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Electrical Engineering (Industry Power)

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POWER SYSTEM ANALYSIS OF GRID CONNECTED EMBEDDED GENERATOR

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DEDICATION

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ABSTRACT

The aim of this project is to study a power system analysis using an iterative power system simulation package, Power World Simulator package Version 8.0 to evaluate the impact of strategically placed Embedded Generation on distribution system with respect to the network losses, power flows and steady-state voltage variation. This project is referring to the Small Renewable Energy Power Program (SREP) introduced by the Malaysia's Government. Embedded Generation (EG) has a potential to promote and encourage the extensive use of renewable sources for grid connected power generation system. The term "Embedded Generation" refers to electricity generation connected at distribution level rather than transmission level. Embedded Generation can reduce the effect of losses while providing reactive power to the network.

ABSTRAK

Projek ini bertujuan untuk mengkaji analisa sistem kuasa menggunakan perisian "*Power World Simulator Version 8.0*" dalam mentaksir kesan Penjanaan Tambahan pada lokasi yang strategik pada sesuatu sistem pengagihan dengan melibatkan kesan pada aspek kehilangan kuasa dalam rangkaian, aliran kuasa dan kestabilan perbezaan voltan. Projek ini merujuk kepada usaha kerajaan Malaysia dalam memperkanalkan "Program Sumber Tenaga Kitar Semula Kecil-kecilan". Penjanaan Tambahan mempunyai potensi untuk mempromosi serta menggalakkan secara meluas penggunaan penjanaan sumber tenaga kitar semula yang akan dijanakan oleh sistem yang mempunyai sambungan grid. Istilah penjanaan tambahan lebih merujuk kepada penjanaan bekalan elektrik yang disambungkan kepada sistem pengagihan berbanding sistem penghantaran. Penjanaan tambahan boleh mengurangkan kesan kehilangan kuasa rangkaian dan membekalkan kuasa reaktif kepada rangkaian.

CONTENT

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

Power system analysis of grid connected embedded generator is an analysis to study the impact of adding new additional generator (Embedded Generator) on the distribution system. Embedded Generator (EG) will generate the energy from the renewable energy. Before adding the EG, some factors should be considered especially the location and characteristics of the EG. In this project, the study will focused on the power flow, network losses, and steady-state voltage variation. At the same time, it will showed the effect of the active power and reactive power when the EG is added. The introduction of EG on the distribution system can reduced some problems especially for the capacity of the energy in future. This project will be done using Power World Simulator.

1.1 Aims And Objectives

The aim of this project is to conduct a power system analysis using Power World Simulator to evaluate the impact of strategically placed Embedded Generator (EG) on distribution systems which will focus on the following statement:

- Network's losses
- Power flows
- Steady state voltage variation

While the objectives of this project are as followed:

- To make a comparison between the three types of the bus test system
- To search deeply the effect of the power factor to the active power and reactive power
- To monitor the system when the additional generator is embedded into the distribution system

1.2 Approach

Before adding the additional generator to a distribution system, several technical considerations must be take action. An accurate way to analyze the behavior of the system with EG is to perform load flow simulation using The Power World Simulator package Version 8.0 to analyze the, power flow, network losses and steady-state voltage variation. will be used to analyze the system behavior.

Three type bus test system that have been chosen are listed below:

1. IEE 5 Bus test system
2. IEEE 24 Bus test system
3. IEEE 37 Bus test system

1.3 Scope Of Project

This project commences with an overview of renewable energy and the potential of introducing EG using renewable sources. This is followed by a literature review with an up to date findings and theoretical. Then the project is continued with the project methodology will be discussed in detail. Finally, the project will conclude the summary findings and also recommendation of RE for future development.

CHAPTER 2

RENEWABLE ENERGY IN MALAYSIA

The Malaysian economy has been growing steadily, bringing the net demand for energy to higher levels than ever before. As of 2008, Malaysia will be a net importer of oil and by 2040; the nation's gas supplies will be depleted. The prospect of diminishing oil and gas supplies has forced the government to find sources of renewable energy (RE) which will result in lower greenhouse gas emissions [1].

2.1 Overview

The Malaysia Prime Minister recently chaired a meeting of a Cabinet Committee to find a way looking for alternative fuels in particular renewable sources. The Cabinet Committee give a support to the Government's to promote all types of RE in the planning for a more energy sector. In the year 2000, the Government introduced the Five-Fuel Policy, where under this policy; RE has been identified as important resources for the country's fuel mix together with oil, natural gas, coal and hydro. The Government's hope that as a result of this policy, the vast potentials of RE can be fully tapped and contribute to the growth and sustainability of energy sector [1].

To ensure that RE projects can be implemented. Ministry of Energy, Communication and Multimedia has established the Small Renewable Energy Project (SREP) Program on 11^{th} May 2001. The SREP program has been success based on the number small-scale projects that have been approved (see Table 2.1 below) [2].

Table 2.1: Status of approved SREP as reported by Energy Commission

Type of Renewable Energy	No of approved application	Capacity MW
Biomass	14	105
Biogas	2	5
Minihydro	1	2
Wind and Solar	0	0
Total	17	112

Malaysia ratified the Kyoto Protocol in September 2002. Despite Malaysia having no obligations regarding greenhouse gas (GHG) reduction, the Malaysian government, with support from the United Nations Development Program (UNDP) and the private sector, has created programs to promote small RE power plants in the industrial sector and thereby creating opportunities for Clean Development Mechanism (CDM) projects in Malaysia [1].

The 8th Malaysia Plan (2001-2005) includes provisions to promote the efficient use of RE. The Government allocated 120 million dollars for RE initiatives. Many of the opportunities are offshoots of developments in the RE sectors [1].

2.2 Energy Demand In Malaysia

Malaysia is in the midst of an era or vigorous industrial growth. The Government's vision of turning Malaysia into a humane industry country by the year 2020 will have a great impact on usage of energy in country. Table 2.2 and Table 2.3 showing the energy demand required in Malaysia [2].

Table 2.2: Final Commercial Energy Demand by Source (%)

Source	1995	2000	2005
Petroleum products	72.8	68.9	67
Natural gas	8.8	10.3	10.9
Electrical	15.2	17.6	18.8
Coal and Coke	3.2	3.2	3.3
Total (PJ)	928	1168	16998
Per Capita Consumption	44.3	50.1	66.4

Table 2.3: Final Commercial Energy Demand by Sector (%)

Sector	1995	2000	2005
Industrial	36.4	37.1	38.2
Transport	35.3	36.2	37.8
Residential/ Commercial	12.8	12.7	12.5
Agricultural/Foresting	2.9	1.8	1.8
Non-Energy	13.5	12.2	9.8
Total (PJ)	92.8	1167	1699.8

Table 2.4 below showing type of fuels been generate in Malaysia between 1995 to 2005 [2].

Table 2.4: Electricity Generation Mix (1995-2006) (%)

Fuel	1995	2000	2005
Oil	36.4	37.1	38.2
Coal	35.3	36.2	37.8
Gas	12.8	12.7	12.5
Hydro	12.8	12.7	12.5
Other	2.9	1.8	1.8
Total Generation (GWh)	13.5	12.2	9.8
Peak Demand (MW)	7212	10673	16384

2.3 The Sources Of the Renewable Energy

Malaysia currently has a lot of renewable energy sources will be discussed below, such as:

2.3.1 Biomass

Biomass is the largest RE in Malaysia. Our country is a largest palm oil producer in the world. This industry is selling the production in dollars has not been affected by the crisis and is driving the market with more than 300 palm oil mills in operation producing an estimated 19 million tons of crop residues per year [3].

2.3.1.1 Wood Fuel

Malaysia is one of the major wood processing countries in the region. Generally, auto-generation of electrical power using wood waste material is considered cost-competitive with the tariffs charged by the electric utility companies. The supply of excess power to the grids is not yet practiced. With the emergence of alternative uses for wood waste materials (e.g. fiber board), wood residue volumes as a source of fuel are decreasing. Emphasis in the sector will be not so much on expansion of capacities, but rather on higher efficiencies in existing industries [3].

2.3.1.2 Crop Residue

In Malaysia, crop residue utilization for power generation is dominated by one single sector: the palm-oil industry. Empty fruit bunches, shells, fiber, and even palm-oil mill wastewater can be used for the generation of steam and electric power. There are some 281 palm-oil mills in operation on the year 1995 with an aggregate installed capacity of around 200 MW. All this capacity is installed to meet own demand [3].

For 1995, it was estimated that around 17 million tons of waste fresh fruit bunches were produced in Malaysia. For low-pressure systems with an assumed conversion rate of 2.5 kg of palm oil waste per kWh, potentially 7,000 GWh could be theoretically generated. Also for empty fruit bunches however, alternative uses (such as Medium Density fiberboard) are becoming available. These competing alternatives may eventually result in waste shortages at palm-oil mills [3].

These shortages, combined with the stricter enforcement of environmental standards, will lead to a call for more efficient (high pressure ~ 80 bar), environmentally friendly co-generation equipment. Retrofitting existing palm-oil mills with (partly) new co-generation equipment is expected to become an interesting commercial opportunity. Boilers typically have a rate capacity of 25-30 t/h. for power generation; turbines are usually not larger than 1-1.5 MW, practically always in a backpressure set-up with the first priority for heat generation for sterilization purposes [3].

2.3.1.3 Paddy waste

While milling the paddy, rice mills produce rice husk, which can be considered as fuel for heat and power generation provided the waste volume, is sufficient and regular. With a total volume of rice paddy amounting to 2.2 million tons (1994) and for 22 % consisting of rice husk, a theoretical volume of 0.47 million tons of rice husks would be available [3].

So far, experiences in Malaysia with the utilization of rice residues for heat and power generation have remained quite limited. A central problem is that paddy needs to be dried actual rice milling can be done all year round where required heat/power ratios for co-generation will vary with the season. In addition, rice husk is a very difficult biomass for incineration with a relatively low calorific value, high volatile matter content and high ash content [3].

Actually, the high commercial value of the ashes (silica, sold in the metal industry) may provide more incentive to venture into co-generation than the heat and power by themselves. Techno-economically speaking, co-generation systems are only feasible for rice mills with a minimum production capacity of 5 tons per hour. It appears there is some renewed interest in rice-husk co-generation systems after a successful project in Pendang (steam boiler 6.5 t/h, 30 bars, 450KWh back pressure turbine and heat exchanger (1,200,000 kcal/hr)). The system is used 3 months of heating (paddy drying) as well as for the plants power supply. Typical size of boiler for rice mills is 5-15 tons/hours coupled with a 0.5 - 1 MW turbine [3].

2.3.2 Energy From Waste

Although certainly some potential for power generation (e.g. from urban waste) might be present (through incineration or landfill gasification), the technologies as well as pilot programs are still at the infant stage. Little data is available [3].

2.3.3 Solar

2.3.3.1 Solar Thermal

The Ministry also wants to promote the use of solar water heating, mainly through national promotion campaigns where the private sector should be involve, this field is more connected in fact with energy conservation [3].

Solar water heaters are widely accepted among the affluent segment of the urban population. Some hotels and beverage industries are equipped with a solar water heater. Both local and imported (mostly Australian) brands are available on the market. There are an estimated 10,000 solar water heaters for domestic purposes installed, with growth rates of around 10-15 % per annum [3].

2.3.3.2 Solar PV

The bulk of the total capacity of PV systems previously installed was for telecommunications. There is some potential for solar home systems in the unelectrified areas of Sabah and Sarawak. With the whole of Peninsular Malaysia electrified, the potential for photovoltaic (PV) power supply appears to be limited to some special applications e.g. telecommunications (relays), lighthouses or sea buoys in remote locations. For Sabah and Sarawak, further electrification by conventional grid extension will remain problematic; no matter how much (centralized) power plant capacity is made available. The dispersed human settlement pattern results in extremely low load densities [3].

Examples are present in Sabah where, with total disregard for the costs associated with the grid extension, the monthly returns of the end-users do not even cover the operational costs of the transmission and distribution. Average insulation for Peninsular Malaysia is 4.5 kWh/m2 per day. No comprehensive data for Sabah and Sarawak are yet available, but the figures are expected to be slightly lower due to regular (equatorial) lifting of air masses and subsequent cloud formation [3].

About 4 companies are involved in PV system; most of them are dealers of European or American module manufacturers. BP Solar is by far in a leading position, being the only one involved in a large national electrification project with the Ministry of Rural Development. The effort on the government level for the promotion of renewable energy and PV in particular, in the planned information campaigns, should help to increase this on going market [3].

Some other applications could be developed such as powering schools (around 400 schools are without electricity in the peninsula), rural dispensaries, etc. Even if the government is not yet planning to actively help this market in a near future, the needs are still there and some local companies are steadily developing sales. Products and technical back up are certainly needed for local companies that have a limited experience. Indeed sustainable schemes for rural electrification and to launch a partnership with a local company [3].

2.3.4 Small Hydro

A number of run-of-river type mini-hydro plants have been installed both in Peninsular Malaysia (39 units with a total capacity of 16 MW) as well as in Sarawak (7 units with a total capacity of 2.35 MW) and Sabah (5 units with a total capacity of

5 MW). Small hydro projects may have some additional prospects in East Malaysia, replacing existing diesel-powered electricity generation. There is a possibility of private sector involvement in the ownership and operation of mini-hydro schemes [3].

2.3.5 Wind

With only one 150 kW WEC system installed, wind power technology is still considered to be in the initial stages of development. The operator of the system is TNB utility. Status as of December 1999: The system "could operate" but is not operational due to high operational costs related to its remoteness. Data on wind potential and yearly wind regime are only available for a few selected areas [3].

At first glance, it appears that the potential for wind power projects in Malaysia is rather limited. Promising average wind velocities of over 4 m/s are only available in a few coastal areas. Besides, the availability and direction of the wind appears to be seasonal. Some smaller islands have average wind speeds ranging from 6 to 11 m/s. Wind power pilot projects faced many problems ranging from lack of wind to long outage due to technical problems (sophisticated equipment, lack of spare parts) and inaccessibility of the location. For water pumping the low speed wind turbines may offer some opportunities also in areas with average wind speeds of around 3 m/s [3].

2.4 Important Of The Renewable Energy

Renewable energy is very important to Malaysia. This is because of the following reasons:

- To reduce the dependency on fuel sources
- To minimize the negative impact on the environment

- To help regarding greenhouse gas (GHG) reduction
- To mitigate the economic effects of rising oil prices
- To secure electrical power and other convenient forms of energy supplied in a sustainable, efficient and cost-effective manner [4]
- To save foreign currency by producing and using local products [4]
- The increased use of biomass creates additional employment for Malaysian workers [4]

CHAPTER 3

EMBEDDED GENERATION SCHEME

Embedded Generation is an electricity generation, which is connected to the distribution network, rather than the high voltage transmission network. A distribution network is the low voltage network of wires and cables constructed to bring electricity to consumers.

3.1 Introduction To Embedded Generation

Embedded Generation is one type of smaller generation, which is less than 10MW, and then embedded into the distribution system. Embedded Generator (EG) can increase the amount of energy produced through renewable energy.

The introduction of EG can significantly impact the flow of the power and voltage conditions at consumers and utility equipment. The impacts may positively or negatively depend on the characteristics of the distribution system and the EG itself [5].

When connecting an EG to the distribution system, we must be considered such as technical issues: