# POTENTIAL DEMAND SIDE MANAGEMENT OF A PALM OIL REFINERY PLANT THROUGH PINCH ANALYSIS

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To my beloved ummi, late father and siblings

Thank you for your endless support

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# ABSTRACT

The aim of this research is to analyze the profile energy consumption of main refinery processes in palm oil refining plant of an oleochemical industry in Pasir Gudang, Johor and determine the most suitable demand side management (DSM) measures to accommodate needed temperature for main crude palm oil (CPO) storage tank through pinch analysis. Before analyzing using pinch analysis, it is necessary to understand energy flows from both the supply and the demand sides for better understanding of mass energy balance. For easy visualization, the author used Sankey diagrams that would map energy flow for both the demand and supply sides of the streams. The Sankey diagrams proposed for this study would show total energy consumption, useful energy, and energy intensities of crude palm oil (CPO) refinery equipments. After analyze by using pinch analysis, the DSM of any available resources that could lead to reducing energy consumption is identified through retrofitting of heat exchanger network design (HEND). Any reduction in energy consumption can positively reflect on both per capita electricity consumption. Results shows a percentage savings of 65.73% and 57.03% for heating and cooling requirement respectively.

# ABSTRAK

Kajian ini dilakukan bertujuan menganalisa profil penggunaan tenaga proses penapisan minyak kelapa sawit utama dalam industry oleokimia di Pasir Gudang, Johor dan menentukan pengurusan bahagian kehendak (PBK) yang sesuai bagi menampung keperluan suhu tangki penyimpanan minyak sawit mentah menerusi analisis jepit. PBK merupakan salah satu alat yang berkesan untuk mengurangkan kehendak elektrik. Sebelum analisa menggunakan analisis jepit, keperluan untuk memahami aliran tenaga dari sumber ke kehendak amat penting bagi mendalami kefahaman terhadap keseimbangan tenaga massa. Untuk visualisasi yang mudah, penulis telah menggunakan rajah *Sankey* bagi menunjukkan aliran tenaga dari sisi bekalan dan kehendak. Rajah *Sankey* yang dicadangkan dalam kajian ini akan menunjukkan jumlah penggunaan tenaga, tenaga berguna dan intensiti tenaga bagi proses penapisan minyak sawit mentah. Selepas dianalisa menggunakan analisis jepit, PBK dari sebarang sumber yang membawa ke arah pengurangan penggunaan tenaga telah dikenalpasti melalui pengubahsuaian rekaan rangkaian pemindahan haba. Sebarang bentuk pengurangan penggunaan tenaga mampu memberi impak yang positif terhadap penggunaan elektrik per kapita dan emisi gas rumah hijau. Kefahaman yang baik terhadap aliran tenaga dari kedua-dua bekalan dan kehendak amat perlu untuk keseimbangan tenaga massa. Keputusan masing-masing menunjukkan peratusan pengurangan sebanyak 65.73% dan 57.03% bagi keperluan pemanasan dan kesejukan.

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| | | |
|---|---|---|
| ANSI | - | American National Standards Institute |
| ASHRAE | - | American Society of Heating, Refrigerating and Air-Conditioning Engineers |
| BE | - | bleaching earth |
| BPO | - | bleached palm oil |
| CC | - | composite curve |
| CHP | - | combined heat and power |
| COP | - | Conference of Parties |
| CPO | - | crude palm oil |
| DSM | - | demand side management |
| EEI | - | Energy Efficiency Index |
| FA | - | fatty acid |
| FFA | - | free fatty acids |
| GCC | - | grand composite curve |
| GHG | - | greenhouse gases |
| HEN | - | heat exchanger network |
| HEND | - | heat exchanger network design |
| HPS | - | hybrid power systems |
| HVAC | - | heating, ventilation and air conditioning |
| HX | - | heat exchanger |
| kW | - | kilowatt |
| LEAP | - | Long-range Energy Alternatives Planning |
| MILP | - | mixed integer linear programming |
| MINLP | - | mixed integer non-linear programming |

| | | |
|---|---|---|
| MPOC | - | Malaysian Palm Oil Council |
| PFAD | - | palm fatty acid distillate |
| PHE | - | plate heat exchanger |
| POR | - | palm oil refinery |
| PTA | - | problem table analysis |
| QC | - | quality control |
| RBDPO | - | refined bleached deodorized palm oil |
| RE | - | renewable energy |
| RES | - | renewable energy system |
| SHE | - | spiral heat exchanger |
| SPTA | - | simple problem table algorithm |
| SSM | - | supply side management |
| UNFCCC | - | United Nations Framework Convention on Climate Change |
| WBS | - | work breakdown structure |

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# CHAPTER 1

# INTRODUCTION

## 1.1 Background of the Study

The energy consumption has a significant environmental impact and is a major reason for the increasing emissions of greenhouse gases (GHG). According to the Energy Commission (locally known as Suruhanjaya Tenaga), industrial sector contributed to about 27% of the final energy consumption in 2015 with 1.67 toe per capita (Suruhanjaya Tenaga, 2017).

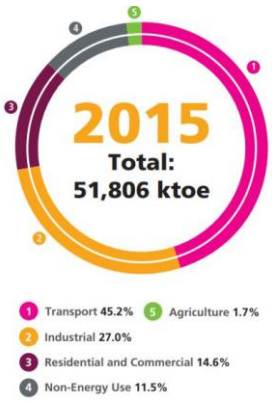


**Figure 1.1** Percentages of final energy consumption by sectors (Suruhanjaya Tenaga, 2017)

As a result from the United Nations Framework Convention on Climate Change (UNFCC) Conference of Parties-15 (COP15) in Copenhagen, Malaysia's energy market is shifting towards green growth strategy through energy efficient initiatives. This transition aims to achieve a significant reduction in GHG emissions of 40% by 2020. The scope includes the electrical energy, thermal sector and transport sector. Changing the energy market is challenging, not only in terms of the regulations and operational processes, but also regarding the structure of assets. For a holistic approach of sustainable energy market, a "smart customer" is also necessary. Demand side management (DSM) can be an additional important mechanism to pointedly use flexibility of the energy demand. Consequently, the transition of the energy market is linked to the technological developments as well as to reassignment of roles to the actors in the market.

In this research study, the author focused on DSM of a refining process for an oleochemical industry. Oleochemicals are chemicals that derived from natural oils or fats. They could be obtained from animal, marine or vegetable oil sources. By breaking the oils or fats into corresponding constituents, they produced fatty acids, glycerol or fatty esters. Common processes involves are hydrolysis or transesterification. In Malaysia, oleochemical industry started in around 1979 to 1980.

## 1.2 Problem Statement

Energy consumption should be properly managed. Generating energy more than necessity would be a waste and incurred operation cost. Therefore, in this study, the author analyze the energy flows of main processes in palm oil refining plant (degumming, bleaching and deodorizing) through pinch analysis in order to locate surplus or deficit of heat in the plant. Pinch analysis is also used to determine how much energy can be recovered and reused internally within the refining plant. As for

visualization tool, the energy consumption is mapped using Sankey diagram. From the Sankey diagram, the author identified the potential DSM for waste heat recovery.

## 1.3 Objectives of the Study

In this study, the objectives were as follows:

a) To analyze the profile energy consumption of main refinery processes in palm oil refining plant.

b) To determine the most suitable DSM measures to accommodate needed temperature through retrofitting heat exchanger network design (HEND).

## 1.4 Scope of the Study

This study covers the potential DSM of main processes in palm oil refining plant in Pasir Gudang, Johor. The main palm oil physical refining processes are degumming, bleaching and deodorizing. Identified potential DSM will be mapped and analyzed using Sankey diagram and pinch analysis respectively.

## 1.5 Limitations of the Study

There are several limitations in this study. First, the data from the processes is collected from a limited time period and thus seasonal variations are not accounted for in this study. The time period selected is in July 2018. This period was selected since the plant has steady production during mid-year. Secondly, variations in heat transfer capacity of heat exchangers cannot be analyzed because the time period is short. Thirdly, since the energy flows is varies depending on the production output (that affected by customer needs), the average values for temperature is used in this study. Finally, this study only focussed on the existing plant and will not consider future reconstruction within the plant. The author focuses on how the process is today and how the process integration can be applied to the plant at Pasir Gudang, Johor.

## 1.6 Significance of the Study

In energy management, ability to optimize results in a constrained environment is a key to success for load management. Thus, this study has been proposed to analyze and determine the most suitable DSM measures to accommodate needed energy for main crude palm oil (CPO) storage tank for an oleochemical industry in Pasir Gudang, Johor by using pinch analysis.

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