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Environmental Effects on Energy Consumption of Smart Grid Consumers

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Abstract**—**Environment and surrounding plays a pivotal rule in structuring life-style of the consumers. Living standards intern effect the energy consumption of the consumers. In smart grid paradigm, climate drifts, weather parameter and green environmental directly relates to the energy profiles of the various consumers, such as residential, commercial and industrial. Considering above factors helps policy in shaping utility load curves and optimal management of demand and supply. Thus, there is a pressing need to develop correlation models of load and weather parameters and critical analysis of the factors effecting energy profiles of smart grid consumers. In this paper, we elaborated various environment and weather parameter factors effecting demand of consumers. Moreover, we developed correlation models, such as Pearson, Spearman, and Kendall, an inter-relation between dependent (load) parameter and independent (weather) parameters. Furthermore, we validated our discussion with real-time data of Texas State. The numerical simulations proved the effective relation of climatic drifts with energy consumption of smart grid consumers.

Keywords—Climatic drifts, correlation analysis, energy consumption, smart grid, weather parameter.

I. Introduction

SMART Grid (SG) system is an integration of various Renewable Energy Resources (RERs), such as wind energy and solar energy, utilities retail dealers and whole-sale dealers, bi-directional communication infrastructure, consumer's empowerment, demand response program, and advance monitoring and management infrastructure. Due to high complexity, non-linearity, and wide-infrastructure of SG, energy consumption of the consumers is an alarming issue. With increased energy demand, energy market planners have to adopt alternative ways of load curtailment, such as energy (load) forecasting and incentive-based energy program for consumer's energy profile estimation, load dependent factors must be calculated for better accuracy. This means that correlation estimation between dependent parameters (load) and various independent parameters, such as dry bulb temperature, relative humidity, dew point, precipitation, and wind speed are of much importance for enhanced factors, namely: (a) CO_2 emission, (b) Forestry, (c) Living standards, and (d) Climate drifts plays pivotal role in shaping energy profiles indirectly.

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Various state-of-the-art works are discussed in literature highlighting weather effects an energy consumption of the consumers. For example, the authors [1] discussed short term electrical demand. Short term electrical demand possesses bulky impact of the climatic change, such as temperature, wind speed, humidity, and precipitation. The authors proposed topology for short term electrical demand and effects of climatic change. In [2], the authors presented artificial neural network for prediction of electrical demand and modeled a sensitive climatic model. The results of simulation showed total electrical demand have greatly affected by change in temperature. In [3], the authors examined the monthly electrical usage in Wales (England), predicted the effect of climatic variable on electrical usage. Numerous regression methodologies were proposed to estimate monthly electric usage in presence of climatic variable, such as growth of people and GDP (gross domestic product). In [4], a resilient electrical network for Great Britain is modeled. This could predict the impact of weather changes on the flexible Great Britain Electrical System. In [5], the authors analyzed the air conditioning system, changing in climatic variables, such as temperature and humidity cause to change cooling load. The authors described relation among the energy utilization of air conditioning system and climatic changes. In [6], the authors used Bayesian demand forecasting for estimating peak prediction using average temperature estimation variables. The authors concluded that short term demand estimation model is good for energy system. The authors in [7] explored the climatic changing, that impact the energy demand. The climatic changes probably lead to change the climatic variables, such as cloud cover, wind speed, temperature, humidity, and precipitation, by changing these parameters lead to change in electrical demand. In [8], authors proposed a complete summary of energy in India, find the energy consumption and factors effecting on it. They find some resolution, which can improve energy demand. The author in [9] discussed the energy consumption and green housing gas releasing model in Beijing, China.

Although the aforementioned works described effects of climatic and weather drift with respect to consumer's demand, they lack, such as they did not incorporate with correlation between the energy consumption and weather parameters, and environmental effects, such as forestry, consumer's location, living standards, seasonal variations, dry bulb temperature, dew point, SI. Furthermore, inter-relation between dependent variable and independent variable are not critically analyzed.

In the light of above stated issues, the main contribution of our work are:

a) We analyzed the environment and weather parameters effect on energy consumption of consumers.
b) Our work discussed various correlation models, such as Spearman, Pearson, and Kendall for evaluation of relationships between dependent and independent variables.
c) Real-time Texas (US) state data are used to validate the above claims.

The rest of the paper is structure as follows: Section II presents environmental and climatic drift effecting consumer's life styles and energy consumption, Section III describes the statistical analysis of various correlations between dependent and independent variables. Performance validation and simulation results are described in Section IV. Section V concludes the paper with a brief summary and proposal for future works.

II. Environmental and Climatic Drift Effecting Consumers Life Styles and Energy Consumption

A. Forestry (F)

Forestry contributes protection to the earth surface, such as transmission, absorption and reflection of solar radiance and warmth. Forestry can affect air-temperature, local precipitation, atmospheric Humidity, soil, wind erosion and water erosion. Dense Forestry affects air temperature, such that temperatures in winter and autumn are lower than summer and spring. Moreover, it affects the amount of rain by absorbing carbon dioxide emission. Forests increase the everyday minimum temperature, while decrease the maximum daily temperature. Forestry also effects the precipitation at high altitude, such as precipitation at mountains is higher than low altitude regions. Woody hills have higher precipitation than woodless hills. Precipitation changes with the change of species of forest i.e. broad leaved species have lower precipitation than coniferous trees. And precipitation can affect the consumption of consumers. The Humidity of forestry area is larger than non-forestry area. On the blowy day, the Humidity is higher in the forest area. The most important feature of the forest is protection of soil during wind and water erosion.

B. Carbon Dioxide (CO_2) Emissions

Carbon dioxide goes to atmosphere upon burning of fuels like coal, natural gas, oil, trees and wood products give rise to effect known as greenhouse effect. This effect can be minimized by absorption of CO_2 by plants in biological carbon cycle. Greenhouse effect is calculated through three factors that is concentration of gas in air, how long gases stay in atmosphere, and how strongly they react to environment. Increasing low-carbon electric power industry is the key method to deal with greenhouse effect. Most of the carbon emission is due to Coal based energy production. Renewable energy sources upon penetration into power grid can efficiently lessen the carbon emission of grid up to satisfied level. Though, renewable lacks the systematic approach to forecast a medium and long-term carbon emission for power grid. As a result, different methods and model are proposed by different authors to overcome the forecasting issue of carbon emission from RERs Putting an explicit price on carbon dioxide emissions and increasing demand response is a way to reduce carbon emissions. In a study by [17], due to SG deployment, demand-side resources (DSR) play an important role in the power balance of supply and demand. Furthermore, low carbon SG requires some policy backgrounds, like carbon emission trading (CET) that should be considered. The proposed model benefits different resources on the demand side, like electric vehicles, demand response, and distributed generation, but also reflect the CET on the generation schedule. An improved particle swarm optimization (IPSO) algorithm is also implemented to sort out the problem.

The energy saving dispatch enhance the energy usage and reduce the CO_2 emission which lead to sustainable development of a country. The author in [18] suggested new energy saving dispatch problem although taking into account the energy saving and emission reduction potentials of generation as well as demand side or interaction.

A two-level optimization model is developed to point out the interaction between energy-saving dispatch of thermal units and users. The overall strategy is to minimize CO_2 emissions by efficiently accommodating renewable energy sources by realistically evaluating system changes by taking into account ramping costs, demand functions, contingencies and linked probability distributions of stochastic variables like wind generation.

C. Consumer Location (CL)

CL is the one of key factor affecting on the consumer load consumption. On earth there are three major locations which are classified as:

- Near See Level Region;
- Plain Area Region; and
- Mountainous Region

The load consumption varies with varying their location. At these CL temperature, humidity, wind speed and dew point are different from one another at seasons. At sea level, the temperature does not change dramatically during summer and winter. These load consumptions are affected little bit but not too much in summer and winter i.e. in Texas (Copano Bay) is situated at near sea. Copano Bay temperature does not change dramatically with season. Average season temperature is proximately in between 16 ℃ to 26 ℃. Thus, load consumption is not too much affected. Wind speed minimizes load consumption of consumer during summer by lowering air temperature in atmosphere. Humidity is normally greater at sea level than plane and mountain area. In summer the evaporation rate become decrease when humidity is very high. As a result, human's body feel warm and use more cooling appliances for cooling purposes and load consumption is increased during summer on high humidity day. In plane area the temperature is changing dramatically as compare to sea level. Due to this dramatically change in temperature during summer and winter the load consumption is more than sea level i.e. in Texas, plane area average temperature difference between maximum and minimum is more than sea level. Hence, in summer load consumptions are more than sea level due to using more cooling appliance in their homes. While, in winter load consumption is more than sea level by using more heating appliance.

In hilly areas, temperature also changes dramatically during reason (summer, winter) but not a similar way to plane regions. In hilly areas, temperature can reach extreme lows (minus degree) in winter, and as a result, more heating appliances are used than on the plane and sea level areas. Meanwhile, in summer the average temperature of hilly area is pleasant (not too high), and hence, there is less reliance on cooling appliances, and therefore the load consumption declines during the summer in hilly areas compared to plane and sea level areas. The load consumption changes with changing altitude of consumers. At sea level altitude, energy consumption is different than that of plane and mountainous areas throughout the seasons. In the mountainous areas, the altitude is higher resulting in the different load consumption of SG consumers.

D. Dry Bulb Temperature (DBT)

The temperature of the open air free from moisture and radiation is called the Dry Bulb Temperature (DBT). DBT is also called thermodynamic temperature. DBT is directly proportional to the average kinetic energy of molecules and represents the heat volume in the atmosphere.

$$\hat{E} = \beta_0 + \beta_1 T_{mean} \tag{1}$$

where $\hat{E}$ presents power demand, β_0 and β_1 are two the constants, and T_{mean} is the monthly average temperature.

In [11], Author described correlation between load and temperature. During summer, correlation is high positive but in winter correlation between load and temperature is negative. Increasing DBT can change the load consumption and peak demand of electricity and the daily average usage will also decrease with decrease in temperature while temperature increase in winter will cause to decrease the daily load consumption and peak demand.

In [12], the authors modeled a load consumptions model for various seasons, such as summer and winter. When a load exceeds the prescribed limit, due to demand-supply miss-management, blackouts occur. Bove blackout cases occurred in various countries [13], for example France 2003. The relation between electricity consumption and temperature changes with altitude. Likewise at high latitude areas hot weather will cause to decrease consumption like in United Kingdom (UK) but will increase 5% to 100% electricity consumption at low latitude areas like in South East Asian countries [14].

E. Relative Humidity (RH)

Humidity is defined as quantity of water vapor in atmosphere. The ratio between Equilibrium Vapor Pressure and Partial pressure of water at given temperature is called RH. RH depends upon pressure and temperature of air system. To obtain maximum RH at high temperature more air vapors are not required while at low temperature, as shown in (2):

$$\phi = \frac{P_{H_2O}}{P^*_{H_2O}} \tag{2}$$

where $P^*_{H_2O}$ shows Equilibrium vapor pressure and P_{H_2O} shows partial pressure. Normally RH is measured in percentage.

$$P = \frac{1}{24}\sum_{d=1}^{N_d}\sum_{h=1}^{24}(Q - Q_b)(\gamma_h) \tag{3}$$

where Q_b is reference enthalpy at 25.6 ^{o}C and Q is the enthalpy of hourly estimation that is measure in KJ/Kg and γ_h is the indicator function.

Atmosphere contains air with water vapors and other air constituents. Absolute humidity reflects existence of water vapors in complex air mixture [14]. RH is measured in percentage. Humidity and temperature are related to each other. When humidity is high, the evaporation rate from human body is low and hence people feel warm, and consequently, rely more on the use of electrical appliances for the purpose of cooling, which resulted in increased load consumption. Similarly, if humidity in the air is low then the evaporation rate of heat and moisture from the human body is high and people will feel cold. Hence, consumers will not use more cooling appliances, and thus, there is a decrease in load consumption.

F. Precipitation (P)

In numbers of definition precipitation is defined “Amount of water fall down at particular of time and particular region” Or precipitation may be defined as “the quantity of hail, rain and snow at particular of time and particular region”.

$$P = \frac{1}{24}\sum_{d=1}^{N_d}\sum_{h=1}^{24}(Q - Q_b) \tag{4}$$

where Q_b is reference enthalpy at 25.6 ^{o}C and Q is the enthalpy of hourly estimation that is measure in KJ/Kg and γ_h is the indicator function.

P is represented in centimeter or inches of water. P has two type of impact on the consumption, direct and indirect impact. People are forced to stay at their houses during snow or heavy rain condition due to the darkness. Upon stay at their houses, people will consume more electrical energy for their warm up purpose, entertainment devices and lighting. Snow or heavy rain also causes to decrease the temperature. There is both positive and negative impact on the electricity demand. With positive impact electricity demand is lower while with negative impact (low temperature) electricity demand is more

[10]. Winter temperatures tend to be much lower due to snows or heavy rain that can force people to stay indoors, and results in more usage of electrical energy for lighting and heating purposes. While, in the summer months temperatures are lower due to heavy rains bringing cooler weather, which motivates people to switch off cooling devices, thus resulting in a decrease in electricity demand.

G. Wind Speed (WS)

At lower humidity rate, WS decreases the temperature and increases the evaporation rates and as a result people feel cool.

In summer on blowy day people use less cooling devices and result in lower load consumption. On blowy day the total generation will increase whenever we used multi-generation, such as hydropower generation, renewable power generation containing wind energy generation. We can compensate short fall during windy day by increasing wind power generation because wind energy is more economical then thermal power generation and hydro power generation. On blowy day the domestic demand will be decrease because temperature totally depends on the WS. While, in winter on blowy day people feeling cooler and will use more heating appliances; hence, electricity consumption will increase during winter days [15]. However, the total generation of power will still increase in winter like in summer. Furthermore, WS is an important impact factor that not only increases the electricity but also decrease the electricity consumption in summer.

H. Cloud Cover (CC)

On the cloud day, the electricity demand is extremely dependent on the cloud thickness and height of the cloud.

CC means that how much sky cover by cloud. The unit of the CC is okta. CC value is in between “0” and “10”. The value “10” okta mean sky fully covered by cloud and zero okta mean clear sky.

Cloud has not too much impact on the electricity demand when it thin and high. CC is unnoticed and ignored for electricity consumption because it has not enough change in temperature. CC is more impact when cloud is thick and at low height. CC cause to change the temperature and lead to change the electricity consumption. Effeteness of CC on the electricity load is high at day time and cooling value is zero at night time because no sun light. Green house impact traps hotness into the air and their mal radiation reflect back from earth into the surface at night. Thus, temperature can significantly increase at night time by CC. Hence, on coming day consumption will increase in summer. Half of the out-going rays are reflected by the effect of greenhouse gases, while 90% of out-going rays is reflected by thermal reflection. Mean thermal radiation of cloud play a significant role in hotness than greenhouse. CC affects temperature as well as light intensity during day. During the day time more sun light is blocked CC are low and thick. So people will use more electricity for lighting their homes and will result in increased electricity consumption.

I. Dew Point (DP)

DP is defined as measurement of moisture in air (atmosphere). DP is also termed as Dew point temperature. DP is not considered comfortable when exceed from 67 ^oF or 20 ^oC, while higher humanity when exceed from 72 ^oF or 22 ^oC. Normally DP relates directly with humidity of weather parameter. Whenever, humidity is higher in air mean DP is higher and the evaporation rate is decrease. So human body will feel hotter than normal days and people will consume more electricity for cooling purpose that result in more load consumption. When the area is warm then DP and humidity will increase and cause to cool the weather and increase the vaporization. Thus, weather become cold and electricity usage will decrease by witching off cooling appliances.

J. Solar Irradiance (SI)

SI is defined as measurement of electromagnetic rays after air scattering and absorption at earth or in atmosphere. With average climatic condition every year global received 1725 kWh/m^2 solar radiation. In which 537 kWh/m^2 (31%) amount diffuse and 1,188 kWh/m^2 (69%) reach to earth surface [16] and cause to increase the solar energy radiation. In summer, SI effect is high and people use cooling appliance for cooling purpose that leads to increase the load consumption. While in winter the effect of SI become high and people will switch off their heating appliances and via this load consumption will decrease in winter. Normally at morning time the impact of SI is not too much high thus no effect on load consumption but in at noon time SI effect is higher on the human bodies. Furthermore, at noon time load consumption will increase or decrease it’s depended upon season (winter or summer).

III. Statistical Correlation Analysis

Correlation is a statistical tool and helps to analyze and measure the degree of relation between dependent and independent variables. Correlation is termed to be positive when both variables are increasing or decreasing at the same time and said to be negative when one variable is increasing while other one is decreasing. Sample correlations use only two variables and multiple correlations use more than two variables. In linear correlation, changing ratio of variables is constant. While, in nonlinear correlation changing ratio of variables is not constant.

A. Pearson Coefficient (PC)

PC is defined as “linear rotation between dependent variable and independent variable.” The maximum value is positive one (+1) and minimum value is negative one (-1). Correlation is perfect when its value is 1 and is considered very strong when value is between 0.75 and 1. Correlation is termed moderate when value is between 0.5 and 0.75 while for value between 0.25 to 0.5 correlations is termed as weak. Zero means no correlation between dependent and independent variable.

$$r = \frac{correlation(x, y)}{S\tan dard\ Deviation(x) \times S\tan dard\ Deviation(y)} \quad (5)$$

$$r = \frac{\sum x_i y_i - \frac{\sum x_i y_i}{n}}{\sqrt{\left(\sum x_i^2 - \frac{\sum x_i^2}{n}\right)\left(\sum y_i^2 - \frac{\sum y_i^2}{n}\right)}} \quad (6)$$

where "x" and "y" are independent and dependent variables and "n" is the number of rank of variables.

B. Spearman Correlation

Spearman Correlation uses monotonic function and ordinal variables and gives non-linear relation between variables. Monotonic function is the one in which independent variable increases but the function value remains the same. Function is said to be monotonically increasing if independent variable is increasing and dependent variable is never decreasing and, if independent variable is increasing but dependent variable is decreasing, then function is said to be monotonically decreasing function. Function is not monotonic when independent variable increases and dependent variable sometime increases and sometime decreases. Maximum value is positive one (+1) and minimum value is negative one (-1).

$$\rho = 1 - \frac{6\sum d_i^2}{n(n^2 - 1)} \quad (7)$$

where "n" is number of rank of variables and $d_i = x_i - y_i$ is the different between ranks.

C. Kendall Rank Correlation Coefficient

Kendall Rank Correlation Coefficient known as Kendall's tau coefficient. It measures and analyzes the difference between two pairs of given two order set. It also defined as difference between the number of concordant pair and discordant pairs.

$$\tau = \frac{A - B}{\frac{1}{2} n(n - 1)} \quad (8)$$

where "A" denoted number of concordant and "B" denoted number of discordant pairs. Concordant pair is the one in which x_i is not equal to x_j and y_i not equal to y_j too. Discordant pair is the one in which x_i greater than x_j and same for y[a]. "n" denotes the number of pairs.

IV. Performance Validation

The data has been collected from Capano Bay Texas, United States [19]. This data contains load consumption and weather parameter, such as DBT, DP, CC, and WS. We calculated the relationship between load and various weather parameters. In this paper, one month is analyzed for three seasons for winter, summer and spring as a case study. Fig. 1 presents the relation between load consumption and DBT. The stem graph show relationship between CC and load consumption in Fig. 2. Fig. 3 describes a comparison between load and WS. Fig. 4 represents a real time graph between DP and load. Fig. 5 presents the relation between load consumption and DBT. The stem graph show relationship between CC and load consumption in Fig. 6. Fig. 7 describes the relation between load and WS. Fig. 8 represents the real time graph between DP and load. Fig. 9 presents the relation between load consumption and DBT. The stem graph show relationship between CC and load consumption in Fig. 10. Fig. 11 shows the relation between load and WS. Fig. 12 represents the real time graph between DP and load. In this analysis load (consumer demand) is a dependent variable and climatic variables are independent variables.

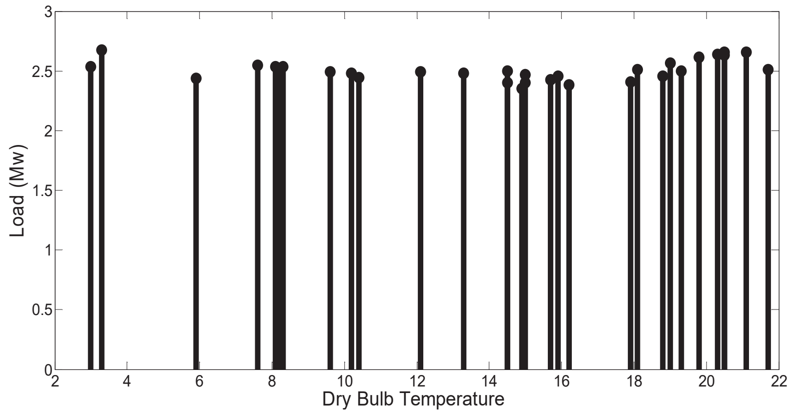

Fig. 1 Relation between Load and DBT

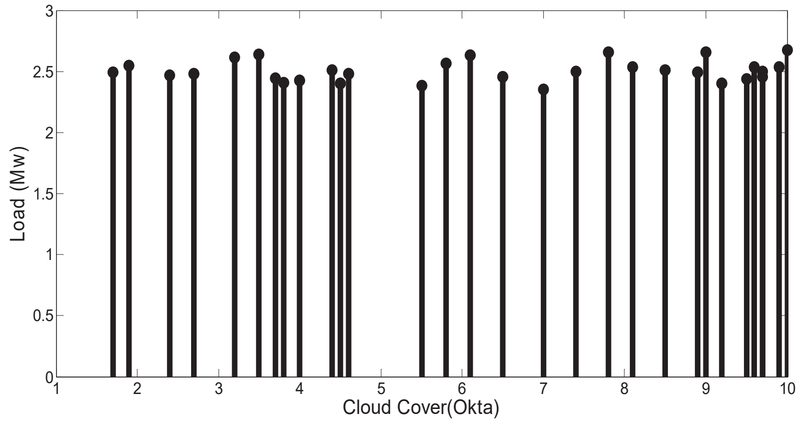

Fig. 2 Relation between Load and CC

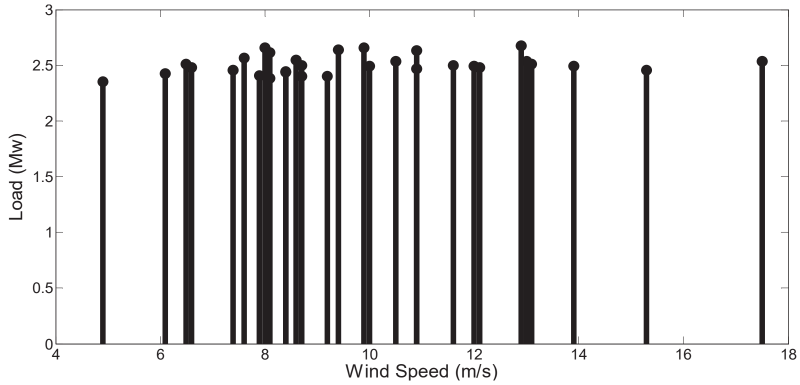

Fig. 3 Relation between Load and WS

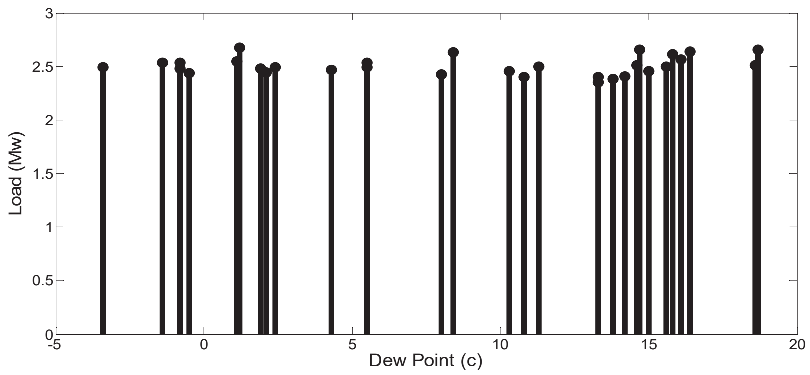

Fig. 4 Relation between Load and DP

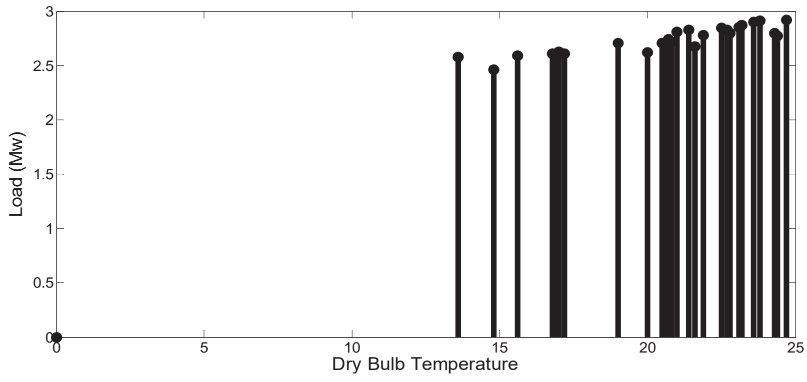

Fig. 5 Relation between Load and DBT

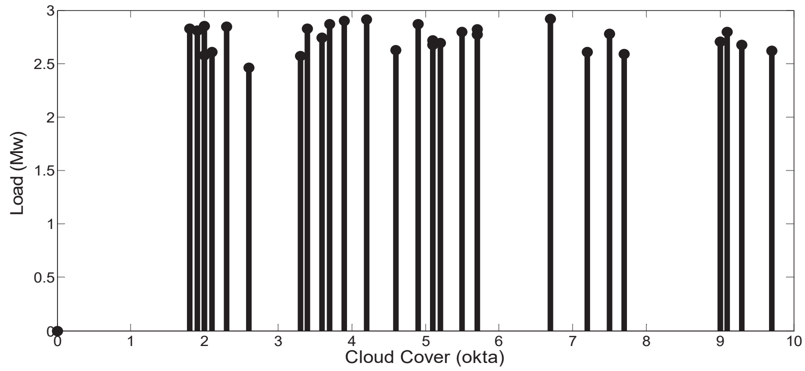

Fig. 6 Relation between Load and CC

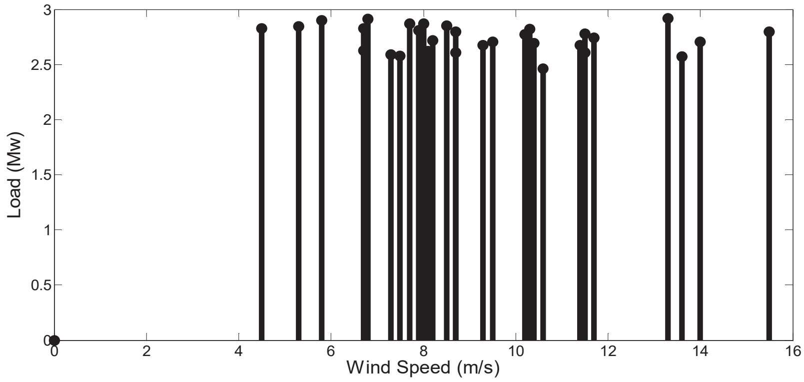

Fig. 7 Relation between Load and WS

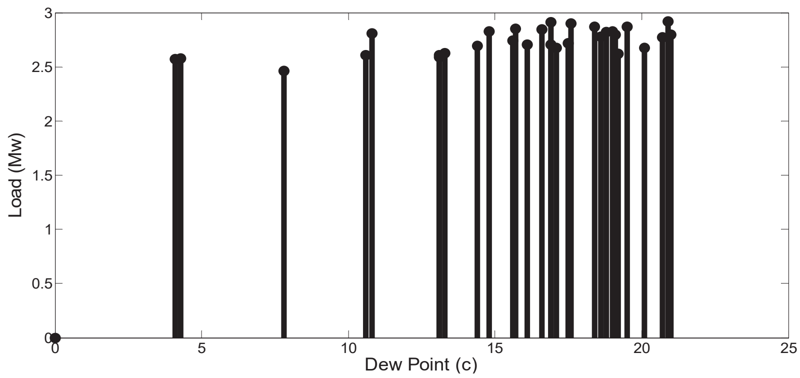

Fig. 8 Relation between Load and DP

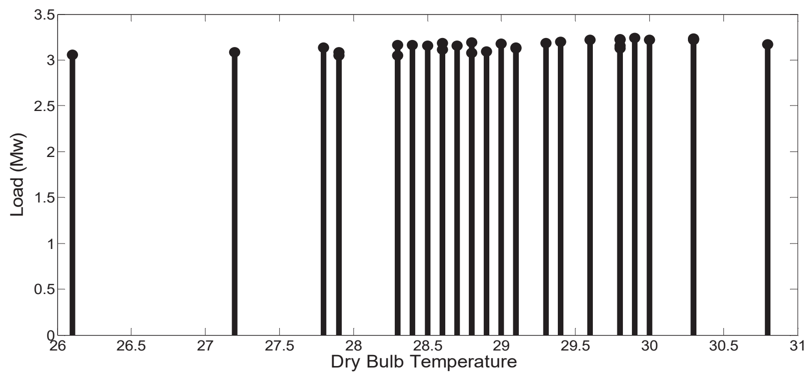

Fig. 9 Relation between Load and DBT

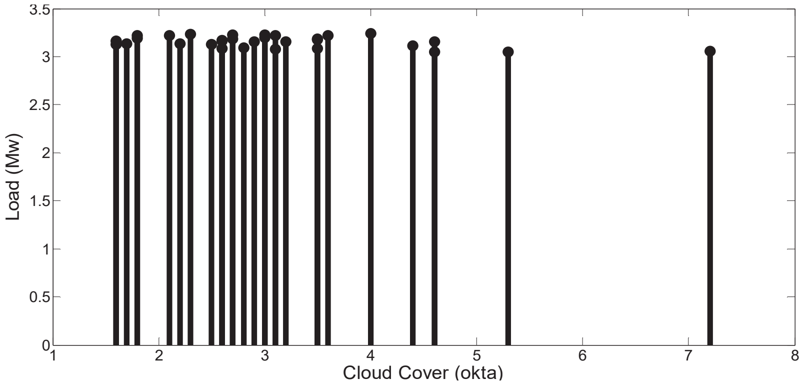

Fig. 10 Relation between Load and CC

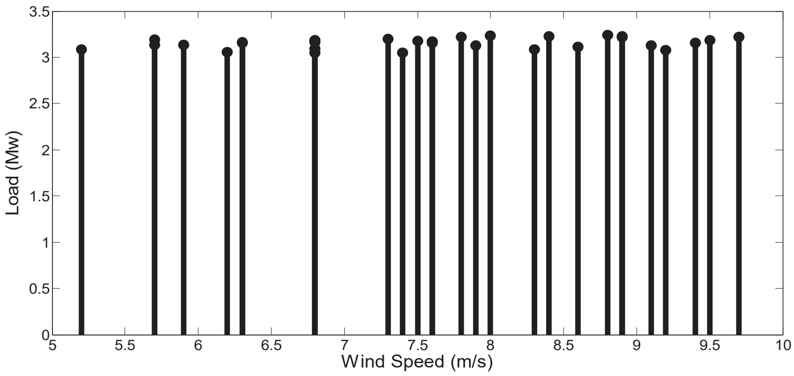

Fig. 11 Relation between Load and WS

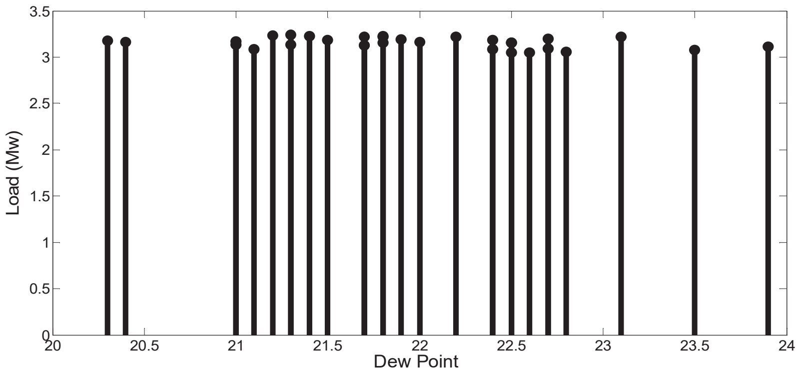

Fig. 12 Relation between Load and DP

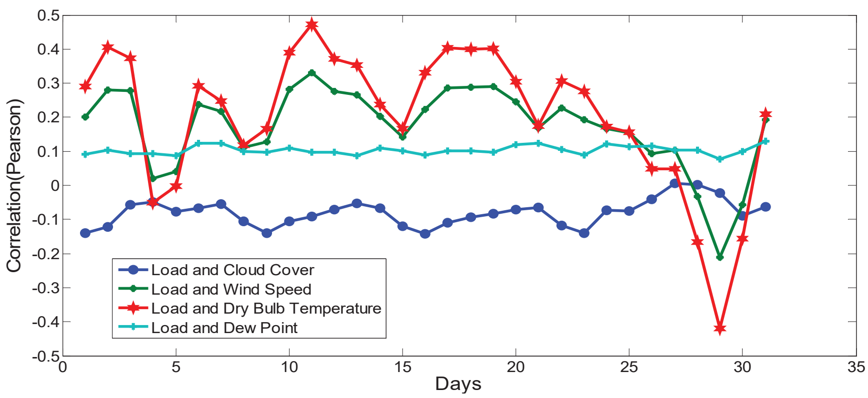

Fig. 13 Pearson Correlation between Load and weather parameters

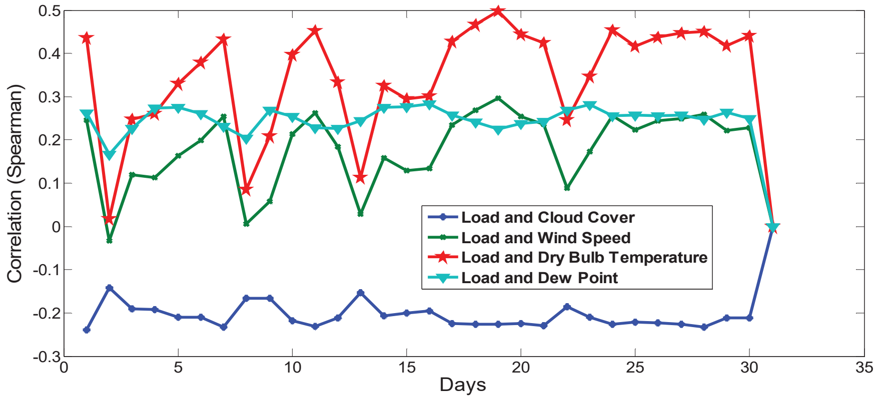

Fig. 14 Spearman Correlation between Load and weather parameters

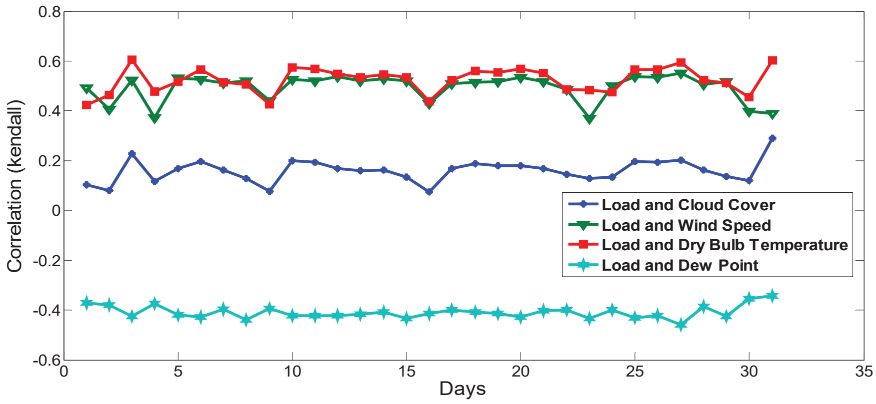

Fig. 15 Kendall Correlation between Load and weather parameters

In this paper, analysis of correlation between load and different weather parameter such as, DBT, CC, DP and WS is also evaluated. Three types of correlation have been calculated in this paper. Pearson correlation applied on the January data that is shown in Fig. 13 and derived that DP and CC have not consistently correlated with load while WS and DBT have consistently correlated with load. Spearman correlation is applied on the April data and the graph shown in Fig. 14. CC is consistently correlated with load but the other weather variables are not. Kendall correlation is applied on July data and calculated correlation between load and weather parameter in Fig. 15.

V. Conclusion

Weather and climatic drifts plays a pivotal role in SG operation with correlation models and statistical analysis, energy profiles of various consumers will be re-shaped and smoothened. Moreover, using correlation statistic between dependent and independent parameters will help utilities and policy maker for financial assessment of generation plants and demand supply management. Furthermore, above elaboration is vital in many respects of SGs, such as: (a) energy management, (b) consumer empowerment, (c) optimized demand response program management, (d) local forecasting, and (e) energy estimation.

References

[1] Oliveira, M. O., D. P. Marzec, G. Bordin, A. S. Bretas, and D. Bernardon. "Climate Change Effect on Very Short-term Electric Load Forecasting." 2011 IEEE Trondheim PowerTech (2011): n. pag. Web.

[2] Chen, Gerk Hing, and Tek Tjing Lie. "The Impact of Climate Change on New Zealand's Electricity Demand." 2010 IEEE 11th International Conference on Probabilistic Methods Applied to Power Systems (2010): n. pag. Web.

[3] Hor, C.-L., S.j. Watson, and S. Majithia. "Analyzing the Impact of Weather Variables on Monthly Electricity Demand." IEEE Trans. Power Syst. IEEE Transactions on Power Systems 20.4 (2005): 2078-085. Web.

[4] Panteli, M., Mancarella, P., Cotton, I., Pickering, C., Wilkinson, S., Anderson, K., … Dawson, R. (2015). Impact of climate change on the resilience of the UK power system. IET International Conference on Resilience of Transmission and Distribution Networks (RTDN) 2015. doi:10.1049/cp.2015.0878

[5] Liu, K., Wang, M., Tian, Z., & Xiang, C. (2012). The Research about the Impact of Climate Change on Power Load of Air Conditioning. 2012 Asia-Pacific Power and Energy Engineering Conference. doi:10.1109/appeec.2012.6307560

[6] Douglas, A., Breipohl, A., Lee, F., & Adapa, R. (1998). The impacts of temperature forecast uncertainty on Bayesian load forecasting. IEEE Trans. Power Syst. IEEE Transactions on Power Systems, 13(4), 1507-1513. doi:10.1109/59.736298

[7] Parkpoom, S.j., and G.p. Harrison. "Analyzing the Impact of Climate Change on Future Electricity Demand in Thailand." IEEE Trans. Power Syst. IEEE Transactions on Power Systems 23.3 (2008): 1441-448. Web

[8] Paul, Jai Sachith, Akhil P. Sivan, and K. Balachandran. "Energy Sector in India: Challenges and Solutions." *2013 International Conference on Green Computing, Communication and Conservation of Energy (ICGCE)* (2013): n. pag. Web.

[9] Liu, Fei. "Application of Environmental Management on Energy Saving and Green House Gas Reduction in Beijing." *2010 International Conference on Management and Service Science* (2010): n. pag. Web.

[10] Azadeh, A., Saberi, M., & Seraj, O. (2010). An integrated fuzzy regression algorithm for energy consumption estimation with non-stationary data: A case study of Iran. *Energy, 35*(6), 2351-2366. doi: 10.1016/j.energy.2009.12.023

[11] D. Paravan, A. Debs, C. Hansen, D. Becker, P. Hirsch, and R. Golob."Influence of temperature on short-term load forecasting using the EPRI-ANNSTLF."

[12] A. Pardo, V. Meneu, and E. Valor, "Temperature and seasonality influences on Spanish electricity load," *Energy Economics*, vol. 24, pp. 55-70, 2002.

[13] Lal, M.; Harasawa H.; Murdiyarso, D. Asia. In: Climate Change 2001 Impacts, Adaptation and Vulnerability. McCarthy, J.J.; Canziani. O.F.; Leary, N.A.; Dokken D.J.; and White K.S. (Eds.). Cambridge University Press, Chap+ I 1 I 2001

[14] S. S. Wyer, "A treatise on producer-gas and gas-producers," *The Engineering and Mining Journal*, London, pp. 23, 1906.

[15] Fahad, Muhammad Usman, and Naeem Arbab. "Factor Affecting Short Term Load Forecasting." Journal of Clean Energy Technologies JOCET 2.4 (2014): 305-09. Web

[16] L. Hadjioannou, "Three years of operation of the radiation centre in Nicosia", Cyprus. Meteorological Note Series No. 2, Meteorological Service, March (1987).

[17] S. M. Ali, C. A. Mehmood, M. Jawad, B. Khan, U. Farid, A. Majid, M. Ali, M. Jawad, "Stochastic and Statistical Analysis of Utility Revenues and Weather Data Analysis for Consumer Demand Estimation in Smart Grid", PLOS ONE J., 2016

[18] S. M. Ali, M. Asif, "Energy Management Scheme for Residential Community in Smart Grids using FEDRP", *Canadian J. of Electrical and Electronic Engineering*, vol. 3, no. 8, pp. 439-447, 2012.

[19] "U.S. Energy Information Administration - EIA - Independent Statistics and Analysis." U.S. Energy Information Administration (EIA). N.p., n.d. Web. 14 July 2016.