CHAPTER 1

Introduction

1.1 Rationale and Motivation

Energy problem is one of the most concern problems in many countries. The costs of fossil-fuelled electricity generation have been gradually increasing as the fossil fuel resources are decreasing. Accordingly, renewable energy is one of the good alternatives. Renewable energy mitigates the shortage of energy and reduces the environmental impacts. According to the Copenhagen Accord, greenhouse-gas emissions have collectively fallen short of what would be required to attain the goal of limiting the global temperature increase not exceeding 2 °C [IEA, 2010].

In Thailand, the renewable energy is influenced in electricity generation planning by the Power Development Plan 2010 (PDP 2010) [EGAT, 2010]. In PDP 2010, the electricity generation contributed from renewable energy resources would be greater than 5 % after the year 2020; especially solar, wind, hydro, biomass and biogas are included in the strategic plan to mitigate the fossil-fuel shortage problem and to decrease environment impacts. Furthermore, the Thai government has encouraged both industrial and public sectors to increase renewable energy share. The renewable energy potential and target for electricity generation in Thailand are shown in Table 1.1.

Nevertheless, an increasing of renewable energy in power system influences the reliability of the system due to intermittent behavior of some resources such as wind and solar. One of the important issues to be concerned is the impact of renewable generation on the generation reliability evaluation.

Table 1.1 Renewable energy potential and target for electricity generation in Thailand during 2008-2022.

Unit (MW)	Actual 2009		Target		
	Potential	existing	2008-2011	2012-2016	2017-2022
Solar	50000	32	55	95	500
Wind	1600	1	115	375	800
Mini/micro hydropower	700	56	165	281	324
Biomass	4400	1610	2800	3220	3700
Biogas	190	46	60	90	120
Municipal solid waste	400	5	78	130	160
Hydrogen	-	-	0	0	3.5
Total		1750	3273	4191	5608

Source: EGAT [EGAT, 2010] and Ministry of Energy [Ministry of Energy, 2008].

1.2 Problem Statement

The renewable energy is the fastest-growing source of electric power generation and will make up a quarter of the global power mix by 2018 [IEA, 2012]. The growth of renewable energy in the power system influences the reliability of the system. Many issues, which are concerned, are (1) the impact of renewable generation unit in the power system, (2) how to evaluate the generation reliability in case that there is renewable generation in the power system, (3) how the penetration of renewable energy sources affects generation reliability, and (4) what is the equivalence between conventional capacity and renewable capacity. In other words, how much renewable capacity is needed to replace conventional capacity while maintaining generation reliability.

1.3 Literature Review

Nowadays, electricity generation from renewable energy resources has been increasing worldwide in accordance with concerns on energy problems (e.g. supply shortages, price spikes) and environmental impacts. The renewable energy resources have been promoted worldwide in order to reduce CO_2 emission and energy import. The rapid expansion of renewable energy resources, especially wind power and solar

(photovoltaic) power, has cemented the position of renewable energy resources as an indispensable part of the global energy mix. Power generation from renewable energy resources increases by over 7,000 TWh from 2011 to 2035, making up almost half of the increase in total generation [IEA, 2013].

Nevertheless, an increasing of renewable energy unit in the power system influences the reliability of the system due to the intermittent characteristics of renewable energy resources. In term of electricity generation, the reliability of the power system is the one of most importance in generation planning especially the power system with renewable energy units. There are at least two approaches for generation reliability evaluation. The analytical approach [Voorspools and D'haeseleer, 2006] is properly applicable to conventional power plants. The stochastic approach, based on either Monte Carlo method [Billinton and Chen, 1998; Vallee, Lobry and Deblecker, 2008] or fuzzy mathematics [Narasimhan and Asgarpoor, 2000] is capable to reflect operational behavior of renewable power plants.

In recent year, the reliability assessment for renewable energy units becomes more interested such as wind unit [El-Tamaly and ElBaset Mohammed, 2005; Dimitrovski and Tomsovic, 2006; Voorspools and D'haeseleer, 2006; Wen, Zheng and Donghan, 2009; Amelin and Söder, 2010] and photovoltaic unit [El-Tamaly and ElBaset Mohammed, 2005].

Many reliability problems are studied such as the impact of interconnection photovoltaic/wind system with utility on their reliability (Loss of load probability, LOLP) using fuzzy logic scheme [El-Tamaly and ElBaset Mohammed, 2005], the impact of wind generation uncertainty on generating capacity adequacy in hypothetical example of the western US interconnection to show how different percentage of wind penetration effect this adequacy by using LOLP and loss of load expectation (LOLE) indices [Dimitrovski and Tomsovic, 2006] and the impact of wind power on power supply adequacy in Sweden market by using different capacity credit definitions [Amelin and Söder, 2010].

Most of the articles attempted to investigate generation system adequacy evaluation in the analytical domain. A number of computational methods have been

proposed to evaluate generation reliability of renewable power plants [El-Tamaly and ElBaset Mohammed, 2006; Dimitrovski and Tomsovic, 2006; Wen, Zheng and Donghan, 2009]. The concept of capacity credit [Amelin and Söder, 2010; Patil and Ramakumar, 2010; Dent, Keane and Bialek, 2010] is widely proposed to determine the contribution of renewable capacity on generation reliability. The definitions of capacity credit are divergent but none of them is commonly acceptable. Besides, capacity credit may not be comparable among different generation systems.

1.4 Objectives

1.4.1 To determine proper models of renewable energy resources for generation reliability assessment.

1.4.2 To evaluate the intermittent nature of renewable energy resources on generation reliability.

1.5 Scope of Work

1.5.1 The renewable energy resources are solar (photovoltaic), wind, small hydro, biomass, and biogas.

1.5.2 Each renewable energy resource is considered as an aggregated model.

1.5.3 The generation reliability criteria are loss of load probability, expected energy not supplied, and capacity credits.

1.5.5 Transmission network constraints are neglected.

1.6 Research Strategy

The key objective of this research is to determine proper models of renewable energy resources for generation reliability assessment. Renewable energy resources under consideration are solar (photovoltaic), wind, small hydro, biomass, and biogas. The research strategy is presented as shown in Figure 1.1.

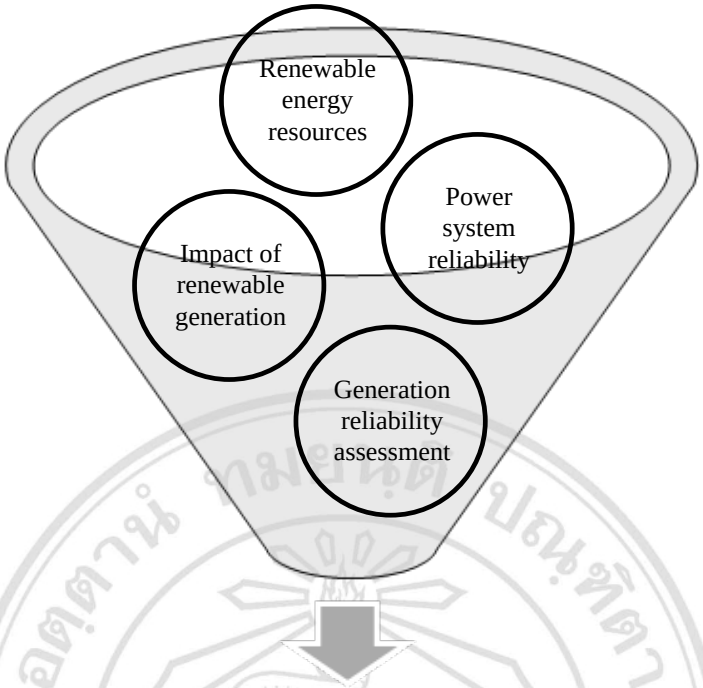

Figure 1.1 Research strategy.

Firstly, the power system reliability in system adequacy domain and the modeling of renewable energy resources are studied. Also, the impact assessment of renewable generation on electricity demand characteristics is studied to find the impacts of renewable generation unit in the power system. These impacts are investigated with a time frame from seasonal basis to annual basis. It is proposed to treat renewable generation as negative load. Electricity demand is characterized by using peak demand, energy demand, and load factor as well as it is divided into three groups: peak, intermediate, and base.

Then, the reliability modeling of renewable energy resources is proposed in order to evaluate the generation reliability in case that there are renewable generation units in the power system. The reliability evaluations, which are the reliability evaluation using conventional approach and modified approach, are proposed to find the proper reliability modeling of renewable energy resources. The concept of effective capacity is also proposed to quantify the contribution on generation reliability, compared between renewable and conventional power plants. The effective capacity of renewable power plant for generation reliability evaluation is proposed with two definitions. The effective

capacity can be computed from generation capacities of renewable and conventional power plants as well as effective load carrying capability.

1.7 Thesis Overview

From the research strategy, this thesis is organized as follow: the concept of generation reliability assessment is described in Chapter 2. The renewable energy resources in Thailand and the simplified modeling of renewable energy resources including solar (photovoltaic), wind, small hydro, biomass and biogas are described in Chapter 3. In Chapter 4, the reliability contributions of renewable generation which are the capacity credit and the effective capacity are presented. Chapter 5 presents the reliability modeling evaluation using conventional approach and modified approach. The results and the discussion of this research are presented in Chapter 6. Finally, the thesis conclusions are presented in Chapter 7.