Gen 1.Queue	0.00	0.000000000	0.00	0.00
Backup Gen 2.Queue	0.00	(Insufficient)	0.00	0.00
Eskom.Queue	0.00	0.000000000	0.00	0.00

Other

Number Waiting	Average	Half Width	Minimum Value	Maximum Value
Abs Chill 1.Queue	0.00	(Insufficient)	0.00	0.00
Abs Chill 2.Queue	0.00	(Insufficient)	0.00	0.00
Absorption Chillers.Queue	0.00	(Insufficient)	0.00	0.00
Backup Gen 1.Queue	0.00	(Insufficient)	0.00	0.00
Backup Gen 2.Queue	0.00	(Insufficient)	0.00	0.00
Backup Gen 3.Queue	0.00	(Insufficient)	0.00	0.00
Backup Gen 4.Queue	0.00	(Insufficient)	0.00	0.00
Backup Gen 5.Queue	0.00	(Insufficient)	0.00	0.00
Backup Gen 6.Queue	0.00	(Insufficient)	0.00	0.00
Eskom.Queue	0.00	(Insufficient)	0.00	0.00
Gas.Queue	0.00	(Insufficient)	0.00	0.00
Gas1.Queue	0.00	(Insufficient)	0.00	0.00
Gas2.Queue	0.00	(Insufficient)	0.00	0.00
Phase 1 Generator 1.Queue	0.00	(Insufficient)	0.00	0.00
Phase 1 Generator 2.Queue	0.00	(Insufficient)	0.00	0.00
Phase 2 Generator 1.Queue	0.00	(Insufficient)	0.00	0.00
Phase 2 Generator 2.Queue	0.00	(Insufficient)	0.00	0.00

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Category Overview

October 4, 2011

Unnamed Project

Replications: 1 Time Units: Seconds

Resource				
Usage				
Instantaneous Utilization	Average	Half Width	Minimum Value	Maximum Value
BU_Gen 1	1.0000	(Insufficient)	0.00	1.0000
BU_Gen 2	0.6306	(Insufficient)	0.00	0.9000
BU_Gen 3	0.00	(Insufficient)	0.00	0.00
BU_Gen 4	0.00	(Insufficient)	0.00	0.00
BU_Gen 5	0.00	(Insufficient)	0.00	0.00
BU_Gen 6	0.00	(Insufficient)	0.00	0.00
R_Abs Chill 1	0.00	(Insufficient)	0.00	0.00

R_Abs Chill 2	0.00	(Insufficient)	0.00	0.00
R_Eskom	1.0000	(Insufficient)	0.00	1.0000
R_Gas 1	0.00	(Insufficient)	0.00	0.00
R_Gas 2	0.00	(Insufficient)	0.00	0.00

Number Busy	Average	Half Width	Minimum Value	Maximum Value
BU_Gen 1	20.0000	(Insufficient)	0.00	20.0000
BU_Gen 2	12.6111	(Insufficient)	0.00	18.0000
BU_Gen 3	0.00	(Insufficient)	0.00	0.00
BU_Gen 4	0.00	(Insufficient)	0.00	0.00
BU_Gen 5	0.00	(Insufficient)	0.00	0.00
BU_Gen 6	0.00	(Insufficient)	0.00	0.00
R_Abs Chill 1	0.00	(Insufficient)	0.00	0.00
R_Abs Chill 2	0.00	(Insufficient)	0.00	0.00
R_Eskom	20.0000	(Insufficient)	0.00	20.0000
R_Gas 1	0.00	(Insufficient)	0.00	0.00
R_Gas 2	0.00	(Insufficient)	0.00	0.00

Number Scheduled	Average	Half Width	Minimum Value	Maximum Value
BU_Gen 1	20.0000	(Insufficient)	20.0000	20.0000
BU_Gen 2	20.0000	(Insufficient)	20.0000	20.0000
BU_Gen 3	20.0000	(Insufficient)	20.0000	20.0000
BU_Gen 4	20.0000	(Insufficient)	20.0000	20.0000
BU_Gen 5	20.0000	(Insufficient)	20.0000	20.0000
BU_Gen 6	20.0000	(Insufficient)	20.0000	20.0000
R_Abs Chill 1	10.0000	(Insufficient)	10.0000	10.0000
R_Abs Chill 2	10.0000	(Insufficient)	10.0000	10.0000
R_Eskom	20.0000	(Insufficient)	20.0000	20.0000
R_Gas 1	10.0000	(Insufficient)	10.0000	10.0000
R_Gas 2	10.0000	(Insufficient)	10.0000	10.0000

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Category Overview

October 4, 2011

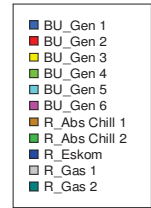
Unnamed Project

Replications: 1 Time Units: Seconds

Resource

Usage

Scheduled Utilization	Value
BU_Gen 1	1.0000
BU_Gen 2	0.6306
BU_Gen 3	0.00
BU_Gen 4	0.00
BU_Gen 5	0.00
BU_Gen 6	0.00
R_Abs Chill 1	0.00
R_Abs Chill 2	0.00
R_Eskom	1.0000
R_Gas 1	0.00
R_Gas 2	0.00



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Category Overview

October 4, 2011

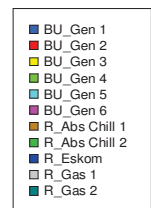
Unnamed Project

Replications: 1 Time Units: Seconds

Resource

Usage

Total Number Seized	Value
BU_Gen 1	380.00
BU_Gen 2	240.00
BU_Gen 3	0.00
BU_Gen 4	0.00
BU_Gen 5	0.00
BU_Gen 6	0.00
R_Abs Chill 1	0.00
R_Abs Chill 2	0.00
R_Eskom	380.00
R_Gas 1	0.00
R_Gas 2	0.00



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Category Overview

October 4, 2011

Unnamed Project

Replications: 1 Time Units: Seconds

User Specified

Counter

Count ...

	Value
Record AC Demand Created	501.00
Record AC Demand Satisfied by Chiller	0.00
Record Backup Under Capacity	0.00
Record Demand Created	499.00
Record No Power	0.00
Record Over Capacity	0.00
Record Total Satisfied	947.00
Record UPS Critical Demand	0.00

