POTENTIAL ENERGY SAVING OF MALAYSIA MANUFACTURING INDUSTRY – CASE STUDY ON POWDERED METALLURGY SINTERING FACTORY

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To my beloved family, friends and my supportive project supervisor who supported me throughout my pursuance of part-time master degree course

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ABSTRACT

The energy consumption in industrial sector has always been high all-time in the nation as well as around the world. Because of that, energy saving have become an essential topic of interests in this industrial sector as the energy price keeps increasing over the years. Research has shown that electrical power demand has experienced an exponential inclining rate over the years due to rapid economic development. In the case of an uncontrolled planning and power wastage in the near future, the industrial sector will experience frequent power shortages and costly utility expenses which indirectly leads to higher operational costs. In this project, study of potential energy saving aims to reduce electric power consumption of a Malaysian industry in sintered metallurgy to about 5% to 10%. by identifying the major consumption equipment through site visits, the overall energy efficiency can be potentially increased. After performing research and market study in potential energy saving schemes on such equipment, the reduction rate, rate of return, return of investment and payback period are then calculated. The study has found that proposed energy saving is feasible in the furnace and air compressors as they are the major equipment which ranks the highest of the overall consumption. This research clearly shows that the proposed energy saving schemes is able to achieve energy saving of at least 5%.

ABSTRAK

Penggunaan tenaga dalam sektor industri sentiasa tinggi semua masa di negara ini dan juga di seluruh dunia. Oleh kerana itu, penjimatan tenaga telah menjadi satu topik penting dalam kepentingan dalam sektor industri ini sebagai harga tenaga terus meningkat sejak beberapa tahun. Penyelidikan telah menunjukkan bahawa keperluan kuasa elektrik mengalami kadar kenaikan eksponen sejak beberapa tahun yang disebabkan oleh pembangunan ekonomi yang pesat. Sektor industri akan mengalami kekurangan kuasa elektrik yang kerap dan perbelanjaan utiliti mahal yang secara tidak langsung membawa kepada kos operasi yang lebih tinggi sekiranya terwujudnya perancangan yang tidak terkawal dan pembaziran kuasa elektrik. Dalam projek ini, kajian potensi penjimatan tenaga bertujuan untuk mengurangkan penggunaan kuasa elektrik bagi industri Malaysia dalam metalurgi tersinter kepada kira-kira 5% kepada 10%. dengan mengenal pasti peralatan penggunaan utama melalui lawatan tapak, kecekapan tenaga keseluruhan boleh berpotensi meningkat. Selepas melaksanakan penyelidikan dan kajian pasaran dalam skim penjimatan tenaga yang berpotensi ke atas peralatan itu, kadar pengurangan itu, kadar pulangan, pulangan pelaburan dan tempoh bayar balik kemudian dikira. Kajian ini telah mendapati bahawa penjimatan tenaga yang dicadangkan boleh dilaksanakan dalam relau dan udara pemampat kerana mereka adalah peralatan utama yang berada di kedudukan tertinggi penggunaan keseluruhan. Kajian ini jelas menunjukkan bahawa skim penjimatan tenaga yang dicadangkan mampu untuk mencapai penjimatan tenaga sekurang-kurangnya 5%.

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kWh	-	Kilo Watt-Hour
kW	-	Kilo Watt, Real Power
MWh	-	Mega Watt-Hour
W	-	Watt, Real Power
^0C	-	Degree Celsius
J	-	Joule
MJ	-	Mega Joule
GJ/h	-	Giga Joule per hour
kVA	-	Kilo Volt-Ampere, Apparent Power
kVAR	-	Reactive Power
Pa	-	Pascal
mm	-	Millimeter
ROI	-	Return of Investment
HID	-	High Intensity Discharge
LED	-	Light Emitting Diode
lx	-	Illumination level unit

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CHAPTER 1

INTRODUCTION

1.1 Overview

In recent years, environmental issues have raised a great amount of concern around the world. For instance, considering one of the serious issues, global warming, the main culprit of such issues has always been carbon emission. The carbon emission rate indicates an increasing trend and the ever growing figures are causing more concerns [1]. Throughout the years, Malaysia might just be another major contributor to greenhouse effects due to the rapid urban development and expansion as its carbon emission rate has even surpassed the neighboring countries such as Thailand and Indonesia [2].

This would eventually lead to worsening global warming where it results in drastic change in climates and the loss of ecosystems. Greenhouse gases are mainly produced by transportation, industrial sector etc. and power generation (electricity) has all this while been highly dependent on the fossil fuels (non-renewable) such as coals or natural gas as the raw material, which in turns contributes to the highest percentage of the overall emission. Figure 1.1 below is a chart showing the sectors that contributed to carbon emission [3].

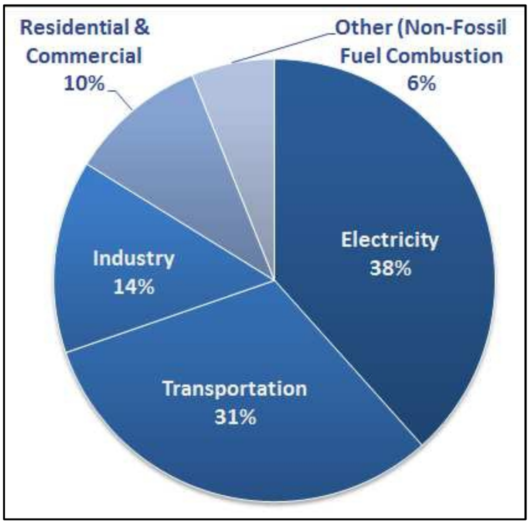

Figure 1.1: Carbon Emission Chart [3]

In order to minimise such adverse impacts from worsening and gradually 'consume' our planet, the carbon emission from power generation (electricity) which is the main contributor has to be reduced. In fact, several campaigns and strategies have been raised over the years around the world such as the *Earth Hour* initiated by Ridley [4] and the Carbon Footprint Awareness Campaign in launched in certain countries such as Costa Rica [5] as efforts in reducing carbon emission and for sustainable environment to save the planet. Other than the damage on ecological environment, energy shortage is also gradually sweeping the world so as to cope with the ever expanding population and demand to the extent that the concern on energy, electricity and power saving should not be neglected or ignored.

On the other hand, the electricity tariff rate has been increasing over the years with average of 12% in every tariff revision. Recently, the local utility TNB has just announced that there will be a hike (increase) in the tariff rate effective on 1st January 2014 with an increase of 4.99 cents per kWh, which is 14.89% higher than the current average of 33.54 cents per kWh to 38.53 cents per kWh [6]. Such increasing trend has placed heavy burdens on commercial and industrial sectors with the impact of costly monthly utility bills while minor impact on residential sectors. In fact, industrial consumers will experience an average increase of 16.85%, which ranges from 0.9% to about 17% [6].

“*Tariff hike will hit firms hard*” [7], as quoted from local media headline, it is expected that the rise of electricity rate would severely affect the bottom lines of businesses ranging from industrial and commercial consumers who are heavy users of electricity. This will lead to higher costs of running business as power is a major part of the operational costs of the industrial sectors.

Hence, the reduction on the cost electricity bills is highly essential for every industrial consumers though the means of implementing energy saving schemes and improving the energy efficiency of the system.

Nonetheless, while it is essential to come up with energy saving strategies to ensure sustainable development, researchers are looking for alternative renewable energy and simultaneously methods to save energy has become an important research topic around the world.

As a matter of fact, to aid in the carbon emission reduction from power generation industry and to ultimately reduce operational cost due to utility cost, obviously energy saving is an essential effort for every industrial, commercial and residential sector. Industrial sector in Malaysia consume 42% of energy produced that contribute to 14% carbon emission. If this sector can save at least 5% of energy usage so 42% energy can be saved and 14% of carbon emission can be reduced. Pertaining to that, this project aims to study potential energy saving by one of the heavy industries. One case study has been done on one of the Malaysian manufacturing factory. The factory selected for this study is, an established multinational manufacturer of the powder metallurgical products and their main products are automotive sintered parts through powder metallurgy such as parts for engines, transmission, variable-valve actuation, suspension, intake and exhaustion, bearing etc. This study consists of a thorough and detailed analysis and study on the existing factory, proposal of potential energy saving schemes and the calculation of the amount of energy saved.

1.2 Background of the Study

Nowadays, rapid development in terms of economic growth and urban expansion has triggered rise in energy use and these economic changes have influenced several sectors mainly the industrial sector. The energy demand was minimal until the industrial revolution. The needs for energy have greatly multiplied over the years until a state that the world is constantly hungry for more electric power to be consumed. In an effort to solve this arising issue, efficient usage of energy is essential. Energy saving has slowly proven its importance in its existence over the years.

Currently, numerous research and development of renewable energy are in progress to search for alternatives to replace fossil fuels for massive power generation. In addition, the utility company has been increasing the price of energy and it placed a heavy impact on commercial and industrial consumers as they depend heavily on electric power for operation. In some countries, even taxes are imposed to energy consumption which further worsens the burden of the consumers while it is, in a way, good for energy saving.

Electricity consumption is huge for industry in their manufacturing process owing to the fact that most industries apply complex processes. It may involve very huge and complex technical data and sometimes very difficult to achieve energy saving objective. This is because the industrial sectors alone have occupied 47% among all other sectors such as transportation, residential, commercial etc. and the manufacturing sectors have occupied 60% of the industrial sectors energy consumption according to a research [8]. However, energy saving by technologies is widely used for reducing energy usage. A lot of studies have been done on motors application energy saving as motors exist in most of the industrial machineries. For instance, study has shown that variable speed motors are more efficient and energy saving than constant fixed speed motors and these are applied in this research. This study aims to rectify the high energy consumption in the manufacturing sector.

Energy saving not only reduce operational cost of the industrial sector, it also plays an important role in minimizing the amount of carbon emission of the power plant as the decrease in electrical power demand would indicate lesser power generators loadings and operations, which indirectly produces lesser carbon emission and conserving the environment.

1.3 Problem Statement

The main problems that are the main concerns and origins of this research project are as the following:

1.3.1 High Electric Power Consumption & Demand

The power or energy consumption rate in the manufacturing industry of Malaysia is currently is extremely high and is expected to incline continuously due to rapid economic growth of the country, hence triggering increasingly great demand for electric power and electricity of the nation.

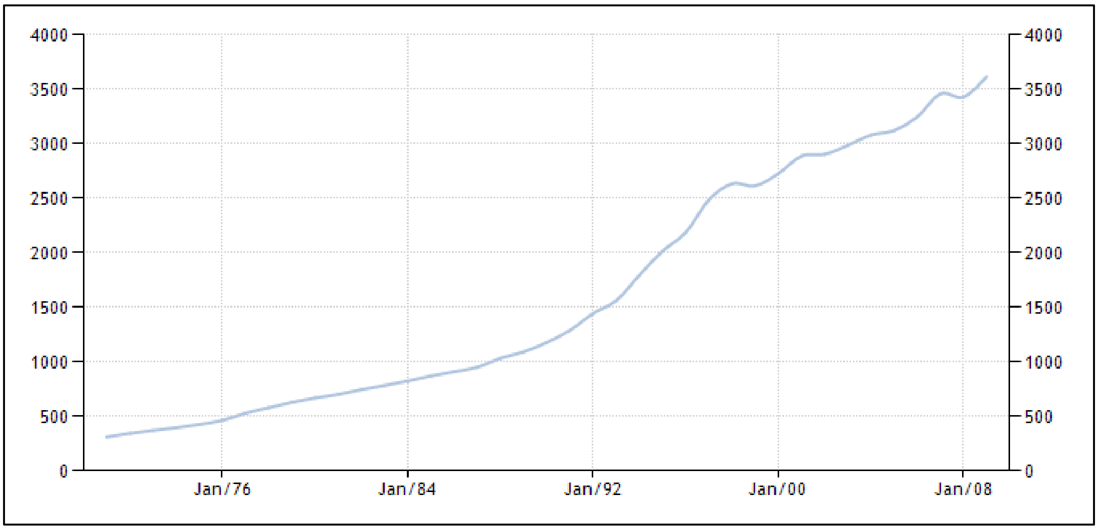

Figure 1.2: Electric Power Consumption (kWh per capita) in Malaysia from 1970 to 2010 [9]

Referring to figure 1.2, the electric power consumption (in unit kWh per capita) in Malaysia has experienced an exponential increase over the past 30 years (from 1970 to present) and such inclining trend will persist as long as economic development of the country is ever expanding.

Subsequently, electric power consumption is defined as the measurement of electricity power generation of power plants (in operation) and combined heat and power plants with the exclusion of losses (through heat and others) due to transmission, distribution and transformation and own use.

In fact, in 1971, according to the World Bank Indicators, the electric power consumption of Malaysia is recorded at 309.76 kWh per capita, 3,613.53 kWh per capita in 2009 and 4,117.35 kWh per capita in 2010 [9]. This clearly proves that the demand for more electricity is ever expanding in Malaysia with an exponential behaviour. Other than that, a great amount of energy is wasted from the industrial and commercial sectors due to poorly planned and uncontrolled energy usage as well as inefficient energy and poor power quality. Malaysia as a fast growing and developing country will have to overcome more energy hungers, demands and crisis in the near future as we, human relies ultimately on electricity for survival and to sustain lives. Therefore, this problem is the main motive behind this research i.e. energy saving, which is one of the effective ways of solving such arising issue. Energy saving has been an important topic nowadays in order to reduce any undesired wastage of power and cope up with the power demands in every nations.

1.3.2 Increase of Electricity Tariff Rate

The electricity tariff rate of Malaysia has been increasing over the years with a percentage of approximately 7.12% as compared to previous rates. This is mainly due to the inclining rates of coal prices over the years which serve as the raw material for power plants operation and the effects of new government policies to phase out energy subsidies to local industries [10].

Table 1.1 below indicates the tariff rate revision by Malaysian local electricity providers, Tenaga Nasional Berhad (TNB) over the years:

Table 1.1: TNB Tariff Rate Revision in Malaysia [11]

Year	Events
1997	Tariff increased to RM 0.80/kWh
2006	Tariff increased by 12%
2008	Total 24% tariff increase due to increasing gas price
2011	Tariff increased by 7.12% due to increasing gas price
2014	Tariff increased by 4.99 cents/kWh

The Malaysian government has recently declared that there will, again, be another rate revision of the electricity tariff rate effective on 1st January 2014 onwards. Owing to such revision, it is estimated that the new the electricity bills for commercial consumers will experience an increase of approximately 6% to 8% and roughly 10% for industrial consumers [11].

From an excerpt of local media, it is stated that the increase of electricity tariff rate has placed heavy burden to both the commercial and industrial sectors as the expenses in electricity bills is getting more expensive in the recent years for the consumers in that categories [12].

Under the newly revised tariff rate, table 1.2 shows the comparison between the current and the new rates effective from 1st January 2014 for Tariff E2 consumers, the Medium Voltage Peak/Off-Peak Industrial Tariff. This tariff class is selected to be compared based on the selected manufacturer in this case study whose electricity usage falls under industrial tariff E2 category.

Table 1.2: TNB Tariff Rate Comparison (Tariff E2) [11]

Tariff E2 Medium Voltage Peak/Off-Peak Industrial Tariff	**Previous Rates (1 June 2011)**	**Current Rates (1 Jan 2014)**
For each kilowatt of maximum demand per month during the peak period	RM 31.70 /kW	RM 37.00 /kW
For all kWh during the peak period	30.40 cents /kWh	35.50 cents /kWh
For all kWh during the off-peak period	18.70 cents /kWh	21.90 cents /kWh

The new rates from 1 January 2014 onwards was increased 16.8% to 17.1% and not neglecting the minimum monthly charge of RM 600.00 which would cause a significant impact on the monthly utility bills that are already burdensome.

It is commonly known that industrial consumers rely heavily on electricity in their businesses and operations and utility expenses have been a significant part of the operational cost of the consumers. Therefore, the revised tariff rate will undoubtedly place an impact on the operational cost industrial sectors. Foreseeing the tariff rate will only be rising in the future, significant energy saving in the industrial sectors plays an imperative role in lowering the operational expenses of the consumers.

1.3.3 Environmental Issues from Power Generation

The major power generation or power plants in Malaysia require fossil fuels such as coals, natural gas etc. as raw material in the process. During this process, a huge amount of carbon dioxide and other wastes are exposed and released into the air and the surroundings.

In fact, the great amount of released carbon dioxide gas cannot effectively be absorbed by the trees due to the high electric power demands which in turns require faster and more power generation. Moreover, since more rainforests and ecosystem have been devastated to make way for rapid development, the pollution and global warming issues has been ever critical.

As mentioned earlier, electric power generation is the largest contributor of greenhouse gas emissions, thus, it is of utmost importance that by saving energy or even utilizing renewable energy, the demand for power can be reduced and hence the reduction in greenhouse gases emission. This is because of the decrease in burdens of the power plants in order to cope with the demands of electricity.

As a result, this research and case study are of utmost importance owing to the three major problems mentioned above. In fact, a majority of industrial and commercial consumers or even us nowadays are looking for any feasible and possible energy saving alternatives in order to tackle and overcome overly-expensive utility bills, looking to reduce operational costs and expenses. The saving of energy usage of a significant amount would also mean lesser demands of electricity which would indirectly lead to reduced coals burning in power plants, hence minimising adverse effects to the environment through carbon emissions.

1.4 Objectives of Research

The ultimate objective of this research is to come up with schemes and proposals to reduce electric power consumption and save energy in the sintered powdered metal manufacturing factory. Moreover, the objective of this research is also to do projection based on the case study for energy saving for same industrial sector i.e. manufacturing industry. Malaysian manufacturing industrial sector which will eventually reduce the expenses on utility or electricity bills of the industrial consumer, hence directly reduce the operational cost.

Ultimately, the author has targeted to reduce about 5% to 10% of overall electric power consumption of the plant and identify loads which contributed to high power consumption.

1.5 Scope of Research

Throughout the research, there are a few limitations and assumptions that has been made for the data analysis and research. This research is centered on a case study on a multinational manufacturing factory specializing in powder metallurgy sintering located in North Port, Klang. For data acquisition and analysis, the limitation in this study is focused on electricity billings extracted on a monthly basis (e.g. month of October, November and December) for analysis of the overall power consumption (in kWh). This is due to the fact that the main focus of this study is to achieve energy saving due to increasing tariff rate and schemes of the local utility company (Tenaga Nasional Berhad).

The proposal of the energy saving schemes for this case study is based on a few assumptions as listed below:

a) During the energy auditing process, other than taking down the records of the loads of the plant machineries and equipment using their respective load readings over a period, part of the connected loads in the factory are also based on the a dedicated load profile. In the load profile applied in this research, it is based on the working schedule and daily operation of the factory in order to take into account of the daily load and usage of other electrical services such as lighting system, HVAC system (heating, ventilation and air-conditioning), pump system etc. of the whole factory and office buildings. For instance, the operation of the production center is divided into two working shifts, each with twelve working hours while there is eight hours for office operation including break time and lunch hours. This indicates that the load profiles of the production and office are based on a 24-hour and 8-hour operations respectively.

b) Due to the great numbers of machineries and equipment that are present in this factory, only a few of the machines or equipment which have been audited and confirmed to rank the few highest in power consumption (in kWh) are taken into the analysis for the energy saving scheme proposal. The machines and equipment include:

i) Two numbers of Sintering Furnaces
ii) Six numbers of Air compressors

Nonetheless, the power factor used for the measurement and analysis in this research is limited to the overall power quality of the factory electrical system and office rather than the individual power factor readings of each of machines or equipment.

1.6 Research Methodology

The methodology of this case study will be as the following:

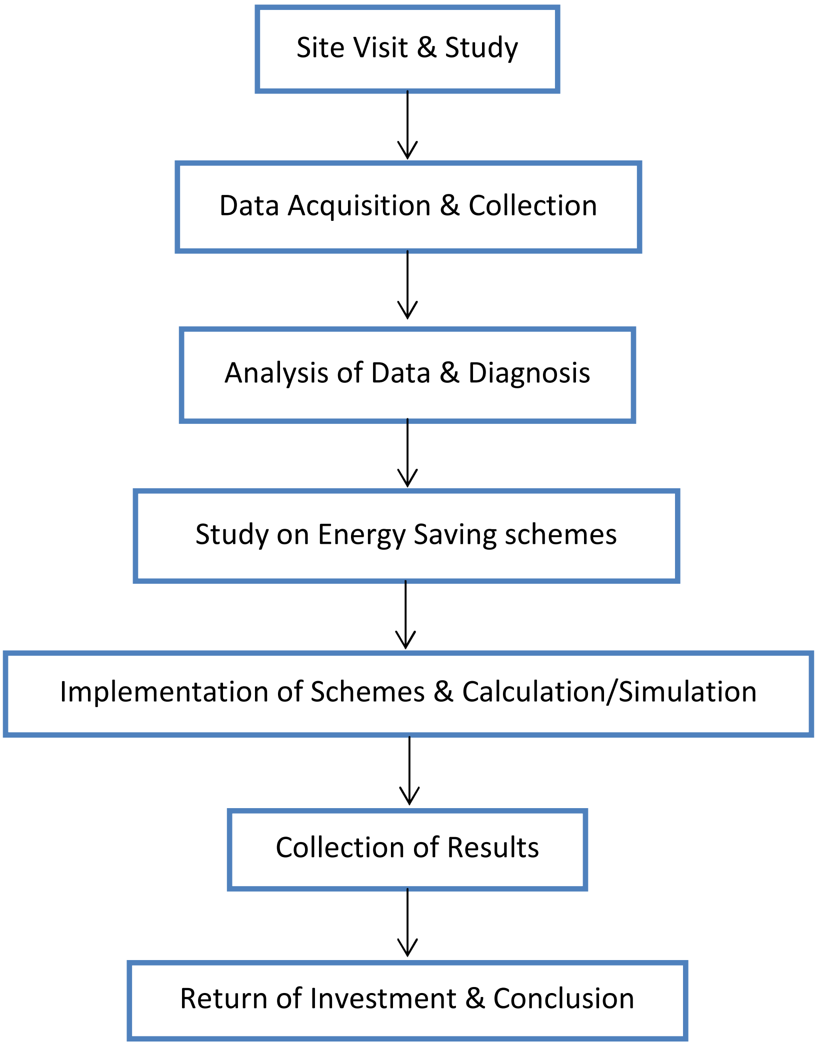

Figure 1.3: Research Methodology Flowchart

The first stage of this research is to conduct a site visit to study and understand the existing electric power distribution system design and the operations of the case factory. The objectives of the next stage are to acquire data such as machines loads from the digital power meter readings and a study is done on the load profile of the production and office.

The overall power consumption in kWh of the case is taken from monthly electricity bills for four to five months and the figures acquired are inserted into calculation sheets for further analysis and for determination of the current utility expenses. Since electricity bills only manage to indicate the overall power consumption of the factory, a record for monthly consumption reading of all the machines are done.

To further analysis and understand the power consumption, the work schedules and working hours of the productions and office are also acquired as load profile. The next step is the diagnosis of existing loads of all connected equipment and services to determine the equipment or machines with the highest power consumption through the meter readings so that they will be the subjects of analysis of energy saving schemes in the next step. An in-depth study of the diagnosed machines with the highest power consumption will be performed after acquiring the schematics, brands and details of them.

A research and study on potential energy saving alternatives and schemes will be carried out in the next step based on the selected machines (highest power consumption) from the current available technologies which provide energy saving solutions. Then, implementation of such energy saving schemes will be done on the said machines through calculations of the 'before-and-after' comparison and simulations as results. From the results, a Return of Investment (ROI) or Rate of Return will be analysed and calculated to determine the payback period of the implemented energy saving schemes.

In the last stage, a study of services other than plant machineries such as lighting system, Heating, Ventilation and Air Conditioning system etc. are done for further analysis of energy saving potentials of the factory.

1.7 Work Program and Schedules

The overall schedules and the work program of this research project with the timeline of each stage of this case study is appended in figure 1.4 for both Project 1 *(MEP 1813)* and Project 2 *(MEP 1825)*.

Item	Description of Work	Year 2013				Year 2014					
		Month				Month					
		September	October	November	December	January	February	March	April	May	June
1	**First Stage**										
a)	Site visit										
b)	Data acquisition										
2	**Second Stage**										
a)	Identify highest loads										
b)	Analysis of load profile										
c)	Record monthly kWh consumption										
	of the furnace & air compressors										
3	**Third Stage**										
a)	Study on energy saving scheme:										
	> Furnace										
	> Air compressors										
b)	Implement by simulation &										
	calculation:										
	> Furnace										
	> Air compressors										
4	**Fourth Stage**										
a)	Results & Comparisons										
b)	Return of Investment (ROI)										
c)	Other energy saving schemes:										
	> Lighting										
	> HVAC										
	> Others										
5	**Final Stage**										
a)	Thesis Compilaton & Binding										

Figure 1.4: Work Program and Schedule of Research

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