Renewable and Sustainable Energy Reviews 94 (2018) 551–564

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Review of baseline studies on energy policies and indicators in Malaysia for future sustainable energy development

M.A. Hannan[a,*], R.A. Begum[b], M.G. Abdolrasol[c], M.S. Hossain Lipu[c], A. Mohamed[c], M.M. Rashid[d]

[a] Department of Electrical Power Engineering, Universiti Tenaga Nasional, 43000 Kajang, Malaysia
[b] Center for Water Cycle, Marine Environment and Disaster Management (CWMD), Kumamoto University, Kumamoto 860-8555, Japan
[c] Centre for Integrated Systems Engineering and Advanced Technologies, Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia
[d] Department of Mechatronics Engineering, International Islamic University Malaysia, 53100 Jalan Gombak, Kuala Lumpur, Malaysia

ARTICLE INFO

Keywords:
Malaysian energy policies
Indicators
Efficiency
Baseline studies on energy
Renewable energy

ABSTRACT

Malaysia's framework for energy development was established in the early 1970s. Henceforth, many successive policies were introduced as potential resources for electricity generation and utilization. Currently, as a signatory to the United Nations Framework Convention on Climate Change, Malaysia is sparing no effort to comply with the policy to meet the challenges of mitigating over-dependence on fossil fuels, reducing carbon levels, and achieving sustainable national development. This paper reviews the baseline studies on electrical energy policies and the measurement indicators used in Malaysia's electric power system. This research involves a comprehensive survey of electrical energy policies in Malaysia that focus on issues pertaining to energy supply, utilization, its environmental impact and considerations, renewable energy (RE) policies, production and consumption, energy efficiency, and feed-in tariffs. Fourteen energy indicators for sustainable development in Malaysia were investigated through the identification of energy policies in significant areas, such as reliability, safety, adequacy and cost-effectiveness of energy supply; increasing energy efficiency; minimizing environmental impact; and enhancing quality of life in terms of social well-being. The policies and the indicators are classified into different sustainable dimensions and summarized in tables along with the corresponding key references. In this study, future energy planning and options, especially in nuclear and RE programs, as well as the conflict between them, are illustrated through the overall performance relative to targets and benchmarks for past and future projections up to the year 2030. This review seeks to examine the past, present, and future policies and indicators to provide a sufficient overview of Malaysian energy policies for optimizing sustainable development. The goal is for this review to lead to increased efforts to accommodate the increasing demand for the management and utilization of RE, promote energy efficiency, and improve performance in achieving sustainable national development.

1. Introduction

In an electric power system, electrical tools are employed to generate, transmit, and distribute electric power. The electric power network that supplies power to homes and industries within a sizable region is called the national grid or the grid in which the generators deliver power to the transmission system. The transmission system then carries power from the generators to the distribution system, i.e., the load centers and the distribution system subsequently supply the power to the load at homes and industries, as shown in Fig. 1 [1,2].

Multiple power sources are connected to most power systems, i.e., external and internal power sources [1]. By contrast, batteries, fuel cells, or photovoltaic cells supply direct current power. The devices known as turbo generators connected to a rotor that revolves in a magnetic field generate alternating current power. Numerous techniques have been used to spin a turbine's rotor from steam-heated approaches using fossil fuels (such as coal, gas, oil, or nuclear energy), hydro-electric power generation from falling water, and wind power generation [3]. Electric power systems transmit power to the distribution system, i.e., in loads ranging from household appliances to industrial machineries. In general, most loads are rated with a fixed number of phases of voltage and current with a certain frequency and [2]. Most home appliances are typically single-phase or sometimes three-phase equipment operating at 50 Hz, with the voltage depending on national standards.

The conductor carries power from the generators to the load. In

* Corresponding author.
E-mail address: hannan@uniten.edu.my (M.A. Hannan).

https://doi.org/10.1016/j.rser.2018.06.041
Received 8 August 2017; Received in revised form 23 May 2018; Accepted 20 June 2018
1364-0321/

Nomenclature

AC	Alternating current
CEB	Central Electricity Board
DC	Direct current
EC	Energy Commission (Suruhanjaya Tenaga)
EIA	Energy Information Administration
EPP	Entry Point Projects
EPU	Economic Planning Unit
ETP	Economic Transformation Program
FIT	Feed-in tariff
GHG	Greenhouse gas
GTFS	Green Technology Financing Scheme
HVDC	High voltage direct current
IPPs	Independent Power Producers
KED	Kinta Electrical Distribution
MESITA	Malaysia Electricity Industry Trust Account
MEWC	Ministry of Energy, Water and Communications
MNPC	Malaysia Nuclear Power Corporation
NEB	National Electricity Board
NEPIO	Nuclear Energy Programme Implementing Organization
PRHEP	Perak River Hydro Electric Power Company
PTM	Malaysia Energy Centre (Pusat Tenaga Malaysia)
PWR	Pressurized water reactor
R&D	Research and development
RE	Renewable energy
REPPA	Renewable Energy Power Purchase Agreement
SESB	Sabah Electricity Sdn. Bhd.
SESCO	Sarawak Electricity Supply Company
SIRIM	Standard and Industrial Research Institute of Malaysia
SREP	Small Renewable Energy Programme
TNB	Tenaga Nasional Berhad
toe	Ton of oil equivalent
TSO	Technological Support Organization

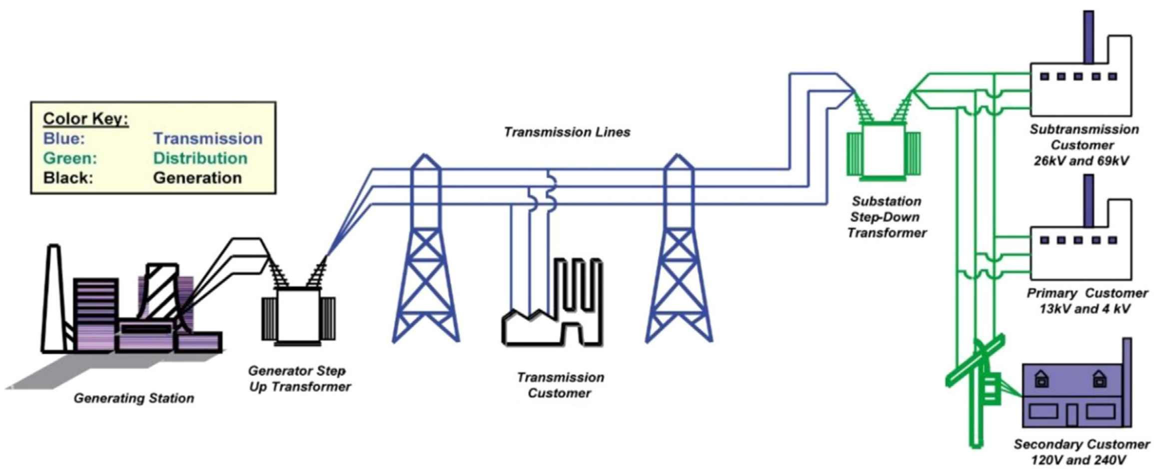

Fig. 1. Basic structure of an electric power system [1,2].

general, conductors are categorized as components of the transmission line that transmits power with high voltages from the generators to the load or the distribution system that supplies power with low voltages from load centers to homes and industries [4]. The conductors of a power system are typically situated either underground or overhead. Overhead conductors are usually constructed with air insulation and sustained on glass, porcelain, or polymer insulators. By contrast, underground conductors have insulation that covers wires with flexible insulation or cross-linked polyethylene [4,5].

Most power system loads are typically linear, i.e., resistive or inductive loads in which the current lags behind the voltage. However, some loads are non-linear. In a power system, reactive power is not measurable but is transmitted between the reactive power source and the load cycle. The transmission of reactive power through generators is recognized as a cost-effective method. If reactive power is provided through capacitors, the capacitors are usually installed near inductive loads to decrease the current load on the power system. To increase the voltage level, power factor correction can be installed at adjacent large loads or the central substation [6]. Reactors are employed to control the voltage on long transmission lines that consume reactive power. In most cases, reactors are placed in a series in a power system to minimize rushes of current flow. Small reactors with capacitors are also placed in a series to limit the rush current associated with switching capacitors. The fault current of a power system can also be limited by connecting series reactors [7].

Power electronics are switching devices that can change the amounts of power fluctuating from a few hundred watts to several hundred megawatts. The AC-to-DC converter or vice versa is the basic function of power electronic devices [8]. HVDC is a power electronics system used to alternate between AC and DC power for long-distance power transmission. HVDC is reliable and economic, entails low transmission loss, and is environment friendly relative to AC voltage transmission systems. Power systems comprise protective devices, such as fuses, to avoid injury or destruction during failures. The fuse element melts when the current flowing through a fuse exceeds the threshold value. Subsequently, an arc is produced across the resulting gap, which, in turn, interrupts the circuit. The protective relays then sense a fault, initiate a trip, and separate the faulty circuit from the rest of the system in high-powered applications [9].

The current work reviews the baseline studies on energy policies and indicators in Malaysia. A comprehensive survey of Malaysian energy policies and indicators is analyzed for future sustainable energy production, consumption, national development, and related issues. Issues, challenges, and conflicts are highlighted for sustainable energy development in Malaysia through the identification of energy policies for priority areas, such as the adequacy and cost effectiveness of energy supply, improvement of energy efficiency, minimization of environmental impact, and enhancement of quality of life and social well-being.

2. Power systems in Malaysia

Malaysia is located in the southern part of Asia and consists of two separate territories, Peninsular Malaysia and East Malaysia, isolated by