Scheduling of Electricity Distribution at UTP GDC Plant Using Linear Programming

By

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11006

Dissertation report submitted in partial fulfillment of

the requirements for the

Bachelor of Engineering (Hons)

(Mechanical Engineering)

SEPT 2011

Universiti Teknologi PETRONAS

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CERTIFICATION OF APPROVAL

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A project dissertation submitted to the
Mechanical Engineering Programme
In partial fulfillment of the requirements for the
BACHELOR OF ENGINEERING (Hons)
MECHANICAL ENGINEERING

Approved by,

……………………………………………….
AP IR DR MOHD AMIN ABDUL MAJID
Project Supervisor

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK
Sept 2011

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the reference and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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TAJUL SYAZWAN BIN TAJOR AMAR

ACKNOWLEDGEMENT

The author wishes to express his gratitude to Allah, for His blessings and for giving me the strength to begin and end this research successfully and, in particular to my project supervisor, AP. Ir. Dr. Mohd. Amin Bin Abdul Majid, which has been a source of great encouragement, sincere thanks for his dedicated attitude while supervising me over a period of two semesters.

Of those who have offered technical advice, I would like to acknowledge the assistance of those who has assisted me direct or indirectly towards the success of this project. Further, I am grateful to my family, lecturers and friends who have supported me physically and emotionally during hard times in conducting the experiment.

ABSTRACT

Demands of electricity by University Technology PETRONAS (UTP) for student and office usage are high. This demand supplied by UTP Gas District Cooling plant (GDC plant) which is located at UTP. UTP GDC plant has two gas turbines to produce electricity but unfortunately, the electricity is also used for the four electric chillers in the plant and for plant usage. To ensure good electricity distribution, proper scheduling is needed. This could be achieved by using scheduling model. In this study, scheduling model using linear programming is proposed. The proposed model is used to distribute the generated kWh of electricity from the two gas turbines to the four electric chillers, UTP and plant usage. Four scenarios are used for the study, namely: operations during peak hours on weekdays, operations during off peak hours on weekdays, operations during peak hours on weekends and lastly, operations during off peak hours on weekends. The spreadsheet model is used for the analysis using Microsoft Excel Solver. Based on the analysis, the results are the kWh per month of electricity distribution to each destination for each scenario and the total distribution cost for a month. Sensitivity analysis was done in order to know the sensitivity of the modeling. The results show that the kWh per month of electricity that need to be distributed to each destinations based on the demand from the destinations for January to October 2009. The study shows that with electricity scheduling, the cost of distributions can be minimize.

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CHAPTER 1: INTRODUCTION

1.1 BACKGROUND

Energy demand grows at higher rate due to the strong economic growth in Malaysia. Because of this reason, various studies are done to improve the efficiency of energy usage. One of the options is the gas district cooling system. PETRONAS, the national oil company, studied and chose the gas district cooling system using natural gasses as the primary source of fuel. Natural gasses are use due to natural gas reserves are four times that of its crude oil reserves in Malaysia. One of the Gas District Cooling Plant implemented in Malaysia is the University Technology PETRONAS Gas District Cooling plant (UTP GDC plant). This plant is situated near UTP which is at Tronoh, Perak.

UTP GDC plant consists of two units of gas turbines which are used to generate electricity by using natural gasses as its fuel. This electricity is supplied to UTP but it is also used by the plant for its internal usage and four electric chillers in the plant. The electric chillers are used by the plant to produce chilled water and supplied it to UTP for air conditioning system usage. Because of this distribution, UTP might receive insufficient electricity for UTP big demand. This problem can be solved by developing electricity scheduling modeling for the plant by using linear programming.

Linear programming (LP) is a widely used mathematical technique designed to help operations managers plan and make decisions necessary to allocate resources. For this study, the author needs to study linear programming and how to solve linear programming problems. The linear programming problem that is involve in this case is transportation problem where it deal with the distribution of goods (which in this case is electricity) through a distribution network at minimum cost.

The transportation problem is one of the subclasses of linear programming problem where the objective is to transport various quantities of a single homogeneous product that are initially stored at various origins, to different destinations in such a way that the total transportation is minimum. F.I. Hitchaxic developed the basic transportation problem in 1941. However it could be solved for optimally as an answer to complex business problem only in 1951, when George B. Dantzig applied the concept of Linear Programming in solving the Transportation models.

In this study, the author adopted linear programming to solve transportation problems that occurred in the distribution of electricity of UTP GDC plant. Based on the study, it shows that UTP GDC plant consist of four types of operations which are differ in term of machine used. The operations are operation during peak hours on weekdays, operation during off peak hours on weekdays, operation during peak hours on weekend and lastly operation during off peak hours on weekend. The peak hours is from 8.00 am – 9.0 pm (13 hours) and the off peak hours is from 10.00 pm – 7.00 am (11 hours).

The data that is needed for the study are cost per unit for each electricity distribution (RM/kWh/month), demand of electricity of the electric chillers (kWh/month), plant usage and UTP (kWh/month), capacity of electricity distributed (kWh/month), and the numbers of working hours of the machines used (hours/month). After the modeling were developed and solved. To solve the problem, the author used Microsoft Excel Solver to solve the transportation modeling and linear programming. Then the electricity scheduling modeling for the UTP GDC plant was analyzed.

1.2 PROBLEM STATEMENT

There are two gas turbines at UTP GDC plant to generate electricity. The electricity is supplied to UTP and also used for operating four electric chillers at plant and for plant usage. UTP required the supply of electricity to meet UTP demand during peak and off peak hours. Cases occurred where UTP received insufficient electricity for meeting demand. When UTP receive insufficient electricity, the UTP GDC plant had to depend on Tenaga Nasional Berhad (TNB) for supply. UTP GDC plant has to incur substantial cost when this occurred due to high maximum demand charges. Hence, there is a need for UTP GDC plant to have capability in optimizing the scheduling of electricity. One of the alternatives is to use distribution model. This is the intend of the study.

1.3 OBJECTIVE AND SCOPE OF STUDY

The primary objective for this project is to develop electricity scheduling modeling at UTP GDC plant to ensure optimize electricity distribution to the three types of demand namely electric chillers, UTP and plant usage.

The scopes of study for the projects are to:

1) Determine how much kWh of electricity per month that needs to be produced and distribute for each destinations during peak and off peak hours on weekdays and weekends.
2) Determine the alternatives to optimize electricity distribution to the users.

CHAPTER 2: LITERATURE REVIEW AND THEORY

2.1 DISTRICT COOLING SYSTEM

DCS involves centralizing of the thermal media (chilled water) required for the air-conditioning of buildings within a specific area or district and producing the chilled water from one central plant. The chilled water produced from the plant is then distributed to the respective buildings via a network distribution pipeline.

According to L.S. Chan (2007)

"A district cooling system is a sustainable means of distribution of cooling energy through mass production. A cooling medium like chilled water is generated at a central refrigeration plant and supplied to serve a group of consumer building through a piping network."

DCS is actually not a new system in the industrialized countries because it has been implemented since the sixties. However, in Asia, the use of the system has been used mainly in Japan and then being implemented in Malaysia, Singapore, Hong Kong and Taiwan. Unfortunately, almost all the DCS operation in Japan is electrically driven. Thus, the gas based DCS or Gas District Cooling (GDC) is still a new system in Asia. The low acceptance for the GDC system today is mainly attributed to the difficulty in obtaining supply of natural gas in some countries. This is why; Malaysia which a country with a high natural gas reserves is really suitable country to use GDC system.

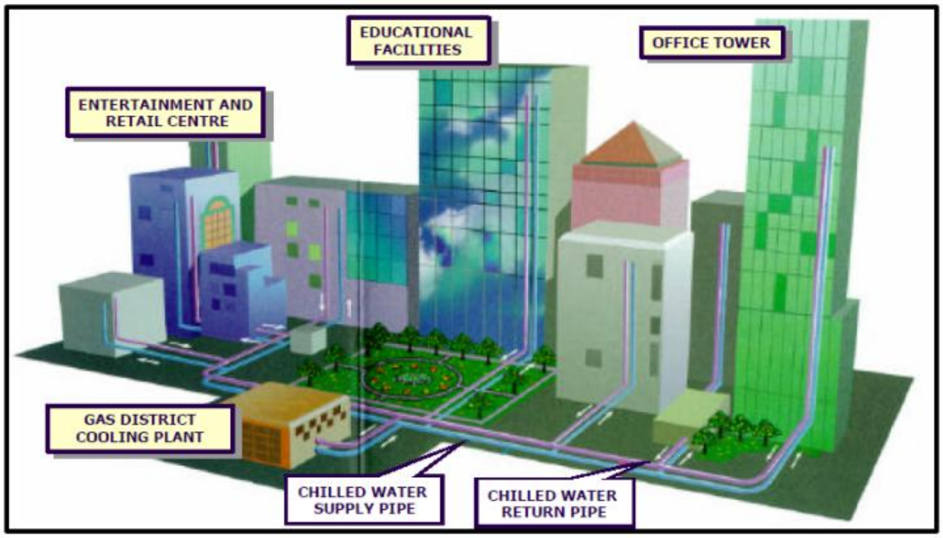


Figure 1: Typical Layout of a District Cooling Plant [A Razak A Rahman 2008]

2.2 GAS DISTRICT COOLING (GDC) AND COGENERATIVE SYSTEM

GDC system involves DCS but uses natural gas as its fuel. In order to produce the chilled water using chillers, GDC system provides two options. The first method involves burning of the gas in direct fired absorption chiller to produce chilled water. The second method uses natural gasses to fire the boilers to produce steam which is the used to drive the steam turbine centrifugal chillers (STC), or steam absorption chillers (SAC).

For the STC, refrigerant R134 is used to produce the chilled water, whereas in the case of directly fired absorption chillers and SAC, the chemical lithium bromide is used. The choice of chiller to be used depends entirely on the temperature of chilled water required by the customers.

Leif Mortensen (2004) mentioned that "Cogeneration is the process of simultaneous generation of two different forms of useful energy using one single primary energy source." The two types of energy generated are usually electrical and thermal. GDC and cogeneration system means that the use of energy source which is natural gas to generate electricity and also chilled water.

In order to consider cogeneration as an option to configure a GDC system, there are three factors that need to be taken which are: the volume of chilled water required by customers, amount of steam needed to drive the SACs or STCs, and finally the chilled water demand profile. In the GDC and cogeneration system, the natural gasses are supplied to two equipments, which are the auxiliary gas boiler and the gas turbine generator. In the auxiliary gas boiler, the gas is used to produce steam and the steam is supplied to the steam-driven chillers which produce chilled water.

The chilled water is then supplied to customers. The gas supplied to the gas turbine generator is use to generate electricity which is supplied to customer and also used for plant usage. The gas from the gas turbine generator is supplied to the heat recovery steam generator to heat up the steam that had been used by the steam-driven chillers and then supplied back to the chillers. The system configuration of a GDC and cogeneration system is shown in Figure 2.

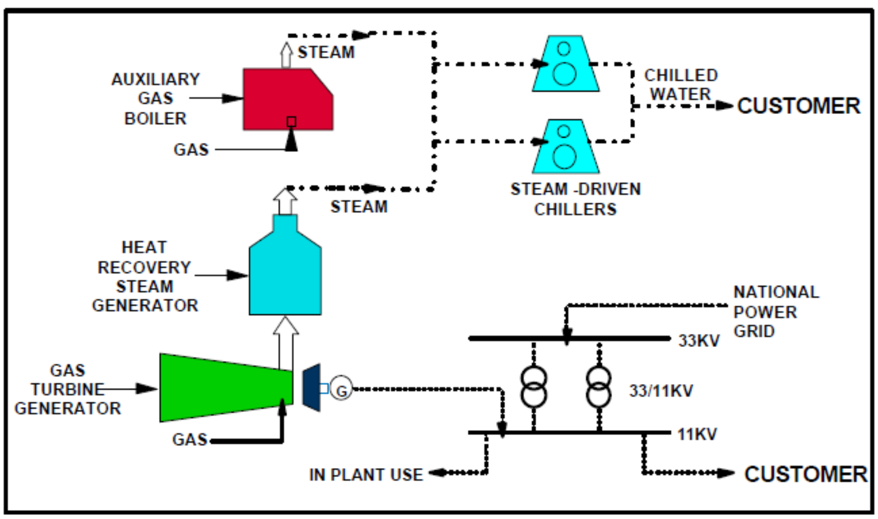


Figure 2: Typical System Configuration of a Gas District Cooling (GDC) and Cogeneration System [A Razak A Rahman 2008]

Seth Haron [5] stated that there are many benefits of using GDC and cogeneration system. The benefits of using GDC and cogeneration system are:

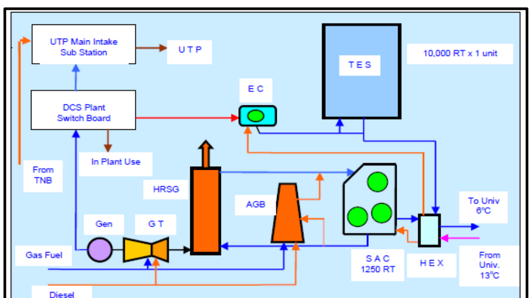
- Saving in capital cost
- Saving in operating cost
- Optimize building space
- High efficiency factor
- Higher system reliability
- Environment friendly system

2.3 UNIVERSITY TECHNOLOGY PETRONAS GDC PLANT

UTP GDC plant which was built in late 2001 provides electricity and chilled water for the University. Gilani (2008) stated that UTP GDC plant was built because the location of UTP does not have sufficient power quality as required by the University.

UTP also uses TNB supply as backup. The plant configurations are as follow:

- 2 units of 1250 RT SACs
- 4 units of 325 RT Electric Chillers (ECs)
- 1 unit of 10000 RTh of Thermal Energy Storage (TES) tank
- 2 units of 12 ton per hours of steam, HRSG
- 1 unit of 6 ton per hours of steam, AGB
- 2 units of 4.2 MW GTs



RTh	Tons of Refrigeration hour
GDC	Gas District Cooling
TNB	Tenaga Nasional Berhad (National Utility Company)
HRSG	Heat Recovery Steam Generator
AGB	Auxiliary Gas Boiler
GT	Gas Turbine
EC	Electric Chillers
SAC	Steam Absorption Chillers
TES	Thermal Energy Storage
Gen	Electric Generator
HEX	Heat Exchanger
CW	Cooling Water

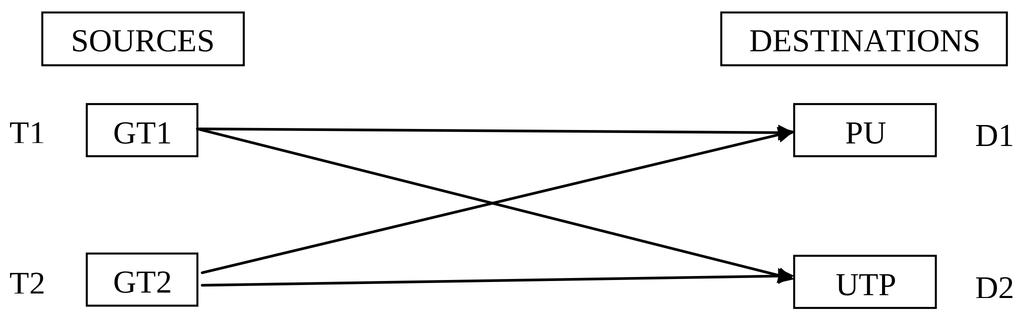
Figure 3: Schematic Diagram of UTP GDC Plant [Gilani 2008]

The electricity generate by the gas turbines are used for UTP usage and also for the plant usage. The waste heat from the gas turbines is used to generate steam through HRSGs for chilled water generation by SACs which operate mainly during daytime. In order to supply chilled water during daytime, TES tank is used.

There are four different categories of operations use by UTP GDC plant in order to distribute electricity. These four types of operations are operation during peak hours on weekdays, operation during off peak hours on weekdays, operation during peak hours on weekend and lastly operation during off peak hours on weekend. The peak hours is from 8.00 am – 9.00 pm (13 hours) and the off peak hours is from 10.00 pm – 7.00 am (11 hours).

The first category of operation is the operation during peak hours on weekdays. During this operation, two gas turbines are used to generate electricity. This electricity is then supplied to only UTP and also to the plant for plant usage. During peak hours, UTP electricity demand is highest so it needs more electricity and the plant also needs electricity.

In this operation, electric chillers are not used to generate chilled water. Steam absorption chillers (SAC) are used during this time. This operation does not affect the distribution and usage of chilled water because the chilled water amounts that are produced before and during peak hours are stored in the TES tank.



Where;

GT1 = Gas turbine 1

GT2 = Gas turbine 2

PU = Plant usage

UTP = University Technology PETRONAS

T1 = Electricity supplied by gas turbine 1 (kWh)

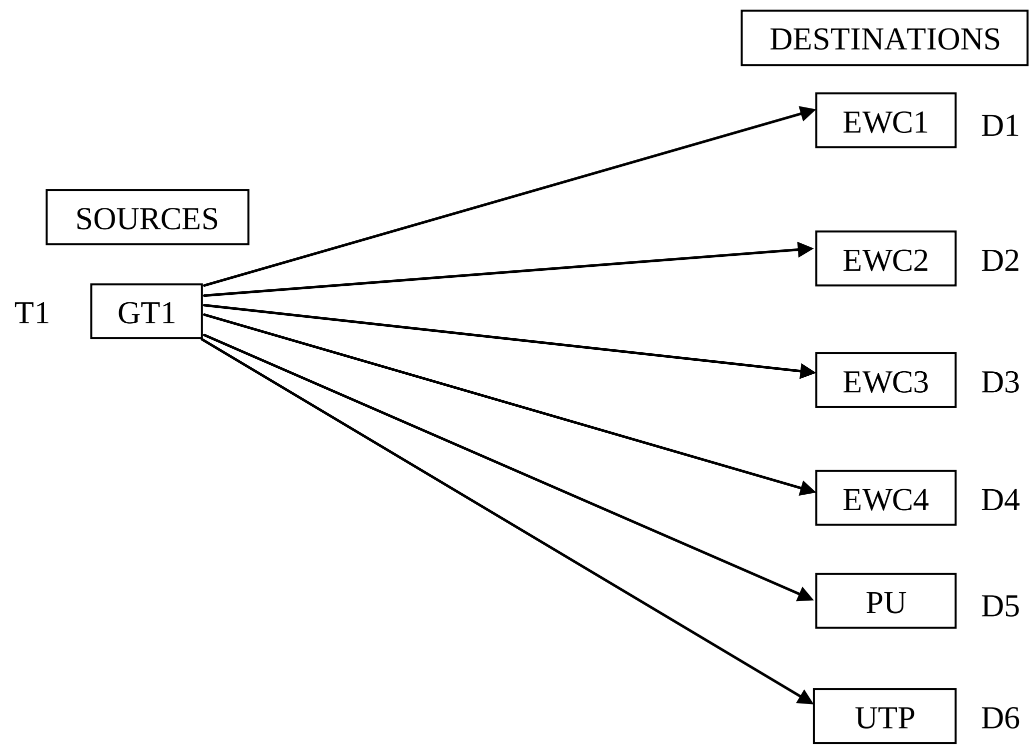
T2 = Electricity supplied by gas turbine 1 (kWh)

D1 = Electricity demand by plant for plant usage (kWh)

D2 = Electricity demand by UTP (kWh)

Figure 4: Electricity Distribution during Peak Hours (8.00 am – 9.00 pm) on Weekdays

The second category of operation is the operation during off peak hours on weekdays. During this operation, only one gas turbine is used to generate electricity and this electricity is then distributed to four electric chillers, UTP and plant usage. During off peak hours, the demand from UTP is quite low. The four electric chillers are used to generate chilled water.

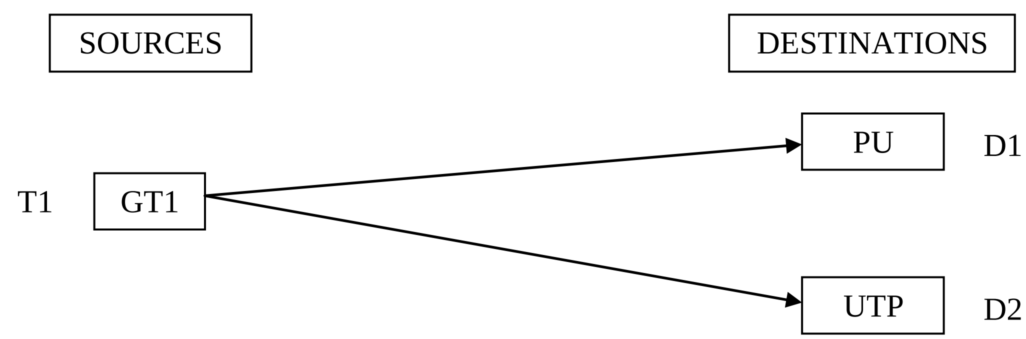


Where;

GT1 = Gas turbine 1	T1 = Electricity supplied by gas turbine 1 (kWh)
EWC1 = Electric water chiller 1	D1 = Electricity demand by Electric water chiller 1 (kWh)
EWC2 = Electric water chiller 2	D2 = Electricity demand by Electric water chiller 2 (kWh)
EWC3 = Electric water chiller 3	D3 = Electricity demand by Electric water chiller 3 (kWh)
EWC4 = Electric water chiller 4	D4 = Electricity demand by Electric water chiller 4 (kWh)
PU = Plant usage	D5 = Electricity demand by plant for plant usage (kWh)
UTP = University Technology PETRONAS	D6 = Electricity demand by UTP (kWh)

Figure 5: Electricity Distribution during Off Peak Hours (9.00 pm – 8.00 am) on Weekdays

The third and fourth category of operation is operation during peak hours on weekend and operation during off peak hours on weekend. Both of these operations are the same where only one gas turbine is used to generate electricity and the electricity generated are distributed to plant for plant usage and also UTP. During weekend, all the office blocks are close means that only the student's hostels needs electricity. Thus, only one gas turbine needs to operate in order to meet the demand. Even though the electricity distribution operations during both peak hours and off peak hours are same during weekend, the demands on peak hours and off peak hours are totally different.



Where;

GT1 = Gas turbine 1

PU = Plant usage

UTP = University Technology PETRONAS

T1 = Electricity supplied by gas turbine 1 (kWh)

T2 = Electricity supplied by gas turbine 1 (kWh)

D1 = Electricity demand by plant for plant usage (kWh)

D2 = Electricity demand by UTP (kWh)

Figure 6: Electricity Distribution during Peak Hours and Off Peak Hours on Weekend

2.4 LINEAR PROGRAMMING

Linear programming (LP) is a mathematical technique that is widely used for solving optimization problems in the industry. According to Leonid N. Vaserstein (2003, p.2), “optimization problems can be divided into two, which is maximization problems and minimization problems. In maximization problem, we want to maximize the function over a set and in minimization problem; we want to minimize the function over a set.” This shows that, linear programming is suitable to be used for the study. The study required that the amount of electricity that should be supplied to UTP is maximized.

Jay Heizer and Barry Render (2001, P.741) said that “There are four requirements of a LP problem.” The four requirements are:

1) Objective function - a mathematical expression in linear programming that maximizes or minimizes some quantity.
2) Constraints – restriction that limit the degree to which an engineer can pursue an objective.
3) There must be alternative courses of action to choose from.
4) The objective and constraints in linear programming problems must be expressed in term of linear equations or inequalities.

This study consists of the entire requirement needed for the author to use LP. Gerard Sierksma (2002, P.332) also said that “one of the applications of LP is for public utilities and natural sources.” This proves that linear programming is suitable to be used in the study. To solve LP problems for the study, the author need to use Microsoft excel solver. “Microsoft excel solver is limited to 200 changing cells (variables), each with 2 boundary constraints and up to 100 additional constraints. These capabilities make Solver suitable for the solution of complex, real-world problems.” Jay Heizer and Barry Render (2001, P.759).

2.4.1 SENSITIVITY ANALYSIS OF LINEAR PROGRAMMING

For operation managers, it is important for them to have more than the optimal solution to an LP problem. In addition to knowing the value of each decision variable and the value of the objective function, they want to know how sensitive these answers are to input parameter changes. For example, what happens if the coefficients of the objective function are not exact, or if they change by10% or 20 %? Because solutions are based on the assumption that input parameters are constant, the subject of sensitivity analysis comes into play.

Jay Heizer and Barry Render (2001, P.749) said that "Sensitivity analysis is the study of how sensitive solutions are to parameter changes." LP software like Excel can be use to perform sensitivity analysis.

2.5 TRANSPORTATION PROBLEMS

"Transportation problems in general are concerned with distributing any commodity from any group of supply centers called sources, to any group of receiving centers, called destinations, in such a way as to minimize the total distribution cost." Frederick S. Hillier and Mark S. Hillier (2003, p.222). This statement shows that the problem of this study can be categorized as transportation problems of linear programming.

In this study, the sources of commodity which is electricity are the two gas turbines and the destinations are four electric chillers, in plant usage and UTP. Each source has a certain supply of unit to distribute to the destinations and each destination has a certain demand for units to be received from the sources. The general model of a distribution-network problem is shown in table below.

Table 1: Terminology for a Transportation Problem

General Model
Units of commodity
Sources
Destinations
Supply from a source
Demand at destination
Cost per unit distributed from a source to a destination

For this type of problem, the assumptions that need to be make about the supplies and demands are:-

- Each source has a fixed supply of units, where this entire supply must be distributed to the destinations.
- Each destination has a fixed demand for units, where this entire demand must be received from sources.

The assumptions mean that there needs to be a balance between the total supply from all sources and the total demand at all destinations. "A transportation problem will have feasible solutions only if the sum of its supplies is equal to the sum of its demands." Frederick S. Hillier and Mark S. Hillier (2003, p.223).

For the cost per unit distributed in the study, the assumption that can be made is that the cost of distributing units from any particular destination is directly proportional to the number of units distributed. Therefore, the cost is just the unit cost of distribution times the number of units distributed.

The only data needed for the study are the supplies, demands, and unit costs. All of these data are the parameters of model. With all of this data, the problem can be solved by formulating the problem in Microsoft Excel.

2.5.1 DEMAND NOT EQUAL TO SUPPLY

A common situation in real-world problems is the case in which total demand is not equal to total supply. This so called “unbalanced” situation can be handle by introducing dummy sources or dummy destinations. If total demand is higher that total supply, the total supply can be made exactly equal to total demand by creating dummy source.

CHAPTER 3: METHODOLOGY AND PROJECT WORK

3.1 RESEARCH METHODOLOGY

The methodology adopted for the study is shown in Figure 7.

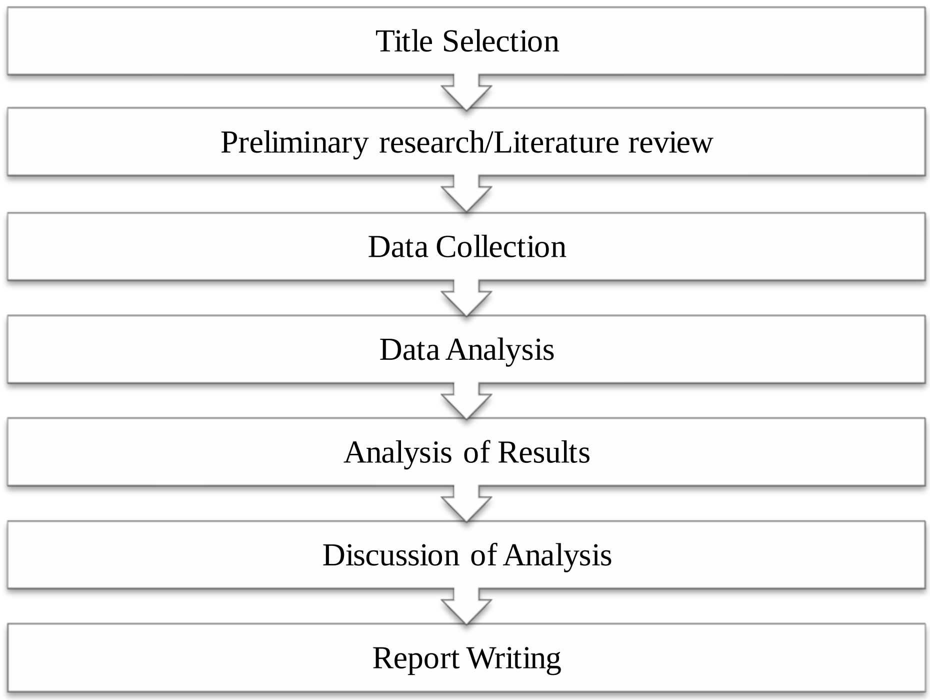


Figure 7: Flow chart of the research methodology

Title Selection: After discussing with the lecturer, the title selected was Scheduling of Electricity Distribution at UTP GDC Plant Using Linear Programming.

Preliminary research/Literature review: Before proceed with the study, the author need to cover all the basic understanding about linear programming, transportation models, UTP GDC plant and others related to the project.

Data collection: Data from electric distribution of UTP GDC plant was collected.

Data analysis: The data was analyzed first. Then after that, the problem was solved by using linear programming method.

Analysis of result: The result was analyzed and compared to the actual electric distribution.

3.2 GANTT CHART

<table>
<tr><th rowspan="2">Activity</th><th colspan="3">FYP 1</th><th colspan="3">FYP 2</th></tr>
<tr><th>June</th><th>July</th><th>Aug</th><th>Oct</th><th>Nov</th><th>Dec</th></tr>
<tr><td>Title Awarded</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Research on UTP GDC plant and linear programming</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Formulating Problem in Linear programming Terms</td><td></td><td></td><td colspan="2">7th Oct</td><td></td><td></td></tr>
<tr><td>Formulating of the Spreadsheet Model</td><td></td><td></td><td></td><td>14th Oct</td><td></td><td></td></tr>
<tr><td>Apply the Model to Analyze the Problem and Develop Recommendation for Management</td><td></td><td></td><td></td><td colspan="2">18th Nov</td><td></td></tr>
<tr><td>Data analysis</td><td></td><td></td><td></td><td></td><td colspan="2">2nd Dec</td></tr>
<tr><td>Draft of Report</td><td></td><td></td><td></td><td></td><td></td><td>16th Dec</td></tr>
<tr><td>Report Completion</td><td></td><td></td><td></td><td></td><td></td><td>23rd Dec</td></tr>
</table>

Figure 8: Gantt chart

3.3 PROJECT ACTIVITIES

In order to develop electricity scheduling modeling for UTP GDC plant, the author adopted the following activities:

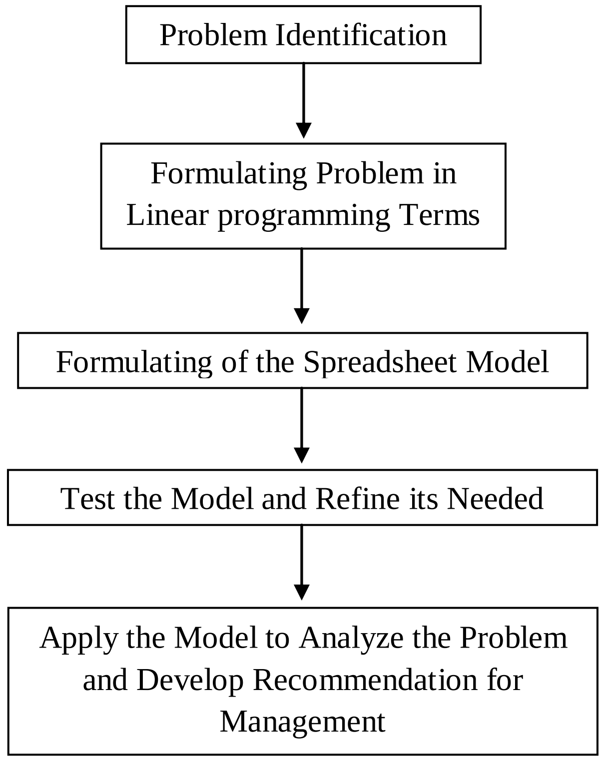


Figure 9: Project activities

3.3.1 PROBLEM IDENTIFICATION

The problem highlighted in the problem statement part before is categorized as a transportation problem of linear programming problems where it deals with the distribution of goods (which in this case is electricity) through a distribution network at minimum cost. In order to solve this problem, transportation modeling was adopted. The sources of the electricity are the two gas turbines and the destinations are the four water chillers, plant usage and also UTP. By considering minimizing the cost, linear programming was used to calculate the minimum amount of electricity that need to be distributed to the four water chillers and plant usage.

Four cases were considered for the operations of the GDC plant. The four operations are:

i. operation during peak hours on weekdays,
ii. operation during off peak hours on weekdays,
iii. operation during peak hours on weekend and lastly
iv. operation during off peak hours on weekend.

Summarize of the operations are shown in the Figure 2.

Table 2: Numbers of machines used during each case of operation

Machines	No of machines use			
	Weekdays		Weekend	
	Day	Night	Day	Night
Gas Turbine	2	1	1	1
Electric Chillers	1	4	0	0

3.3.2 FORMULATING PROBLEM IN LINEAR PROGRAMMING TERM

First, it is shown in the problem that each source has a certain supply of units to distribute to the destination and each destination has a certain demand for unit to be received from the source. The problem and the general model correspond in terminology for any distribution-network problem is summarized in Table 3..

UTP GDC Plant Problem	**General Model.**
Electricity distributed	Units of commodity
Gas turbines.	Sources
Four electric chillers, plant usage and UTP.	Destinations
Electricity distribute from gas turbines.	Supply from sources
Electricity demand for four electric chillers, plant usage and UTP.	Demand at a destination
Distribution cost per unit of electricity from sources to destination.	Cost per unit distributed from a source to a destination

Table 3: Terminology for a distribution-network problem and the study

Formulating the Linear Programming problem involved the following steps:

i. Analyzing the problem to four categories of operations that UTP GDC plant applied in the plant namely operation during peak hours on weekdays, operation during off peak hours on weekdays, operation during peak hours on weekend and lastly operation during off peak hours on weekend.
ii. The four categories of operations were considered.
iii. The modeling that need to be develop are only two which are for weekends and weekdays.

There are some assumptions that need to be made before formulating the modeling.

Assumption:

- Each source (two gas turbines) has a fixed supply of units, where this entire supply must be distributed to the destinations.
- Each destination (four electric chillers, plant usage and UTP) has a fix demand kWh of electricity, where this entire demand must be receive from the sources.
- The sum of electricity generated by the two turbines is equal the sum of supply to electric chillers, plant usage and UTP.
- The cost of distributing units from any particular source to any particular destination is directly proportional to the number of units distributed.
- Each actual electricity distribution operation during each operation time are exactly as the theoretical electricity distribution operation.

The only data needed for a transportation problem are kWh generated by two turbines, kWh required by four electric chillers, in plant usage and UTP and unit cost. These are the parameters of the model. All of these data had been collected by the author. The data for the kWh generated by two turbines, kWh required by four electric chillers, in plant usage and UTP and unit cost that had been gathered are from year 2009 from January to October. Example data is shown in Table 4.

Based on the data, we can see the electricity demand by the plant for plant usage, UTP and the four electric chillers during peak hours, Tp and also during off peak hours, To for 1st January 2009 until 31st January 2009. The top-up supply of electricity that TNB had supplied to UTP GDC plant also shown in the data. All of these data are in kWh.

Table 4 : Data for kWh of electricity of top up supply that TNB need to supply to plant and kWh of electricity required by four electric chillers, in plant usage and UTP for January 2009

	PLANT		UTP		EC1		EC2		EC3		EC4		TOTAL		TNB	
	Tp	To	Tp	To	Tp	To	Tp	To	Tp	To	Tp	To	Tp	To	Tp	To
1	14,154	10,368	30,366	25,251	1,168	1,085	3,257	3,377	3,278	3,293	345	233	52,568	43,608	0	0
2	12,993	11,955	44,535	26,633	1,168	1,085	3,257	3,377	3,278	3,293	345	233	65,576	46,576	0	607
3	12,884	14,177	27,505	25,038	1,938	2,212	2,127	3,588	2,361	2,850	1,927	2,048	48,740	49,915	0	422
4	13,236	8,779	27,369	20,788	1,168	918	3,257	2,857	3,707	3,136	3,026	3,125	51,762	39,604	0	0
5	10,173	12,098	46,333	26,757	517	1,783	0	1,961	664	2,461	0	1,796	57,687	46,856	7,320	452
6	10,061	15,920	47,341	27,985	646	2,196	0	3,773	0	3,388	429	1,775	58,477	55,037	6,732	817
7	1,168	517	918	1,783	13,236	10,173	8,779	12,098	27,369	46,333	20,788	26,757	72,259	97,661	3,257	0
8	11,921	15,930	48,651	28,695	518	2,216	1,077	3,611	983	3,504	298	1,899	63,449	55,854	6,881	600
9	9,676	12,490	47,201	30,938	21	1,621	1,278	3,387	827	3,379	4	1,605	59,007	53,421	5,087	5,506
10	13,236	518	10,173	2,216	1,168	11,921	517	15,930	918	48,651	1,783	28,695	27,795	107,932	8,779	1,077
11	518	21	2,216	1,621	11,921	9,676	15,930	12,490	48,651	47,201	28,695	30,938	107,932	101,947	1,077	1,278
12	21	1,168	1,621	11,921	9,676	13,236	12,490	518	47,201	10,173	30,938	2,216	101,947	39,233	1,278	517
13	11,301	15,193	56,323	34,526	212	1,392	882	3,466	646	3,037	0	3,259	69,363	60,872	15,019	2,006
14	9,855	14,951	56,076	33,557	20	1,778	335	3,109	370	3,324	0	3,053	66,658	59,772	13,614	3,248
15	10,558	16,184	51,769	32,119	228	2,028	1,112	3,477	537	3,272	114	3,848	64,318	60,928	8,894	721
16	14,586	11,465	53,498	30,313	1,582	1,293	993	2,665	0	2,243	2,448	1,958	73,106	49,937	1,469	75
17	9,632	9,670	35,836	30,006	711	479	3,339	2,844	2,319	2,867	0	1,982	51,837	47,847	0	0
18	9,530	12,271	34,582	29,176	2,437	1,854	54	2,426	2,972	2,601	0	2,642	49,575	50,970	0	0
19	21,443	15,595	60,718	32,679	869	1,960	4,041	3,126	1,295	3,112	4,080	3,141	92,446	59,612	0	0
20	23,698	9,135	63,235	32,715	2,487	1,186	3,871	1,781	3,817	1,801	1,674	1,801	98,784	48,418	0	1,986
21	13,429	8,903	61,424	31,359	807	1,210	1,257	1,818	1,019	1,796	0	0	77,935	45,086	24,177	4,702
22	12,013	14,543	60,241	33,422	699	2,026	1,029	3,295	651	3,208	0	0	74,633	56,494	21,619	2,929
23	9,402	13,179	56,865	31,580	21	1,912	0	3,059	0	2,876	0	0	66,288	52,605	16,391	498
24	12,252	14,148	33,164	28,691	171	2,195	3,076	3,306	3,609	3,443	0	0	52,273	51,783	4,359	0
25	14,283	8,190	28,144	27,327	2,361	1,394	3,799	2,177	3,769	2,207	0	0	52,356	41,294	0	0
26	7,848	7,597	35,139	28,003	2,189	1,256	485	1,893	1,138	2,037	0	0	46,799	40,786	0	0
27	10,641	12,426	32,286	28,982	130	1,961	3,981	4,000	3,879	3,917	0	0	50,916	51,286	0	0
28	18,656	10,613	60,888	8,981	1,723	506	2,670	3,415	2,612	3,334	0	0	86,549	26,849	0	0
29	19,222	13,651	59,811	33,118	1,248	1,496	3,632	3,666	3,516	2,959	0	0	87,430	54,891	528	966
30	20,067	10,692	60,507	33,426	2,503	2,264	3,983	3,608	2,479	698	0	0	89,539	50,688	0	0
31	11,870	8,105	43,187	31,087	676	1,212	2,512	2,169	2,649	2,222	0	0	60,894	44,794	5,613	571

Another data that is important in order to formulate the modeling is the unit cost of electricity distribution for each distribution. The data is shown on table below.

Table 5: Tariff charge of electricity distribution for year 2009

Tariff Charge	Unit	For all kWh during peak hours	For all kWh during off peak hours	For all kWh of top-up supply
C2	RM/kWh/month	0.29	0.18	$\frac{(35.6/numbers\ of\ hours)}{numbers\ of\ days\ per\ month}$

Based on the data shown in Table 5, it shows that the unit cost of electricity distribution during peak hours is RM 0.29 kWh / month and for off peak hours is RM 0.18 kWh / month. For the top-up supply from TNB, the unit cost is depends on the numbers of hours for each operation during peak hours and off peak hours which is 8.00 am – 9.00 pm (13 hours) for peak hours and the 10.00 pm – 7.00 am (11 hours) for off peak hours. The unit cost also depends on the numbers of day for a month which varies for each month in year.

After all of the data are collected, the modeling was developed. In order to develop the modeling, it is important to know the operations of electricity distribution at the plant. For UTP GDC plant, the operations are different between the peak hours weekdays, off peak hours weekdays, peak hours weekend and off peak hours weekend. For each operation, a modeling needs to be developed to make sure the study is done thoroughly.

Developing the modeling for UTP GDC plant was done but firstly, the author needs to understand the operations that are used in the plant. Figure below show the general network representation of UTP GDC plant problem. Where the arrows show the possible routes for electricity supply to the destinations.

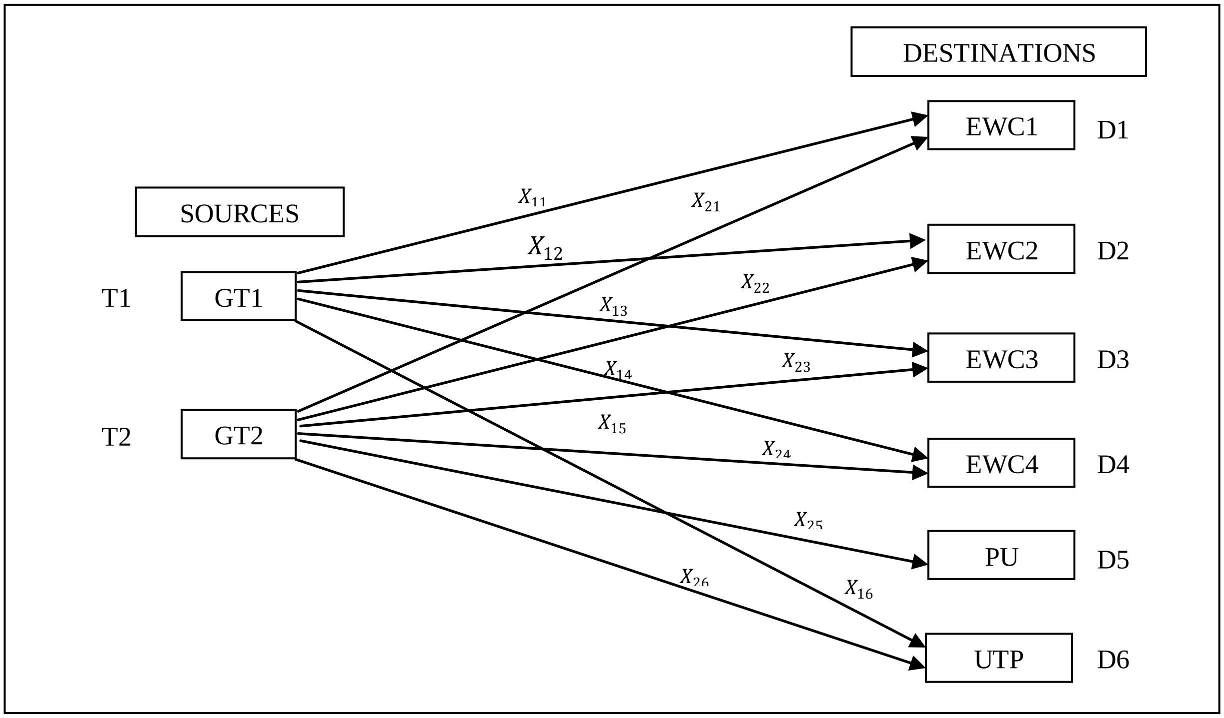


Figure 10: General network representation of electricity distribution for UTP GDC plant

GT- gas turbine

EWC- electric water chillers

PU- plant usage

UTP-University Technology PETRONAS

X_{ij} - Amount of electricity supplied from GT_i to D_j (kWh)

C_{ij} - Unit cost to supply electricity from T_i to D_j (RM/kWh/month)

T1- amount of electricity generated by GT1 (kWh)

T2- amount of electricity generated by GT2 (kWh)

D1- amount of electricity demand by EWC1 (kWh)

D2- amount of electricity demand by EWC2 (kWh)

D3- amount of electricity demand by EWC3 (kWh)

D4- amount of electricity demand by EWC4 (kWh)

D5- amount of electricity demand by PU (kWh)

D6- amount of electricity demand by UTP (kWh)

Now, the mathematical model was formulated in algebraic form. First, let x_{ij} be the amount of electricity to be distributed from gas turbine i to destination j for each i = 1,2 and j =1,2,3,4,5,6. The objective function is to minimize the cost of distribution. Which means to choose the values of these 12 decision variables (x_{ij}) in order to have the minimum cost of distribution.

Objective function:

$$Minimize\ cost = cost\ per\ unit\ of\ electricity\ (\$/kwh) \times amount\ of\ electricity (kwh)$$

$$Minimize\ cost = \sum_{i=1}^{n} \sum_{j=1}^{n} c_{ij}\ x_{ij}$$

Subject to constraints:-

There are two types of constraints that the author needs to consider, which are the supply constraint and the demand constraint. For the supply constraint, we know that the amount of electricity that generate by the gas turbines must be equal to the amount of electricity that distributed to destinations. The mathematical model of the supply constraint is shown below.

Supply constraints:-

$$\sum_{i=1,\ j=1}^{n} x_{ij} \leq T_i\ (T)$$

For the demand constraints, the electricity demand of each of destination is equal to the sum of amount of electricity distributed to each destination. The mathematical model is shown below.

Demand constraints:-

$$\sum_{i=1\ ,\ j=1}^{n} x_{ij} \leq D_j\ (T)$$

For the nonnegative constraints, we know that each value of the electricity must not be negative.

Nonnegative constraint:-

$X_{ij} \geq 0$,$C_{ij} \geq 0$, $1 \geq 0$, $T2 \geq 0$, D1≥ 0 , D2≥ 0 , D3≥ 0 , D4≥ 0 , D5≥ 0 , D6≥ 0

In order to solve the problem for each case of operation, the author needs to formulate two sets of formula for each case which are for weekdays and weekend.

For weekdays, the objective function is to minimize the cost of electricity distribution during weekdays for both peak hours and off peak hours. For this operation, the network representation is shown below.

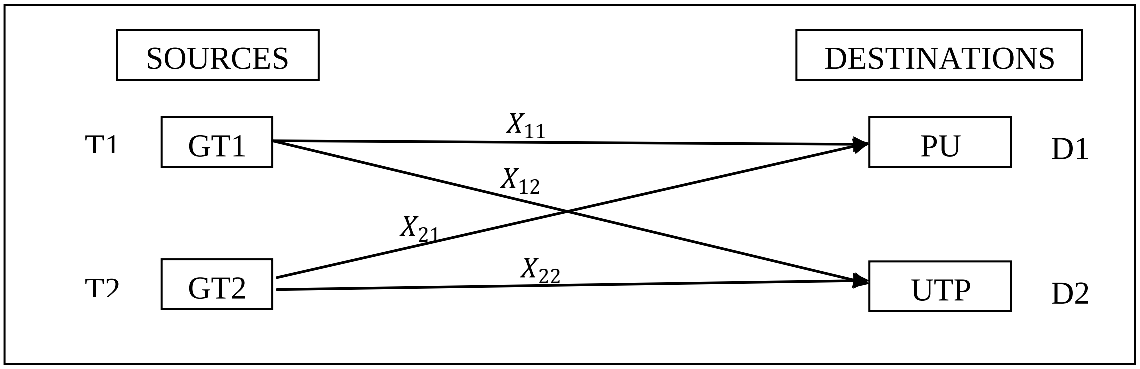


Figure 11: Network representation of Electricity Distribution during Peak Hours (8.00 am – 9.00 pm) on Weekdays

Where;

GT1 = Gas turbine 1

GT2 = Gas turbine 2

PU = Plant usage

UTP = University Technology PETRONAS

T1 = Electricity supplied by gas turbine 1 (kWh) during peak hours

T2 = Electricity supplied by gas turbine 1 (kWh) during peak hours

D1 = Electricity demand by plant for plant usage (kWh) during peak hours

D2 = Electricity demand by UTP (kWh) during peak hours

X_{11} - Amount of electricity supplied from GT_1 to D_1 (kWh)

X_{12} - Amount of electricity supplied from GT_1 to D_2 (kWh)

X_{21} - Amount of electricity supplied from GT_2 to D_1 (kWh)

X_{22} - Amount of electricity supplied from GT_2 to D_2 (kWh)

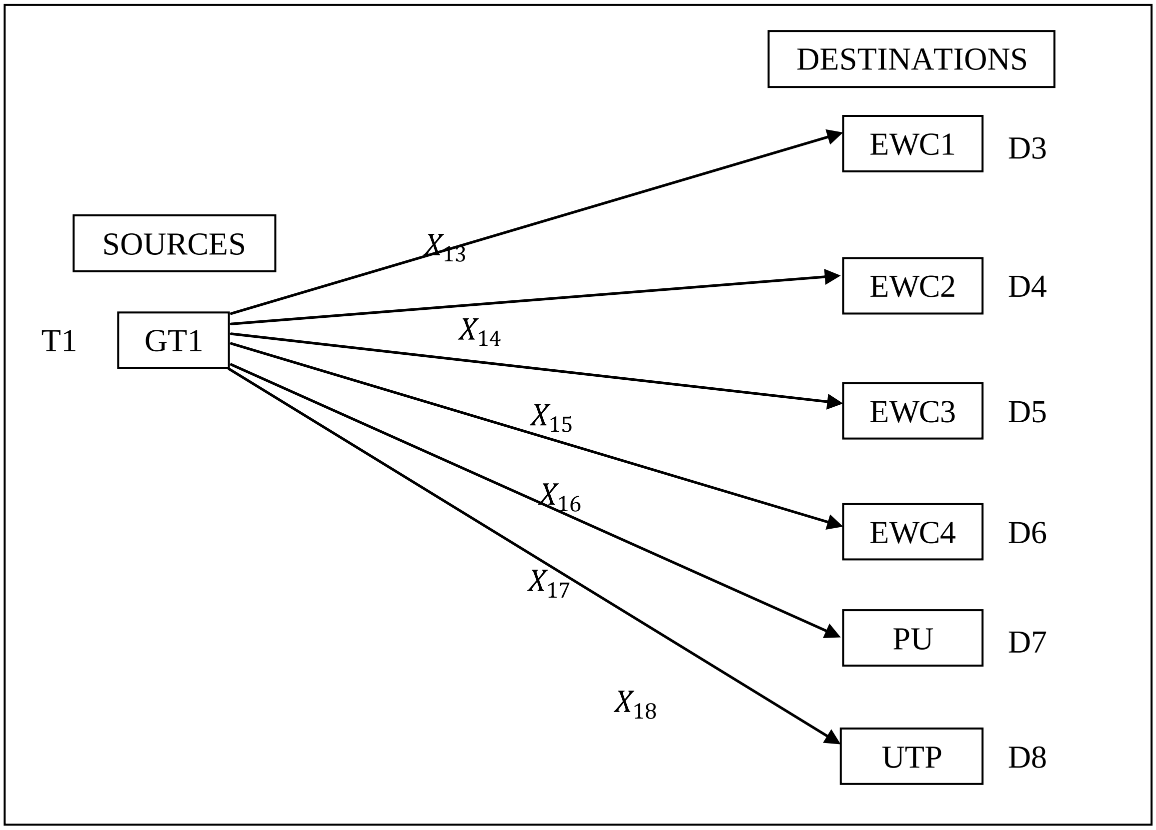


Figure 12: Network representation of Electricity Distribution during Off Peak Hours (9.00 pm – 8.00 am) on Weekdays

Where;

GT1 = Gas turbine 1

T1 = Electricity supplied by gas turbine 1 (kWh)

EWC1 = Electric water chiller 1

D3 = Electricity demand by Electric water chiller 1 (kWh) during off peak hours

EWC2 = Electric water chiller 2

D4 = Electricity demand by Electric water chiller 2 (kWh) during off peak hours

EWC3 = Electric water chiller 3

D5 = Electricity demand by Electric water chiller 3 (kWh) during off peak hours

EWC4 = Electric water chiller 4

D6 = Electricity demand by Electric water chiller 4 (kWh) during off peak hours

PU = Plant usage

D7 = Electricity demand by plant for plant usage (kWh) during off peak hours

UTP = University Technology PETRONAS

D8 = Electricity demand by UTP (kWh) during off peak hours

X_{13}- Amount of electricity supplied from GT_1 to D_3 (kWh)

X_{14}- Amount of electricity supplied from GT_1 to D_4 (kWh)

X_{15}- Amount of electricity supplied from GT_1 to D_5 (kWh)

X_{16}- Amount of electricity supplied from GT_1 to D_6 (kWh)

X_{17}- Amount of electricity supplied from GT_1 to D_7 (kWh)

X_{18}- Amount of electricity supplied from GT_1 to D_8 (kWh)

Based on both of the network distribution, the mathematical modeling for the weekdays operations are:-

Objective function:

$$Minimize\ cost = cost\ per\ unit\ of\ electricity\ (RM/kwh) \times amount\ of\ electricity (kwh)$$

$$Minimize\ cost = C_P(X_{11} + X_{12} + X_{21} + X_{22}) + C_{OP}(X_{13} + X_{14} + X_{15} + X_{16} + X_{17} + X_{18})$$

Where C_P, is the cost per unit for peak hours which is RM 0.29/kWh/month and C_{OP} is the cost per unit for off peak hours which is RM 0.18/kWh/month. X_{11} , X_{12} , X_{21} , X_{22} , X_{13} , X_{14} , X_{15} , X_{16} , X_{17} and X_{18} is the kWh of electricity that need to be distributed to destination in a month.

Subject to constraints:-

Supply constraint during peak hours:

$$X_{11} + X_{12} + X_{21} + X_{22} \leq (T_1 + T_2)(T_P)$$

Where. X_{11} , X_{12} , X_{21} and X_{22} are the variables of the kWh that the plant need to distribute to the demand during peak hours per month. The sum of all the variables must be less or equal to the supplied electricity by gas turbine 1 and gas turbine 2 which is equal to 8.4 MW multiplied by the amount of hours for peak hours for that particular month.

Supply constraint during off peak hours:

$$X_{13} + X_{14} + X_{15} + X_{16} + X_{17} + X_{18} \leq T_1(T_O)$$

Where X_{13} , X_{14} , X_{15} , X_{16} , X_{17} and X_{18} are the variables of the kWh that the plant need to distribute to the demand during peak off hours per month. The sum of all the variables must be less or equal to the supplied electricity by gas turbine 1which is equal to 4.2 MW multiplied by the amount of hours for peak hours for that particular month.

Capacity constraint:

For peak hours:

$$D_1 + D_2 \leq (T_1 + T_2)(T_P)$$

Where D_1 and D_2 are both the demand of electricity from the plant and UTP. The sum of both demands during peak hours per month must be less or equal to the sum of supply from both gas turbines which are 8.4 MW multiplied by the amount of hours for peak hours for that particular month.

For off peak hours:

$$D_3 + D_4 + D_5 + D_6 + D_7 + D_8 \leq T_1(T_O)$$

Where D_3 , D_4 , D_5 , D_6 , D_7 and D_8 are the demands of electricity from the four electric chillers, plant and UTP. The sum of the demands during off peak hours per month must be less or equal to the sum of supply from both gas turbines which are 4.2 MW multiplied by the amount of hours for off peak hours for that particular month.

For weekend, the objective function is to minimize the cost of electricity distribution during weekend for both peak hours and off peak hours. For this operation, the network representation is shown below.

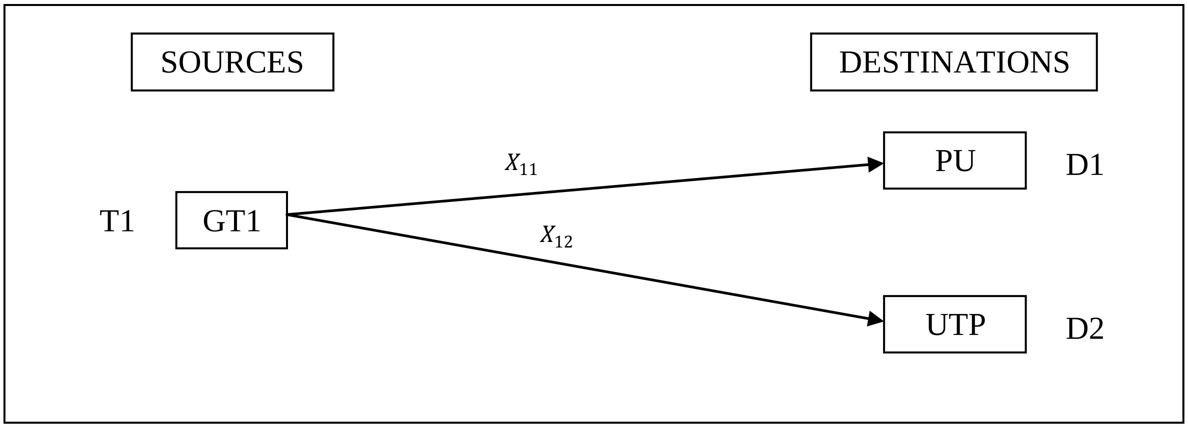


Figure 13: Network representation of Electricity Distribution during Peak Hours (8.00 am – 9.00 pm) on Weekend

Where;

GT1 = Gas turbine 1

PU = Plant usage

UTP = University Technology PETRONAS

T1 = Electricity supplied by gas turbine 1 (kWh) during peak hours

D1 = Electricity demand by plant for plant usage (kWh) during peak hours

D2 = Electricity demand by UTP (kWh) during peak hours

X_{11}- Amount of electricity supplied from GT_1 to D_1 (kWh)

X_{12}- Amount of electricity supplied from GT_1 to D_2 (kWh)

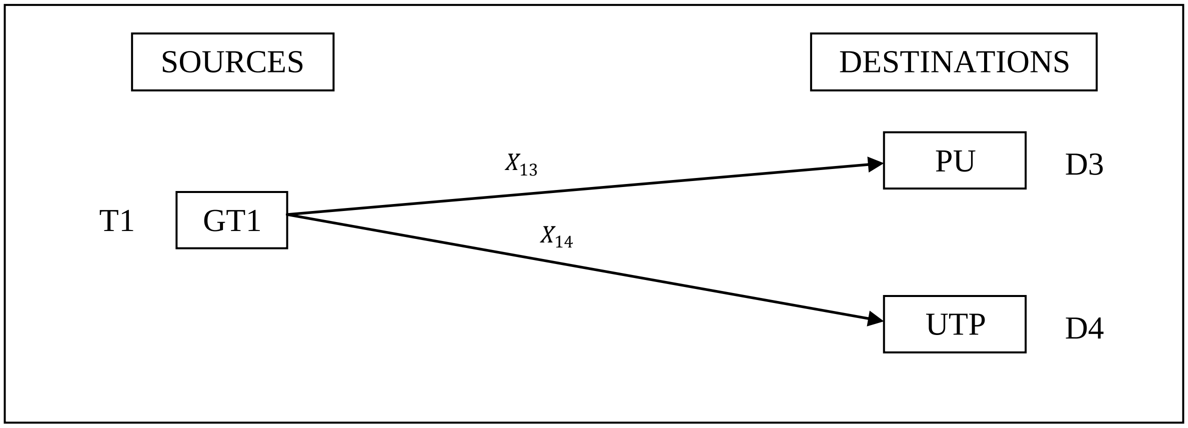


Figure 14: Network representation of Electricity Distribution during Off Peak Hours (9.00 pm – 8.00 am) on Weekend

Where;

GT1 = Gas turbine 1

PU = Plant usage

UTP = University Technology PETRONAS

T1 = Electricity supplied by gas turbine 1 (kWh) during off peak hours

D1 = Electricity demand by plant for plant usage (kWh) during off peak hours

D2 = Electricity demand by UTP (kWh) during off peak hours

X_{13}- Amount of electricity supplied from GT_1 to D_3 (kWh)

X_{14}- Amount of electricity supplied from GT_1 to D_4 (kWh)

Based on both of the network distribution, the mathematical modeling for the weekdays operations are:-

Objective function:

$$Minimize\ cost = cost\ per\ unit\ of\ electricity\ (RM/kwh) \times amount\ of\ electricity(kwh)$$

$$Minimize\ cost = C_{OP}(X_{13} + X_{14}) + C_P(X_{11} + X_{12})$$

Where C_P, is the cost per unit for peak hours which is RM 0.29/kWh/month and C_{OP} is the cost per unit for off peak hours which is RM 0.18/kWh/month. X_{11} and X_{12} is the kWh of electricity that need to be distributed to destination in a month.

Subject to constraints:-

Supply constraint during peak hours:

$$X_{11} + X_{12} \leq T_1(T_O)$$

Where. X_{11} and X_{12} are the variables of the kWh that the plant need to distribute to the demand during peak hours per month. The sum of all the variables must be less or equal to the supplied electricity by gas turbine 1 which is equal to 4.2 MW multiplied by the amount of hours for peak hours for that particular month.

Supply constraint during off peak hours:

$$X_{13} + X_{14} \leq T_1(T_P)$$

Where. X_{13} and X_{14} are the variables of the kWh that the plant need to distribute to the demand during off peak hours per month. The sum of all the variables must be less or equal to the supplied electricity by gas turbine 1 which is equal to 4.2 MW multiplied by the amount of hours for peak hours for that particular month.

Capacity constraint:

For peak hours:-

$$D_1 + D_2 \leq (T_1)(T_P)$$

Where $D_1$and D_2 are both the demand of electricity from the plant and UTP. The sum of both demands during peak hours per month must be less or equal to the sum of supply from gas turbine 1 which are 4.2 MW multiplied by the amount of hours for peak hours for that particular month.

For off peak hours:

$$D_3 + D_4 \leq (T_1)(T_O)$$

Where D_3 and D_4 are both the demand of electricity from the plant and UTP. The sum of both demands during peak off hours per month must be less or equal to the sum of supply from gas turbine 1 which are 4.2 MW multiplied by the amount of hours for off peak hours for that particular month.

3.3.3 FORMULATING OF THE SPREADSHEET MODEL

Now that the mathematical modules for each case had been developed as shown in the previous section, the formulation of the spreadsheet model can be developed. Because of the big amount of data, it is not suitable for the author to solve the problem using manual method such as the North West corner rules. For this problem, it is essential for the author to use Microsoft Excel Solver in order to solve the problem. Before the problem can be solve, the spreadsheet model need to be developed.

For the first step of formulating the spreadsheet model, all of the data need to be put into a table. The data that need to be put into the table are the unit cost for each distribution of electricity, all of the kWh demand of electricity and the kWh supplied of electricity by the gas turbine. Based on the cases of operations that are mentioned from previous section, for each month, the author needs to develop four spreadsheet model for each cases which are for peak hours weekdays, off peak hours weekdays, peak hours weekend and lastly for off peak hours weekend. The examples tables for each operation are shown below.

Table 6: Data for peak hours weekdays January 2009

DATA

COSTS	PU (Tp)	UTP (Tp)	SUPPLY
GT1	0.29	0.29	1,201,200.00
GT2	0.29	0.29	1,201,200.00
DEMAND	272,886.27	1,035,746.91	1308633.17889399\2402400

From the table above, it shows that the unit cost of distribution during peak hours for each distribution which is RM 0.29/kWh/month. The demand for peak hours weekdays January 2009 for plant usage (PU) is 272886.27kWh/month and for UTP is 1035746.91kWh/month. The amount of electricity supplied by both gas turbines is the same which is 1201200 kWh/month.

Table 7: Data for off peak hours weekdays January 2009

DATA

COSTS	EC1 (To)	EC2 (To)	EC3 (To)	EC4 (To)	PU (To)	UTP (To)	SUPPLY
GT1	0.18	0.18	0.18	0.18	0.18	0.18	1,016,400.00
TNB	0.36	0.36	0.36	0.36	0.36	0.36	140,069.60
DEMAND	**55,663.00**	**74,477.08**	**113,438.61**	**53,574.59**	**254,572.58**	**604,743.75**	1156469\1156469

From the table above, it shows that the unit cost of distribution during off peak hours for each distribution which is RM 0.18/kWh/month. The demand for off peak hours weekdays January 2009 for electric chillers 1 is 55663 kWh/month, electric chillers 2 is 74477.08 kWh/month , electric chillers 3 is 113438.61 kWh/month, electric chillers 4 is 53574.59 kWh/month, plant usage (PU) is 254572.58 kWh/month and for UTP is 604743.75 kWh/month. The amount of electricity supplied by gas turbine is 1016400 kWh/month. Unfortunately, due to insufficient supply by the plant, the plant needs to have top up supply from TNB for 140069.60 kWh/month that will cost RM0.36/kWh/month.

Table 8: Data for peak hours weekend January 2009

DATA

COSTS	PU (Tp)	UTP (Tp)	SUPPLY
GT1	0.29	0.29	1,201,200.00
DEMAND	**97,442.34**	**242,174.63**	339616.96961527\1201200

From the table above, it shows that the unit cost of distribution for peak hours for each distribution which is RM 0.29/kWh/month. The demand for peak hours weekend January 2009 for plant usage (PU) is 97441.34 kWh/month and for UTP is 242174.63 kWh/month. The amount of electricity supplied by the gas turbine is 1201200 kWh/month.

Table 9: Data for off peak hours weekend January 2009

DATA

COSTS	PU (Tp)	UTP (Tp)	SUPPLY
GT1	0.18	0.18	1,201,200.00
DEMAND	**75,880.61**	**195,949.90**	271830.513136813\1201200

From the table above, it shows that the unit cost of distribution for 0ff peak hours for each distribution which is RM 0.18/kWh/month. The demand for off peak hours weekend January 2009 for plant usage (PU) is 75880.61 kWh/month and for UTP is 195949.9 kWh/month. The amount of electricity supplied by the gas turbine is 1201200 kWh/month.

After all the data had been put into the table, now, a table for each operation needs to be developed. In these tables, the variables, which are the amount of electricity need to be distributed to each destination, can be calculated by using Solver function. An example of the table is shown in figure below.

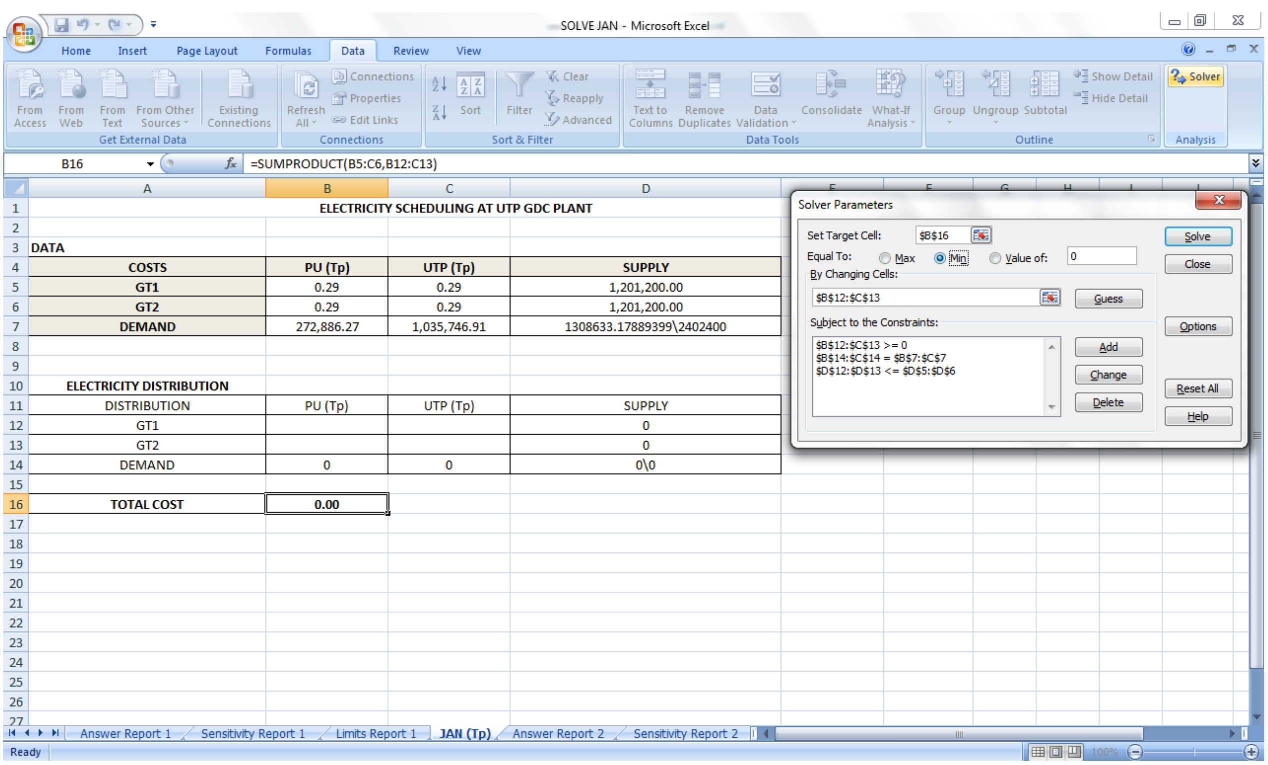


Figure 15: Table and Solver Function Use to Solve Problem

In the figure shown before, on the second table, at the demand row, the function is put into the excel where the value of demand for both plant (PU) and UTP must be equal to the sum of kWh electricity distributed to each destination which in this case are to the plant and UTP. For the supply column, the total amount of supply from gas turbine 1 (GT1) must be equal to the sum of kWh electricity distributed from GT1 to PU and UTP.

After inserting the formula in excel, the problem can be solve by using Solver. By using solver function, the total cost can be calculated. In the total cost box, the formula for calculating cost is inserted in term of excel formula. Then, all of the information needed by Solver function need to be key in. The information that is needed by the Solver is shown in the figure 12.

Now, the spread sheet model is ready to be used to solve the problem. Solver function also can help the user to have sensitivity report for the problem. To have the sensitivity report, after click the solve button, there is an option shown to choose which report to be develop. This function is shown in figure below.

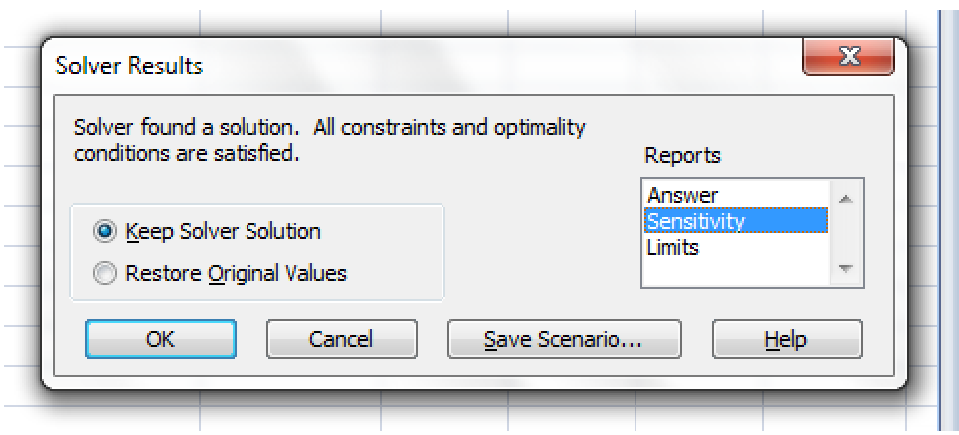


Figure 26: Options of Report That Can be Developed by Solver

3.3.4 TEST THE MODEL AND REFINE ITS NEEDED

After developing both the mathematical and spreadsheet models, both of them need to be tested. For the mathematical models, each case of operation is studied thoroughly in order to have an accurate mathematical modeling that symbolizes the operations. To achieve this, the author had gone to UTP GDC plant to investigate and studies the operations.

Based on the study, the mathematical model was developed. To test the models, the actual data is inserted into the models to see the result whether the result is good or not. After testing the model with the actual data, some the model need to be refined its needed. The test is also done by the help of Ap Ir Dr Mohd Amin that consult the author about the models.

The test is done until the author is satisfied with the modeling. Now, the modeling is ready to be used to analyze and solved the problem.

3.3.5 APPLY THE MODEL TO ANALYZE THE PROBLEM AND DEVELOP RECOMMENDATION FOR MANAGEMENT

For this project activity, the result had been analyzed and show in the next section. For this study, the author had solved the problem using Solver function for each month for January 2009 until October 2009. The total cost for each month had been calculated and some recommendation had been done in order to minimize the total cost of electricity distribution at UTP GDC plant.

CHAPTER 4: RESULTS AND DISCUSSIONS

4.1 ELECTRICITY DISTRIBUTION TO EACH DESTINATION

Based on the model developed shown in previous sections, the model is used to solve the problem. The kWh of electricity distribution to each destination is calculated for each operation. The results show the feasible kWh of electricity distribution to each destination that can give the minimum total cost of electricity distribution to the plant. The results are for January 2009 until October 2009. The result for each operation is shown in table below.

Table 10: kWh/month of Electricity Distribution for Peak Hours Weekdays

Month	From GT1 to Plant (kWh/month)	From GT1 to UTP (kWh/month)	From GT2 to Plant (kWh/month)	From GT2 to UTP (kWh/month)
January	136443.13	517873.45	136443.13	517873.45
February	190256.79	625688.99	190256.79	625688.99
March	235621.33	619748.06	235621.33	619748.06
April	235645.50	726324.04	235645.50	726324.04
May	269028.11	623586.89	269028.11	623586.89
June	225366.86	570397.10	225366.86	570397.10
July	256070.10	628637.18	256070.10	628637.18
August	200652.58	590387.23	200652.58	590387.23
September	184490.00	527116.37	184490.00	527116.37
October	155992.08	503895.44	155992.08	503895.44

Table 11: kWh/month of Electricity Distribution for Off Peak Hours Weekdays

Month	January	February	March	April	May	June	July	August	September	October
From GT1 to EC1 (kWh/month)	**32,318.06**	**14,513.77**	**7,254.65**	**0.00**	**0.00**	**34,314.09**	**28,642.92**	**22,635.59**	**9,179.95**	**0.00**
From GT1 to EC2 (kWh/month)	**51,132.15**	**31,443.86**	**35,612.59**	**18,322.54**	**276.15**	**15,795.68**	**10,286.31**	**21,587.30**	**53,711.75**	**36,792.66**
From GT1 to EC3 (kWh/month)	**90,093.68**	**55,173.14**	**26,372.51**	**15,365.99**	**13,230.82**	**51,848.91**	**32,377.93**	**19,628.88**	**39,107.03**	**35,367.30**
From GT1 to EC4 (kWh/month)	**30,229.65**	**0.00**	**0.00**	**4,809.14**	**43,407.77**	**51,322.80**	**38,889.36**	**29,663.39**	**44,779.29**	**24,250.47**
From GT1 to Plant (kWh/month)	**231,227.64**	**223,982.80**	**288,169.35**	**265,765.29**	**288,654.10**	**274,051.14**	**254,807.43**	**235,960.03**	**217,394.92**	**197,411.90**
From GT1 to UTP (kWh/month)	**581,398.81**	**598,886.44**	**658,990.91**	**712,137.04**	**624,631.16**	**589,067.38**	**651,396.06**	**640,724.80**	**643,840.32**	**583,977.67**
From TNB to EC1 (kWh/month)	**23,344.93**	**21,861.02**	**30,322.40**	**36,717.37**	**33,806.75**	**0.00**	**3,962.14**	**9,018.27**	**0.00**	**8,983.82**

From TNB to EC2 (kWh/month)	**23,344.93**	**29,312.84**	**30,322.40**	**41,313.06**	**56,451.96**	**18,220.25**	**3,962.14**	**24,686.83**	**0.00**	**9,987.47**
From TNB to EC3 (kWh/month)	**23,344.93**	**3,539.22**	**30,322.40**	**41,623.94**	**39,810.03**	**2,094.25**	**3,962.14**	**6,735.14**	**0.00**	**9,987.47**
From TNB to EC4 (kWh/month)	**23,344.93**	**2,424.76**	**0.00**	**13,024.32**	**14,245.35**	**0.00**	**3,962.14**	**13,385.84**	**0.00**	**9,987.47**
From TNB to Plant (kWh/month)	**23,344.93**	**38,459.76**	**30,322.40**	**36,480.57**	**44,567.76**	**6,336.07**	**3,962.14**	**0.00**	**0.00**	**9,987.47**
From GT1 to UTP (kWh/month)	**23,344.93**	**55,947.38**	**30,322.40**	**45,594.19**	**14,696.23**	**0.00**	**25,221.10**	**32,149.67**	**0.00**	**9,987.47**

Table 12: kWh/month of Electricity Distribution for Peak Hours Weekend

Month	January	February	March	April	May	June	July	August	September	October
From GT1 to Plant (kWh/month)	97442.343	79726.903	95577.64	88262.42	107109.6	81832.43	76642.27	149398.3	136759.2	165553
From GT1 to UTP (kWh/month)	242174.6271	327197.1855	348154.2	350843.3	396077	253225.9	310910.7	425606	388704.3	442257.2

Table 13: kWh/month of Electricity Distribution for Off Peak Hours Weekend

Month	January	February	March	April	May	June	July	August	September	October
From GT1 to Plant (kWh/month)	75880.61	71312.1	92573.77783	86265.68	95817.54	100386	94173.13	93019.9	80105.6	92717.95
From GT1 to UTP (kWh/month)	195949.9027	231301	252466.033	246949.6	293311.07	198808.2	236713.6	272980.9	219905.4	251582.7

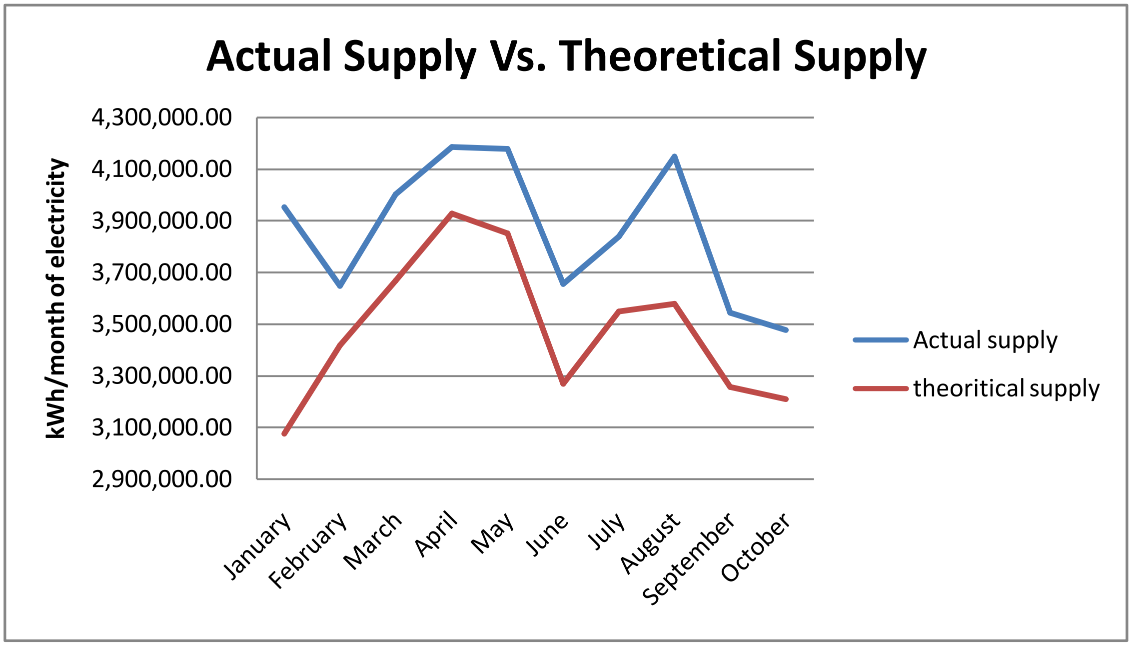


Figure 17: Graph for Actual Supply vs. Theoretical Supply

Graph above shows the kWh of actual and theoretical supply of electricity to each destination. The graph approved that after adopting the electricity scheduling, the kWh of electricity distribution can be decrease. This happen due to the electricity distributed to destinations are based on the demands.

From these results, we can see that for operation on off peak hours during weekdays, the plant has to rely on the top up electricity from TNB due to insufficient supply of electricity from the plant. This situation happens only during the off peak hours on weekdays because of the usage of the four electric chillers during the off peak hours. The four electric chillers are used by the plant to generate chilled water and the chilled water is stored to be used on the peak hours. The chilled water is supplied by the plant to UTP for air conditioning usage. The chilled water stored is important for the plant to backup the chilled water supply during the peak hours.

The demand from UTP during the off peak hours which is mainly from the student hostel are quite high due to the usage of electricity appliance such as laptop by the student to do their studies or other usage. Because of these factors, the plant cannot supply enough electricity for each destination during this time. The figure below shows the total kWh/month demand of electricity from January 2009 until October 2009.

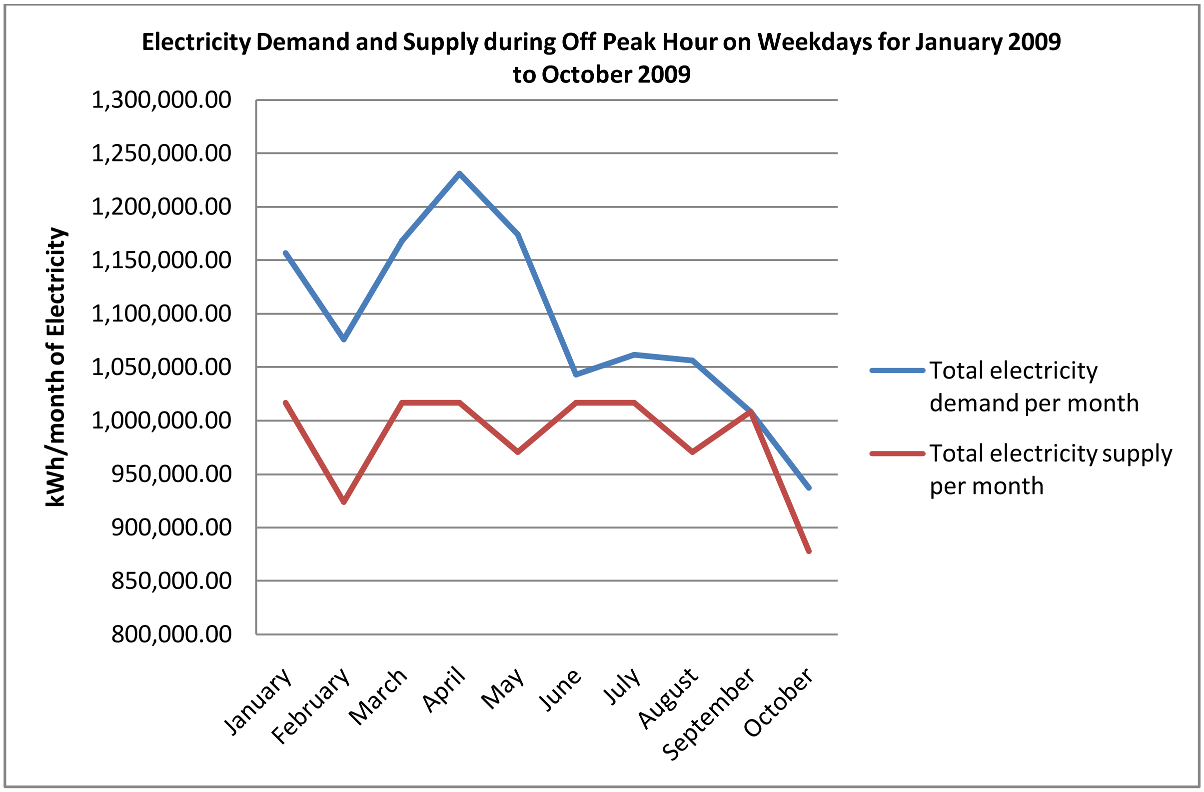


Figure 18: Graph for Total Electricity Demand and Supply during Off Peak Hours on Weekdays for January 2009 to October 2009

Based on figure 14, it's clearly shows that the total electricity demand during off peak hours on weekdays are higher than the total electricity supplied by the plant. Because of this, the plant has to rely on the top up supply by TNB to meet these demands. The top up supply will cost RM 35.60 per kW and this unit cost is quite high. During off peak hours on weekdays, the operation of the plant only using a single gas turbine which only can generate about 4.2MW maximum. With this operation surely the plant cannot meet the demand.

In order to meet the demand, UTP GDC plant needs to use two gas turbines for operations on off peak hours during weekdays. By using two gas turbines, the plant will surely meet the demand. An evaluation has been made using linear programming in order to know the effect of using two gas turbines during this operation. The results are shown in figure 15 below.

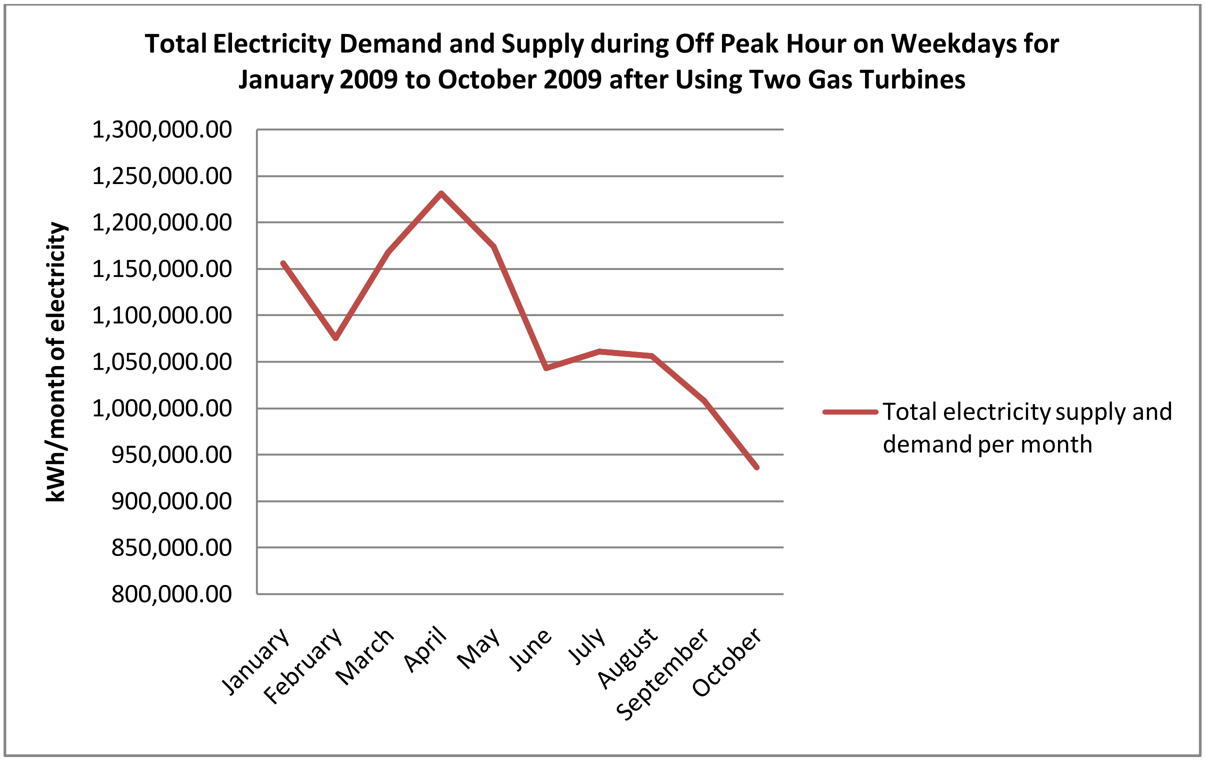


Figure 19: Graph for Total Electricity Demand and Supply during Off Peak Hours on Weekdays for January 2009 to October 2009 after Using Two Gas Turbines

Figure 15 shows that by using two gas turbines, the plant can meet the demand even though each of the gas turbine did not generate maximum electricity.

4.2 TOTAL COST OF ELECTRICITY DISTRIBUTION

By using linear programming, the amount of the total cost of electricity distribution is minimized by scheduling the appropriate amount of kWh/month of electricity that needs to be distributed to each destination. After applying the modeling towards the problem, the total cost of each month can be calculated. The total cost of electricity distribution for each month is shown in Table 14.

Table 14: Total Cost of Electricity Distribution for Each Month

Month	Total Cost of Electricity Distribution (RM/month)
January	**760,299.09**
February	**868,916.10**
March	**924,435.97**
April	**1,005,525.01**
May	**981,608.08**
June	**884,243.67**
July	**884,243.67**
August	**897,021.79**
September	**831,871.14**
October	**800,189.46**

The total cost of electricity distribution not only depends on the kWh/month of electricity distributed to each destination, it also depends on the unit cost of electricity which differs every year. For 2009, the unit cost of electricity for peak hours is RM0.29/kWh/month and for off peak hours is RM0.18/kWh/month. The top up supply unit cost is RM 35.60/kW.

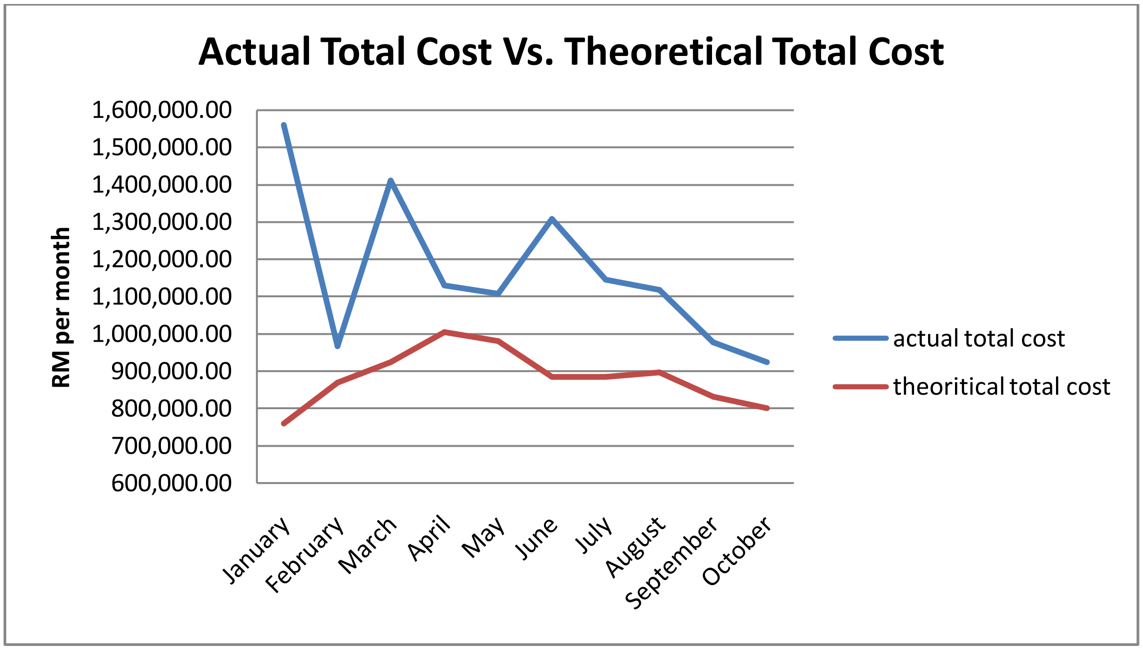


Figure 20: Graph for Actual Total Cost vs. Theoretical Total Cost

Graph in Figure 20 shows the actual total cost of electricity distribution vs. the theoretical total cost of electricity distribution. In this graph, it shows that after adopting electricity scheduling, the amount of total cost can be reduced.

Even though by using linear programming to scheduling the electricity distribution can minimize the cost of distribution, the total cost can be reduce more by changing the operations for off peak hours during weekdays. By using two gas turbines, the cost can be reduced more due to the lower unit cost use. When the plant cannot meet the electricity demand, the plant needs top up supply from TNB but the top up supply will cost more to the plant.

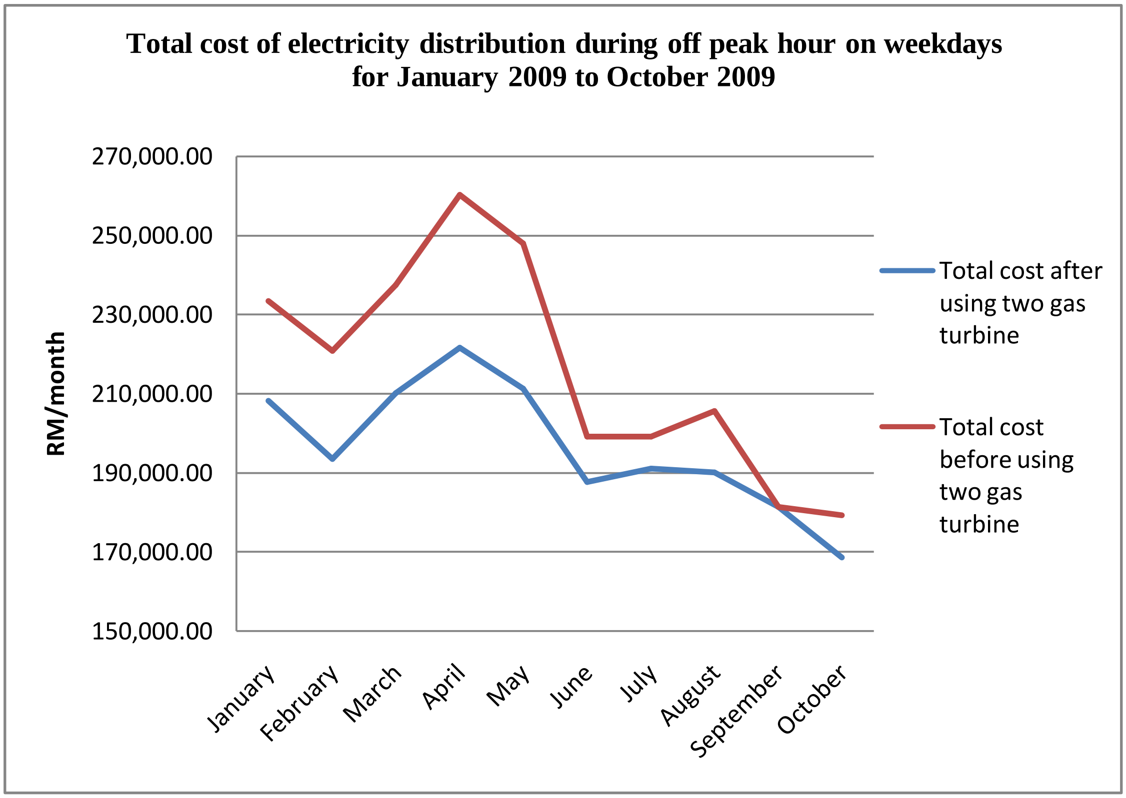


Figure 21: Graph for Total Cost of Electricity Distribution during Off Peak Hours on Weekdays for January 2009 to October 2009

The graph in figure 21 clearly shows that the total cost can be reduce by changing the operation during off peak hours on weekdays from using only a gas turbine to two gas turbines.

4.3 SENSITIVITY ANALYSIS

Sensitivity analysis is important to know how much a solution might change if there were changes in the variables or input data. For this study, the author had done sensitivity analysis towards the results. From the sensitivity analysis done, it shows that the electricity scheduling is very sensitive towards any changes on the variable.

For example, from the data for January 2009, during the peak hours on week days, the value of kWh of electricity distributed to each destination and the total cost of distribution are shown in Table 15.

Table 15: Total Cost of Electricity Distribution and kWh/month of Electricity Distribution for January 2009

Month	From GT1 to Plant (kWh/month)	From GT1 to UTP (kWh/month)	From GT2 to Plant (kWh/month)	From GT2 to UTP (kWh/month)	Total cost of distribution (RM/month)
January	136443.13	517873.45	136443.13	517873.45	343,891.96

If all of the data for kWh/month of electricity distribution is increased by 10%, the total cost will be increased by 10%. The value is shown in Table 16.

Table 16: Total Cost of Electricity Distribution and kWh/month of Electricity Distribution for January 2009 When increase by 10%

Month	From GT1 to Plant (kWh/month)	From GT1 to UTP (kWh/month)	From GT2 to Plant (kWh/month)	From GT2 to UTP (kWh/month)	Total cost of distribution (RM/month)
January	15008.74487	569660.8	15008.74487	569660.8	378281.16

$$Total\ cost\ percentage\ increase = \frac{(378281.16 - 343891.96)}{343891.96} * 100 = 10\%$$

The same thing happened when the entire variable is decreased by 10%. The total cost also decreased by 10%. The value is shown in Table 17.

Table 17: Total Cost of Electricity Distribution and kWh/month of Electricity Distribution for January 2009 When Decrease by 10%

Month	From GT1 to Plant (kWh/month)	From GT1 to UTP (kWh/month)	From GT2 to Plant (kWh/month)	From GT2 to UTP (kWh/month)	Total cost of distribution (RM/month)
January	**12279.88216**	**466086.1089**	**12279.88216**	**466086.1089**	**309502.7672**

$$Total\ cost\ percentage\ decrease = \frac{(309502.7672 - 343891.96)}{343891.96} * 100 = -10\%$$

The electricity scheduling is very sensitive towards any changes on the variable due to the value of unit cost for the electricity distribution used for the problem. The unit cost used is the same for all the electricity distribution during the peak hours. Same thing happens during the off peak hours. Because of this factor, even a slightly change in the variables may lead to the changes of the total cost of electricity distribution.

CHAPTER 5: CONCLUSSION AND RECOMMENDATION

The study shows that scheduling of electricity distribution can be done by using linear programming. The amount of kWh of electricity to be distributed to each destination can be determined by using Microsoft Excel Solver.

There are four cases that were considered by the author which are different in term of electricity distribution. The four cases are operation during peak hours on weekend, operation during off peak hours on weekend, operation during peak hours on weekdays and operation during off peak hours on weekdays.

By considering the four cases, the models were developed by having two mathematical models namely for weekend and weekdays. Each of the models contains the distribution during peak and off peak hours. After the mathematical models were been developed, spreadsheet models were developed. The problem was then solved by using Solver function in Microsoft excel.

The amount of kWh electricity per month that needs to be distributed to each destination were calculated in the study and the study shows that the scheduling of electricity can minimize the cost of distribution.

Based on the analysis to the linear programming, the following recommendations are proposed:

1) Having schedule of electricity distribution which can minimize the cost of electricity distribution for the plant.
2) Using two gas turbines for operation during off peak hours on weekdays which can minimize the cost.

For further study of this project, the study should include the cost of producing or generating electricity by the gas turbines. This data could help in to ensure that the study is more comprehensive.

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APPENDICES

APPENDIX 1: Data for kWh of electricity of top up supply that TNB need to supply to plant and kWh of electricity required by four electric chillers, in plant usage and UTP for January 2009

JANUARY 2009

	PLANT		UTP		EC1		EC2		EC3		EC4		TOTAL		TNB	
	Tp	To	Tp	To	Tp	To	Tp	To	Tp	To	Tp	To	Tp	To	Tp	To
1	14,153.53	10,368.43	30,366.26	25,251.40	1,168.44	1,085.35	3,256.88	3,376.50	3,278.21	3,292.69	344.55	233.15	52,567.87	43,607.52	0.00	0.00
2	12,992.60	11,955.32	44,535.42	26,633.18	1,168.44	1,085.35	3,256.88	3,376.50	3,278.21	3,292.69	344.55	233.15	65,576.09	46,576.19	0.00	606.76
3	12,884.16	14,177.44	27,504.56	25,038.50	1,937.54	2,212.34	2,126.63	3,588.46	2,360.86	2,850.29	1,926.74	2,047.82	48,740.49	49,914.84	0.00	422.07
4	13,235.71	8,779.30	27,368.84	20,788.42	1,168.44	918.37	3,256.88	2,857.04	3,706.90	3,136.10	3,025.67	3,125.08	51,762.42	39,604.30	0.00	0.00
5	10,173.30	12,098.41	46,332.98	26,757.08	516.53	1,782.52	0.00	1,960.59	664.22	2,461.20	0.00	1,795.83	57,687.02	46,855.63	7,320.32	451.78
6	10,060.95	15,920.07	47,340.53	27,984.62	646.12	2,196.30	0.00	3,772.62	0.00	3,388.41	429.05	1,774.76	58,476.65	55,036.77	6,731.76	816.80
7	1,168.44	516.53	918.37	1,782.52	13,235.71	10,173.30	8,779.30	12,098.41	27,368.84	46,332.98	20,788.42	26,757.08	72,259.07	97,660.81	3,256.88	0.00
8	11,921.45	15,929.86	48,651.20	28,695.42	518.46	2,215.61	1,076.95	3,610.64	982.69	3,503.88	298.42	1,898.78	63,449.17	55,854.19	6,880.91	599.79
9	9,676.45	12,490.08	47,200.91	30,938.00	20.68	1,621.24	1,278.08	3,387.03	826.87	3,379.20	3.72	1,605.49	59,006.71	53,421.04	5,087.45	5,505.52
10	13,235.71	518.46	10,173.30	2,215.61	1,168.44	11,921.45	516.53	15,929.86	918.37	48,651.20	1,782.52	28,695.42	27,794.86	107,932.00	8,779.30	1,076.95
11	518.46	20.68	2,215.61	1,621.24	11,921.45	9,676.45	15,929.86	12,490.08	48,651.20	47,200.91	28,695.42	30,938.00	107,932.00	101,947.35	1,076.95	1,278.08
12	20.68	1,168.44	1,621.24	11,921.45	9,676.45	13,235.71	12,490.08	518.46	47,200.91	10,173.30	30,938.00	2,215.61	101,947.35	39,232.96	1,278.08	516.53
13	11,300.75	15,192.74	56,323.34	34,525.79	211.84	1,392.15	881.60	3,465.73	645.89	3,036.89	0.00	3,258.98	69,363.40	60,872.28	15,019.49	2,006.24
14	9,855.13	14,950.53	56,076.11	33,557.26	20.49	1,777.58	335.48	3,109.04	370.38	3,324.03	0.00	3,053.43	66,657.58	59,771.88	13,614.24	3,248.29
15	10,557.73	16,184.23	51,769.38	32,119.07	228.17	2,028.06	1,112.05	3,477.31	536.86	3,271.79	113.77	3,847.84	64,317.96	60,928.31	8,894.24	720.79
16	14,586.10	11,465.20	53,497.98	30,312.72	1,581.66	1,293.09	992.55	2,664.83	0.00	2,243.49	2,447.59	1,958.09	73,105.88	49,937.43	1,468.95	74.54
17	9,632.32	9,670.14	35,835.81	30,005.53	711.06	478.98	3,339.01	2,844.22	2,319.17	2,866.64	0.00	1,981.67	51,837.37	47,847.18	0.00	0.00
18	9,529.94	12,271.47	34,581.79	29,175.70	2,437.40	1,853.51	53.55	2,426.32	2,972.26	2,601.29	0.00	2,641.87	49,574.95	50,970.17	0.00	0.00
19	21,443.38	15,594.93	60,717.94	32,679.18	869.24	1,959.67	4,040.72	3,125.57	1,295.21	3,111.98	4,079.94	3,140.97	92,446.45	59,612.30	0.00	0.00
20	23,698.49	9,134.96	63,235.43	32,714.59	2,487.20	1,185.90	3,871.44	1,780.51	3,816.64	1,800.65	1,674.36	1,801.44	98,783.56	48,418.04	0.00	1,986.18
21	13,428.99	8,902.76	61,423.79	31,358.81	806.66	1,209.91	1,256.83	1,817.87	1,019.14	1,796.42	0.00	0.00	77,935.42	45,085.77	24,176.74	4,701.83
22	12,013.25	14,542.80	60,240.88	33,422.34	698.62	2,025.76	1,029.19	3,294.85	650.57	3,208.22	0.00	0.00	74,632.51	56,493.96	21,618.65	2,929.25
23	9,401.91	13,178.84	56,865.08	31,580.13	20.63	1,911.54	0.00	3,058.89	0.00	2,875.80	0.00	0.00	66,287.61	52,605.20	16,390.87	497.86
24	12,252.42	14,147.82	33,163.51	28,691.47	171.08	2,194.78	3,076.27	3,305.59	3,609.45	3,442.97	0.00	0.00	52,272.73	51,782.64	4,358.86	0.00
25	14,283.29	8,190.15	28,144.14	27,326.50	2,360.70	1,393.61	3,799.11	2,177.34	3,768.66	2,206.61	0.00	0.00	52,355.90	41,294.21	0.00	0.00
26	7,848.05	7,596.70	35,138.73	28,003.37	2,189.31	1,256.48	484.66	1,892.83	1,137.89	2,036.95	0.00	0.00	46,798.63	40,786.33	0.00	0.00
27	10,640.54	12,426.11	32,285.72	28,981.85	130.46	1,961.44	3,980.52	3,999.72	3,878.72	3,916.76	0.00	0.00	50,915.96	51,285.88	0.00	0.00
28	18,655.70	10,613.44	60,887.85	8,980.60	1,722.56	505.57	2,670.47	3,414.86	2,612.37	3,334.28	0.00	0.00	86,548.95	26,848.74	0.00	0.00
29	19,222.09	13,650.64	59,810.90	33,118.33	1,248.06	1,496.48	3,632.41	3,666.45	3,516.19	2,958.77	0.00	0.00	87,429.65	54,890.67	527.88	965.89
30	20,066.75	10,691.57	60,506.90	33,426.03	2,502.97	2,264.01	3,982.52	3,607.87	2,479.49	698.25	0.00	0.00	89,538.62	50,687.73	0.00	0.00
31	11,870.34	8,105.15	43,187.08	31,086.93	675.74	1,212.17	2,511.77	2,168.59	2,649.10	2,221.50	0.00	0.00	60,894.02	44,794.34	5,613.21	571.16
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APPENDIX 2: Data for kWh of electricity of top up supply that TNB need to supply to plant and kWh of electricity required by four electric chillers, in plant usage and UTP for February 2009

FEBRUARY 2009

	PLANT		UTP		EC1		EC2		EC3		EC4		TOTAL		TNB	
	Tp	To	Tp	To	Tp	To	Tp	To	Tp	To	Tp	To	Tp	To	Tp	To
1	10,588.35	5,127.01	34,467.40	30,709.14	21.38	22.06	3,931.59	1,999.35	3,848.02	2,026.52	0.00	0.00	52,856.74	39,884.08	0.00	0.00
2	19,618.77	11,135.34	62,489.23	33,737.52	906.42	519.11	4,066.66	3,913.37	3,949.01	3,768.24	0.00	0.00	91,030.09	53,073.58	0.00	0.00
3	19,022.96	12,047.45	50,171.63	36,025.61	2,361.02	2,120.21	3,627.09	3,404.32	3,674.46	3,264.44	0.00	0.00	78,857.15	56,862.02	0.00	0.00
4	22,163.33	13,880.41	62,014.20	11,744.96	2,547.42	2,379.21	4,030.72	3,876.73	3,895.57	3,758.68	0.00	0.00	94,651.25	35,639.99	0.00	0.00
5	19,222.09	13,650.64	59,810.90	33,118.33	2,544.74	1,555.33	440.17	3,043.16	3,897.92	3,142.67	0.00	0.00	85,915.81	54,510.13	0.00	0.00
6	14,003.01	8,590.12	59,988.28	33,136.18	472.22	489.72	3,886.60	2,632.34	888.23	2,939.78	0.00	0.00	79,238.34	47,788.14	0.00	0.00
7	3,888.85	8,386.91	41,238.02	30,989.59	533.75	2,077.43	0.00	25.07	0.00	2,927.16	0.00	0.00	45,660.62	44,406.14	0.00	0.00
8	10,149.66	12,021.74	35,774.66	32,170.43	109.05	1,990.77	4,009.38	3,880.19	3,368.09	3,211.99	0.00	0.00	53,410.84	53,275.12	0.00	0.00
9	8,633.32	12,307.62	38,152.03	33,456.10	1,341.26	1,994.43	0.00	2,792.06	1,528.67	3,005.28	0.00	0.00	49,655.28	53,555.48	0.00	0.00
10	22,434.23	11,547.05	68,791.55	39,045.66	2,607.01	2,411.13	4,079.34	3,193.34	2,345.00	714.91	0.00	0.00	100,257.13	56,912.08	0.00	0.00
11	21,373.15	16,963.43	67,326.13	37,687.21	1,016.35	2,424.76	3,968.33	3,904.96	3,851.05	3,793.71	1,016.35	2,424.76	98,551.36	67,198.82	0.00	0.00
12	20,759.92	14,122.39	68,355.98	38,180.78	2,578.60	2,407.17	1,225.25	2,469.26	3,951.81	3,787.75	0.00	0.00	96,871.55	60,967.35	0.00	0.00
13	20,736.63	14,901.11	68,992.05	38,156.04	855.36	2,042.75	4,038.83	3,322.37	3,918.11	3,221.35	0.00	0.00	98,540.98	61,643.61	0.00	0.00
14	13,311.26	8,676.61	52,861.57	7,341.74	1,500.48	1,790.36	0.00	141.40	2,374.61	2,821.89	0.00	0.00	70,047.92	20,772.00	0.00	0.00
15	8,726.20	4,947.41	35,347.84	32,897.81	2,091.45	500.55	0.00	520.32	2,093.71	720.41	0.00	0.00	48,259.19	39,586.51	0.00	0.00
16	17,829.07	15,765.11	67,316.24	33,840.54	823.47	2,089.39	2,056.78	3,761.60	3,952.95	3,677.67	0.00	0.00	91,978.52	59,134.31	0.00	0.00
17	17,928.86	15,036.73	67,808.75	34,746.66	903.46	2,136.45	2,201.34	3,233.51	3,836.65	3,149.29	0.00	0.00	92,679.05	58,302.64	0.00	0.00
18	18,879.69	13,673.84	68,409.14	33,964.94	1,891.43	1,893.74	1,257.49	3,035.29	3,903.97	2,937.97	0.00	0.00	94,341.71	55,505.78	0.00	0.00
19	20,287.48	15,697.01	66,007.59	34,382.97	1,273.62	2,165.81	3,184.07	3,497.38	3,908.14	3,367.83	0.00	0.00	94,660.91	59,111.01	0.00	0.00
20	20,509.83	13,337.75	64,609.64	34,499.77	2,559.40	1,656.36	1,381.45	2,613.32	1,153.60	2,575.72	0.00	0.00	90,213.92	54,682.93	0.00	0.00
21	11,867.70	8,674.62	47,026.21	32,988.04	1,515.09	862.63	784.93	2,083.07	739.74	2,070.40	0.00	0.00	61,933.65	46,678.76	0.00	0.00
22	9,507.28	14,788.32	36,727.47	31,512.89	1,240.31	2,324.05	283.80	2,804.11	1,724.30	3,470.49	0.00	0.00	49,483.15	54,899.86	0.00	0.00
23	19,744.31	14,199.71	61,658.63	33,569.70	610.59	2,238.53	3,958.19	3,208.44	3,792.51	3,144.90	0.00	0.00	89,764.23	56,361.28	0.00	0.00
24	19,599.19	12,362.48	64,045.76	10,460.56	2,494.12	1,710.20	874.47	2,506.53	895.25	2,158.72	0.00	0.00	87,908.80	29,198.48	0.00	0.00
25	18,600.73	11,347.36	62,285.19	35,840.71	950.31	1,343.65	2,873.64	2,037.21	3,785.14	2,039.06	0.00	0.00	88,495.01	52,607.99	0.00	0.00
26	18,817.68	9,996.74	61,961.71	35,038.50	1,967.84	1,319.81	2,302.17	1,987.39	2,871.81	1,347.06	0.00	0.00	87,921.20	50,289.50	0.00	0.00
27	20,349.34	11,880.27	61,183.35	34,201.07	2,499.95	1,477.03	1,330.45	2,324.14	3,809.59	2,317.34	0.00	0.00	89,172.69	52,199.85	0.00	0.00
28	11,687.61	8,689.48	43,754.02	32,691.34	1,213.64	1,249.05	2,003.20	1,853.41	3,903.97	2,937.97	0.00	0.00	62,562.45	47,421.24	0.00	0.00

APPENDIX 3: Data for kWh of electricity of top up supply that TNB need to supply to plant and kWh of electricity required by four electric chillers, in plant usage and UTP for March 2009

MARCH 2009

	PLANT		UTP		EC1		EC2		EC3		EC4		TOTAL		TNB	
	Tp	To	Tp	To	Tp	To	Tp	To	Tp	To	Tp	To	Tp	To	Tp	To
1	6,661.31	11,090.71	42,923.00	32,112.31	722.87	2,371.43	0.00	323.13	739.74	2,070.40	0.00	0.00	51,046.92	47,967.98	0.00	0.00
2	23,631.49	18,161.96	64,209.10	35,161.09	2,475.24	2,273.82	3,924.39	3,862.46	954.24	3,272.05	0.00	0.00	95,194.46	62,731.37	0.00	0.00
3	19,042.52	14,357.42	64,044.50	35,963.40	519.88	494.30	3,967.31	3,658.03	3,725.75	3,604.70	0.00	0.00	91,299.96	58,077.86	0.00	0.00
4	20,667.79	12,361.58	67,944.67	10,459.80	1,933.67	1,745.85	1,404.37	872.15	1,251.35	2,593.08	0.00	0.00	93,201.85	28,032.46	0.00	0.00
5	20,763.51	16,419.33	64,106.08	35,329.34	2,500.34	2,337.80	1,290.78	3,389.09	3,751.49	3,659.25	0.00	0.00	92,412.20	61,134.82	0.00	0.00
6	20,035.45	12,853.06	66,814.50	35,112.95	2,084.12	1,641.55	1,240.57	2,502.06	3,779.86	2,440.33	0.00	0.00	93,954.50	54,549.95	0.00	0.00
7	16,805.02	10,361.14	48,668.35	34,366.86	1,602.43	1,169.78	2,652.64	1,924.47	2,275.98	1,788.61	0.00	0.00	72,004.41	49,610.86	0.00	0.00
8	10,386.96	6,214.13	36,148.60	30,700.60	1,213.64	1,249.05	0.00	877.67	3,371.72	1,093.94	0.00	0.00	51,120.92	40,135.38	0.00	0.00
9	11,830.68	14,833.31	36,157.64	29,871.13	775.95	2,358.58	3,877.42	3,826.96	0.00	1,396.11	0.00	0.00	52,641.68	52,286.10	0.00	0.00
10	21,128.80	13,170.17	65,906.22	33,222.36	2,350.90	1,616.60	1,162.48	2,576.18	3,436.29	2,262.70	0.00	0.00	93,984.69	52,848.01	0.00	0.00
11	18,912.98	10,700.78	66,838.19	34,625.63	779.64	1,132.14	3,998.38	2,912.00	786.38	192.57	0.00	0.00	91,315.57	49,563.12	0.00	0.00
12	21,515.64	16,065.89	64,640.76	35,539.03	2,545.95	2,103.48	1,930.73	3,189.01	1,159.88	3,289.29	0.00	0.00	91,792.96	60,186.71	0.00	0.00
13	20,612.70	9,379.87	64,342.17	36,499.36	760.27	1,201.47	3,859.06	1,685.45	1,301.12	1,697.56	0.00	0.00	90,875.32	50,463.71	0.00	0.00
14	7,832.58	5,196.11	47,496.70	4,396.70	20.12	663.44	0.00	886.29	0.00	981.21	0.00	0.00	55,349.39	12,123.75	0.00	0.00
15	9,450.61	2,486.36	35,780.96	33,595.36	2,157.24	493.87	0.00	886.29	0.00	232.08	0.00	0.00	47,388.81	37,693.96	0.00	0.00
16	19,709.64	15,618.32	67,048.15	35,813.21	793.34	1,680.41	3,993.49	3,753.92	733.22	3,215.61	0.00	0.00	92,277.84	60,081.48	0.00	0.00
17	20,330.01	10,843.63	67,361.00	36,829.60	2,580.92	1,653.81	1,127.53	3,201.72	3,819.49	2,754.48	0.00	0.00	95,218.95	55,283.25	0.00	0.00
18	20,685.89	10,300.28	65,388.51	36,141.61	898.93	1,233.92	4,143.56	2,077.09	3,849.05	1,567.20	0.00	0.00	94,965.94	51,320.10	0.00	0.00
19	18,063.06	8,543.02	64,237.17	36,994.77	2,487.37	989.41	51.20	1,574.30	19.32	1,466.18	0.00	0.00	84,858.12	49,567.68	0.00	0.00
20	23,763.25	11,306.53	61,980.48	35,787.67	1,648.26	1,443.82	3,902.84	3,098.20	2,647.32	2,346.38	0.00	0.00	93,942.15	53,982.60	0.00	0.00
21	7,976.92	12,946.47	38,026.96	30,209.66	1,512.31	1,912.79	982.47	3,255.23	352.48	1,641.23	0.00	0.00	48,851.15	49,965.39	0.00	0.00
22	14,196.52	17,250.39	29,643.70	28,556.95	2,545.95	2,103.48	1,000.59	3,898.56	3,769.07	3,629.86	0.00	0.00	51,155.84	55,439.24	0.00	0.00
23	16,491.83	15,429.13	0.00	0.00	2,549.46	2,404.14	2,998.55	3,421.87	0.00	2,990.17	0.00	0.00	22,039.85	24,245.31	55,989.57	30,955.70
24	56,508.28	30,806.97	0.00	26,067.43	2,176.73	2,398.32	0.00	3,074.56	0.00	3,286.49	0.00	0.00	58,685.01	65,633.77	15,668.39	16,968.35
25	15,959.26	16,867.62	55,997.62	29,068.14	1,990.52	2,233.69	396.00	3,755.21	0.00	3,033.95	0.00	0.00	74,343.40	54,958.61	0.00	0.00
26	19,509.11	15,557.36	53,255.67	30,749.93	1,627.09	2,266.94	2,675.58	3,845.42	2,667.81	2,157.84	0.00	0.00	79,735.26	54,577.49	0.00	0.00
27	20,044.11	16,018.32	50,021.00	30,775.74	1,675.15	2,113.92	2,654.81	3,086.44	2,523.40	3,158.77	0.00	0.00	76,918.46	55,153.19	0.00	0.00
28	8,489.35	11,544.22	37,824.05	28,989.28	737.79	1,575.06	1,375.94	2,338.33	123.90	2,328.68	0.00	0.00	48,551.03	46,775.57	0.00	0.00
29	13,778.37	15,484.24	31,641.83	29,538.31	2,157.00	2,369.43	2,247.05	3,101.17	3,899.32	3,694.07	0.00	0.00	53,723.58	54,187.23	0.00	0.00
30	19,893.60	15,662.85	63,821.36	33,537.62	533.12	1,861.44	3,980.00	3,407.28	417.70	2,959.34	0.00	0.00	88,645.78	57,428.53	0.00	0.00
31	22,143.07	13,234.35	65,381.37	35,763.48	899.74	391.62	4,053.97	3,165.59	1,835.55	3,350.87	0.00	0.00	94,313.70	55,905.92	0.00	0.00

APPENDIX 4: Data for kWh of electricity of top up supply that TNB need to supply to plant and kWh of electricity required by four electric chillers, in plant usage and UTP for April 2009

APRIL 2009

	PLANT		UTP		EC1		EC2		EC3		EC4		TOTAL		TNB	
	Tp	To	Tp	To	Tp	To	Tp	To	Tp	To	Tp	To	Tp	To	Tp	To
1	22,392.00	13,162.25	64,024.41	36,627.02	2,599.28	1,862.76	2,037.36	2,972.67	3,902.04	3,210.57	0.00	0.00	**94,955.10**	**57,835.26**	**0.00**	**0.00**
2	22,159.36	13,186.01	66,101.49	37,052.12	1,578.83	1,975.59	2,901.85	2,649.26	1,619.67	3,205.49	0.00	0.00	**94,361.21**	**58,068.48**	**0.00**	**0.00**
3	22,537.05	13,457.77	66,951.26	36,529.37	1,629.24	1,184.31	1,830.32	2,691.84	3,802.79	3,040.71	0.00	0.00	**96,750.66**	**56,904.00**	**0.00**	**0.00**
4	12,967.68	12,557.47	50,639.75	10,625.55	1,489.83	1,925.70	897.48	3,476.34	884.21	2,755.54	0.00	0.00	**66,878.94**	**31,340.60**	**0.00**	**0.00**
5	7,268.37	8,733.65	37,556.72	33,196.52	778.83	1,336.03	1,186.59	1,467.16	1,100.15	1,427.43	0.00	0.00	**47,890.65**	**46,160.79**	**0.00**	**0.00**
6	23,196.07	18,274.43	65,544.68	36,881.53	2,494.61	2,374.60	2,536.03	3,780.32	1,548.55	3,514.34	0.00	0.00	**95,319.95**	**64,825.22**	**0.00**	**0.00**
7	20,631.56	14,664.83	69,478.72	38,901.34	1,545.30	2,057.84	2,142.66	3,293.09	1,204.61	1,278.41	0.00	0.00	**95,002.85**	**60,195.52**	**0.00**	**0.00**
8	20,459.25	13,163.01	67,509.18	37,758.35	2,538.09	1,718.64	1,366.46	3,067.48	1,301.80	896.53	0.00	0.00	**93,174.79**	**56,604.00**	**0.00**	**0.00**
9	21,366.44	13,045.73	66,123.48	38,558.64	2,406.54	1,949.18	1,370.94	2,423.94	3,641.57	3,062.79	0.00	0.00	**94,908.98**	**59,040.28**	**0.00**	**0.00**
10	22,529.90	12,932.54	65,375.65	36,335.80	2,473.82	1,951.60	2,434.70	2,474.63	3,727.18	3,027.77	0.00	0.00	**96,541.25**	**56,722.34**	**0.00**	**0.00**
11	15,840.75	8,220.29	48,952.47	34,135.03	263.49	1,330.80	3,398.86	1,622.67	3,292.43	2,065.77	0.00	0.00	**71,748.01**	**47,374.56**	**0.00**	**0.00**
12	5,199.87	9,829.97	47,340.80	34,639.87	171.11	249.21	680.77	2,684.56	771.22	2,369.11	0.00	0.00	**54,163.76**	**49,772.73**	**0.00**	**0.00**
13	23,090.03	16,740.62	70,583.89	37,998.26	374.57	1,011.42	3,975.79	3,898.01	3,636.20	3,655.88	0.00	0.00	**101,660.49**	**63,304.18**	**0.00**	**0.00**
14	19,264.92	16,177.37	70,777.72	13,688.54	653.28	823.92	1,573.25	3,881.51	1,469.44	3,477.63	0.00	0.00	**93,738.61**	**38,048.98**	**0.00**	**0.00**
15	21,426.40	14,603.31	70,450.95	37,094.52	286.69	218.86	3,959.38	3,944.21	3,408.67	3,510.74	0.00	0.00	**99,532.09**	**59,371.65**	**0.00**	**0.00**
16	22,009.14	12,642.79	66,293.47	37,818.88	1,278.53	506.65	2,819.44	3,114.94	2,294.96	2,279.36	0.00	0.00	**94,695.55**	**56,362.61**	**0.00**	**0.00**
17	21,573.34	11,898.52	67,294.58	36,438.62	2,102.22	1,931.02	1,936.66	1,570.56	3,959.25	1,544.84	0.00	0.00	**96,866.05**	**53,383.56**	**0.00**	**0.00**
18	13,164.67	12,459.03	46,581.21	34,517.39	890.93	2,056.55	1,472.42	2,667.98	1,446.03	1,753.15	0.00	0.00	**63,555.27**	**53,454.10**	**0.00**	**0.00**
19	12,548.45	10,309.98	36,200.91	32,065.65	2,484.10	2,425.60	1,447.03	206.56	0.00	542.19	0.00	0.00	**52,680.49**	**45,549.99**	**0.00**	**0.00**
20	8,037.38	11,960.03	39,881.85	32,213.29	2,263.56	2,241.70	0.00	0.00	1,146.91	2,803.62	0.00	0.00	**51,329.70**	**49,218.64**	**0.00**	**0.00**
21	24,489.40	15,617.08	64,364.90	35,364.66	2,441.11	2,366.50	3,937.94	3,468.77	1,845.31	1,788.18	3,465.23	3,386.91	**100,543.90**	**61,992.10**	**0.00**	**0.00**
22	22,650.74	10,672.33	67,803.27	34,425.69	1,072.78	1,904.44	4,107.44	732.73	3,844.13	587.86	1,346.63	2,775.16	**100,825.00**	**51,098.20**	**0.00**	**0.00**
23	21,609.26	16,297.03	69,717.75	37,212.19	2,120.26	2,229.33	1,572.94	3,567.20	1,227.99	2,313.90	3,593.17	3,188.33	**99,841.38**	**64,807.99**	**0.00**	**0.00**
24	21,440.87	15,724.13	70,974.90	13,305.03	1,440.81	2,037.52	2,432.60	2,989.34	1,278.70	2,564.39	3,615.65	2,902.64	**101,183.53**	**39,523.04**	**0.00**	**0.00**
25	10,203.05	13,052.65	45,584.31	33,893.71	1,254.50	1,353.90	227.34	2,811.00	190.31	2,170.12	1,669.93	2,424.18	**59,129.44**	**55,705.56**	**0.00**	**0.00**
26	11,069.60	11,102.64	37,987.16	33,875.92	774.37	1,566.91	0.00	2,203.38	845.71	2,625.99	2,809.31	1,495.00	**53,486.15**	**52,869.84**	**0.00**	**0.00**
27	22,887.70	9,470.86	66,839.45	37,291.98	847.02	513.49	4,072.03	1,036.94	3,836.79	3,679.46	1,764.63	380.61	**100,247.62**	**52,373.34**	**0.00**	**0.00**
28	21,801.17	15,504.94	67,007.81	37,196.54	2,594.38	2,399.77	2,265.75	2,350.11	3,857.70	3,651.23	381.58	1,798.51	**97,908.40**	**62,901.10**	**0.00**	**0.00**
29	21,344.80	9,505.53	66,156.85	32,638.37	1,636.07	1,395.52	2,893.23	2,174.79	3,346.23	1,677.29	1,722.59	1,013.96	**97,099.76**	**48,405.46**	**1,265.83**	**4,579.39**
30	24,394.22	13,544.77	63,391.80	36,400.48	2,516.62	2,062.72	3,982.56	3,553.27	1,435.20	2,218.94	3,505.91	2,387.34	**99,226.30**	**60,167.52**	**0.00**	**0.00**

APPENDIX 5: Data for kWh of electricity of top up supply that TNB need to supply to plant and kWh of electricity required by four electric chillers, in plant usage and UTP for May 2009

MAY 2009

	PLANT		UTP		EC1		EC2		EC3		EC4		TOTAL		TNB	
	Tp	To	Tp	To	Tp	To	Tp	To	Tp	To	Tp	To	Tp	To	Tp	To
1	40,382.32	32,933.98	0.00	0.00	320.65	1,427.19	423.34	2,438.84	337.92	2,321.80	6,093.52	10,869.58	**47,557.75**	**49,991.39**	**0.00**	**0.00**
2	9,870.91	8,032.00	38,273.90	31,886.85	556.25	838.62	32.06	1,333.27	381.25	1,258.30	2,328.50	1,853.98	**51,442.87**	**45,203.04**	**0.00**	**0.00**
3	11,417.09	8,839.08	33,403.43	30,500.81	1,804.29	488.27	3,104.91	2,735.08	36.26	668.54	2,185.16	2,746.49	**51,951.13**	**45,978.27**	**0.00**	**0.00**
4	24,263.05	12,903.50	62,088.66	10,918.35	2,505.57	1,822.31	3,341.21	3,080.60	2,476.45	2,868.42	2,867.30	689.38	**97,542.24**	**32,282.56**	**0.00**	**0.00**
5	23,640.90	8,279.74	61,600.31	34,693.75	869.87	216.04	3,910.91	1,862.34	3,648.19	1,508.47	3,406.28	1,676.49	**97,076.46**	**48,236.83**	**0.00**	**0.00**
6	21,003.52	9,380.10	62,196.55	35,525.41	2,486.49	1,070.36	2,996.10	1,787.17	2,801.61	1,665.72	680.90	1,688.29	**92,165.18**	**51,117.05**	**0.00**	**0.00**
7	21,635.84	12,786.55	64,914.98	35,655.49	746.01	1,553.52	3,986.49	2,354.53	3,748.31	2,186.48	1,684.98	2,322.38	**96,716.60**	**56,858.94**	**0.00**	**0.00**
8	6,505.80	8,632.73	40,020.17	31,786.44	338.67	987.90	243.25	1,617.06	247.79	1,274.01	407.50	1,435.57	**47,763.18**	**45,733.71**	**0.00**	**0.00**
9	8,322.37	7,139.42	38,602.77	32,648.27	532.63	1,666.02	649.96	0.00	1,996.62	0.00	491.69	2,367.46	**50,596.05**	**43,821.17**	**0.00**	**0.00**
10	11,372.09	16,294.28	38,767.88	32,319.63	1,254.44	2,450.83	1,275.36	2,591.70	2,166.51	3,218.48	1,542.21	3,457.17	**56,378.49**	**60,332.08**	**0.00**	**0.00**
11	23,339.43	19,112.18	68,762.62	35,537.39	2,517.15	2,409.25	2,688.93	3,900.08	1,200.36	3,104.88	3,605.39	3,415.39	**102,113.89**	**67,479.17**	**0.00**	**0.00**
12	25,158.73	18,029.80	67,423.77	35,890.20	2,592.87	2,338.12	3,621.60	3,761.32	1,263.55	2,890.21	3,568.08	3,298.22	**103,628.60**	**66,207.87**	**0.00**	**0.00**
13	24,191.32	16,468.19	71,132.18	36,984.20	2,499.36	1,585.70	3,175.06	3,483.05	3,795.44	3,143.53	3,561.13	3,037.42	**108,354.49**	**64,702.08**	**0.00**	**0.00**
14	24,429.93	16,651.73	67,780.47	14,089.93	2,516.28	2,129.31	1,418.14	2,578.22	3,843.14	3,451.96	3,459.83	3,023.30	**103,447.79**	**41,924.45**	**0.00**	**0.00**
15	23,672.79	10,686.87	67,420.80	36,289.81	2,566.19	1,175.74	1,407.04	1,912.94	3,904.14	1,830.04	2,872.79	1,749.99	**101,843.76**	**53,645.38**	**0.00**	**0.00**
16	13,625.23	9,450.22	53,128.09	33,683.64	907.64	1,014.71	1,512.30	1,699.36	1,583.34	1,724.82	188.14	1,584.93	**70,944.74**	**49,157.68**	**0.00**	**0.00**
17	6,942.85	4,504.50	39,343.13	32,405.62	534.85	43.26	32.19	588.04	35.66	676.28	12.58	492.89	**46,901.26**	**38,710.60**	**0.00**	**0.00**
18	24,203.21	17,258.34	66,800.13	37,212.33	841.70	2,089.97	3,792.54	3,127.08	3,821.60	3,304.30	3,311.61	2,928.50	**102,770.78**	**65,920.52**	**0.00**	**0.00**
19	25,680.32	15,957.06	68,407.26	38,601.77	2,617.07	2,175.45	4,093.11	1,591.64	3,979.73	3,408.05	1,466.98	3,102.57	**106,244.47**	**64,836.55**	**0.00**	**0.00**
20	24,779.28	13,686.04	68,000.09	37,173.45	2,582.62	1,730.74	3,304.48	2,987.02	3,944.66	2,085.89	1,636.07	2,362.49	**104,247.20**	**60,025.63**	**0.00**	**0.00**
21	23,998.70	11,898.49	67,283.58	39,122.73	2,549.12	687.88	3,299.47	2,384.59	1,376.84	2,639.89	3,539.96	2,378.96	**102,047.67**	**59,112.55**	**0.00**	**0.00**
22	64,500.60	37,607.65	24,180.21	11,659.21	2,622.05	1,563.75	2,313.19	2,726.04	3,979.18	2,641.55	1,962.84	644.18	**99,558.07**	**56,842.39**	**0.00**	**0.00**
23	18,206.45	11,317.24	45,788.67	34,891.29	1,730.17	1,335.79	2,816.22	1,509.37	2,659.63	2,150.15	2,408.38	2,613.67	**73,609.51**	**53,817.50**	**0.00**	**0.00**
24	7,157.36	11,026.54	40,268.94	9,330.15	970.29	1,497.18	375.70	2,345.72	0.00	2,187.78	81.57	2,013.09	**48,853.86**	**28,400.46**	**0.00**	**0.00**
25	22,609.53	18,918.96	70,771.96	35,687.48	2,616.58	2,307.36	1,345.34	3,654.02	1,378.19	3,742.81	3,589.88	3,268.27	**102,311.49**	**67,578.91**	**0.00**	**0.00**
26	23,844.36	17,655.70	62,123.10	34,546.52	2,460.81	2,195.05	3,909.56	3,609.06	1,354.28	3,496.85	3,469.36	3,147.19	**97,161.46**	**64,650.36**	**0.00**	**0.00**
27	24,313.02	11,524.95	62,735.44	33,129.31	2,641.87	1,374.35	3,228.96	2,441.14	1,511.38	1,980.69	3,609.45	2,120.61	**98,040.11**	**52,571.05**	**0.00**	**0.00**
28	24,368.79	10,640.27	63,365.57	32,869.87	2,522.32	1,485.11	3,953.86	2,681.54	4,085.40	2,749.88	3,498.73	2,309.18	**101,794.67**	**52,735.84**	**0.00**	**0.00**
29	21,534.79	12,209.02	60,165.92	31,953.75	877.19	1,481.64	4,085.40	2,749.88	1,269.97	745.41	1,199.28	2,185.16	**89,132.56**	**51,324.86**	**0.00**	**0.00**
30	12,105.98	11,519.14	34,680.47	28,539.84	1,395.64	1,532.11	488.84	2,730.44	442.67	2,162.07	2,963.65	2,335.43	**52,077.25**	**48,819.04**	**0.00**	**0.00**
31	8,089.28	7,695.12	33,819.74	27,104.97	209.89	761.68	1,249.92	1,698.72	1,250.03	1,856.84	390.13	1,778.00	**45,008.98**	**40,895.34**	**0.00**	**0.00**

APPENDIX 6: Data for kWh of electricity of top up supply that TNB need to supply to plant and kWh of electricity required by four electric chillers, in plant usage and UTP for June 2009

JUNE 2009

	PLANT		UTP		EC1		EC2		EC3		EC4		TOTAL		TNB	
	Tp	To	Tp	To	Tp	To	Tp	To	Tp	To	Tp	To	Tp	To	Tp	To
1	21,919.38	11,258.93	46,951.61	28,210.86	2,244.67	1,590.83	0.00	0.00	2,520.90	2,593.95	2,329.90	1,818.34	**75,966.45**	**45,472.92**	**0.00**	**0.00**
2	21,998.01	11,436.21	47,400.65	28,434.06	2,248.28	1,555.21	0.00	0.00	2,542.17	2,059.26	2,357.09	1,931.80	**76,546.20**	**45,416.54**	**0.00**	**0.00**
3	21,144.30	10,474.97	49,373.77	27,948.37	1,997.74	1,562.32	0.00	0.00	2,580.65	2,129.11	2,362.42	1,728.55	**77,458.87**	**43,843.32**	**0.00**	**0.00**
4	8,756.57	11,212.06	38,117.30	9,487.13	945.63	1,769.12	0.00	0.00	85.82	2,642.88	1,044.76	2,094.24	**48,950.09**	**27,205.43**	**0.00**	**0.00**
5	10,305.93	11,692.13	30,931.69	26,520.30	470.92	1,808.31	0.00	0.00	1,348.94	2,706.28	2,176.43	2,155.66	**45,233.91**	**44,882.68**	**0.00**	**0.00**
6	20,660.68	5,727.24	50,985.64	28,537.56	2,173.96	1,072.01	0.00	0.00	2,634.43	1,041.66	1,924.19	13.53	**78,378.89**	**36,392.01**	**0.00**	**0.00**
7	21,486.63	11,705.51	54,070.34	28,881.85	2,014.91	1,712.37	0.00	0.00	3,808.22	2,669.23	3,148.43	2,516.72	**84,528.54**	**47,485.68**	**0.00**	**0.00**
8	20,818.44	10,628.66	52,471.04	29,023.56	2,113.30	1,422.47	0.00	0.00	3,720.13	3,814.86	3,400.00	2,741.31	**82,522.90**	**47,630.85**	**0.00**	**0.00**
9	20,701.07	9,700.92	52,269.73	28,594.15	2,222.31	1,693.06	0.00	0.00	2,864.68	2,264.98	2,163.32	13.67	**80,221.10**	**42,266.78**	**0.00**	**0.00**
10	23,107.85	8,415.49	52,223.92	29,578.15	1,993.69	1,472.38	0.00	0.00	3,078.71	1,381.16	3,075.54	13.61	**83,479.72**	**40,860.79**	**0.00**	**0.00**
11	6,779.11	6,191.03	38,381.49	29,656.31	413.37	1,230.11	0.00	0.00	0.00	0.00	601.09	13.36	**46,175.05**	**37,090.80**	**0.00**	**0.00**
12	6,328.36	11,872.29	36,939.21	32,844.25	476.86	1,447.80	0.00	0.00	11.23	2,235.10	52.56	2,605.21	**43,808.22**	**51,004.65**	**0.00**	**0.00**
13	26,316.22	15,451.06	58,635.94	33,691.25	2,657.79	1,857.11	0.00	0.00	4,026.74	3,056.32	3,574.62	3,002.96	**95,211.31**	**57,058.70**	**3,111.74**	**1,433.28**
14	24,384.16	10,849.40	60,021.83	9,180.26	933.19	523.45	0.00	0.00	3,930.76	2,522.19	3,541.84	2,126.80	**92,811.78**	**25,202.10**	**2,653.74**	**1,052.19**
15	25,857.05	13,511.56	57,729.90	36,236.60	2,424.39	1,856.89	0.00	0.00	3,755.59	2,125.51	3,228.71	2,817.00	**92,995.64**	**56,547.56**	**2,055.99**	**655.34**
16	26,386.91	10,268.04	58,859.14	35,285.00	2,578.95	1,174.54	0.00	0.00	115.91	417.18	3,444.15	997.17	**91,385.05**	**48,141.93**	**2,712.96**	**270.48**
17	25,713.71	11,499.03	59,806.02	36,537.09	2,562.12	518.22	0.00	0.00	0.00	0.00	3,489.28	2,399.06	**91,571.13**	**50,953.40**	**2,499.26**	**819.88**
18	23,843.52	18,109.98	44,799.46	35,251.44	2,526.04	2,434.60	0.00	0.00	0.00	0.00	3,492.58	3,448.93	**74,661.60**	**59,244.94**	**2,244.33**	**1,243.83**
19	6,472.34	7,590.17	32,481.98	35,135.89	696.16	1,044.65	0.00	0.00	0.00	0.00	1,632.48	1,818.28	**41,282.95**	**45,588.99**	**0.00**	**0.00**
20	24,665.55	14,709.03	61,298.27	37,495.24	877.95	521.19	0.00	0.00	0.00	0.00	3,607.37	3,002.07	**90,449.14**	**55,727.53**	**0.00**	**0.00**
21	24,581.82	12,793.10	61,836.62	37,869.30	2,593.39	2,273.75	2,127.25	870.15	0.00	0.00	3,562.68	1,066.16	**94,701.77**	**54,872.47**	**0.00**	**0.00**
22	24,832.68	10,158.40	59,712.94	35,084.02	2,291.18	1,527.02	2,577.18	694.21	0.00	0.00	3,149.54	2,188.25	**92,563.51**	**49,651.89**	**371.30**	**1,256.85**
23	23,705.48	13,970.50	62,223.79	36,411.54	2,629.76	1,767.56	2,350.89	1,966.38	0.00	0.00	3,572.77	2,602.58	**94,482.70**	**56,718.56**	**3,111.74**	**1,433.28**
24	19,520.93	8,390.49	56,998.69	7,099.64	1,639.96	1,157.18	2,229.61	1,216.68	840.83	87.10	2,273.37	1,318.22	**83,503.39**	**19,249.23**	**477.40**	**553.67**
25	6,262.27	11,206.18	47,918.84	34,217.49	21.25	1,894.72	113.79	642.09	81.66	2,371.62	12.20	2,416.37	**54,410.00**	**52,749.06**	**8,380.26**	**1,966.05**
26	7,894.17	16,299.31	41,340.77	33,600.80	1,328.12	2,440.55	850.53	3,314.82	203.12	2,215.25	1,137.80	3,441.26	**52,754.51**	**61,311.99**	**711.88**	**1,907.53**
27	26,222.04	19,220.39	66,018.99	36,803.32	2,584.56	2,424.23	2,508.54	3,287.28	3,450.60	3,331.73	3,550.90	3,384.08	**104,335.62**	**68,451.02**	**0.00**	**219.30**
28	23,443.70	16,415.63	64,486.95	36,859.19	1,415.53	2,103.81	3,422.99	2,928.30	2,733.89	2,585.81	2,849.15	3,032.22	**98,352.20**	**63,924.96**	**0.00**	**0.00**
29	21,928.16	12,380.61	62,683.80	34,326.97	1,662.58	1,476.14	3,398.41	2,576.32	1,333.62	2,014.38	3,537.03	2,415.48	**94,543.61**	**55,189.92**	**0.00**	**0.00**
30	22,745.46	9,804.42	61,214.79	34,529.18	2,634.36	1,363.39	2,293.06	709.13	3,526.80	2,245.62	2,516.59	1,721.92	**94,931.06**	**50,373.66**	**0.00**	**0.00**

APPENDIX 7: Data for kWh of electricity of top up supply that TNB need to supply to plant and kWh of electricity required by four electric chillers, in plant usage and UTP for July 2009

JULY 2009

	PLANT		UTP		EC1		EC2		EC3		EC4		TOTAL		TNB	
	Tp	To	Tp	To	Tp	To	Tp	To	Tp	To	Tp	To	Tp	To	Tp	To
1	25,166.98	10,839.73	59,667.44	31,392.33	2,621.42	1,247.28	1,540.27	1,638.96	3,653.06	1,931.82	3,609.39	2,126.24	**96,258.55**	**49,236.36**	**0.00**	**0.00**
2	24,290.09	14,343.16	54,462.16	31,057.86	2,614.00	1,889.35	4,093.81	2,755.19	2,684.86	2,649.97	1,712.91	2,479.32	**89,857.82**	**55,174.85**	**0.00**	**0.00**
3	24,212.38	12,322.88	60,212.70	31,249.16	1,112.11	1,519.75	4,168.78	2,317.41	2,527.26	2,249.70	3,651.38	2,292.71	**95,884.61**	**51,951.61**	**0.00**	**0.00**
4	26,664.36	15,544.89	58,072.02	13,153.37	2,649.25	1,894.38	4,144.93	3,023.11	4,015.92	2,855.85	2,404.21	2,675.69	**97,950.69**	**39,147.30**	**0.00**	**0.00**
5	9,917.89	7,898.28	34,801.81	27,495.49	162.39	1,099.95	663.04	1,872.04	0.00	0.00	3,214.78	2,470.45	**48,759.91**	**40,836.22**	**0.00**	**0.00**
6	8,204.20	8,971.60	37,617.24	27,407.08	1,210.59	1,613.05	0.00	1,631.38	0.00	531.57	321.69	2,110.84	**47,353.72**	**42,265.52**	**0.00**	**0.00**
7	11,629.76	13,640.79	30,876.05	28,036.98	1,995.46	1,889.74	0.00	2,494.15	3,109.34	2,941.04	15.31	2,362.70	**47,625.92**	**51,365.41**	**0.00**	**0.00**
8	23,905.71	8,744.86	56,738.66	25,805.52	2,632.86	808.66	4,114.74	2,408.84	4,013.94	1,677.48	431.65	779.14	**91,837.56**	**40,224.50**	**0.00**	**2,109.44**
9	21,694.25	11,462.75	59,278.58	31,086.11	844.81	207.76	4,139.22	2,977.87	4,004.46	2,519.84	1,230.51	2,722.41	**91,191.84**	**50,976.74**	**0.00**	**0.00**
10	21,786.74	12,442.46	63,655.91	32,631.38	2,611.49	1,535.75	1,306.84	2,549.48	1,276.35	2,569.56	3,572.35	2,322.77	**94,209.68**	**54,051.41**	**0.00**	**0.00**
11	25,194.38	15,265.69	56,006.39	32,862.36	1,294.77	2,167.44	4,139.26	2,415.63	3,427.91	2,858.27	3,618.00	2,430.57	**93,680.70**	**57,999.96**	**0.00**	**0.00**
12	24,541.74	9,438.22	54,246.60	29,511.35	2,657.16	1,495.10	3,759.28	2,464.79	4,057.96	2,361.49	1,197.14	527.98	**90,459.89**	**45,798.93**	**0.00**	**0.00**
13	9,395.73	9,614.52	34,100.27	26,847.39	200.95	1,413.40	1,568.06	1,853.45	1,160.02	1,824.74	13.23	1,905.63	**46,438.25**	**43,459.13**	**0.00**	**0.00**
14	7,826.41	15,158.73	29,952.59	12,826.61	430.50	2,173.89	7.01	2,814.36	1,066.16	3,211.09	337.17	3,132.61	**39,619.83**	**39,317.29**	**0.00**	**0.00**
15	14,093.07	13,378.69	54,761.08	28,973.11	746.32	1,426.52	714.04	3,056.47	655.86	2,215.71	1,043.29	2,750.06	**72,013.66**	**51,800.55**	**20,976.53**	**1,784.60**
16	16,868.92	16,402.38	52,525.81	30,212.40	881.20	2,006.92	2,466.10	3,265.87	1,239.69	3,363.00	1,339.21	2,790.28	**75,320.92**	**58,040.86**	**20,458.75**	**2,752.45**
17	15,884.58	13,707.04	50,336.45	28,168.71	1,408.35	1,554.73	243.51	3,210.26	1,194.17	3,029.05	1,040.96	2,101.66	**70,108.02**	**51,771.45**	**16,571.81**	**854.26**
18	18,254.52	14,980.21	51,146.72	28,520.09	1,265.46	1,674.27	0.00	0.00	1,769.62	2,832.53	1,618.29	3,063.13	**74,054.60**	**51,070.22**	**9,502.00**	**1,192.21**
19	14,445.08	15,450.40	52,397.03	28,870.81	964.69	2,106.72	0.00	0.00	286.79	3,128.32	1,206.70	2,552.27	**69,300.29**	**52,108.53**	**18,694.34**	**1,851.31**
20	9,052.94	15,187.07	34,104.88	25,424.39	175.09	1,716.22	0.00	0.00	922.96	2,730.44	1,188.73	3,104.23	**45,444.59**	**48,162.95**	**0.00**	**0.00**
21	14,012.03	13,734.83	27,767.60	27,558.54	1,101.62	1,750.63	0.00	0.00	660.62	2,773.34	3,500.05	2,919.60	**47,041.93**	**48,736.94**	**0.00**	**0.00**
22	24,994.55	14,402.90	54,843.26	28,749.89	2,573.80	1,885.48	0.00	0.00	3,946.14	3,090.83	3,577.04	2,835.39	**89,934.80**	**50,964.49**	**0.00**	**0.00**
23	24,721.91	16,549.57	54,951.95	30,052.79	2,591.73	2,153.15	0.00	0.00	3,961.94	3,107.70	3,595.66	3,132.01	**89,823.18**	**54,995.23**	**0.00**	**0.00**
24	24,178.37	17,153.68	57,920.89	14,514.65	2,529.67	2,287.48	0.00	0.00	3,880.00	3,629.42	3,525.39	3,298.60	**92,034.33**	**40,883.83**	**0.00**	**1,091.50**
25	24,428.74	16,820.43	53,897.07	28,115.44	2,667.18	2,240.56	0.00	0.00	4,078.92	3,605.07	3,708.93	3,278.77	**88,780.84**	**54,060.27**	**5,319.94**	**8,364.31**
26	23,544.95	14,061.26	51,438.81	28,176.95	2,511.48	2,061.21	0.00	0.00	3,796.51	2,720.54	3,454.50	2,394.86	**84,746.25**	**49,414.82**	**0.00**	**3,248.75**
27	6,439.40	12,673.89	31,940.28	25,747.67	220.37	1,663.45	0.00	0.00	230.36	2,701.43	13.09	2,178.30	**38,843.50**	**44,964.74**	**0.00**	**0.00**
28	15,271.97	11,404.56	26,867.02	24,958.91	2,407.53	1,367.06	0.00	0.00	748.11	2,523.83	3,393.50	2,405.99	**48,688.12**	**42,660.35**	**0.00**	**0.00**
29	21,944.52	9,177.71	49,432.86	28,467.60	1,897.25	1,051.63	0.00	0.00	2,621.79	1,547.02	3,125.50	2,298.48	**79,021.92**	**42,542.45**	**0.00**	**0.00**
30	22,358.13	10,883.01	48,519.03	28,610.22	2,357.39	1,568.29	0.00	0.00	2,720.31	2,392.10	2,539.18	1,798.39	**78,494.04**	**45,252.01**	**0.00**	**0.00**

APPENDIX 8: Data for kWh of electricity of top up supply that TNB need to supply to plant and kWh of electricity required by four electric chillers, in plant usage and UTP for August 2009

AUGUST 2009

	PLANT		UTP		EC1		EC2		EC3		EC4		TOTAL		TNB	
	Tp	To	Tp	To	Tp	To	Tp	To	Tp	To	Tp	To	Tp	To	Tp	To
1	8,629.30	8,559.05	32,859.52	29,103.60	0.00	0.00	1,440.92	2,391.22	1,430.89	3,000.75	11.56	11.62	**44,372.20**	**43,066.24**	**0.00**	**0.00**
2	8,920.05	6,405.25	28,972.13	26,348.52	0.00	0.00	2,101.13	2,236.22	805.20	1,944.22	1,123.77	518.71	**41,922.27**	**37,452.92**	**0.00**	**0.00**
3	20,231.35	7,472.38	50,236.77	28,583.02	1,742.50	1,664.93	2,471.74	2,139.10	2,005.72	77.46	2,587.58	2,049.43	**79,275.66**	**41,986.32**	**0.00**	**0.00**
4	25,957.48	16,623.46	48,188.38	14,066.01	2,370.58	2,191.45	3,114.27	2,720.31	3,147.55	2,609.75	3,599.57	3,394.05	**86,377.83**	**41,605.03**	**0.00**	**0.00**
5	19,633.16	10,383.53	47,090.99	29,320.65	1,587.16	1,030.13	2,703.81	1,895.98	2,231.35	1,707.54	2,238.16	1,949.53	**75,484.63**	**46,287.36**	**0.00**	**0.00**
6	22,519.72	7,983.95	48,801.20	29,573.48	1,973.81	1,129.61	2,669.87	1,024.73	2,693.14	1,390.06	2,759.01	1,268.06	**81,416.75**	**42,369.89**	**0.00**	**0.00**
7	18,772.29	9,444.58	50,757.65	30,622.76	1,979.67	1,525.02	2,640.65	2,305.74	78.06	85.33	2,708.58	1,968.35	**76,936.90**	**45,951.79**	**0.00**	**0.00**
8	7,663.70	11,465.81	37,552.10	29,587.49	781.36	1,784.85	560.75	2,045.55	306.72	2,124.25	20.55	1,920.62	**46,885.18**	**48,928.57**	**0.00**	**0.00**
9	10,210.17	10,825.52	37,861.03	31,825.86	1,879.74	2,054.59	2,832.90	2,375.58	719.49	2,527.04	15.38	633.24	**53,518.72**	**50,241.82**	**0.00**	**0.00**
10	24,233.24	17,472.70	66,499.08	35,064.29	2,293.30	2,428.30	3,396.78	3,261.94	1,058.36	1,813.14	3,565.02	3,421.68	**101,045.78**	**63,462.05**	**0.00**	**0.00**
11	23,338.63	16,394.79	68,233.37	36,842.44	1,721.08	2,416.82	2,463.61	2,554.32	740.22	843.89	3,581.67	3,444.78	**100,078.57**	**62,497.04**	**0.00**	**0.00**
12	22,384.49	18,681.79	70,318.73	36,944.02	2,276.67	2,394.39	2,177.28	2,781.88	3,532.33	3,336.57	1,051.23	3,322.20	**101,740.74**	**67,460.85**	**0.00**	**0.00**
13	23,376.64	15,526.46	69,075.32	38,532.19	2,502.89	2,273.79	3,093.21	3,176.67	1,052.54	895.13	3,478.38	3,244.67	**102,578.98**	**63,648.92**	**0.00**	**0.00**
14	22,373.14	11,482.37	68,551.89	9,715.85	2,564.93	1,551.53	1,890.35	2,680.09	965.59	904.11	3,550.82	2,523.54	**99,896.72**	**28,857.49**	**0.00**	**0.00**
15	19,042.65	11,827.43	53,334.71	37,641.59	1,628.08	1,873.88	2,526.03	2,012.92	2,829.97	1,728.65	2,368.88	1,919.51	**81,730.32**	**57,003.97**	**0.00**	**0.00**
16	18,467.58	6,180.28	49,788.97	38,149.35	2,320.41	840.08	3,117.46	528.88	292.77	236.79	3,293.67	995.26	**77,280.86**	**46,930.65**	**0.00**	**0.00**
17	24,339.78	10,711.91	63,786.18	35,890.37	2,612.95	1,496.90	3,417.84	2,227.21	1,114.85	730.98	3,586.84	2,485.91	**98,858.44**	**53,543.28**	**0.00**	**0.00**
18	21,192.73	11,829.65	66,095.39	36,024.28	979.82	1,608.66	3,319.49	2,421.92	1,150.80	766.01	3,472.99	2,697.53	**96,211.22**	**55,348.05**	**0.00**	**0.00**
19	21,575.98	14,850.50	65,787.08	35,844.20	2,577.32	1,853.36	3,311.19	2,928.93	641.65	2,950.22	2,111.66	2,574.24	**96,004.86**	**61,001.45**	**0.00**	**0.00**
20	22,805.64	15,875.96	66,260.05	35,706.47	1,209.85	2,056.99	2,463.61	3,018.74	2,900.55	2,546.92	3,543.64	3,035.76	**99,183.34**	**62,240.85**	**0.00**	**0.00**
21	22,289.88	11,252.73	60,250.97	36,354.97	2,552.90	1,803.16	3,373.64	2,326.82	78.27	235.90	3,550.86	2,572.40	**92,096.53**	**54,545.98**	**0.00**	**0.00**
22	7,795.19	7,345.76	45,561.66	33,901.66	38.11	1,199.12	1,157.09	1,702.03	873.60	78.07	1,123.24	1,839.53	**56,548.89**	**46,066.16**	**0.00**	**0.00**
23	1,209.85	2,552.90	2,056.99	1,803.16	22,805.64	22,289.88	15,875.96	11,252.73	66,260.05	60,250.97	35,706.47	36,354.97	**143,914.96**	**134,504.61**	**2,463.61**	**3,373.64**
24	24,072.66	13,470.72	60,462.26	11,398.30	2,341.80	1,555.12	3,145.99	2,360.46	2,656.51	2,585.63	3,263.88	1,840.50	**95,943.11**	**33,310.72**	**0.00**	**0.00**
25	23,438.26	5,425.96	60,655.29	34,794.85	2,489.80	432.19	3,359.99	1,663.64	1,335.67	196.21	3,412.53	12.02	**94,691.54**	**42,524.86**	**0.00**	**0.00**
26	19,144.56	5,868.96	61,136.01	35,599.69	2,454.89	504.65	3,257.10	743.52	131.75	78.04	985.28	688.68	**87,109.59**	**43,483.53**	**0.00**	**0.00**
27	19,857.99	11,982.36	61,831.13	35,943.65	2,447.52	1,914.50	1,568.47	2,783.64	1,114.85	730.98	3,411.30	2,769.68	**90,231.26**	**56,124.82**	**0.00**	**0.00**
28	20,214.32	8,947.67	58,800.78	34,948.62	2,262.36	1,427.72	3,050.42	2,270.24	77.50	77.67	3,212.78	1,879.99	**87,618.15**	**49,551.91**	**0.00**	**0.00**
29	9,299.41	4,207.27	39,632.26	31,805.99	57.74	682.05	1,658.41	825.26	77.61	77.96	1,546.19	12.47	**52,271.61**	**37,611.00**	**0.00**	**0.00**
30	7,840.25	9,760.05	32,580.62	30,524.92	698.24	2,295.40	1,298.71	3,114.37	0.00	0.00	686.51	693.73	**43,104.34**	**46,388.46**	**0.00**	**0.00**
31	9,873.41	8,168.21	33,362.01	33,393.14	546.21	1,247.70	1,026.68	1,876.67	0.00	0.00	2,760.35	2,319.67	**47,568.67**	**47,005.38**	**0.00**	**0.00**

APPENDIX 9: Data for kWh of electricity of top up supply that TNB need to supply to plant and kWh of electricity required by four electric chillers, in plant usage and UTP for September 2009

SEPTEMBER 2009

	PLANT		UTP		EC1		EC2		EC3		EC4		TOTAL		TNB	
	Tp	To	Tp	To	Tp	To	Tp	To	Tp	To	Tp	To	Tp	To	Tp	To
1	17,521.20	5,878.72	60,818.90	35,004.46	74.12	300.87	2,859.38	634.48	78.27	235.90	3,453.43	2,096.12	**84,805.29**	**44,150.56**	**0.00**	**0.00**
2	20,748.82	8,249.37	62,157.72	32,310.44	2,320.53	790.29	3,361.54	2,190.07	0.00	0.00	2,208.09	1,607.88	**90,796.70**	**45,148.05**	**0.00**	**2,928.20**
3	21,368.57	12,098.90	61,623.27	36,717.59	2,431.04	1,658.85	2,683.51	2,865.85	77.59	0.00	3,459.82	3,055.36	**91,643.79**	**56,396.55**	**0.00**	**100.90**
4	20,505.48	13,033.94	61,777.25	11,028.72	1,088.74	1,156.14	3,434.15	3,269.92	77.76	77.68	3,607.11	3,415.08	**90,490.49**	**31,981.48**	**0.00**	**0.00**
5	12,074.76	11,717.66	44,254.31	33,787.28	23.19	1,000.33	2,190.62	2,933.56	77.72	77.78	2,498.49	3,401.36	**61,119.09**	**52,917.96**	**0.00**	**0.00**
6	10,576.96	10,688.08	36,044.56	32,862.89	1,013.84	892.77	1,908.15	3,167.60	77.58	77.57	2,321.33	2,619.29	**51,942.41**	**50,308.20**	**0.00**	**0.00**
7	7,357.78	11,460.12	39,297.08	34,342.95	62.94	892.48	587.00	3,142.54	77.54	77.39	1,751.57	3,023.15	**49,133.91**	**52,938.62**	**0.00**	**0.00**
8	22,587.24	11,035.31	65,871.96	37,184.13	21.56	22.39	3,458.72	3,007.33	3,073.05	748.10	3,229.98	3,071.62	**98,242.52**	**55,068.87**	**0.00**	**0.00**
9	23,351.91	15,385.73	61,487.15	37,433.82	21.57	21.89	3,372.14	3,335.30	3,448.69	3,391.79	3,488.86	3,436.77	**95,170.31**	**63,005.29**	**0.00**	**0.00**
10	22,801.11	15,469.37	62,450.28	37,198.37	198.71	244.97	3,336.71	3,298.99	3,419.52	3,361.85	3,447.92	3,394.67	**95,654.26**	**62,968.23**	**0.00**	**0.00**
11	22,708.36	11,059.82	60,258.42	32,541.65	32.81	519.36	3,405.34	1,895.90	3,544.08	2,981.92	3,490.48	1,490.71	**93,439.49**	**50,489.36**	**0.00**	**1,265.04**
12	10,116.40	9,182.65	43,994.51	34,320.52	16.39	694.42	1,336.98	2,032.42	2,133.87	2,202.49	10.50	1,200.56	**57,608.66**	**49,633.05**	**0.00**	**0.00**
13	8,938.53	12,683.17	37,124.79	33,658.61	16.43	16.84	2,001.73	3,202.50	438.90	2,818.40	702.73	2,623.33	**49,223.10**	**55,002.84**	**0.00**	**0.00**
14	22,866.91	11,232.73	64,327.90	9,504.62	17.16	16.99	3,501.15	2,676.54	3,687.10	2,502.62	2,820.56	2,481.60	**97,220.77**	**28,415.10**	**0.00**	**0.00**
15	22,673.79	13,831.65	63,407.94	37,267.11	913.14	244.93	3,329.14	2,940.42	3,483.74	2,963.67	2,184.54	2,818.01	**95,992.30**	**60,065.79**	**0.00**	**0.00**
16	24,854.44	13,150.63	59,679.16	35,095.97	1,142.55	1,048.25	3,379.01	2,812.13	3,560.93	2,738.20	3,479.30	2,361.56	**96,095.37**	**57,206.74**	**0.00**	**0.00**
17	22,788.07	9,974.89	59,485.38	34,821.45	328.89	733.78	3,283.57	2,241.00	3,457.78	2,125.26	3,373.44	2,004.93	**92,717.13**	**51,901.32**	**0.00**	**0.00**
18	18,118.08	6,732.15	46,019.95	31,353.91	16.58	16.95	2,842.42	1,975.63	3,454.75	2,004.53	2,050.58	1,885.58	**72,502.36**	**43,968.76**	**0.00**	**0.00**
19	5,201.95	4,163.87	26,131.00	23,999.98	0.00	0.00	278.47	1,270.45	225.02	1,521.08	0.00	0.00	**31,836.42**	**30,955.37**	**0.00**	**0.00**
20	10,564.94	3,547.03	24,225.02	23,311.27	0.00	0.00	3,432.85	835.77	3,551.32	807.26	0.00	0.00	**41,774.14**	**28,501.33**	**0.00**	**0.00**
21	9,652.90	8,322.80	21,387.01	21,602.28	0.00	0.00	3,245.35	2,532.24	3,341.50	3,067.56	0.00	0.00	**37,626.76**	**35,524.88**	**0.00**	**0.00**
22	9,823.46	6,469.60	23,061.91	21,478.38	0.00	0.00	3,279.12	2,445.60	3,306.26	2,023.66	0.00	0.00	**39,470.74**	**32,417.24**	**0.00**	**0.00**
23	17,132.92	7,346.42	45,124.08	24,890.99	0.00	0.00	3,297.99	2,573.94	3,341.89	2,487.98	0.00	0.00	**68,896.88**	**37,299.33**	**0.00**	**0.00**
24	16,706.69	10,385.90	41,400.02	8,788.07	16.29	16.55	3,076.40	3,246.69	3,237.60	3,312.26	2,344.21	3,419.36	**66,781.21**	**29,168.93**	**0.00**	**0.00**
25	21,710.19	12,998.65	43,508.97	23,418.74	17.03	17.41	3,174.09	3,147.29	3,299.95	2,562.26	3,563.11	3,229.00	**75,273.33**	**45,373.35**	**0.00**	**0.00**
26	9,772.58	8,141.07	28,197.39	25,144.43	16.16	17.09	249.06	2,583.26	3,648.87	2,204.40	13.95	1,928.08	**41,898.00**	**40,018.33**	**0.00**	**0.00**
27	9,892.49	4,760.14	25,642.12	23,494.22	16.09	16.82	2,244.35	1,681.91	2,115.61	1,706.59	13.05	13.54	**39,923.71**	**31,673.22**	**0.00**	**0.00**
28	19,168.55	5,714.60	55,419.33	28,119.54	16.16	16.15	3,443.59	1,006.73	3,576.55	564.61	358.49	695.79	**81,982.67**	**36,117.41**	**0.00**	**0.00**
29	22,628.54	12,038.79	55,931.13	30,406.41	16.80	17.07	3,315.79	2,907.82	3,465.12	2,955.07	3,410.34	2,948.75	**88,767.72**	**51,273.91**	**0.00**	**0.00**
30	21,525.58	10,746.73	62,828.50	32,656.95	16.47	16.27	3,323.51	2,517.09	3,448.61	2,411.84	3,394.32	1,596.11	**94,536.98**	**49,944.99**	**0.00**	**7,673.93**

APPENDIX 10: Data for kWh of electricity of top up supply that TNB need to supply to plant and kWh of electricity required by four electric chillers, in plant usage and UTP for October 2009

OCTOBER 2009

	PLANT		UTP		EC1		EC2		EC3		EC4		TOTAL		TNB	
	Tp	To	Tp	To	Tp	To	Tp	To	Tp	To	Tp	To	Tp	To	Tp	To
1	22,913.95	11,036.84	61,722.44	36,841.72	0.00	0.00	2,904.25	1,397.54	3,500.33	2,456.11	3,494.94	2,662.89	94,535.90	54,395.11	0.00	0.00
2	20,332.20	11,993.65	64,887.27	38,437.25	0.00	0.00	3,383.00	2,578.93	3,544.35	2,513.66	1,171.18	2,734.34	93,318.00	58,257.82	0.00	0.00
3	12,477.78	13,280.78	47,733.46	37,100.35	0.00	0.00	2,214.28	2,305.12	2,252.46	3,091.65	2,144.03	3,143.45	66,822.03	58,921.36	0.00	0.00
4	11,929.38	9,935.32	36,413.31	8,406.81	0.00	0.00	3,379.14	3,198.46	1,727.40	995.85	746.51	2,418.72	54,195.74	24,955.17	0.00	0.00
5	22,449.55	5,724.66	61,602.22	34,874.99	0.00	0.00	3,313.98	2,442.96	3,422.02	301.07	3,382.55	292.96	94,170.32	43,636.63	0.00	0.00
6	21,385.76	12,989.05	61,704.67	34,824.67	0.00	0.00	3,385.85	2,810.05	3,572.01	2,892.22	2,389.64	2,829.19	92,437.93	56,345.18	0.00	0.00
7	20,361.79	12,051.35	65,104.45	35,648.68	19.58	19.72	3,082.83	2,462.81	2,197.71	2,684.34	3,407.90	2,709.93	94,174.26	55,576.84	0.00	0.00
8	21,189.03	11,245.73	65,351.20	35,778.08	20.86	21.39	3,169.11	2,283.43	3,520.73	2,520.50	2,401.73	2,538.22	95,652.66	54,387.35	0.00	0.00
9	23,259.33	11,242.80	62,269.70	36,656.92	2,091.43	458.37	3,171.20	2,437.70	1,538.29	2,359.52	3,543.90	2,322.54	95,873.85	55,477.85	0.00	0.00
10	16,577.45	7,519.18	43,457.03	33,229.65	1,958.34	1,504.42	2,904.25	1,651.63	1,017.02	1,698.89	2,840.57	10.11	68,754.66	45,613.88	0.00	0.00
11	9,366.88	7,394.98	37,264.82	32,639.95	2,079.04	1,295.47	1,489.47	1,368.62	484.58	2,378.68	12.54	10.70	50,697.33	45,088.39	0.00	0.00
12	25,155.19	15,430.74	64,653.65	37,805.02	1,612.31	1,063.68	3,000.44	3,156.67	3,474.37	3,417.18	3,339.78	2,045.68	101,235.74	62,918.97	0.00	0.00
13	25,002.19	14,546.20	65,364.80	37,000.87	2,676.62	2,138.94	1,222.40	817.07	3,630.94	3,023.89	3,578.07	3,102.49	101,475.03	60,629.45	0.00	0.00
14	21,338.23	9,911.76	67,592.50	8,386.87	2,583.98	619.77	1,486.65	2,670.08	779.38	756.52	3,527.91	2,420.37	97,308.66	24,765.37	0.00	0.00
15	21,253.98	11,277.93	66,308.42	38,400.18	1,651.61	1,768.88	3,375.29	2,300.32	3,557.89	2,556.09	0.00	0.00	96,147.19	56,303.40	0.00	0.00
16	6,385.95	8,839.65	36,589.67	33,367.82	86.97	1,295.69	490.37	2,280.85	790.54	2,086.04	0.00	0.00	44,343.51	47,870.05	0.00	0.00
17	7,055.82	5,114.87	40,653.08	33,000.64	455.05	20.65	875.80	2,460.54	974.92	633.43	0.00	0.00	50,014.66	41,230.13	0.00	0.00
18	9,938.74	13,018.94	37,153.83	32,452.61	1,184.08	1,872.52	661.23	3,235.42	1,192.89	3,419.78	1,139.07	14.54	51,269.84	54,013.81	0.00	0.00
19	24,622.06	15,911.41	64,480.60	35,957.90	2,634.46	1,942.23	3,420.27	2,933.44	2,128.10	3,066.07	3,555.14	2,687.44	100,840.63	62,498.50	0.00	0.00
20	22,962.99	14,094.32	62,357.72	36,921.65	1,048.00	1,730.45	3,358.25	3,081.35	1,932.51	786.32	3,499.84	3,228.19	95,159.30	59,842.28	0.00	0.00
21	23,616.07	14,155.83	65,691.16	37,342.02	20.86	21.39	3,407.31	2,621.38	3,569.13	3,108.97	3,501.46	3,090.78	99,806.00	60,340.37	0.00	0.00
22	22,773.84	13,317.99	65,756.09	38,411.61	20.86	21.39	3,351.17	3,127.58	3,514.24	3,085.71	3,448.66	2,671.85	98,864.85	60,636.14	0.00	0.00
23	22,885.23	12,578.99	65,085.34	36,231.80	20.86	21.39	3,027.26	2,903.16	3,569.82	2,808.73	3,498.80	2,768.76	98,087.31	57,312.83	0.00	0.00
24	5,120.69	10,928.84	42,944.16	9,247.48	20.86	21.39	263.20	2,816.52	974.09	2,839.88	151.58	2,256.05	49,474.58	28,110.16	0.00	0.00
25	13,207.83	12,553.94	35,812.96	32,384.70	20.86	21.39	2,195.74	2,680.02	3,243.03	3,360.42	886.93	2,464.70	55,367.35	53,465.18	0.00	0.00
26	23,975.26	14,021.56	62,093.49	34,197.59	482.66	522.80	3,416.88	3,276.20	3,582.53	3,427.67	3,250.89	1,999.29	96,801.71	57,445.11	0.00	0.00
TOTAL (overall)	477,537.17	300,117.32	1,450,048.05	845,547.83	20,689.30	16,381.91	65,949.64	65,297.88	63,691.28	62,269.19	58,913.61	50,423.19	2,136,829.05	1,340,037.32	0.00	0.00
TOTAL (WEEKDAYS)	311,984.17	#######	1,007,790.89	593,965.15	12,235.26	8,983.82	44,831.55	######	######	45,354.77	35,917.71	######	1,454,708.38	936,721.19	0.00	0.00
COST	97,339.06	39,820.68	314,430.76	114,041.31	3,817.40	1,724.89	######	8,981.79	######	8,708.12	11,206.33	6,573.69	453,869.02	179,850.47	0.00	0.00
TOTAL (WEEKEND)	165,553.00	92,717.95	442,257.16	251,582.68	8,454.04	7,398.09	21,118.08	18,517.75	######	16,914.42	######	16,185.24	682,120.66	403,316.13	0.00	0.00
COST	51,652.54	17,801.85	137,984.23	48,303.88	2,637.66	1,420.43	6,588.84	3,555.41	6,783.65	3,247.57	7,174.72	3,107.57	212,821.65	77,436.70	0.00	0.00