# Chapter 16
# A Service Cost-Base Supply Balance of Sustainable Power Generation

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## ABSTRACT

*Recently, renewable power sources such as WTG and PV have become viable economic options for generating sustainable energy. However, WTG and PV have an inconstant power production problem. To solve this problem, multi-state models have been proposed. The electricity generated from these units varies with different time scales: hourly, daily and seasonally. Since planning an optimal size generates cost losses to the customer, three models should be built: a load model, generation model, and service cost model. Loss of energy expectation (LOEE) and loss of load expected (LOLE) are calculated for the load and generation model. The reliability value is calculated to determine the number of required renewable generators. As a result, the system is constructed to have sufficient capacity, and the utility cost became the main objective of the total service costs.*

## 1. INTRODUCTION

The Kyoto Protocol was adopted by the UNFCCC (United Nations Framework Convention on Climate Change) on December 11, 1997 in Kyoto, Japan. However, Japan did not enforce the Protocol until February 16, 2005. The Kyoto Protocol created the foundation of political strategies for the utilization of renewable energy as a major goal on fighting global warming for all the industries (Yaakob, Watada, Tsuguhiro & Okamoto, 2010). Renewable energy, as stated, is the energy generated from natural sources

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such as wind, sun- light, rain, geothermal heat and tides (Yaakob, Watada, & Liu, 2010). Not only does this help reduce carbon emissions, but also it becomes a sustainable energy for the future. In 2007 a break- through occurred, investing more than $100 billion in research and development, leading to the innovation of manufacturing plants and increasing renewable energy capacity. However, rapid changes in recent years had created a gap between public awareness and the reality of renewable energy.

## 1.1 Power Supply Systems with Renewable Energy Application

Renewable energy power supply system generates electricity in a safe and clean manner; the electricity utilization from a renewable source makes the system environmentally friendly. There is no pollution or emissions that can cause harm on the end user. Electricity production has a large impact and long-lasting consequences on not only on local and regional, but also in global environment.

Most of these consequences are generated from sulfur oxides (SOX) emissions, nitrogen oxides (NOX) emissions, and solid particles that can be diminished with investment in emission reduction technology and abatement facilities. The most harmful damage is caused by carbon dioxide (CO2). Carbon dioxide is the main cause of global warming, or greenhouse effect, and ocean acidification, since carbon dioxide can exist in the atmosphere and dissolves in water in the form of carbonic acid (Adelsberger, Collis & Pawlowski, 2002). Moreover its regulation and cost is complex and expensive. Since the power industry has been a major contributor on global CO2 emissions; renewable resources such as solar and wind energy generation have attracted the attention. In 2007, 240GW of renewable electricity was generated worldwide (which was a 50% increase since 2004), becoming 5% of power capacity and 3.4% of power generation in the world (El-Ashry & Chairman, 2007). Wind energy and solar energy became an alternative to fossil power generation with photovoltaic (PV) and wind turbine generators (WTG) that are economic and emissions free. In 2007, WTG generation capacity reached 95 GW, representing an increase of 28%; in comparison with 2006, the annual capacity additions levels increased to 40%. The grid-connected PV system is a fast growing technology with an annual installed capacity increase of 50% that represents a 7.7 GW between 2006 and 2007. In other words, the worldwide PV grid increased with 1.5 million home solar systems that provide the grid (Choi, Jeong, Bo, Park, El-Keib & Watada, 2007). One of the disadvantages of these renewable sources is the hourly, daily and seasonally inconstant power generation. The short-term prediction of wind plant prediction variability has a negative influence on the reliability of design/operation of PV and WTG systems.

## 1.2 Power System Reliability Evaluation

In an electrical power system, it is necessary to supply electricity to final users economically and with an acceptable reliability level. The definition of reliability is the ability of a system of component to perform its required functions under stated conditions for a specified period of time according to IEEE. The assurance of power system reliability provides confidence to the final users on the service quality and continuity. However, while assuring the service reliability and continuity, the finals users' needs and related costs must also be met. Higher-level system re- liability is proportional to a considerable investment. Power system designers and engineers have an unreal task to design a high reliable system with a reasonable budget. When designing a power system, the power system size is determined by an optimal reliability-cost value analysis. By assuring a considerable reliability level, the system ability to achieve its basic function is also assured. Power system reliability can be viewed as two interrelated