J. Chosun Natural Sci.
Vol. 12, No. 1 (2019) pp. 20 – 23
https://doi.org/10.13160/ricns.2019.12.1.20

# Planning ESS Managemt Pattern Algorithm for Saving Energy Through Predicting the Amount of Photovoltaic Generation

**Seung-Uk Shin[1], Jeong-Min Park[2], and Eun-A Moon[3†]**

Abstract

Demand response is usually operated through using the power rates and incentives. Demand management based on power charges is the most rational and efficient demand management method, and such methods include rolling base charges with peak time, sliding scaling charges depending on time, sliding scaling charges depending on seasons, and nighttime power charges. Search for other methods to stimulate resources on demand by actively deriving the demand reaction of loads to increase the energy efficiency of loads. In this paper, ESS algorithm for saving energy based on predicting the amount of solar power generation that can be used for buildings with small loads not under electrical grid.

**Keywords**: Demand Forecast, Energy Management System, Operating Pattern, Photovoltaic, Prediction of Load Data per Hour

## 1. Introduction

Demand management for power is conducted by electricity companies to lead the electricity usage patterns of consumers into reasonable ways in order to match the consumers desire for electronic energy service with minimal cost.

Recently, as part of least cost planning, the importance of demand management is more emphasized as demand management method is one of important criteria of electricity supplying plans with the expansion of integrated resources planning targeted to find the optimal combination of the alternatives of demanding side and alternatives of supplying side.

The ultimate purpose of demand management is to reduce cost through increasing load factors through reasonable control of demand for electricity, and taking part in saving energy resources domestically.

Furthermore, the rise of awareness for serious environmental pollution caused by fossil fuels emphasizes electricity demand management as alternative eco-friendly energy politic[1-3].

Hence, this paper seeks to construct algorithm to decide the charging and discharging amounts of ESS to increase the life span of batteries by decreasing the amount of unnecessary charging and discharging of batteries and maximize economical profit by applying managing schedule for charging and discharging of ESS facilities based on data from real time weather information and amount of sunshine at generator and algorithm for predicting the amount of generated power[4].

## 2. Related Research

Load management is conducted through demand reaction. Demand reaction is a method to maintain balance of electricity supply by controlling load usage from the receptors in the cases of unbalance in electricity supply.

It can be divided into peak clipping, where the maximum demand based on seasons or time is suppressed; peak shifting, where the demand for electricity supply during peak time is moved to time with light load; valley filling, where the companies increase the amount of electricity sold by increasing the usage of facility through increasing demand on time with light load[5].

The United States of America is regulating increase

[1]Weisseti Co., Ltd., Gyeonggi Province, Yongin
[2]Department of Automatic System, Chosun University College of Science & Technology, Gwangju
[3]Department of Electricity, Chosun University College of Science & Technology, Gwangju

†Corresponding author : eamoon@cst.ac.kr
(Received : March 08, 2019, Revised : March 13, 2019, Accepted : March 15, 2019)

in energy efficiency and usage of EMS based on laws about energy independence and safety, and is continuing to try supply EMS for efficient usage of domestic electricity[6-8].

Electricity consumption makes up for 80% of the Federal Government of the U.S., and the U.S. has set goal to save energy and maintain stable electricity supply by constructing demand of electricity through EMS.

EMS program is currently available for houses, and the necessity for electricity on demand has been increased with development of energy saving technology for stabilizing electricity[9,10].

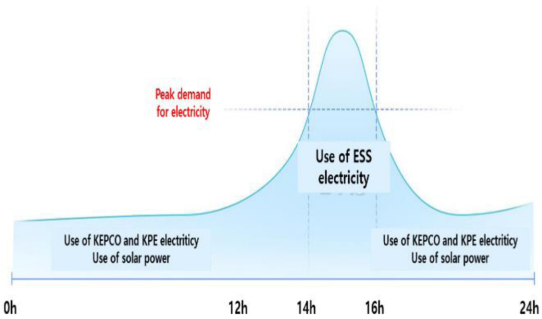


**Fig. 1.** Active battery management.

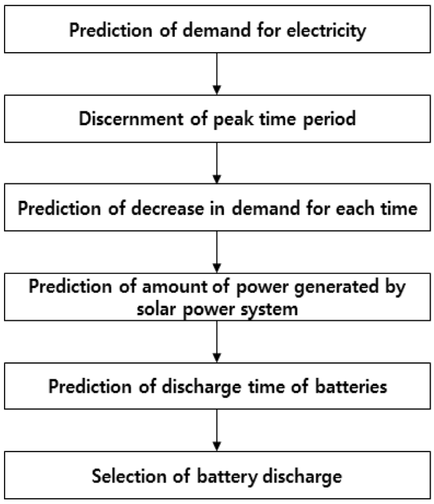


**Fig. 2.** Procedures for managing EMS system.

## 3. Main Paragraph

### 3.1 Constructing Algorithm to Respond to Peak Electricity Demand based on Current Situation of Batteries

ESS system primarily must be managed in consideration of solar power system because power generation by solar power system and electricity usage by load occur simultaneously as dispersed generation happen for demand management.

Secondarily, power manager can move the load to other time or suppress the load amount. But by discharging electricity at ESS while generating power with solar power system when decrease in load amount is needed primarily, the load is decreased.

### 3.2 Determine Factors to Estimate Solar Power Generation by Time

Algorithm is constructed to establish the optimal operation schedule in real time by predicting power amount per hour, and expect adequate prediction with no sufficient past data.

Weather information by time, power generated by time, and sunset/sunrise time have been set for variables to predict the total amount of power generated per hour.

### 3.3 Prediction of Load Data per hour

Load data per hour is predicted by using temperature, which is closely related to load data of receptor with the influence of cooling and heating loads, and interrelated data out of various weather variables.

a) Selection of temperature variables to be used for predicting load data of the receptor per hour based on the lowest/highest temperature and interrelated information on load data

b) Selection of past data for predicting 24 hour pattern of load data: Selection of data from the past 3 years and calculation of modification factors

c) Modification of maximum/minimum load data using modification factors

d) Prediction of 24 hours pattern for load data using modified maximum/minimum load data

e) Prediction of load data per hour on selected day using 24 hours pattern and modified maxi mum/minimum load data

### 3.4 Explanatory Variables for Prediction Model for Solar Radiation Quantities

Even in the case where electricity charge is different per hour, the algorithm is designed to minimize the total charge by managing charging and discharging of ESS

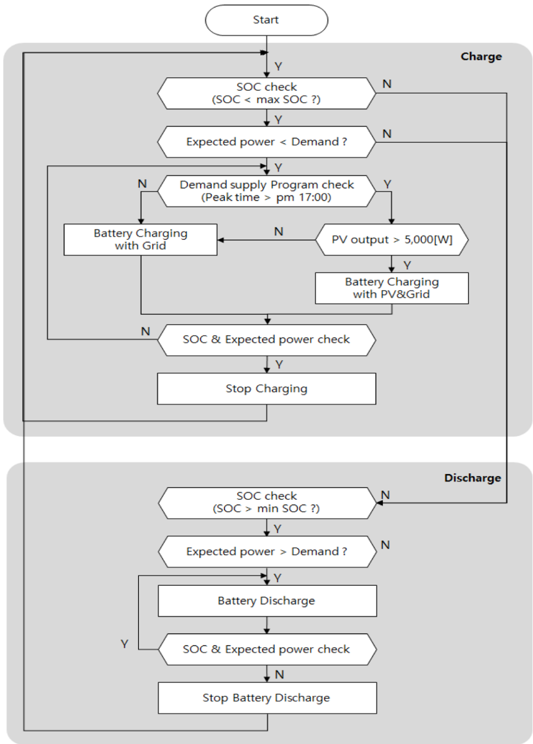


**Fig. 3.** Responsive algorithm for peak demand on electricity based on current situation of batteries.

economically based on charge unit.

Operation algorithms for the entire program is distinguished by operation modes which include independent operation.

Operation mode is selected based on the electricity flow of load in each mode, and the electricity supply and demand for load of ESS.

### 3.5 Normalization

Before predicting load, electricity loads have been classified into each season using k-means method, one of data mining methods.

Also, the appropriate target for selected load has been deduced through autonomous grouping rather than defining prediction target prior to predictions as this prediction is for small load size such as buildings rather than entire demand for electricity intended for power system.

Before classifying the data statistically and mathematically, the algorithm has been designed to reflect the properties of loads, check the results for demand prediction easily, and modify variables when managing the system.

Seasonal classification is made through selecting random K number of vectors from set of data $[x_1,..., x_N]$, and making initial core set $[y_1,..., y_k]$.

If data $x_n$ is closest to $y_1$, cluster the data to be included in cluster $X_1$. Ultimately, the set of data are divided into K number of cluster $[X_1,..., X_K]$.

$$X_i = x_n | d(x_n, y_i) \le d(x_n, y_i)\ ,\ j = 1,..., K \quad (1)$$

Renew each core for new clusters calculated in step 2.

$$y_i = c(X_i)\ ,\ i = 1,..., K \quad (2)$$

Calculate the total distortion by adding the distances among cores of clusters closest to the data.

$$D = \sum_{n=1}^{N} d(X_n, Y_{i(n)}) \qquad i(n) = k, \text{if } x_n \in X_k \quad (3)$$

Finish calculation when the core values of new cluster is the same as the value of prior iteration.

If not, repeat the process with the core values of new cluster.

Data have been normalized by classifying loads into the following categories through the use of k-mean.

$$L(d,h)_N = \frac{L(d,h)_A}{L_{MAX}} \quad (4)$$

Group patterns have been filtered through hierarchical clustering analysis by classifying loads into each season and extracting potentially useful information from data to predict loads.

Data classified into seasons have been fragmented and classified into weekdays based on time.

## 4. Conclusions

Managing demand for electricity until recently have been conducted based on the schedules of power system and big factories. Properties of loads have not been properly reflected or only complicated prediction methods were available to be applied for smaller loads such as buildings, and it was not possible to apply the system for demand characteristics of loads or management environment.

However, in this paper, solar power system and ESS system have been applied to predict demands for loads for building using patterns of demand for electricity for loads of building and related systems for the purpose of managing electricity loads for buildings.

The algorithm predicts demands for electricity with reflection on the properties of loads based on accumulated data. Real time errors which can occur using reference demand using similar pattern have been fixed through periodic modifications of errors.

## Acknowledgments

This research was supported by the Ministry of Trade, Industry & Energy(MOTIE), Korea Institute for Advancement of Technology(KIAT) through the Encouragement Program for The Industries of Economic Cooperation Region.

## References

[1] W.-P. Sung, "A Study on Quantitative Methodology for Security Evaluation of EMS According to Smart Grid System," Korea Energy Society, Energy Engineering, Vol. 24, No. 1, pp. 123-131, 2015.

[2] K.-H. Kim, "Design and Implementation of Script-based EMS for Flexible Operation of Stand-Alone Micro Grid," Korea Multimedia Society, Multimedia Society Journal, Vol. 18, No. 10, pp. 1231-1240, 2015.

[3] S.-J. Moon, "Development of power saving EMS using real-time monitoring technology," Korea Society of Mechanical Engineers, Vol. 36, No. 12, pp. 1708-1721, 2011.

[4] K.-H. Kim, "Micro-EMS Implementation and Empirical Analysis for EES Control," IEICE, Electronics and Communications Society, Vol. 52, No. 1, pp. 155-161, 2015.

[5] Y.-H. Kwak, "EMS Application Using Simulation for Building Energy Saving," Korean Society of Facilities Engineers Conference, pp. 145-150, 2010.

[6] M.-C. Kang, J.-M. Sohn, J.-Y. Park, S.-K. Lee, and Y.-T. Yoon, "Development of algorithm for day ahead PV generation forecasting using data mining method," 2011 IEEE 54th International Midwest Symposium on Circuits and Systems (MWSCAS).

[7] A. Yona, T. Senjyu, A. Y. Saber, T. Funabashi, H. Sekine, and C.-H Kim, "Application of Neural Network to One-Day-Ahead 24 hours Generating Power Forecasting for Photovoltaic System," International Conference on Intelligent Systems Applications to Power Systems 2007 (ISAP 2007).

[8] A. Chaouachi, R. M. Kamel, R. Ichikawa, and K. Nagasaka, "Neural Network Ensemble based Solar Power Generation Short-Term Forecasting," Journal of Advanced Computational Intelligence and Intelligent Informatics, Vol. 14, No. 1, pp. 69-75, 2010.

[9] C. Chen, S. Duan, T. Cai, and B. Liu, "Online 24-h solar power forecasting based on weather type classification using artificial neural network," Solar Energy, Vol. 85, No. 11, pp. 2856-2870, 2011.

[10] M. Ding, L. Wang, and R. Bi, "An ANN-based Approach for Forecasting the Power Output of Photovoltaic System," Procedia Environmental Sciences, Vol. 11, pp. 1308-1315, 2011.