الجامعة الإسلامية العالمية ماليزيا
INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA
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# ENERGY SAVING STRATEGIES AND IMPLEMENTATION IN SELECTED AIRPORT TERMINALS IN MALAYSIA-TOWARDS EFFECTIVE ENERGY MANAGEMENT POLICY

BY

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A dissertation submitted in partial fulfilment of the requirements for the degree of Masters of Science in Building Services Engineering

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# ABSTRACT

Airport terminals are one of the most energy intensive building types due to its size, design, occupants' activities and twenty four hour operation. Due to recent development trends in airport design such as large expanse of glass and large air-conditioned volumes, energy issues have emerged as an area of concern. In a tropical climate such as Malaysia, reduction in cooling load and energy management have come to the fore due to rising energy costs. This dissertation attempts to shed some lights on energy consumption pattern and load trends in large Malaysian airports with a focus on three case studies representing three categories of high passenger movement. During this study the general passive and active energy related features were assessed. Energy data was collected from these terminals by means of data loggers, documents and personal communications. Using the collected energy data, the relevant analysis was made to propose potential energy saving mechanisms and strategies. Among the obtained results include the load apportioning, building energy intensity, and load profile for these terminals. It is hoped that this study can contribute to the energy policy recommendations developed for Malaysian airports. This study can contribute to start implementation of energy efficiency policies and focus on the energy saving in terminal buildings which bring towards long-term operational cost savings and international recognition in sustainable design.

# ملخص البحث

تعد محطات الطرفية للمطارات من المباني التى تستهلك الطاقة بأعلى درجة من حيث كثافة الطاقة ، وذلك نظرا للحجم وتصميم تلك المبانى وأنشطة مستخدميها و إستخدامها أربعة وعشرين ساعة . لقد أصبحت قضية الطاقة من قضايا المهمة نظرا لإتجاه التنمية فى تصميم المطارات ، مثل إستخدام الزجاج فى بناء الحوائط وزيادة مساحات المكيفة فى المبانى. وفى المناخ المداري مثل ماليزيا، تناقص الطاقة المحتاجه للتكيف وإدارة مجال الطاقة أصبحت فى مقدمة الأبحاث بسبب إتفاع تكاليف الطاقة. هذا البحث يحاول إلقاء الضوء على نمط إستهلك الطاقة فى مطارات ماليزيا مع التركيز على ثلاثة دراسات تمثل ثلاثة فئات من حيث عدد الركاب. والبحث يدرس الصفات السلبية و الإيجابية المتصلة فى الإقتصاد فى إستهلاك الطاقة. لقد تم جمع المعلومات المطلوبة عن الطريق جهاز جمع البيانات ومقياس التيار الكهربائى والوثائق و المقابلات الشخصية. وجرى تحليل هذه المعلومات لإعداد المقترحات التى تؤدى إلى الإقتصاد فى إستهلاك الطاقة. و من بين نتائج هذا البحث تعد التعرف على مجالات إستهلاك الطاقة وكثافة إستخدام الطاقة فى محطات الطرفية لهذه المطارات. هذه الدراسة تهدف أن تسهم فى وضع توصيات لإعداد سياسة الطاقة فى مطارات ماليزيا. ويمكن إستخدام نتائج هذا البحث لبدء تنفيذ سياسات كفاءة الطاقة فى مبانى هذه المطارات. هذا وبالتالى تؤدى على تخفيض فى تكاليف إدارة المطارات والإعتراف الدولي بها بالإدارة المستدامة.

# APPROVAL PAGE

I certify that I have supervised and read this study and that in my opinion, it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Master of Science in Building Services Engineering.

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Dr. Puteri Shireen Bt. Jahn Kassim
Supervisor

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Master of Science in Building Services Engineering.

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This dissertation was submitted to the Department of Building Technology Engineering and is accepted as a partial fulfilment of the requirements for the degree of Master of Science in Building Services Engineering.

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# DECLARATION

I hereby declare that this dissertation is the result of my own investigations, except where otherwise stated. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at IIUM or other institutions.

Abdul Matheen Mohamed

Signature …… Date ……..

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# DECLARATION OF COPYRIGHT AND AFFIRMATION OF FAIR USE OF UNPUBLISHED RESEARCH



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Affirmed by Abdul Matheen Mohamed

……. ……

Signature Date

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# TABLE OF CONTENTS

# LIST OF TABLES

# LIST OF FIGURES

# LIST OF ABBREVIATIONS

| | |
|---|---|
| AHU | Air Handling Unit |
| ASHRAE | American Society for Heating Refrigerating and Air-Conditioning Engineers |
| BAS | Building Automation System |
| BEI | Building Energy Index |
| BMS | Building Management System |
| CAV | Constant Air Volume |
| CFL | Compact Fluorescent Light |
| CP | Contact Pier |
| CT | Current Transformer |
| EMS | Energy Management System |
| FIDS | Flight Information Display System |
| GDC | Gas District Cooling |
| HVAC | Heating Ventilation and Air-Conditioning |
| IES | Illuminating Engineering Society |
| KLIA | Kuala Lumpur International Airport |
| kWh | Kilo Watt Hour |
| LED | Light Emitting Diodes |
| LEED | Leadership in Energy and Environmental Design |
| LEO | Low Energy Office |
| MAHB | Malaysian Airports Holding Berhad |
| MTB | Main Terminal Building |
| MVAC | Mechanical Ventilation and Air-conditioning System |

| | |
|---|---|
| OTTV | Overall Thermal Transfer Value |
| PAHU | Primary Air Handling Unit |
| PLB | Passenger Loading Bridge |
| PTM | Pusat Tenaga Malaysia |
| PV | Photo Voltaic |
| RTTV | Roof Thermal Transfer Value |
| SCADA | Supervisory Control and Automatic Data Acquisition |
| TAM | Total Airport Management |
| TNB | Tenaga Nasional Berhad |
| UPS | Un-Interruptible Power Supply |
| VAV | Variable Air Volume |
| VFD | Variable Frequency Drive |
| VSD | Variable Speed Drive |
| WWR | Window to Wall Ratio |
| LT | Light Transmittance |
| LR | Light Reflectance |
| ST | Total Solar Radiant Heat Transmittance |
| SC | Total Shading Coefficient |
| UV | U-Value |

# LIST OF SYMBOLS

| | |
|---|---|
| Ar | Opaque roof area ($m^2$) |
| Ur | Thermal transmittance of opaque roof area ($W/m^2K$) |
| TDeq | Equivalent temperature difference (K) |
| As | Skylight Area ($m^2$) |
| Us | Thermal transmittance of skylight area ($W/ m^2$) |
| $\Delta T$ | Temperature difference between exterior and interior design conditions (5K) |
| SC | Shading coefficient |
| SF | Solar factor ($W/ m^2$) |
| Ao | Gross roof area ($m^2$) |
| CF | Correction Factor with reference to the orientation of the roof and the pitch angle of its skylight |
| Aoi | Gross exterior wall area for orientation *i* |
| $\alpha$ | Solar absorptivity of opaque wall |
| Uw | Thermal transmittance of opaque wall ($W/m^2K$) |
| *oi* | Orientations of the building |
| A | Ampere |
| V | Voltage |
| k | kilo (One Thousand) |
| VA | Volt Ampere |
| VAr | Volt Ampere Reactive |
| W | Watt |
| M | Mega (One million) |