ASSESSMENT OF OFFICE BUILDING ENERGY EFFICIENCY USING GREEN BUILDING INDEX AND LEADERSHIP IN ENERGY AND ENVIRONMENTAL DESIGN

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To everyone that has supported me, Thank you.

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ABSTRACT

Energy conservation becomes a hot topic in the commercial industry. Energy performance of a building can be rated through green building rating tools. The available tools like Building Research Establishment Environmental Assessment Method (BREEAM), Leadership in Energy and Environmental Design (LEED), Comprehensive Assessment System for Built Environment Efficiency (CASBEE), and Green Building Index (GBI) can guide the government, building designers, pemaju, and users on the energy performance of the building and green building awareness. This paper will investigate the energy performance of an office building with GBI and LEED schemes and comparison of both schemes in term of their assessment methods, scopes, performance criteria and energy rating scales. The differences and similarities of both schemes will be discussed further. The office building will be qualified as green building for certain levels based on the credit awarded. Suggestions and improvements will be given after evaluation from both schemes. The Quick Energy Simulation Tool (eQUEST) is simulated with four different models; T8 to T5, VSD Chiller, Fan Power, and Temperature Control to identify the potential improvement project for this building. A number of energy conservation projects are determined and can generate near to 700 MWh energy saved with RM150k investment.

ABSTRAK

Pengurusan tenaga elektrik dengan cekap menjadi pembincangan hangat di seluruh industri. Prestasi tenaga bagi setiap bangunan boleh dinilai melalui bangunan hijau alat pengukur. Alat pengukur dalam pasaran adalah seperti Building Research Establishment Environmental Assessment Method (BREEAM), Leadership in Energy and Environmental Design (LEED), Comprehensive Assessment System for Built Environment Efficiency (CASBEE), dan Green Building Index (GBI) boleh digunakan untuk panduan kerajaan, pereka bangunan, pemaju, dan pengguna dalam prestasi bangunan dan kesedaran bangunan hijau. Artikel ini mengkaji prestasi tenaga pejabat dengan menggunakan kaedah GBI dan LEED dan membuat pembandingan kaedah tersebut dalam cara pengkajian, skop, prestasi dan markah tenaga. Persamaan dan perbezaaan akan juga dibincang. Bangunan ini akan digelarkan sebagai bangunan hijau selepas mendapat markah tertentu. Cadangan dan kemajuan akan diberikan selepas penilaian daripada dua kaedah tersebut. Quick Energy Simulation Tool (eQUEST) akan disimulasi dengan empat cara; T8 to T5, VSD Chiller, Kuasa Kipas, and Kawalan Suhu supaya potensi kemajuan project dapat diketahui. Projek untuk pengurusan tenaga elektrik dengan cekap telah diketahui dalam bangunan ini dan berjaya mencapai 700 MWh penjimatan tenaga dengan melabur RM150 ribu.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Nowadays, developing countries are facing energy crisis due to growth in economy and population. Energy increase is foreseen to continue and at the mean time our main energy resource fossil fuel is getting lesser and lesser. According to the International Energy Agency (IEA), the world energy demand is predicted to rise 1.2% annually which has 70% of the energy demand contributing from developing countries from 2008 to 2035. [1] The combustion of fossil fuels raises the concern on sustainability of ecosystem. Utilization of fossil fuels can cause climate change issue due to emission of greenhouse gases (GHG). Hydrocarbons, nitrogen oxide, and volatile compounds can contribute to environmental concern. Fig. 1.1 shows global total carbon dioxide emission from year 1980 to 2008. 31,577 million tons of carbon dioxide emissions was recorded in 2008 and it was a leap huge increase comparing to 19,380 million tons in 1980. It will reach 40 billion in year 2030 if the growth of renewable energy remains stagnant and fossil fuels are the main contributor to power generation. [2]

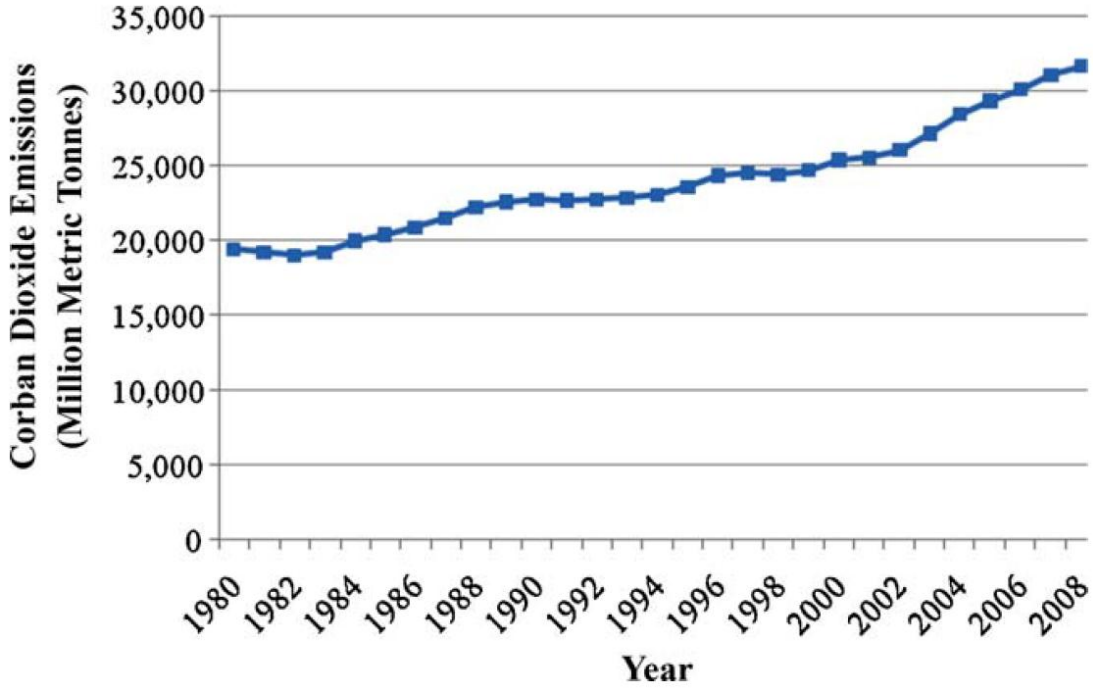

Figure 1.1: Increase trend of carbon dioxide emissions since 1982 **[1]**

Continuously monitoring with guidelines on country development would help to reduce emission of greenhouse gas. [3] Malaysia had signed an agreement to the Kyoto protocol which has proposed to fight against global warming. At the International Climate Convention in Kyoto (1997), developed country agreed to reduce greenhouse gas emissions by certain percentage and moved to use renewable energies not fossil fuels. [4] Prime Minister of Malaysia committed to reduce carbon emission of 40% from 2005 level by 2020 at 15 Copenhagen Climate Change Summit (COP15) in Denmark, December 2009. To achieve this mission, Public Works Department Malaysia (PWD) was assigned to formulate guidelines and sustainable practices to reduce carbon emission from energy, building, transportation and waste management sectors. [5]

Green building is the future trend promoting by Malaysia government. This approach can minimize the amount of carbon emission and establish high energy efficiency building in Malaysia. Although there are hundreds of green building rating tools available in the market, existing office and industry building are seldom getting

involved in the evaluation. Awareness of improve building performance and extend the building life span may not effectively deliver to the existing office and industry building owners. They may think that green building rating tools can only be applied to new building. However, energy performance assessment is critical and provides helpful information of a building in terms of energy efficiency, environmental, water efficiency and other aspects. [3]

1.2 Power Generation in Malaysia

In Malaysia, 27.73 million of population covering an area of 329,750 km^2 is recorded. The energy demand will be expected to rise with growth of GDP at rate of 5.7% over the last 6 years. Fig. 1.2 shows primary energy supply in Malaysia increasing from 20 Mtoe in 1990 to 64 Mtoe in 2008 over 18 years. Besides, the final energy consumption increases rapidly from 1990 to 2008 and is recorded at 44.9 Mtoe in 2008. The annual growth rate of 7.2% is mainly contributed by industrialization and urbanization. Industry sector which is the highest energy consumption sector in Malaysia reaches 19.1 Mtoe in year 2008 and followed by transportation sector. By year 2020, Malaysia's energy demand can reach 83.5 Mtoe. Manufacturing and transportation sector are the main contributor to the growth of energy demand. Fig. 1.3 shows the final energy consumption by sector in Malaysia from 1990 to 2008. [2] [6]

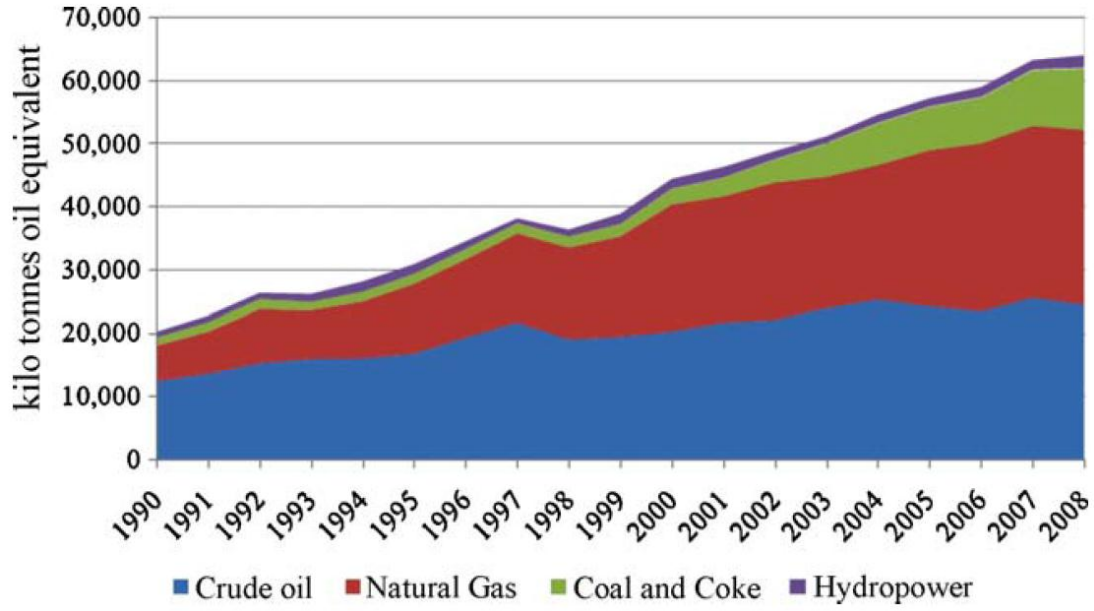

Figure 1.2: Primary energy supply by fuel type between 1990-2008 **[2]**

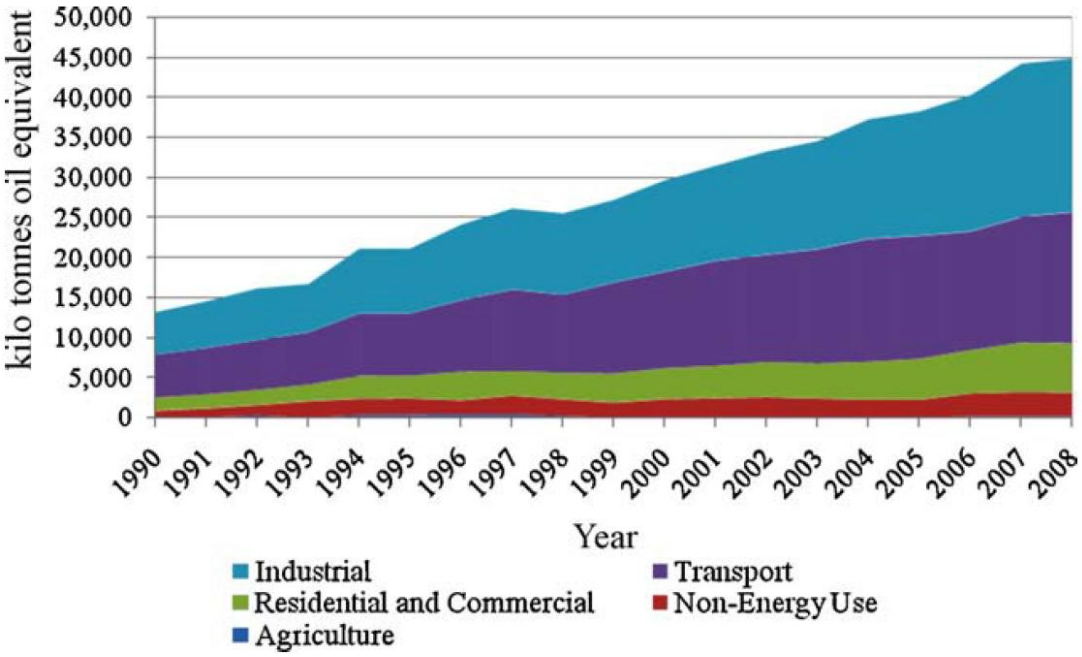

Figure 1.3: Final energy consumption by sector in Malaysia **[2]**

Tenaga National Berhad (TNB), Sabah Electricity Sdn. Bhd (SESB) and Sarawak Electricity Berhad (SEB) are the main utilities providers in Malaysia. Oil was main power generation in Malaysia in 1978. Malaysia government introduced

Four Fuel Diversification Policy in year 1981 to reduce the dependency of oil and use gas, hydro and coal as other optional type electricity generation. Today, natural gas and coal generate electricity power to fulfill increase of power demand. Although coal will pollute environment, it is the cheapest fossil fuel in the market. To balance between cost and environment, new technology will help to ensure generation of clean electricity and improve efficiency of electricity production. [7]

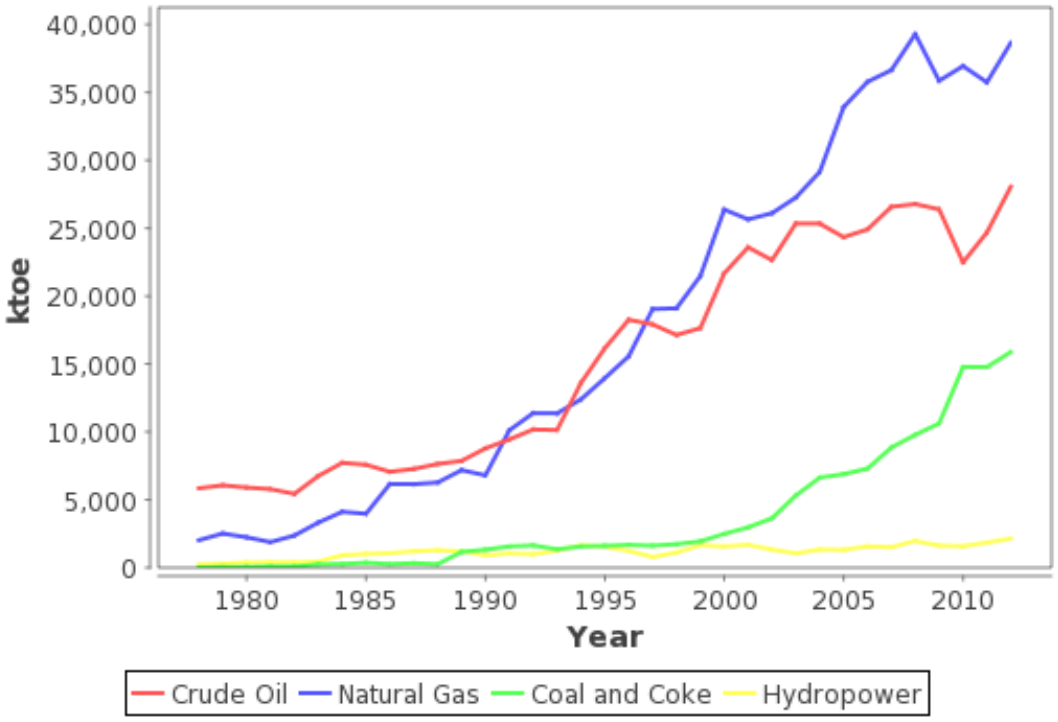

Figure 1.4: Electricity Generation in Malaysia (1978-2012) **[7]**

1.3 Energy Policy Malaysia

In year 1975, Malaysia government introduced the first energy policy and plan, National Petroleum Policy 1975 to scrutiny energy concerns raised by public. It was formulated to optimize the use of petroleum resources and made sure exploitation of petroleum following the regulation of ownership, management and operation to cater the fast growing of petroleum industry in Malaysia. National

Energy Policy of Malaysia in year 1979 had focused on three main objectives which were supply, utilization and environment. These objectives made sure that adequate supply of energy, efficient utilization of energy and lower down environmental impact of energy production. When 7th Malaysia Plan was strategized for year 1996-2000, the plan had encouraged efficient utilization of energy for the energy supply side. [8]

In year 2001, Malaysia's government introduced Five Fuel Diversification which was aimed to reduce dependent of fossil fuels and develop potential of biomass, biogas , municipal waste, solar and mini-hydro as electricity generation. Small Renewable Energy Power (SREP) was embedded in this policy with implemntation of Eighth Malaysia Plan (2000-2005) to promote utilization of renewable energy in power generation. Small power generation plants could sell the electricity through the distribution grid system. Special Committee on Renewable Energy (SCORE) coordinated this program to ensure efficient implementation of projects. However, the progress of Fifth Fuel Diversification Policy was disappointed due to low participation of market players. During Ninth Malaysia Plan (2006-2010), government decided to size down the capacity from 500 MW or 5% to 350 MW or 1.8% in Energy Mix. Malaysia Energy Centre or Pusat Tenaga Malaysia (PTM) presented Renewable Energy Policy 2011 and their action plan was in conjunction of Tenth Malaysia Plan (10MP) 2011-2015. The objectives of this policy were to promote the growth of Renewable Energy (RE) industry, to raise RE contribution in the power generation mix, to increase awareness on the role and important of RE, to take care environment for future generation, and to obtain fair RE generation cost. Enforcement of the Renewable Energy Act 2011 and the Sustainable Energy Development Authority 2011 was important after identifying the reason behind of poor performance of past policy. Feed-in Tariff (FiT) system was launched on December 2011. This system was proven strategy to foster the growth of renewable energy. Germany, Spain, Italy, Thailand and other countries has implemented this strategy and get benefit of it. Every kilowatt hour generated from renewable energy can be exported to main grid and FiT system promises a guaranteed of fixed rate

payment at the stipulated time frame to the developer. Fig. 1.5 shows the renewable energy policy development in Malaysia. [9] [10]

The National Green Technology Policy in year 2009 promoted Green Building Index and Green Technology. [11] In Samari et.al's survey, high initial investment cost of developing of green building was one of the barriers to promote green building in Malaysia. Incentives such as stamp duty and tax exemption were given and yet little of construction firms could take the risk of investment to build green building.

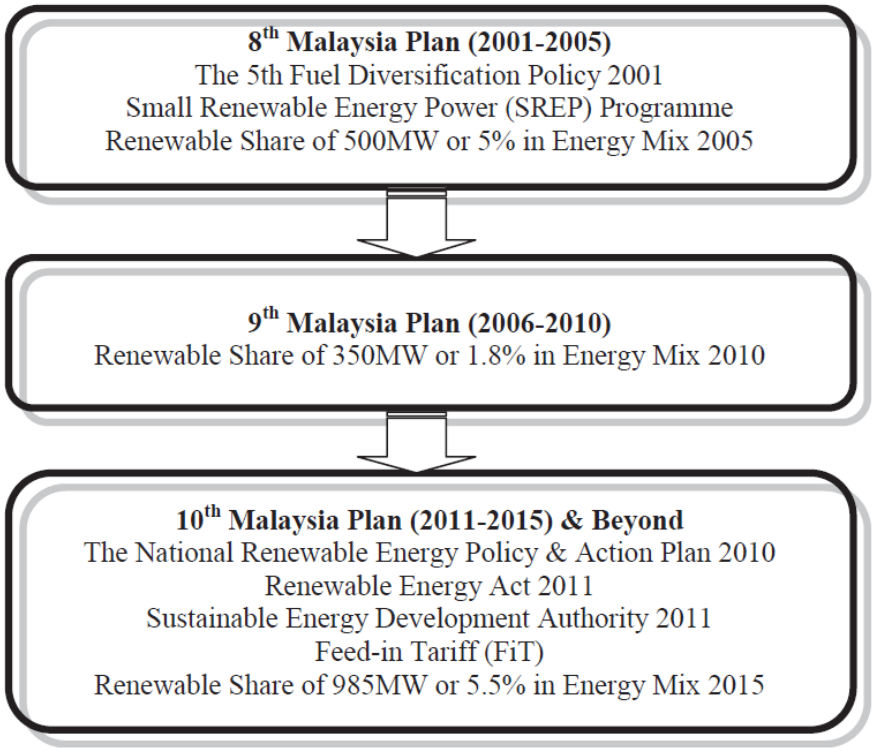

Figure 1.5: The Renewable Energy Policy Timeline in Malaysia **[9]**

1.4 Energy Efficiency

Energy efficiency is typically divided into two groups which are supply side and demand side. Power generation, transmission and distribution of electricity are positioned in supply side while energy uses in the industrial, commercial and residential are part of demand side. Power generation plants can obtain a great saving using high efficiency power generation technology. For instance, advanced gas turbine power plant can provide 58-60% of energy efficiency compare to typical steam generation power plant which has 33-35% of energy efficiency. United Nation Development Program (UNDP), Global Environmental Facility (GEF), private sector and government have funded the Malaysian Industrial Energy Efficiency Improvement Project (MIEEIP) for identified eight industrial sectors and eight components under MIEEIP and developed to promote energy efficient in industry sectors. Under commercial, government launches a new green building rating tool which is called Green Building Index (GBI) to booster construction of green building in Malaysia. The Energy Start Rating Label has been introduced to evaluate the energy performance of residential appliance. Televisions, refrigerators, domestic electric fans and split air conditioners which have 5 star labels indicate that there are energy efficient products in the market. [11]

1.5 Problem Statement

Until 15 October 2014, there are seven buildings certified under Non-Residential Existing Building (NREB) categories. Knowledge and study on green building rating system for Malaysian existing non-residential are limited and people are lack of awareness of important of energy performance in a building. They are reluctant to pay for high capital investment cost to improve the energy performance of the building and end up with increasing of maintenance and operation cost. [12] Rohini Brahme et al. studied on occupant behavior on the energy consumption. They

found that awareness of occupant on energy conservation can lower down the energy consumption by one third and improve the efficiency of the building. [13]

World Business Council for Sustainable Development find that real estate and construction professionals are overestimated the cost of constructed a green building by 300 percent. In fact, only five percent of actual cost is higher than typical building construction. Therefore, proper cost estimation of going green building is needed. Ng Ban Huat et al. researched on energy efficient design of the office building in Malaysia by analyzing through Building Energy Index (BEI) method. Inefficiency area of the building was identified and improvements and suggestions were given. However, economic feasible study was not done for the improvement projects. [14] Building energy efficiency has to be analyzed to identify energy saving project in the building. Simple Payback Period (SPP) is important in the sense that to study the feasibility of the project implementation.

1.6 Objectives

The objectives of this study:-

a. To investigate electrical demand profile and operation of an office building;
b. To assess the energy efficiency of office building using GBI and LEED rating system;
c. To assess financial feasibility to upgrade the office building to achieve requirement in GBI and LEED rating system.

1.7 Scope of Works

Author will examine the energy efficiency of this building based on LEED 2009 under aspect of energy and atmosphere and Green Building Index for Non-

Residential Existing Building under criteria of Energy Efficiency. Besides, identifying the difference of LEED and GBI rating system for office building is part of scope of works. Last and not least, author has to analyze the financial investment needed for energy improvement projects implemented in the building without affecting existing operation and reliability of the building. Nevertheless, author will not discuss on Indoor Environment Quality, Sustainable Site Planning & Management, Materials & Resources, Water Efficiency, and Innovation category in GBI and LEED rating tool.

1.8 Project Organization

This project is represented by five chapters as below:

Chapter 1 : Introduction of this project is being presented. The problem statement, objectives, scope of works and project outline is being elaborated.

Chapter 2 : Literature review on green building, building rating tools in the market and eQUEST. Previous research paper and challenges faced by the industries in this project research area will be discussed and critically review.

Chapter 3 : Discussion about the methodology and the simulation software being used in this project.

Chapter 4 : Discussion on electrical demand, operation of building, difference of GBI and LEED under different criteria for KM6, and simulation result.

Chapter 5 : Conclusion future development of this research area and barriers will be elaborated in order for continuous future development in this research area.

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