

# Estimating the Global Demand of Photovoltaic System

*Yi-Fen Chen, Chung Yuan Christian University, Taiwan*

*Bi-Chu Chen, Jinwen University of Science and Technology, Taiwan*

*Chia-Wen Tsai, Ming Chuan University, Taiwan*

*Wen-Yu Chen, Chinese Culture University, Taiwan*

*Lee-Wei Wei, Chung Yuan Christian University, Taiwan*

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## ABSTRACT

*The purpose of this research is to predict the total market demand of photovoltaic (PV) system of the world. By using the Grey forecasting model, the results were precise and valid. Then, the sensitivity analysis was conducted to select the most appropriate horizontal adjusting factor (HAF) and to determine the growth type of PV industry. The result showed the HAF was 0.4, which indicated the growth speed is in a low speed but very close to normal speed. The average residual error was 10.5% from 1995 to 2007 compared to the actual value in the same period. Then, the forecasted value from 2008 to 2011 showed an increasing shape and would reach 8554.9 MW in 2011. This research found the growth type of PV industry of the world, offering meaningful information for firms to decide the strategy in the future. For government, the result could also help to implement adequate policies to support the development of PV industry in the future.*

*Keywords: Grey Forecasting Model, Photovoltaic Industry, Renewable Resources, Sensitivity Analysis, Total Market Demand*

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## 1. INTRODUCTION

We know the natural resources are decreasing, according to a recent study from statistics of department of energy of USA, the stock of crude oil of the world is only 43 years available, liquefied natural gas is 62 years available, while coal is around two hundred and 30 years available, finally, the uranium which used for nuclear energy is only 64 years available. On

economic side, we know the amount of natural resources can influence the world economy, as the world population grows; the higher demand of natural resources causes the shortage of it. For example, the oil price has been fluctuated since 2007, reached a peak in 2008, slid down since in the end of 2008, influencing the good price seriously all over the world.

In addition, the abuse of the natural resources made the carbon dioxide emission (CO<sub>2</sub>) increased and causing the global warming, which raising the awareness of environment protection and made all the countries start

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to pay attention to this issue. With the Kyoto protocol was effective on February 16, 2005; the world has caught the alternative resources fever. Many countries have pursuing the alternative renewable energy in order to reduce the CO<sub>2</sub> emission; meanwhile, they also have to maintain their national competitiveness and economy situation in the future. So far, many alternative resources have been developed, like wind power, solar energy, and geothermal power, and so on. Among these, the solar energy is the most popular one because it has many advantages like no pollution, low maintain cost, and unlimited region to absorb the sunlight... etc. Thus, many countries are very enthusiastic about the development of PV industry and have been developing the utilization of solar energy.

The purpose of this research is to find out the market demand of the PV system of the world, thus, firms would know how much they should produce, and decide the appropriate strategy to expand their business. Also, government can understand how PV industry grows more clearly in order to propose adequate policies to support in the future.

## 2. METHODOLOGY

Prediction is a kind of technique in management which can reduce the uncertainty in the future. The administrator can use it to make an appropriate decision. Thus, a precise prediction method is needed. Deng (1982) submitted the Grey system theory in 1982, constructing a Grey forecasting model to do forecasting and make strategic decisions. Grey forecasting model is the basis and also the core of grey system theory (Tien, 2005; Chang et al., 2005; Chan, 2006; Lin et al., 2009; Lin & Yang, 2004). The Grey system theory treats all variables as a grey capacity within a certain range (Hsu & Chen, 2003; Tseng et al., 2001; Lin et al., 2011). In the grey procedure, the variables are related to time. The Grey capacity is not achieved by formulating the statistical regulation. It looks at the nature of internal regularity to manage the disorganized primitive data. Another char-

acteristic of Grey forecasting model is it only requires few amounts of observations and can be very precise, while traditional method need large observations (Wang & Hung, 2003). In Grey forecasting model, only four observations can construct a forecasting model.

So far, Grey forecasting model has been widely used. Liu, Huang, and Lin (2008) applied GM (1,1) model to find the relaxation law of autofrettaged residual stresses in stable temperature and under pressure fluctuation in order to prove the efficiency of autofrettaged treatment. Chuang, Hsu, Wang, and Wang (2004) applied GM (1,1) model to forecast the stock price index in Taiwan. Lin and Yang (2003) applied the Grey forecasting model to predict the output value of Taiwan's opto-electronics industry. Jiang, Yao, Deng, and Ma (2004) applied the Grey forecasting model to predict the operating energy performance for an air cooled water chiller (ACWC) units so as to install the Heating Ventilation and Air Conditioning (HVAC). Chang (2005) adopted Grey forecasting model to predict the production of TFT-LCD industry in Taiwan. Moreover, Hsu (2011) used improved grey forecasting models to forecast the output of opto-electronics industry.

The GM (1,1) model means the first-differential equation and only one variable, we often use it as a forecasting model. Below are the calculating procedures of the GM (1,1) model:

Suppose the first sequence with  $n$  entries is:

$$X^{(0)} = \begin{cases} X^{(0)}(1), X^{(0)}(2), X^{(0)}(3), \dots, \\ X^{(0)}(i), \dots, X^{(0)}(n) \end{cases} \quad (1)$$

where  $X^0(1), X^0(2), X^0(3), \dots, X^0(n)$  are initial variables used to construct the Grey forecasting model,  $n$  indicates the  $n^{\text{th}}$  variable of this sequence.

Based on first sequence, we applied accumulated generating operation (AGO) to formed the second sequence,  $X^{(1)}$ , which shows:

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