TEMPERATURE REDUCTION PINCH ANALYSIS (TERPA): APPLICATION OF PINCH ANALYSIS FOR TREE PLANTING TARGETING

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I dedicate this to my parents,
Ravinttiran Nalayini,and Siva Kaliamma

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ABSTRACT

The global climate change as a result of rapid development is an important environmental problem nowadays. Concern about climate change are leading to the requirements to curb the Urban Heat Island (UHI) effect by different type of tree planting strategy. The electricity consumption in a building for cooling purpose increased tremendously due to UHI problem. To support the tree planting strategy as well as to save energy, target-oriented pinch analysis is recommended for identifying a systematic solution for energy planning and management problem. In this paper, a method known as Temperature Reduction Pinch Analysis (TERPA) is developed to examine the implication of dual objective – planting area utilization as well temperature reduction target in sustainable areal development which focused on building. TERPA is capable in rooftop planting targeting, vertical planting targeting as well as tree planting targeting through graphical representation. Rooftop planting and vertical planting is considered as zero land area consumption due to the fact that those planting is done within the building and no need extra land which tree planting in need of it. TERPA will be able to provide meaning and illustration to the effect of changing the target according to the future needs. A general methodology of TERPA is presented through the demonstration of a Malaysia's case study. The result from this study is that a 17.24˚C temperature reduction can be achieved via proper type of planting targeting with the minimum land usage to give way for other facilities that are in need of land.

ABSTRAK

Perubahan iklim global akibat pembangunan pesat adalah masalah alam sekitar yang penting pada masa kini. Kebimbangan mengenai perubahan iklim membawa kepada keperluan untuk mengekang kesan Pulau Haba Bandar (UHI) dengan pelbagai jenis strategi penanaman. Penggunaan elektrik di bangunan untuk tujuan penyejukan meningkat dengan ketara kerana masalah UHI. Untuk menyokong program penanaman pokok serta menjimatkan tenaga, analisis pinch berorientasikan sasaran disarankan untuk digunapakai bagi mengenal pasti penyelesaian sistematik untuk perancangan serta pengurusan tenaga. Dalam kajian ini, satu kaedah yang dikenali sebagai Analisa Pinch Pengurangan Suhu (TERPA) dibangunkan untuk mengkaji implikasi penggunaan dua hala - penggunaan kawasan penanaman serta sasaran pengurangan suhu dalam pembangunan kawasan lestari yang memberi tumpuan kepada bangunan. TERPA mampu menargetkan penanaman bumbung, penanaman menegak serta penanaman pokok melalui perwakilan grafik. Penanaman di bumbung dan penanaman menegak dianggap sebagai mengunakkan kawasan tanah sifar kerana penananaman itu dilakukan di dalam bangunan dan tidak memerlukan tanah ekstra yang ditanam pokok. TERPA akan dapat memberi makna dan ilustrasi kepada kesan perubahan sasaran mengikut keperluan masa depan. Metodologi umum TERPA dibentangkan melalui demonstrasi kajian kes Malaysia. Hasil daripada kajian ini ialah pengurangan suhu 17.24˚C boleh dicapai melalui penargetan jenis penanaman yang sesuai dengan penggunaan tanah minimum untuk memberi laluan kepada kemudahan lain yang memerlukan tanah.

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TERPA	-	Temperature Reduction Pinch Analysis
WAMPA	-	Waste Management Pinch Analysis
M	-	Micro
%	-	Percentage
G	-	Gram
Hr	-	Hour
e.g.	-	Example
m^3	-	meter cube
Min	-	Minute
$\sum$	-	Total
T	-	Time

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Green is unity, a symbolic implication, a deep significance within our present realm of reality. It has moved beyond being just another band on the color spectrum and is now an all-encompassing attitude, a common consciousness, a global movement. Green is about finding a balance between growth, waste, sustenance, resources and limits, which is what the notion of sustainability is all about. There are three major groups of problem for sustainability such as population growth, depletion of resource and atmospheric pollution. The common denominator of items depletion of resource and atmospheric pollution, this is energy. CO2 emissions are largely caused by energy use, thus the best measure of CO2 emissions, therefore sustainability, is energy demand. This is closely linked to the problem of diminishing sources of energy. The problem can be attacked from two directions (Szokolay,2008):

1. Reduce energy demands of buildings
2. Substitute renewable sources of energy as far as possible

Malaysia is a developing country where its growing population and expansion of economic activities especially in the manufacturing sector have been the major drivers for the increasing demand for energy supply. Historically, the nation's energy demand growth rates were higher than the growth rates of its Gross Domestic Products (GDP). The energy demand growth, especially the demand growth for electricity, was accelerated by the industrialization process in the past two decades. The electricity consumption during the period grew at an annual average growth rate of 9% to reach 104,519 GWh. At the same time, Malaysia's GDP grew at an annual average growth rate of 6% (Ministry of Energy, Green Technologies and Water, 2014). Malaysia is determined to maintain its economic growth over the next decade, but the growth in its energy consumption must be managed to ensure the productivity and competitiveness of its economy.

Energy is increasingly costly and the condition is worsened by global warming due to greenhouse gas emission. Clearly, the need for quality, office buildings in particular, is on the rise. Construction of office and industrial development the fastest growing sectors in the construction industry. The energy consumption in office building is 70-300 kW h/m2 which is 10-20 times bigger than residential sectors (Yang et al, 2008) and (Saidur, 2009) reported that office building air conditioner had the highest energy consumption of 57% and followed by lighting (19%), elevators (18%), pumps and other equipment (6%).

Buildings consume up to 40% of the total global energy. By the year 2030, the consumption is expected to increase to 50%. In Malaysia, buildings consume a total of 48% of the electricity generated in the country. Commercial buildings consume up to 38,645 Giga watts (GWh) while Residential buildings consume 24,709 Gwh. Literature studies indicate more than 50% of this energy is used in buildings for occupants comfort. Demand for electricity in the country is expected to rise from 91,539 GWh in the year 2007 to 108,732 GWh in 2011. By the year 2020, the energy demand in Malaysia is expected to reach 116 Million tons of oil equivalents (Mtoe), which equal to 134,000 Gwh. (Hassan et al, 2014)

The imbalance ratio between energy demand and GDP is indicative of the more energy-intensive economic activities driving the growth. In this regard, the need to promote efficient use of energy in the country has become clear. Therefore, the Malaysia Energy Efficiency Action Plan presents the instruments for a successful implementation of energy efficiency strategies in the country for a period of 10 years which will address and mitigate those barriers. The Malaysia Energy Efficiency Action Plan presents a strategy for a well-coordinated and cost-effective implementation of energy efficiency measures in the industrial, commercial and residential sectors, which will lead to reduced energy consumption and economic savings for the consumers and the nation.

Emissions in the process utilization produce adverse effects on the environment that influence human health, organism growth, climatic changes and so on. The Kyoto protocol, produced by the United Nations Framework Convention on Climate change (UNFCC) in December 1997, prescribed a legally binding greenhouse gas emission target about 5% below their 1990 level. About 160 countries including Malaysia now adopt this protocol. Electricity generation is one of the main contributors to emissions in the country. In order to calculate the potential emissions produced by this activity, the type of fuel use should be identified. Malaysia hopes to gradually change fuel use from 70% gas, 15% coal, 10% hydro, and 5% petroleum in the year 2000 to 40% gas, 30% hydro, 29% coal, and only 1% petroleum by the year 2020. The changes in fuel type have changed the pattern of emission production. This study attempts to predict the pattern of emissions from 2002 to 2020 due to the changes in fuel use. The calculation is based on emissions for unit electricity generated and the percentages of fuel use for electricity generation. The study found that the electricity generation company has produced huge emissions from their power plants in this country.

Plan implementation will result in a total capacity saving of 2,268 MW. The fuel savings derived from the Malaysia Energy Efficiency Action Plan will also lead to less environmental impact and reduction in greenhouse gas emissions. Carbon dioxide (CO_2) emission in the country has increased by 221%, which lists the nation

at 26th among the top 30 greenhouse gas emitters in the world. The total reduction of greenhouse gas emission over the plan is projected to be 40 million tonnes CO2 equivalent. A total reduction of 96 million tonnes of CO2 equivalent will be achieved over the lifetime of the energy-efficient technologies adopted and adapted from the plan implementation.

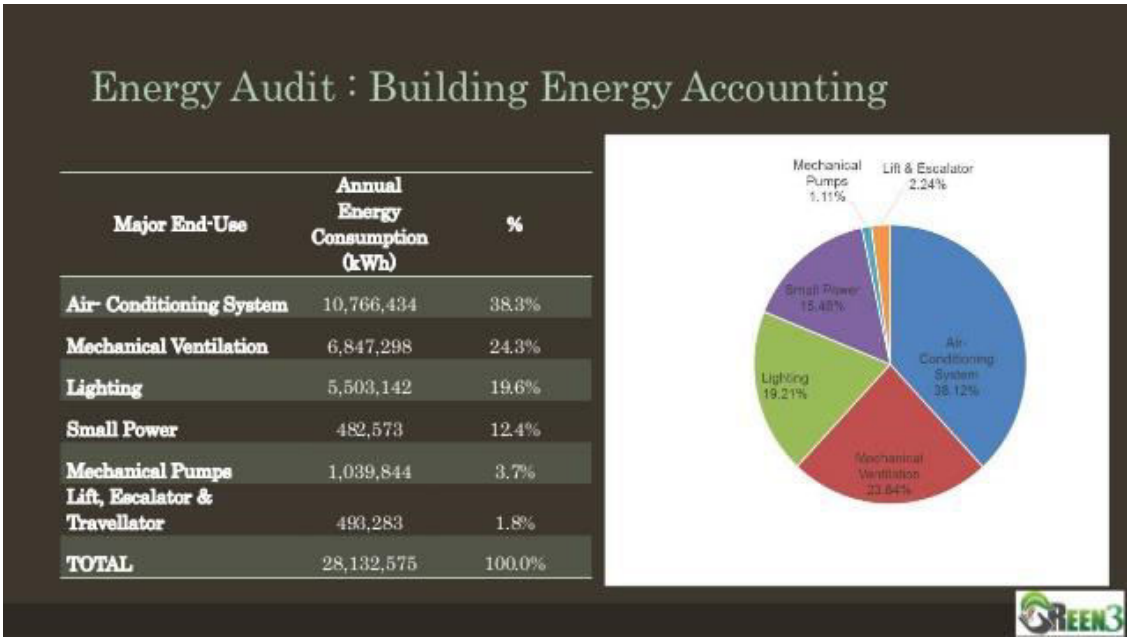

Figure 1.1 Building Energy Accounting by Green3 Energy Sdn. Bhd

Trees play a great vital role towards our climate in three primary ways: they lower temperatures, reduce energy usage and reduce or remove air pollutants. Each part of the tree contributes to climate control, from leaves to roots. Surprisingly it is estimated that there are just over 3 trillion mature trees in the world. Leaves help turn down the thermostat. They cool the air through a process called evapotranspiration. Evapotranspiration is the combination of two simultaneous processes: evaporation and transpiration, both of which release moisture into the air. During evaporation, water is converted from liquid to vapor and evaporates from soil, lakes, rivers and even pavement. During transpiration, water that was drawn up through the soil by the roots evaporates from the leaves. It may seem like an invisible process to our eyes, but a large oak tree is capable of transpiring 40,000 gallons of water into the atmosphere during one year. Chow & Abu Bakar (2012) showed that Kuala

Lumpur's green areas have been reduced to 59.4% or 14386 hectare from its original 24222 hectare of city area. This shows urbanization has affected the green area in Kuala Lumpur thus creating many environmental problems and creating high demand for its urban green spaces.

A roof is part of a building envelope. It is the covering on the uppermost part of a building or shelter which provides protection from animals and weather, notably rain or snow, but also heat, wind and sunlight. The word also denotes the framing or structure which supports that covering. In most countries a roof protects primarily against rain. The roof of a garden conservatory protects plants from cold, wind, and rain, but admits light. Since the roof top area covered a significant percentage compared to total area of any building, thus it must be fully utilized.

1.2 Problem Statement

Since studies shows that 57% of the electricity consumed by air conditioner and and the major electricity consumption of a building goes to the cooling purpose to reach a comfort zone. Previous research works show tree planting is positively contributes to the temperature reduction of a building which further results in the sense of energy saving of building because different type of planting result in different amount of temperature. Since different type of tree planting consume different of land space which considered as one of the most expensive market value. However, there is no tree planting targeting method available till date on different type of tree planting method to optimize the land area consumption for planting. In response to this problem, a well-known pinch analysis method is intended to develop a tree planting targeting on a building as a proposed solution.

1.3 Objective

(1) To develop tree planting targeting which consist of ground planting, vertical planting and rooftop planting and the ability of each type of planting on temperature reduction in a building using pinch analysis.

(2) To carry out sensitivity analysis on area allocated for different type of tree planting and the temperature reduction achieved. The sensitivity analysis covers to study the relationship between area reduction of a particular type of tree planting to the area of other type of planting.

1.4 Scope of Study

With the growing demand on reducing the cooling demand in a building on a sustainable and environmental friendly basis, the following 6 scopes are included in this study.

- A numerical targeting method is developed to reach a thermal reduction by different type of tree planting.
- The data collection for this study will be based on literature review. Data such as area of planting for different type of planting and the ability of the planting system in reducing the temperature is taken from literature review for this study.
- For the first objective, Pinch Analysis method will be developed for different type of tree planting targeting namely ground planting, vertical planting and rooftop planting after done a review on state of the art about Pinch Analysis.

- The targeting method will be then performed on a case study to study the relationship between different type of planting and the temperature reduction.
- For second objective, a sensitivity analysis will be then carried out based on area of planting and quantity of plant for the temperature reduction.
- From the sensitivity analysis, the effect of reducing the plantation area of the rooftop planting from the base case towards the area of ground planting is studied by fixing plantation area of vertical planting. Not only that, the effect reducing area of ground planting towards the area of vertical planting will be studied as well by keeping constant the rooftop planting area. The effect of reducing area of vertical planting towards the area of rooftop planting is studied as well while the ground planting area is kept constant.

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