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Analyzing the demand for electricity in Greece

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I would like to thank:

Professor Nikolaos Thomaidis for his essential guidance and motivation,

Iro my wife for her endless support in me.

“Dedicated to my wife Iro”

Abstract

This dissertation explores the electricity demand in Greece over the period 2015–2023, utilizing the hourly electricity total load data from the ENTSO-E Transparency Platform. By combining exploratory data analysis, regression modeling, and traditional time-series techniques, it aims to identify the statistical properties of electricity demand, develop robust forecasting models, and evaluate their predictive capabilities to enhance the understanding and management of electricity demand in Greece. The analysis begins with a descriptive examination of the data through statistical and graphical tools for demand patterns, such as trends and seasonality at hourly, daily, and monthly intervals, seeking to uncover the key properties of electricity consumption in order to lay the foundation for the development of estimation models. Based on these findings, regression analysis is employed to quantify the impact of various factors, including time trends, seasonal variations, but also lagged-time variables and to design models that capture the dynamic features of electricity demand of Greece. Building upon these models, the study evaluates their short-term predictive capabilities and compares their performance against traditional time-series forecasting techniques, including Simple Moving Average (SMA) and Exponentially Weighted Moving Average (EWMA). The forecasting accuracy of the various models is assessed using metrics such as Mean Absolute Error (MAE), Mean Absolute Percentage Error (MAPE), and Root Mean Square Error (RMSE) highlighting the strengths and limitations of the various models under different conditions. Overall, the findings of this dissertation seek to contribute to a deeper understanding of electricity demand dynamics in Greece and its fundamental characteristics enhancing the theoretical understanding of the topic but also potentially providing some valuable insights for practical implications.

Keywords

Electricity, demand properties, regression, forecasting.

Αναλύοντας τη ζήτηση ηλεκτρικής ενέργειας στην Ελλάδα

Παναγιώτης Μαραγκός

Περίληψη

Η παρούσα διπλωματική εργασία εξετάζει τη ζήτηση ηλεκτρικής ενέργειας στην Ελλάδα κατά την περίοδο 2015–2023, αξιοποιώντας τα δεδομένα ωριαίου συνολικού ηλεκτρικού φορτίου από την ENTSO-E Transparency Platform. Συνδυάζοντας την ανάλυση δεδομένων, τη δημιουργία μοντέλων παλινδρόμησης και τις παραδοσιακές τεχνικές χρονοσειρών, στοχεύει να αποκαλύψει τις στατιστικές ιδιότητες της ζήτησης ηλεκτρικής ενέργειας, να αναπτύξει αξιόπιστα μοντέλα πρόβλεψης και να αξιολογήσει τις προβλεπτικές τους δυνατότητες, με στόχο την ενίσχυση της κατανόησης και της διαχείρισης της ηλεκτρικής ενέργειας στην Ελλάδα. Η ανάλυση ξεκινά με την περιγραφική εξέταση των δεδομένων μέσω στατιστικών και γραφικών εργαλείων, των μοτίβων ζήτησης, όπως οι τάσεις και η εποχικότητα σε ωριαία, ημερήσια και μηνιαία διαστήματα, με στόχο την αποκάλυψη βασικών μοτίβων κατανάλωσης ηλεκτρικής ενέργειας για την δημιουργία της βάσης στην ανάπτυξη των μοντέλων εκτίμησης. Βάσει αυτών των ευρημάτων, χρησιμοποιείται παλινδρόμηση για την ποσοτικοποίηση της επίδρασης διαφόρων παραγόντων, όπως οι τάσεις, οι εποχικές διακυμάνσεις αλλά και οι μεταβλητές χρονικής υστέρησης και για τον σχεδιασμό μοντέλων που αποτυπώνουν τα δυναμικά χαρακτηριστικά της ζήτησης ηλεκτρικής ενέργειας στην Ελλάδα. Βασιζόμενη σε αυτά τα μοντέλα, η μελέτη αξιολογεί τις βραχυπρόθεσμες προβλεπτικές τους δυνατότητες και συγκρίνει την απόδοσή τους με παραδοσιακές τεχνικές πρόβλεψης χρονοσειρών, συμπεριλαμβανομένων του Απλού Κινούμενου Μέσου (SMA) και του Εκθετικού Σταθμισμένου Κινούμενου Μέσου (EWMA). Η ακρίβεια πρόβλεψης των διάφορων μοντέλων αξιολογείται χρησιμοποιώντας δείκτες όπως το Μέσο Απόλυτο Σφάλμα (MAE), το Μέσο Απόλυτο Ποσοστιαίο Σφάλμα (MAPE) και το Τετραγωνικό Μέσο Σφάλμα (RMSE), επισημαίνοντας τα πλεονεκτήματα

και τις αδυναμίες των διάφορων μοντέλων υπό διαφορετικές συνθήκες. Συνολικά, τα ευρήματα αυτής της εργασίας αποσκοπούν να συμβάλουν σε μια βαθύτερη κατανόηση των δυναμικών της ζήτησης ηλεκτρικής ενέργειας στην Ελλάδα και των θεμελιωδών χαρακτηριστικών της, ενισχύοντας τόσο τη θεωρητική κατανόηση όσο και παρέχοντας πολύτιμες πληροφορίες για πρακτικές εφαρμογές.

Λέξεις – Κλειδιά

Ηλεκτρισμός, ιδιότητες ζήτησης, παλινδρόμηση, τεχνικές προβλέψεων.

Table of Contents

List of Figures

List of Tables

1. Introduction

1.1 Literature review

Electricity demand is the cornerstone for the effective power system management, as it plays a vital role in ensuring the reliable operation, optimization, and strategic planning of energy systems. Though accurate predictions of the electricity consumption, the system operator can balance more effectively supply and demand on a real time basis, ensuring system reliability and reducing the risks of blackouts (Iman Ghalehkhondabi, Ehsan Ardjmand, Gary R. Weckman, & William A. Young II, 2017). This capability is crucial for short-term decisions, such as optimizing unit commitments and energy allocations, which directly minimize operational costs and resource waste (Heiko Hahn, Silja Meyer-Nieberg, & Stefan Pickl, 2009). More specifically, overestimation or underestimation of electricity load can significantly affect production costs, with a mere 1% reduction in the mean absolute percentage error potentially decreasing generation costs by 0.1% to 0.3%, highlighting the economic importance of precision (Naqash Ahmad, Yazeed Ghadi, Muhammad Adnan, & Mansoor Ali, 2022).

More over moving away from the dependence of operational efficiency and direct costs from effective demand forecasting, electricity forecasting can help market participants especially in deregulated markets align the energy needs with pricing ensuring stable market dynamics and effective pricing strategies (Heiko Hahn, Silja Meyer-Nieberg, & Stefan Pickl, 2009). The dynamic relationship and the intrinsic complexity between electricity pricing and fundamental market factors, such as temperature, electricity load forecasts, renewable energy contributions, fossil fuel costs, and CO2 emission allowances (Eleftheria G. Paschalidou & Nikolaos S. Thomaidis, 2025), not only emphasizes the multifaceted nature of electricity but also underscores the dynamic interplay between demand and supply conditions. Simultaneously, accurate forecasting can help facilitate the integration of renewable energy sources by predicting load variability and adjusting operations to accommodate the intermittent nature of solar and wind power (Naqash Ahmad, Yazeed Ghadi, Muhammad Adnan, & Mansoor Ali, 2022). Meanwhile, medium-term and long-term forecasting can provide critical insights for infrastructure investments, guiding decisions to new facilities, expansions, and technology upgrades contributing to future electricity demand sustainability (Heiko Hahn, Silja Meyer-Nieberg, & Stefan Pickl, 2009). Beyond these technical and economic aspects, demand forecasting aligns energy production with socioeconomic changes, enabling the transition toward sustainable and efficient energy systems and serving as an indispensable tool for both immediate operational efficiency and long-term energy system sustainability.

The importance of electricity demand is further underscored by the extensive number of methodologies and techniques that have been developed and published for forecasting over the years reflecting the evolving challenges and complexities of forecasting in diverse contexts. This range of techniques can broadly be categorized into Traditional, Modified Traditional, and Soft Computing methods (Arunesh Kumar Singh, Ibraheem, S. Khatoon, Md. Muazzam, & D. K. Chaturvedi, 2012). Additionally to the methodology that is used in the various techniques, electricity load forecasting techniques are classified based on the time horizons —Very Short-Term (minutes to an hour), Short-Term (hour to a week), Medium-Term (week to a year), and Long-Term (over a year)— with each category tailored to specific operational needs and complexities (Mahmoud A. Hammad, Borut Jereb, Bojan Rosi, & Dejan Dragan, 2020).

The traditional approaches like regression, exponential smoothing, and iterative reweighted least squares rely on established statistical models to predict load based on historical data and influencing factors. While these methods provide foundational insights, they often struggle with nonlinear dynamics and changing conditions. To address these challenges, Modified Traditional Techniques —such as adaptive demand forecasting, stochastic time series models (ARIMA, ARMA), and Support Vector Machines (SVMs)— introduce adaptability and better handling of seasonality and trend variations (Arunesh Kumar Singh, Ibraheem, S. Khatoon, Md. Muazzam, & D. K. Chaturvedi, 2012).

The evolution of forecasting has shifted toward Soft Computing Techniques, which mimic human cognitive processes to address uncertainty and complexity. Methods like Genetic Algorithms (GAs), Fuzzy Logic, and Artificial Neural Networks (ANNs) enable more flexible predictions by optimizing models, integrating diverse data types, and uncovering intricate patterns in historical data. Meanwhile the emerging hybrid models, combining approaches such as fuzzy logic with neural networks, enhance precision and adaptability further, while innovations like real-time data integration and smart grid technologies reflect the trend toward intelligent and responsive energy systems (Arunesh Kumar Singh, Ibraheem, S. Khatoon, Md. Muazzam, & D. K. Chaturvedi, 2012).

On the opposing view, while advanced models offer higher accuracy and adaptability—and it might seem logical to rely solely on these sophisticated techniques for addressing electricity demand forecasting challenges—traditional methods like regression remain relevant and efficient. Particularly in less volatile, long-term contexts, these simpler approaches not only ensure their continued role as a fundamental part of effective forecasting strategies (Mahmoud A. Hammad, Borut Jereb, Bojan Rosi, & Dejan Dragan, 2020), but also highlight the inherent complexity of electricity demand. This complexity arises from its dependence on a wide range of influencing factors, varying forecasting scenarios, and diverse objectives. By acknowledging the relevance of both advanced and traditional models, it becomes evident that no single approach can comprehensively address all forecasting needs, reinforcing the importance of unrevealing the multifaceted nature of electricity demand for each forecasting scenario.

1.2 Electricity Demand in Greece

Electricity demand in Greece is shaped by a combination of factors, including economic activity, population dynamics, seasonal variations, and evolving energy policies. The country's energy sector has undergone significant transformations over the last years, reflecting broader European trends such as the integration of renewable energy sources, the liberalization of energy markets, the increasing focus on sustainability but also the reduction of the dependance from Russian fossil fuels and the shift to liquified LNG (International Energy Agency, 2023). Additionally, this interplay between renewable energy production and traditional fossil fuel-based generation has created new challenges for balancing supply and demand in real-time, emphasizing the importance of precise forecasting (George Varelas, Giannis Tzimas, & Panayiotis Alefragis, 2024). It is evident that these changes have made the analysis and forecasting of electricity demand more critical and complex, especially given the intermittent nature of renewable energy, the push for decarbonization alongside with the volatile global market, notably triggered by geopolitical events such as the war in Ukraine and Gaza.

Over the last years also, Greece experienced shifts in its electricity consumption patterns due to economic recovery after the financial crisis, changes in industrial and residential energy use, especially due to Covid-19 pandemic, and the adoption of energy-efficient technologies (International Energy Agency, 2023). These dynamics, alongside the country's Mediterranean climate leading to pronounced seasonal consumption patterns, have resulted in varying electricity demand profiles, influenced by factors like weather conditions, economic cycles, and government initiatives promoting renewable energy adoption.

Despite the growing complexity, understanding the statistical properties and trends of electricity demand in Greece remains vital for ensuring grid reliability, optimizing energy market operations, and planning future infrastructure investments. Accurate demand forecasts are especially crucial in Greece's context, where the transition to a more sustainable energy system requires effective integration of renewable energy sources and adaptation to changes in consumption behavior.

1.3 Dissertation Thesis

The purpose of this dissertation is to analyze the actual electricity demand (system load) in Greece from 2015 to 2023. By leveraging hourly load data from the ENTSO-E Transparency Platform, this study seeks to uncover the stylized facts of electricity demand and develop estimation models using time-series and regression analysis. The research will try to provide insights into the statistical properties of Greece's electricity demand and assess the effectiveness of various forecasting methodologies in capturing these patterns. More specifically, through this analysis, the dissertation aims to address the following research questions:

1. What are the statistical properties of system load?

This research will unveil the statistical properties inherent in the system load data. Exploratory data analysis will uncover patterns such as seasonality, trends, periodicity compared hourly, daily and monthly, shedding light on the underlying structure of electricity demand in Greece.

2. Can we create models that incorporate the driving factors of electricity demand and reproduce the main features of the demand data?

The dissertation seeks to develop robust estimation models capable of capturing the driving factors influencing electricity demand. Utilizing regression analysis techniques, the models will endeavor to replicate the primary features observed in the demand data.

3. What is the level of predictability of electricity demand in the short term?

Assessing the level of predictability of electricity demand in the short term is a crucial aspect of the research. By employing forecasting methodologies, the study will evaluate the accuracy of prediction models in capturing fluctuations in demand over short time horizons.

4. What is the rate at which typical models can predict demand fluctuations over time?

The dissertation aims to quantify the predictive performance of typical models employed in forecasting electricity demand. Through comparative analysis, the study will assess the efficacy of traditional modeling approaches against regression in accurately predicting demand fluctuations over time.

Overall, this dissertation seeks to contribute both theoretically and practically to the field of electricity demand forecasting. On the theoretical side, it aims to advance the understanding of demand dynamics in Greece, adding to the body of knowledge on electricity demand modeling while on the practical side, the findings will offer valuable insights to policymakers, energy market participants, and grid operators in Greece aiding them to make informed decisions about energy planning, infrastructure investment, and market operations.

2. Research methodology

2.1 Descriptive analysis report

The first step in the analysis will be a descriptive analysis of the actual data of the hourly electricity total load of Greece from the European Network of Transmission System Operators for Electricity (ENTSO-E) transparency platform for the period 01/01/2015 to 31/12/2023 that will try to identify the behavior and the properties of the electricity demand (system load) in Greece. By leveraging detailed statistical and graphical tools, calculating and visualizing the mean hourly total loads alongside with graphical representations, such as line charts and boxplots and time series plots that are employed to discern trends, peak hours, and the dispersion of electricity usage, an exploratory data analysis will be used to uncover patterns such as seasonality, trends, periodicity compared hourly, daily and monthly, shedding light on the underlying structure of electricity demand in Greece. Overall, by dissecting the electricity demand behavior in Greece for the period 2015-2023, the descriptive analysis implies properties of trend, monthly and weekday seasonality that differ between different time zones in electricity demand in Greece creating the basis of the creation of the estimation models.

2.2 Variable significance evaluation

Taking into account the outcome of the descriptive analysis of the hourly total load of electricity, the next step in the analysis is the statistical confirmation of these implications. More specifically, it is obligatory to test if the first observations from the descriptive analysis of the electricity total load are statistically sound and significant. This confirmation is going to happen through regression analysis.

We are going to create a basic regression model with the dependent variable be the hourly total load of each time zone and the explanatory variables including a trend component as well as the monthly and weekday seasonality. Transforming the hourly total load of electricity using its natural logarithm is necessary to linearize potential non-linear relationships between the dependent and explanatory variables, stabilize variance and mitigate the effects of potential skewness in the electricity load data, ensuring the model satisfies the assumptions of linear regression (Kenneth Benoit, 2011). Given that the regression is

$$Ln(E_t) = c_0 + c_1 t + c_2 t^2 + \sum_{j=1}^{11} a_j M_{jt} + \sum_{i=1}^{6} b_i D_{it} + e_t$$

where $Ln(E_t)$ is the natural logarithm of hourly total load of electricity for each time zone, c_0 is the constant term, t is a linear time-trend variable with c_1 the linear-trend coefficient, t^2 is a quadratic trend variable with c_2 the quadratic trend coefficient, M_{jt}, $j = 1,2 \dots 11$ is a set of 11 monthly dummy variables from January to November with a_j, $j = 1,2 \dots 11$ the monthly dummy variables coefficients, D_{it}, $i = 1,2 \dots 6$ is a set of 6 weekday dummy variables from Monday to Saturday with b_i, $i = 1,2 \dots 6$ the weekday dummy variables coefficients and e_t is the disturbance term.

Through running the regression analysis for each time zone, we are going to test at 5% significance if the variables that are included in the regression are statistically significant using a variable t-test. The null and alternative hypotheses for each variable are going to be:

H_0 : variable coefficient=0 (independent variable is not statistically significant)

H_1 : variable coefficient $\neq 0$ (independent variable is statistically significant)

If the p-value is lower than 0.05, then the null is rejected and it can be concluded that the independent variable has statistically significant impact on the dependent variable. Otherwise, there is no sufficient evidence to reject the null hypothesis.

2.3 Models that reproduce electricity demand driving factors

The next step in our analysis is to create models with the above findings and identify their ability to reproduce the dynamic features of electricity demand in Greece.

However, to further improve our understanding and predictive capabilities, the incorporation of lagged-time variables becomes critical. These lagged variables, representing the past values of the hourly electricity total load, can reveal immediate and delayed dependencies that contribute to short-term fluctuations in demand (Luke Keele & Nathan J. Kelly, 2005). The inclusion of these lagged-time variables is expected to significantly enhance the model's accuracy, enabling it to better predict short-term variations and sudden changes in electricity consumption. The integration of lagged terms will allow us to account for the short-term dynamics distinctive to each time zone, offering a more tailored and detailed specific model that reproduces the dynamics of electricity demand for each time zone.

In the following chapter, we are going to create again a basic regression model with the dependent variable be the hourly total load of each time zone that not only will include independent variables that will express the trend component, the monthly and weekday seasonality based on the descriptive analysis and the variable significance report but also will contain two lagged time variables that represent the past observations. The regression is

$$Ln(E_t) = c_0 + c_1 t + c_2 t^2 + \sum_{j=1}^{11} a_j M_{jt} + \sum_{i=1}^{6} b_i D_{it} + d_1 Ln(E_{t-1}) + d_2 Ln(E_{t-2}) + e_t$$

where $Ln(E_{t-1})$ is the natural logarithm of the one-day prior hourly total load of electricity, $Ln(E_{t-2})$ is the natural logarithm of the two-day prior hourly total load of electricity and e_t is the disturbance term.

Running the regression analysis for each time zone, it is going to be tested again, as like the variable significance evaluation, at 5% significance if the variables that are included in the regression are statistically significant using a variable t-test.

In the scenario that there are statistically insignificant variables in a model, the statistically insignificant variables are going to be excluded from the regression model and the regression analysis is going to executed again until we conclude to a model that contains only statistically significant variables. Then each final model is going to be the tested for its suitability to reproduce the demand driving factors.

2.4 Forecasts with regression models

Building upon the regression models developed to replicate the dynamic properties and driving factors of electricity demand, the focus of the analysis shifts to testing their forecasting ability. In order to evaluate the predictive capability of the regression models, the data of hourly electricity load data is needed to split into two distinct periods, an estimation sample spanning from 2015 to 2022 and a forecasting sample serving as an independent validation set to ensure that the models are going to be tested on unseen data.

To facilitate forecasting, the regression analysis is going to be re-runed for each time zone using the variables that are included in the final models developed during the previous analysis phase. The regression models for each time zone need to be recalibrated based the estimation sample. In the next step, based on the new models that will be occurred containing only the statistically significant variables alongside with the new estimated coefficients, forecasts are going to be generated for the hourly electricity total load of Greece in 2023 for each time zone.

Since the models are tested about their short-term forecasting ability of the models utilizing time-lagged variables, the forecasting horizon of the models is inherently limited to one-day-ahead prediction. This is because the models rely on actual observed data for the lagged variables, such as the electricity total load from the prior day, to generate accurate forecasts. The forecasts of each model are then compared against observed values from the forecasting sample in order to test the forecasting accuracy of the model.

To assess the accuracy of the forecasting models and determine their reliability in forecasting the hourly electricity demand for each time zone, three widely used metrics need to be applied the Mean Absolute Error (MAE), the Mean Absolute Percentage Error (MAPE) and the Root Mean Square Error (RMSE).

2.4.1 MAE

The Mean Absolute Error (MAE) measures the average magnitude of errors between the actual observed values and the forecasted values. So, the formula for MAE for each model is going to be

$$MAE = \frac{\sum_{i=1}^{n} \left| E_i - \hat{E}_i \right|}{n}$$

MAE provides a straightforward and intuitive measure of accuracy by averaging the absolute errors, irrespective of their direction (positive or negative). This metric is particularly useful in identifying the average deviation between predictions and actual outcomes, offering insights into the general precision of the model. Lower MAE values indicate higher accuracy, making this metric ideal for evaluating overall forecast reliability without overemphasizing extreme deviations (T. Chai, 2014).

2.4.2 MAPE

The Mean Absolute Percentage Error (MAPE) expresses forecast errors as percentages of the actual observed values where the formula is:

$$MAPE = \frac{\sum_{i=1}^{n} \frac{\left| E_i - \hat{E}_i \right|}{E_i}}{n} x100$$

This metric is particularly useful for comparing forecast accuracy across different models, as it normalizes the errors relative to the scale of the observed values (Paul Goodwin & Richard Lawton, 1999). MAPE is highly effective in identifying how well the model performs under different demand conditions, such as peak and off-peak periods. A lower MAPE indicates that the model maintains consistent accuracy across diverse scenarios, providing a relative measure of performance that complements MAE.

2.4.3 RMSE

The Root Mean Square Error (RMSE) measures the square root of the average squared differences between the forecasted and observed values and it is computed as follow,

$$RMSE = \sqrt{\frac{\sum_{i=1}^{365}(E_i - \hat{E}_i)^2}{365}}$$

RMSE is particularly sensitive to large forecasting errors, making it a critical metric for assessing the impact of significant deviations. While MAE treats all errors equally, RMSE penalizes larger discrepancies more heavily, providing insights into the robustness of the model against extreme outliers (T. Chai, 2014). This sensitivity is crucial in electricity demand forecasting, where substantial errors during peak demand periods could lead to costly operational inefficiencies or grid instability.

Conclusively, MAE provides a simple average of errors while MAPE allows for percentage-based comparisons and RMSE offers insight into the model's handling of large deviations. Overall, these three metrics can offer a well-rounded forecasting evaluation of the models, capturing overall error magnitude (MAE), relative accuracy across varying scales (MAPE), and sensitivity to significant outliers (RMSE) leading to a comprehensive understanding of the predictive capabilities in short-term electricity demand forecasting for each model.

2.5 Incorporation of typical models in the analysis

While the previous chapters focused on the calibration and use of regression models for electricity demand, this chapter shifts attention to more traditional time-series models, Simple Moving Average (SMA) and Exponentially Weighted Moving Average (EWMA), which are widely used in forecasting due to their simplicity. The primary objective of this chapter is to assess the rate at which these typical models can predict electricity demand fluctuations over time. To achieve this, SMA and EWMA models with various configurations need to be applied to predict hourly electricity total load for 2023 across all time zones in order their performance be compared with the one of the regression models developed. In this way, through the analysis of the performance of these different models, it can be determined which forecasting approach offers greater reliability, precision, and adaptability under different demand conditions and time zones.

2.5.1 SMA Models

More specifically, the Simple Moving Average (SMA) models forecasts in general by calculating the unweighted average of past data points over a fixed time window while the size of this time window determine how quickly the model responds to changes in demand and is given by the following equation

$$\widehat{Y_t} = \frac{\sum_{i=1}^{q} Y_{t-i}}{q}$$

where $\widehat{Y_t}$ is the forecast about the data, Y_{t-i} is the observed data for each previous period and q is the window that determines which previous data are going to be included in the forecast (Volodymyr Lotysh, Larysa Gumeniuk, & Pavlo Humeniuk , 2023). The SMA models that is going to be used for the prediction of electricity demand are:

- $\text{SMA}(q = 2)$

Where the model uses the two past observations of electricity total load, making it a fast-moving model that reacts swiftly to recent changes but is prone to noise due to its limited averaging window.

- $\text{SMA}(q = 4)$

Where the model uses the four past observations of electricity total load, trying to balance responsiveness and stability by averaging over a slightly larger window, capturing short-term patterns more effectively.

- $\text{SMA}(q = 7)$

Where the model uses the seven past observations of electricity total load, creating a moderately slow-moving average that try to capture weekly electricity demand trends, reducing the influence of daily volatility.

- $\text{SMA}(q = 14)$

Where the model uses the fourteen past observations of electricity total load, creating a slow-moving model that try to focus in long-term demand trends but possibly will be sacrifice sensitivity to sudden changes.

2.5.2 EWMA models

The Exponentially Weighted Moving Average (EWMA) model is a more advanced time-series forecasting technique that applies exponentially decreasing weights to past observations given by the following equation

$$\widehat{Y}_t = (1-\lambda)Y_{t-1} + \lambda\widehat{Y}_{t-1}$$

where $\widehat{Y}_t$ is the forecast about the data, Y_{t-1} is the last observed data, $\widehat{Y}_{t-1}$is the last forecast about the data, and λ is the smoothing factor which actually controls how much weight is assigned to the most recent observations with smaller λ giving more weight to the most recent data and vice versa (Radek Hendrych & Tomas Cipra, 2019). The models that are going to be used in forecasting electricity demand are:

- $EWMA\ (\lambda = 0.1)$

Where model tend to have very fast adjustment and be highly reactive to the latest data points, but potentially unstable in the presence of noise or erratic fluctuations.

- $EWMA\ (\lambda = 0.3)$

Where the model has a fast adjustment to changes as it also assigns significant weight to recent observations, making the model responsive to short-term demand spikes but incorporating also weight to past data.

- $EWMA\ (\lambda = 0.6)$

Where the model, while it gives more weight to past observations, maintains a moderate responsiveness to fluctuations.

- $EWMA\ (\lambda = 0.9)$

Where the model gives strong emphasis on past data, making the model less responsive to recent changes but potentially better at capturing long-term demand trends.

2.5.3 Comparison of typical models and regression models forecasting accuracy

In the next stage, after the use of the models to make the forecasts, the evaluation of the results will be conducted using the three established metrics—Mean Absolute Error (MAE), Mean Absolute Percentage Error (MAPE), and Root Mean Square Error (RMSE)—that was described in the previous chapter. These metrics will allow to assess the predictive performance of SMA and EWMA models for each time zone, compare their results with those of the regression models developed in the previous chapter and possibly identify strengths and weaknesses of each model in different demand scenarios, including peak and off-peak periods.

3. Empirical analysis

3.1 Descriptive analysis

Starting the analysis of the demand data for the electricity in Greece we create a graph with the means of the hourly total loads for the period from 2015 to 2023.

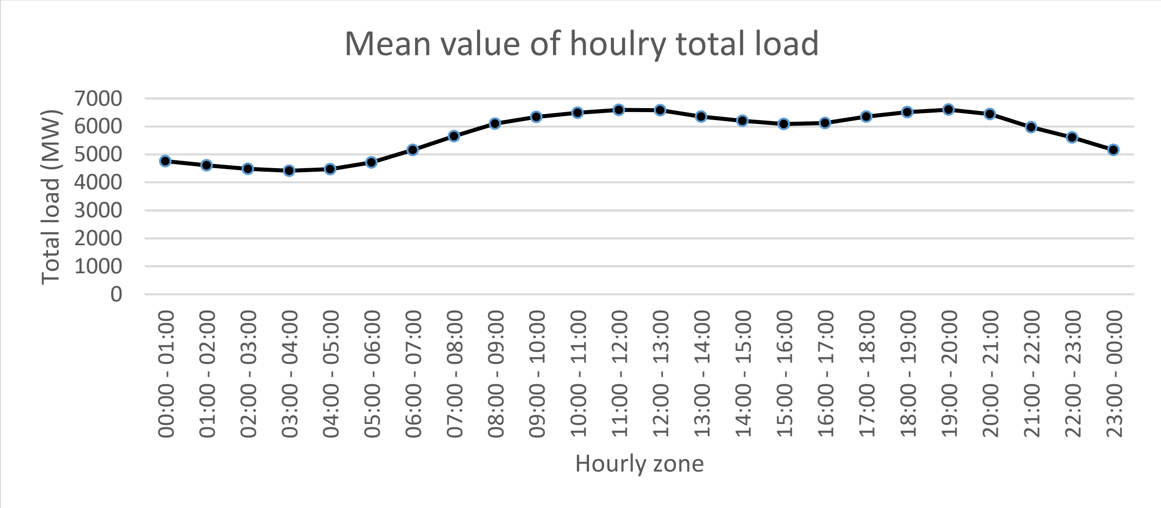

Figure 1: Mean value of houlry total load

The hourly total load curve of Figure 1 shows that the electricity demand reaches its lower levels at night from 02:00 to 05:00 while reaches its higher levels at midday from 10:00 -13:00 and at late afternoon from 18:00 to 21:00. At the night the lower level of the mean total load is observed in the 03:00-04:00 zone creating the base of the mean total load at the value of 4417 MW approximately. As concern the midday and afternoon peaks, the midday peak load is observed in the 11:00-12:00 zone with a mean value of 6590 MW approximately and the afternoon peak load is observed in the 19:00-20:00 zone with a mean value of 6598 MW.

As the analysis is continued, we create a boxplot graph for the hourly zones of the total load of electricity to analyze the dispersion of the data.

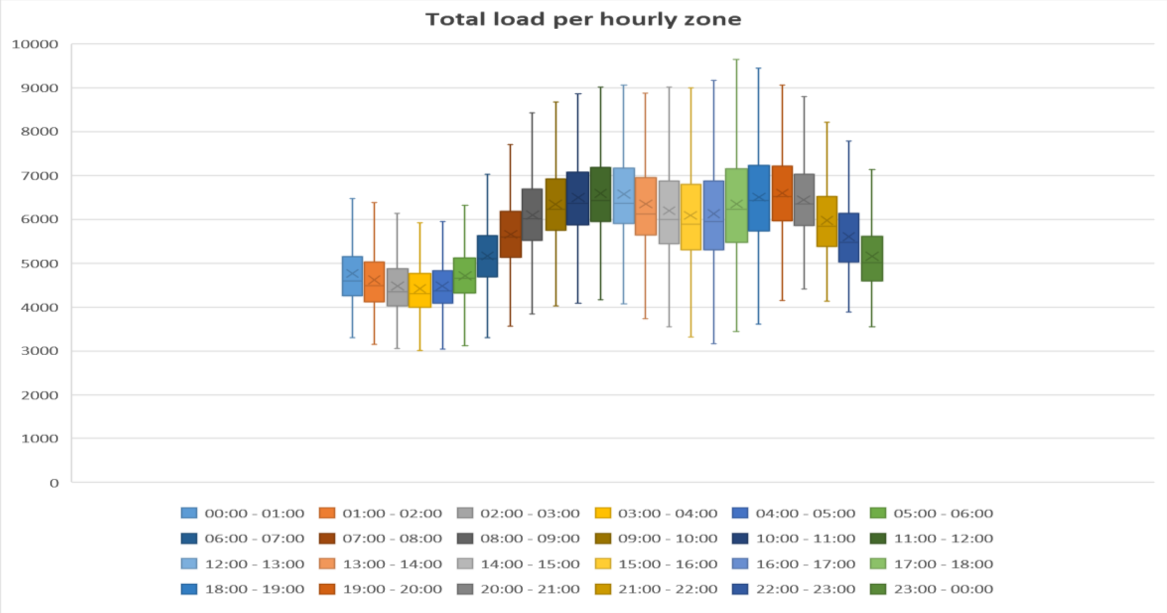

Figure 2: Total load per hourly zone

As it can be observed, while the boxplot graph verifies the findings of the Figure 1, it reveals that the electricity demand in Greece differ per hourly zone not only in the mean total load. The demand differs per time zone as concerns the way the data are distributed and concentrated. For example, it is revealed that at night not only that there are lower levels of electricity demand but also that the electricity total load is more concentrated with smaller range and interquartile range in comparison with other hourly zones with higher levels of electricity demand. Overall, the Figure 1 and Figure 2 reveal the different needs of electricity for different time zones implying that electricity demand has different behavior for different time zones.

3.1.1 Actual total load of electricity

Given the above, it is reasonable to continue the analysis separately for each time zone in order to examine the electricity demand's behavior and its driving properties. The time-plots from Figure 34 to Figure 57 in Appendix A refer to the actual total load of electricity in Greece from 2015 to 2023 for the twenty-four hourly time zones. These time-plots help to visualize the electricity total load for the time zones and make some first observations for the total load behavior over the years. As it can be observed, the electricity total load has a slightly downward trend over the years for the twenty-four hourly times zones. More over to that we can spot that for all the time zones in general there is a drop in electricity total load in the autumn and spring months while there is a peak in the total load in the winter and summer months. This prevails that there is seasonality in respect to month in electricity demand that must be taken into account.

3.1.2 Actual total load of electricity against the month of the year

A better understanding of the electricity demand seasonality offer the figures from Figure 58 to Figure 105 in the Appendix B. As we can observe from these figures, the level of the electricity total load differs among different months of the year which indicate that the electricity demand for the different time zones is clearly affected from monthly seasonality. More specifically, for all time periods, although there are spotted different levels of electricity total load and different range of observations for different time periods, the spring months April and May along with the autumn months October and November show a drop in electricity demand with the lowest level of electricity total load alongside with the lowest spread of values respectively for each time zone. At the same time the summer months July and August and the winter months January and February show the higher need of electricity for each time zone alongside with the greater differences between the observations of electricity total load.

It must be noted although the overall above seasonality, monthly impact in electricity demand appears to have different characteristics for each time zone. For example, at night hours from 00:00 to 06:00, while there is high electricity need in the winter months, there is clear peak in electricity demand in July and August with the higher level of electricity total load and alongside with the higher desperation of the observations. The same behavior is observed for the periods from 09:00 to 17:00 and 21:00 to 24:00. On contrast, for the time period from 17:00 to 20:00 the peak both in level and in dispersion of electricity demand appears to happen in winter months of January and February. At the same time, for the period from 06:00 to 09:00 the peaks of electricity demand in winter and summer are seem to be at the same level approximately. Overall, the above support the need to analyze the electricity demand separately for each time zone.

3.1.3 Actual total load of electricity against the day of the week

Another factor that must be taken account in the analysis of the electricity demand is the behavior of the demand against the day of the week. The figures from Figure 106 to

Figure 153 in Appendix C imply a connection between electricity total load and the day of the week with the fact of a day be a weekday or a weekend day impacting the electricity total load. Although that there is a clear impact of the day as a factor in electricity demand, the impact differs again between different time zones.

More specifically, for the time zones from 06:00 to 21:00 it is shown that the day impacts strongly the electricity demand. For this time period in weekdays, it cannot be observed clear and strong differences in the electricity total load level and dispersion although Monday's and Friday's total load are slightly lower. On the other hand, it is not the same case for the weekend days. As it can be observed a significant drop is caused in electricity total load in the weekends in regard to the weekdays with a drop in Saturday and a greater drop in Sunday. For the time zones between 21:00 and 24:00, while the same behavior it is appeared, this drop in electricity total load at weekends does not appear that important.

The controversial part appears in the time zones between 00:00 to 06:00 where the slight drop in the electricity total load does not appear to happen in the Saturday and Sunday but in Sunday and Monday. As it is observed in the night hours, the day as driving factor for electricity demand does not seem to variate the electricity total load likewise the other periods of the day. Not only there is not a lower level of electricity demand for Saturday but also the electricity total load in Sunday and Monday is closer to the level and spread of electricity total load of weekdays.

3.2 The significance of the findings from the descriptive analysis

Based on the regression analysis results for the 24 models, that are detailed extensively in Appendix D, Table **1** summarizes the p-values of the explanatory variables for each time zone while it highlights in bold the statistically insignificant variables that are identified by the p-values exceeding 0.05.

	Linear term	Quadradic term	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
00:00-01:00	0.005	<.001	<.001	0.023	<.001	<.001	<.001	**0.206**	<.001	<.001	0.002	<.001	<.001	<.001	0.020	<.001	<.001	<.001	<.001
01:00-02:00	0.003	<.001	<.001	<.001	<.001	<.001	<.001	**0.065**	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
02:00-03:00	0.002	<.001	<.001	<.001	0.001	<.001	<.001	**0.517**	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
03:00-04:00	0.002	<.001	<.001	<.001	<.001	<.001	<.001	**0.099**	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	**0.241**
04:00-05:00	<.001	<.001	<.001	<.001	0.004	<.001	<.001	**0.175**	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
05:00-06:00	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
06:00-07:00	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	**0.278**	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
07:00-08:00	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	**0.214**	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
08:00-09:00	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	0.008	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
09:00-10:00	<.001	<.001	<.001	0.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
10:00-11:00	<.001	<.001	<.001	0.007	<.001	<.001	<.001	**0.521**	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
11:00-12:00	<.001	<.001	<.001	0.022	<.001	<.001	<.001	**0.050**	<.001	<.001	**0.172**	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
12:00-13:00	<.001	<.001	<.001	**0.069**	<.001	<.001	<.001	<.001	<.001	<.001	**0.775**	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
13:00-14:00	<.001	<.001	<.001	**0.400**	<.001	<.001	<.001	<.001	<.001	<.001	**0.763**	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
14:00-15:00	<.001	<.001	<.001	**0.618**	<.001	<.001	<.001	0.002	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
15:00-16:00	<.001	<.001	<.001	0.003	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
16:00-17:00	<.001	<.001	**0.233**	<.001	<.001	<.001	<.001	<.001	<.001	**0.052**	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
17:00-18:00	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	0.003	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
18:00-19:00	<.001	<.001	<.001	**0.422**	<.001	<.001	<.001	<.001	**0.269**	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
19:00-20:00	<.001	<.001	<.001	**0.145**	<.001	<.001	<.001	<.001	0.037	**0.067**	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
20:00-21:00	<.001	<.001	<.001	**0.264**	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
21:00-22:00	0.049	<.001	<.001	**0.595**	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
22:00-23:00	<.001	<.001	<.001	**0.134**	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
23:00-24:00	0.013	<.001	<.001	**0.149**	<.001	<.001	<.001	**0.884**	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001

Table 1: P-value of explanatory variables for each time zone

As it can be concluded from the above table, the regression analysis of the hourly total load of electricity in Greece from 2015 to 2023 confirms the initial observations from the descriptive analysis, providing statistical evidence for the trend, monthly, and weekday seasonality effects on electricity demand across different time zones. For the majority of time zones, most independent variables—representing the linear and quadratic trends, monthly, and weekday dummy variables—are statistically significant at the 5% level, indicating their substantial impact on the electricity load. Notably, certain variables - June and February mainly, and a few others like January, July, August, September and Saturday - are found to be insignificant in specific time zones, suggesting that their influence on electricity demand is not uniform throughout the day. The findings from the regression models reinforce the initial descriptive analysis while at the same time, with the insignificance of some cases in the models, demonstrate that electricity demand in Greece is influenced by complex and varying factors across different time zones. This robust significance across different hours highlights the importance of considering these variables when modeling and forecasting electricity demand in Greece while the findings emphasize the necessity of segmenting the analysis by time zone and prompt a segmented analysis for the development of accurate estimation models.

3.3 Regression models for reproducing electricity demand

Incorporating the findings of the above chapters while adding the lagged time components, the 24 regressions models for each time zone through SPSS Statistics were runed while it was evaluated their ability to recreate the driving factors of electricity demand in Greece.

3.3.1 Regression model for time zone 00:00 – 01:00

The regression for this time zone containing all the statistically significant variables that is produced from the procedure is,

$$Ln(E_t) = c_0 + c_2 t^2 + \sum_{j=1}^{8} a_j M_{jt} + \sum_{i=1}^{5} b_i D_{it} + d_1 Ln(E_{t-1}) + e_t$$

where $Ln(E_t)$ is the natural logarithm of the hourly total load of electricity for each time zone, c_0 is the constant term , t^2 is a quadratic trend variable with c_2 the quadratic trend coefficient , M_{jt} , $j = 1,2 \ldots 8$ is a set of 8 monthly dummy variables for March, April, May, July, August, September, October and November with a_j, $j = 1,2 \ldots 8$ the monthly dummy variables coefficients, D_{it} , $i = 1,2 \ldots 5$ is a set of 5 weekday dummy variables from Tuesday to Saturday with b_i , $i = 1,2 \ldots 5$ the weekday dummy variables coefficients, $Ln(E_{t-1})$ is the natural logarithm of the one-day prior hourly total load of electricity, and e_t is the disturbance term. The coefficients of the regression are described in Table 2.

Coefficients[a]					
	Unstandardized Coefficients		Standardized Coefficients		
Model	B	Std. Error	Beta	t	Sig.

1	(Constant)	1.035	.071		14.517	<.001
	Quadradic term	-1.056E-9	.000	-.024	-4.574	<.001
	MAR	-.009	.003	-.018	-3.373	<.001
	APR	-.022	.003	-.042	-7.433	<.001
	MAY	-.018	.003	-.035	-6.047	<.001
	JUL	.028	.003	.056	8.915	<.001
	AUG	.012	.003	.024	3.944	<.001
	SEP	-.014	.003	-.027	-5.044	<.001
	OCT	-.022	.003	-.042	-7.182	<.001
	NOV	-.015	.003	-.028	-4.936	<.001
	TUESDAY	.074	.002	.182	31.796	<.001
	WEDNESDAY	.045	.002	.111	19.781	<.001
	THURSDAY	.038	.002	.093	16.594	<.001
	FRIDAY	.039	.002	.095	16.877	<.001
	SATURDAY	.044	.002	.108	19.247	<.001
	lagged log total load 1st grade	.875	.008	.875	104.510	<.001
a. Dependent Variable: log total load 00:00 - 01:00						

Table 2: Coefficient summary of log total load 00:00 - 01:00

From Model summary of Table 3, we get that the estimated regression model has $R^2 = 0.920$. That implies that about 92.00% of the variations in the log total load of demand electricity are explained by the explanatory variables that are included in the model. Because the R^2 is above 90.00% and close to one, it can be concluded that the estimated multiple regression model is a good fit.

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.959[a]	.920	.919	.040467520517504
a. Predictors: (Constant), lagged log total load 1st grade, WEDNESDAY, SEP, MAR, THURSDAY, Quadradic term, FRIDAY, NOV, APR, SATURDAY, AUG, MAY, TUESDAY, OCT, JUL				

Table 3: Model summary of log total load 00:00 - 01:00

Moreover, in order to compare the estimated total load of our model with the actual total load of electricity demand, we take the exponential of each value produced by the regression model and we create a time-plot that compares the actual total load for time zone 00:00-01:00 with the estimated total load produced by the regression model as shown in the Figure 3. As it can be observed, the model reproduces respectively good enough the actual total load for time zone 00:00-01:00 and recreates the dynamic properties of electricity demand as concerns monthly and weekly seasonality and trends.

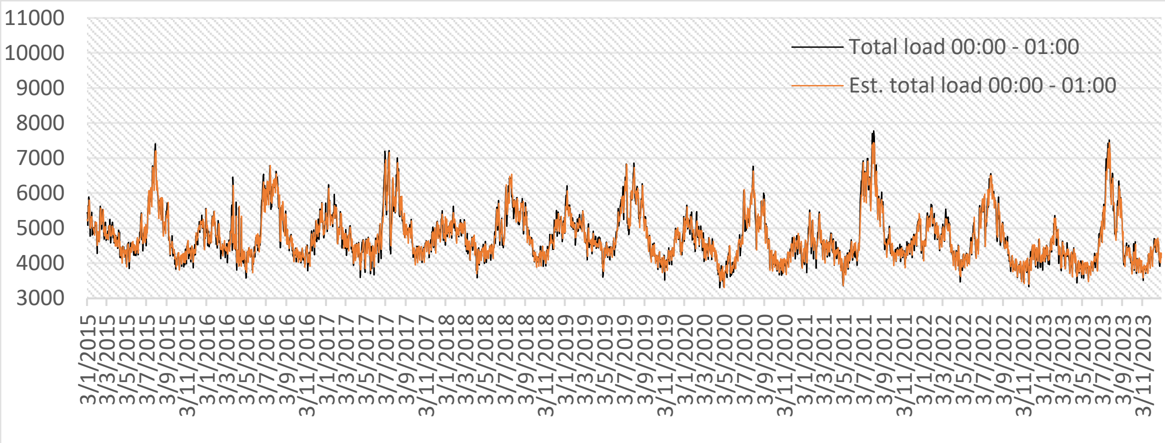

Figure 3: Time plot Total load vs Est. total load of 00:00-01:00

3.3.2 Regression model for time zone 01:00 – 02:00

The regression for this time zone containing all the statistically significant variables that is produced from the procedure is,

$$Ln(E_t) = c_0 + c_2 t^2 + \sum_{j=1}^{8} a_j M_{jt} + \sum_{i=1}^{6} b_i D_{it} + d_1 Ln(E_{t-1}) + e_t$$

where $Ln(E_t)$ is the natural logarithm of the hourly total load of electricity for each time zone, c_0 is the constant term , t^2 is a quadratic trend variable with c_2 the quadratic trend coefficient , M_{jt} , $j = 1,2 \ldots 8$ is a set of 8 monthly dummy variables for March, April, May, July, August, September, October and November with a_j, $j = 1,2 \ldots 8$ the monthly dummy variables coefficients, D_{it}, $i = 1,2 \ldots 6$ is a set of 6 weekday dummy variables from Monday to Saturday with b_i, $i = 1,2 \ldots 6$ the weekday dummy variables coefficients, $Ln(E_{t-1})$ is the natural logarithm of the one-day prior hourly total load of electricity and e_t is the disturbance term. The coefficients of the regression are described in the Table 4.

Coefficients[a]				
Model	Unstandardized Coefficients	Standardized Coefficients	t	Sig.

		B	Std. Error	Beta		
1	(Constant)	1.061	.072		14.670	<.001
	Quadradic term	-1.108E-9	.000	-.025	-4.702	<.001
	MAR	-.009	.003	-.019	-3.338	<.001
	APR	-.023	.003	-.045	-7.621	<.001
	MAY	-.021	.003	-.042	-6.807	<.001
	JUL	.026	.003	.052	8.295	<.001
	AUG	.010	.003	.019	3.235	.001
	SEP	-.016	.003	-.032	-5.677	<.001
	OCT	-.024	.003	-.048	-7.742	<.001
	NOV	-.015	.003	-.029	-4.893	<.001
	MONDAY	.010	.003	.024	3.606	<.001
	TUESDAY	.083	.003	.206	30.000	<.001
	WEDNESDAY	.048	.003	.120	17.906	<.001
	THURSDAY	.043	.003	.106	15.853	<.001
	FRIDAY	.044	.003	.110	16.399	<.001
	SATURDAY	.050	.003	.124	18.406	<.001
	lagged log total load 1st grade	.871	.008	.871	102.532	<.001
a. Dependent Variable: log total load 01:00 - 02:00						

Table 4: Coefficient summary of log total load 01:00 - 02:00

From Model summary of Table 5, we get that the estimated regression model has $R^2 = 0.914$. That implies that about 91.40% of the variations in the log total load of demand electricity are explained by the explanatory variables that are included in the model. Because the R^2 is above 90.00% and close to one, it can be concluded that the estimated multiple regression model is a good fit.

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.956[a]	.914	.914	.041263710920825
a. Predictors: (Constant), lagged log total load 1st grade, WEDNESDAY, MAR, SEP, THURSDAY, Quadradic term, NOV, FRIDAY, APR, MONDAY, AUG, OCT, SATURDAY, MAY, JUL, TUESDAY				

Table 5: Model summary of log total load 01:00 - 02:00

Following the same procedure of time zone 00:00-01:00, Figure 4 is created. As it can be observed, the model again reproduces respectively good enough the actual total load for time zone 01:00-02:00.

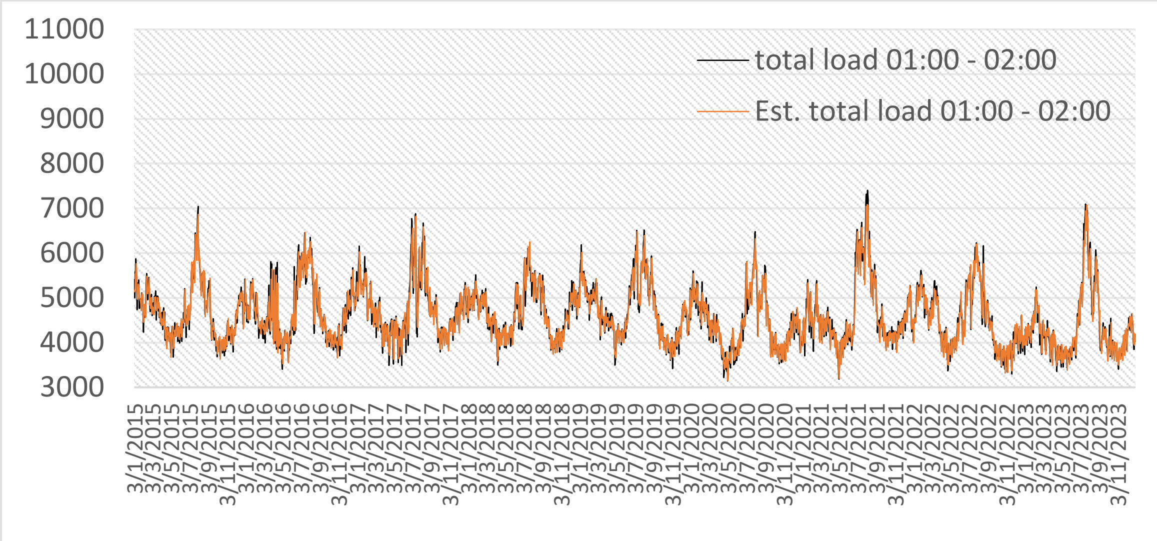

Figure 4: Time plot Total load vs Est. total load of 01:00-02:00

3.3.3 Regression model for time zone 02:00 – 03:00

The regression for this time zone containing all the statistically significant variables that is produced from the procedure is,

$$Ln(E_t) = c_0 + c_2 t^2 + \sum_{j=1}^{9} a_j M_{jt} + \sum_{i=1}^{6} b_i D_{it} + d_1 Ln(E_{t-1}) + e_t$$

where $Ln(E_t)$ is the natural logarithm of the hourly total load of electricity for each time zone, c_0 is the constant term, t^2 is a quadratic trend variable with c_2 the quadratic trend coefficient , M_{jt} , $j = 1,2 \dots 9$ is a set of 9 monthly dummy variables for January, March, April, May, July, August, September, October and November with a_j, $j = 1,2 \dots 9$ the monthly dummy variables coefficients, D_{it}, $i = 1,2 \dots 6$ is a set of 6 weekday dummy variables from Monday to Saturday with b_i, $i = 1,2 \dots 6$ the weekday dummy variables coefficients, $Ln(E_{t-1})$ is the natural logarithm of the one-day prior hourly total load of electricity and e_t is the disturbance term. The coefficients of the regression are described in the Table 6.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	T	Sig.
1	(Constant)	1.173	.076		15.479	<.001
	Quadradic term	-1.105E-9	.000	-.026	-4.596	<.001
	JAN	.007	.003	.015	2.483	.013
	MAR	-.008	.003	-.015	-2.545	.011
	APR	-.023	.003	-.045	-7.160	<.001
	MAY	-.020	.003	-.041	-6.234	<.001
	JUL	.030	.003	.062	8.953	<.001
	AUG	.014	.003	.028	4.264	<.001
	SEP	-.013	.003	-.027	-4.469	<.001
	OCT	-.023	.003	-.046	-7.111	<.001
	NOV	-.014	.003	-.028	-4.472	<.001
	MONDAY	.021	.003	.053	7.428	<.001
	TUESDAY	.089	.003	.227	31.398	<.001
	WEDNESDAY	.053	.003	.136	19.187	<.001
	THURSDAY	.046	.003	.119	16.788	<.001
	FRIDAY	.048	.003	.122	17.252	<.001
	SATURDAY	.050	.003	.129	18.177	<.001
	lagged log total load 1st grade	.856	.009	.856	95.605	<.001
a. Dependent Variable: log total load 02:00 - 03:00						

Table 6: Coefficient summary of log total load 02:00 - 03:00

From Model summary of Table 7, we get that the estimated regression model has $R^2 = 0.905$. That implies that about 90.50% of the variations in the log total load of demand electricity are explained by the explanatory variables that are included in the model. Because the R^2 is above 90.00% and close to one, it can be concluded that the estimated multiple regression model is a good fit.

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.951[a]	.905	.904	.042381559696578
a. Predictors: (Constant), lagged log total load 1st grade, WEDNESDAY, MAR, SEP, THURSDAY, Quadradic term, JAN, FRIDAY, NOV, APR, MONDAY, AUG, OCT, SATURDAY, MAY, JUL, TUESDAY				

Table 7: Model summary of log total load 02:00 - 03:00

Following the same procedure of time zone 00:00-01:00, we create Figure 5. As it can be observed, the model again reproduces respectively good enough the actual total load for time zone 02:00-03:00.

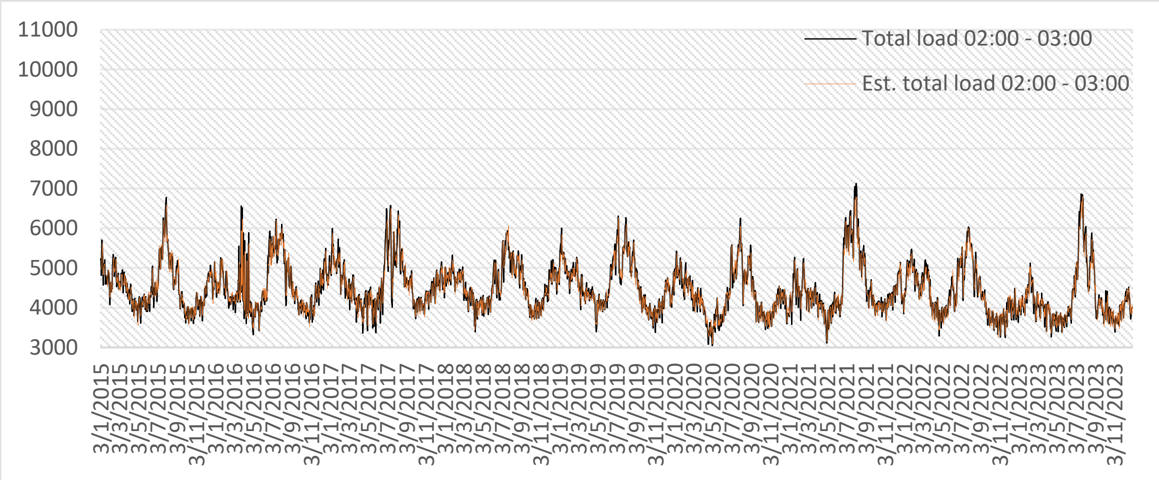

Figure 5: Time plot Total load vs Est. total load of 02:00-03:00

3.3.4 Regression model for time zone 03:00 – 04:00

The regression for this time zone containing all the statistically significant variables that is produced from the procedure is,

$$Ln(E_t) = c_0 + c_2 t^2 + \sum_{j=1}^{8} a_j M_{jt} + \sum_{i=1}^{5} b_i D_{it} + d_1 Ln(E_{t-1}) + d_2 Ln(E_{t-2}) + e_t$$

where $Ln(E_t)$ is the natural logarithm of the hourly total load of electricity for each time zone, c_0 is the constant term, t^2 is a quadratic trend variable with c_2 the quadratic trend coefficient, M_{jt}, $j = 1,2 \dots 8$ is a set of 8 monthly dummy variables for March, April, May, July, August, September, October and November with a_j, $j = 1,2 \dots 8$ the monthly dummy variables coefficients, D_{it}, $i = 1,2 \dots 5$ is a set of 5 weekday dummy variables for Monday, Tuesday, Wednesday, Thursday and Friday with b_i, $i = 1,2 \dots 5$ the weekday dummy variables coefficients, $Ln(E_{t-1})$ is the natural logarithm of the one-day prior hourly total load of electricity, $Ln(E_{t-2})$ is the natural logarithm of the two-day prior hourly total load of electricity and e_t is the disturbance term. The coefficients of the regression are described in the Table 8.

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	T	Sig.
1	(Constant)	1.279	.082		15.571	<.001
	Quadradic term	-1.162E-9	.000	-.028	-4.626	<.001
	MAR	-.012	.003	-.025	-3.911	<.001
	APR	-.026	.003	-.055	-8.163	<.001
	MAY	-.020	.003	-.043	-6.127	<.001
	JUL	.030	.003	.063	8.729	<.001
	AUG	.012	.003	.024	3.582	<.001
	SEP	-.017	.003	-.035	-5.549	<.001
	OCT	-.025	.003	-.053	-7.566	<.001
	NOV	-.015	.003	-.032	-4.827	<.001
	MONDAY	.074	.003	.195	28.789	<.001
	TUESDAY	.046	.003	.122	16.449	<.001
	WEDNESDAY	.037	.003	.099	14.487	<.001
	THURSDAY	.038	.003	.100	14.755	<.001
	FRIDAY	.030	.003	.080	11.820	<.001
	lagged log total load 1st grade	.749	.017	.750	43.708	<.001
	lagged log total load 2st grade	.095	.017	.095	5.506	<.001
a. Dependent Variable: log total load 03:00 - 04:00						

Table 8: Coefficient summary of log total load 03:00 - 04:00

From Model summary of Table 9, we get that the estimated regression model has $R^2 = 0.888$. That implies that about 88.80% of the variations in the log total load of demand electricity are explained by the explanatory variables that are included in the model. Because the R^2 is close to 90.00% and respectively close to one, it can be concluded that the estimated multiple regression model is an approximately good fit.

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.942[a]	.888	.888	.044225429316342
a. Predictors: (Constant), lagged log total load 2st grade, WEDNESDAY, SEP, MAR, THURSDAY, Quadradic term, NOV, FRIDAY, APR, MONDAY, AUG, OCT, TUESDAY, MAY, JUL, lagged log total load 1st grade				

Table 9: Model summary of log total load 03:00 - 04:00

Following the same procedure of time zone 00:00-01:00, we create Figure 6. As it can be observed, the model again reproduces respectively good enough the actual total load for time zone 03:00-04:00.

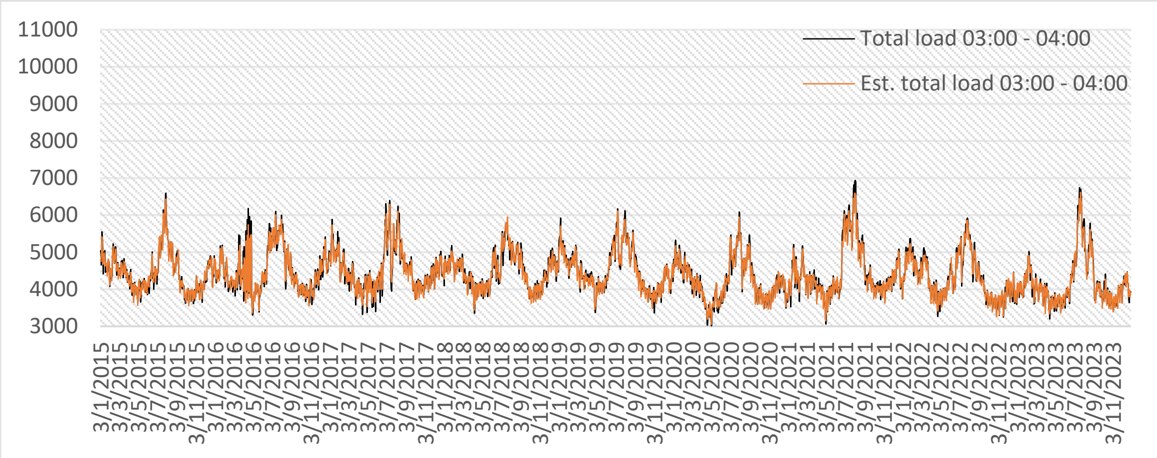

Figure 6: Time plot Total load vs Est. total load of 03:00-04:00

3.3.5 Regression model for time zone 04:00 – 05:00

The regression for this time zone containing all the statistically significant variables that is produced from the procedure is,

$$Ln(E_t) = c_0 + c_2 t^2 + \sum_{j=1}^{9} a_j M_{jt} + \sum_{i=1}^{6} b_i D_{it} + d_1 Ln(E_{t-1}) + d_2 Ln(E_{t-2}) + e_t$$

where $Ln(E_t)$ is the natural logarithm of the hourly total load of electricity for each time zone, c_0 is the constant term, t^2 is a quadratic trend variable with c_2 the quadratic trend coefficient, M_{jt}, $j = 1,2 \dots 9$ is a set of 9 monthly dummy variables for January, March, April, May, July, August, September, October and November with a_j, $j = 1,2 \dots 9$ the monthly dummy variables coefficients, D_{it}, $i = 1,2 \dots 6$ is a set of 6 weekday dummy variables from Monday to Saturday with b_i, $i = 1,2 \dots 6$ the weekday dummy variables coefficients, $Ln(E_{t-1})$ is the natural logarithm of the one-day prior hourly total load of electricity, $Ln(E_{t-2})$ is the natural logarithm of the two-day prior hourly total load of electricity and e_t is the disturbance term. The coefficients of the regression are described in the Table 10.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.191	.082		14.568	<.001
	Quadradic term	-9.643E-10	.000	-.025	-4.049	<.001
	JAN	.007	.003	.017	2.509	.012
	MAR	-.007	.003	-.015	-2.217	.027
	APR	-.021	.003	-.047	-6.787	<.001
	MAY	-.018	.003	-.041	-5.684	<.001
	JUL	.028	.003	.062	8.374	<.001
	AUG	.011	.003	.025	3.572	<.001
	SEP	-.012	.003	-.027	-4.152	<.001
	OCT	-.020	.003	-.044	-6.224	<.001
	NOV	-.012	.003	-.026	-3.835	<.001
	MONDAY	.062	.003	.173	21.710	<.001
	TUESDAY	.097	.003	.271	33.886	<.001
	WEDNESDAY	.070	.003	.195	23.601	<.001
	THURSDAY	.061	.003	.169	21.685	<.001
	FRIDAY	.060	.003	.167	21.566	<.001
	SATURDAY	.042	.003	.119	15.280	<.001
	lagged log total load 1st grade	.785	.017	.785	44.989	<.001
	lagged log total load 2st grade	.067	.017	.067	3.850	<.001
a. Dependent Variable: log total load 04:00 - 05:00						

Table 10: Coefficient summary of log total load 04:00 - 05:00

From Model summary of Table 11, we get that the estimated regression model has $R^2 = 0.887$. That implies that about 88.70% of the variations in the log total load of demand electricity are explained by the explanatory variables that are included in the model Because the R^2 is close to 90.00% and respectively close to one, it can be concluded that the estimated multiple regression model is an approximately good fit.

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.942[a]	.887	.886	.042250902621322

a. Predictors: (Constant), lagged log total load 2st grade, MAR, MONDAY, SEP, THURSDAY, Quadradic term, JAN, NOV, FRIDAY, APR, WEDNESDAY, AUG, OCT, SATURDAY, MAY, JUL, TUESDAY, lagged log total load 1st grade

Table 11: Model summary of log total load 04:00 - 05:00

Following the same procedure of time zone 00:00-01:00, we create Figure 7. As it can be observed, the model again reproduces respectively good enough the actual total load for time zone 04:00-05:00.

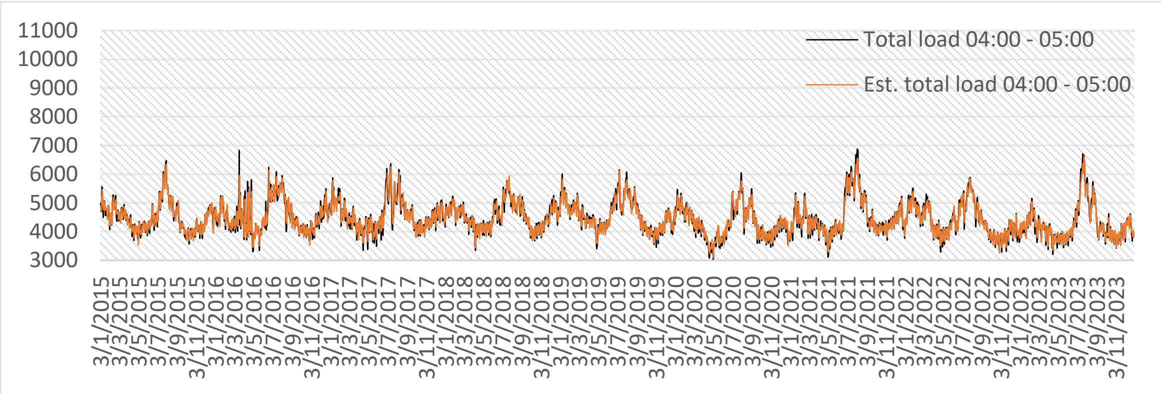

Figure 7: Time plot Total load vs Est. total load of 04:00-05:00

3.3.6 Regression model for time zone 05:00 – 06:00

The regression for this time zone containing all the statistically significant variables that is produced from the procedure is,

$$Ln(E_t) = c_0 + c_2t^2 + \sum_{j=1}^{7} a_jM_{jt} + \sum_{i=1}^{6} b_iD_{it} + d_1Ln(E_{t-1}) + d_2Ln(E_{t-2}) + e_t$$

where $Ln(E_t)$ is the natural logarithm of the hourly total load of electricity for each time zone, c_0 is the constant term, t^2 is a quadratic trend variable with c_2 the quadratic trend coefficient, $M_{jt}, j = 1,2 \dots 7$ is a set of 7 monthly dummy variables for January, April, May, July, September, October and November with $a_j, j = 1,2 \dots 7$ the monthly dummy variables coefficients, $D_{it}, i = 1,2 \dots 6$ is a set of 6 weekday dummy variables from Monday to Saturday with $b_i, i = 1,2 \dots 6$ the weekday dummy variables coefficients, $Ln(E_{t-1})$ is the natural logarithm of the one-day prior hourly total load of electricity, $Ln(E_{t-2})$ is the natural logarithm of the two-day prior hourly total load of electricity and e_t is the disturbance term. The coefficients of the regression are described in the Table 12.

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.220	.084		14.593	<.001
	Quadradic term	-8.050E-10	.000	-.021	-3.115	.002
	JAN	.011	.003	.025	3.621	<.001
	APR	-.024	.003	-.052	-7.107	<.001
	MAY	-.024	.004	-.053	-6.721	<.001
	JUL	.021	.003	.046	6.454	<.001
	SEP	-.012	.003	-.027	-3.898	<.001
	OCT	-.018	.003	-.040	-5.464	<.001
	NOV	-.008	.003	-.018	-2.548	.011
	MONDAY	.138	.003	.388	44.420	<.001
	TUESDAY	.129	.004	.362	33.663	<.001
	WEDNESDAY	.097	.003	.271	28.032	<.001
	THURSDAY	.090	.003	.252	27.809	<.001
	FRIDAY	.083	.003	.234	25.937	<.001
	SATURDAY	.029	.003	.082	9.200	<.001
	lagged log total load 1st grade	.733	.017	.732	42.164	<.001
	lagged log total load 2st grade	.114	.017	.114	6.642	<.001
a. Dependent Variable: log total load 05:00 - 06:00						

Table 12: Coefficient summary of log total load 05:00 - 06:00

From Model summary of Table 13, we get that the estimated regression model has $R^2 = 0.861$. That implies that about 86.10% of the variations in the log total load of demand electricity are explained by the explanatory variables that are included in the model. Because the R^2 is close to 90.00% and respectively close to one, it can be concluded that the estimated multiple regression model is an approximately good fit.

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.928[a]	.861	.860	.046625398760220

a. Predictors: (Constant), lagged log total load 2st grade, SEP, WEDNESDAY, Quadradic term, NOV, THURSDAY, JAN, APR, MONDAY, OCT, FRIDAY, JUL, SATURDAY, MAY, TUESDAY, lagged log total load 1st grade

Table 13: Model summary of log total load 05:00 - 06:00

Following the same procedure of time zone 00:00-01:00, we create Figure 8. As it can be observed, the model again reproduces respectively good enough the actual total load for time zone 05:00-06:00.

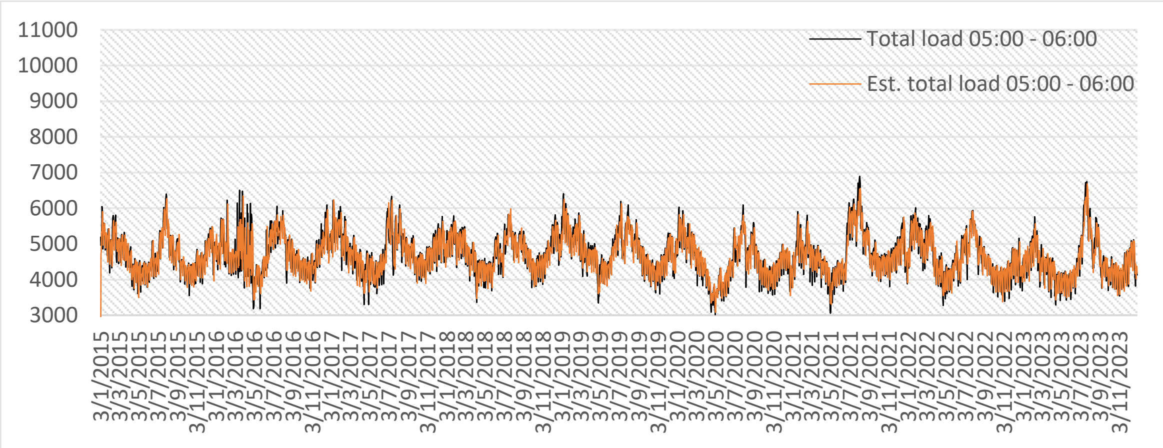

Figure 8: Time plot Total load vs Est. total load of 05:00-06:00

3.3.7 Regression model for time zone 06:00 – 07:00

The regression for this time zone containing all the statistically significant variables that is produced from the procedure is,

$$Ln(E_t) = c_0 + c_2 t^2 + \sum_{j=1}^{8} a_j M_{jt} + \sum_{i=1}^{6} b_i D_{it} + d_1 Ln(E_{t-1}) + d_2 Ln(E_{t-2}) + e_t$$

where $Ln(E_t)$ is the natural logarithm of the hourly total load of electricity for each time zone, c_0 is the constant term, t^2 is a quadratic trend variable with c_2 the quadratic trend coefficient, M_{jt}, $j = 1,2 \dots 8$ is a set of 8 monthly dummy variables from January, April, May, June, July, September, October and November with a_j, $j = 1,2 \dots 8$ the monthly dummy variables coefficients, D_{it}, $i = 1,2 \dots 6$ is a set of 6 weekday dummy variables from Monday to Saturday with b_i, $i = 1,2 \dots 6$ the weekday dummy variables coefficients, $Ln(E_{t-1})$ is the natural logarithm of the one-day prior hourly total load of electricity, $Ln(E_{t-2})$ is the natural logarithm of the two-day prior hourly total load of electricity and e_t is the disturbance term. The coefficients of the regression are described in the Table 14.

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.491	.095		15.691	<.001
	Quadradic term	-1.044E-9	.000	-.024	-3.565	<.001
	JAN	.016	.004	.031	4.479	<.001
	APR	-.031	.004	-.060	-7.853	<.001
	MAY	-.029	.004	-.057	-7.067	<.001
	JUN	-.008	.004	-.015	-2.086	.037
	JUL	.020	.004	.038	5.433	<.001
	SEP	-.019	.004	-.037	-5.177	<.001
	OCT	-.024	.004	-.047	-6.168	<.001
	NOV	-.011	.004	-.021	-2.961	.003
	MONDAY	.242	.004	.596	66.816	<.001
	TUESDAY	.168	.006	.412	29.226	<.001
	WEDNESDAY	.133	.004	.326	31.293	<.001
	THURSDAY	.128	.004	.315	32.155	<.001
	FRIDAY	.118	.004	.289	29.599	<.001
	SATURDAY	.013	.004	.033	3.409	<.001
	lagged log total load 1st grade	.734	.017	.734	42.047	<.001
	lagged log total load 2st grade	.079	.017	.079	4.562	<.001
a. Dependent Variable: log total load 06:00 - 07:00						

Table 14: Coefficient summary of log total load 06:00 - 07:00

From Model summary of Table 15, we get that the estimated regression model has $R^2 = 0.864$. That implies that about 86.40% of the variations in the log total load of demand electricity are explained by the explanatory variables that are included in the model. Because the R^2 is close to 90.00% and respectively close to one, it can be concluded that the estimated multiple regression model is an approximately good fit.

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate

1	.929[a]	.864	.863	.052714395733345
a. Predictors: (Constant), lagged log total load 2st grade, WEDNESDAY, JUN, SEP, Quadradic term, NOV, THURSDAY, JAN, APR, MONDAY, JUL, OCT, FRIDAY, SATURDAY, MAY, TUESDAY, lagged log total load 1st grade				

Table 15: Model summary of log total load 06:00 - 07:00

Following the same procedure of time zone 00:00-01:00, we create Figure 9. As it can be observed, the model again reproduces respectively good enough the actual total load for time zone 06:00-07:00.

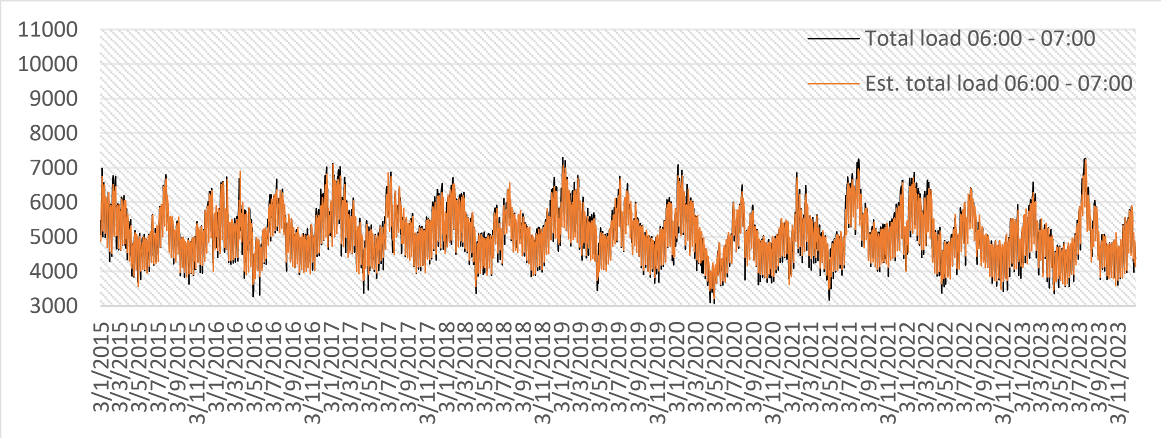

Figure 9: Time plot Total load vs Est. total load of 06:00-07:00

3.3.8 Regression model for time zone 07:00 – 08:00

The regression for this time zone containing all the statistically significant variables that is produced from the procedure is,

$$Ln(E_t) = c_0 + \ c_2 t^2 + \sum_{j=1}^{8} a_j M_{jt} + \sum_{i=1}^{6} b_i D_{it} + d_1 Ln(E_{t-1}) + d_2 Ln(E_{t-2}) + \ e_t$$

where $Ln(E_t)$ is the natural logarithm of the hourly total load of electricity for each time zone, c_0 is the constant term, t^2 is a quadratic trend variable with c_2 the quadratic trend coefficient, $M_{jt},\ \ j = 1,2 \ldots 8$ is a set of 8 monthly dummy variables for January, March, April, May, July, September, October and November with $a_j,\ j = 1,2 \ldots 8$ the monthly dummy variables coefficients, $D_{it},\ i = 1,2 \ldots 6$ is a set of 6 weekday dummy variables from Monday to Saturday with $b_i, i = 1,2 \ldots 6$ the weekday dummy variables coefficients, $Ln(E_{t-1})$ is the natural logarithm of the one-day prior hourly total load of electricity,

$Ln(E_{t-2})$ is the natural logarithm of the two-day prior hourly total load of electricity and e_t is the disturbance term. The coefficients of the regression are described in the Table 16.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.496	.095		15.671	<.001
	Quadradic term	-1.082E-9	.000	-.024	-3.619	<.001
	JAN	.014	.004	.027	3.832	<.001
	MAR	-.008	.004	-.016	-2.322	.020
	APR	-.032	.004	-.060	-7.942	<.001
	MAY	-.027	.004	-.051	-6.546	<.001
	JUL	.022	.004	.042	5.868	<.001
	SEP	-.019	.004	-.035	-4.966	<.001
	OCT	-.026	.004	-.049	-6.523	<.001
	NOV	-.014	.004	-.026	-3.579	<.001
	MONDAY	.283	.004	.678	76.127	<.001
	TUESDAY	.194	.006	.464	31.854	<.001
	WEDNESDAY	.157	.004	.377	37.064	<.001
	THURSDAY	.146	.004	.351	36.106	<.001
	FRIDAY	.137	.004	.330	34.504	<.001
	SATURDAY	.036	.004	.087	9.294	<.001
	lagged log total load 1st grade	.706	.017	.706	40.580	<.001
	lagged log total load 2st grade	.106	.017	.106	6.152	<.001

a. Dependent Variable: log total load 07:00 - 08:00

Table 16: Coefficient summary of log total load 07:00 - 08:00

From Model summary of Table 17, we get that the estimated regression model has $R^2 = 0.865$. That implies that about 86.50% of the variations in the log total load of demand electricity are explained by the explanatory variables that are included in the model. Because the R^2 is close to 90.00% and respectively close to one, it can be concluded that the estimated multiple regression model is an approximately good fit.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.930[a]	.865	.864	.053794018358900

a. Predictors: (Constant), lagged log total load 2st grade, MAR, WEDNESDAY, SEP, Quadradic term, NOV, THURSDAY, JAN, MONDAY, APR, OCT, JUL, SATURDAY, MAY, FRIDAY, TUESDAY, lagged log total load 1st grade

Table 17: Model summary of log total load 07:00 - 08:00

Following the same procedure of time zone 00:00-01:00, we create Figure 10. As it can be observed, the model again reproduces respectively good enough the actual total load for time zone 07:00-08:00.

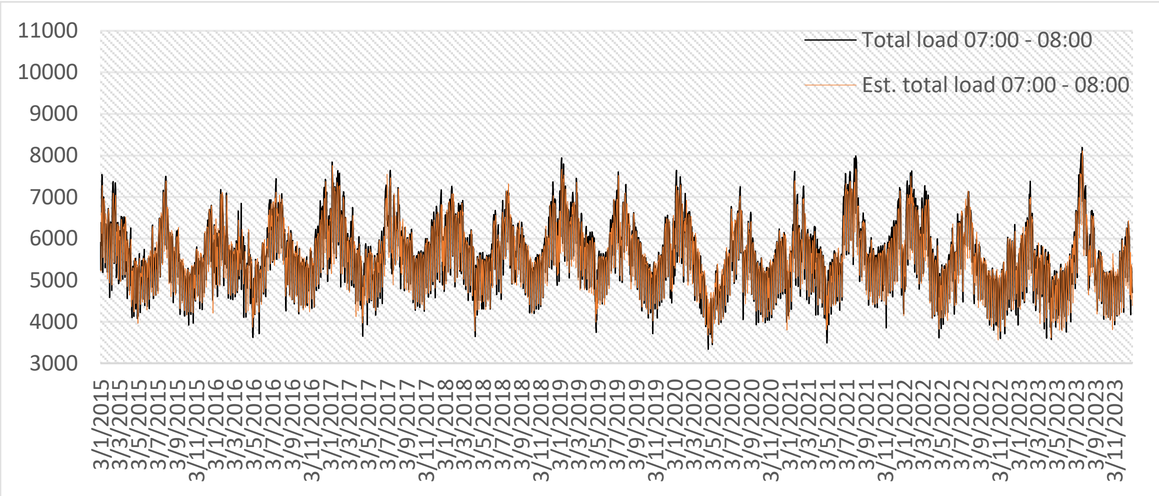

Figure 10: Time plot Total load vs Est. total load of 07:00-08:00

3.3.9 Regression model for time zone 08:00 – 09:00

The regression for this time zone containing all the statistically significant variables that is produced from the procedure is,

$$Ln(E_t) = c_0 + c_1 t + c_2 t^2 + \sum_{j=1}^{8} a_j M_{jt} + \sum_{i=1}^{6} b_i D_{it} + d_1 Ln(E_{t-1}) + d_2 Ln(E_{t-2}) + e_t$$

where $Ln(E_t)$ is the natural logarithm of the hourly total load of electricity for each time zone, c_0 is the constant term, t is a linear time-trend variable with c_1 the linear-trend coefficient, t^2 is a quadratic trend variable with c_2 the quadratic trend coefficient, M_{jt} , $j = 1,2 \dots 8$ is a set of 8 monthly dummy variables from January, March, April, May, July, September, October and November with a_j, $j = 1,2 \dots 8$ the monthly dummy variables coefficients, D_{it}, $i = 1,2 \dots 6$ is a set of 6 weekday dummy variables from Monday to Saturday with b_i, $i = 1,2 \dots 6$ the weekday dummy variables coefficients, $Ln(E_{t-1})$ is the natural logarithm of the one-day prior hourly total load of electricity, $Ln(E_{t-1})$ is the natural logarithm of the two-day prior hourly total load of electricity and e_t is the disturbance term. The coefficients of the regression are described in the Table 18.

Coefficientsa						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.552	.098		15.895	<.001
	linear term	8.066E-6	.000	.052	1.984	.047
	Quadradic term	-3.436E-9	.000	-.076	-2.851	.004
	JAN	.015	.004	.028	3.886	<.001
	MAR	-.012	.004	-.023	-3.307	<.001
	APR	-.035	.004	-.065	-8.384	<.001
	MAY	-.027	.004	-.052	-6.612	<.001
	JUL	.023	.004	.044	6.023	<.001
	SEP	-.019	.004	-.035	-4.923	<.001
	OCT	-.029	.004	-.055	-7.090	<.001
	NOV	-.017	.004	-.033	-4.386	<.001
	MONDAY	.269	.004	.645	71.472	<.001
	TUESDAY	.186	.006	.447	32.368	<.001
	WEDNESDAY	.151	.004	.362	36.648	<.001
	THURSDAY	.140	.004	.336	35.284	<.001
	FRIDAY	.129	.004	.309	32.977	<.001
	SATURDAY	.047	.004	.113	12.267	<.001
	lagged log total load 1st grade	.700	.017	.699	40.213	<.001
	lagged log total load 2st grade	.108	.017	.108	6.254	<.001
a. Dependent Variable: log total load 08:00 - 09:00						

Table 18: Coefficient summary of log total load 08:00 - 09:00

From Model summary of Table 19, we get that the estimated regression model has $R^2 = 0.860$. That implies that about 86.00% of the variations in the log total load of demand electricity are explained by the explanatory variables that are included in the model. Because the R^2 is close to 90.00% and respectively close to one, it can be concluded that the estimated multiple regression model is an approximately good fit.

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.927[a]	.860	.859	.054773293364494
a. Predictors: (Constant), lagged log total load 2st grade, MAR, WEDNESDAY, SEP, linear term, NOV, MONDAY, JAN, THURSDAY, APR, OCT, SATURDAY, JUL, MAY, FRIDAY, TUESDAY, lagged log total load 1st grade, Quadradic term				

Table 19: Model summary of log total load 08:00 - 09:00

Following the same procedure of time zone 00:00-01:00, we create Figure 11. As it can be observed, the model again reproduces respectively good enough the actual total load for time zone 08:00-09:00.

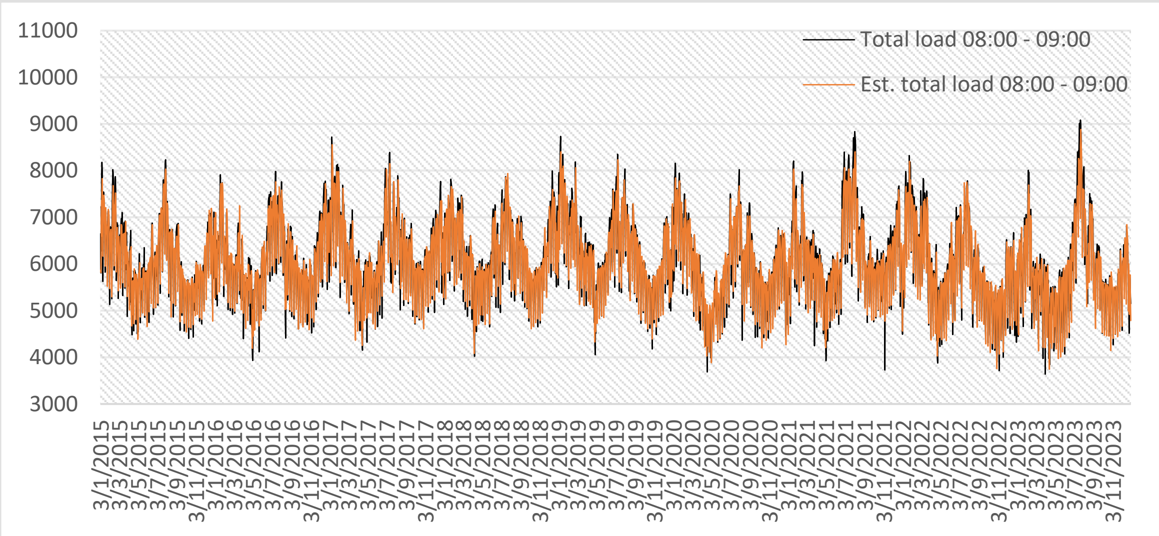

Figure 11: Time plot Total load vs Est. total load of 08:00-09:00

3.3.10 Regression model for time zone 09:00 – 10:00

The regression for this time zone containing all the statistically significant variables that is produced from the procedure is,

$$Ln(E_t) = c_0 + c_1 t + c_2 t^2 + \sum_{j=1}^{8} a_j M_{jt} + \sum_{i=1}^{6} b_i D_{it} + d_1 Ln(E_{t-1}) + d_2 Ln(E_{t-2}) + e_t$$

where $Ln(E_t)$ is the natural logarithm of the hourly total load of electricity for each time zone, c_0 is the constant term, t is a linear time-trend variable with c_1 the linear-trend coefficient, t^2 is a quadratic trend variable with c_2 the quadratic trend coefficient, M_{jt}, $j = 1,2 \dots 8$ is a set of 8 monthly dummy variables from January, March, April, May, July, September, October and November with a_j, $j = 1,2 \dots 8$ the monthly dummy variables coefficients, D_{it}, $i = 1,2 \dots 6$ is a set of 6 weekday dummy variables from Monday to Saturday with b_i, $i = 1,2 \dots 6$ the weekday dummy variables coefficients, $Ln(E_{t-1})$ is the natural logarithm of the one-day prior hourly total load of electricity, $Ln(E_{t-2})$ is the natural logarithm of the two-day prior hourly total load of electricity and e_t is the disturbance term. The coefficients of the regression are described in the Table 20.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.610	.098		16.415	<.001
	linear term	9.662E-6	.000	.065	2.351	.019
	Quadradic term	-3.839E-9	.000	-.087	-3.151	.002
	JAN	.013	.004	.025	3.425	<.001
	MAR	-.016	.004	-.031	-4.142	<.001
	APR	-.036	.004	-.070	-8.657	<.001
	MAY	-.028	.004	-.054	-6.619	<.001
	JUL	.025	.004	.049	6.387	<.001
	SEP	-.018	.004	-.034	-4.591	<.001
	OCT	-.031	.004	-.060	-7.459	<.001
	NOV	-.021	.004	-.040	-5.113	<.001
	MONDAY	.212	.004	.524	57.008	<.001
	TUESDAY	.147	.005	.362	28.929	<.001
	WEDNESDAY	.118	.004	.292	29.698	<.001
	THURSDAY	.109	.004	.269	28.237	<.001
	FRIDAY	.094	.004	.232	24.559	<.001
	SATURDAY	.035	.004	.087	9.347	<.001
	lagged log total load 1st grade	.718	.017	.718	41.175	<.001
	lagged log total load 2st grade	.087	.017	.087	5.035	<.001

a. Dependent Variable: log total load 09:00 - 10:00

Table 20: Coefficient summary of log total load 09:00 - 10:00

From Model summary of Table 21, we get that the estimated regression model has $R^2 = 0.849$. That implies that about 84.90% of the variations in the log total load of demand electricity are explained by the explanatory variables that are included in the model. Because the R^2 is close to 90.00% and respectively close to one, it can be concluded that the estimated multiple regression model is an approximately good fit.

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.921[a]	.849	.848	.055258520460413
a. Predictors: (Constant), lagged log total load 2st grade , SEP, WEDNESDAY, MAR, linear term , MONDAY, NOV, JAN , THURSDAY, OCT, SATURDAY, APR, JUL, MAY, FRIDAY, TUESDAY, lagged log total load 1st grade , Quadradic term				

Table 21: Model summary of log total load 09:00 - 10:00

Following the same procedure of time zone 00:00-01:00, we create Figure 12 As it can be observed, the model again reproduces respectively good enough the actual total load for time zone 09:00-10:00.

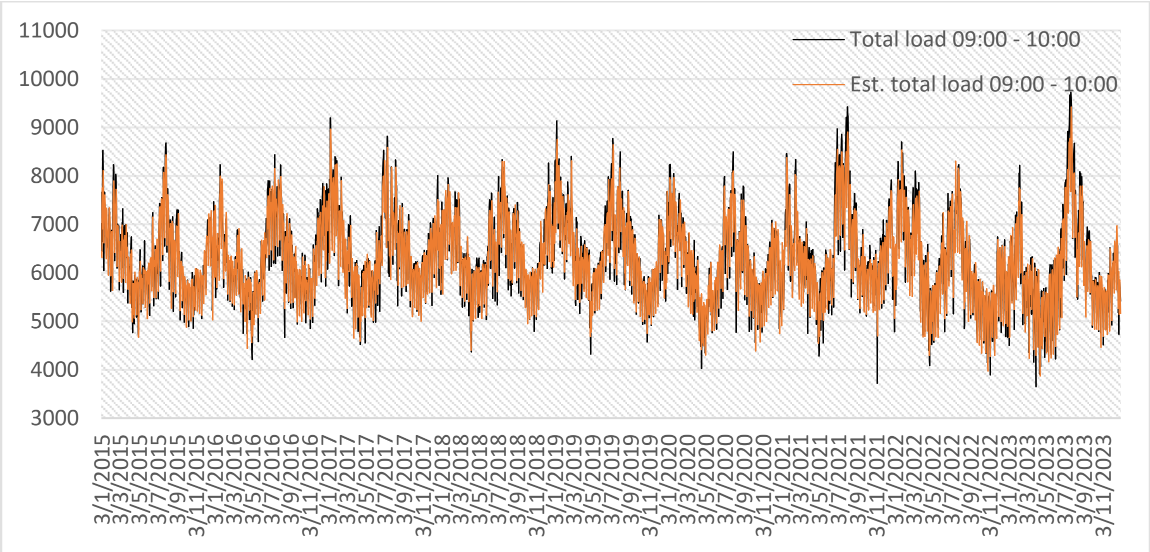

Figure 12: Time plot Total load vs Est. total load of 09:00-10:00

3.3.11 Regression model for time zone 10:00 – 11:00

The regression for this time zone containing all the statistically significant variables that is produced from the procedure is,

$$Ln(E_t) = c_0 + c_1 t + c_2 t^2 + \sum_{j=1}^{9} a_j M_{jt} + \sum_{i=1}^{6} b_i D_{it} + d_1 Ln(E_{t-1}) + d_2 Ln(E_{t-2}) + e_t$$

where $Ln(E_t)$ is the natural logarithm of the hourly total load of electricity for each time zone, c_0 is the constant term, t is a linear time-trend variable with c_1 the linear-trend coefficient, t^2 is a quadratic trend variable with c_2 the quadratic trend coefficient, M_{jt}, $j = 1,2 \dots 9$ is a set of 9 monthly dummy variables from January, March, April, May, July, August, September, October and November with a_j, $j = 1,2 \dots 9$ the monthly dummy variables coefficients, D_{it}, $i = 1,2 \dots 6$ is a set of 6 weekday dummy variables from Monday to Saturday with b_i, $i = 1,2 \dots 6$ the weekday dummy variables coefficients, $Ln(E_{t-1})$ is the natural logarithm of the one-day prior hourly total load of electricity, $Ln(E_{t-2})$is the natural logarithm of the two-day prior hourly total load of electricity and e_t is the disturbance term. The coefficients of the regression are described in the Table 22.

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.726	.102		16.975	<.001
	linear term	1.048E-5	.000	.071	2.455	.014
	Quadradic term	-4.206E-9	.000	-.096	-3.322	<.001
	JAN	.013	.004	.027	3.294	<.001
	MAR	-.016	.004	-.032	-4.005	<.001
	APR	-.036	.004	-.071	-8.210	<.001
	MAY	-.026	.004	-.051	-5.990	<.001
	JUL	.031	.004	.062	7.220	<.001
	AUG	.009	.004	.019	2.318	.021
	SEP	-.014	.004	-.028	-3.480	<.001
	OCT	-.030	.004	-.059	-6.937	<.001
	NOV	-.021	.004	-.042	-5.017	<.001
	MONDAY	.161	.004	.400	42.149	<.001
	TUESDAY	.116	.005	.288	24.929	<.001
	WEDNESDAY	.089	.004	.221	22.105	<.001

	THURSDAY	.086	.004	.214	21.986	<.001
	FRIDAY	.061	.004	.152	15.607	<.001
	SATURDAY	.023	.004	.057	6.032	<.001
	lagged log total load 1st grade	.719	.017	.719	41.207	<.001
	lagged log total load 2st grade	.076	.017	.076	4.342	<.001
a. Dependent Variable: log total load 10:00 - 11:00						

Table 22: Coefficient summary of log total load 10:00 - 11:00

From Model summary of Table 23, we get that the estimated regression model has $R^2 = 0.834$. That implies that about 83.40% of the variations in the log total load of demand electricity are explained by the explanatory variables that are included in the model. Because the R^2 is close to 90.00% and respectively close to one, it can be concluded that the estimated multiple regression model is an approximately good fit.

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.913[a]	.834	.833	.057375187128963
a. Predictors: (Constant), lagged log total load 2st grade, SEP, WEDNESDAY, MAR, linear term, MONDAY, JAN, NOV, THURSDAY, AUG, OCT, FRIDAY, APR, SATURDAY, JUL, MAY, TUESDAY, lagged log total load 1st grade, Quadradic term				

Table 23: Model summary of log total load 10:00 - 11:00

Following the same procedure of time zone 00:00-01:00, we create Figure 13. As it can be observed, the model again reproduces respectively good enough the actual total load for time zone 10:00-11:00.

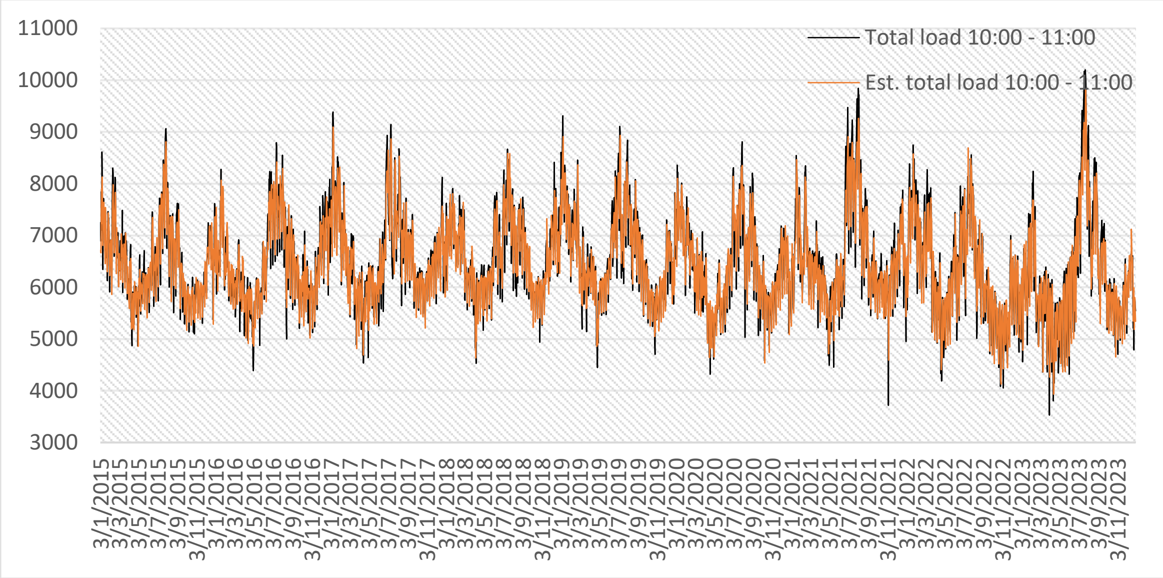

Figure 13: Time plot Total load vs Est. total load of 10:00-11:00

3.3.12 Regression model for time zone 11:00 – 12:00

The regression for this time zone containing all the statistically significant variables that is produced from the procedure is,

$$Ln(E_t) = c_0 + c_1 t + c_2 t^2 + \sum_{j=1}^{8} a_j M_{jt} + \sum_{i=1}^{6} b_i D_{it} + d_1 Ln(E_{t-1}) + d_2 Ln(E_{t-2}) + e_t$$

where $Ln(E_t)$ is the natural logarithm of the hourly total load of electricity for each time zone, c_0 is the constant term, t is a linear time-trend variable with c_1 the linear-trend coefficient, t^2 is a quadratic trend variable with c_2 the quadratic trend coefficient, M_{jt}, $j = 1,2 \dots 8$ is a set of 8 monthly dummy variables for January, March, April, May, July, August, October and November with a_j, $j = 1,2 \dots 8$ the monthly dummy variables coefficients, D_{it}, $i = 1,2 \dots 6$ is a set of 6 weekday dummy variables from Monday to Saturday with b_i, $i = 1,2 \dots 6$ the weekday dummy variables coefficients, $Ln(E_{t-1})$ is the natural logarithm of the one-day prior hourly total load of electricity, $Ln(E_{t-2})$ is the natural logarithm of the two-day prior hourly total load of electricity and e_t is the disturbance term. The coefficients of the regression are described in the Table 24.

Coefficients[a]					
	Unstandardized Coefficients		Standardized Coefficients		
Model	B	Std. Error	Beta	t	Sig.

1	(Constant)	1.753	.103		17.074	<.001
	linear term	1.039E-5	.000	.069	2.349	.019
	Quadradic term	-4.195E-9	.000	-.094	-3.199	.001
	JAN	.015	.004	.029	3.701	<.001
	MAR	-.014	.004	-.028	-3.519	<.001
	APR	-.033	.004	-.064	-7.569	<.001
	MAY	-.022	.004	-.042	-5.086	<.001
	JUL	.039	.004	.075	8.688	<.001
	AUG	.017	.004	.033	4.069	<.001
	OCT	-.027	.004	-.052	-6.267	<.001
	NOV	-.019	.004	-.036	-4.459	<.001
	MONDAY	.146	.004	.356	36.992	<.001
	TUESDAY	.106	.005	.258	23.209	<.001
	WEDNESDAY	.076	.004	.187	18.753	<.001
	THURSDAY	.082	.004	.199	20.495	<.001
	FRIDAY	.051	.004	.123	12.639	<.001
	SATURDAY	.027	.004	.065	6.792	<.001
	lagged log total load 1st grade	.726	.017	.726	41.549	<.001
	lagged log total load 2st grade	.067	.017	.067	3.823	<.001
a. Dependent Variable: log total load 11:00 - 12:00						

Table 24: Coefficient summary of log total load 11:00 - 12:00

From Model summary of Table 25, we get that the estimated regression model has $R^2 = 0.829$. That implies that about 82.90% of the variations in the log total load of demand electricity are explained by the explanatory variables that are included in the model. Because the R^2 is close to 90.00% and respectively close to one, it can be concluded that the estimated multiple regression model is an approximately good fit.

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.910[a]	.829	.828	.059511993807944
a. Predictors: (Constant), lagged log total load 2st grade, WEDNESDAY, MAR, linear term, MONDAY, JAN, NOV, FRIDAY, OCT, AUG, THURSDAY, MAY, APR, SATURDAY, JUL, TUESDAY, lagged log total load 1st grade, Quadradic term				

Table 25: Model summary of log total load 11:00 - 12:00

Following the same procedure of time zone 00:00-01:00, we create Figure 14 As it can be observed, the model again reproduces respectively good enough the actual total load for time zone 11:00-12:00.

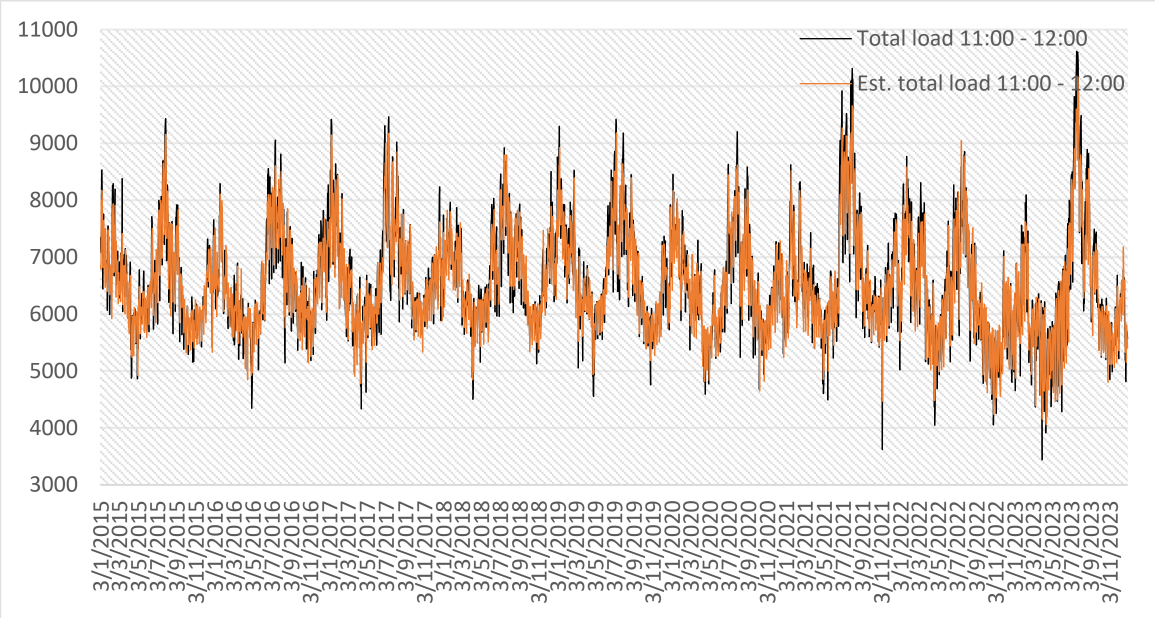

Figure 14: Time plot Total load vs Est. total load of 11:00-12:00

3.3.13 Regression model for time zone 12:00 – 13:00

The regression for this time zone containing all the statistically significant variables that is produced from the procedure is,

$$Ln(E_t) = c_0 + c_1 t + c_2 t^2 + \sum_{j=1}^{9} a_j M_{jt} + \sum_{i=1}^{6} b_i D_{it} + d_1 Ln(E_{t-1}) + d_2 Ln(E_{t-2}) + e_t$$

where $Ln(E_t)$ is the natural logarithm of the hourly total load of electricity for each time zone, c_0 is the constant term, t is a linear time-trend variable with c_1 the linear-trend coefficient, t^2 is a quadratic trend variable with c_2 the quadratic trend coefficient, $M_{jt}, j = 1,2 \ldots 9$ is a set of 9 monthly dummy variables for January, March, April, May, June, July, August, October and November with a_j, $j = 1,2 \ldots 9$ the monthly dummy variables coefficients, D_{it}, $i = 1,2 \ldots 6$ is a set of 6 weekday dummy variables from Monday to Saturday with b_i, $i = 1,2 \ldots 6$ the weekday dummy variables coefficients, $Ln(E_{t-2})$ is the natural logarithm of the one-day prior hourly total load of electricity, $Ln(E_{t-2})$ is the natural

logarithm of the two-day prior hourly total load of electricity and e_t is the disturbance term. The coefficients of the regression are described in the Table 26.

Coefficients[a]						
Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	1.784	.104		17.169	<.001
	linear term	9.918E-6	.000	.062	2.139	.033
	Quadradic term	-3.985E-9	.000	-.085	-2.903	.004
	JAN	.017	.004	.032	3.923	<.001
	MAR	-.012	.004	-.022	-2.716	.007
	APR	-.031	.005	-.057	-6.633	<.001
	MAY	-.019	.005	-.036	-4.166	<.001
	JUN	.015	.004	.027	3.320	<.001
	JUL	.048	.005	.089	9.866	<.001
	AUG	.026	.005	.047	5.587	<.001
	OCT	-.025	.005	-.046	-5.425	<.001
	NOV	-.017	.005	-.030	-3.609	<.001
	MONDAY	.168	.004	.389	40.103	<.001
	TUESDAY	.118	.005	.274	24.857	<.001
	WEDNESDAY	.091	.004	.211	21.618	<.001
	THURSDAY	.097	.004	.224	23.374	<.001
	FRIDAY	.066	.004	.152	15.749	<.001
	SATURDAY	.049	.004	.113	11.892	<.001
	lagged log total load 1st grade	.716	.017	.716	41.047	<.001
	lagged log total load 2st grade	.071	.017	.071	4.039	<.001
a. Dependent Variable: log total load 12:00 - 13:00						

Table 26: Coefficient summary of log total load 12:00 - 13:00

From Model summary of Table 27, we get that the estimated regression model has $R^2 = 0.830$. That implies that about 83.00% of the variations in the log total load of demand electricity are explained by the explanatory variables that are included in the model. Because the R^2 is close to 90.00% and respectively close to one, it can be concluded that the estimated multiple regression model is an approximately good fit.

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.911[a]	.830	.829	.062485858644608
a. Predictors: (Constant), lagged log total load 2st grade, WEDNESDAY, JUN, linear term, MAR, MONDAY, JAN , NOV, FRIDAY, OCT, THURSDAY, AUG, MAY, SATURDAY, APR, JUL, TUESDAY, lagged log total load 1st grade , Quadradic term				

Table 27: Model summary of log total load 12:00 - 13:00

Following the same procedure of time zone 00:00-01:00, we create Figure 15. As it can be observed, the model again reproduces respectively good enough the actual total load for time zone 12:00-13:00.

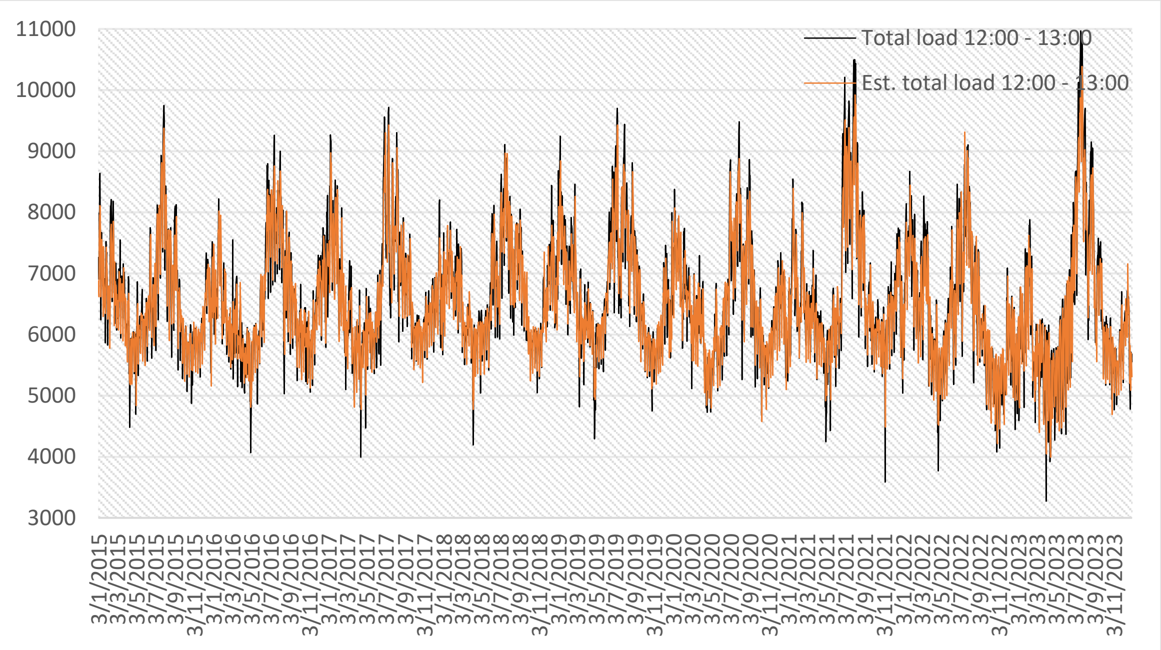

Figure 15: Time plot Total load vs Est. total load of 12:00-13:00

3.3.14 Regression model for time zone 13:00 – 14:00

The regression for this time zone containing all the statistically significant variables that is produced from the procedure is,

$$Ln(E_t) = c_0 + c_2 t^2 + \sum_{j=1}^{9} a_j M_{jt} + \sum_{i=1}^{6} b_i D_{it} + d_1 Ln(E_{t-1}) + d_2 Ln(E_{t-2}) + e_t$$

where $Ln(E_t)$ is the natural logarithm of the hourly total load of electricity for each time zone, c_0 is the constant term, t^2 is a quadratic trend variable with c_2 the quadratic trend coefficient, M_{jt}, $j = 1,2 \dots 9$ is a set of 9 monthly dummy variables for January, March, April, May, June, July, August, October and November with a_j, $j = 1,2 \dots 9$ the monthly dummy variables coefficients, D_{it}, $i = 1,2 \dots 6$ is a set of 6 weekday dummy variables from Monday to Saturday with b_i, $i = 1,2 \dots 6$ the weekday dummy variables coefficients, $Ln(E_{t-1})$ is the natural logarithm of the one-day prior hourly total load of electricity, $Ln(E_{t-2})$ is the natural logarithm of the two-day prior hourly total load of electricity and e_t is the disturbance term. The coefficients of the regression are described in the Table 28.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.755	.104		16.804	<.001
	Quadradic term	-1.068E-9	.000	-.021	-2.887	.004
	JAN	.016	.005	.027	3.439	<.001
	MAR	-.014	.005	-.023	-2.861	.004
	APR	-.033	.005	-.055	-6.469	<.001
	MAY	-.021	.005	-.036	-4.295	<.001
	JUN	.017	.005	.028	3.508	<.001
	JUL	.054	.005	.092	10.174	<.001
	AUG	.031	.005	.052	6.094	<.001
	OCT	-.026	.005	-.044	-5.307	<.001
	NOV	-.016	.005	-.027	-3.286	.001
	MONDAY	.213	.005	.453	46.839	<.001
	TUESDAY	.142	.005	.303	26.568	<.001
	WEDNESDAY	.119	.005	.252	26.235	<.001
	THURSDAY	.116	.004	.246	25.890	<.001
	FRIDAY	.093	.004	.197	20.749	<.001
	SATURDAY	.064	.004	.137	14.548	<.001
	lagged log total load 1st grade	.700	.017	.700	40.191	<.001
	lagged log total load 2st grade	.087	.017	.087	5.005	<.001

a. Dependent Variable: log total load 13:00 - 14:00

Table 28: Coefficient summary of log total load 13:00 - 14:00

From Model summary of Table 29, we get that the estimated regression model has $R^2 = 0.835$. That implies that about 83.05% of the variations in the log total load of demand electricity are explained by the explanatory variables that are included in the model. Because the R^2 is close to 90.00% and respectively close to one, it can be concluded that the estimated multiple regression model is an approximately good fit.

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.914[a]	.835	.834	.067145898333651
a. Predictors: (Constant), lagged log total load 2st grade, JUN, WEDNESDAY, Quadradic term, MAR, MONDAY, JAN, NOV, THURSDAY, OCT, FRIDAY, AUG, MAY, SATURDAY, APR, JUL, TUESDAY, lagged log total load 1st grade				

Table 29: Model summary of log total load 13:00 - 14:00

Following the same procedure of time zone 00:00-01:00, we create Figure 16. As it can be observed, the model again reproduces respectively good enough the actual total load for time zone 13:00-14:00.

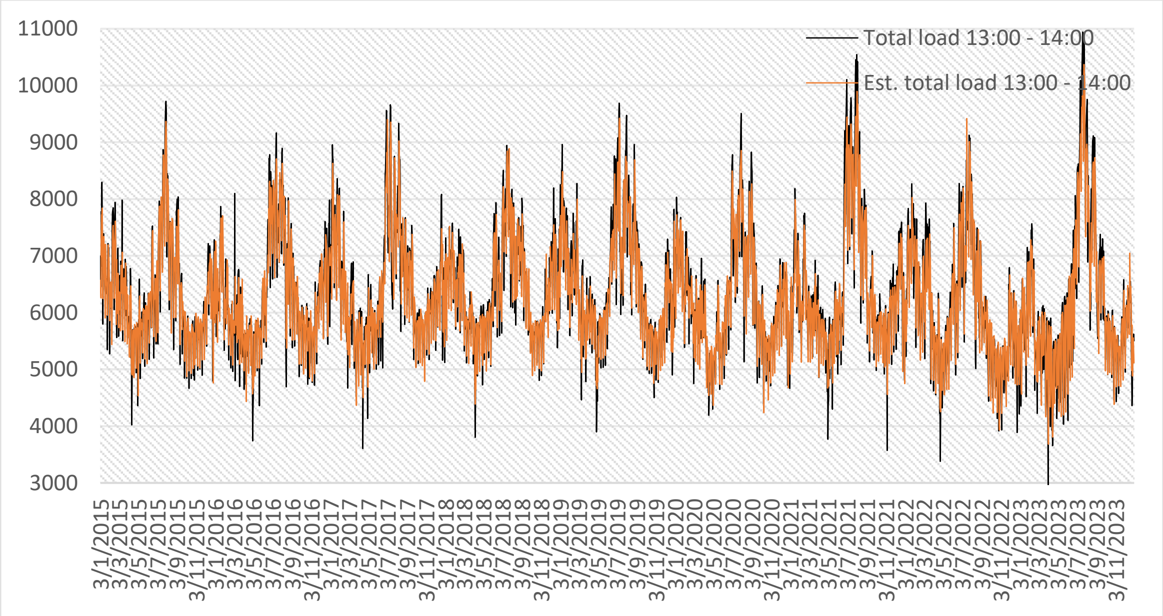

Figure 16: Time plot Total load vs Est. total load of 13:00-14:00

3.3.15 Regression model for time zone 14:00 – 15:00

The regression for this time zone containing all the statistically significant variables that is produced from the procedure is,

$$Ln(E_t) = c_0 + c_2t^2 + \sum_{j=1}^{9} a_jM_{jt} + \sum_{i=1}^{6} b_iD_{it} + d_1Ln(E_{t-1}) + d_2Ln(E_{t-2}) + e_t$$

where $Ln(E_t)$ is the natural logarithm of the hourly total load of electricity for each time zone, c_0 is the constant term, t^2 is a quadratic trend variable with c_2 the quadratic trend coefficient, M_{jt}, $j = 1,2 \dots 9$ is a set of 9 monthly dummy variables for January, March, April, May, July, August, September, October and November with a_j, $j = 1,2 \dots 9$ the monthly dummy variables coefficients, D_{it}, $i = 1,2 \dots 6$ is a set of 6 weekday dummy variables from Monday to Saturday with b_i, $i = 1,2 \dots 6$ the weekday dummy variables coefficients, $Ln(E_{t-1})$ is the natural logarithm of the one-day prior hourly total load of electricity, $Ln(E_{t-2})$ is the natural logarithm of the two-day prior hourly total load of electricity and e_t is the disturbance term. The coefficients of the regression are described in the Table 30.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.633	.101		16.198	<.001
	Quadradic term	-1.068E-9	.000	-.020	-2.825	.005
	JAN	.011	.005	.017	2.219	.027
	MAR	-.020	.005	-.032	-4.162	<.001
	APR	-.043	.005	-.068	-8.213	<.001
	MAY	-.037	.005	-.059	-6.993	<.001
	JUL	.040	.005	.064	7.596	<.001
	AUG	.017	.005	.028	3.411	<.001
	SEP	-.020	.005	-.032	-4.181	<.001
	OCT	-.040	.005	-.064	-7.692	<.001
	NOV	-.021	.005	-.033	-4.153	<.001
	MONDAY	.219	.005	.442	47.358	<.001
	TUESDAY	.143	.006	.289	25.914	<.001
	WEDNESDAY	.120	.005	.241	25.895	<.001
	THURSDAY	.117	.005	.237	25.675	<.001
	FRIDAY	.098	.005	.199	21.503	<.001
	SATURDAY	.062	.005	.126	13.804	<.001
	lagged log total load 1st grade	.710	.017	.711	40.799	<.001

	lagged log total load 2st grade	.091	.017	.091	5.242	<.001
a. Dependent Variable: log total load 14:00 - 15:00						

Table 30: Coefficient summary of log total load 14:00 – 1500

From Model summary of Table 31, we get that the estimated regression model has $R^2 = 0.845$. That implies that about 84.50% of the variations in the log total load of demand electricity are explained by the explanatory variables that are included in the model. Because the R^2 is close to 90.00% and respectively close to one, it can be concluded that the estimated multiple regression model is an approximately good fit.

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.919[a]	.845	.844	.068548472285053
a. Predictors: (Constant), lagged log total load 2st grade, SEP, WEDNESDAY, JUN, linear term, MAR, MONDAY, NOV, JAN, THURSDAY, APR, FRIDAY, AUG, OCT, SATURDAY, JUL, MAY, TUESDAY, lagged log total load 1st grade, Quadradic term				

Table 31: Model summary of log total load 14:00 - 15:00

Following the same procedure of time zone 00:00-01:00, we create Figure 17. As it can be observed, the model again reproduces respectively good enough the actual total load for time zone 14:00-15:00.

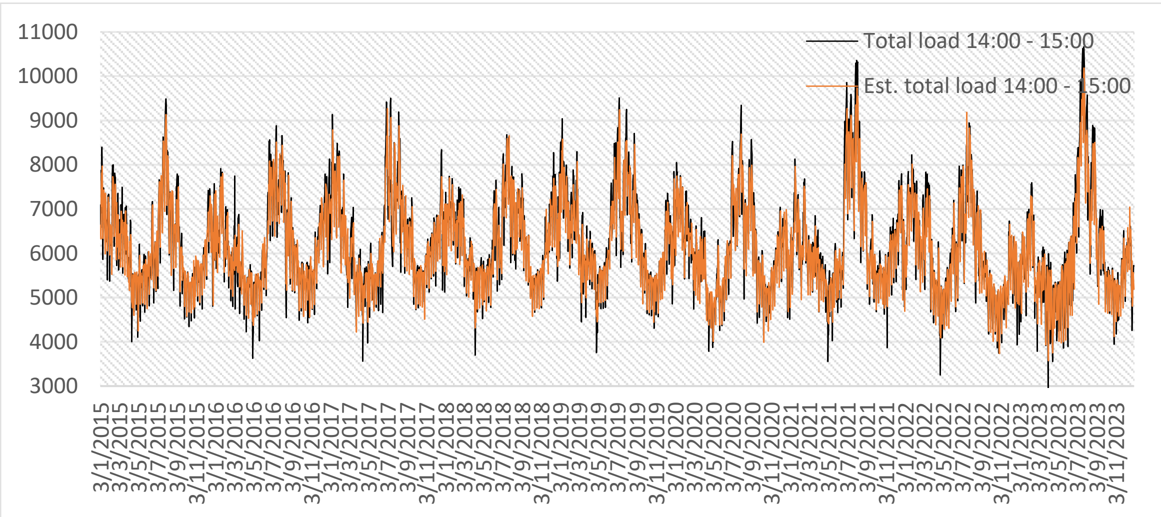

Figure 17: Time plot Total load vs Est. total load of 14:00-15:00

3.3.16 Regression model for time zone 15:00 – 16:00

The regression for this time zone containing all the statistically significant variables that is produced from the procedure is,

$$Ln(E_t) = c_0 + c_2 t^2 + \sum_{j=1}^{7} a_j M_{jt} + \sum_{i=1}^{6} b_i D_{it} + d_1 Ln(E_{t-1}) + d_2 Ln(E_{t-2}) + e_t$$

where $Ln(E_t)$ is the natural logarithm of the hourly total load of electricity for each time zone, c_0 is the constant term, t^2 is a quadratic trend variable with c_2 the quadratic trend coefficient, $M_{jt}, j = 1,2 \dots 7$ is a set of 7 monthly dummy variables for March, April, May, July, September, October and November with $a_j, j = 1,2 \dots 7$ the monthly dummy variables coefficients, $D_{it}, i = 1,2 \dots 6$ is a set of 6 weekday dummy variables from Monday to Saturday with $b_i, i = 1,2 \dots 6$ the weekday dummy variables coefficients, $Ln(E_{t-1})$ is the natural logarithm of the one-day prior hourly total load of electricity, $Ln(E_{t-2})$ is the natural logarithm of the two-day prior hourly total load of electricity and e_t is the disturbance term. The coefficients of the regression are described in the Table 32.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.412	.092		15.400	<.001
	Quadradic term	-9.692E-10	.000	-.018	-2.665	.008
	MAR	-.025	.005	-.040	-5.571	<.001
	APR	-.046	.005	-.072	-9.044	<.001
	MAY	-.040	.005	-.063	-7.809	<.001
	JUL	.028	.005	.045	6.227	<.001
	SEP	-.027	.005	-.042	-5.967	<.001
	OCT	-.041	.005	-.066	-8.253	<.001
	NOV	-.020	.005	-.031	-4.249	<.001
	MONDAY	.206	.004	.412	46.346	<.001
	TUESDAY	.134	.005	.267	25.461	<.001
	WEDNESDAY	.110	.004	.221	24.822	<.001
	THURSDAY	.110	.004	.221	25.093	<.001
	FRIDAY	.092	.004	.184	20.892	<.001
	SATURDAY	.059	.004	.118	13.535	<.001

	lagged log total load 1st grade	.744	.017	.744	42.733	<.001
	lagged log total load 2st grade	.084	.017	.084	4.864	<.001
a. Dependent Variable: log total load 15:00 - 16:00						

Table 32: Coefficient summary of log total load 15:00 – 1600

From Model summary of Table 33, we get that the estimated regression model has $R^2 = 0.858$. That implies that about 85.80% of the variations in the log total load of demand electricity are explained by the explanatory variables that are included in the model. Because the R^2 is close to 90.00% and respectively close to one, it can be concluded that the estimated multiple regression model is an approximately good fit.

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.926[a]	.858	.857	.066073686207769
a. Predictors: (Constant), lagged log total load 2st grade, SEP, WEDNESDAY, MAR, Quadradic term, MONDAY, NOV, THURSDAY, APR, FRIDAY, JUL, OCT, SATURDAY, MAY, TUESDAY, lagged log total load 1st grade				

Table 33: Model summary of log total load 15:00 - 16:00

Following the same procedure of time zone 00:00-01:00, we create Figure 18. As it can be observed, the model again reproduces respectively good enough the actual total load for time zone 15:00-16:00.

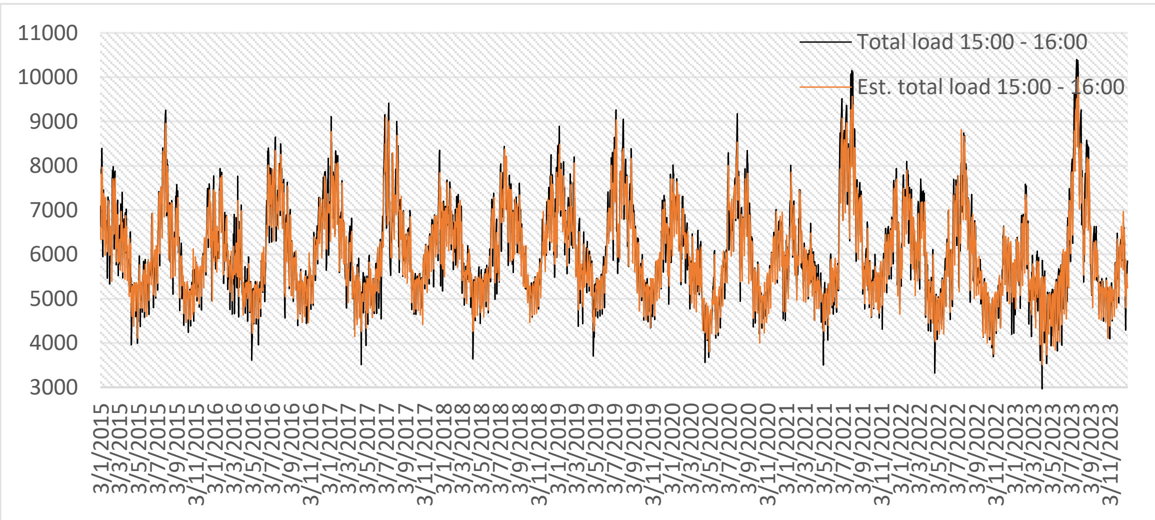

Figure 18: Time plot Total load vs Est. total load of 15:00-16:00

3.3.17 Regression model for time zone 16:00 – 17:00

The regression for this time zone containing all the statistically significant variables that is produced from the procedure is,

$$Ln(E_t) = c_0 + \sum_{j=1}^{9} a_j M_{jt} + \sum_{i=1}^{6} b_i D_{it} + d_1 Ln(E_{t-1}) + d_2 Ln(E_{t-2}) + e_t$$

where $Ln(E_t)$ is the natural logarithm of the hourly total load of electricity for each time zone, c_0 is the constant term, M_{jt}, $j = 1,2 \dots 9$ is a set of 9 monthly dummy variables for February, March, April, May, June, July, September, October and November with a_j, $j = 1,2 \dots 9$ the monthly dummy variables coefficients, D_{it} , $i = 1,2 \dots 6$ is a set of 6 weekday dummy variables from Monday to Saturday with b_i, $i = 1,2 \dots 6$ the weekday dummy variables coefficients, $Ln(E_{t-1})$ is the natural logarithm of the one-day prior hourly total load of electricity, $Ln(E_{t-2})$ is the natural logarithm of the two-day prior hourly total load of electricity and e_t is the disturbance term. The coefficients of the regression are described in the Table 34.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.389	.094		14.860	<.001
	FEB	-.017	.004	-.026	-3.769	<.001
	MAR	-.035	.005	-.057	-7.545	<.001
	APR	-.056	.005	-.088	-10.143	<.001
	MAY	-.046	.005	-.075	-8.583	<.001
	JUN	-.013	.005	-.021	-2.863	.004
	JUL	.018	.004	.029	4.162	<.001
	SEP	-.035	.005	-.056	-7.619	<.001
	OCT	-.045	.005	-.072	-8.513	<.001
	NOV	-.017	.005	-.028	-3.819	<.001
	MONDAY	.186	.004	.376	45.445	<.001
	TUESDAY	.125	.005	.253	25.868	<.001
	WEDNESDAY	.096	.004	.194	23.109	<.001
	THURSDAY	.104	.004	.209	25.556	<.001
	FRIDAY	.085	.004	.171	20.708	<.001

	SATURDAY	.050	.004	.101	12.371	<.001
	lagged log total load 1st grade	.762	.017	.762	43.646	<.001
	lagged log total load 2st grade	.070	.017	.070	4.024	<.001
a. Dependent Variable: log total load 16:00 - 17:00						

Table 34: Coefficient summary of log total load 16:00 – 1700

From Model summary of Table 35, we get that the estimated regression model has $R^2 = 0.877$. That implies that about 87.70% of the variations in the log total load of demand electricity are explained by the explanatory variables that are included in the model. Because the R^2 is close to 90.00% and respectively close to one, it can be concluded that the estimated multiple regression model is an approximately good fit.

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.936[a]	.877	.876	.060981735006224
a. Predictors: (Constant), lagged log total load 2st grade, WEDNESDAY, NOV, JUN, SEP, MONDAY, FEB, MAR, FRIDAY, THURSDAY, OCT, JUL, SATURDAY, APR, TUESDAY, MAY, lagged log total load 1st grade				

Table 35: Model summary of log total load 16:00 - 17:00

Following the same procedure of time zone 00:00-01:00, we create Figure 19. As it can be observed, the model again reproduces respectively good enough the actual total load for time zone 16:00-17:00.

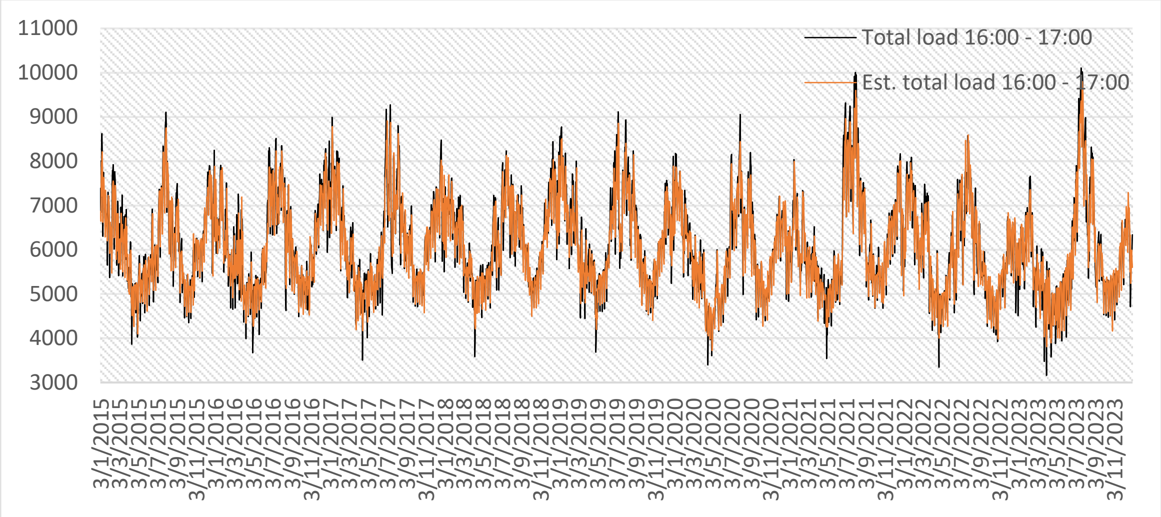

Figure 19: Time plot Total load vs Est. total load of 16:00-17:00

3.3.18 Regression model for time zone 17:00 – 18:00

The regression for this time zone containing all the statistically significant variables that is produced from the procedure is,

$$Ln(E_t) = c_0 + \sum_{j=1}^{9} a_j M_{jt} + \sum_{i=1}^{6} b_i D_{it} + d_1 Ln(E_{t-1}) + d_2 Ln(E_{t-2}) + e_t$$

where $Ln(E_t)$ is the natural logarithm of the hourly total load of electricity for each time zone, c_0 is the constant term, M_{jt}, $j = 1,2 \ldots 9$ is a set of 9 monthly dummy variables for February, March, April, May, June, August, September, October and November with a_j, $j = 1,2 \ldots 9$ the monthly dummy variables coefficients, D_{it}, $i = 1,2 \ldots 6$ is a set of 6 weekday dummy variables from Monday to Saturday with b_i, $i = 1,2 \ldots 6$ the weekday dummy variables coefficients, $Ln(E_{t-1})$ is the natural logarithm of the one-day prior hourly total load of electricity, $Ln(E_{t-2})$ is the natural logarithm of the two-day prior hourly total load of electricity and e_t is the disturbance term. The coefficients of the regression are described in the Table 36.

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.227	.089		13.835	<.001
	FEB	-.013	.004	-.021	-3.406	<.001

	MAR	-.037	.004	-.059	-8.764	<.001
	APR	-.060	.005	-.095	-11.340	<.001
	MAY	-.050	.005	-.081	-9.644	<.001
	JUN	-.022	.004	-.036	-5.166	<.001
	AUG	-.015	.004	-.025	-4.041	<.001
	SEP	-.042	.004	-.067	-9.654	<.001
	OCT	-.043	.005	-.070	-8.816	<.001
	NOV	-.019	.004	-.031	-4.702	<.001
	MONDAY	.167	.004	.339	45.628	<.001
	TUESDAY	.113	.004	.229	25.921	<.001
	WEDNESDAY	.081	.004	.165	21.755	<.001
	THURSDAY	.096	.004	.195	26.477	<.001
	FRIDAY	.073	.004	.148	19.700	<.001
	SATURDAY	.042	.004	.085	11.612	<.001
	lagged log total load 1st grade	.784	.017	.785	44.950	<.001
	lagged log total load 2st grade	.069	.018	.069	3.926	<.001
a. Dependent Variable: log total load 17:00 - 18:00						

Table 36: Coefficient summary of log total load 17:00 - 18:00

From Model summary of Table 37, we get that the estimated regression model has $R^2 = 0.900$. That implies that about 90.00% of the variations in the log total load of demand electricity are explained by the explanatory variables that are included in the model. Because the R^2 is 90.00% and close to one, it can be concluded that the estimated multiple regression model is a good fit.

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.949[a]	.900	.899	.054630515184736
a. Predictors: (Constant), lagged log total load 2st grade, NOV, WEDNESDAY, MAR, JUN, MONDAY, SEP, FRIDAY, FEB, AUG, THURSDAY, OCT, SATURDAY, APR, TUESDAY, MAY, lagged log total load 1st grade				

Table 37: Model summary of log total load 17:00 - 18:00

Following the same procedure of time zone 00:00-01:00, we create Figure 20. As it can be observed, the model again reproduces respectively good enough the actual total load for time zone 17:00-18:00.

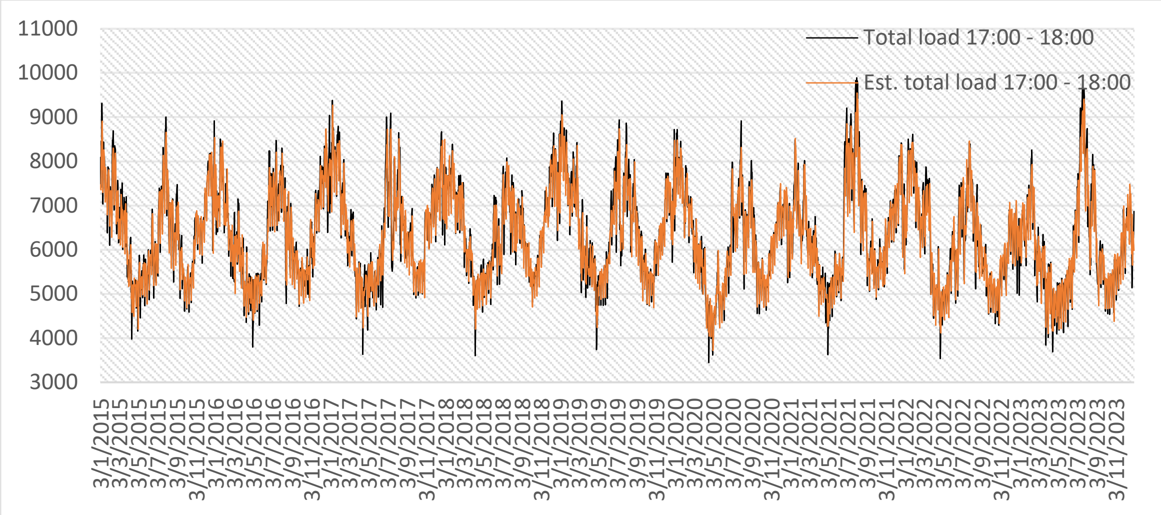

Figure 20: Time plot Total load vs Est. total load of 17:00-18:00

3.3.19 Regression model for time zone 18:00 – 19:00

The regression for this time zone containing all the statistically significant variables that is produced from the procedure is,

$$Ln(E_t) = c_0 + \ c_2 t^2 + \sum_{j=1}^{8} a_j M_{jt} + \sum_{i=1}^{6} b_i D_{it} + d_1 Ln(E_{t-1}) + d_2 Ln(E_{t-2}) + \ e_t$$

where $Ln(E_t)$ is the natural logarithm of the hourly total load of electricity for each time zone, c_0 is the constant term, t^2 is a quadratic trend variable with c_2 the quadratic trend coefficient, $M_{jt}, j = 1,2 \dots 8$ is a set of 8 monthly dummy variables for March, April, May, June, August, September, October and November with $a_j, j = 1,2 \dots 8$ the monthly dummy variables coefficients, $D_{it}, i = 1,2 \dots 6$ is a set of 6 weekday dummy variables from Monday to Saturday with $b_i, i = 1,2 \dots 6$ the weekday dummy variables coefficients, $Ln(E_{t-1})$ is the natural logarithm of the one-day prior hourly total load of electricity, $Ln(E_{t-2})$ is the natural logarithm of the two-day prior hourly total load of electricity and e_t is the disturbance term. The coefficients of the regression are described in the Table 38.

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	1.263	.090		14.041	<.001
	Quadradic term	-1.124E-9	.000	-.023	-4.002	<.001
	MAR	-.024	.003	-.042	-6.821	<.001
	APR	-.053	.005	-.093	-11.392	<.001
	MAY	-.047	.005	-.085	-10.000	<.001
	JUN	-.022	.004	-.039	-5.650	<.001
	AUG	-.015	.003	-.027	-4.438	<.001
	SEP	-.034	.004	-.060	-8.806	<.001
	OCT	-.032	.004	-.057	-7.918	<.001
	NOV	-.017	.004	-.031	-4.755	<.001
	MONDAY	.154	.003	.347	46.168	<.001
	TUESDAY	.104	.004	.234	26.244	<.001
	WEDNESDAY	.075	.003	.168	21.998	<.001
	THURSDAY	.087	.003	.195	26.328	<.001
	FRIDAY	.064	.003	.143	19.044	<.001
	SATURDAY	.040	.003	.090	12.259	<.001
	lagged log total load 1st grade	.792	.017	.792	45.298	<.001
	lagged log total load 2st grade	.058	.018	.058	3.306	<.001
a. Dependent Variable: log total load 18:00 - 19:00						

Table 38: Coefficient summary of log total load 18:00 - 19:00

From Model summary of Table 39, we get that the estimated regression model has $R^2 = 0.898$. That implies that about 89.80% of the variations in the log total load of demand electricity are explained by the explanatory variables that are included in the model. Because the R^2 is very close to 90.00% and respectively close to one, it can be concluded that the estimated multiple regression model is an approximately good fit.

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.948[a]	.898	.898	.049716565129395

a. Predictors: (Constant), lagged log total load 2st grade, WEDNESDAY, NOV, MAR, SEP, Quadradic term, MONDAY, AUG, JUN, FRIDAY, OCT, THURSDAY, SATURDAY, APR, TUESDAY, MAY, lagged log total load 1st grade

Table 39: Model summary of log total load 18:00 - 19:00

Following the same procedure of time zone 00:00-01:00, we create Figure 21. As it can be observed, the model again reproduces respectively good enough the actual total load for time zone 18:00-19:00.

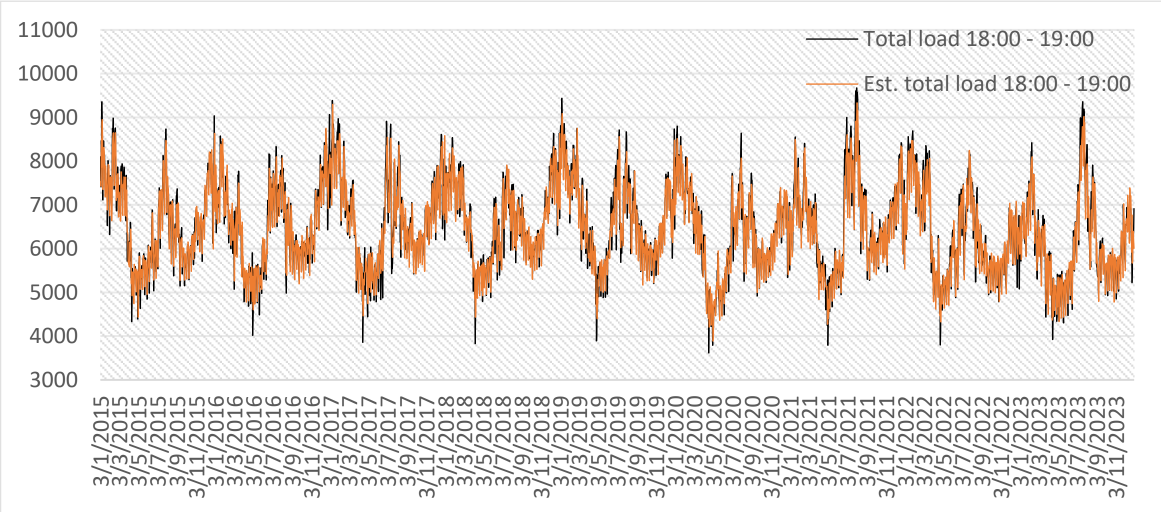

Figure 21: Time plot Total load vs Est. total load of 18:00-19:00

3.3.20 Regression model for time zone 19:00 – 20:00

The regression for this time zone containing all the statistically significant variables that is produced from the procedure is,

$$Ln(E_t) = c_0 + \ c_2 t^2 + \sum_{j=1}^{7} a_j M_{jt} + \sum_{i=1}^{6} b_i D_{it} + d_1 Ln(E_{t-1}) + d_2 Ln(E_{t-2}) + \ e_t$$

where $Ln(E_t)$ is the natural logarithm of the hourly total load of electricity for each time zone, c_0 is the constant term, t^2 is a quadratic trend variable with c_2 the quadratic trend coefficient, $M_{jt}, j = 1,2 \dots 7$ is a set of 7 monthly dummy variables for March, April, May, June, September, October and November with $a_j, j = 1,2 \dots 7$ the monthly dummy variables coefficients, $D_{it},\ i = 1,2 \dots 6$ is a set of 6 weekday dummy variables from Monday to Saturday with $b_i,\ i = 1,2 \dots 6$ the weekday dummy variables coefficients, $Ln(E_{t-1})$ is the natural logarithm of the one-day prior hourly total load of electricity, $Ln(E_{t-2})$ is the natural

logarithm of the two-day prior hourly total load of electricity and e_t is the disturbance term. The coefficients of the regression are described in the Table 40.

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	1.280	.089		14.330	<.001
	Quadradic term	-1.337E-9	.000	-.033	-5.078	<.001
	MAR	-.013	.003	-.028	-4.417	<.001
	APR	-.035	.004	-.073	-9.715	<.001
	MAY	-.037	.004	-.078	-9.355	<.001
	JUN	-.018	.003	-.038	-5.234	<.001
	SEP	-.022	.003	-.046	-6.927	<.001
	OCT	-.029	.004	-.060	-8.061	<.001
	NOV	-.016	.003	-.033	-4.728	<.001
	MONDAY	.133	.003	.351	44.021	<.001
	TUESDAY	.084	.004	.222	22.626	<.001
	WEDNESDAY	.057	.003	.152	18.185	<.001
	THURSDAY	.067	.003	.177	21.948	<.001
	FRIDAY	.043	.003	.113	13.835	<.001
	SATURDAY	.017	.003	.046	5.760	<.001
	lagged log total load 1st grade	.794	.017	.794	45.440	<.001
	lagged log total load 2st grade	.056	.018	.056	3.180	.001

a. Dependent Variable: log total load 19:00 - 20:00

Table 40: Coefficient summary of log total load 19:00 - 20:00

From Model summary of Table 41, we get that the estimated regression model has $R^2 = 0.882$. That implies that about 88.20% of the variations in the log total load of demand electricity are explained by the explanatory variables that are included in the model. Because the R^2 is close to 90.00% and respectively close to one, it can be concluded that the estimated multiple regression model is an approximately good fit.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate

1	.939[a]	.882	.881	.045524743058831
a. Predictors: (Constant), lagged log total load 2st grade, WEDNESDAY, SEP, MAR, NOV, FRIDAY, Quadradic term, JUN, MONDAY, APR, THURSDAY, OCT, SATURDAY, TUESDAY, MAY, lagged log total load 1st grade				

Table 41: Model summary of log total load 19:00 - 20:00

Following the same procedure of time zone 00:00-01:00, we create Figure 22. As it can be observed, the model again reproduces respectively good enough the actual total load for time zone 19:00-20:00.

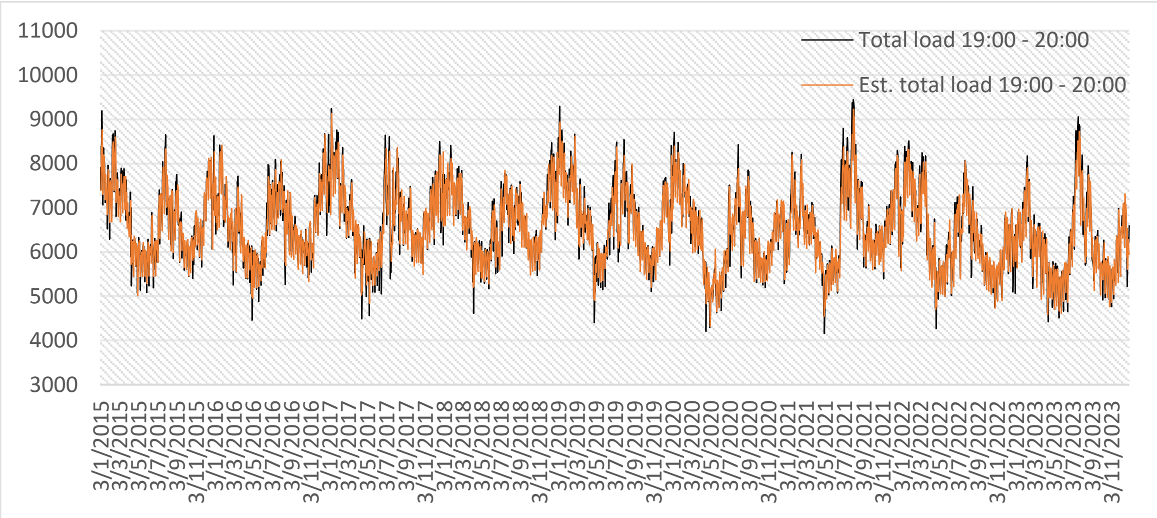

Figure 22: Time plot Total load vs Est. total load of 19:00-20:00

3.3.21 Regression model for time zone 20:00 – 21:00

The regression for this time zone containing all the statistically significant variables that is produced from the procedure is,

$$Ln(E_t) = c_0 + c_2 t^2 + \sum_{j=1}^{7} a_j M_{jt} + \sum_{i=1}^{5} b_i D_{it} + d_1 Ln(E_{t-1}) + d_2 Ln(E_{t-2}) + e_t$$

where $Ln(E_t)$ is the natural logarithm of the hourly total load of electricity for each time zone, c_0 is the constant term, t^2 is a quadratic trend variable with c_2 the quadratic trend coefficient, $M_{jt}, j = 1,2 \ldots 7$ is a set of 7 monthly dummy variables for March, April, May, July, September, October and November with $a_j, j = 1,2 \ldots 7$ the monthly dummy variables coefficients, $D_{it}, i = 1,2 \ldots 6$ is a set of 5 weekday dummy variables from Monday to Friday with $b_i,\ i = 1,2 \ldots 5$ the weekday dummy variables coefficients, $Ln(E_{t-1})$ is the natural logarithm of the one-day prior hourly total load of electricity, $Ln(E_{t-2})$ is the natural

logarithm of the two-day prior hourly total load of electricity and e_t is the disturbance term. The coefficients of the regression are described in the Table 42.

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.172	.075		15.544	<.001
	Quadradic term	-1.414E-9	.000	-.036	-5.896	<.001
	MAR	-.010	.003	-.022	-3.660	<.001
	APR	-.022	.003	-.049	-7.528	<.001
	MAY	-.020	.003	-.045	-6.622	<.001
	JUL	.015	.003	.032	5.218	<.001
	SEP	-.021	.003	-.046	-7.356	<.001
	OCT	-.026	.003	-.058	-8.306	<.001
	NOV	-.013	.003	-.029	-4.549	<.001
	MONDAY	.095	.002	.265	40.394	<.001
	TUESDAY	.049	.002	.136	21.019	<.001
	WEDNESDAY	.037	.002	.103	15.793	<.001
	THURSDAY	.036	.002	.101	15.491	<.001
	FRIDAY	.018	.002	.051	7.849	<.001
	lagged log total load 1st grade	.864	.009	.864	101.370	<.001
a. Dependent Variable: log total load 20:00 - 21:00						

Table 42: Coefficient summary of log total load 20:00 - 21:00

From Model summary of Table 43, we get that the estimated regression model has $R^2 = 0.894$. That implies that about 89.40% of the variations in the log total load of demand electricity are explained by the explanatory variables that are included in the model. Because the R^2 is very close to 90.00% and respectively close to one, it can be concluded that the estimated multiple regression model is an approximately good fit.

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.945[a]	.894	.893	.041025613126402
a. Predictors: (Constant), lagged log total load 1st grade, MAR, TUESDAY, SEP, FRIDAY, APR, NOV, THURSDAY, Quadradic term, JUL, WEDNESDAY, MAY, MONDAY, OCT				

Table 43: Model summary of log total load 20:00 - 21:00

Following the same procedure of time zone 00:00-01:00, we create Figure 23. As it can be observed, the model again reproduces respectively good enough the actual total load for time zone 20:00-21:00.

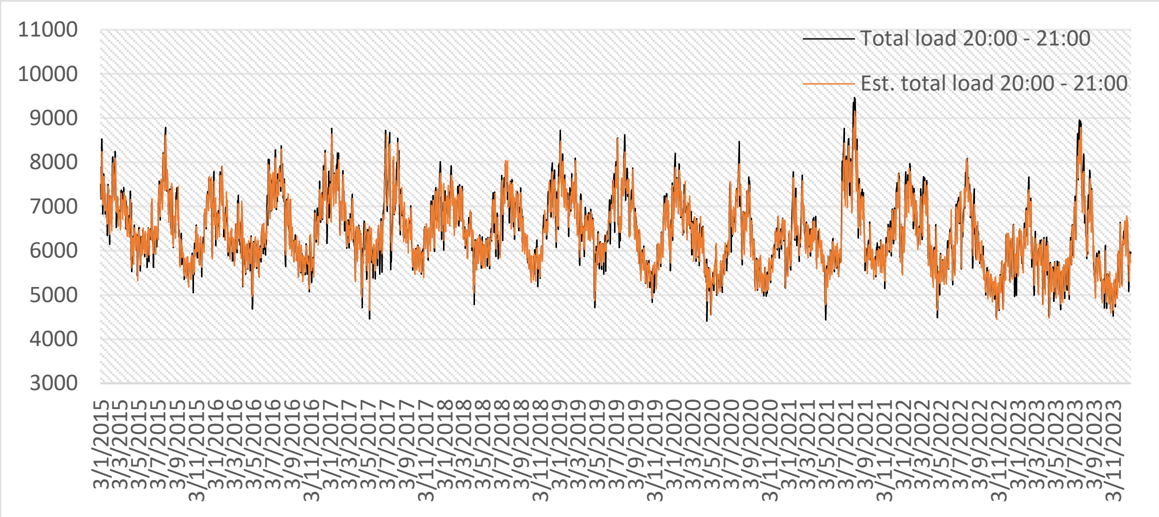

Figure 23: Time plot Total load vs Est. total load of 20:00-21:00

3.3.22 Regression model for time zone 21:00 – 22:00

The regression for this time zone containing all the statistically significant variables that is produced from the procedure is,

$$Ln(E_t) = c_0 + c_2 t^2 + \sum_{j=1}^{7} a_j M_{jt} + \sum_{i=1}^{6} b_i D_{it} + d_1 Ln(E_{t-1}) + d_2 Ln(E_{t-2}) + e_t$$

where $Ln(E_t)$ is the natural logarithm of the hourly total load of electricity for each time zone, c_0 is the constant term, t^2 is a quadratic trend variable with c_2 the quadratic trend coefficient, $M_{jt}, j = 1,2 \dots 7$ is a set of 7 monthly dummy variables for March, April, May, July, September, October and November with $a_j, j = 1,2 \dots 7$ the monthly dummy variables coefficients, $D_{it}, i = 1,2 \dots 6$ is a set of 6 weekday dummy variables from Monday to Saturday with $b_i, i = 1,2 \dots 6$ the weekday dummy variables coefficients, $Ln(E_{t-1})$ is the natural logarithm of the one-day prior hourly total load of electricity, $Ln(E_{t-2})$ is the natural logarithm of the two-day prior hourly total load of electricity and e_t is the disturbance term. The coefficients of the regression are described in the Table 44.

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	T	Sig.
1	(Constant)	1.024	.069		14.897	<.001
	Quadradic term	-1.191E-9	.000	-.029	-5.452	<.001
	MAR	-.010	.003	-.021	-3.965	<.001
	APR	-.022	.003	-.045	-7.933	<.001
	MAY	-.018	.003	-.039	-6.445	<.001
	JUL	.017	.003	.035	6.424	<.001
	SEP	-.021	.003	-.043	-7.803	<.001
	OCT	-.025	.003	-.052	-8.302	<.001
	NOV	-.013	.003	-.027	-4.763	<.001
	MONDAY	.062	.002	.164	25.299	<.001
	TUESDAY	.029	.003	.077	10.571	<.001
	WEDNESDAY	.022	.003	.059	8.687	<.001
	THURSDAY	.022	.003	.058	8.724	<.001
	FRIDAY	.008	.003	.021	3.165	.002
	SATURDAY	-.007	.002	-.019	-2.971	.003
	lagged log total load 1st grade	.962	.017	.962	55.256	<.001
	lagged log total load 2st grade	-.081	.017	-.081	-4.687	<.001
a. Dependent Variable: log total load 21:00 - 22:00						

Table 44: Coefficient summary of log total load 21:00 - 22:00

From Model summary of Table 45, we get that the estimated regression model has $R^2 = 0.920$. That implies that about 92.00% of the variations in the log total load of demand electricity are explained by the explanatory variables that are included in the model. Because the R^2 is above 90.00% and close to one, it can be concluded that the estimated multiple regression model is a good fit.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.959[a]	.920	.920	.037587179680301
a. Predictors: (Constant), lagged log total load 2st grade, MAR, WEDNESDAY, SEP, THURSDAY, APR, MONDAY, Quadradic term, NOV, FRIDAY, MAY, JUL, SATURDAY, OCT, TUESDAY, lagged log total load 1st grade				

Table 45: Model summary of log total load 21:00 - 22:00

Following the same procedure of time zone 00:00-01:00, we create Figure 24. As it can be observed, the model again reproduces respectively good enough the actual total load for time zone 21:00-22:00 capturing the properties of electricity demands as concerns monthly and weekly seasonality and trends.

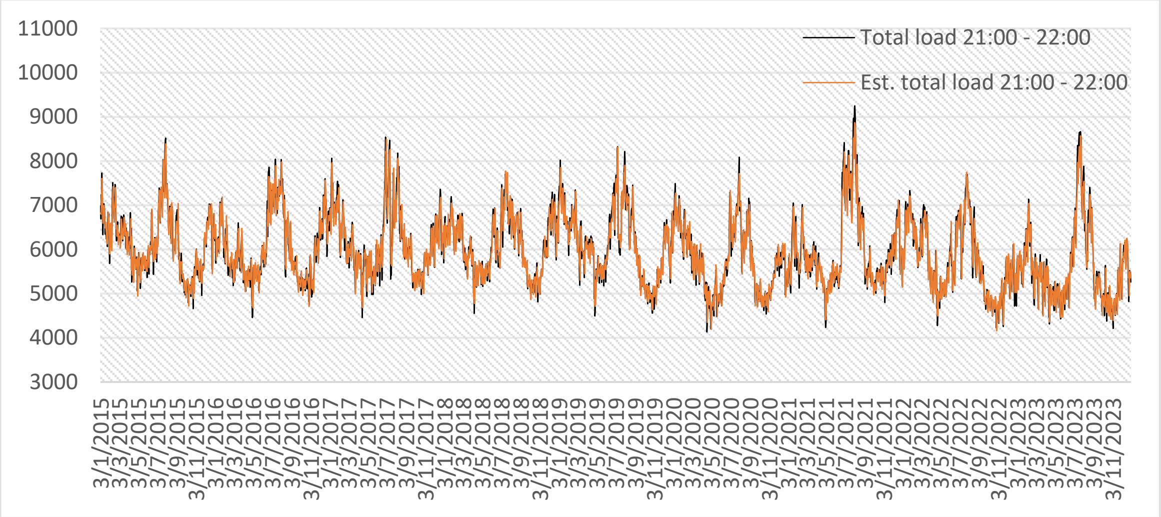

Figure 24: Time plot Total load vs Est. total load of 21:00-22:00

3.3.23 Regression model for time zone 22:00 – 23:00

The regression for this time zone containing all the statistically significant variables that is produced from the procedure is,

$$Ln(E_t) = c_0 + \ c_2 t^2 + \sum_{j=1}^{7} a_j M_{jt} + \sum_{i=1}^{6} b_i D_{it} + d_1 Ln(E_{t-1}) + d_2 Ln(E_{t-2}) + \ e_t$$

where $Ln(E_t)$ is the natural logarithm of the hourly total load of electricity for each time zone, c_0 is the constant term, t^2 is a quadratic trend variable with c_2 the quadratic trend coefficient, $M_{jt}, j = 1,2 \dots 7$ is a set of 7 monthly dummy variables for March, April, May, July, September, October and November with $a_j, j = 1,2 \dots 7$ the monthly dummy variables coefficients, $D_{it}, \ i = 1,2 \dots 6$ is a set of 6 weekday dummy variables from Monday to Saturday with $b_i, i = 1,2 \dots 6$ the weekday dummy variables coefficients, $Ln(E_{t-1})$ is the natural logarithm of the one-day prior hourly total load of electricity, $Ln(E_{t-2})$ is the natural logarithm of the two-day prior hourly total load of electricity and e_t is the disturbance term. The coefficients of the regression are described in the Table 46.

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	.929	.064		14.560	<.001
	Quadradic term	-1.065E-9	.000	-.025	-5.050	<.001
	MAR	-.010	.002	-.021	-4.262	<.001
	APR	-.022	.003	-.043	-8.106	<.001
	MAY	-.018	.003	-.036	-6.516	<.001
	JUL	.018	.003	.035	6.762	<.001
	SEP	-.019	.003	-.038	-7.568	<.001
	OCT	-.022	.003	-.044	-7.777	<.001
	NOV	-.013	.003	-.026	-4.946	<.001
	MONDAY	.063	.002	.159	25.932	<.001
	TUESDAY	.026	.003	.067	9.404	<.001
	WEDNESDAY	.020	.003	.051	7.851	<.001
	THURSDAY	.021	.002	.054	8.598	<.001
	FRIDAY	.013	.002	.034	5.333	<.001
	SATURDAY	-.020	.002	-.051	-8.244	<.001
	lagged log total load 1st grade	.992	.017	.992	57.052	<.001
	lagged log total load 2st grade	-.101	.017	-.101	-5.847	<.001
a. Dependent Variable: log total load 22:00 - 23:00						

Table 46: Coefficient summary of log total load 22:00 - 23:00

From Model summary of Table 47, we get that the estimated regression model has $R^2 = 0.931$. That implies that about 93.10% of the variations in the log total load of demand electricity are explained by the explanatory variables that are included in the model. Because the R^2 is above 90.00% and close to one, it can be concluded that the estimated multiple regression model is a good fit.

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.965[a]	.931	.930	.036553612066100

a. Predictors: (Constant), lagged log total load 2st grade, MAR, WEDNESDAY, SEP, THURSDAY, Quadradic term, APR, FRIDAY, NOV, MONDAY, MAY, JUL, SATURDAY, OCT, TUESDAY, lagged log total load 1st grade

Table 47: Model summary of log total load 22:00 - 23:00

Following the same procedure of time zone 00:00-01:00, we create Figure 25. As it can be observed, the model again reproduces respectively good enough the actual total load for time zone 22:00-23:00.

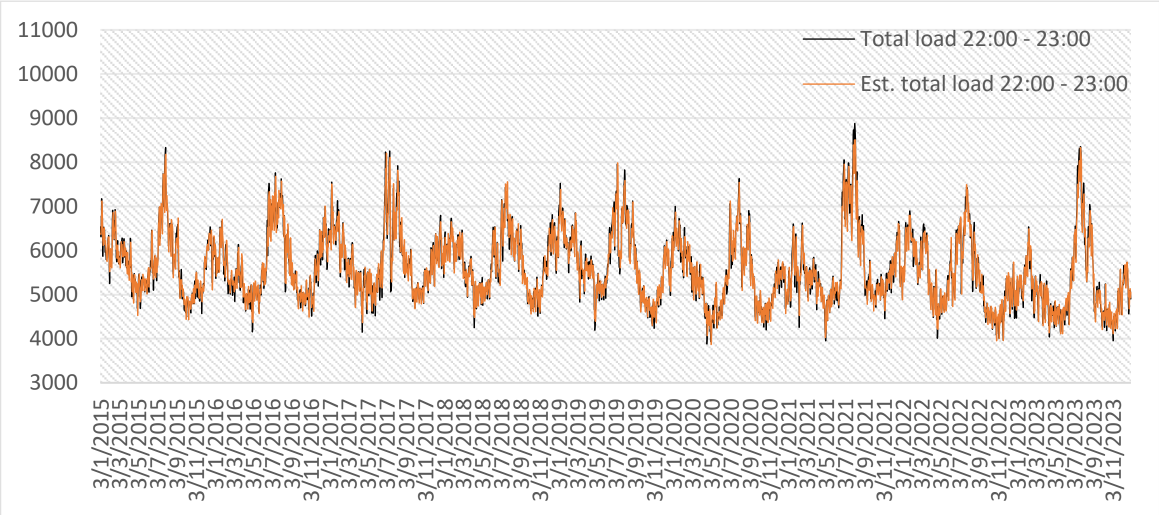

Figure 25: Time plot Total load vs Est. total load of 22:00-23:00

3.3.24 Regression model for time zone 23:00 – 24:00

The regression for this time zone containing all the statistically significant variables that is produced from the procedure is,

$$Ln(E_t) = c_0 + c_2 t^2 + \sum_{j=1}^{8} a_j M_{jt} + \sum_{i=1}^{6} b_i D_{it} + d_1 Ln(E_{t-1}) + d_2 Ln(E_{t-2}) + e_t$$

where $Ln(E_t)$ is the natural logarithm of the hourly total load of electricity for each time zone, c_0 is the constant term, t^2 is a quadratic trend variable with c_2 the quadratic trend coefficient, M_{jt}, $j = 1,2 \ldots 8$ is a set of 8 monthly dummy variables for March, April, May, July, August, September, October and November with a_j, $j = 1,2 \ldots 8$ the monthly dummy variables coefficients, D_{it}, $i = 1,2 \ldots 6$ is a set of 6 weekday dummy variables from Monday to Saturday with b_i, $i = 1,2 \ldots 6$ the weekday dummy variables coefficients, $Ln(E_{t-1})$ is the natural logarithm of the one-day prior hourly total load of electricity, $Ln(E_{t-2})$ is the natural

logarithm of the two-day prior hourly total load of electricity and e_t is the disturbance term. The coefficients of the regression are described in the Table 48.

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	T	Sig.
1	(Constant)	.915	.067		13.595	<.001
	Quadradic term	-1.161E-9	.000	-.026	-5.291	<.001
	MAR	-.010	.003	-.020	-4.125	<.001
	APR	-.021	.003	-.040	-7.666	<.001
	MAY	-.017	.003	-.033	-6.060	<.001
	JUL	.022	.003	.043	7.640	<.001
	AUG	.007	.003	.013	2.518	.012
	SEP	-.017	.003	-.033	-6.735	<.001
	OCT	-.021	.003	-.040	-7.334	<.001
	NOV	-.013	.003	-.024	-4.565	<.001
	MONDAY	.071	.002	.172	28.776	<.001
	TUESDAY	.038	.003	.093	13.681	<.001
	WEDNESDAY	.031	.003	.075	12.029	<.001
	THURSDAY	.033	.003	.080	13.021	<.001
	FRIDAY	.033	.003	.079	12.905	<.001
	SATURDAY	-.006	.003	-.013	-2.177	.030
	lagged log total load 1st grade	.946	.017	.946	54.161	<.001
	lagged log total load 2st grade	-.055	.017	-.055	-3.169	.002

Coefficients[a]

a. Dependent Variable: log total load 23:00 - 24:00

Table 48: Coefficient summary of log total load 23:00 - 24:00

From Model summary of Table 49, we get that the estimated regression model has $R^2 = 0.931$. That implies that about 93.10% of the variations in the log total load of demand electricity are explained by the explanatory variables that are included in the model Because the R^2 is above 90.00% and close to one, it can be concluded that the estimated multiple regression model is a good fit.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.966[a]	.933	.933	.037345267310356
a. Predictors: (Constant), lagged log total load 2st grade, WEDNESDAY, MAR, SEP, THURSDAY, Quadradic term, MONDAY, NOV, APR, FRIDAY, AUG, MAY, SATURDAY, OCT, JUL, TUESDAY, lagged log total load 1st grade				

Table 49: Model summary of log total load 23:00 - 24:00

Following the same procedure of time zone 00:00-01:00, we create Figure 26. As it can be observed, the model again reproduces respectively good enough the actual total load for time zone 23:00-24:00.

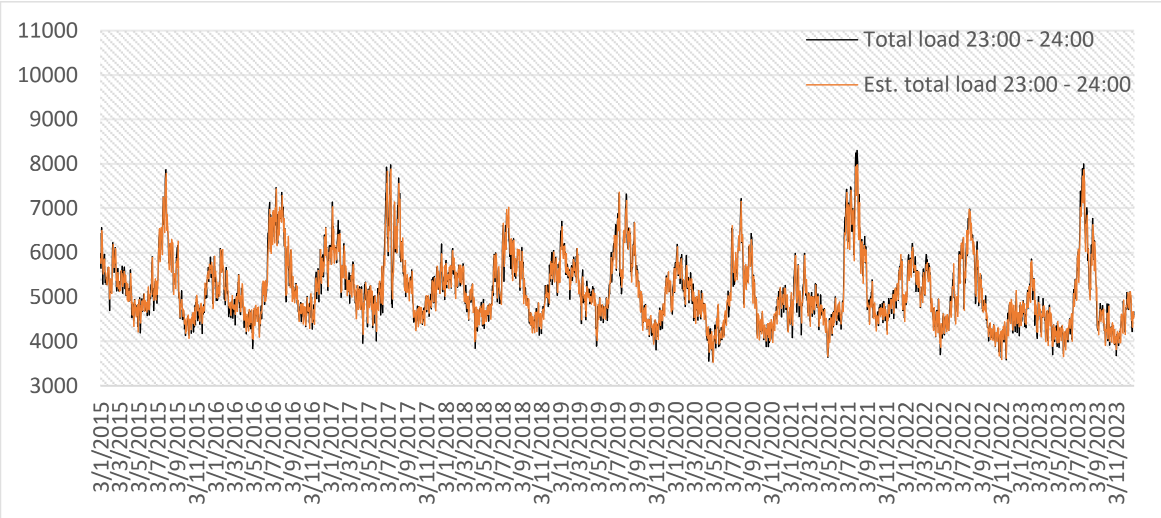

Figure 26: Time plot Total load vs Est. total load of 23:00-24:00

3.3.25 Insights from the performance of the regression models

This chapter has analyzed the factors influencing electricity demand across various time zones, focusing on the statistical models that best capture the dynamics of hourly load demand. The analysis of hourly electricity load across various time zones has revealed significant insights into the seasonal, daily, and temporal dynamics affecting demand. By employing multiple regression models that incorporate trend variables, monthly and daily dummy variables, as well as autoregressive terms, the study effectively captures the complex variations in electricity demand at different times of the day. The models demonstrate high R^2 values across all examined time zones, with each one exceeding 82,90% and several reaching or surpassing 90%, signifying that these models have a strong fit for predicting hourly load within each respective period. More specifically, only the models from 09:00 to 15:00 demonstrate R^2 from 82,90% to 85,00% while the models from 21:00 to 03:00 surpass 90,00% as shown in Figure 27.

These high R^2 values indicate that the chosen variables—monthly and daily patterns, recent load history, and in some cases, quadratic and linear trends—account for most of the variability in the log-transformed total load. This validation supports the robustness of these models and highlights the predictability of electricity load patterns based on historical and seasonal factors.

In addition to the high R-squared values, the time-plots comparing actual and estimated total load for each time zone further validate the effectiveness of the regression models. These visual comparisons reveal that each model reliably replicates the dynamics of total electricity load, closely mirroring the seasonal and monthly demand patterns, including the notable peaks. Although the models successfully capture the qualitative patterns of sudden demand spikes and drops, there are some limitations in accurately quantifying these extreme fluctuations. Nonetheless, the models demonstrate a strong capability to reflect general demand trends, supporting their robustness in reproducing typical variations in electricity demand across the different time zones.

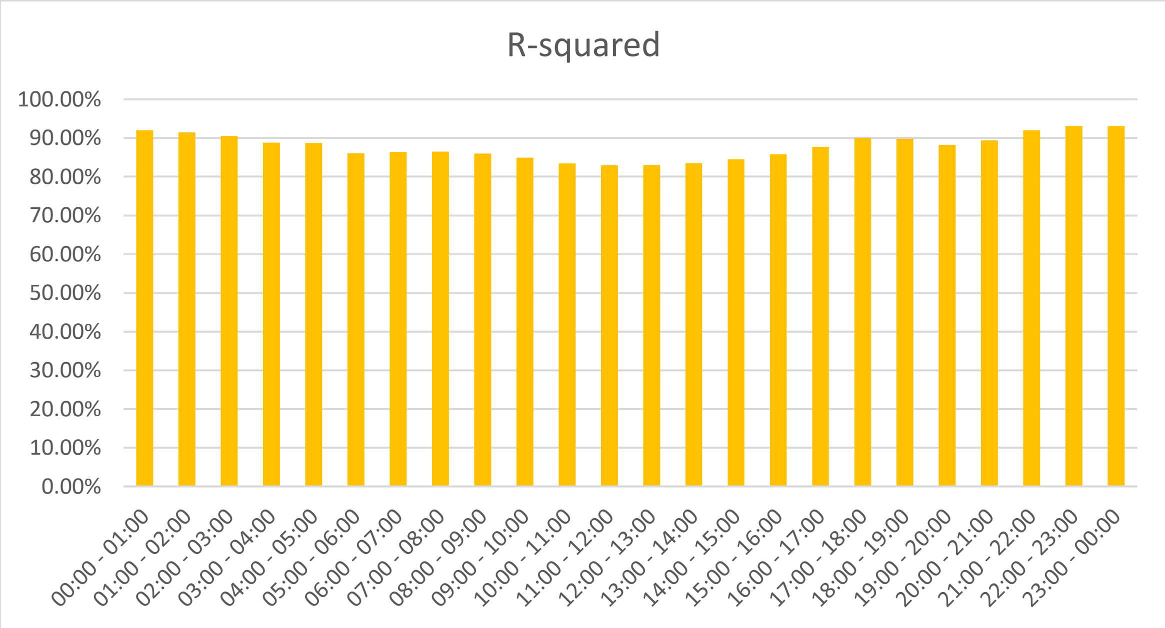

Figure 27: R^2 for regression models from 00:00 – 24:00

Overall, the models not only capture the significant seasonal and daily patterns but also highlight how demand is influenced by both immediate past load (autoregressive terms) and longer-term seasonal trends. More specifically, the most of the models introduce quadratic time trends and, in some cases, linear time trends, capturing the more nuanced curvatures in load that emerge, suggesting that these trends may be particularly useful for modeling electricity load and enhancing further the models' ability to reproduce more complex demand behaviors.

Parallelly, the significant role of the inclusion of autoregressive terms is underscored particularly by the first-grade lagged log total load with the high coefficients associated with this term indicating a pivotal role in the electricity demand models for Greece as it can be observed from Table 50.

	Coefficient of lagged log total load 1st grade	Coefficient of lagged log total load 2st grade
00:00 - 01:00	0.875	-
01:00 - 02:00	0.871	-
02:00 - 03:00	0.856	-
03:00 - 04:00	0.749	0.095
04:00 - 05:00	0.785	0.067
05:00 - 06:00	0.733	0.114
06:00 - 07:00	0.734	0.079
07:00 - 08:00	0.706	0.106
08:00 - 09:00	0.700	0.108
09:00 - 10:00	0.718	0.087
10:00 - 11:00	0.719	0.076
11:00 - 12:00	0.726	0.067
12:00 - 13:00	0.716	0.071
13:00 - 14:00	0.700	0.087
14:00 - 15:00	0.710	0.091
15:00 - 16:00	0.744	0.084
16:00 - 17:00	0.762	0.070
17:00 - 18:00	0.784	0.069
18:00 - 19:00	0.792	0.058
19:00 - 20:00	0.794	0.056
20:00 - 21:00	0.864	-
21:00 - 22:00	0.962	-0.081
22:00 - 23:00	0.992	-0.101
23:00 - 00:00	0.946	-0.055

Table 50: Coefficients of the autoregressive terms for the regression models from 00:00 – 24:00

The first-grade lagged time variable consistently emerges as the dominant factor across all electricity demand models for Greece, with coefficients exceeding 0.70 in all cases and reaching extreme values above 0.90 and close to 1 in certain time zones highlighting the strong correlation between the most immediate past demand and the present consumption patterns and reflecting the persistent nature of electricity usage. This substantial correlation highlights that electricity demand in Greece is heavily reliant on immediate past trends, making essential the inclusion of such terms in the models for capturing the short-term dynamics effectively. The high significance levels (p-values < 0.001) further validate the robustness of this variable in explaining demand fluctuations.

The second-grade lagged time term, while less pronounced and not statistically significant for all zones, still contributes meaningfully to the models adding depth to their understanding of temporal dependencies. Especially for time zones from 21:00 to 24:00, the coefficients of the variable are negative. This negative influence helps balance the extreme positive coefficients of the first-grade lagged time variable ranging from 0.946 to 0.992 during these hours. The interplay between these terms highlights the nuanced nature of temporal dependencies in electricity demand, where the immediate past dominates, but earlier lags can refine the model's accuracy by capturing residual effects and stabilizing predictions.

Together, the high coefficients of the first-grade lagged term and the consistent inclusion of the second-grade term underscore the layered nature of electricity demand dynamics, where recent historical patterns significantly shape present consumption, allowing the models to account for both inertia and short-term fluctuations in demand. This modeling approach not only enhances predictive accuracy but also provides critical insights into the evolution of electricity demand.

3.4 Regression models forecasting accuracy

Running again the 24 regressions for each time zone through SPSS Statistics for the period 2015-2022, the 24 regression models for each time zone were produced. In Appendix E from Table 80 to Table 103, the output of each regression analysis is shown emphasizing in the coefficients of the statistically significant variables.

3.4.1 Insights from the recalibration of the regression models in the estimation sample

First of all, analyzing the results of the new regressions in comparison with the first models, in most of the models all the starting variables are statistically significant for the estimation sample suggesting that these explanatory variables have a stable and meaningful relationship with the dependent variable, making them reliable predictors. Only six variables in six different models are statistically insignificant in the smaller estimation sample, the quadratic term in model of the time zone 05:00-06:00, the dummy variable of June in model of the time zone 06:00-07:00, the dummy variable of August in model of the time zone 10:00-11:00, the quadratic term in model of the time zone 15:00-16:00, the dummy variable of Saturday in model of the time zone 21:00-22:00 and the dummy variable of Saturday in model of the time zone 23:00-24:00 indicating from this loss of significance due to smaller sample that might be weaker predictors.

Moreover, the next features that must be pointed out in the analysis of the new models concern both the sign of the coefficients of the variables but also the values of them. As it was expected all the statistically significant variables have the same sign with the first models respectively, without an exception. At the same time, the values of the coefficients of the variables are very close to the corresponding ones, showing a difference in the second or even the third decimal place of the coefficients. Overall, the fact that the signs and the values of all statistically significant coefficients are consistent across both sets of models indicates that the relationships between the explanatory variables and the dependent variable are stable and reliable reinforcing the robustness of the models.

3.4.2 The forecasting performance metrics for the regression models

Taking into account the above findings, the models are used to produce predictions for each time zone for the year 2023. From Figure 154 to Figure 177 in Appendix E, the hourly forecasted electricity total load of year 2023 for each time zone is presented against the actual electricity total load.

More specifically, from the comparison of the forecasted and the actual electricity total load in these figures, it can be concluded that the models exhibit a high level of accuracy. The alignment between the forecasted values and the actual observed values imply that the models effectively capture the patterns and dynamics of hourly electricity demand for the forecasting sample without significant overestimation or underestimation. Moreover, this absence of systematic biases of either overestimation or underestimation across the time zones highlights the robustness of the models, which consistently capture hourly variations, including peak and off-peak demand. Overall, these figures create great expectations for the models' forecasting accuracy needing although to be verified and quantified through the specific metrics.

The Table 51 displays the performance metrics, Mean Absolute Error (MAE), Mean Absolute Percentage Error (MAPE), and Root Mean Square Error (RMSE), that were calculated for all time zones providing a comprehensive assessment of the models' ability to predict electricity demand.

	MAE	MAPE	RMSE	DIFFERENCE MAE-RMSE
00:00-01:00	134.30	2.96%	179.42	45.13
01:00-02:00	130.81	2.99%	173.31	42.50
02:00-03:00	130.38	3.06%	172.73	42.35
03:00-04:00	93.47	2.21%	123.95	30.48
04:00-05:00	124.38	2.92%	165.11	40.73
05:00-06:00	139.24	3.14%	185.46	46.21
06:00-07:00	177.93	3.72%	247.53	69.60
07:00-08:00	332.81	6.37%	440.66	107.86
08:00-09:00	292.40	5.60%	397.25	104.86
09:00-10:00	312.82	5.31%	425.04	112.22
10:00-11:00	356.84	5.89%	480.01	123.17
11:00-12:00	380.30	6.14%	509.78	129.47
12:00-13:00	393.87	6.33%	527.26	133.39
13:00-14:00	383.26	6.46%	508.11	124.85
14:00-15:00	373.54	6.49%	499.80	126.26
15:00-16:00	329.18	5.84%	440.97	111.79
16:00-17:00	283.83	5.00%	379.22	95.39
17:00-18:00	254.33	4.31%	335.75	81.43
18:00-19:00	225.48	3.71%	305.82	80.35
19:00-20:00	215.84	3.53%	290.19	74.35
20:00-21:00	193.58	3.25%	260.31	66.74
21:00-22:00	174.82	3.13%	235.11	60.28
22:00-23:00	149.18	2.85%	199.43	50.25

23:00-24:00	142.25	2.93%	190.86	48.60

Table 51: Performance metrics for regression models

The analysis of the metrics indicates that all models exhibit strong forecasting accuracy. MAPE scores, consistently below 6.50% for all time zones with a range from 2.21% to 6.49%, demonstrate that the models perform well under both stable and dynamic demand conditions. Moreover, the MAE and RMSE values align closely for the majority of time zones with a range from 93.47 MW to 393,87 MW and from 123.95 to 527.26 respectively, indicating that the models effectively minimize forecasting errors without significant outliers skewing results. The difference between MAE and RMSE highlights the sensitivity of the models to larger errors. For example, in the 12:00-13:00 period, the difference is 133.39, indicating the presence of some larger-than-average forecasting errors, which are likely due to spikes in demand. In contrast, during 03:00-04:00, the difference is only 30.48, suggesting that errors are more evenly distributed without significant outliers. While the metrics confirm the overall forecasting reliability of the models, a more nuanced analysis can be achieved by contrasting the performance metrics across time zones and possibly identify specific patterns or discrepancies that will provide deeper insights into the models' behavior.

3.4.3 The forecasting performance of the models against the variability of electricity demand

A helpful insight in the analysis would be the inclusion of the actual total load data for year 2023, segmented by average and standard deviation, as shown in Table 52, providing additional context for interpreting the metrics. Stable periods are characterized by smaller standard deviations (e.g., 631.17 MW during 05:00-06:00) whereas larger standard deviations would reveal peak periods (e.g., 1354.37 MW during 12:00-13:00) hese variations must be taken into account as they underscore the influence of demand variability on model accuracy.

Time zone	AVERAGE (m)	ST. DEVIATION (s)
00:00-01:00	4486.90	805.49
01:00-02:00	4344.66	749.06

02:00-03:00	4239.25	708.29
03:00-04:00	4188.01	674.31
04:00-05:00	4262.11	644.29
05:00-06:00	4515.15	631.17
06:00-07:00	4948.32	743.44
07:00-08:00	5413.76	860.03
08:00-09:00	5404.84	831.97
09:00-10:00	6087.89	1076.37
10:00-11:00	6233.34	1174.38
11:00-12:00	6338.71	1265.36
12:00-13:00	6351.81	1354.37
13:00-14:00	6162.76	1409.72
14:00-15:00	5997.41	1380.96
15:00-16:00	5866.76	1320.40
16:00-17:00	5882.15	1235.64
17:00-18:00	6033.28	1146.26
18:00-19:00	6140.38	1018.55
19:00-20:00	6191.54	896.65
20:00-21:00	6006.22	883.63
21:00-22:00	5604.76	888.39
22:00-23:00	5226.46	876.14
23:00-24:00	4811.09	847.03

Table 52: Metrics on actual electricity total load per time zone for 2023

Given the above, the following figures contribute into visualizing the above tables and comparing the performance scores.

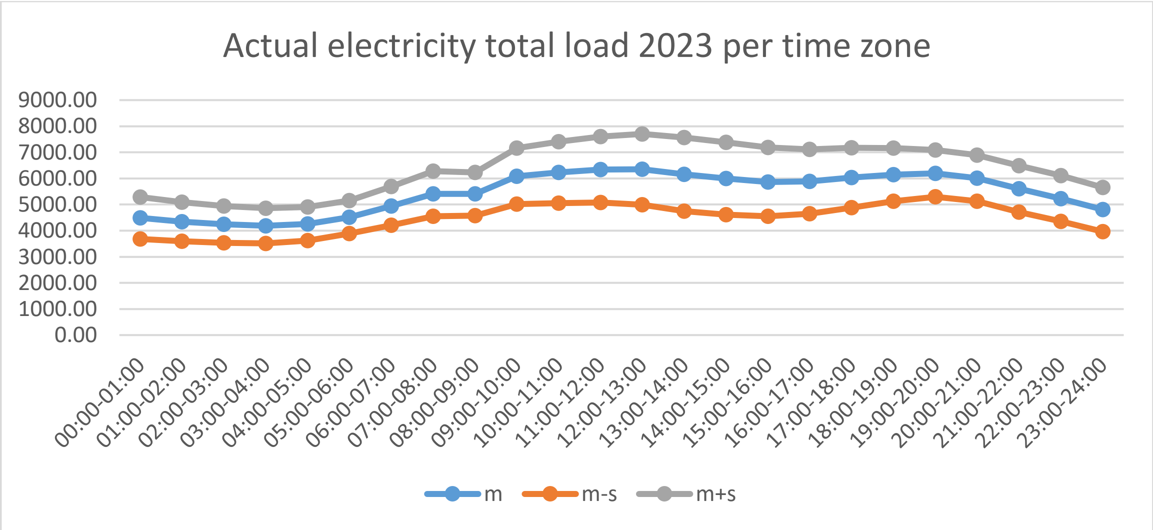

Figure 28: Distribution of actual total load of 2023 per time zone

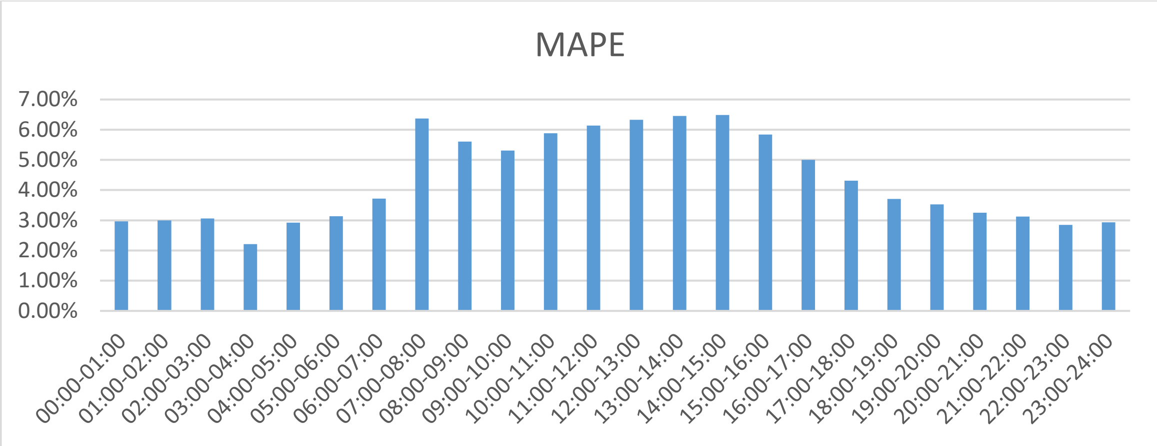

Figure 29: MAPE scores of regression models per time zone

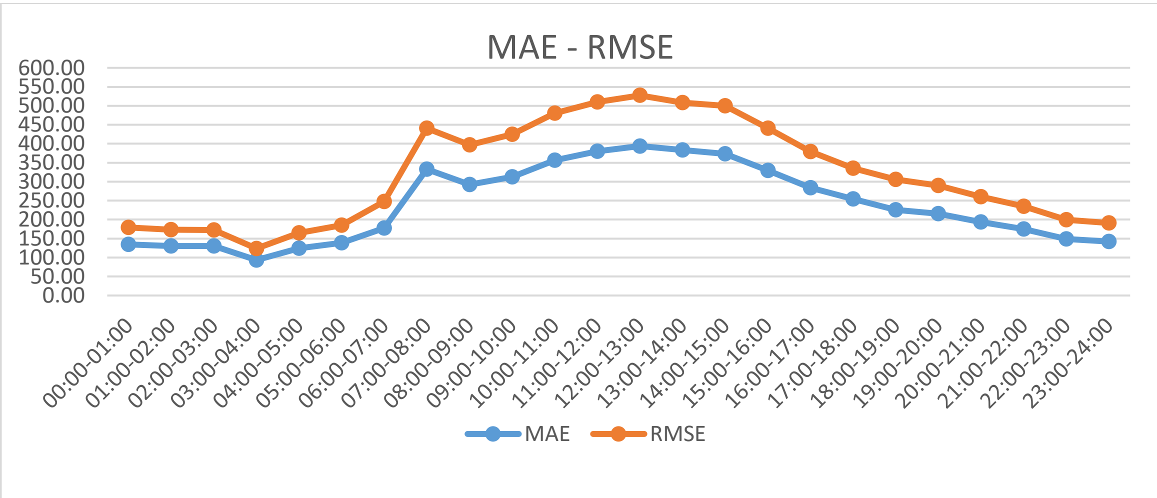

Figure 30: MAE and RMSE scores of regression models per time zone

- Midnight to Early Morning (00:00–07:00)

In these time zones, where as it can be seen in Figure **28** the electricity demand has lower average than other hours of the day with lower viability also, the models exhibit the lowest metrics' values, with minimal deviations between actual and predicted loads. The MAE values range from 93.47 (03:00–04:00) to 177.93 (06:00–07:00) while MAPE remains below 3.8%, with the best scoring model be the one for time zone 03:00-04:00 with a MAPE score only 2.21%, showing overall consistent model performance during these hours of low demand variability. RMSE is also relatively low and higher than MAE across all periods, with the largest deviation from MAE at 69.60 (05:00–06:00) not implicating any strong influence of extreme values in the forecasting procedure. All the above indicate that the models perform best when electricity demand is stable and there are fewer fluctuations in electricity total load

- Morning Hours (07:00–12:00)

In these times zones, metrics begin to reflect increased forecasting difficulty as demand rises. MAE grows significantly starting at 332.81 MW (07:00–08:00) while peaking at 380.30 (11:00–12:00), and RMSE, having the same behavior, shows larger deviations from MAE especially in peak hours (e.g., 129.47 during 11:00–12:00) indicating sensitivity to large errors. MAPE rises moderately but remains below 6.4%, indicating that, although the rise in demand variability impacts the forecasting accuracy of the models, there is still reliable performance despite the higher loads.

- Afternoon Hours (12:00–18:00)

During these peak hours of the day as concerns the variability in electricity demand, the models exhibit higher error rates. Higher MAPE values are more common during the daytime peak periods, with MAPE reaching in the higher level at 14:00-15:00 with 6.49%, suggesting that the relative accuracy drops due to fluctuating electricity demand in these hours. This is evident from the MAE values reaching 393.87 MW (12:00-13:00) and 383.26 MW (13:00-14:00). The RMSE values also peak during these hours, reaching 527.26 and 508.11 respectively underlining the sensitivity of the models to extreme deviations, especially during demand peaks. Although it can be noticed that all the metrics shows a downward trend as demand variability drops for the later time zones respectively.

- Evening to Midnight Hours (18:00–24:00)

In these periods, as demand variability drops as shown in Figure **28**, the metrics begin to improve again. The MAPE score drops below 4% for all the models in this period indicating that the models exhibit a high forecasting accuracy. Accordingly, both MAE and RMSE decline from 225.48MW and 305.82MW (18:00-19:00) to 142.25MW and 190.86MW (23:00-24:00) showing again that the stability of electricity demand ensures consistent model performance.

3.5 The typical models in electricity demand of Greece

In Appendix F, after the production of electricity demand's forecasts for year 2023 with the eight typical models, the performance metrics for each time zone from Table 104 to Table 127 are presented.

3.5.1 Forecasting accuracy of typical models

Starting the analysis with the SMA models, it is revealed varying performance for these models depending on the size of the averaging window and the time zone with MAPE scores range from close to 4% to above 11%. Simultaneously, all the SMA models are affected from the variability of electricity demand in each time zone. In time zones with more stable demand the models demonstrate lower metrics and better performance respectively while in peak demand periods the models create larger errors as it can be concluded both from MAE and RMSE for each model due to their inability to adapt effectively to the changes in electricity demand. The best performing models are the SMA (2) and SMA (7) with SMA (2) excel in all metrics against the other SMA models for the time zones from 00:00 to 06:00 and from 10:00 to 24:00 while the SMA (7) excel for the time zones from 06:00 to 10:00. The other two SMA models reveals poorer performance comparatively. SMA (14) and SMA (4) seem to struggle in adapting to changes in electricity demand with underreacting or overreacting respectively and having as a result moderate to poor MAPE scores in contrast with the other two models, higher MAE and RMSE scores.

On the other hand, EWMA models, benefiting from their dynamic weighting mechanism, performed consistently better than the corresponding SMA models. Although it can be seen that their performance is influenced by the smoothing factor λ with MAPE scores range from above 3.6% to below 9%. EWMA ($\lambda = 0.1$) model consistently emerged as the best-performing model in the different time zones, reflected in lower MAE and RMSE values during not only high-demand but also more stable periods. As it is shown its ability to quickly adapt to sudden changes made it particularly effective in environments, where electricity demand frequently fluctuates as it is shown by the metrics in high peak hours. Conversely, EWMA ($\lambda = 0.9$) model has the poorest performance across all time zones due to its heavy reliance on historical data, resulting in sluggish responses to real-time demand changes. The model's high MAE and RMSE values surpassing 600 MW and 770 MW during peak periods from 12:00 to 15:00 underscored its inability to track rapid demand changes. More over to that, the fact EWMA ($\lambda = 0.3$) model perform better than EWMA ($\lambda = 0.6$) model confirms that the hourly electricity demand in Greece is significantly affected by the recent need of electricity total load given that EWMA ($\lambda = 0.3$) model assigns more weight to recent data than the past one.

3.5.2 Typical models against the regression models

Taking the above into account and the results from Table 104 to Table 127 in Appendix F, the regression models clearly outperformed all other models, including SMA and EWMA, across all time zones demonstrating the lowest MAE, MAPE, and RMSE scores. This superior accuracy, adaptability, and robustness in forecasting electricity demand is derived mainly due to regression models' ability to integrate various predictive variables, such as lagged electricity demand, seasonal effects, and dummy variables for the different time zones.

Although this clear prevalence of regression models, there are perspectives that need to be pointed out by focusing the analysis among the two best-performing typical models, SMA(2) and EWMA ($\lambda = 0.1$), and the regression models.

MAE			
	REGRESSION	Abs. Per. SMA(2) - REGRESSION	Abs. Per. EWMA (λ=0.1) - REGRESSION
00:00-01:00	134.30	39.17%	23.37%
01:00-02:00	130.81	36.76%	21.56%
02:00-03:00	130.38	33.49%	19.13%
03:00-04:00	93.47	86.97%	63.26%
04:00-05:00	124.38	51.35%	33.87%
05:00-06:00	139.24	91.68%	65.10%
06:00-07:00	177.93	142.37%	102.52%
07:00-08:00	332.81	54.40%	29.60%
08:00-09:00	292.40	89.49%	62.12%
09:00-10:00	312.82	73.67%	52.03%
10:00-11:00	356.84	51.13%	33.12%
11:00-12:00	380.30	41.79%	25.25%
12:00-13:00	393.87	39.90%	23.63%
13:00-14:00	383.26	49.23%	31.22%
14:00-15:00	373.54	58.38%	41.11%

15:00-16:00	329.18	52.06%	35.28%
16:00-17:00	283.83	58.10%	40.86%
17:00-18:00	254.33	63.97%	44.23%
18:00-19:00	225.48	72.21%	48.59%
19:00-20:00	215.84	76.12%	48.45%
20:00-21:00	193.58	68.03%	41.83%
21:00-22:00	174.82	57.78%	32.02%
22:00-23:00	149.18	58.63%	33.48%
23:00-24:00	142.25	44.89%	26.49%
	AVERAGE	62.15%	40.75%
	MAX	142.37%	102.52%
	MIN	33.49%	19.13%

Table 53: Comparison of MAE scores of typical models against regression models per time zone

MAPE			
	REGRESSION	Abs. Per. SMA(2) - REGRESSION	Abs. Per. EWMA (λ=0.1) - REGRESSION
00:00-01:00	2.96%	39.41%	24.04%
01:00-02:00	2.99%	37.33%	22.50%
02:00-03:00	3.06%	33.79%	19.91%
03:00-04:00	2.21%	88.64%	64.97%
04:00-05:00	2.92%	52.19%	35.05%
05:00-06:00	3.14%	92.67%	65.99%
06:00-07:00	3.72%	144.20%	103.19%
07:00-08:00	6.37%	55.37%	29.94%
08:00-09:00	5.60%	75.39%	49.43%
09:00-10:00	5.31%	73.60%	51.75%
10:00-11:00	5.89%	51.69%	33.75%
11:00-12:00	6.14%	42.59%	26.06%
12:00-13:00	6.33%	41.04%	24.72%
13:00-14:00	6.46%	49.12%	31.22%
14:00-15:00	6.49%	50.61%	34.59%
15:00-16:00	5.84%	51.24%	34.70%
16:00-17:00	5.00%	57.49%	40.72%
17:00-18:00	4.31%	64.29%	44.70%

18:00-19:00	3.71%	73.73%	50.18%
19:00-20:00	3.53%	76.81%	49.46%
20:00-21:00	3.25%	68.23%	42.38%
21:00-22:00	3.13%	57.71%	32.23%
22:00-23:00	2.85%	58.66%	33.67%
23:00-24:00	2.93%	44.84%	26.66%
AVERAGE		61.69%	40.49%
MAX		144.20%	103.19%
MIN		33.79%	19.91%

Table 54: Comparison of MAPE scores of typical models against regression models per time zone

RMSE			
	REGRESSION	Abs. Per. SMA(2) - REGRESSION	Abs. Per. EWMA (λ=0.1) - REGRESSION
00:00-01:00	179.42	34.02%	19.78%
01:00-02:00	173.31	32.44%	18.36%
02:00-03:00	172.73	29.69%	16.97%
03:00-04:00	123.95	78.81%	58.42%
04:00-05:00	165.11	43.18%	26.22%
05:00-06:00	185.46	75.82%	54.52%
06:00-07:00	247.53	114.03%	90.62%
07:00-08:00	440.66	42.39%	28.59%
08:00-09:00	397.25	70.80%	55.27%
09:00-10:00	425.04	58.57%	44.69%
10:00-11:00	480.01	41.11%	29.03%
11:00-12:00	509.78	33.90%	23.40%
12:00-13:00	527.26	32.63%	23.32%
13:00-14:00	508.11	42.14%	32.70%
14:00-15:00	499.80	48.61%	39.52%
15:00-16:00	440.97	42.25%	32.69%
16:00-17:00	379.22	48.12%	36.36%
17:00-18:00	335.75	53.88%	39.58%
18:00-19:00	305.82	57.24%	41.38%
19:00-20:00	290.19	61.34%	43.57%
20:00-21:00	260.31	55.24%	37.28%

21:00-22:00	235.11	45.51%	26.40%
22:00-23:00	199.43	47.45%	28.21%
23:00-24:00	190.86	37.34%	21.72%
	AVERAGE	51.10%	36.19%
	MAX	114.03%	90.62%
	MIN	29.69%	16.97%

Table 55: Comparison of RMSE scores of typical models against regression models per time zone

Based on Table 53, Table 54 and Table 55 the regression models achieve substantial percentage reductions in forecasting errors against the typical models. In terms of MAE, regression models achieved an average reduction of 62.15% compared to SMA(2) and 40.75% relative to EWMA ($\lambda = 0.1$). Similarly, for MAPE, regression models showed an average reduction of 61.69% against SMA(2) and 40.49% to EWMA ($\lambda = 0.1$) while ,in terms of RMSE, regression models recorded an average reduction of 51.10% compared to SMA(2) and 36.19% against EWMA(λ=0.1). Simultaneously, it can be observed that the range of these metrics vary at a substantial amount from the average values of the metrics, as for example the reduction in the MAE against SMA(2) model varies from 33.49% to 142.37%, implying that the models need to be also compared based on the different time zones. This comparison of the metrics is shown from Figure 31 to Figure 33 where the three performance metrics of all models for each time zone is visualized against its other.

For example, it can be noticed that, during night hours from 21:00 to 05:00, although the regression models maintained the best performance with MAE scores staying below 150 MW and MAPE scores close to 3%, indicating superior precision, both SMA (2) and EWMA ($\lambda = 0.1$) models, taking advantage of the more stable electricity demand conditions, delivered competitive results as well, with MAE and MAPE scores close to those of regression models. However, it must be pointed out that EWMA ($\lambda = 0.1$) model not only performed slightly better than SMA(2) models due to reduced overactivity but also behave substantially well against the regression models succeeding MAPE scores that are greater than the regression ones' just below 1% for most of these time zones.

That is not although the case for time zones 05:00-06:00 and 06:00-07:00 where the demand variability is similar with the above time periods. As it is revealed the SMA(2) and EWMA ($\lambda = 0.1$) models create forecasts that struggle to match the accuracy of regression models during this 05:00-07:00 time period, where demand begins the transition from stable overnight levels to slight increasing morning activity. During this period, the MAE in regards to the regression models for SMA(2) was greater of 127.66 MW (05:00-06:00) and 253.31 MW (06:00-07:00), showing a sharp decline in predictive performance with also EWMA ($\lambda = 0.1$) models showing reduced accuracy, with MAE values exceeding of 90.64 MW (05:00-06:00) and 182.41 MW (06:00-07:00), reflecting the challenge of adjusting to rapidly changing conditions despite its adaptive mechanism

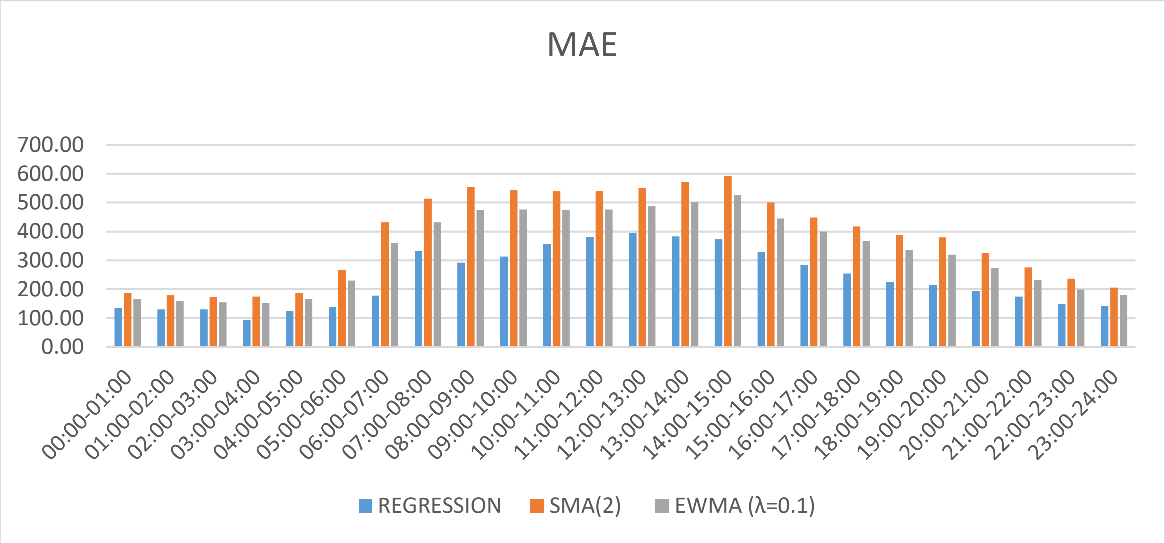

Figure 31: Comparison of MAE scores of best performing models per time zone

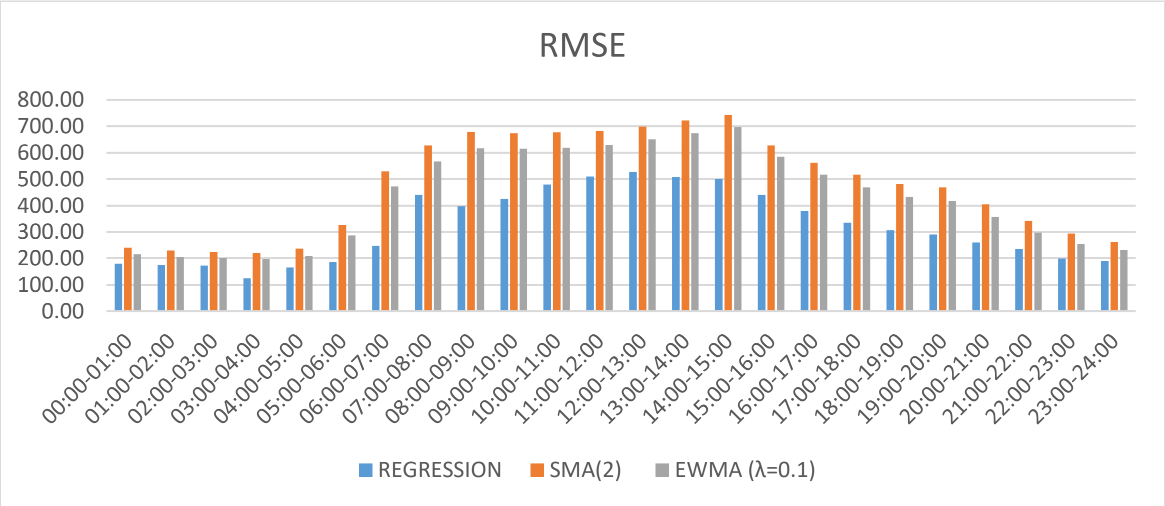

Figure 32: Comparison of RMSE scores of best performing models per time zone

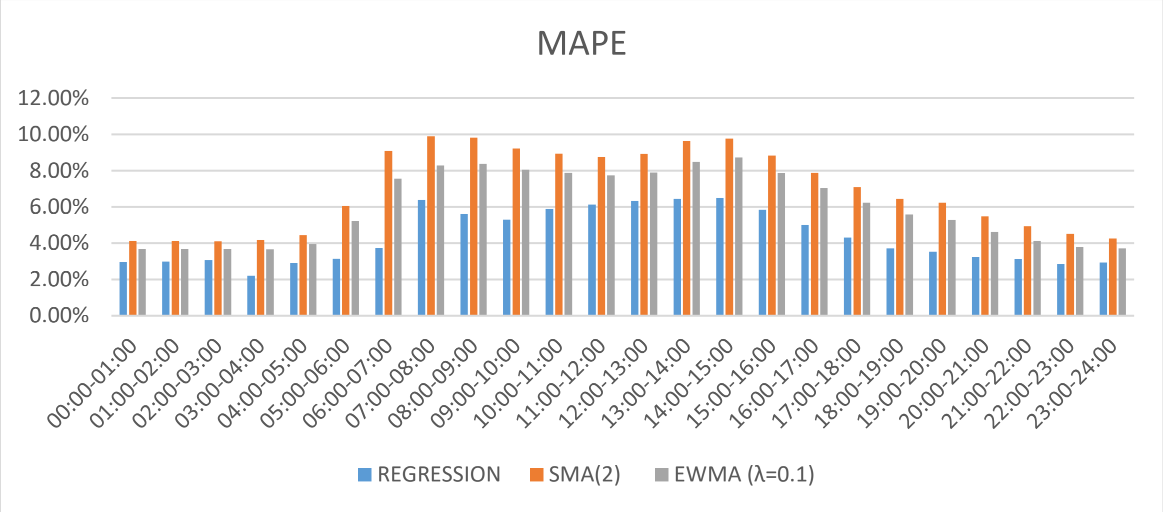

Figure 33: Comparison of MAPE scores of best performing models per time zone

The same pattern is observed in the rest time zones where electricity demand displays peaks and higher volatility with rapid changes as morning, afternoon and late evening hours. During these high-variability periods, regression models clearly outperformed the others, maintaining substantial lower both MAE and RMSE values. The regression models consistently maintained a competitive edge against the simpler SMA and EWMA models, minimizing prediction errors and maximizing forecasting accuracy compared to all.

In summary, the regression models emerged as the most adaptable, performing well across all time zones regardless of demand volatility. Their ability to incorporate multiple predictors and adjust based on recent historical patterns allowed them to remain effective in both stable and more dynamic environments. EWMA ($\lambda = 0.1$) proved the second most adaptable model, effectively capturing short-term trends and reducing forecasting errors when sudden demand changes occurred. In contrast, SMA(2) was least adaptable, excelling only during low-demand and stable periods. Its limited averaging window hindered its ability to maintain accuracy during prolonged high-demand or highly variable conditions. Overall, these metrics confirmed that regression models that where created are respectively well-suited for electricity demand forecasting under diverse scenarios, regardless of demand volatility.

4. Conclusion

This dissertation has focused on analyzing and understanding the electricity demand in Greece exploiting the hourly electricity load data from 2015 to 2023. By leveraging a systematic approach emphasizing in the necessity of segmenting the analysis by time zone and prompting a segmented analysis for the development of accurate estimation models, the study unveiled significant findings regarding the statistical properties of electricity demand and developed models to replicate and predict its behavior.

This research identified through descriptive analysis distinct different behaviors of electricity demand for the different time zones and statistically validated for each time zone inherent patterns and properties including trend, monthly and weekday seasonality illuminating the additional layers of complexity in electricity demand of Greece. Regression models were developed incorporating trend components, monthly and daily dummy variables, and lagged-time terms, effectively capturing these dynamics but also highlighting the strong correlation of electricity total load on direct past observations across all time zones. These models that succeeded to capture the underlying structure of electricity demand created respectively good enough forecasts especially for more stable time zones like the late-night hours. When compared with typical and simpler models like simple moving average and exponential weighted moving average, the regression models demonstrated superior performance across all time zones especially for the time zones that exhibit the most volatile demand, offering a more accurate and nuanced representation of electricity demand.

By incorporating in this dissertation these simpler statistical models, it was prioritized clarity and the ability to uncover the underlying inherent drivers of demand over achieving marginally higher predictive accuracy with complex methodologies. This approach aligns with the objective of fostering a deeper understanding of the fundamental properties of electricity demand of Greece rather than focusing solely on immediate practical applications.

Although this study’s models and findings may not have direct and immediate practical applications, they lay a strong foundation for further investigation. The insights derived can either guide the development of more sophisticated forecasting tools such as hybrid or machine learning models for more precise predictions or inform energy policy and market strategies or even provide a framework for future research whether by examining other regions under different conditions or by incorporating additional external factors such as temperature, energy prices and GDP. Building on this foundation, it would also be valuable to explore the application of data analysis models to predict other key variables of the electricity system, such as wholesale electricity prices. For instance, studies in the Greek day-ahead market have demonstrated how factors such as load demand, renewable energy generation, and fuel costs influence pricing behaviors, highlighting the potential of advanced econometric methods, such as nonlinear panel models, to improve forecast accuracy and market efficiency (Nikolaos S. Thomaidis & Pandelis N. Biskas, 2021). This direction could provide deeper insights into the complex dynamics of electricity demand and enhance decision-making processes for market participants.

In conclusion, this dissertation has demonstrated that even simple models can reveal valuable insights into the complex phenomenon of electricity demand. The deliberate choice to prioritize simplicity and interpretability has facilitated a clearer understanding of the underlying dynamics in Greece’s electricity demand. While the immediate practical utility of this work may be limited, its contribution lies in establishing a basis for future exploration and refinement, potentially advancing the field of electricity demand forecasts.

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Appendix A: Figures of actual total load of electricity per time zone

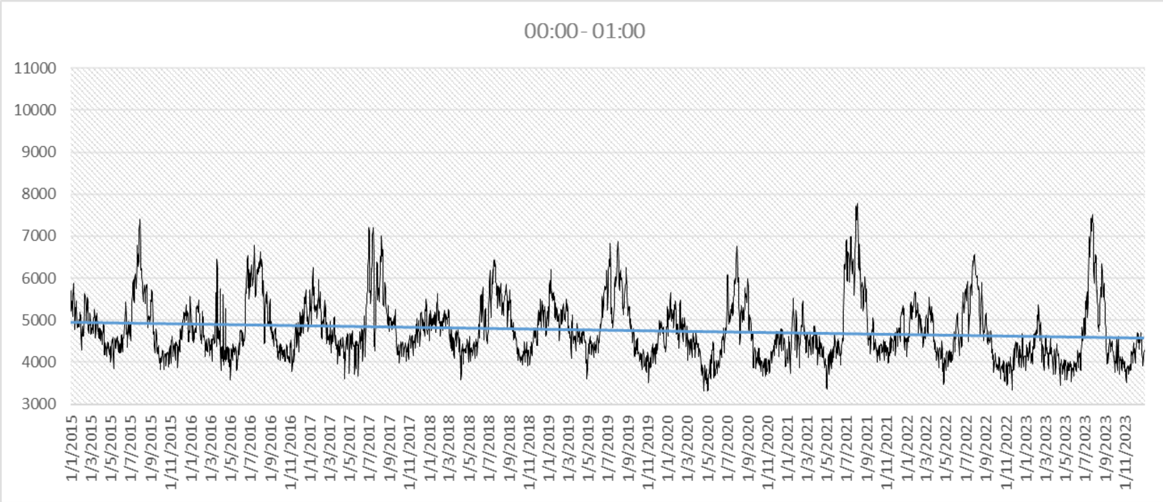

Figure 34: Actual total load of electricity in Greece for time zone 00:00-01:00

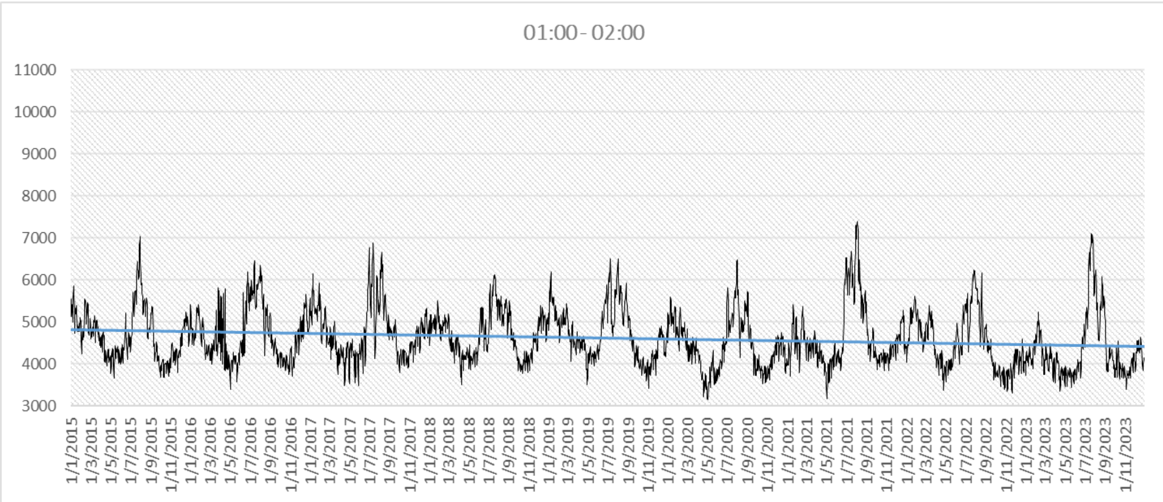

Figure 35: Actual total load of electricity in Greece for time zone 01:00-02:00

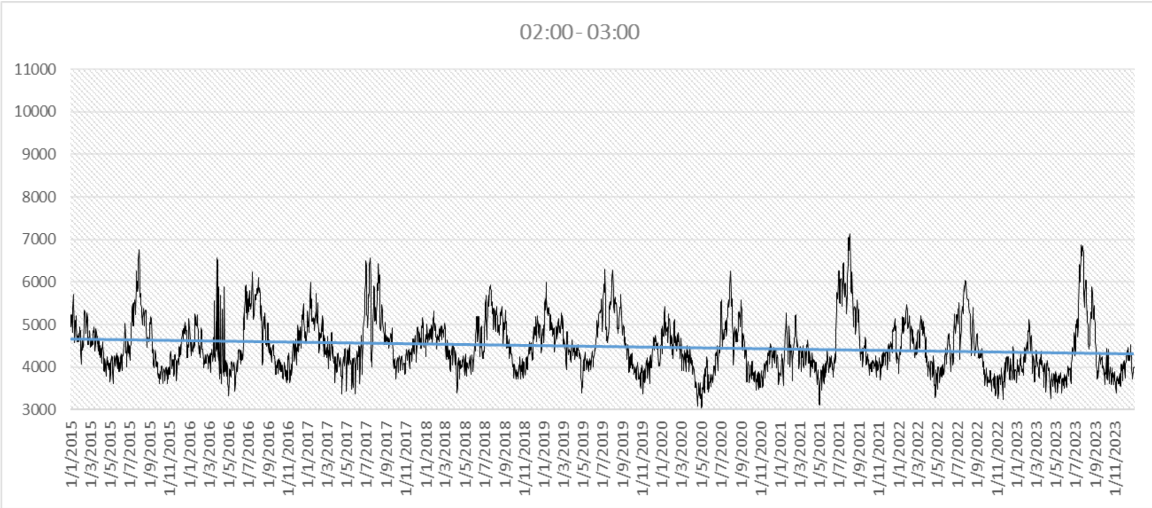

Figure 36: Actual total load of electricity in Greece for time zone 02:00-03:00

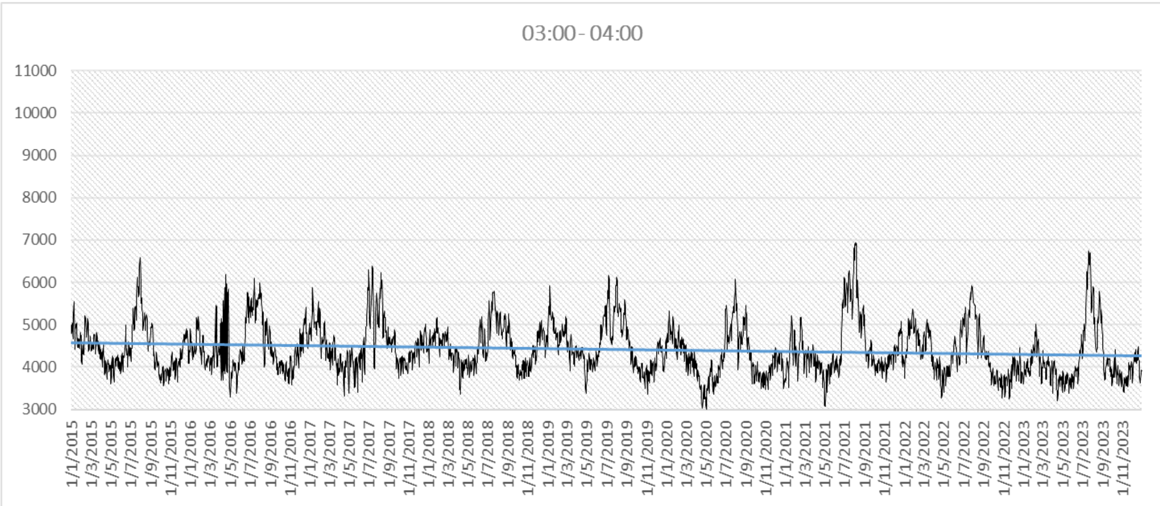

Figure 37: Actual total load of electricity in Greece for time zone 03:00-04:00

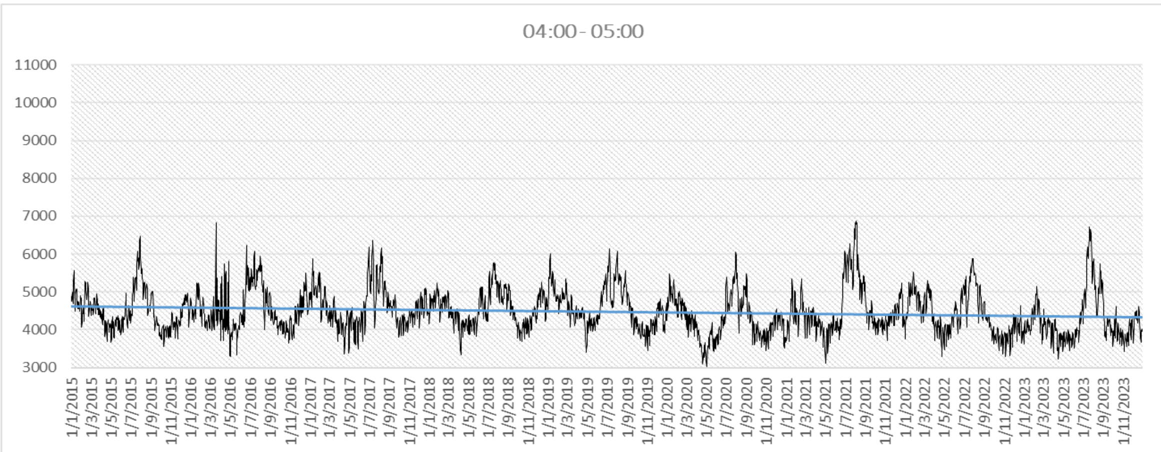

Figure 38: Actual total load of electricity in Greece for time zone 04:00-05:00

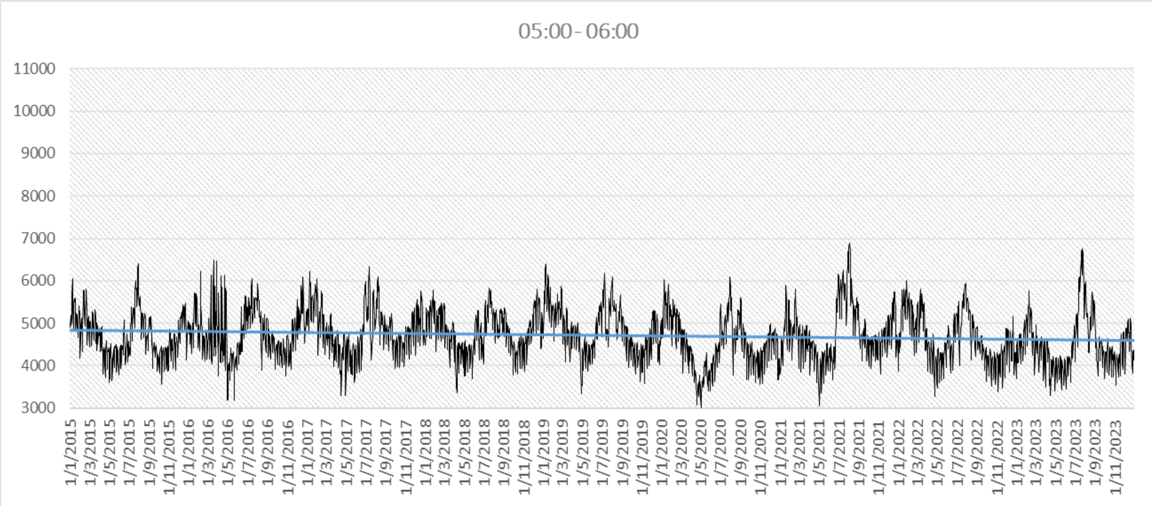

Figure 39: Actual total load of electricity in Greece for time zone 05:00-06:00

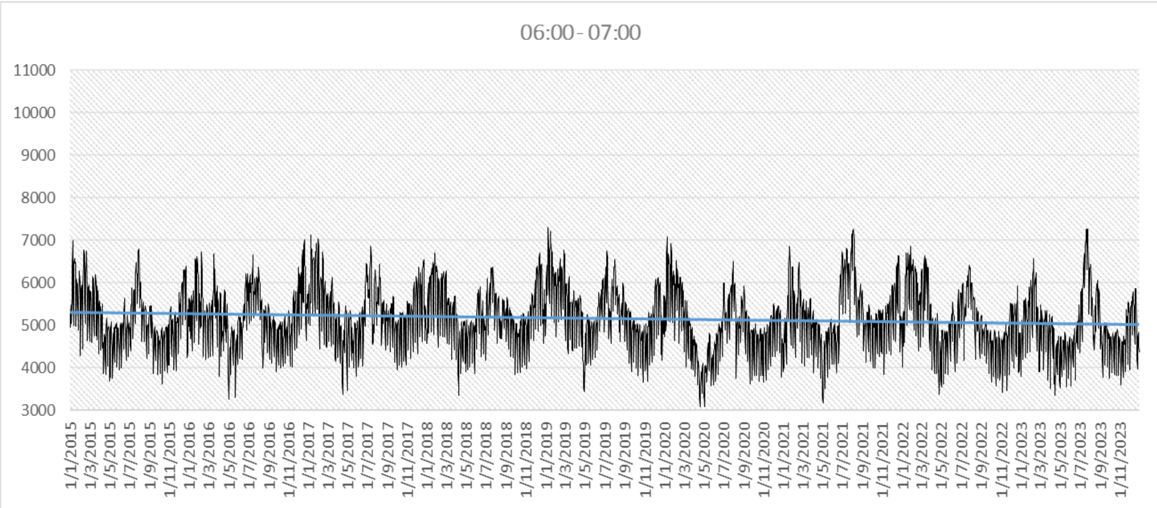

Figure 40: Actual total load of electricity in Greece for time zone 06:00-07:00

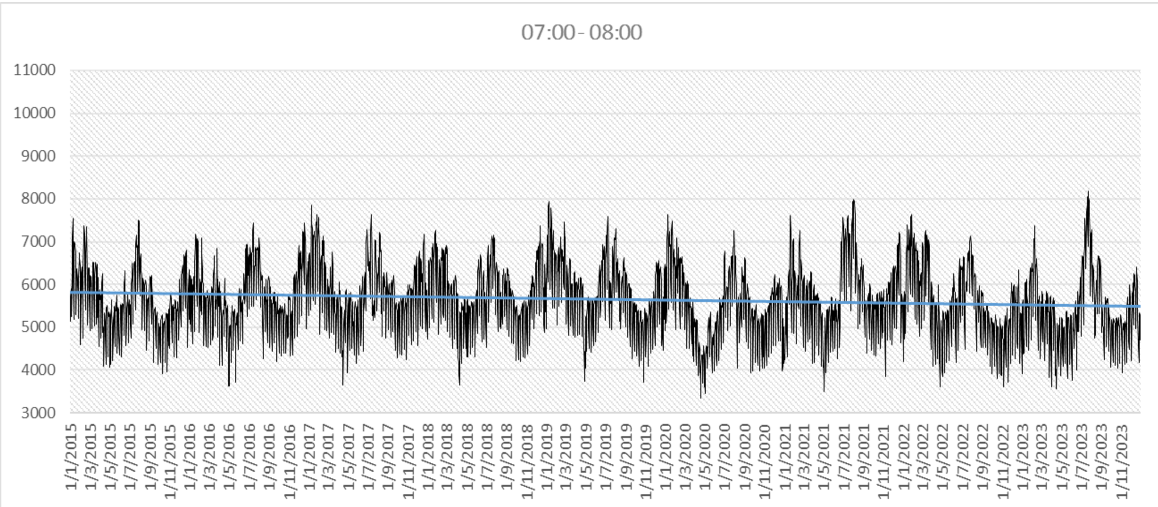

Figure 41: Actual total load of electricity in Greece for time zone 07:00-08:00

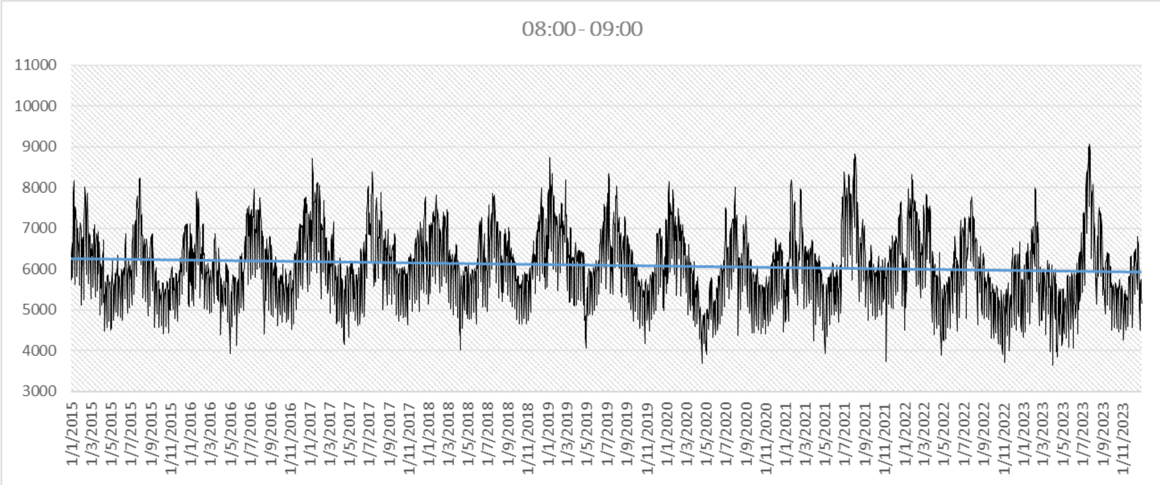

Figure 42: Actual total load of electricity in Greece for time zone 08:00-09:00

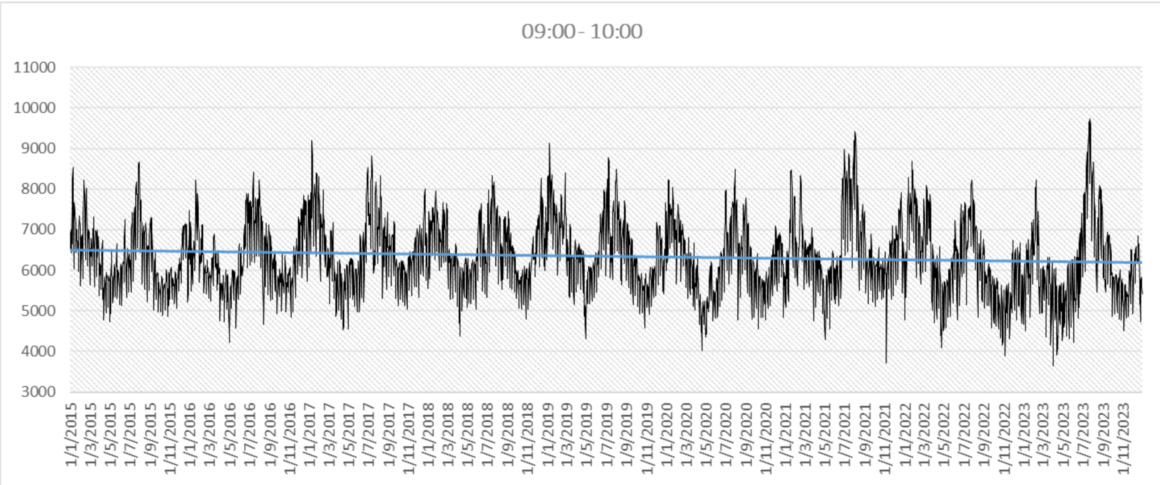

Figure 43: Actual total load of electricity in Greece for time zone 09:00-10:00

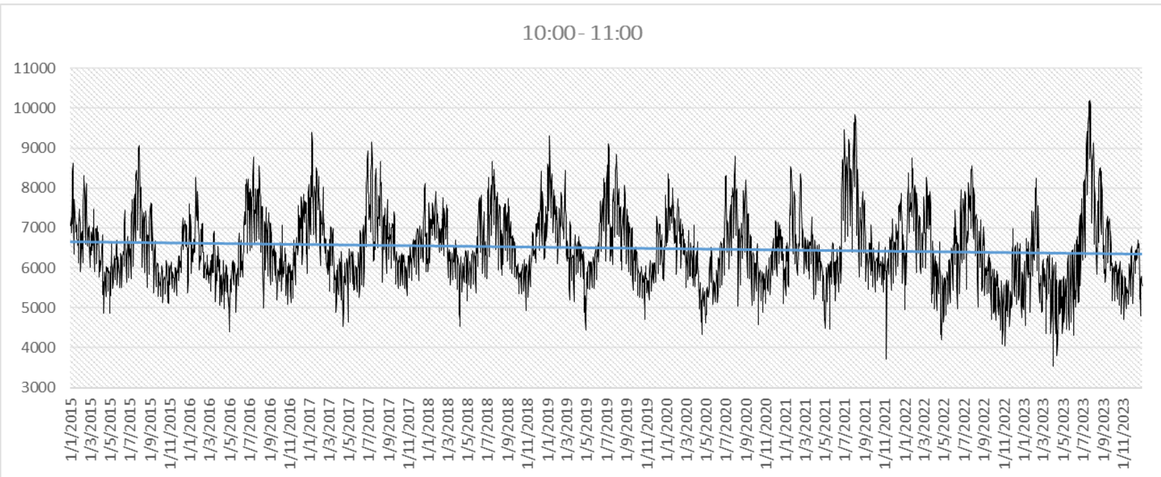

Figure 44: Actual total load of electricity in Greece for time zone 10:00-11:00

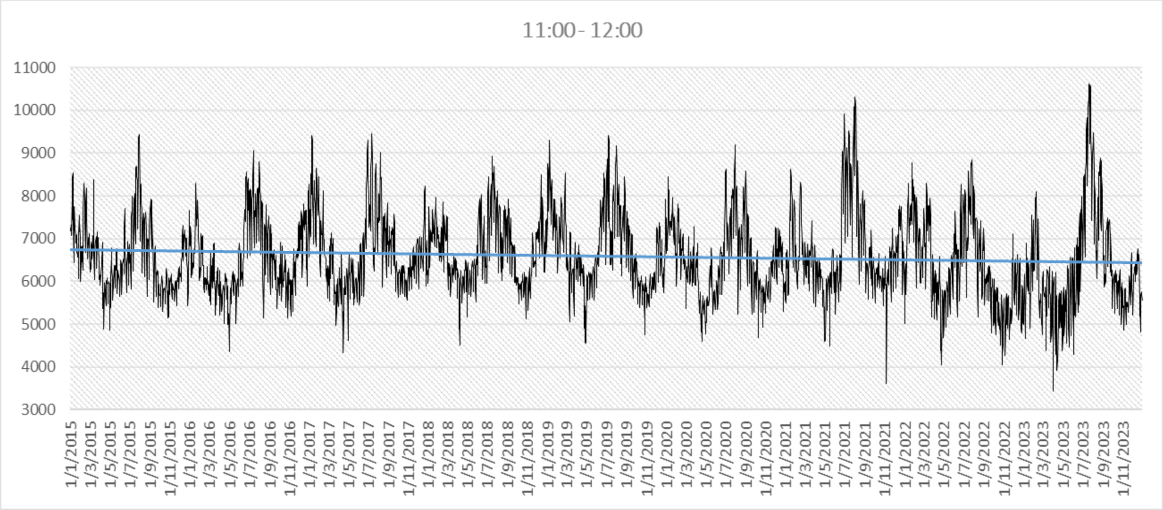

Figure 45: Actual total load of electricity in Greece for time zone 11:00-12:00

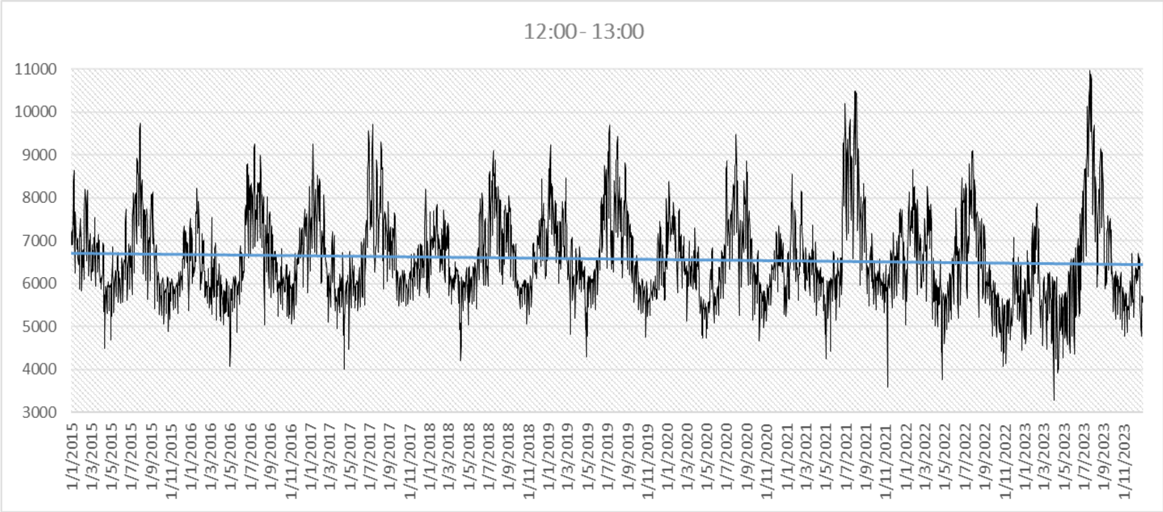

Figure 46: Actual total load of electricity in Greece for time zone 12:00-13:00

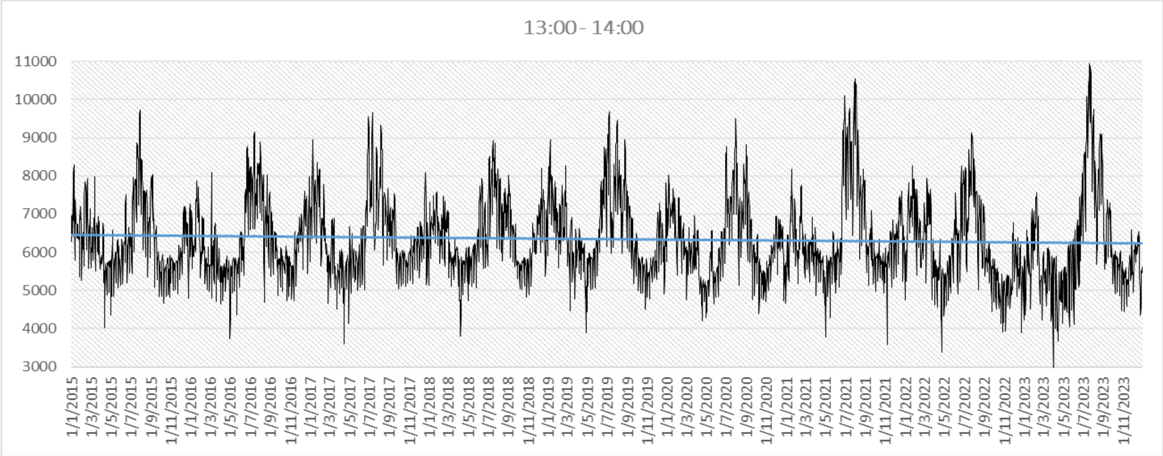

Figure 47: Actual total load of electricity in Greece for time zone 13:00-14:00

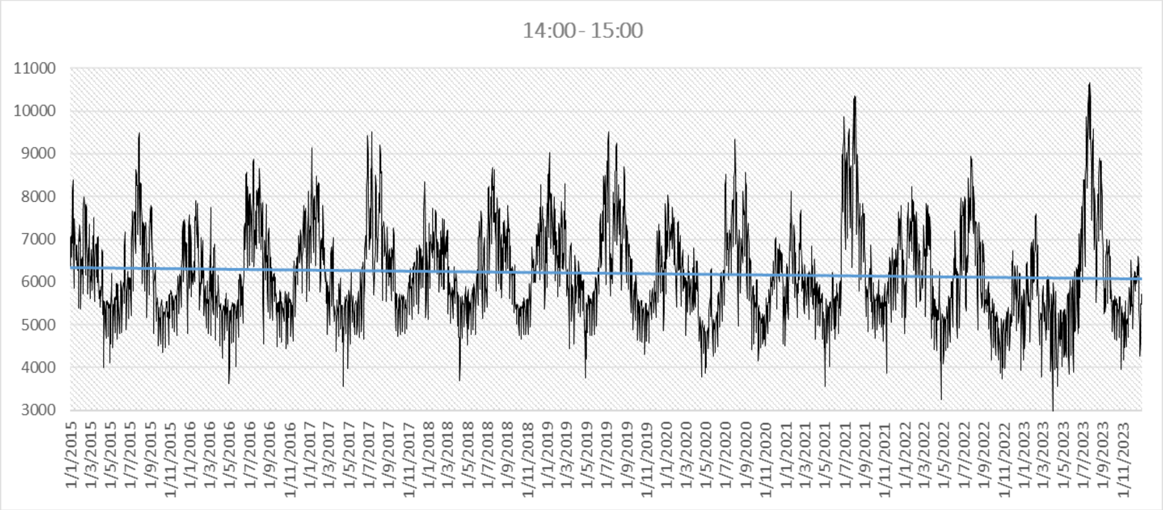

Figure 48: Actual total load of electricity in Greece for time zone 14:00-15:00

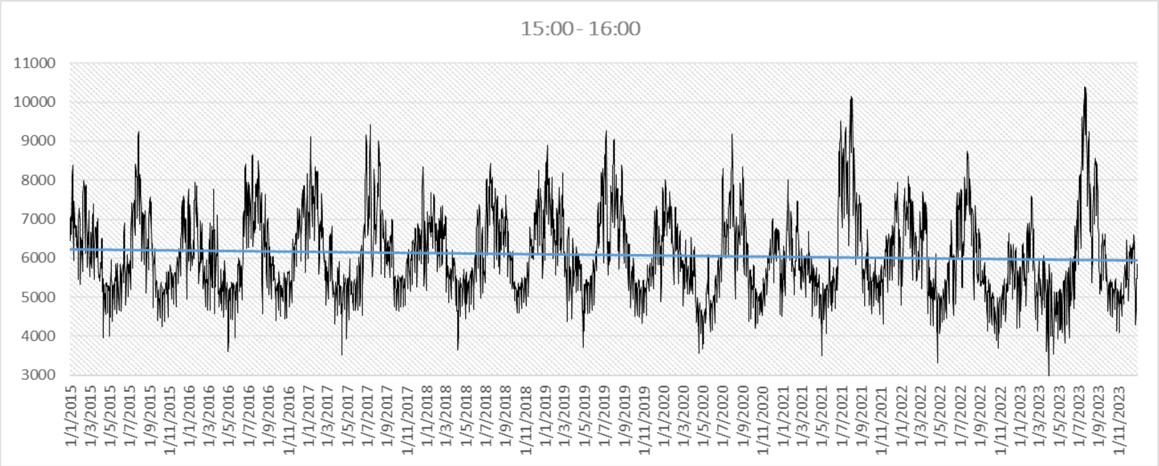

Figure 49: Actual total load of electricity in Greece for time zone 15:00-16:00

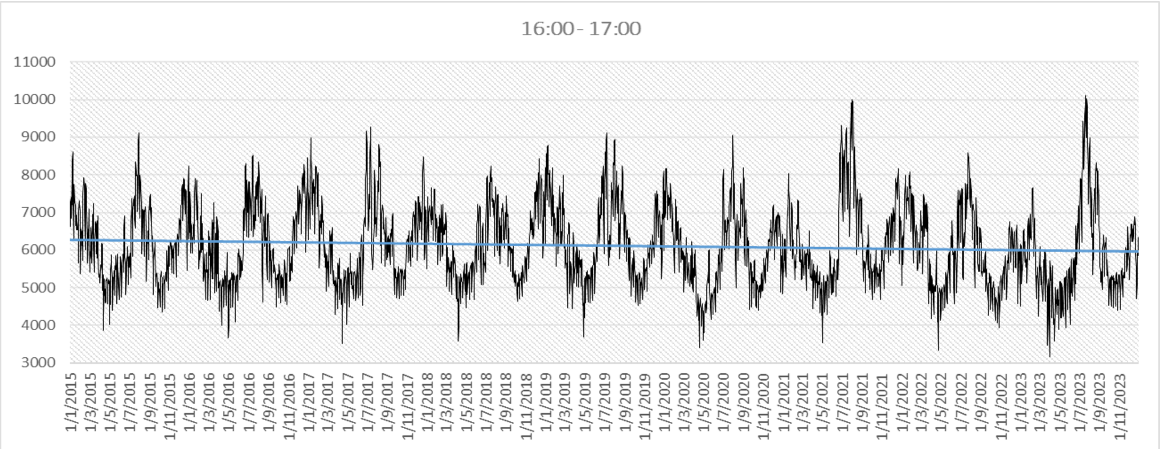

Figure 50: Actual total load of electricity in Greece for time zone 16:00-17:00

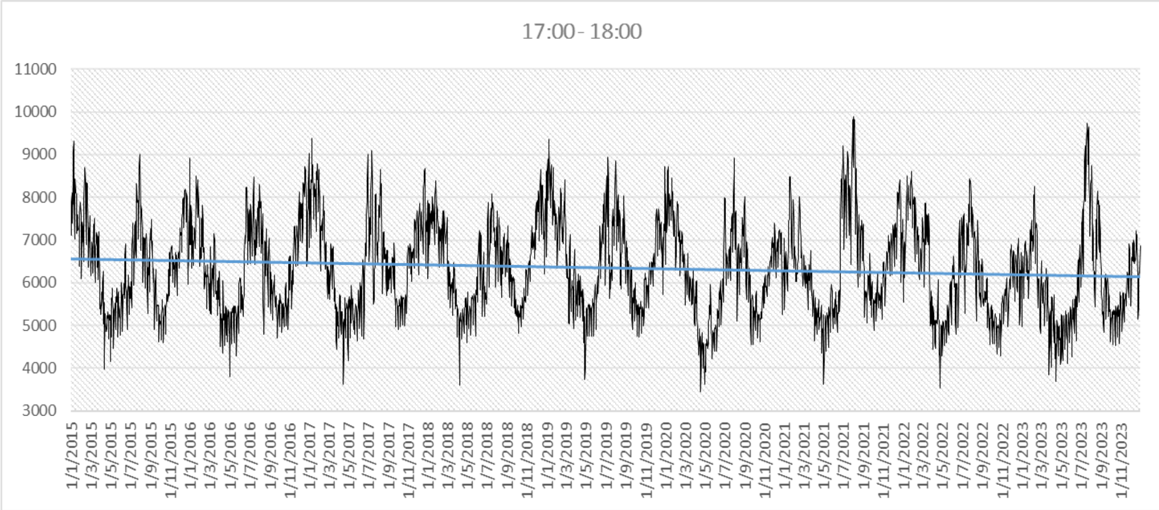

Figure 51: Actual total load of electricity in Greece for time zone 17:00-18:00

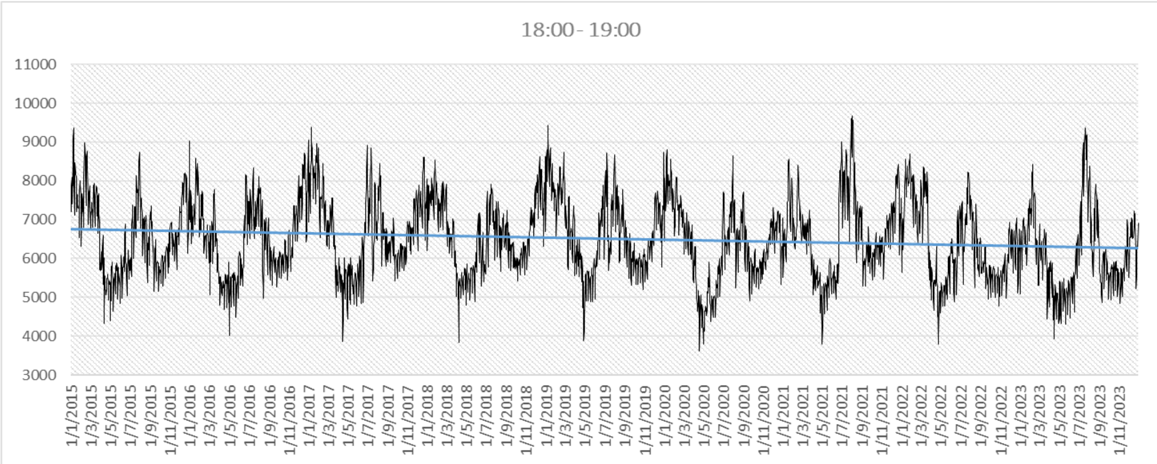

Figure 52: Actual total load of electricity in Greece for time zone 18:00-19:00

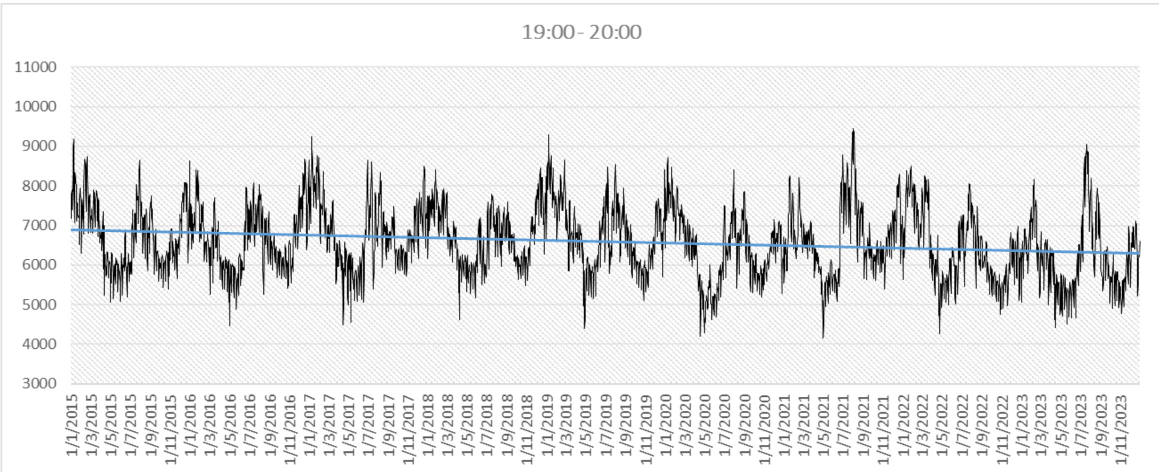

Figure 53: Actual total load of electricity in Greece for time zone 19:00-20:00

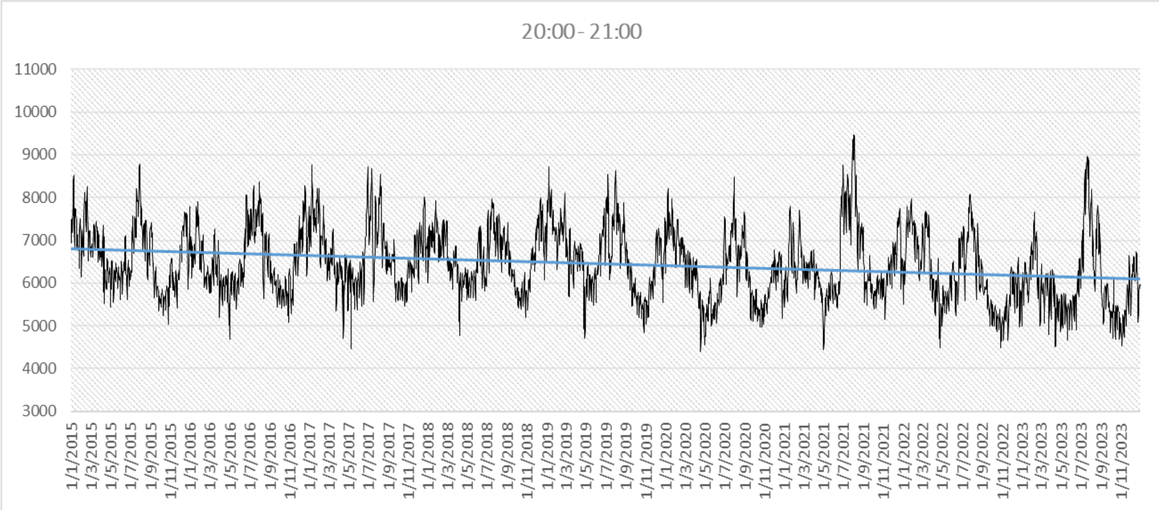

Figure 54: Actual total load of electricity in Greece for time zone 20:00-21:00

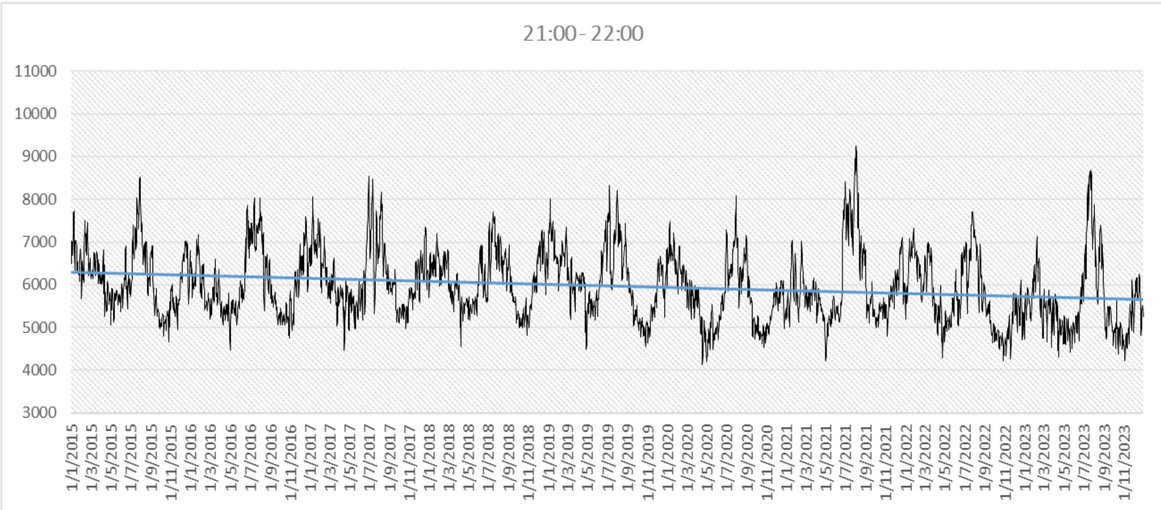

Figure 55: Actual total load of electricity in Greece for time zone 21:00-22:00

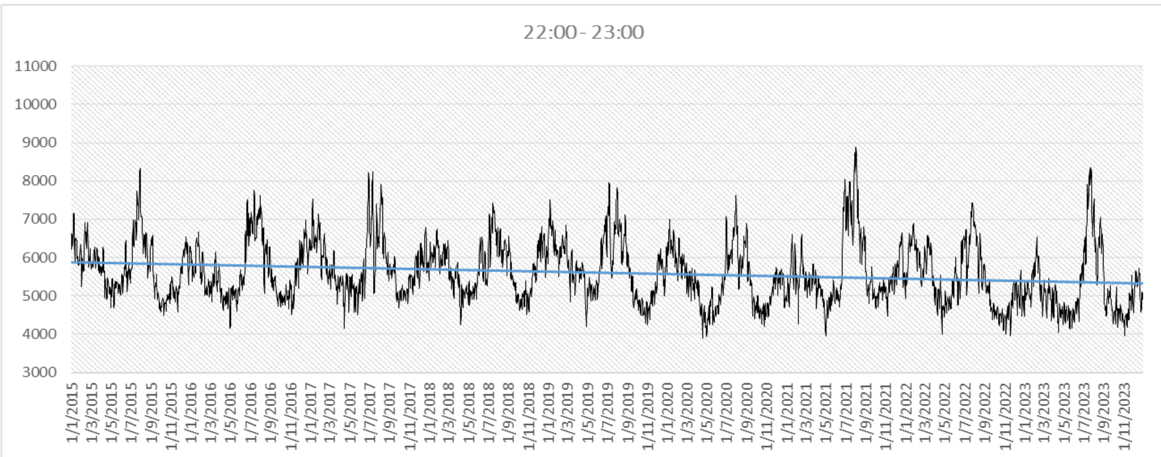

Figure 56: Actual total load of electricity in Greece for time zone 22:00-23:00

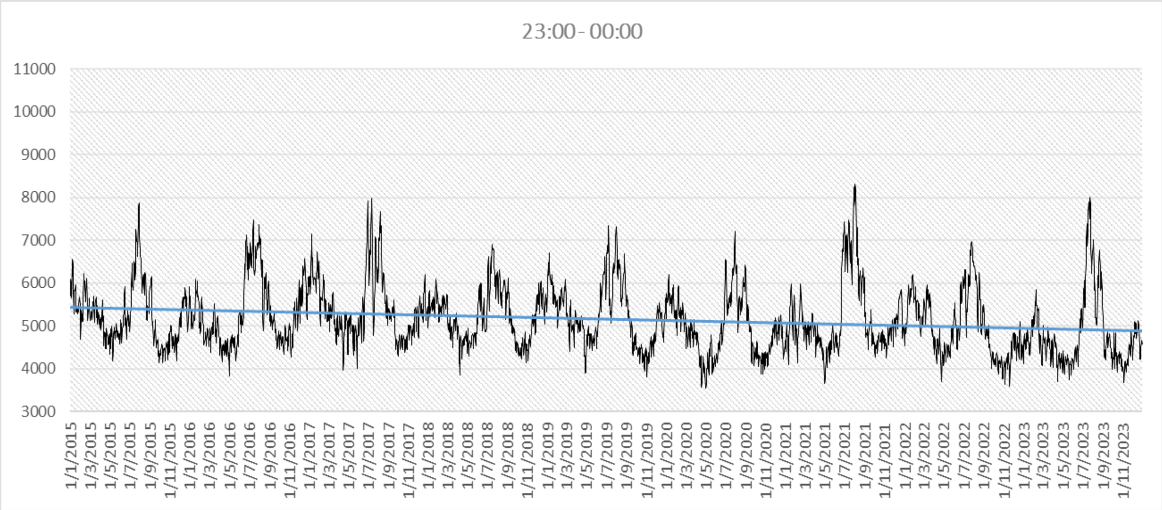

Figure 57: Actual total load of electricity in Greece for time zone 23:00-00:00

Appendix B: Figures of actual total load of electricity against the month of the year

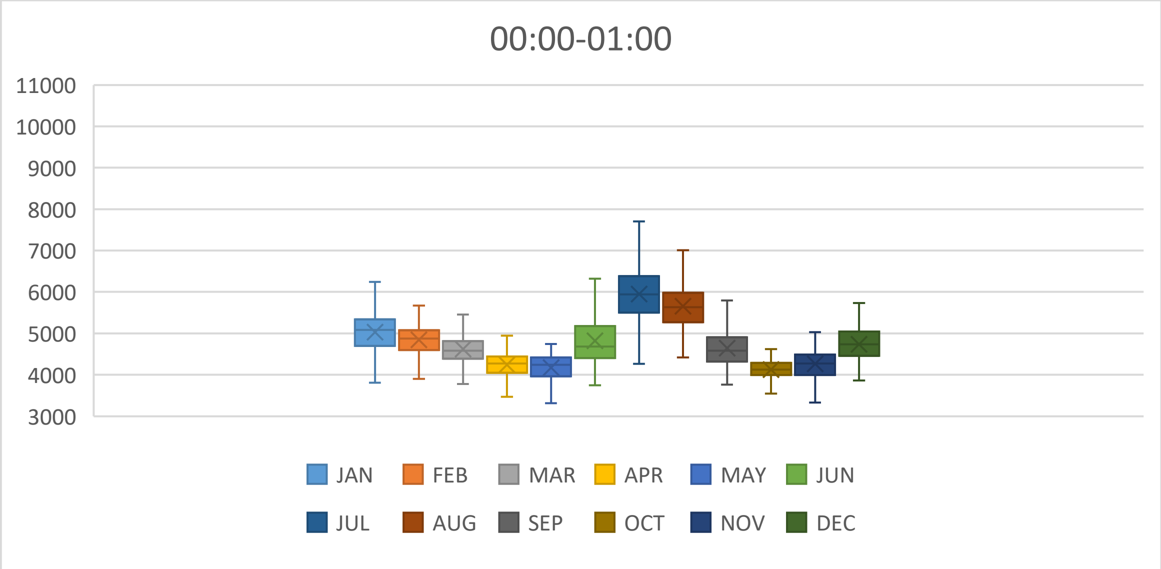

Figure 58: Actual total load of electricity in Greece against the month of the year for time zone 00:00-01:00

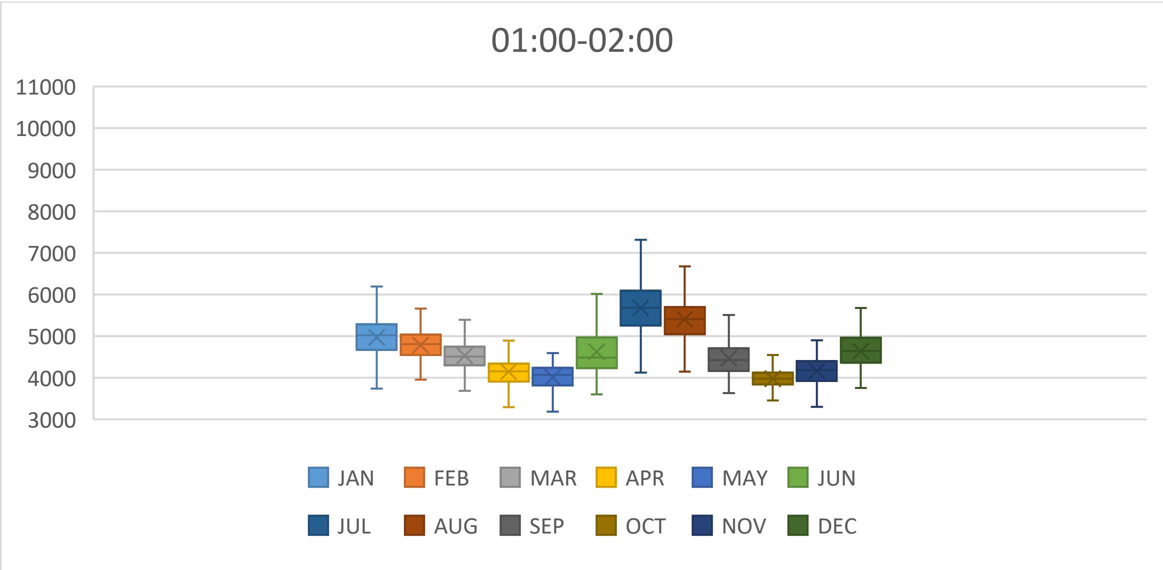

Figure 59: Actual total load of electricity in Greece against the month of the year for time zone 01:00-02:00

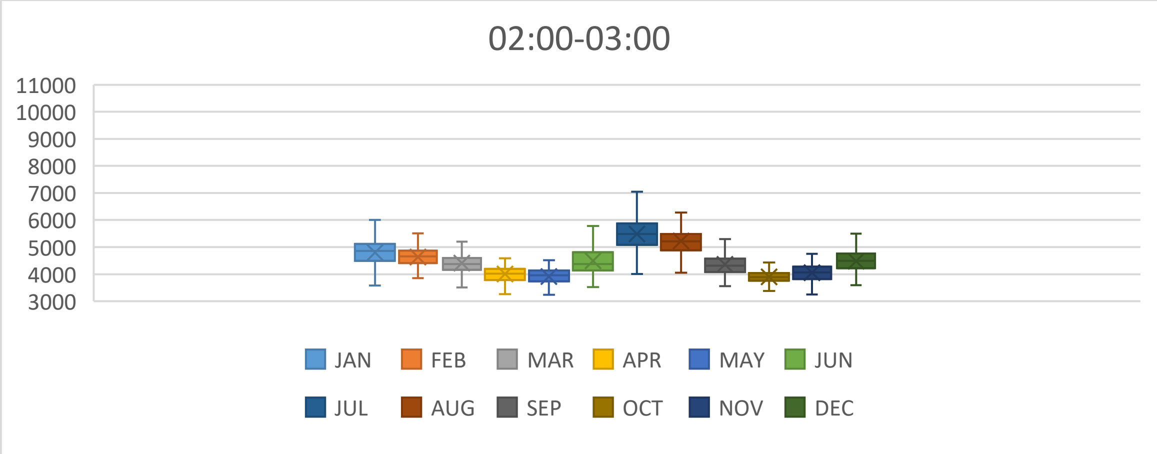

Figure 60: Actual total load of electricity in Greece against the month of the year for time zone 02:00-03:00

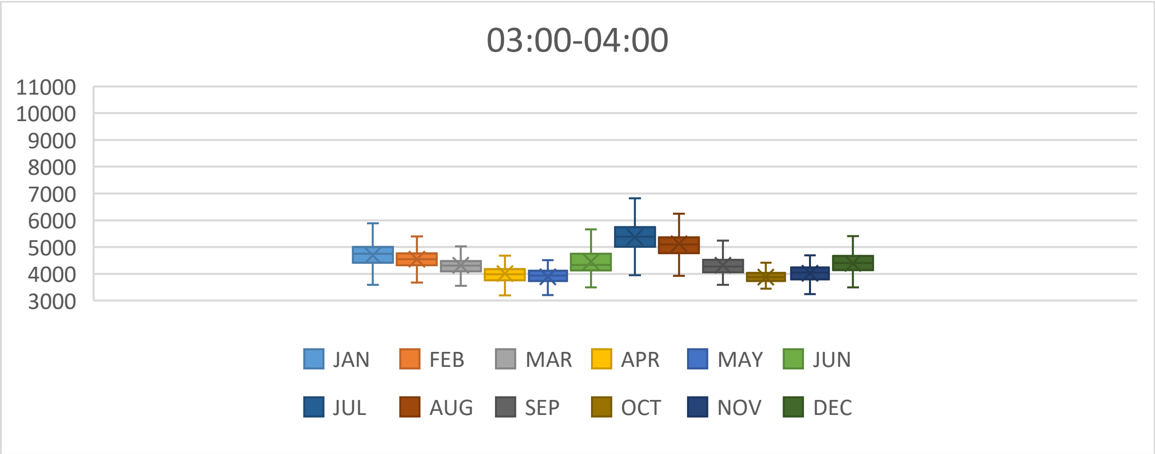

Figure 61: Actual total load of electricity in Greece against the month of the year for time zone 03:00-04:00

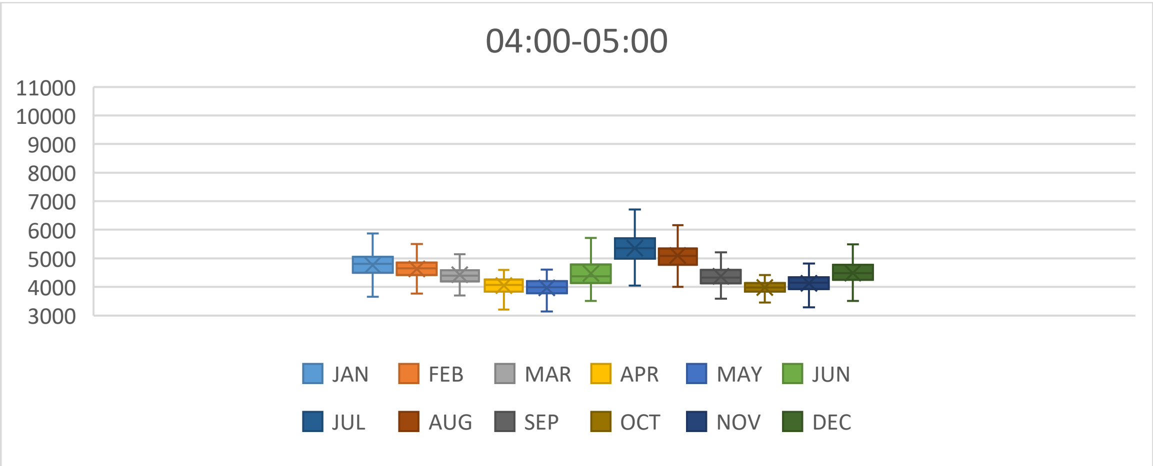

Figure 62: Actual total load of electricity in Greece against the month of the year for time zone 04:00-05:00

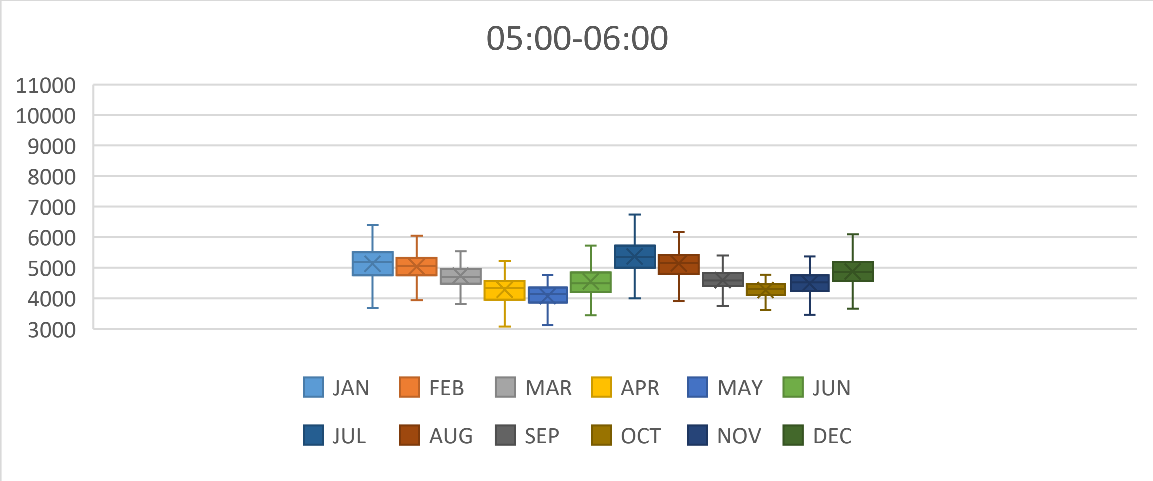

Figure 63: Actual total load of electricity in Greece against the month of the year for time zone 05:00-06:00

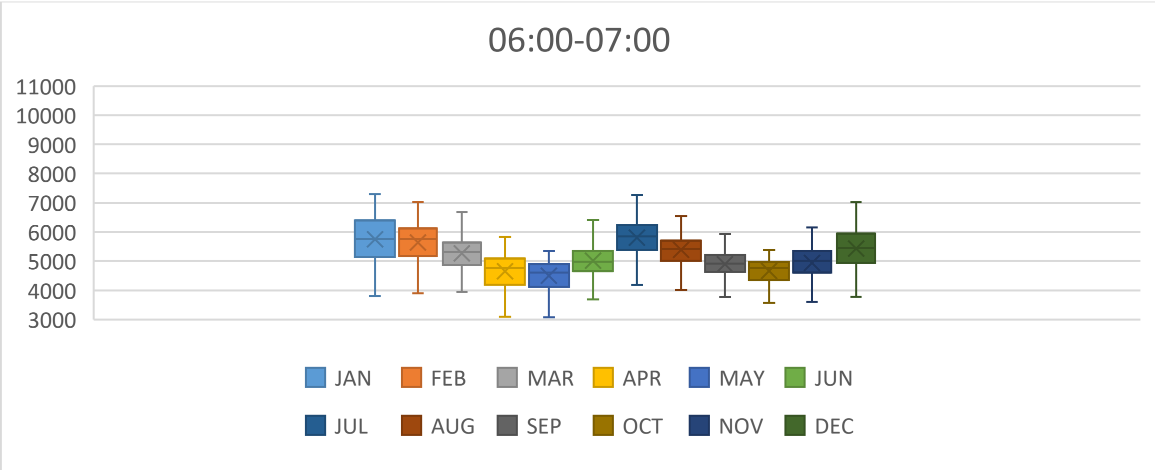

Figure 64: Actual total load of electricity in Greece against the month of the year for time zone 06:00-07:00

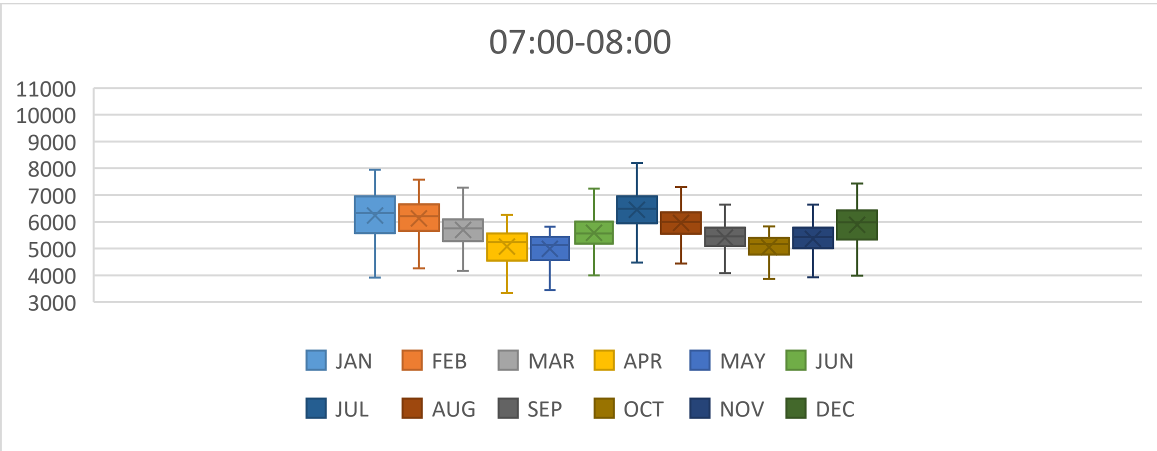

Figure 65: Actual total load of electricity in Greece against the month of the year for time zone 07:00-08:00

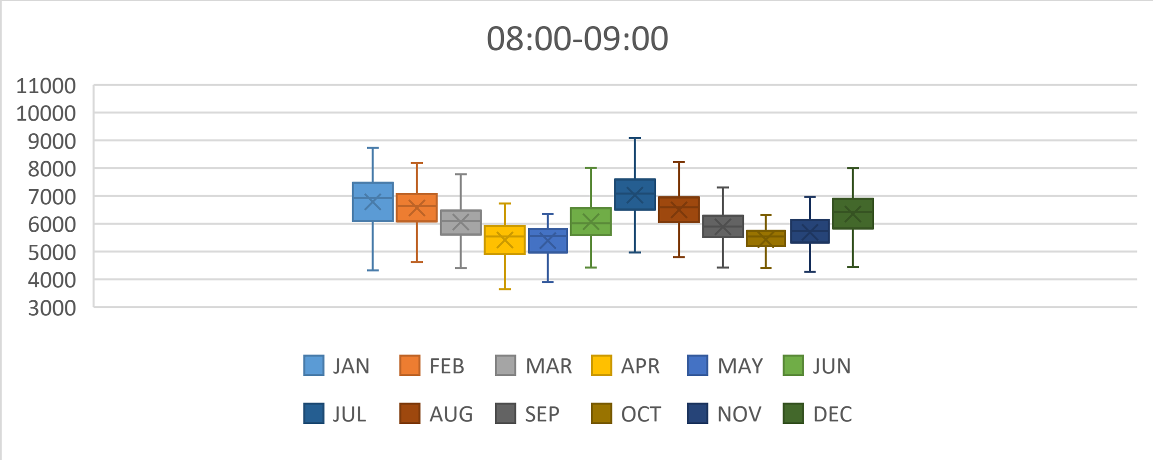

Figure 66: Actual total load of electricity in Greece against the month of the year for time zone 08:00-09:00

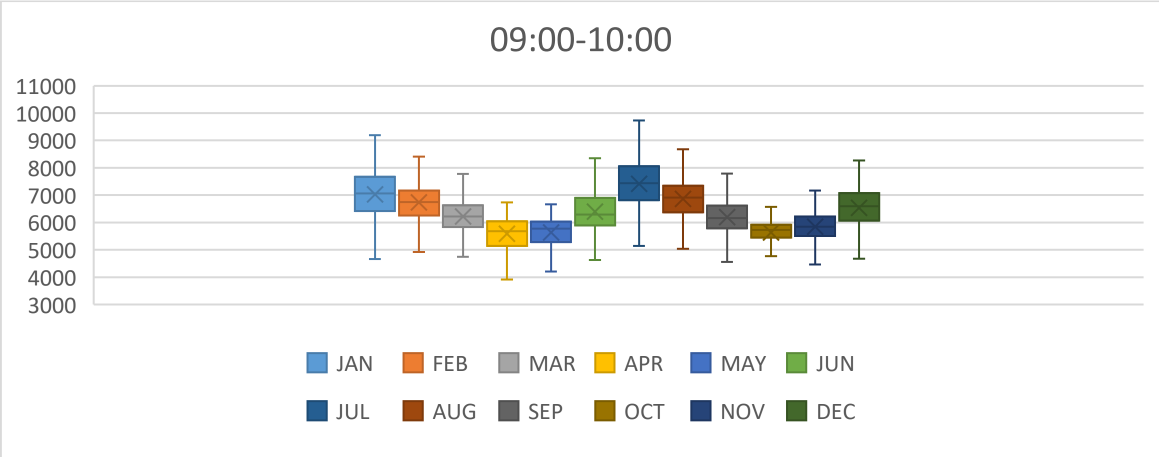

Figure 67: Actual total load of electricity in Greece against the month of the year for time zone 09:00-10:00

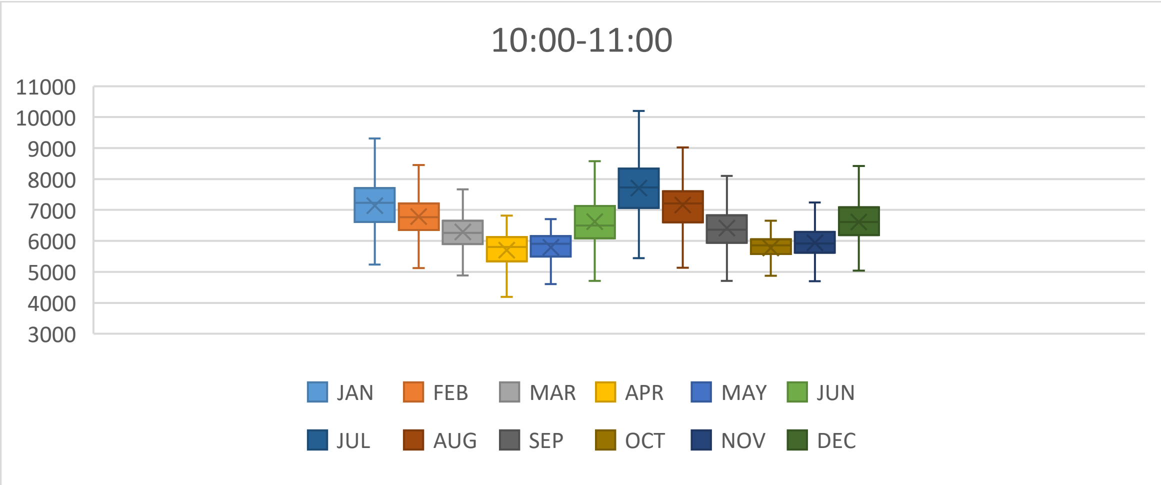

Figure 68: Actual total load of electricity in Greece against the month of the year for time zone 10:00-11:00

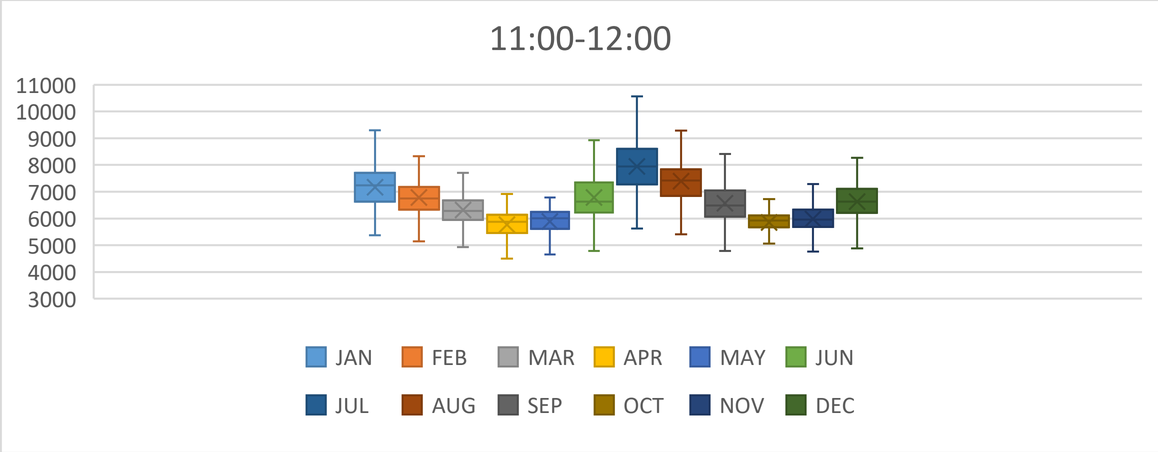

Figure 69: Actual total load of electricity in Greece against the month of the year for time zone 11:00-12:00

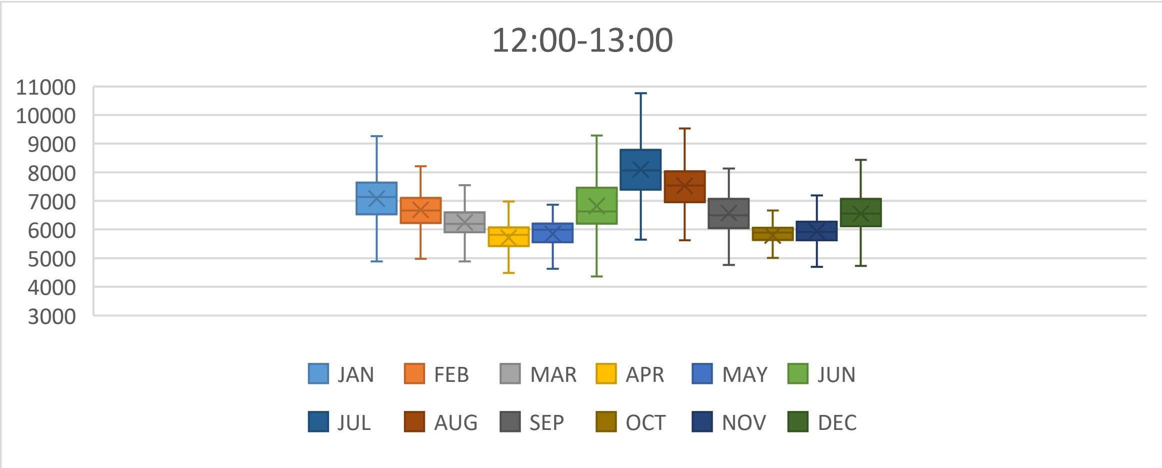

Figure 70: Actual total load of electricity in Greece against the month of the year for time zone 12:00-13:00

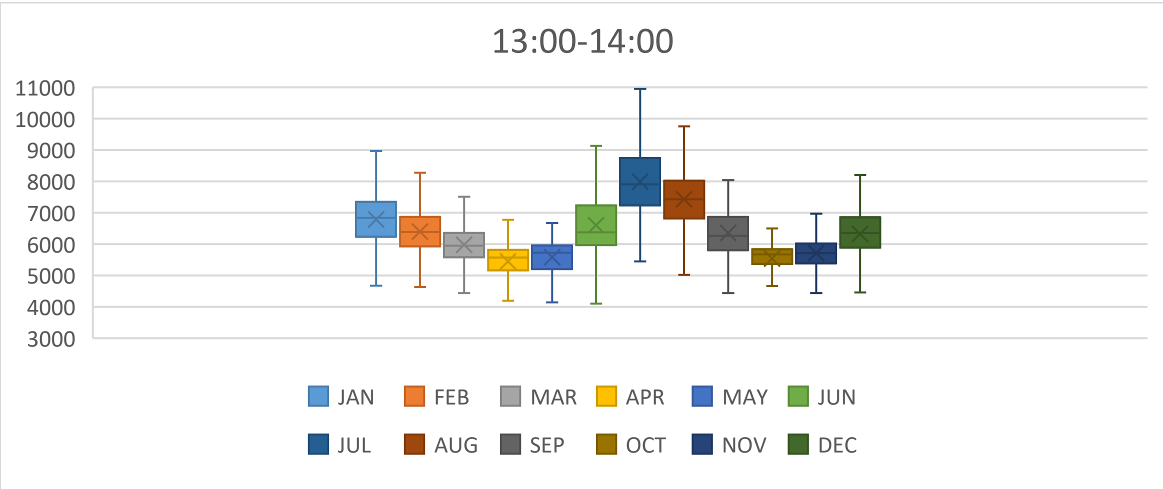

Figure 71: Actual total load of electricity in Greece against the month of the year for time zone 13:00-14:00

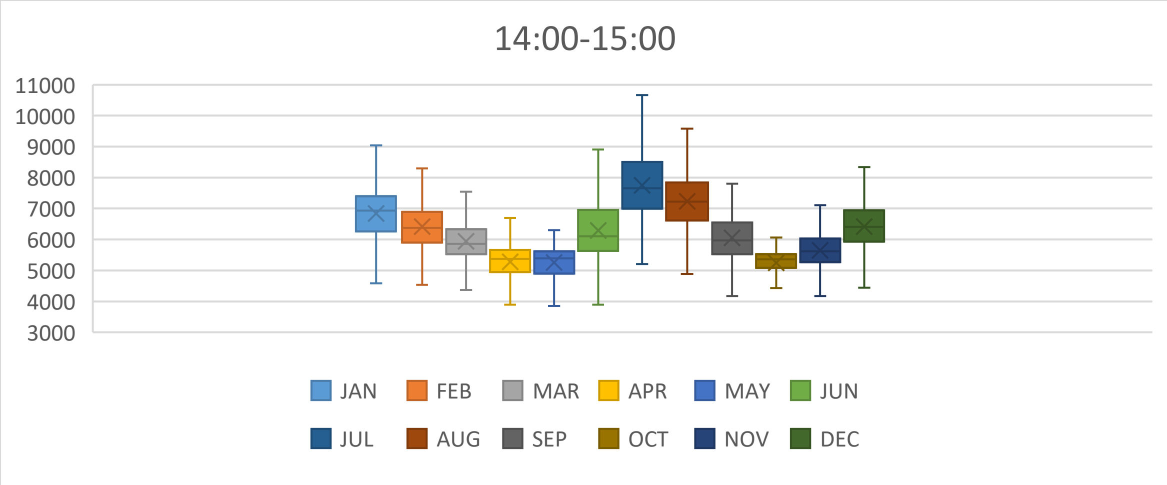

Figure 72: Actual total load of electricity in Greece against the month of the year for time zone 14:00-15:00

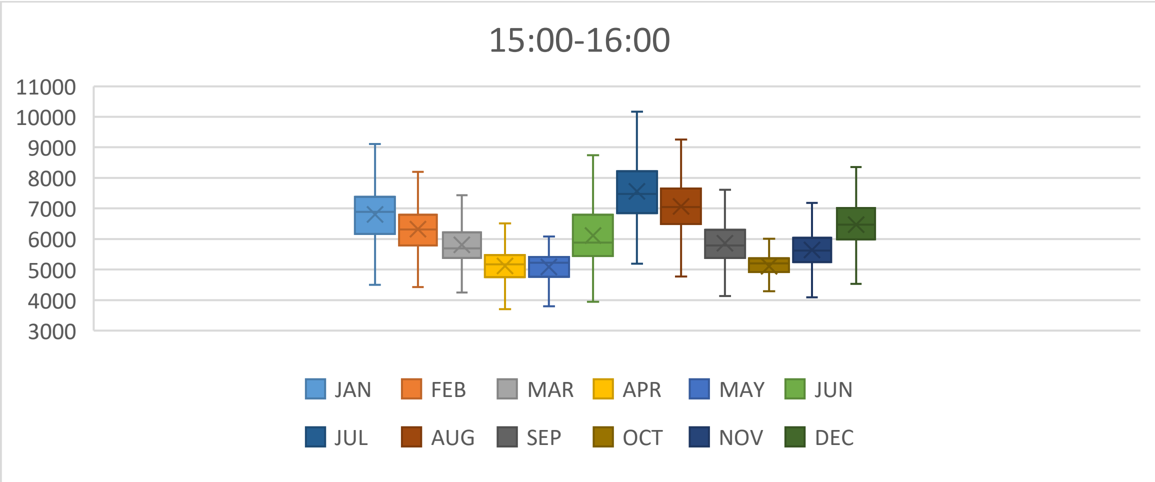

Figure 73: Actual total load of electricity in Greece against the month of the year for time zone 15:00-16:00

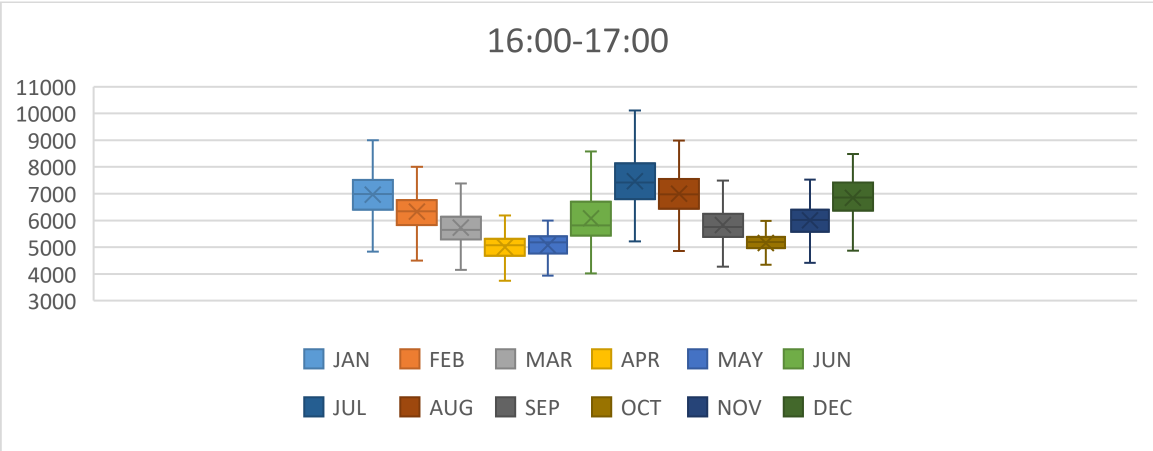

Figure 74: Actual total load of electricity in Greece against the month of the year for time zone 16:00-17:00

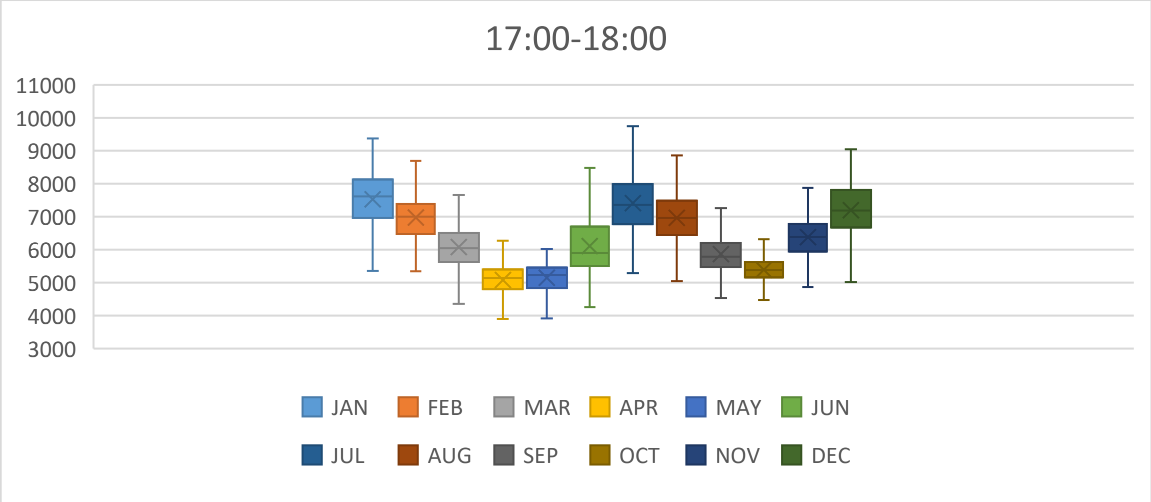

Figure 75: Actual total load of electricity in Greece against the month of the year for time zone 17:00-18:00

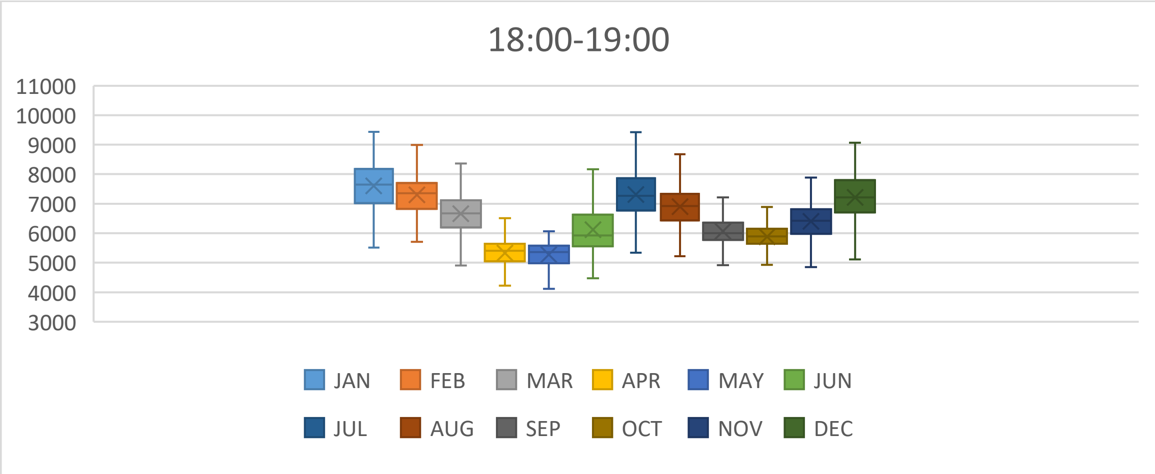

Figure 76: Actual total load of electricity in Greece against the month of the year for time zone 18:00-19:00

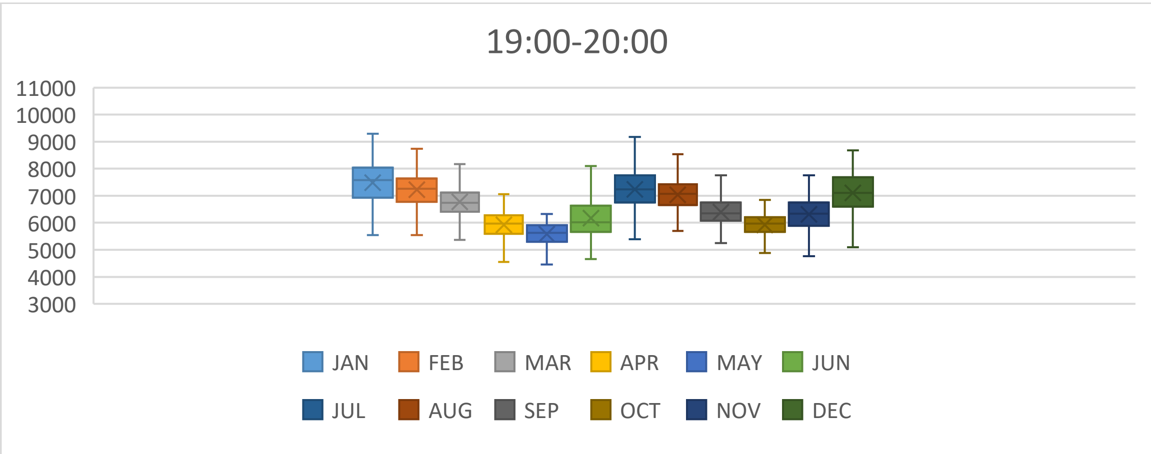

Figure 77: Actual total load of electricity in Greece against the month of the year for time zone 19:00-20:00

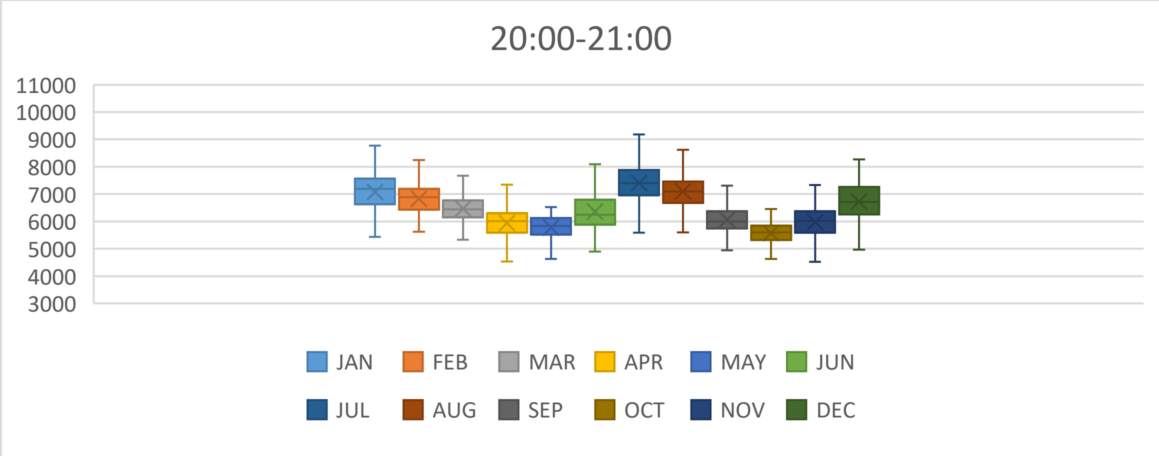

Figure 78: Actual total load of electricity in Greece against the month of the year for time zone 20:00-21:00

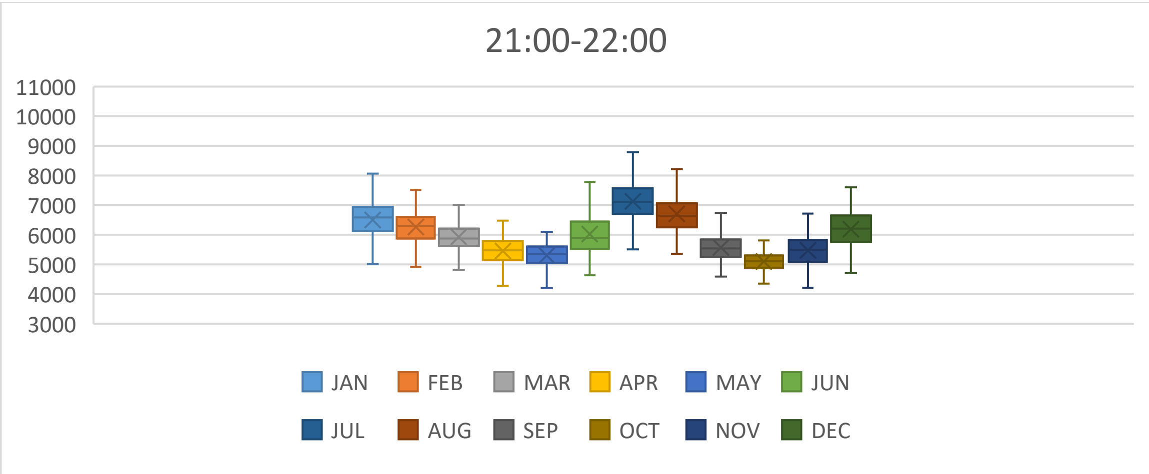

Figure 79: Actual total load of electricity in Greece against the month of the year for time zone 21:00-22:00

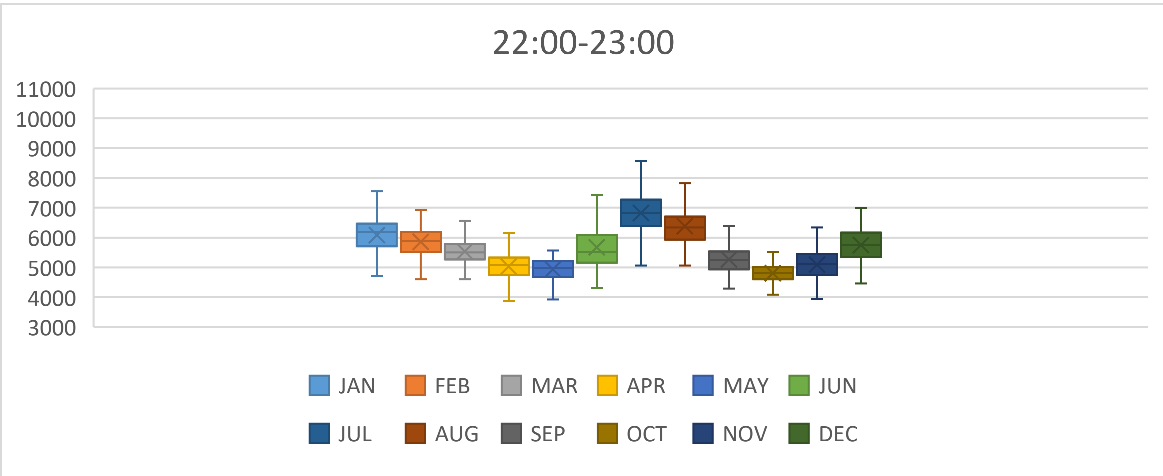

Figure 80: Actual total load of electricity in Greece against the month of the year for time zone 22:00-23:00

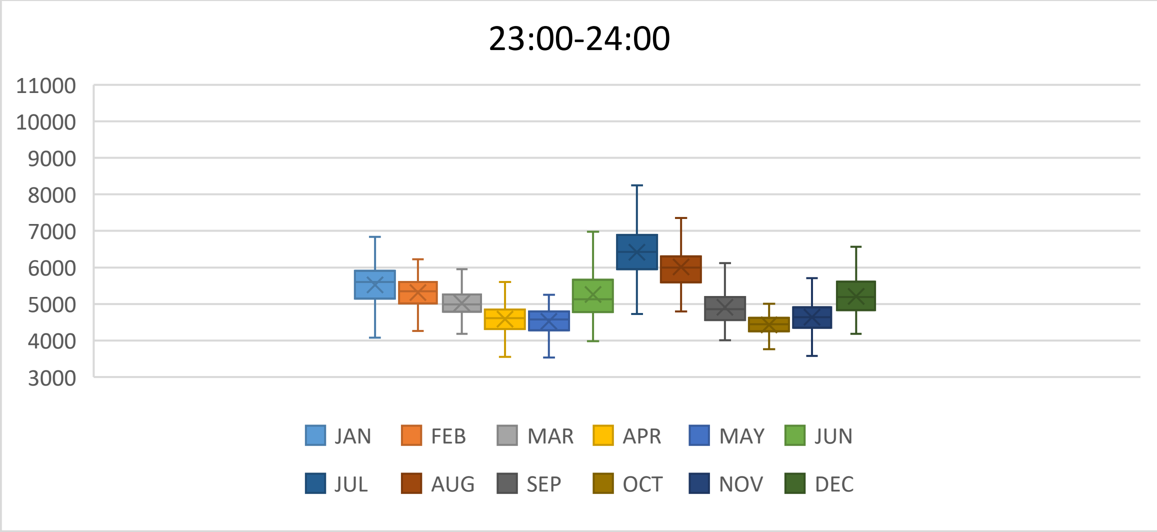

Figure 81: Actual total load of electricity in Greece against the month of the year for time zone 23:00-24:00

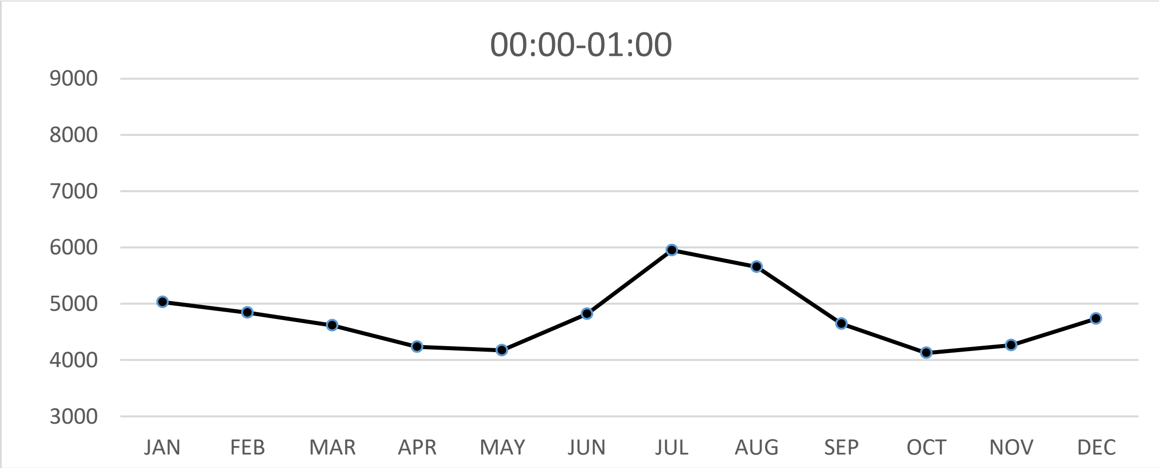

Figure 82: Monthly mean actual total of electricity in Greece for time zone 00:00-01:00

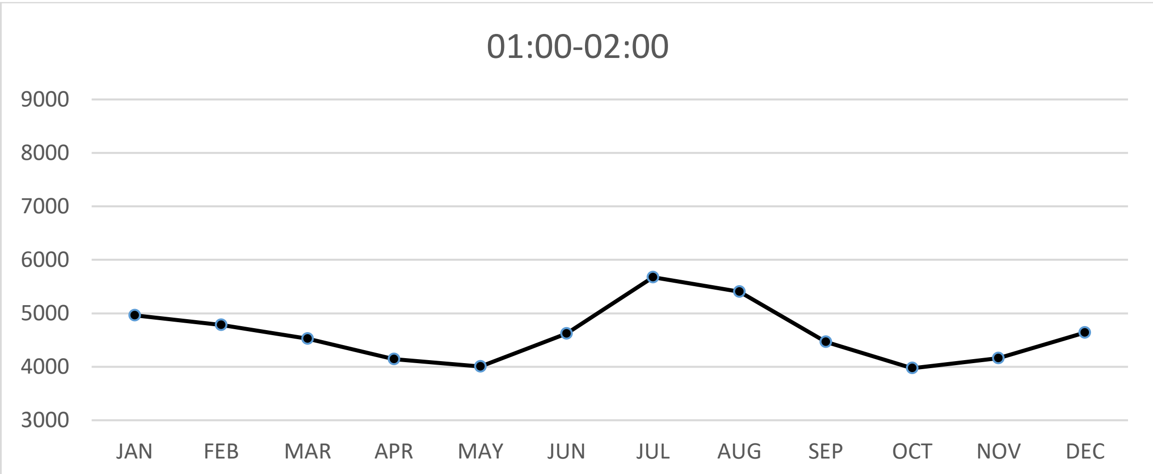

Figure 83: Monthly mean actual total of electricity in Greece for time zone 01:00-02:00

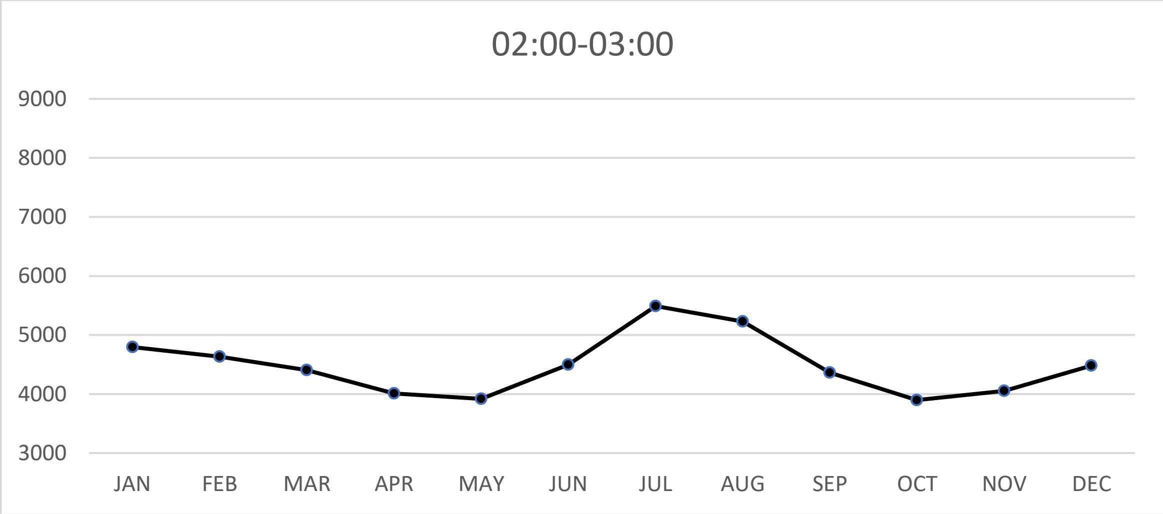

Figure 84: Monthly mean actual total of electricity in Greece for time zone 02:00-03:00

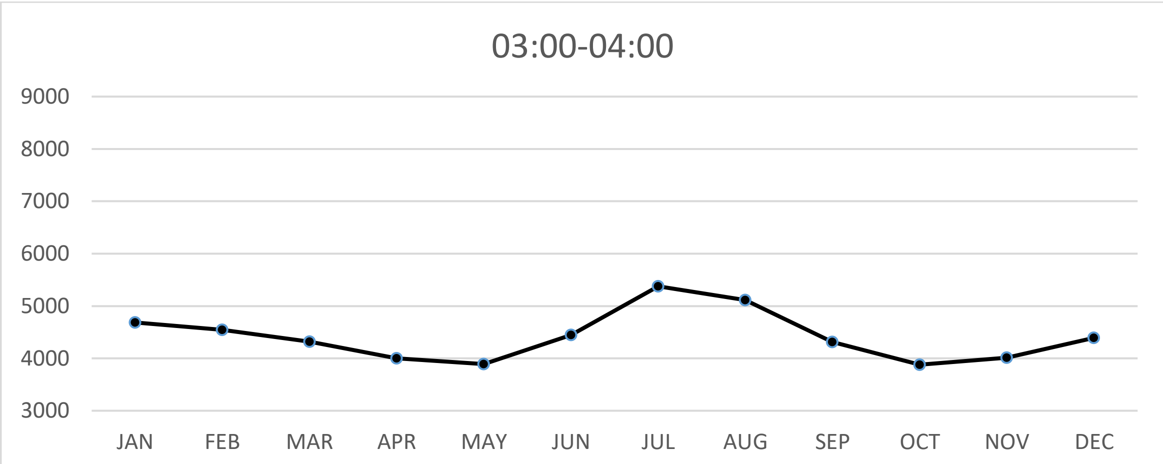

Figure 85: Monthly mean actual total of electricity in Greece for time zone 03:00-04:00

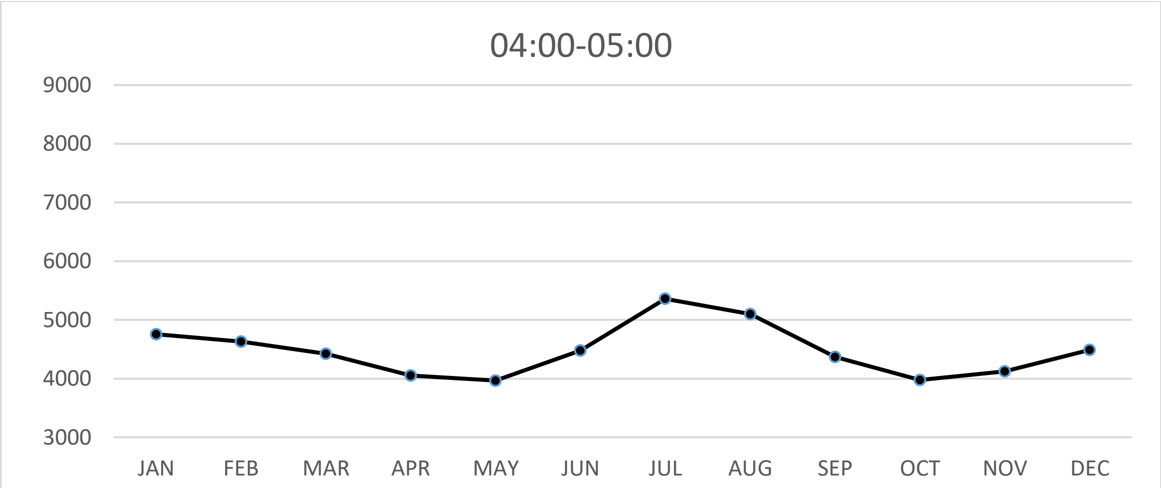

Figure 86: Monthly mean actual total of electricity in Greece for time zone 04:00-05:00

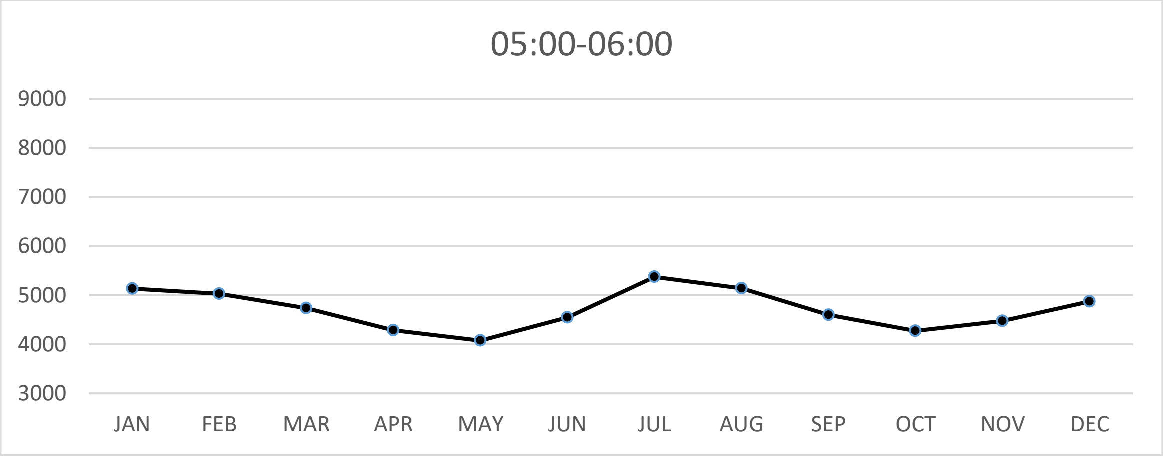

Figure 87: Monthly mean actual total of electricity in Greece for time zone 05:00-06:00

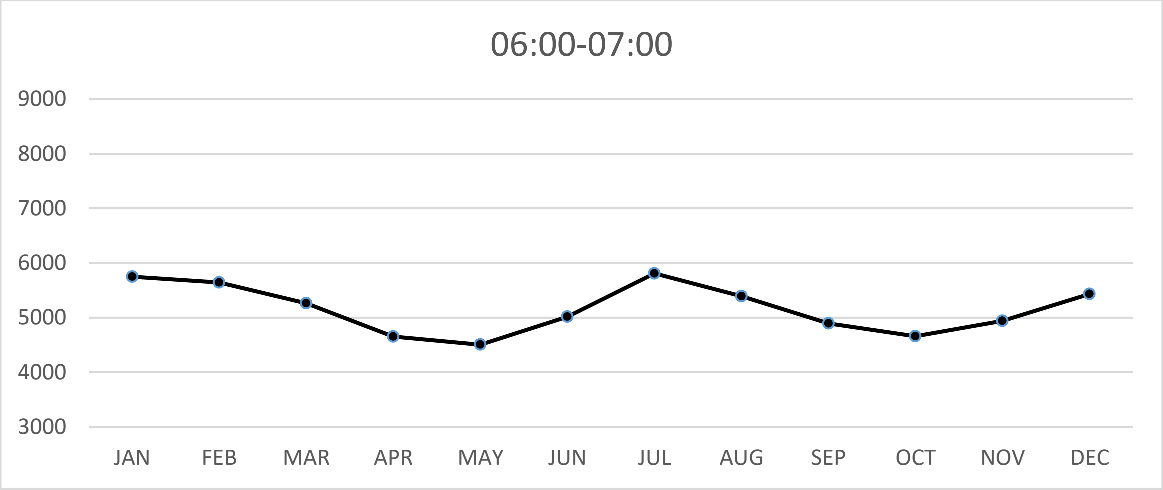

Figure 88: Monthly mean actual total of electricity in Greece for time zone 06:00-07:00

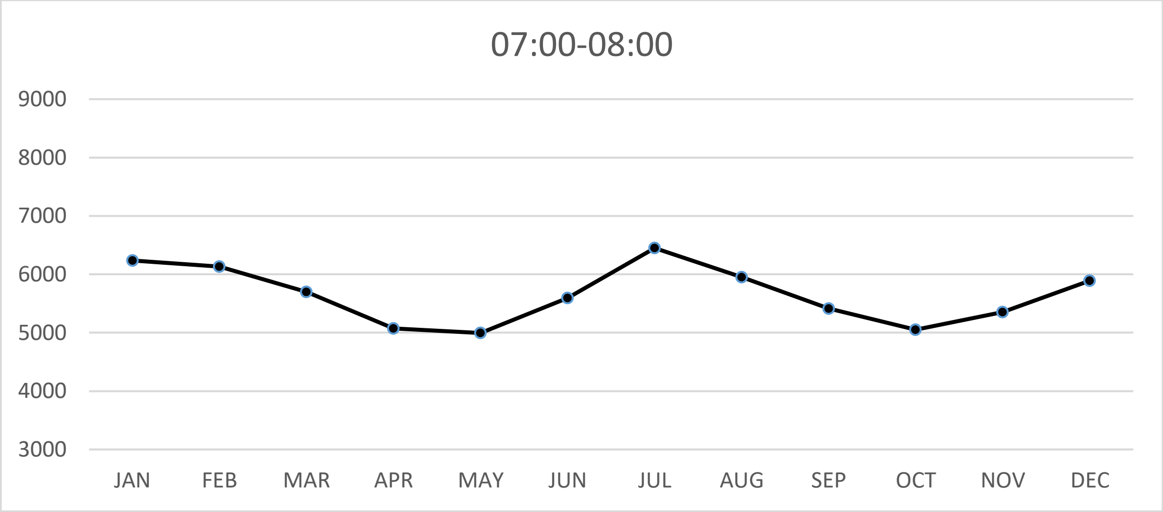

Figure 89: Monthly mean actual total of electricity in Greece for time zone 07:00-08:00

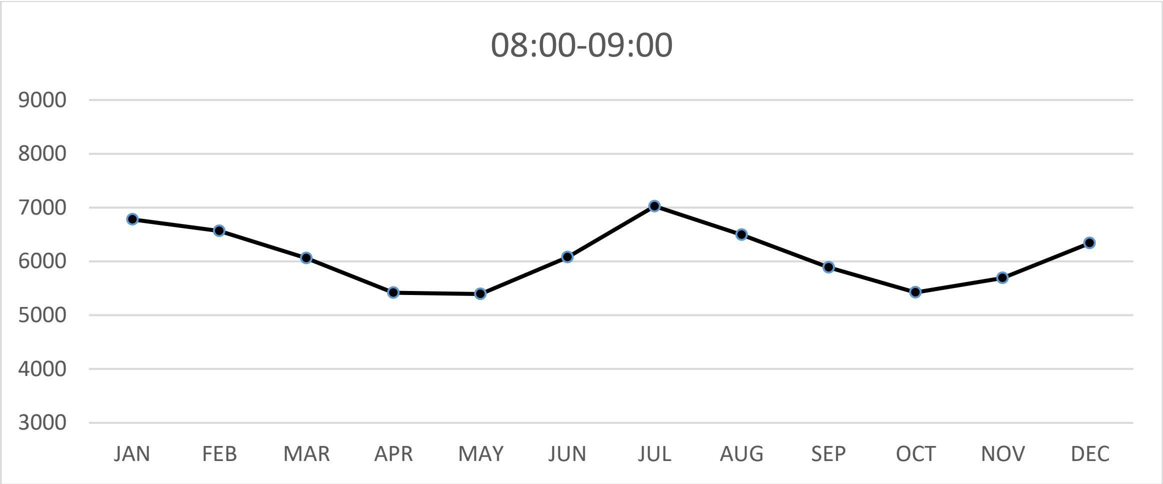

Figure 90: Monthly mean actual total of electricity in Greece for time zone 08:00-09:00

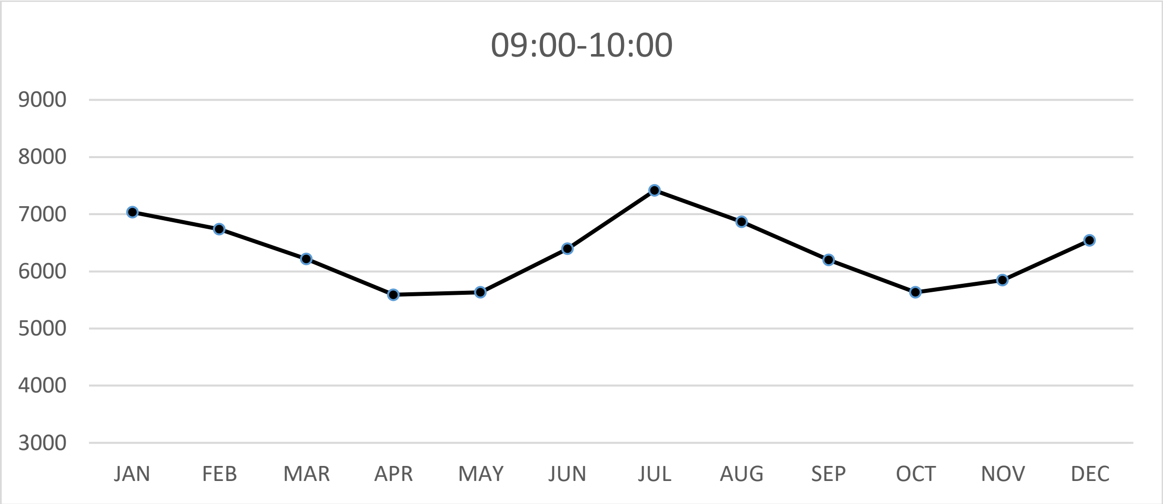

Figure 91: Monthly mean actual total of electricity in Greece for time zone 09:00-10:00

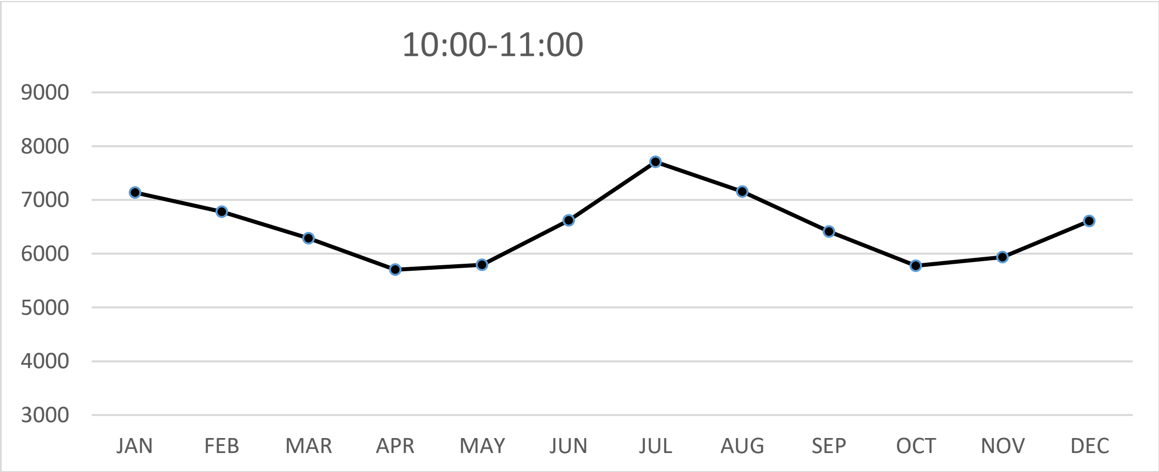

Figure 92: Monthly mean actual total of electricity in Greece for time zone 10:00-11:00

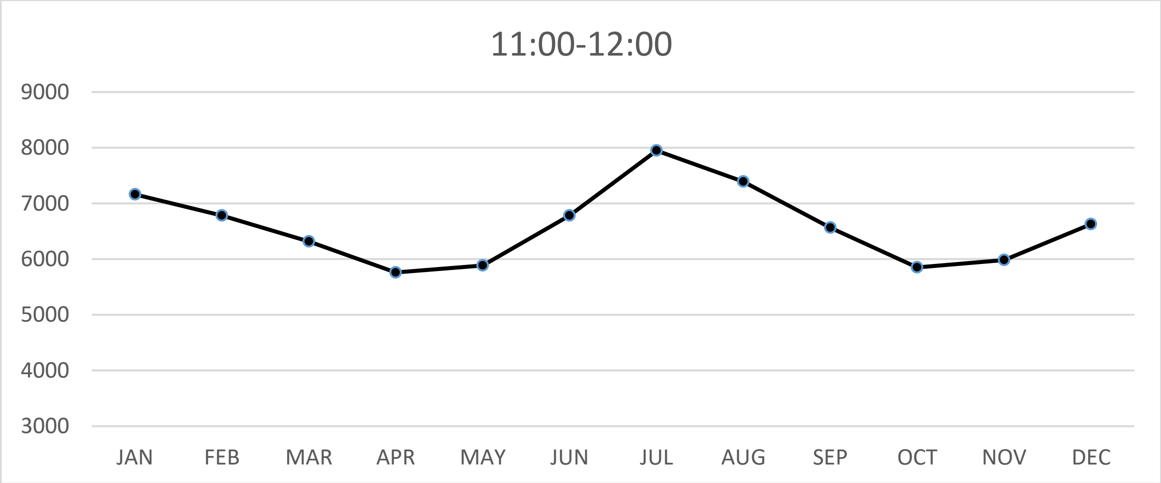

Figure 93: Monthly mean actual total of electricity in Greece for time zone 11:00-12:00

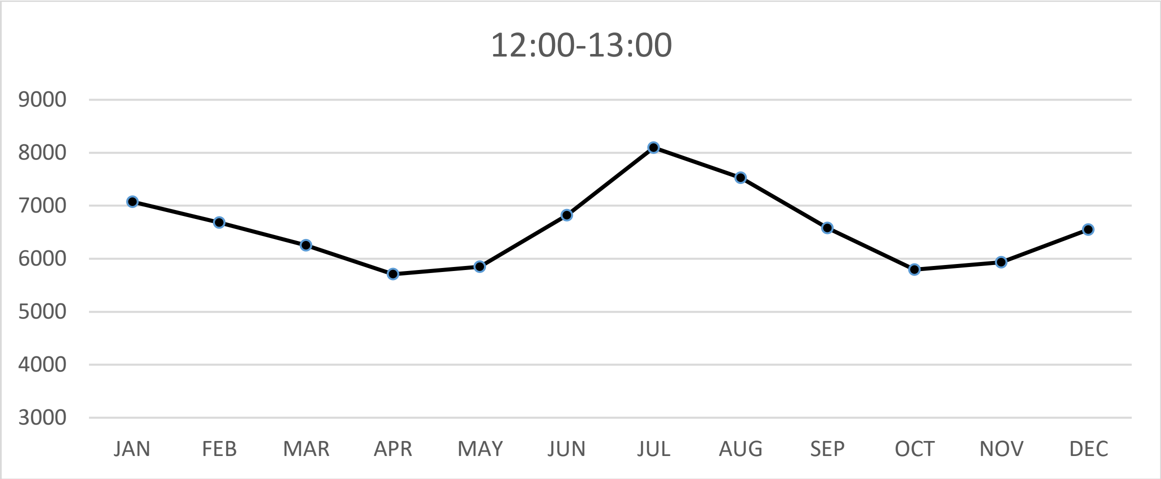

Figure 94: Monthly mean actual total of electricity in Greece for time zone 12:00-13:00

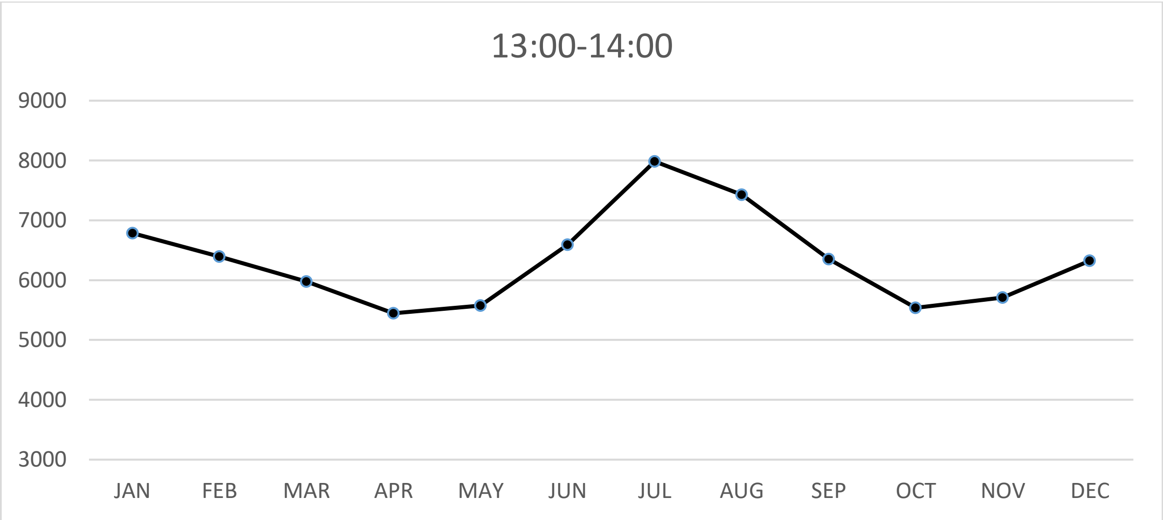

Figure 95: Monthly mean actual total of electricity in Greece for time zone 13:00-14:00

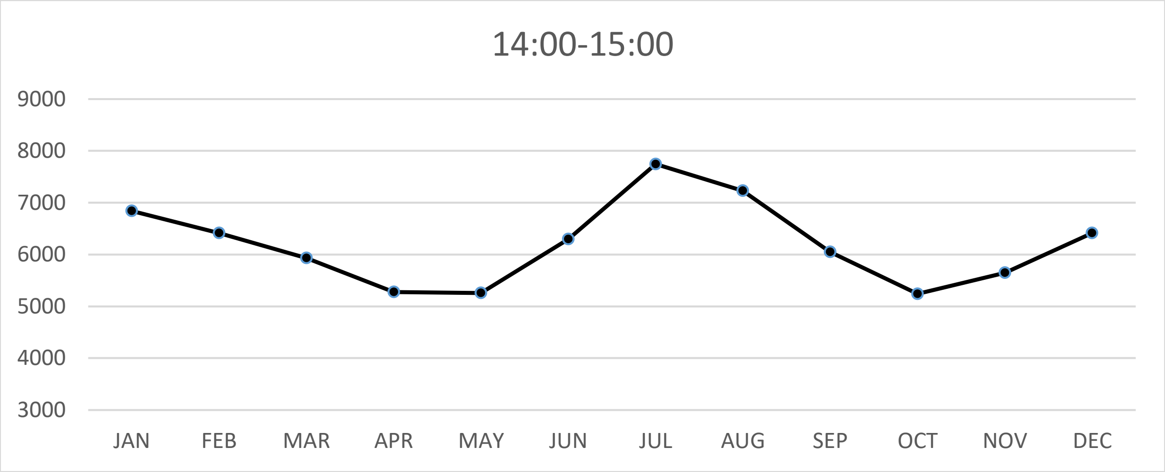

Figure 96: Monthly mean actual total of electricity in Greece for time zone 14:00-15:00

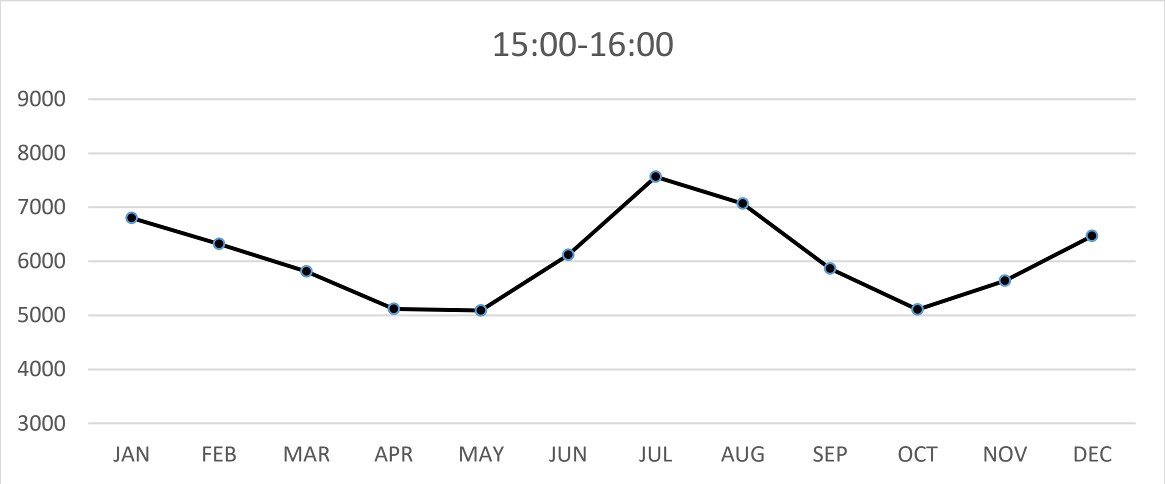

Figure 97: Monthly mean actual total of electricity in Greece for time zone 15:00-16:00

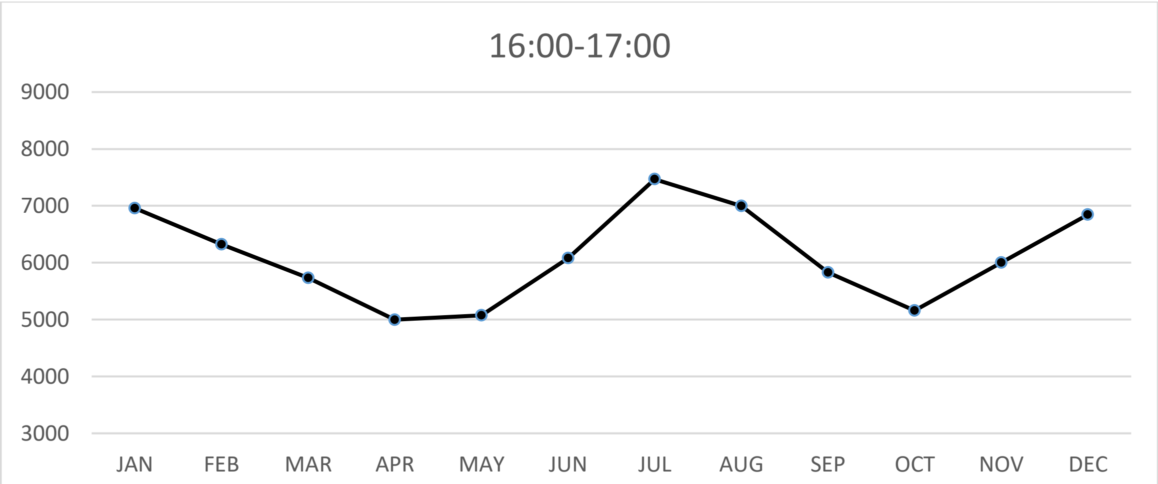

Figure 98: Monthly mean actual total of electricity in Greece for time zone 16:00-17:00

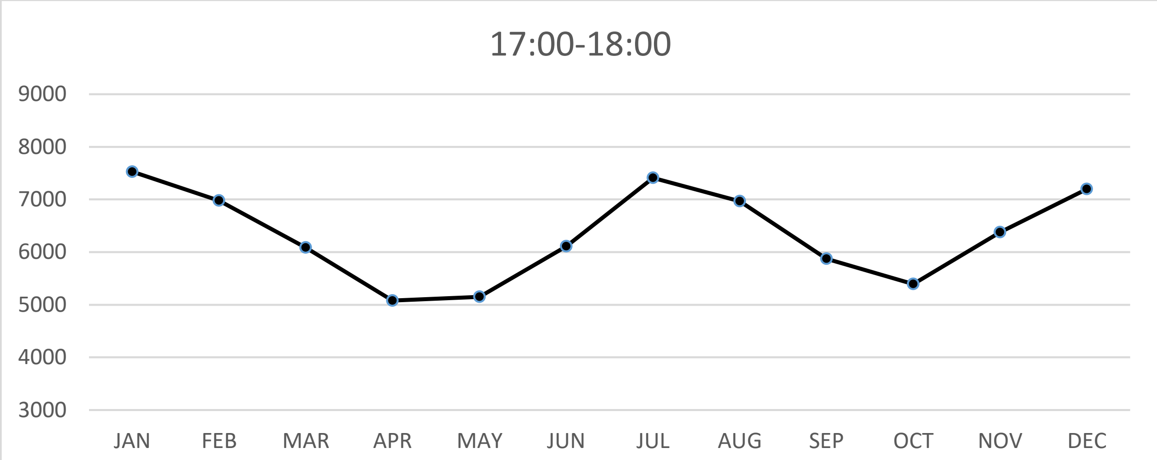

Figure 99: Monthly mean actual total of electricity in Greece for time zone 17:00-18:00

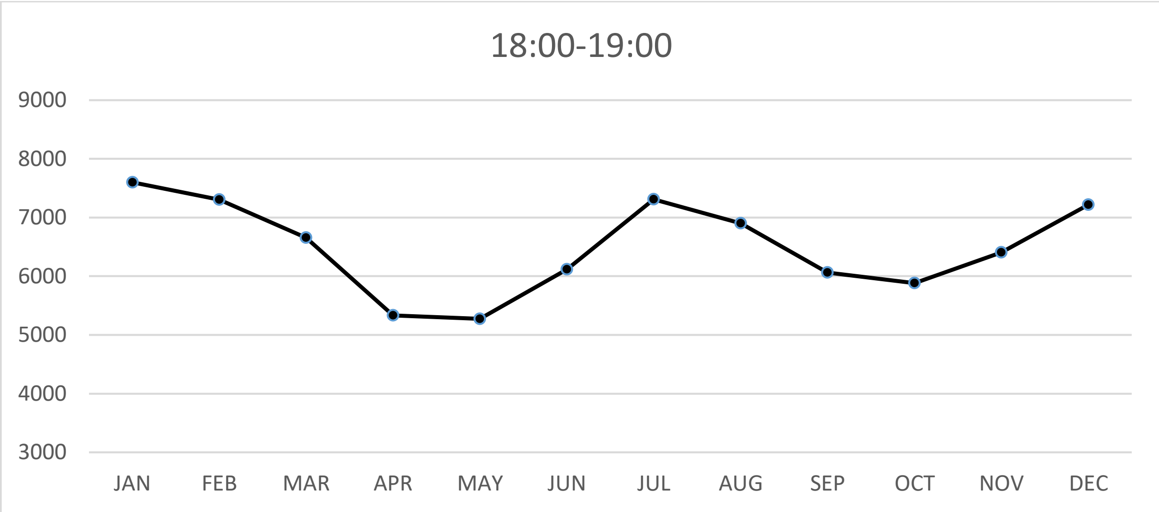

Figure 100: Monthly mean actual total of electricity in Greece for time zone 18:00-19:00

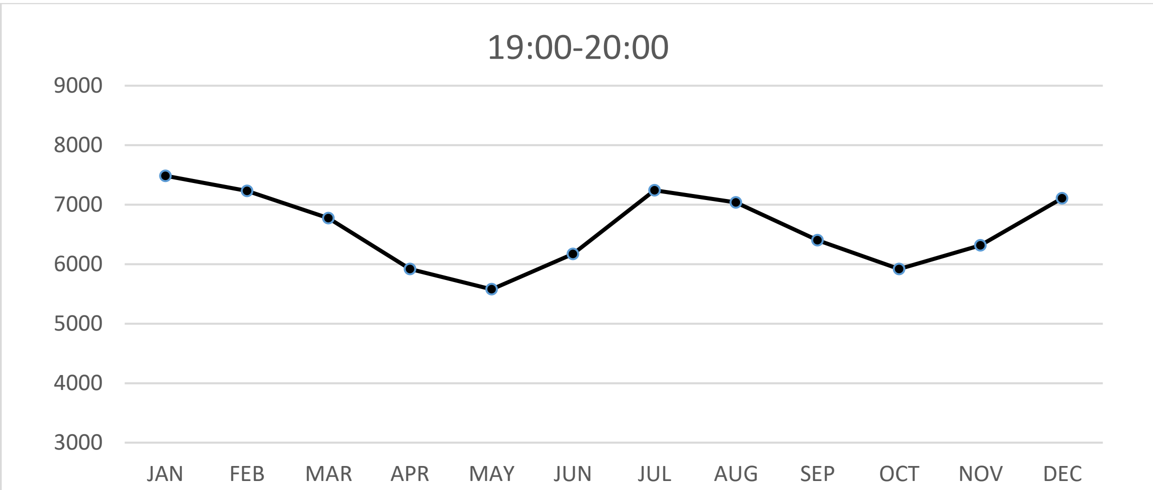

Figure 101: Monthly mean actual total of electricity in Greece for time zone 19:00-20:00

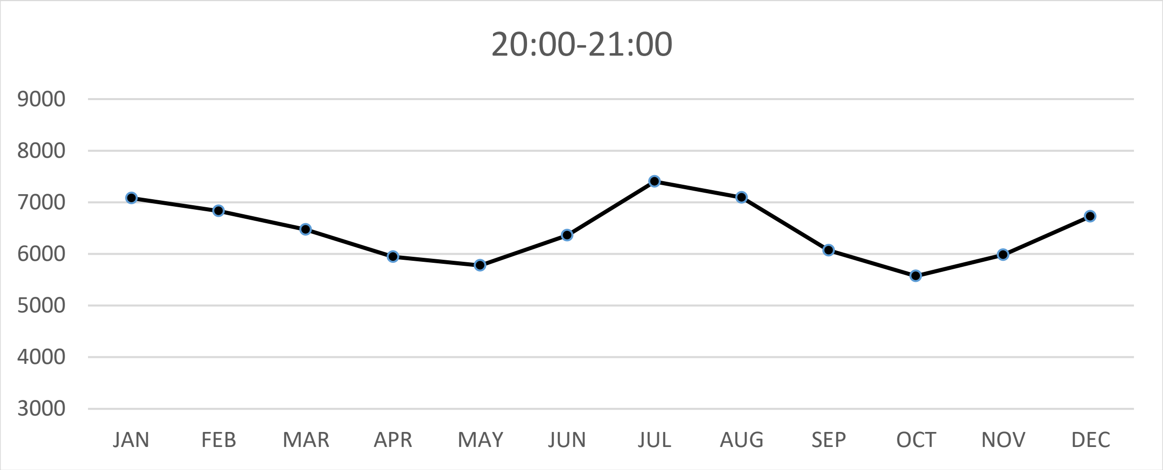

Figure 102: Monthly mean actual total of electricity in Greece for time zone 20:00-21:00

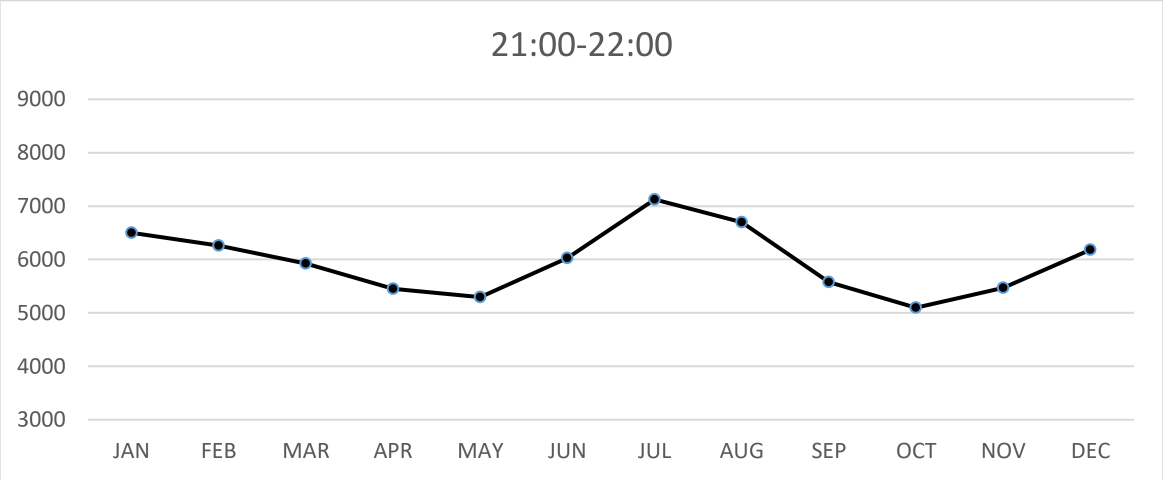

Figure 103: Monthly mean actual total of electricity in Greece for time zone 21:00-22:00

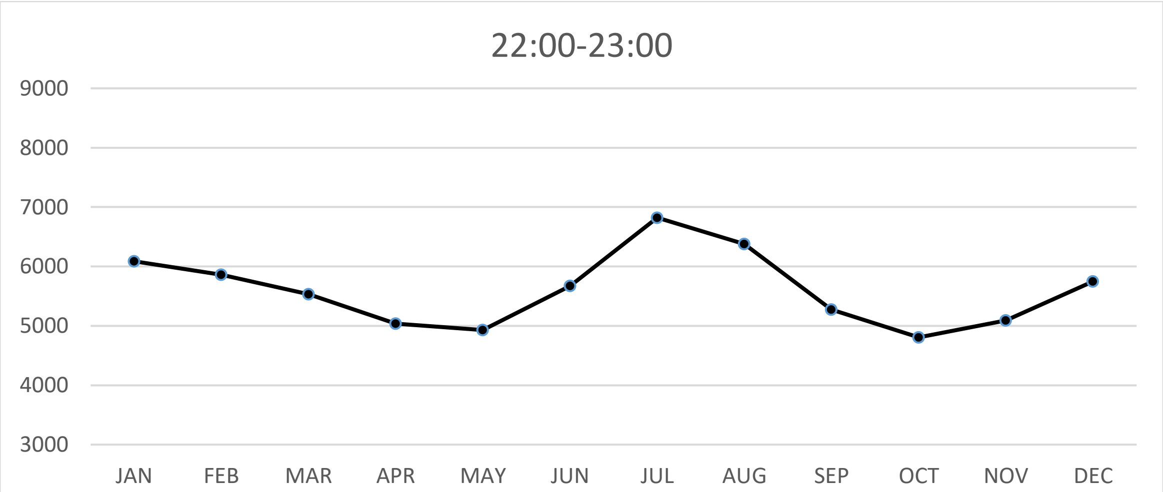

Figure 104: Monthly mean actual total of electricity in Greece for time zone 22:00-23:00

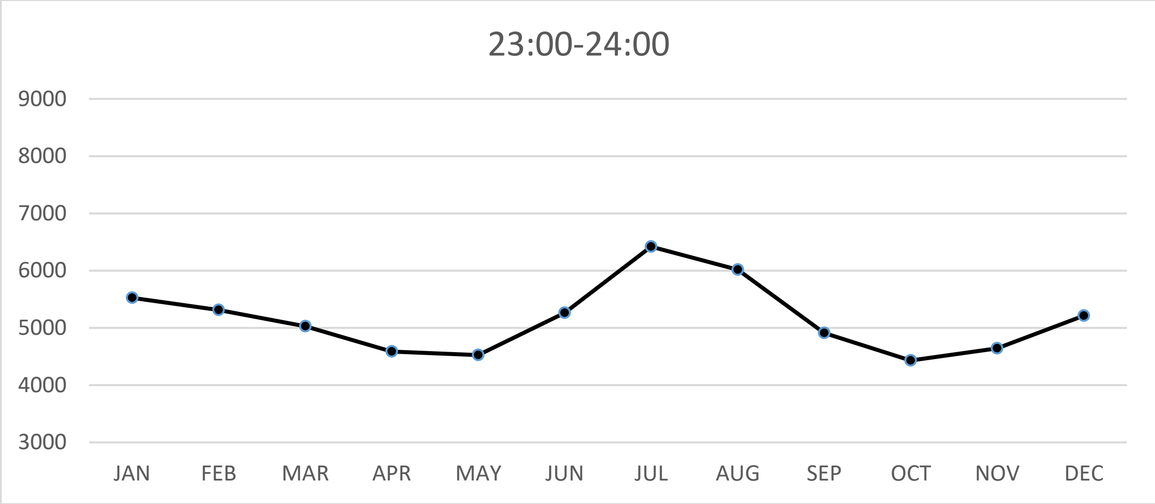

Figure 105: Monthly mean actual total of electricity in Greece for time zone 23:00-24:00

Appendix C: Figures of actual total load of electricity against the day of the week

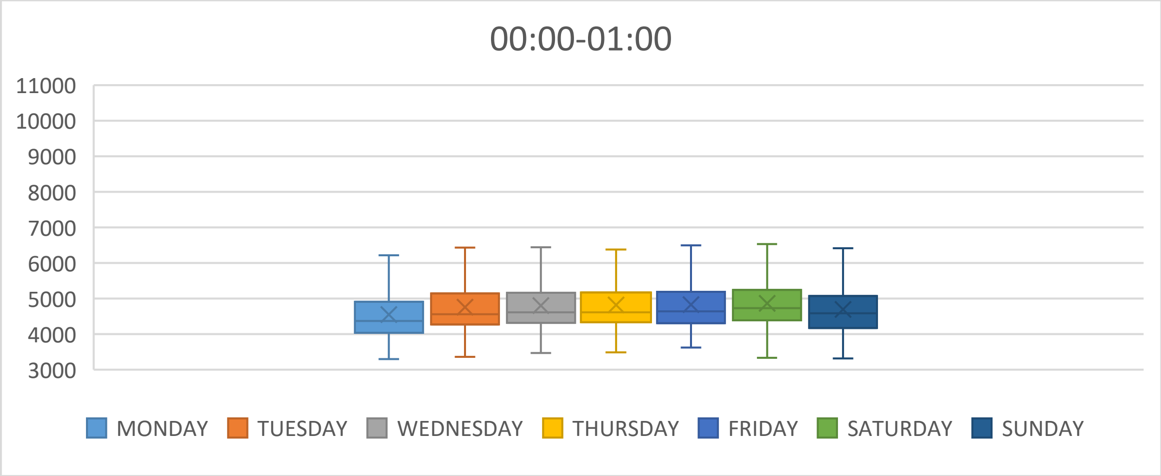

Figure 106: Actual total load of electricity in Greece against the day of the week for time zone 00:00-01:00

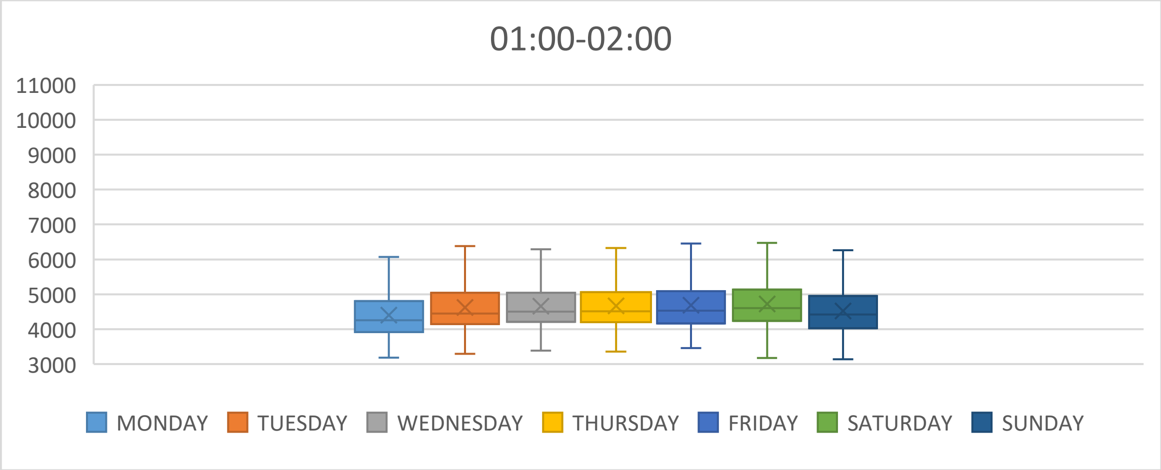

Figure 107: Actual total load of electricity in Greece against the day of the week for time zone 01:00-02:00

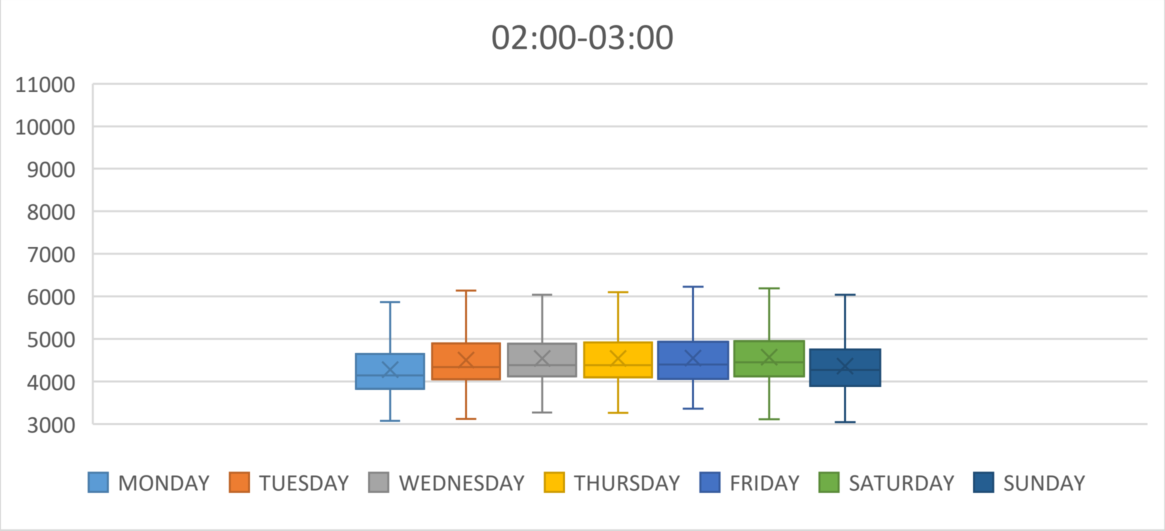

Figure 108: Actual total load of electricity in Greece against the day of the week for time zone 02:00-03:00

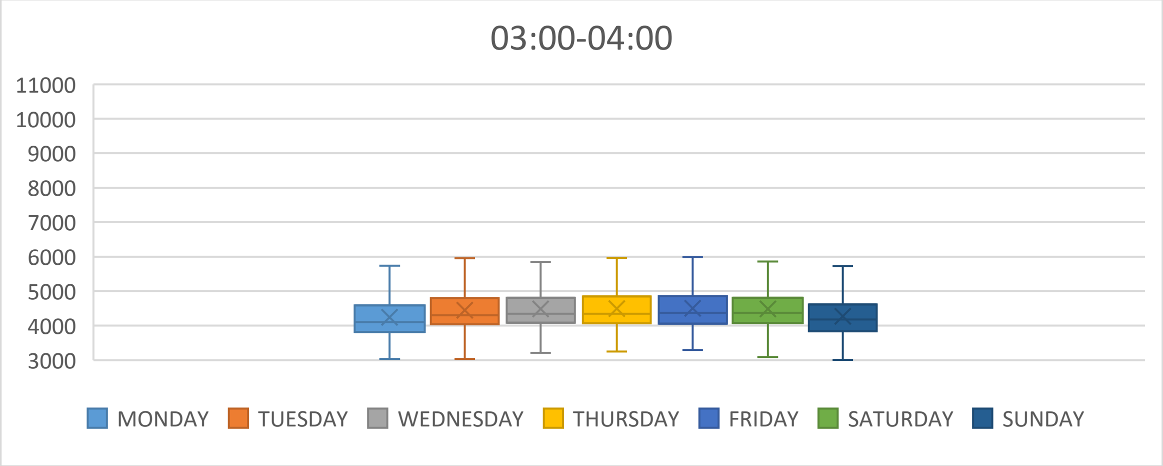

Figure 109: Actual total load of electricity in Greece against the day of the week for time zone 03:00-04:00

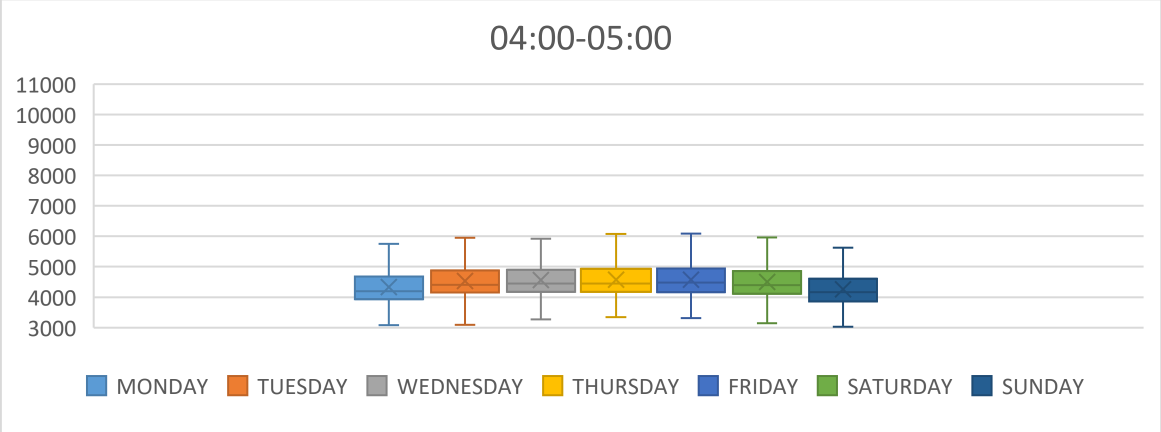

Figure 110: Actual total load of electricity in Greece against the day of the week for time zone 04:00-05:00

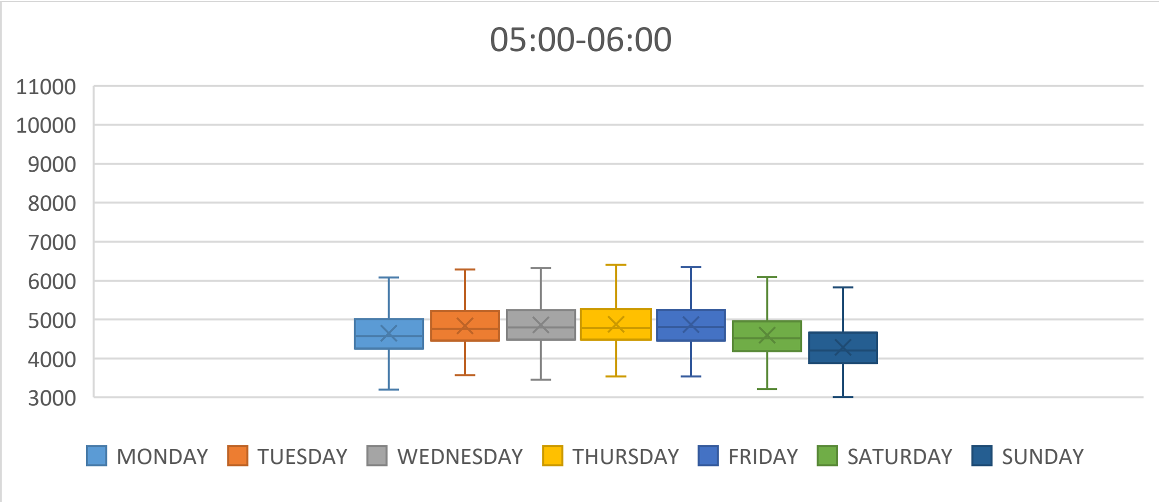

Figure 111: Actual total load of electricity in Greece against the day of the week for time zone 05:00-06:00

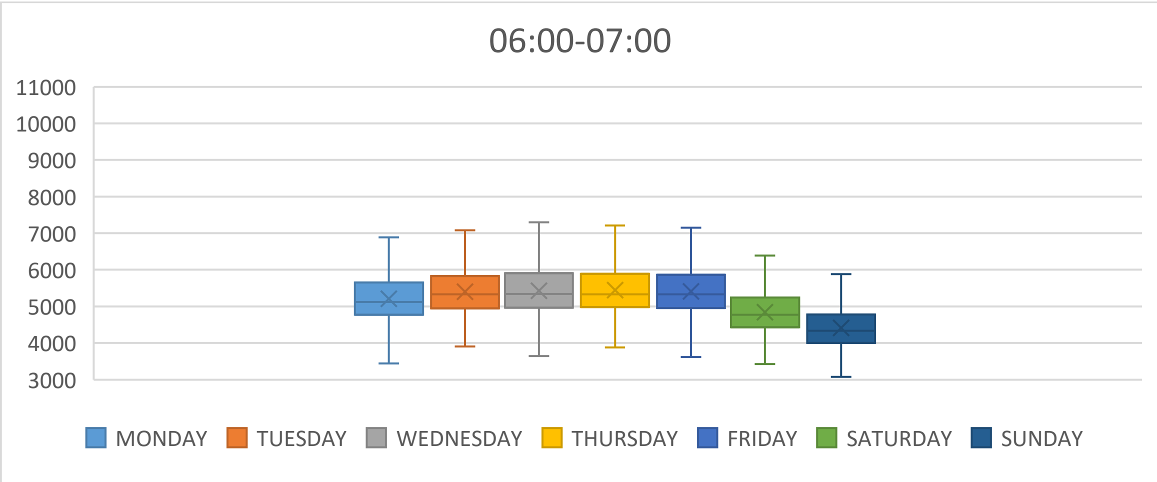

Figure 112: Actual total load of electricity in Greece against the day of the week for time zone 06:00-07:00

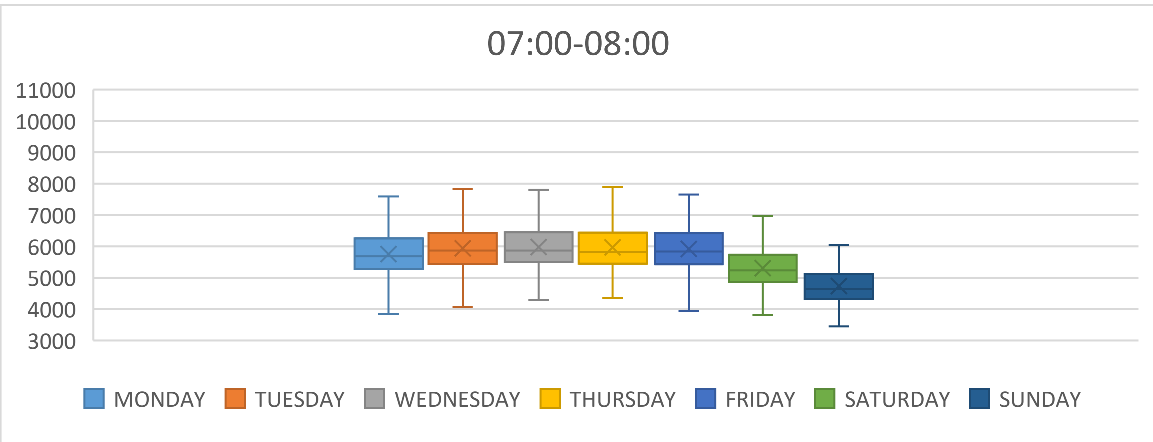

Figure 113: Actual total load of electricity in Greece against the day of the week for time zone 07:00-08:00

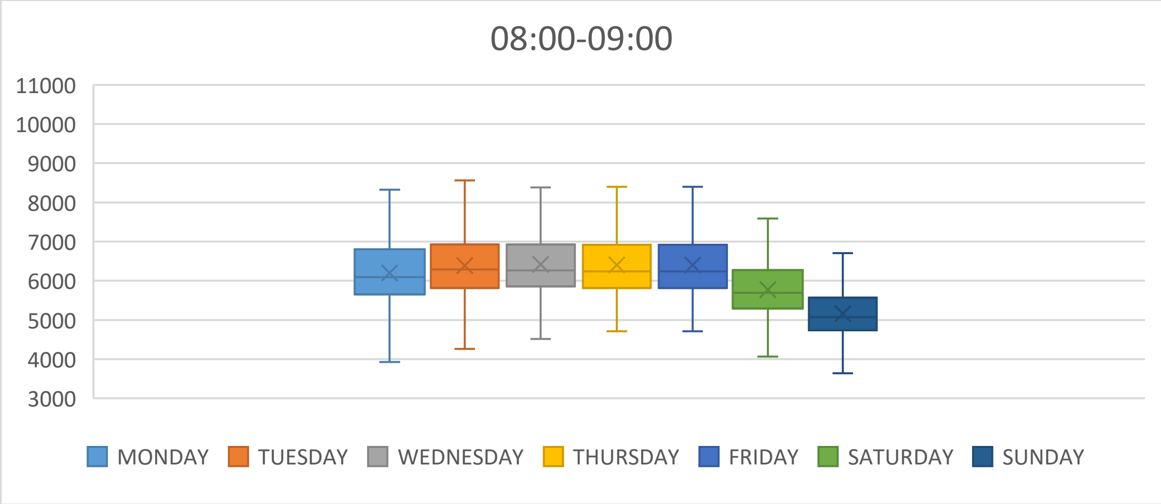

Figure 114: Actual total load of electricity in Greece against the day of the week for time zone 08:00-09:00

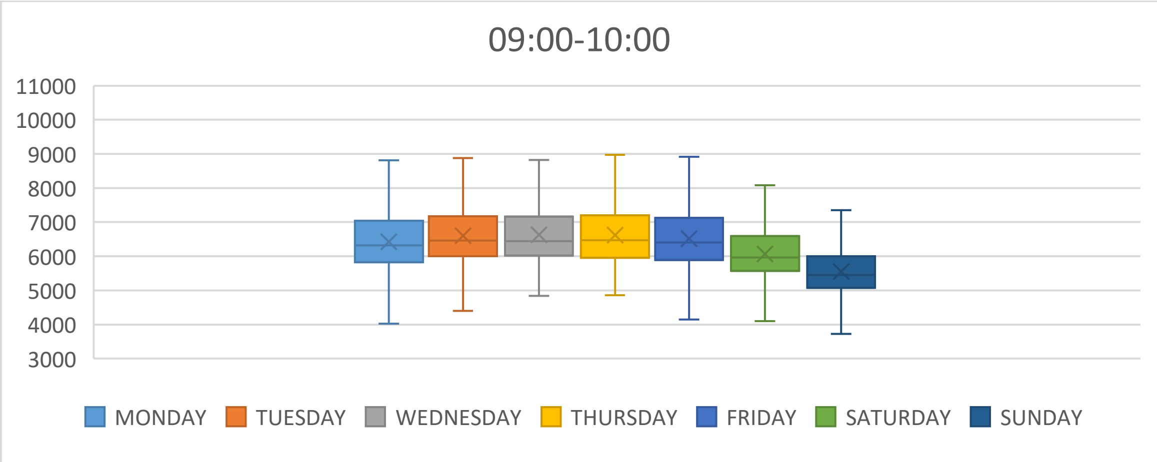

Figure 115: Actual total load of electricity in Greece against the day of the week for time zone 09:00-10:00

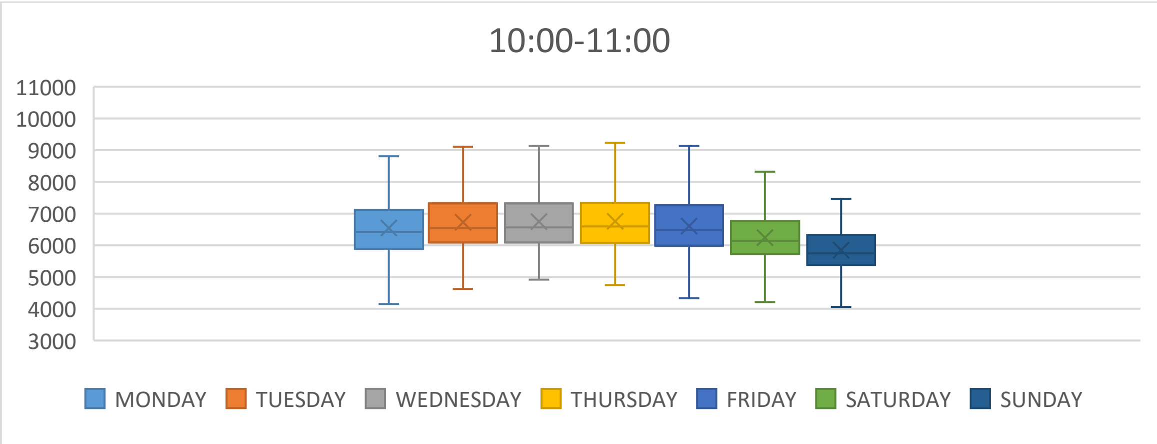

Figure 116: Actual total load of electricity in Greece against the day of the week for time zone 10:00-11:00

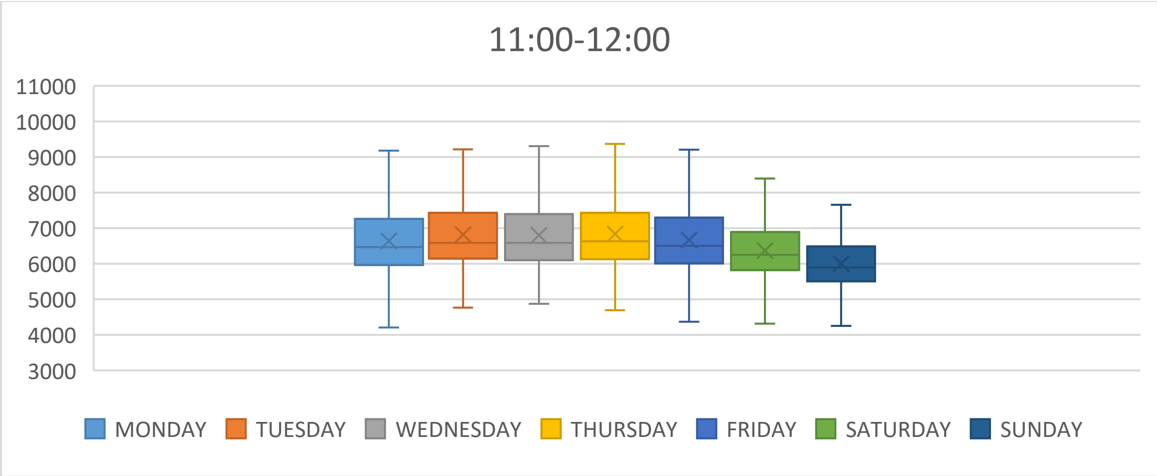

Figure 117: Actual total load of electricity in Greece against the day of the week for time zone 11:00-12:00

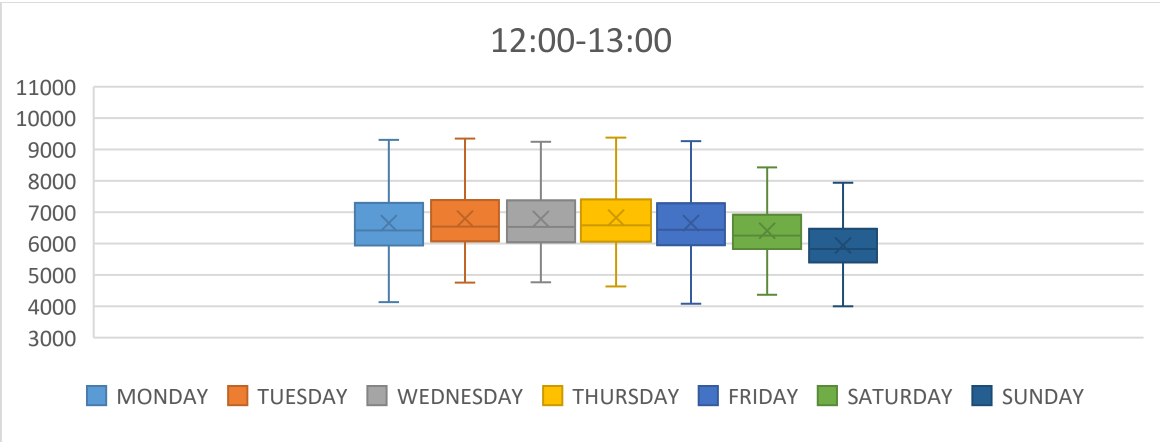

Figure 118: Actual total load of electricity in Greece against the day of the week for time zone 12:00-13:00

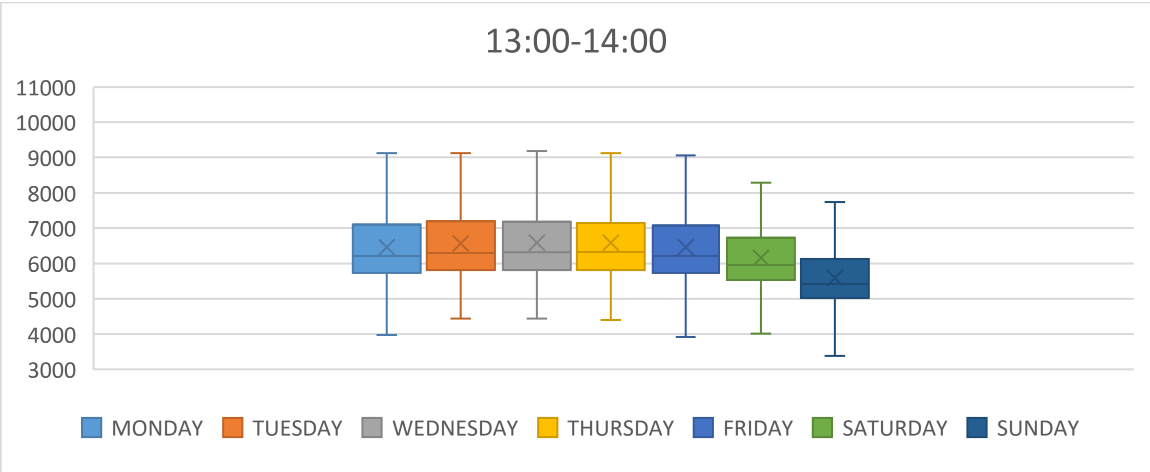

Figure 119: Actual total load of electricity in Greece against the day of the week for time zone 13:00-14:00

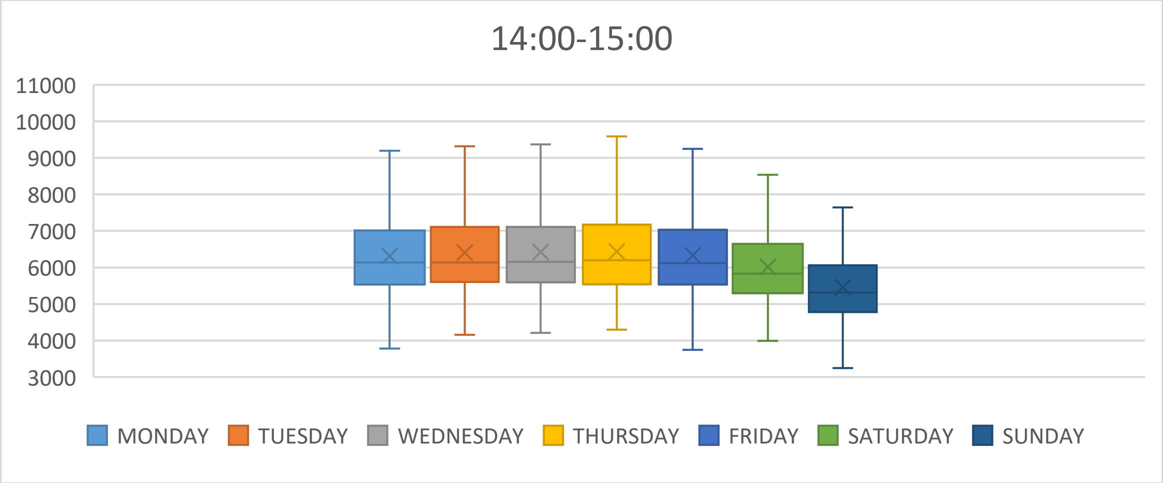

Figure 120: Actual total load of electricity in Greece against the day of the week for time zone 14:00-15:00

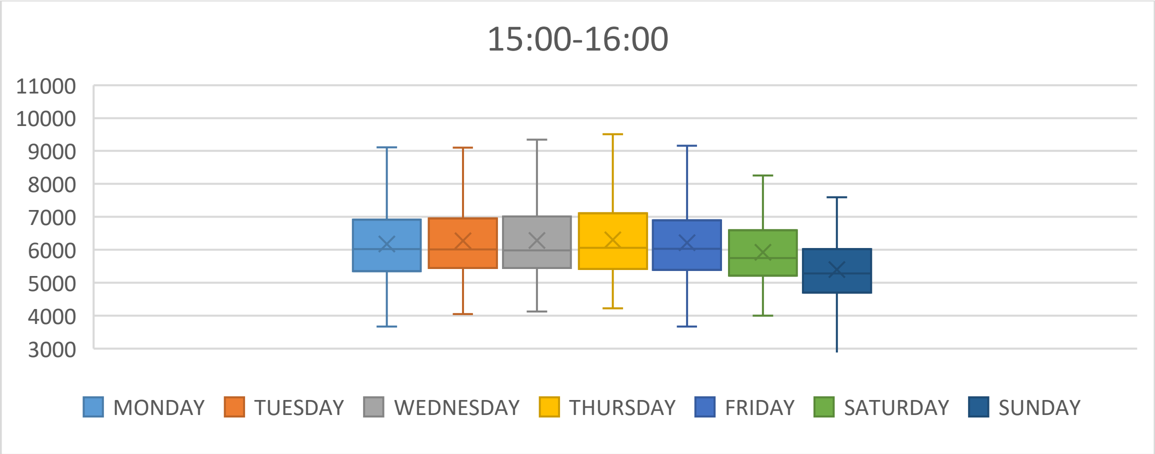

Figure 121: Actual total load of electricity in Greece against the day of the week for time zone 15:00-16:00

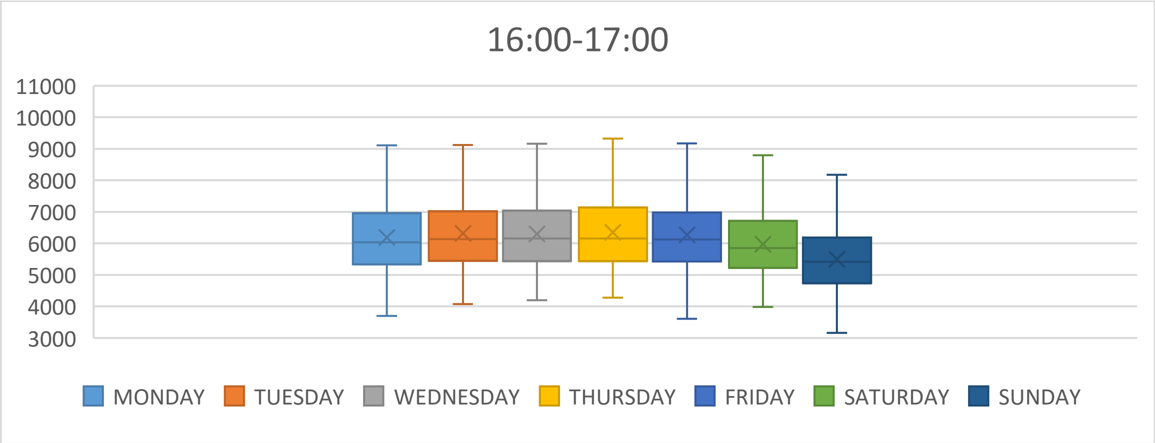

Figure 122: Actual total load of electricity in Greece against the day of the week for time zone 16:00-17:00

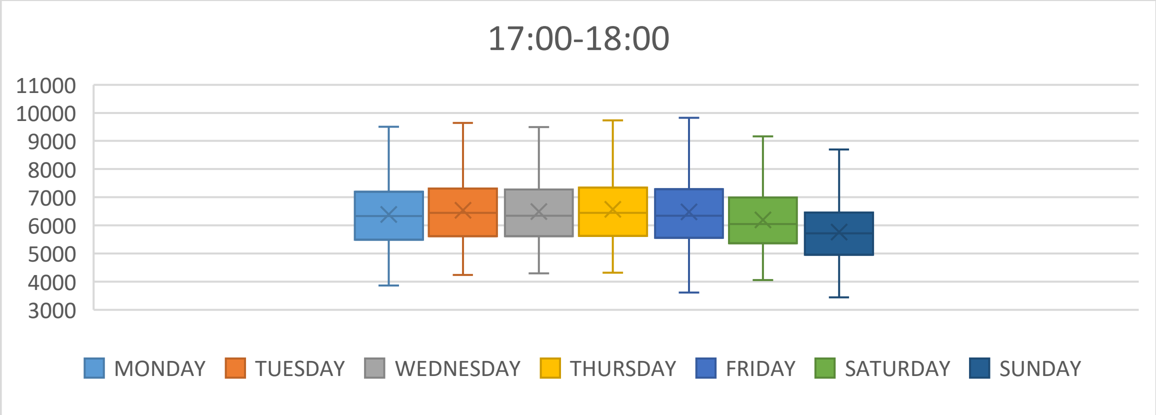

Figure 123: Actual total load of electricity in Greece against the day of the week for time zone 17:00-18:00

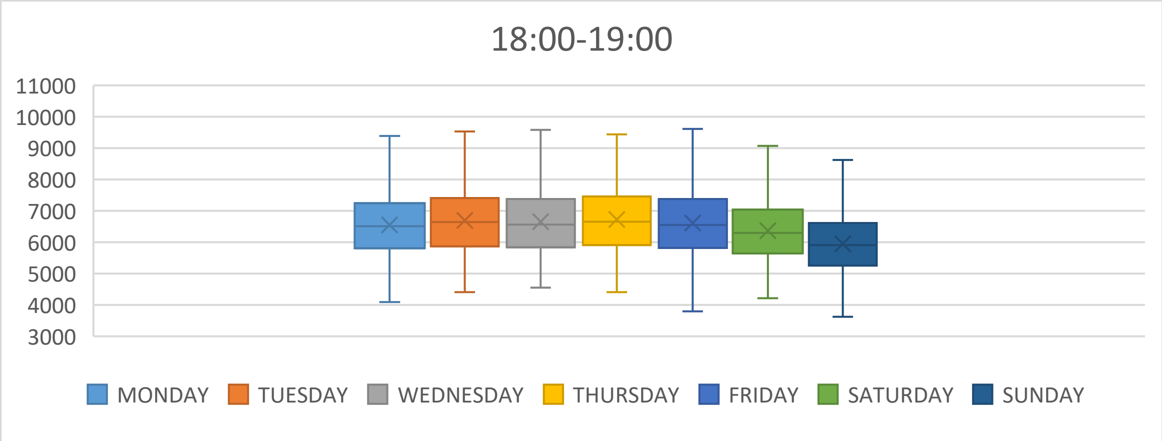

Figure 124: Actual total load of electricity in Greece against the day of the week for time zone 18:00-19:00

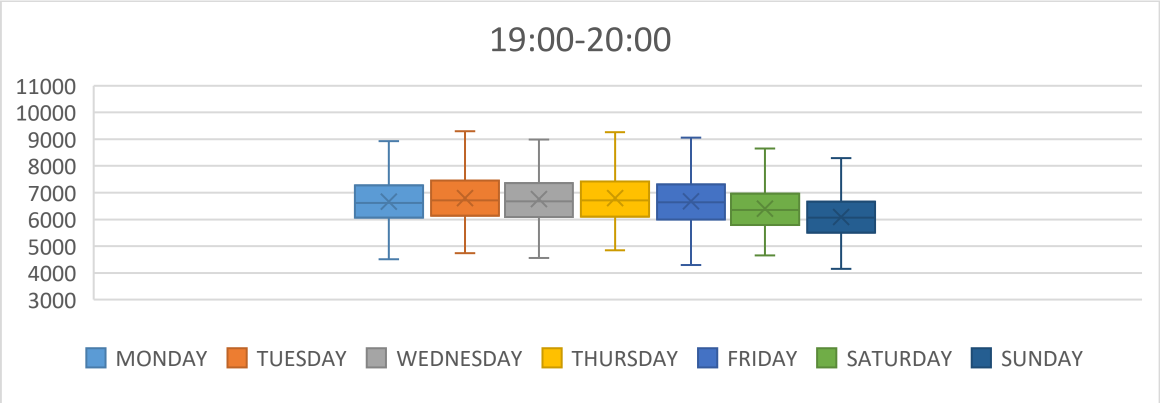

Figure 125: Actual total load of electricity in Greece against the day of the week for time zone 19:00-20:00

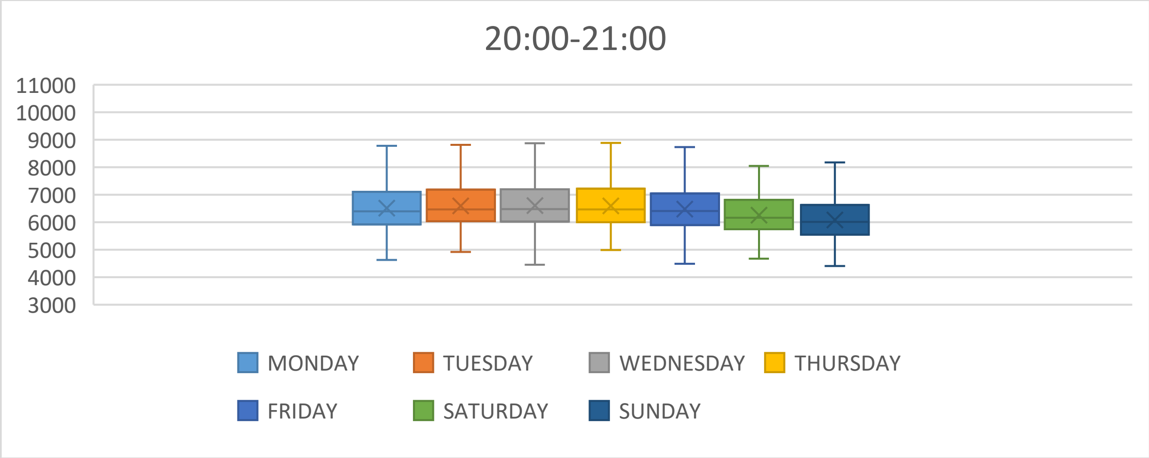

Figure 126 Actual total load of electricity in Greece against the day of the week for time zone 20:00-21:00

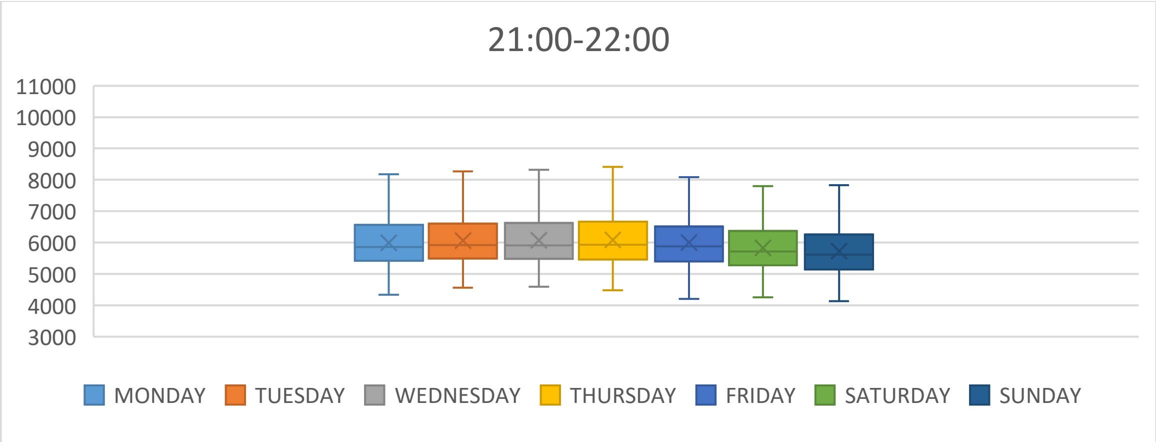

Figure 127: Actual total load of electricity in Greece against the day of the week for time zone 21:00-22:00

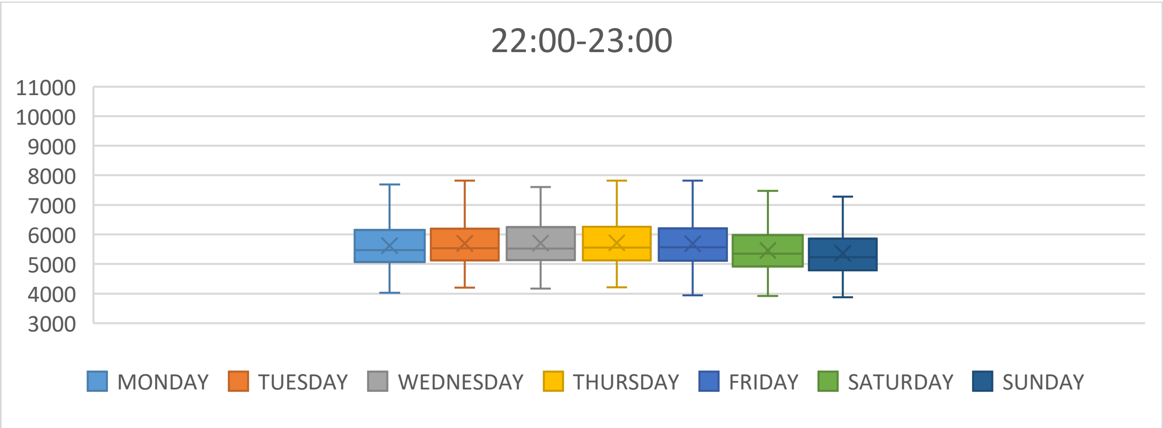

Figure 128: Actual total load of electricity in Greece against the day of the week for time zone 22:00-23:00

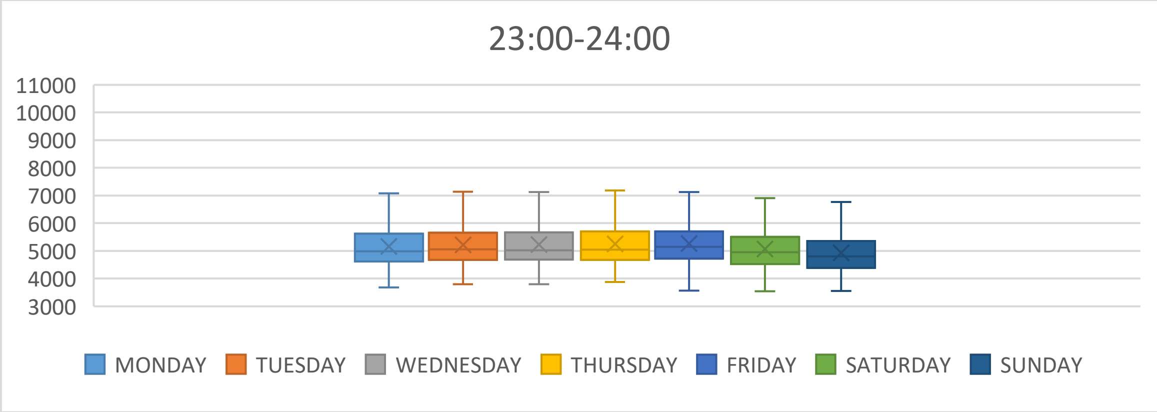

Figure 129: Actual total load of electricity in Greece against the day of the week for time zone 23:00-24:00

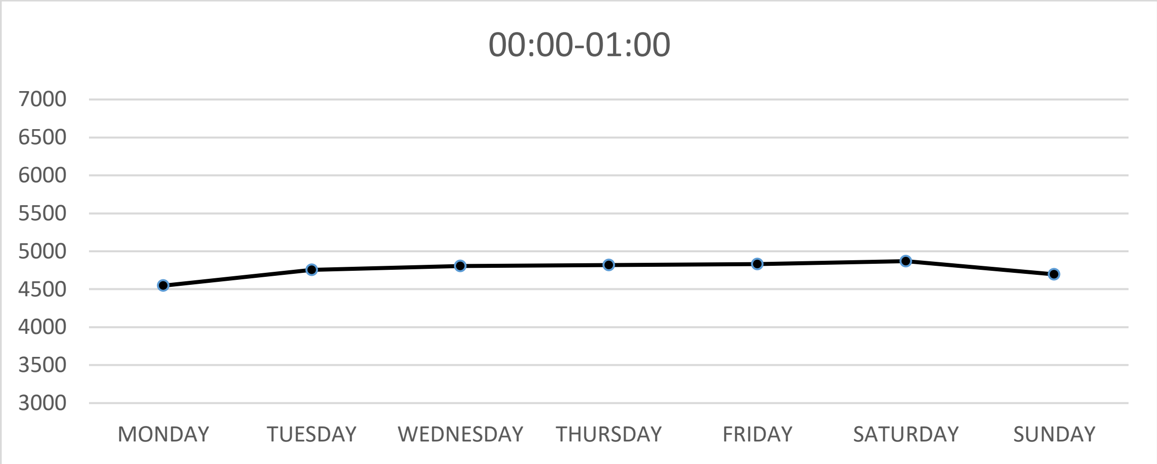

Figure 130: Daily mean actual total of electricity in Greece for time zone 00:00-01:00

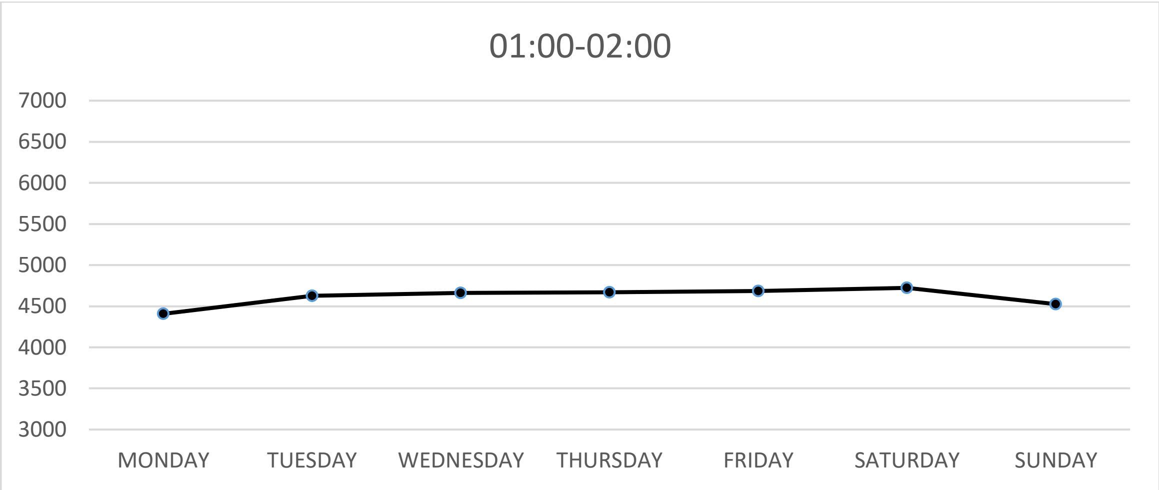

Figure 131: Daily mean actual total of electricity in Greece for time zone 01:00-02:00

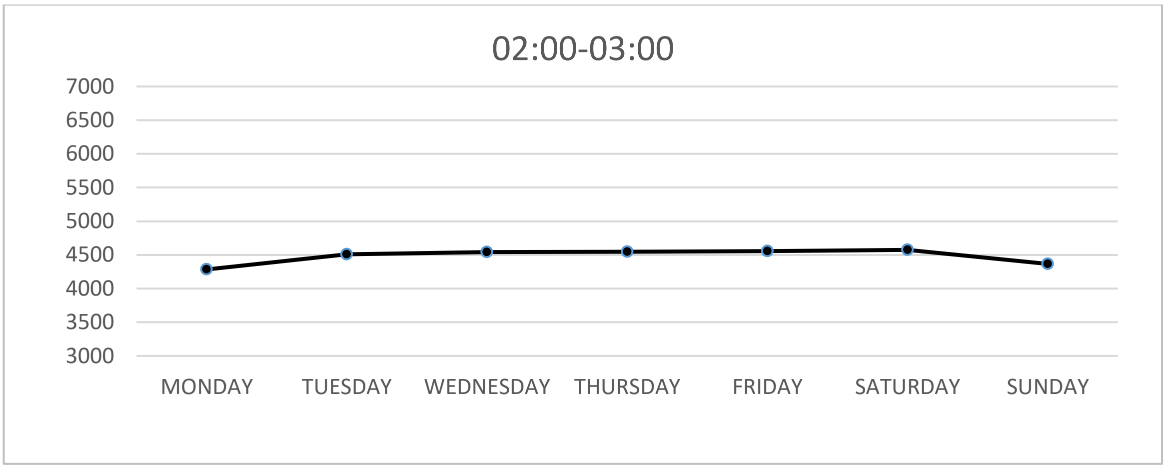

Figure 132: Daily mean actual total of electricity in Greece for time zone 02:00-03:00

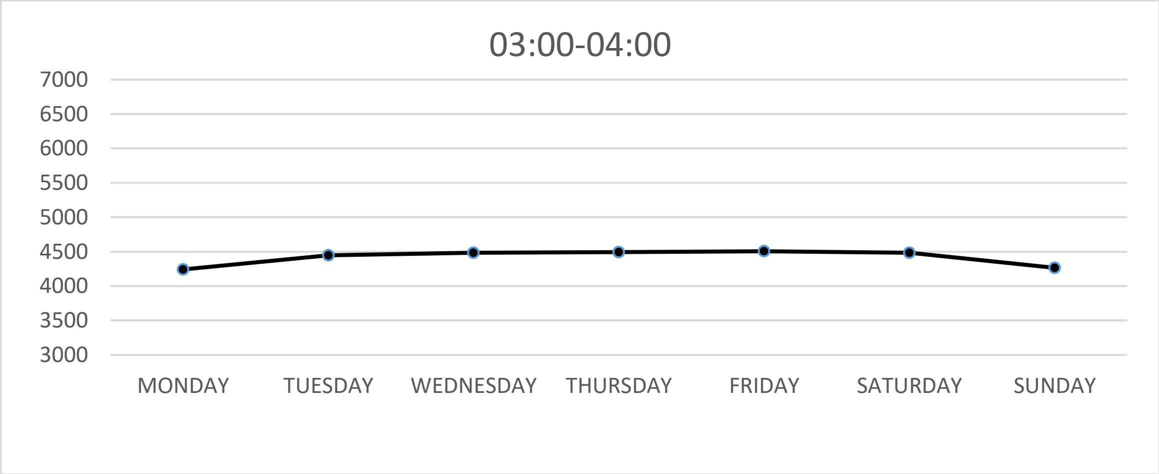

Figure 133: Daily mean actual total of electricity in Greece for time zone 03:00-04:00

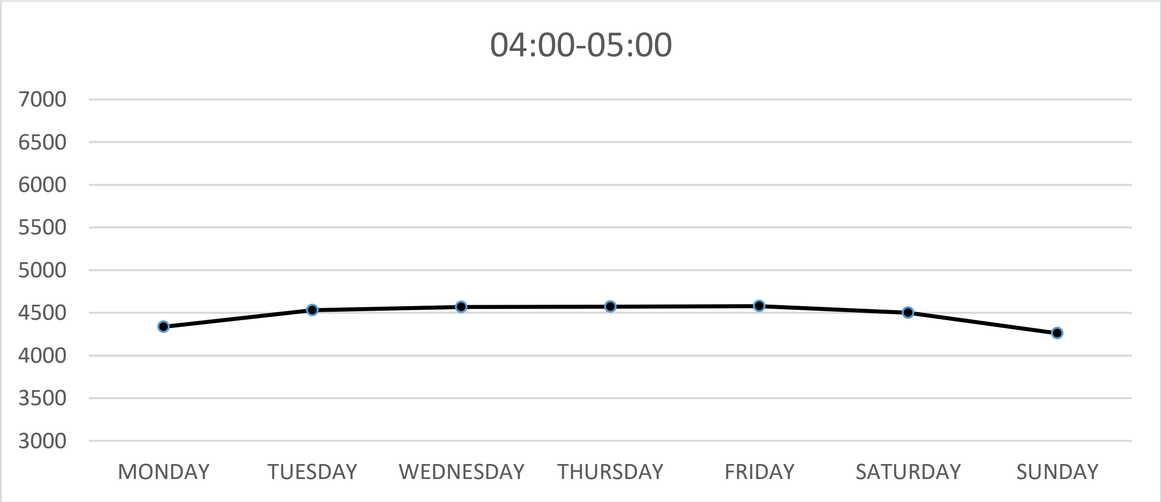

Figure 134: Daily mean actual total of electricity in Greece for time zone 04:00-05:00

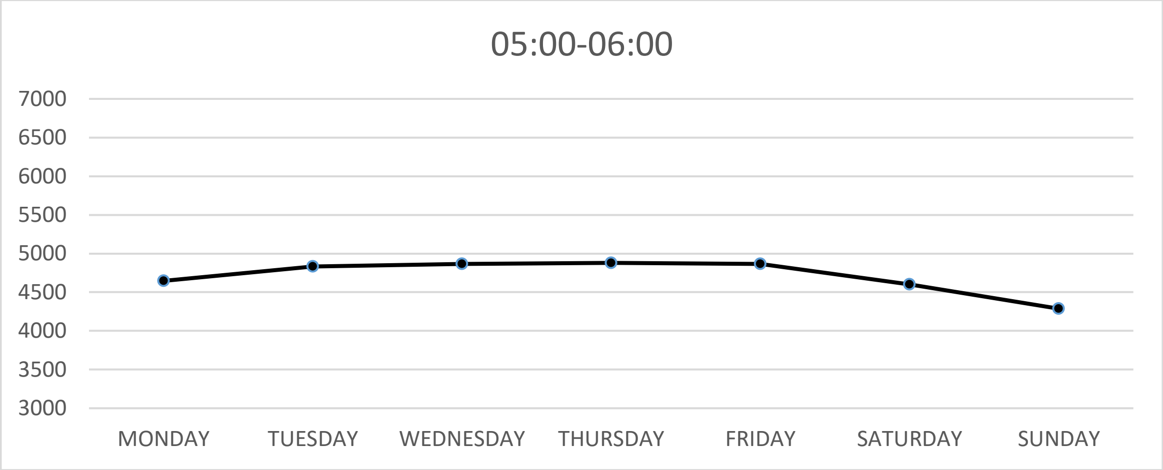

Figure 135: Daily mean actual total of electricity in Greece for time zone 05:00-06:00

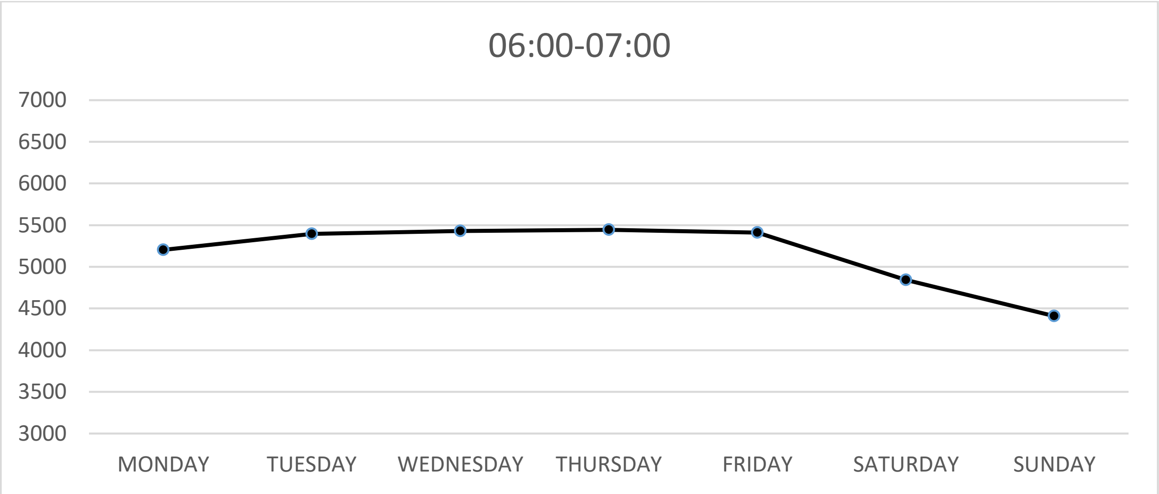

Figure 136: Daily mean actual total of electricity in Greece for time zone 06:00-07:00

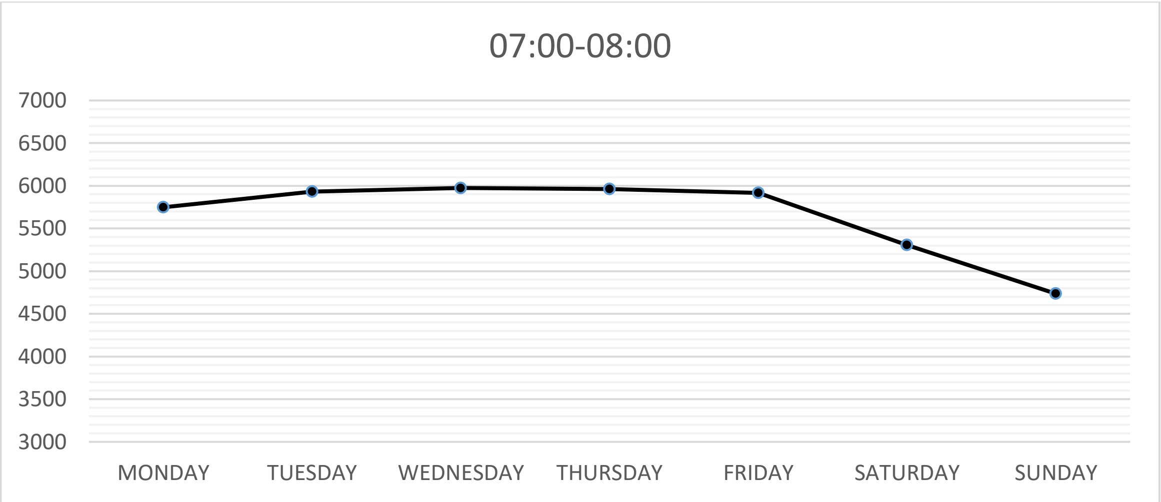

Figure 137: Daily mean actual total of electricity in Greece for time zone 07:00-08:00

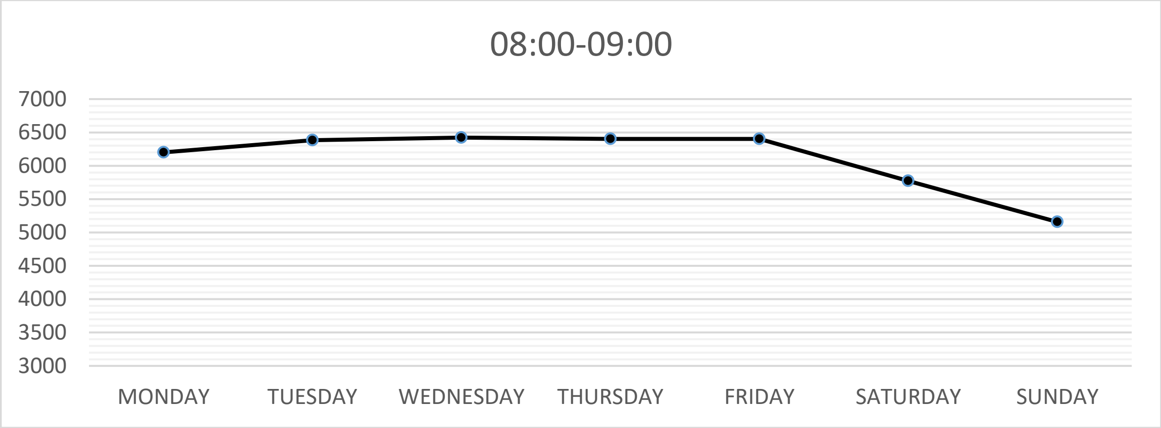

Figure 138: Daily mean actual total of electricity in Greece for time zone 08:00-09:00

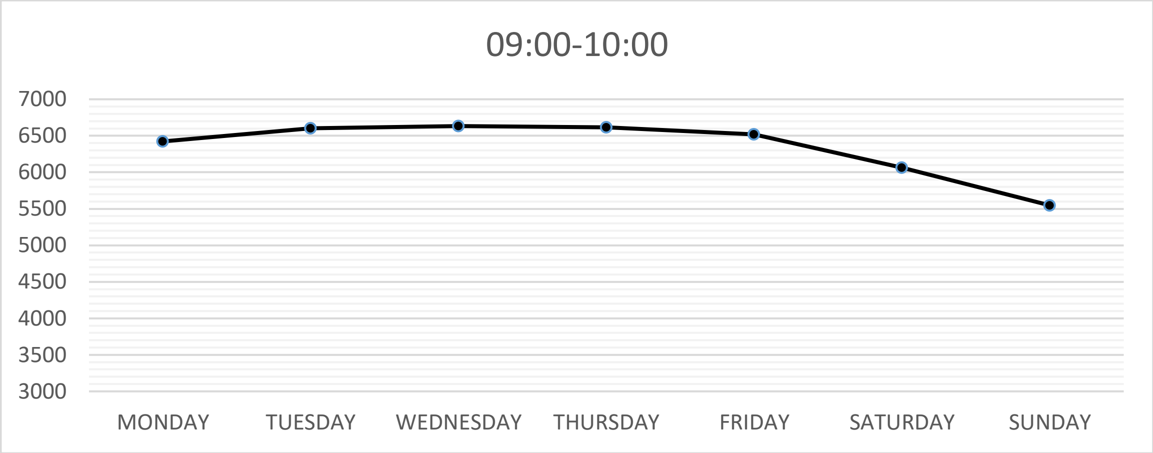

Figure 139: Daily mean actual total of electricity in Greece for time zone 09:00-10:00

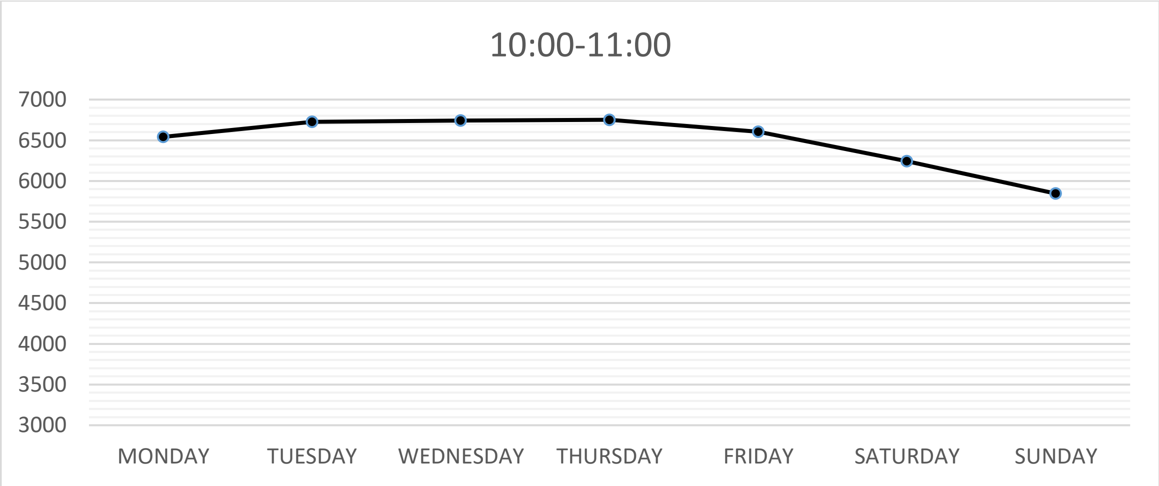

Figure 140: Daily mean actual total of electricity in Greece for time zone 10:00-11:00

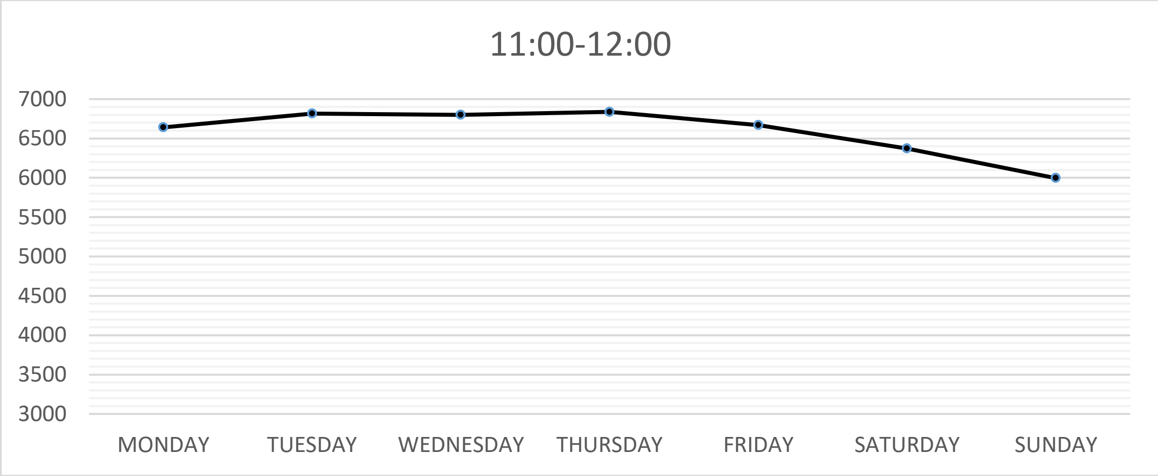

Figure 141: Daily mean actual total of electricity in Greece for time zone 11:00-12:00

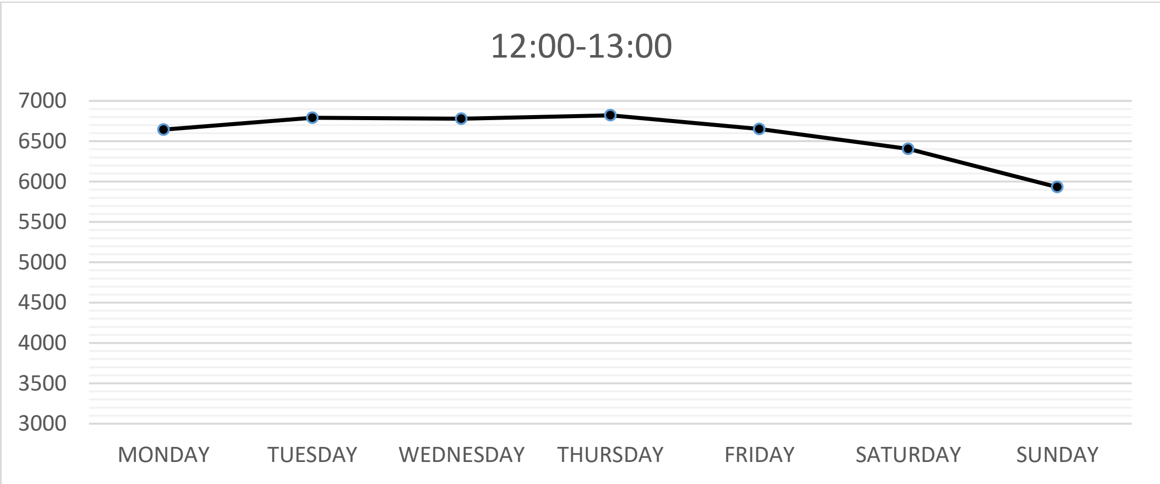

Figure 142: Daily mean actual total of electricity in Greece for time zone 12:00-13:00

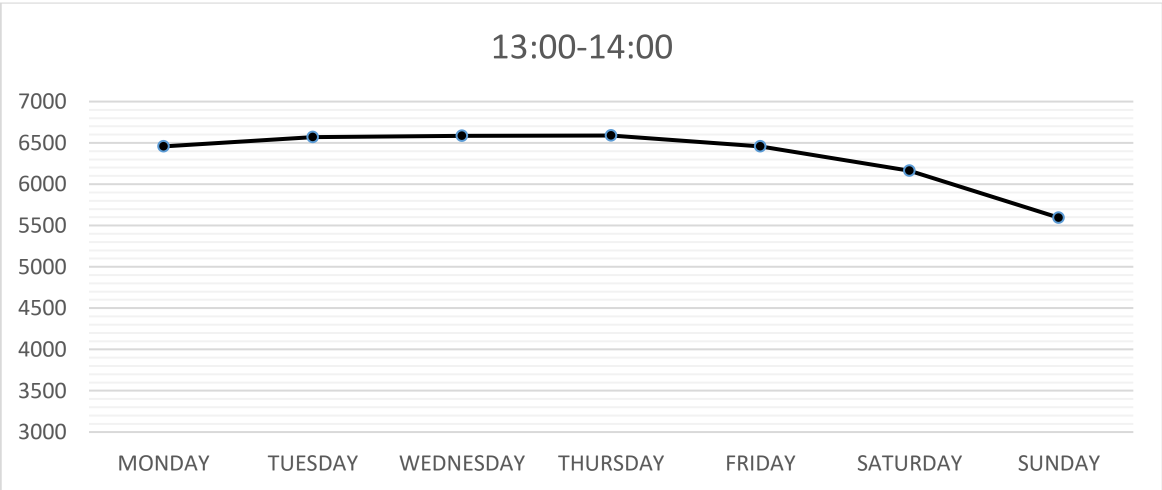

Figure 143: Daily mean actual total of electricity in Greece for time zone 13:00-14:00

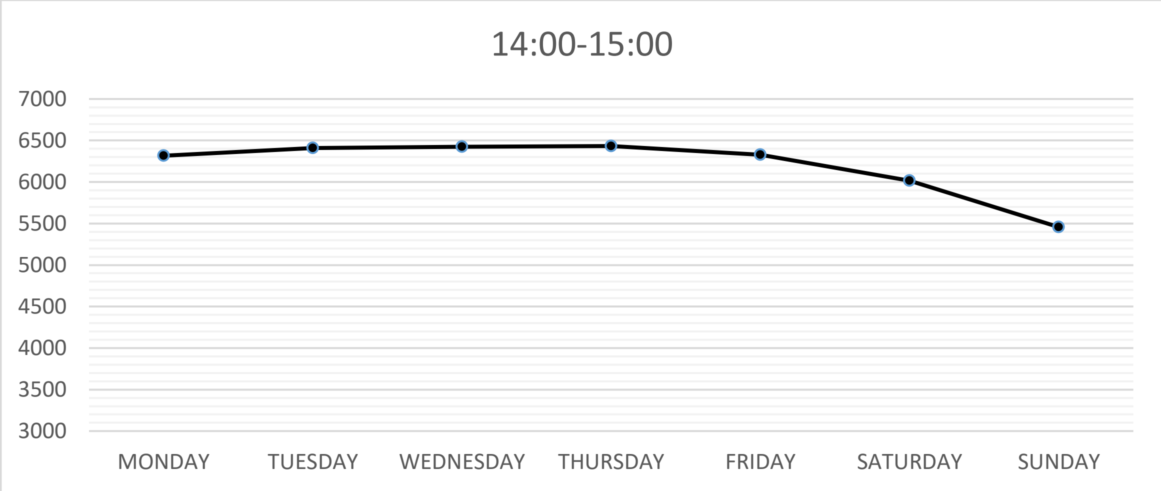

Figure 144: Daily mean actual total of electricity in Greece for time zone 14:00-15:00

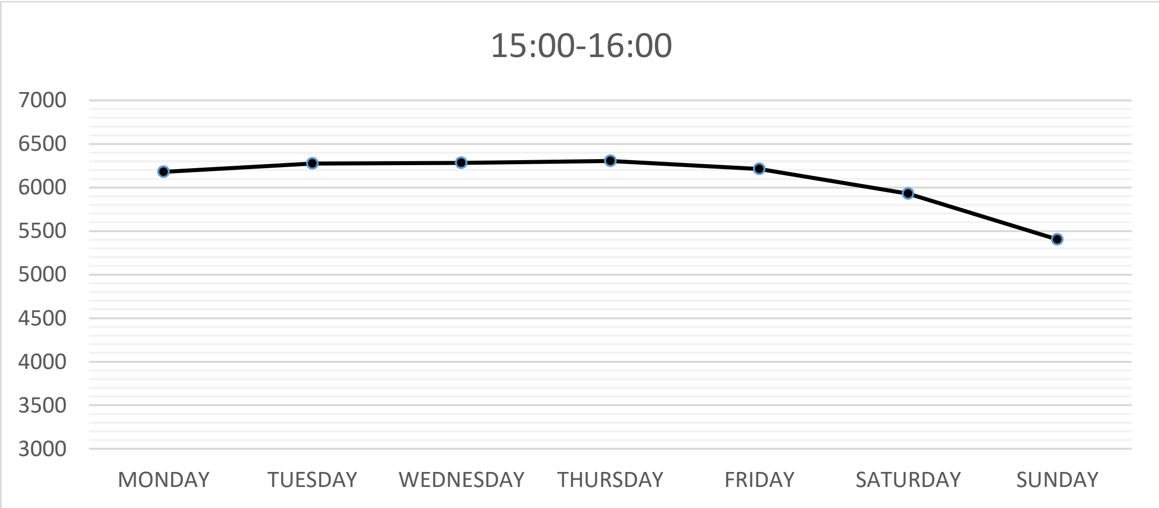

Figure 145: Daily mean actual total of electricity in Greece for time zone 15:00-16:00

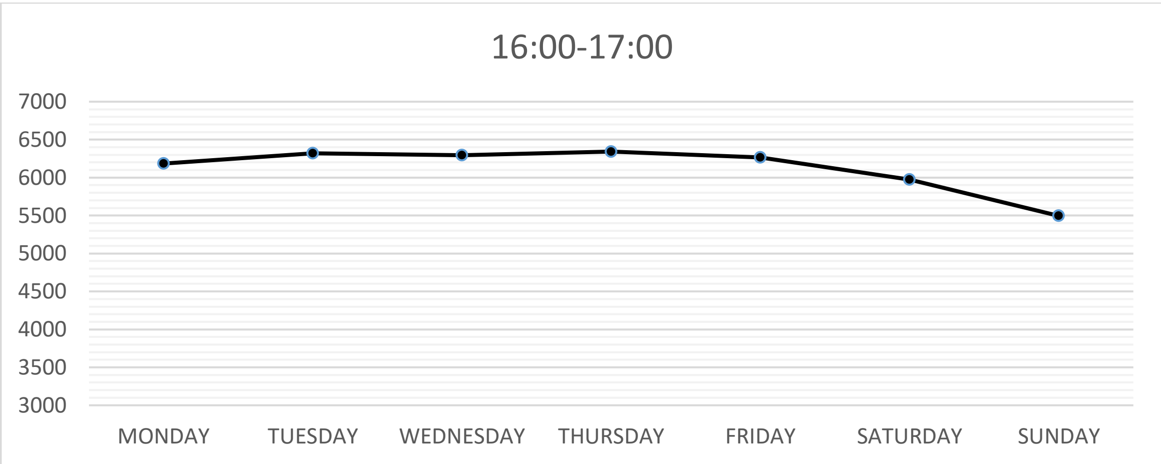

Figure 146: Daily mean actual total of electricity in Greece for time zone 16:00-17:00

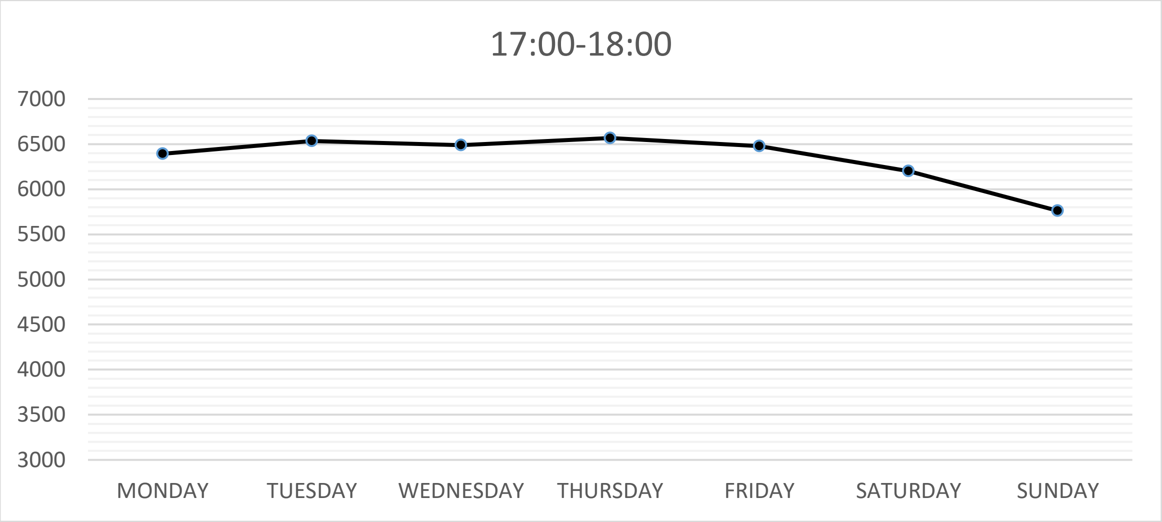

Figure 147: Daily mean actual total of electricity in Greece for time zone 17:00-18:00

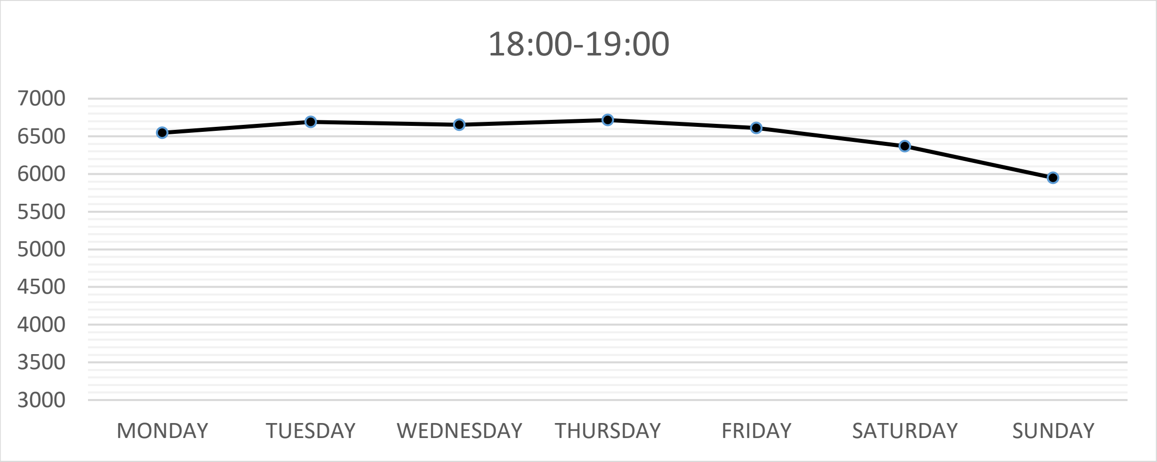

Figure 148: Daily mean actual total of electricity in Greece for time zone 18:00-19:00

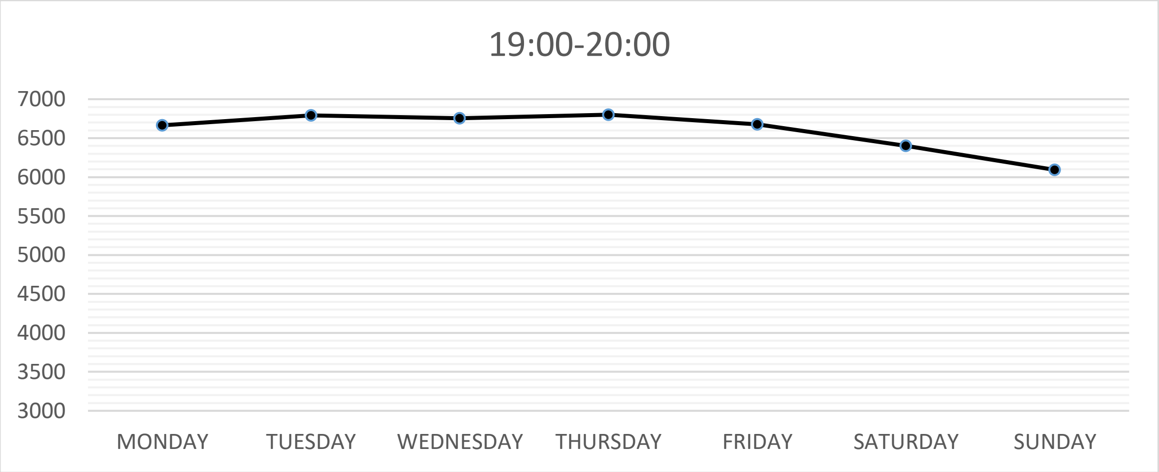

Figure 149: Daily mean actual total of electricity in Greece for time zone 19:00-20:00

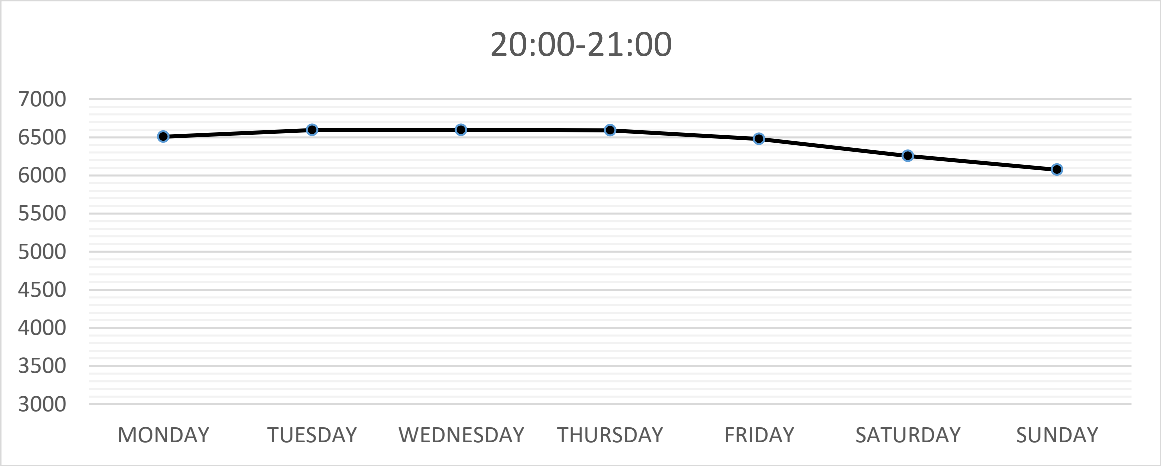

Figure 150: Daily mean actual total of electricity in Greece for time zone 20:00-21:00

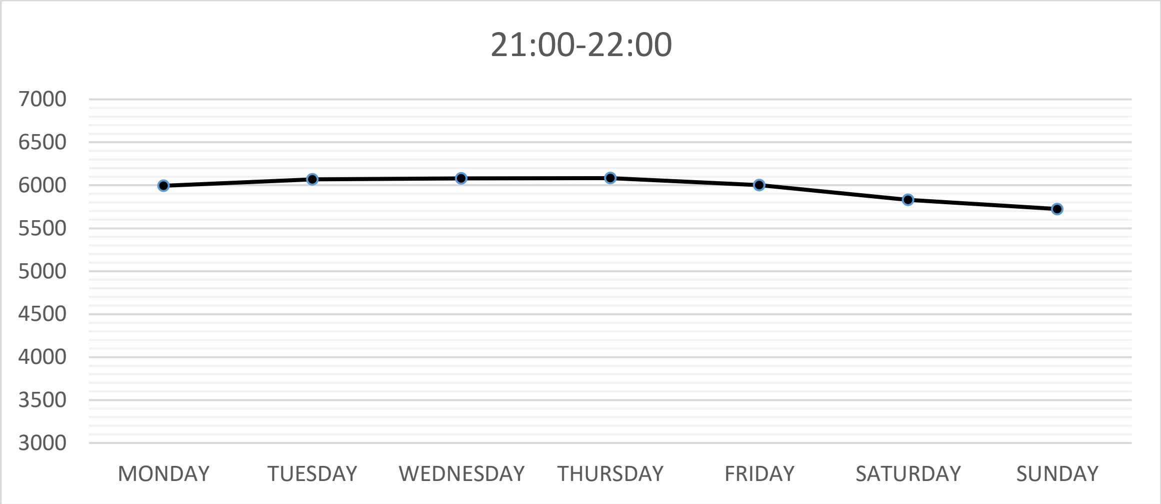

Figure 151: Daily mean actual total of electricity in Greece for time zone 21:00-22:00

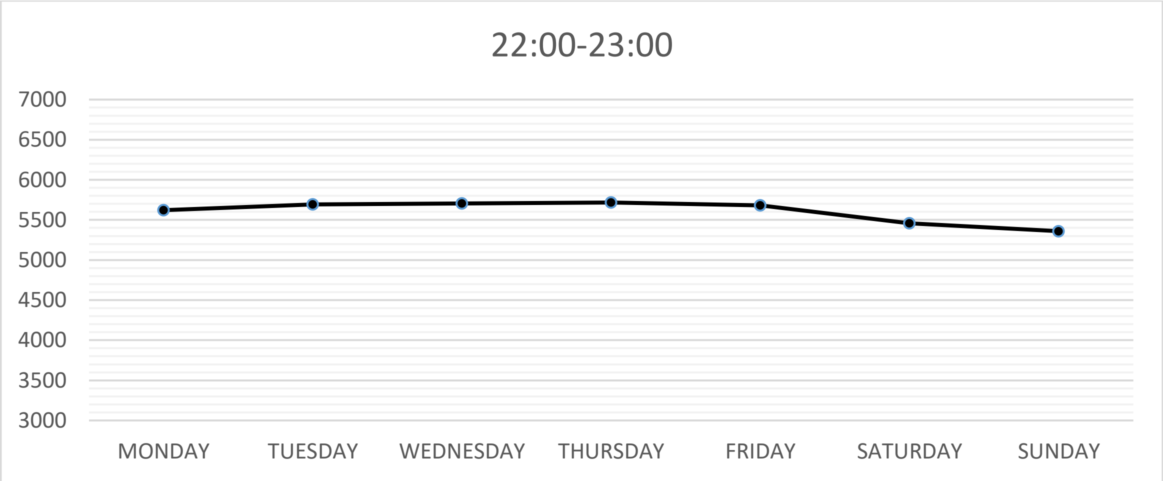

Figure 152: Daily mean actual total of electricity in Greece for time zone 2200-23:00

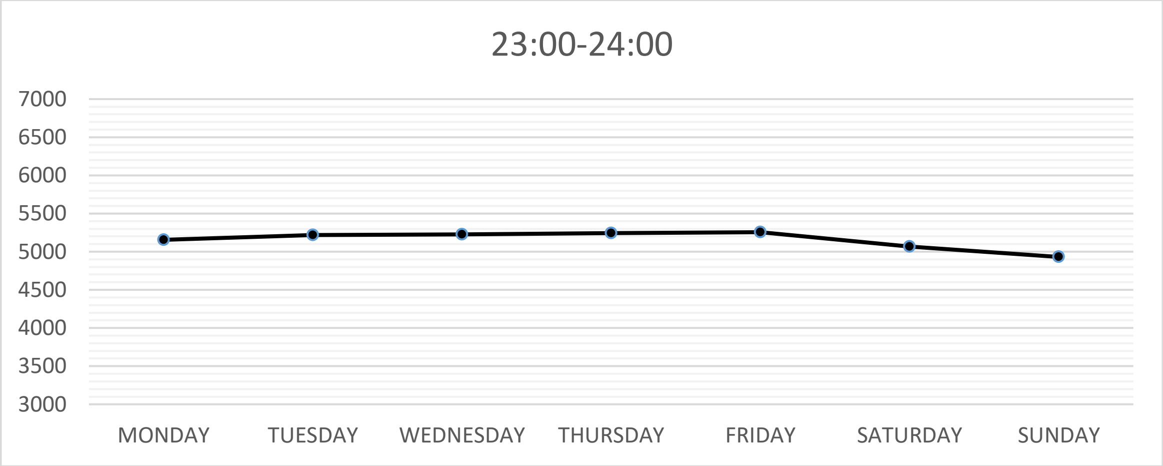

Figure 153: Daily mean actual total of electricity in Greece for time zone 23:00-24:00

Appendix D: Variable significance results

In order to verify the statistical significance of the properties of electricity demand that derived from the descriptive analysis, the 24 regression models for each time zone were runed through SPSS Statistics with the following tables of Coefficients Summary for each model being produced. The standing points of these tables are the second column (Unstandardized Coefficients) where is shown the coefficients of the explanatory variables under column B and the last column (Sig.) where is shown the p-value for each explanatory variable.

- *Time zone 00:00 – 01:00*

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	T	Sig.
1	(Constant)	8.469	.007		1138.715	<.001
	linear term	1.725E-5	.000	.115	2.824	.005
	Quadradic term	-1.319E-8	.000	-.299	-7.335	<.001
	JAN	.052	.007	.101	7.319	<.001
	FEB	.016	.007	.031	2.269	.023
	MAR	-.032	.007	-.062	-4.478	<.001
	APR	-.117	.007	-.225	-16.433	<.001
	MAY	-.130	.007	-.255	-18.482	<.001
	JUN	.009	.007	.017	1.266	***.206***
	JUL	.222	.007	.435	31.593	<.001
	AUG	.174	.007	.341	24.741	<.001
	SEP	-.022	.007	-.043	-3.116	.002
	OCT	-.136	.007	-.267	-19.387	<.001
	NOV	-.104	.007	-.202	-14.738	<.001
	MONDAY	-.033	.005	-.082	-6.168	<.001
	TUESDAY	.013	.005	.031	2.335	.020
	WEDNESDAY	.023	.005	.057	4.255	<.001
	THURSDAY	.026	.005	.064	4.784	<.001
	FRIDAY	.028	.005	.070	5.219	<.001
	SATURDAY	.036	.005	.089	6.676	<.001

Dependent Variable: log total load 00:00 - 01:00

Table 56: Coefficient summary of log total load 00:00 - 01:00

As it is can be concluded from Table 56 all independent variables expect of June have p-value lower than 0.05 indicating that they have statistically significant impact on the total load of electricity for the time zone 00:00 - 01:00 in Greece as the null hypotheses are rejected. As concerns the variable of June, its p-value is greater than 0.05 indicating that there is no sufficient evidence that the impact of June is significant for the electricity demand in the time zone 00:00 – 01:00.

- *Time zone 01:00 - 02:00*

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	8.442	.007		1132.932	<.001
	linear term	1.836E-5	.000	.124	2.999	.003
	Quadradic term	-1.358E-8	.000	-.311	-7.535	<.001
	JAN	.059	.007	.116	8.293	<.001
	FEB	.024	.007	.046	3.329	<.001
	MAR	-.030	.007	-.060	-4.280	<.001
	APR	-.120	.007	-.235	-16.896	<.001
	MAY	-.151	.007	-.299	-21.393	<.001
	JUN	-.013	.007	-.026	-1.848	***.065***
	JUL	.195	.007	.388	27.716	<.001
	AUG	.148	.007	.294	21.053	<.001
	SEP	-.041	.007	-.080	-5.732	<.001
	OCT	-.153	.007	-.304	-21.769	<.001
	NOV	-.109	.007	-.213	-15.315	<.001
	MONDAY	-.028	.005	-.069	-5.075	<.001
	TUESDAY	.022	.005	.055	4.053	<.001
	WEDNESDAY	.030	.005	.074	5.465	<.001
	THURSDAY	.032	.005	.079	5.844	<.001
	FRIDAY	.034	.005	.085	6.313	<.001
	SATURDAY	.042	.005	.105	7.784	<.001

Dependent Variable: log total load 01:00 - 02:00

Table 57: Coefficient summary of log total load 01:00 - 02:00

As it is can be observed from Table 57, the conclusions from the regression results of the actual total load of time zone 01:00-02:00 for the significance of the independent variables are similar of the time zone 00:00-01:00.

- *Time zone 02:00 - 03:00*

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	8.397	.007		1140.536	<.001
	linear term	1.894E-5	.000	.131	3.132	.002
	Quadradic term	-1.300E-8	.000	-.306	-7.303	<.001
	JAN	.059	.007	.121	8.506	<.001
	FEB	.028	.007	.054	3.850	<.001
	MAR	-.023	.007	-.046	-3.236	.001
	APR	-.117	.007	-.235	-16.684	<.001
	MAY	-.138	.007	-.281	-19.795	<.001
	JUN	-.005	.007	-.009	-.648	***.517***
	JUL	.198	.007	.402	28.371	<.001
	AUG	.150	.007	.306	21.606	<.001
	SEP	-.029	.007	-.059	-4.188	<.001
	OCT	-.138	.007	-.280	-19.789	<.001
	NOV	-.099	.007	-.199	-14.141	<.001
	MONDAY	-.020	.005	-.050	-3.638	<.001
	TUESDAY	.032	.005	.083	6.038	<.001
	WEDNESDAY	.040	.005	.103	7.483	<.001
	THURSDAY	.041	.005	.105	7.638	<.001
	FRIDAY	.042	.005	.108	7.897	<.001
	SATURDAY	.046	.005	.119	8.657	<.001
Dependent Variable: log total load 02:00 - 03:00						

Table 58: Coefficient summary of log total load 02:00 - 03:00

As it is can be observed from Table 58, the conclusions from the regression results of the actual total load of time zone 02:00-03:00 for the significance of the independent variables are similar of the time zone 00:00-01:00.

- *Time zone 03:00 - 04:00*

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	8.362	.007		1148.611	<.001
	linear term	1.849E-5	.000	.133	3.097	.002
	Quadradic term	-1.252E-8	.000	-.306	-7.120	<.001
	JAN	.058	.007	.122	8.353	<.001
	FEB	.026	.007	.053	3.728	<.001
	MAR	-.025	.007	-.053	-3.676	<.001
	APR	-.106	.007	-.220	-15.251	<.001
	MAY	-.121	.007	-.255	-17.530	<.001
	JUN	.011	.007	.024	1.651	***.099***
	JUL	.201	.007	.424	29.180	<.001
	AUG	.143	.007	.302	20.765	<.001
	SEP	-.028	.007	-.059	-4.073	<.001
	OCT	-.123	.007	-.261	-17.947	<.001
	NOV	-.086	.007	-.179	-12.403	<.001
	MONDAY	.048	.005	.128	9.110	<.001
	TUESDAY	.057	.005	.151	10.753	<.001
	WEDNESDAY	.058	.005	.154	10.990	<.001
	THURSDAY	.061	.005	.162	11.514	<.001
	FRIDAY	.056	.005	.147	10.488	<.001
	SATURDAY	.006	.005	.016	1.172	***.241***
Dependent Variable: log total load 03:00 - 04:00						

Table 59: Coefficient Summary of log total load 03:00 - 04:00

As it is can be concluded from Table 59 all independent variables expect of June and Saturday have p-value lower than 0.05 indicating that they have statistically significant impact on the total load of electricity for the time zone 03:00 - 04:00 in Greece as the null hypotheses are rejected. As concerns the variables of June and Saturday, their p-value are greater than 0.05 indicating that there is no sufficient evidence that the impact of each of these two variables is significant for the electricity demand in the time zone 03:00 – 04:00.

- *Time zone 04:00 - 05:00*

Coefficients[a]				
Model	Unstandardized Coefficients	Standardized Coefficients	t	Sig.

		B	Std. Error	Beta		
1	(Constant)	8.368	.007		1187.852	<.001
	linear term	2.209E-5	.000	.168	3.818	<.001
	Quadradic term	-1.274E-8	.000	-.328	-7.476	<.001
	JAN	.052	.007	.115	7.729	<.001
	FEB	.026	.007	.056	3.835	<.001
	MAR	-.019	.007	-.043	-2.866	.004
	APR	-.108	.007	-.237	-16.079	<.001
	MAY	-.127	.007	-.282	-18.992	<.001
	JUN	-.009	.007	-.020	-1.357	***.175***
	JUL	.173	.007	.386	25.977	<.001
	AUG	.125	.007	.278	18.735	<.001
	SEP	-.029	.007	-.063	-4.289	<.001
	OCT	-.119	.007	-.265	-17.896	<.001
	NOV	-.084	.007	-.184	-12.487	<.001
	MONDAY	.017	.005	.048	3.315	<.001
	TUESDAY	.062	.005	.174	12.130	<.001
	WEDNESDAY	.071	.005	.198	13.774	<.001
	THURSDAY	.072	.005	.201	13.982	<.001
	FRIDAY	.072	.005	.202	14.052	<.001
	SATURDAY	.055	.005	.155	10.770	<.001
Dependent Variable: log total load 04:00 - 05:00						

Table 60: Coefficient summary of log total load 04:00 - 05:00

As it is can be observed from Table 60, the conclusions from the regression results of the actual total load of time zone 04:00-05:00 for the significance of the independent variables are similar of the time zone 00:00-01:00.

- *Time zone 05:00 - 06:00*

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	8.400	.007		1165.218	<.001
	linear term	2.418E-5	.000	.184	4.083	<.001
	Quadradic term	-1.221E-8	.000	-.315	-7.002	<.001
	JAN	.046	.007	.102	6.694	<.001
	FEB	.028	.007	.059	3.958	<.001

	MAR	-.033	.007	-.075	-4.894	<.001
	APR	-.135	.007	-.296	-19.560	<.001
	MAY	-.182	.007	-.406	-26.639	<.001
	JUN	-.074	.007	-.163	-10.795	<.001
	JUL	.094	.007	.211	13.851	<.001
	AUG	.050	.007	.113	7.391	<.001
	SEP	-.059	.007	-.129	-8.547	<.001
	OCT	-.130	.007	-.291	-19.103	<.001
	NOV	-.085	.007	-.188	-12.401	<.001
	MONDAY	.080	.005	.224	15.234	<.001
	TUESDAY	.121	.005	.340	23.092	<.001
	WEDNESDAY	.128	.005	.358	24.309	<.001
	THURSDAY	.130	.005	.366	24.846	<.001
	FRIDAY	.127	.005	.356	24.152	<.001
	SATURDAY	.071	.005	.198	13.433	<.001
Dependent Variable: log total load 05:00 - 06:00						

Table 61: Coefficient summary of log total load 05:00 - 06:00

As it is can be concluded from Table 61 all independent variables have p-value lower than 0.05 indicating that they have statistically significant impact on the total load of electricity for the time zone 05:00 - 06:00 in Greece as the null hypotheses are rejected.

- *Time zone 06:00 - 07:00*

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	8.444	.008		1088.399	<.001
	linear term	2.509E-5	.000	.167	3.937	<.001
	Quadradic term	-1.269E-8	.000	-.287	-6.763	<.001
	JAN	.051	.007	.099	6.871	<.001
	FEB	.034	.008	.063	4.481	<.001
	MAR	-.036	.007	-.071	-4.917	<.001
	APR	-.159	.007	-.308	-21.536	<.001
	MAY	-.189	.007	-.370	-25.748	<.001
	JUN	-.083	.007	-.160	-11.205	<.001
	JUL	.068	.007	.133	9.234	<.001
	AUG	-.008	.007	-.016	-1.086	***.278***

	SEP	-.103	.007	-.198	-13.900	<.001
	OCT	-.150	.007	-.293	-20.402	<.001
	NOV	-.095	.007	-.184	-12.897	<.001
	MONDAY	.164	.006	.404	29.085	<.001
	TUESDAY	.203	.006	.499	35.901	<.001
	WEDNESDAY	.209	.006	.513	36.958	<.001
	THURSDAY	.212	.006	.521	37.462	<.001
	FRIDAY	.204	.006	.501	36.074	<.001
	SATURDAY	.094	.006	.232	16.663	<.001
Dependent Variable: log total load 06:00 - 07:00						

Table 62: Coefficient summary of log total load 06:00 - 07:00

As it is can be concluded from Table 62 all independent variables expect of August have p-value lower than 0.05 indicating that they have statistically significant impact on the total load of electricity for the time zone 06:00 - 07:00 in Greece as the null hypotheses are rejected. As concerns the variable of August, its p-value is greater than 0.05 indicating that there is no sufficient evidence that the impact of August is significant for the electricity demand in the time zone 06:00 – 07:00.

- *07:00 – 08:00*

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	8.499	.008		1090.093	<.001
	linear term	3.906E-5	.000	.254	6.100	<.001
	Quadradic term	-1.674E-8	.000	-.370	-8.881	<.001
	JAN	.051	.007	.097	6.864	<.001
	FEB	.036	.008	.066	4.782	<.001
	MAR	-.038	.007	-.073	-5.152	<.001
	APR	-.153	.007	-.288	-20.569	<.001
	MAY	-.166	.007	-.318	-22.564	<.001
	JUN	-.056	.007	-.106	-7.575	<.001
	JUL	.091	.007	.174	12.321	<.001
	AUG	.009	.007	.018	1.243	***.214***
	SEP	-.084	.007	-.158	-11.277	<.001
	OCT	-.150	.007	-.286	-20.353	<.001

	NOV	-.095	.007	-.179	-12.829	<.001
	MONDAY	.191	.006	.459	33.682	<.001
	TUESDAY	.225	.006	.540	39.684	<.001
	WEDNESDAY	.233	.006	.558	40.952	<.001
	THURSDAY	.230	.006	.552	40.541	<.001
	FRIDAY	.221	.006	.530	38.897	<.001
	SATURDAY	.113	.006	.272	19.942	<.001
Dependent Variable: log total load 07:00 - 08:00						

Table 63: Coefficient summary of log total load 07:00 - 08:00

As it is can be observed from Table 63, the conclusions from the regression results of the actual total load of time zone 07:00-08:00 for the significance of the independent variables are similar of the time zone 06:00-07:00.

- *08:00 – 09:00*

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	8.582	.008		1085.578	<.001
	linear term	4.404E-5	.000	.286	6.782	<.001
	Quadradic term	-1.837E-8	.000	-.405	-9.609	<.001
	JAN	.059	.007	.113	7.916	<.001
	FEB	.031	.008	.056	3.986	<.001
	MAR	-.051	.007	-.098	-6.860	<.001
	APR	-.162	.008	-.304	-21.438	<.001
	MAY	-.164	.007	-.313	-21.897	<.001
	JUN	-.049	.008	-.092	-6.479	<.001
	JUL	.101	.007	.192	13.489	<.001
	AUG	.020	.007	.038	2.654	.008
	SEP	-.075	.008	-.141	-9.949	<.001
	OCT	-.154	.007	-.294	-20.589	<.001
	NOV	-.108	.008	-.204	-14.380	<.001
	MONDAY	.181	.006	.433	31.417	<.001
	TUESDAY	.213	.006	.510	36.949	<.001
	WEDNESDAY	.219	.006	.524	38.015	<.001
	THURSDAY	.215	.006	.516	37.417	<.001
	FRIDAY	.203	.006	.486	35.217	<.001

	SATURDAY	.112	.006	.268	19.430	<.001
Dependent Variable: log total load 08:00 - 09:00						

Table 64: Coefficient summary of log total load 08:00 - 09:00

As it is can be concluded from Table 64 all independent variables have p-value lower than 0.05 indicating that they have statistically significant impact on the total load of electricity for the time zone 08:00 - 09:00 in Greece as the null hypotheses are rejected.

- *09:00 – 10:00*

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	8.641	.008		1080.466	<.001
	linear term	4.975E-5	.000	.333	7.573	<.001
	Quadradic term	-1.969E-8	.000	-.448	-10.183	<.001
	JAN	.066	.008	.129	8.684	<.001
	FEB	.025	.008	.048	3.276	.001
	MAR	-.056	.008	-.110	-7.378	<.001
	APR	-.161	.008	-.311	-21.043	<.001
	MAY	-.151	.008	-.298	-20.008	<.001
	JUN	-.029	.008	-.056	-3.820	<.001
	JUL	.123	.008	.241	16.235	<.001
	AUG	.044	.008	.087	5.856	<.001
	SEP	-.055	.008	-.106	-7.183	<.001
	OCT	-.147	.008	-.289	-19.430	<.001
	NOV	-.112	.008	-.218	-14.747	<.001
	MONDAY	.143	.006	.353	24.573	<.001
	TUESDAY	.173	.006	.427	29.698	<.001
	WEDNESDAY	.178	.006	.440	30.572	<.001
	THURSDAY	.175	.006	.433	30.078	<.001
	FRIDAY	.158	.006	.391	27.171	<.001
	SATURDAY	.087	.006	.215	14.976	<.001
Dependent Variable: log total load 09:00 - 10:00						

Table 65: Coefficient summary of log total load 09:00 - 10:00

As it is can be concluded from Table 65 all independent variables have p-value lower than 0.05 indicating that they have statistically significant impact on the total load of electricity for the time zone 09:00 - 10:00 in Greece as the null hypotheses are rejected.

- *10:00 – 11:00*

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	8.681	.008		1058.084	<.001
	linear term	5.055E-5	.000	.341	7.500	<.001
	Quadradic term	-2.028E-8	.000	-.465	-10.223	<.001
	JAN	.070	.008	.139	9.027	<.001
	FEB	.022	.008	.041	2.712	.007
	MAR	-.055	.008	-.109	-7.099	<.001
	APR	-.152	.008	-.296	-19.368	<.001
	MAY	-.134	.008	-.266	-17.268	<.001
	JUN	-.005	.008	-.010	-.642	***.521***
	JUL	.150	.008	.298	19.391	<.001
	AUG	.075	.008	.149	9.708	<.001
	SEP	-.031	.008	-.061	-4.011	<.001
	OCT	-.133	.008	-.263	-17.110	<.001
	NOV	-.108	.008	-.210	-13.762	<.001
	MONDAY	.110	.006	.274	18.419	<.001
	TUESDAY	.140	.006	.348	23.409	<.001
	WEDNESDAY	.142	.006	.354	23.756	<.001
	THURSDAY	.143	.006	.357	23.963	<.001
	FRIDAY	.119	.006	.296	19.902	<.001
	SATURDAY	.064	.006	.159	10.712	<.001

Dependent Variable: log total load 10:00 - 11:00

Table 66: Coefficient summary of log total load 10:00 - 11:00

As it is can be concluded from Table 66 all independent variables expect of June have p-value lower than 0.05 indicating that they have statistically significant impact on the total load of electricity for the time zone 10:00 - 11:00 in Greece as the null hypotheses are rejected. As concerns the variable of June, its p-value is greater than 0.05 indicating that there is no sufficient evidence that the impact of June is significant for the electricity demand in the time zone 10:00 – 11:00.

- *11:00 – 12:00*

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	8.695	.008		1027.783	<.001
	linear term	4.944E-5	.000	.327	7.114	<.001
	Quadradic term	-1.988E-8	.000	-.447	-9.719	<.001
	JAN	.072	.008	.139	8.924	<.001
	FEB	.019	.008	.035	2.285	.022
	MAR	-.053	.008	-.103	-6.625	<.001
	APR	-.144	.008	-.276	-17.827	<.001
	MAY	-.120	.008	-.234	-15.029	<.001
	JUN	.016	.008	.030	1.957	***.050***
	JUL	.178	.008	.346	22.265	<.001
	AUG	.104	.008	.203	13.054	<.001
	SEP	-.011	.008	-.021	-1.365	***.172***
	OCT	-.122	.008	-.238	-15.285	<.001
	NOV	-.102	.008	-.195	-12.621	<.001
	MONDAY	.099	.006	.242	16.105	<.001
	TUESDAY	.128	.006	.312	20.713	<.001
	WEDNESDAY	.125	.006	.305	20.269	<.001
	THURSDAY	.130	.006	.318	21.157	<.001
	FRIDAY	.103	.006	.251	16.682	<.001
	SATURDAY	.060	.006	.145	9.660	<.001
Dependent Variable: log total load 11:00 - 12:00						

Table 67: Coefficient summary of log total load 11:00 - 12:00

As it is can be concluded from Table 67 all independent variables expect of June and September have p-value lower than 0.05 indicating that they have statistically significant impact on the total load of electricity for the time zone 11:00 - 12:00 in Greece as the null hypotheses are rejected. As concerns the variables of June and September, their p-values are greater than 0.05 indicating that there is no sufficient evidence that the impact of each of these two variables is significant for the electricity demand in the time zone 11:00 – 12:00.

- *12:00 – 13:00*

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	8.675	.009		985.845	<.001
	linear term	4.594E-5	.000	.288	6.356	<.001
	Quadradic term	-1.847E-8	.000	-.394	-8.682	<.001
	JAN	.071	.008	.130	8.474	<.001
	FEB	.016	.009	.027	1.816	***.069***
	MAR	-.052	.008	-.095	-6.193	<.001
	APR	-.142	.008	-.258	-16.898	<.001
	MAY	-.116	.008	-.213	-13.888	<.001
	JUN	.032	.008	.058	3.813	<.001
	JUL	.207	.008	.382	24.916	<.001
	AUG	.133	.008	.246	16.039	<.001
	SEP	.002	.008	.004	.286	***.775***
	OCT	-.120	.008	-.221	-14.425	<.001
	NOV	-.099	.008	-.179	-11.770	<.001
	MONDAY	.111	.006	.256	17.236	<.001
	TUESDAY	.135	.006	.313	21.089	<.001
	WEDNESDAY	.133	.006	.307	20.691	<.001
	THURSDAY	.139	.006	.322	21.666	<.001
	FRIDAY	.112	.006	.258	17.410	<.001
	SATURDAY	.076	.006	.176	11.840	<.001
Dependent Variable: log total load 12:00 - 13:00						

Table 68: Coefficient summary of log total load 12:00 - 13:00

As it is can be concluded from Table 68 all independent variables expect of February and September have p-value lower than 0.05 indicating that they have statistically significant impact on the total load of electricity for the time zone 12:00 - 13:00 in Greece as the null hypotheses are rejected. As concerns the variables of June and September, their p-values are greater than 0.05 indicating that there is no sufficient evidence that the impact of each of these two variables is significant for the electricity demand in the time zone 12:00 – 13:00.

- *13:00 – 14:00*

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	8.615	.009		920.027	<.001
	linear term	4.494E-5	.000	.259	5.843	<.001
	Quadradic term	-1.783E-8	.000	-.349	-7.874	<.001
	JAN	.065	.009	.110	7.295	<.001
	FEB	.008	.009	.012	.843	***.400***
	MAR	-.061	.009	-.104	-6.898	<.001
	APR	-.153	.009	-.255	-17.113	<.001
	MAY	-.128	.009	-.217	-14.439	<.001
	JUN	.033	.009	.055	3.707	<.001
	JUL	.229	.009	.387	25.843	<.001
	AUG	.156	.009	.263	17.572	<.001
	SEP	.003	.009	.004	.301	***.763***
	OCT	-.130	.009	-.220	-14.670	<.001
	NOV	-.102	.009	-.169	-11.385	<.001
	MONDAY	.141	.007	.299	20.635	<.001
	TUESDAY	.161	.007	.342	23.606	<.001
	WEDNESDAY	.163	.007	.346	23.859	<.001
	THURSDAY	.163	.007	.348	23.965	<.001
	FRIDAY	.141	.007	.300	20.661	<.001
	SATURDAY	.097	.007	.206	14.182	<.001
Dependent Variable: log total load 13:00 - 14:00						

Table 69: Coefficient summary of log total load 13:00 - 14:00

As it is can be observed from Table 69, the conclusions from the regression results of the actual total load of time zone 13:00-14:00 for the significance of the independent variables are similar of the time zone 12:00-13:00.

- *14:00 – 15:00*

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	8.630	.010		876.628	<.001
	linear term	4.157E-5	.000	.228	5.141	<.001

	Quadradic term	-1.732E-8	.000	-.322	-7.276	<.001
	JAN	.058	.009	.094	6.238	<.001
	FEB	-.005	.010	-.007	-.498	***.618***
	MAR	-.083	.009	-.133	-8.872	<.001
	APR	-.198	.009	-.315	-21.126	<.001
	MAY	-.200	.009	-.321	-21.444	<.001
	JUN	-.029	.009	-.046	-3.078	.002
	JUL	.184	.009	.296	19.784	<.001
	AUG	.114	.009	.184	12.272	<.001
	SEP	-.061	.009	-.096	-6.471	<.001
	OCT	-.198	.009	-.319	-21.294	<.001
	NOV	-.127	.009	-.201	-13.488	<.001
	MONDAY	.144	.007	.291	20.126	<.001
	TUESDAY	.162	.007	.328	22.633	<.001
	WEDNESDAY	.164	.007	.331	22.853	<.001
	THURSDAY	.165	.007	.333	23.009	<.001
	FRIDAY	.147	.007	.297	20.475	<.001
	SATURDAY	.098	.007	.198	13.697	<.001
Dependent Variable: log total load 14:00 - 15:00						

Table 70: Coefficient summary of log total load 14:00 - 15:00

As it is can be concluded from Table 70 all independent variables expect of February have p-value lower than 0.05 indicating that they have statistically significant impact on the total load of electricity for the time zone 14:00 - 15:00 in Greece as the null hypotheses are rejected. As concerns the variable of February, its p-value is greater than 0.05 indicating that there is no sufficient evidence that the impact of February is significant for the electricity demand in the time zone 14:00 – 15:00.

- *15:00 – 16:00*

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	8.653	.010		878.922	<.001
	linear term	3.477E-5	.000	.189	4.299	<.001
	Quadradic term	-1.568E-8	.000	-.289	-6.585	<.001
	JAN	.044	.009	.070	4.717	<.001

	FEB	-.029	.010	-.044	-3.019	.003
	MAR	-.113	.009	-.181	-12.174	<.001
	APR	-.239	.009	-.375	-25.424	<.001
	MAY	-.242	.009	-.385	-25.939	<.001
	JUN	-.066	.009	-.104	-7.067	<.001
	JUL	.151	.009	.241	16.252	<.001
	AUG	.084	.009	.133	8.974	<.001
	SEP	-.100	.009	-.157	-10.682	<.001
	OCT	-.233	.009	-.371	-25.040	<.001
	NOV	-.137	.009	-.215	-14.571	<.001
	MONDAY	.132	.007	.265	18.456	<.001
	TUESDAY	.151	.007	.302	21.032	<.001
	WEDNESDAY	.152	.007	.303	21.146	<.001
	THURSDAY	.154	.007	.309	21.518	<.001
	FRIDAY	.138	.007	.276	19.245	<.001
	SATURDAY	.093	.007	.187	13.005	<.001
Dependent Variable: log total load 15:00 - 16:00						

Table 71: Coefficient summary of log total load 15:00 - 16:00

As it is can be concluded from Table 71 all independent variables have p-value lower than 0.05 indicating that they have statistically significant impact on the total load of electricity for the time zone 15:00 - 16:00 in Greece as the null hypotheses are rejected.

- *16:00 – 17:00*

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	8.725	.009		936.400	<.001
	linear term	2.948E-5	.000	.162	3.851	<.001
	Quadradic term	-1.456E-8	.000	-.271	-6.462	<.001
	JAN	.011	.009	.017	1.194	***.233***
	FEB	-.085	.009	-.131	-9.375	<.001
	MAR	-.184	.009	-.297	-20.896	<.001
	APR	-.319	.009	-.506	-35.839	<.001
	MAY	-.301	.009	-.485	-34.162	<.001
	JUN	-.129	.009	-.204	-14.478	<.001
	JUL	.082	.009	.132	9.282	<.001

	AUG	.017	.009	.028	1.947	***.052***
	SEP	-.163	.009	-.258	-18.338	<.001
	OCT	-.279	.009	-.450	-31.705	<.001
	NOV	-.131	.009	-.208	-14.759	<.001
	MONDAY	.118	.007	.238	17.341	<.001
	TUESDAY	.141	.007	.285	20.801	<.001
	WEDNESDAY	.137	.007	.277	20.182	<.001
	THURSDAY	.144	.007	.291	21.166	<.001
	FRIDAY	.130	.007	.262	19.096	<.001
	SATURDAY	.085	.007	.171	12.490	<.001
Dependent Variable: log total load 16:00 - 17:00						

Table 72: Coefficient summary of log total load 16:00 - 17:00

As it is can be concluded from Table 72 all independent variables expect of January and August have p-value lower than 0.05 indicating that they have statistically significant impact on the total load of electricity for the time zone 16:00 - 17:00 in Greece as the null hypotheses are rejected. As concerns the variables of January and August, their p-values are greater than 0.05 indicating that there is no sufficient evidence that the impact of each of these two variables is significant for the electricity demand in the time zone 16:00 – 17:00.

- *17:00 – 18:00*

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	8.791	.009		1006.437	<.001
	linear term	2.744E-5	.000	.151	3.824	<.001
	Quadradic term	-1.473E-8	.000	-.276	-6.975	<.001
	JAN	.038	.008	.062	4.626	<.001
	FEB	-.037	.008	-.057	-4.339	<.001
	MAR	-.175	.008	-.283	-21.166	<.001
	APR	-.353	.008	-.563	-42.358	<.001
	MAY	-.338	.008	-.546	-40.837	<.001
	JUN	-.174	.008	-.277	-20.831	<.001
	JUL	.024	.008	.039	2.925	.003
	AUG	-.037	.008	-.061	-4.528	<.001
	SEP	-.206	.008	-.328	-24.691	<.001

	OCT	-.286	.008	-.464	-34.685	<.001
	NOV	-.120	.008	-.192	-14.457	<.001
	MONDAY	.104	.006	.212	16.393	<.001
	TUESDAY	.127	.006	.259	20.023	<.001
	WEDNESDAY	.120	.006	.245	18.927	<.001
	THURSDAY	.132	.006	.268	20.685	<.001
	FRIDAY	.117	.006	.237	18.351	<.001
	SATURDAY	.075	.006	.153	11.836	<.001
Dependent Variable: log total load 17:00 - 18:00						

Table 73: Coefficient summary of log total load 17:00 - 18:00

As it is can be concluded from Table 73 all independent variables have p-value lower than 0.05 indicating that they have statistically significant impact on the total load of electricity for the time zone 17:00 - 18:00 in Greece as the null hypotheses are rejected.

- *18:00 – 19:00*

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	8.802	.008		1092.271	<.001
	linear term	2.971E-5	.000	.181	4.487	<.001
	Quadradic term	-1.599E-8	.000	-.331	-8.207	<.001
	JAN	.044	.008	.079	5.797	<.001
	FEB	.006	.008	.011	.804	***.422***
	MAR	-.088	.008	-.158	-11.583	<.001
	APR	-.308	.008	-.544	-40.069	<.001
	MAY	-.317	.008	-.568	-41.538	<.001
	JUN	-.174	.008	-.308	-22.674	<.001
	JUL	.008	.008	.015	1.105	***.269***
	AUG	-.049	.008	-.087	-6.397	<.001
	SEP	-.175	.008	-.309	-22.757	<.001
	OCT	-.202	.008	-.362	-26.542	<.001
	NOV	-.119	.008	-.211	-15.543	<.001
	MONDAY	.096	.006	.217	16.431	<.001
	TUESDAY	.119	.006	.268	20.267	<.001
	WEDNESDAY	.113	.006	.254	19.252	<.001
	THURSDAY	.122	.006	.274	20.712	<.001

	FRIDAY	.105	.006	.237	17.939	<.001
	SATURDAY	.069	.006	.156	11.824	<.001
Dependent Variable: log total load 18:00 - 19:00						

Table 74: Coefficient summary of log total load 18:00 - 19:00

As it is can be concluded from Table 74 all independent variables expect of February and July have p-value lower than 0.05 indicating that they have statistically significant impact on the total load of electricity for the time zone 18:00 - 19:00 in Greece as the null hypotheses are rejected. As concerns the variables of February and July, their p-values are greater than 0.05 indicating that there is no sufficient evidence that the impact of each of these two variables is significant for the electricity demand in the time zone 18:00 – 19:00.

- *19:00 – 20:00*

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	8.805	.007		1194.318	<.001
	linear term	2.419E-5	.000	.174	3.994	<.001
	Quadradic term	-1.569E-8	.000	-.383	-8.800	<.001
	JAN	.043	.007	.092	6.208	<.001
	FEB	.010	.007	.021	1.458	***.145***
	MAR	-.055	.007	-.115	-7.833	<.001
	APR	-.188	.007	-.392	-26.770	<.001
	MAY	-.246	.007	-.519	-35.228	<.001
	JUN	-.149	.007	-.310	-21.166	<.001
	JUL	.015	.007	.031	2.090	.037
	AUG	-.013	.007	-.027	-1.830	***.067***
	SEP	-.105	.007	-.219	-14.957	<.001
	OCT	-.180	.007	-.381	-25.877	<.001
	NOV	-.118	.007	-.246	-16.803	<.001
	MONDAY	.090	.005	.239	16.759	<.001
	TUESDAY	.110	.005	.292	20.480	<.001
	WEDNESDAY	.104	.005	.276	19.380	<.001
	THURSDAY	.110	.005	.292	20.512	<.001
	FRIDAY	.091	.005	.241	16.907	<.001
	SATURDAY	.050	.005	.133	9.369	<.001

Dependent Variable: log total load 19:00 - 20:00

Table 75: Coefficient summary of log total load 19:00 - 20:00

As it is can be concluded from Table 75 all independent variables expect of February and August have p-value lower than 0.05 indicating that they have statistically significant impact on the total load of electricity for the time zone 19:00 - 20:00 in Greece as the null hypotheses are rejected. As concerns the variables of February and August, their p-values are greater than 0.05 indicating that there is no sufficient evidence that the impact of each of these two variables is significant for the electricity demand in the time zone 19:00 – 20:00.

- *20:00 – 21:00*

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	T	Sig.
1	(Constant)	8.779	.007		1242.678	<.001
	linear term	2.245E-5	.000	.170	3.869	<.001
	Quadradic term	-1.671E-8	.000	-.429	-9.780	<.001
	JAN	.041	.007	.091	6.109	<.001
	FEB	.008	.007	.016	1.117	***.264***
	MAR	-.046	.007	-.103	-6.933	<.001
	APR	-.131	.007	-.286	-19.382	<.001
	MAY	-.157	.007	-.348	-23.473	<.001
	JUN	-.064	.007	-.140	-9.485	<.001
	JUL	.091	.007	.203	13.685	<.001
	AUG	.049	.007	.110	7.391	<.001
	SEP	-.105	.007	-.229	-15.549	<.001
	OCT	-.187	.007	-.415	-27.977	<.001
	NOV	-.119	.007	-.259	-17.618	<.001
	MONDAY	.069	.005	.193	13.466	<.001
	TUESDAY	.083	.005	.232	16.198	<.001
	WEDNESDAY	.083	.005	.231	16.103	<.001
	THURSDAY	.082	.005	.229	15.966	<.001
	FRIDAY	.064	.005	.178	12.378	<.001
	SATURDAY	.030	.005	.083	5.777	<.001
Dependent Variable: log total load 20:00 - 21:00						

Table 76: Coefficient summary of log total load 20:00 - 21:00

As it is can be concluded from Table 76 all independent variables expect of February have p-value lower than 0.05 indicating that they have statistically significant impact on the total load of electricity for the time zone 20:00 - 21:00 in Greece as the null hypotheses are rejected. As concerns the variable of February, its p-value is greater than 0.05 indicating that there is no sufficient evidence that the impact of February is significant for the electricity demand in the time zone 20:00 – 21:00.

- *21:00 – 22:00*

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	8.717	.007		1194.146	<.001
	linear term	1.181E-5	.000	.084	1.969	.049
	Quadradic term	-1.331E-8	.000	-.323	-7.542	<.001
	JAN	.040	.007	.083	5.710	<.001
	FEB	.004	.007	.008	.531	***.595***
	MAR	-.051	.007	-.106	-7.307	<.001
	APR	-.133	.007	-.275	-19.109	<.001
	MAY	-.160	.007	-.335	-23.102	<.001
	JUN	-.035	.007	-.072	-5.035	<.001
	JUL	.137	.007	.287	19.780	<.001
	AUG	.076	.007	.159	10.972	<.001
	SEP	-.106	.007	-.218	-15.163	<.001
	OCT	-.192	.007	-.402	-27.792	<.001
	NOV	-.124	.007	-.255	-17.758	<.001
	MONDAY	.046	.005	.122	8.699	<.001
	TUESDAY	.060	.005	.157	11.191	<.001
	WEDNESDAY	.061	.005	.160	11.400	<.001
	THURSDAY	.061	.005	.161	11.467	<.001
	FRIDAY	.047	.005	.124	8.873	<.001
	SATURDAY	.019	.005	.049	3.522	<.001

Dependent Variable: log total load 21:00 - 22:00

Table 77: Coefficient summary of log total load 21:00 - 22:00

As it is can be observed from Table 77, the conclusions from the regression results of the actual total load of time zone 21:00-22:00 for the significance of the independent variables are similar of the time zone 20:00-21:00.

- *22:00 – 23:00*

Coefficients[a]						
Mdel		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	T	Sig.
1	(Constant)	8.633	.007		1156.743	<.001
	linear term	2.413E-5	.000	.165	3.936	<.001
	Quadradic term	-1.659E-8	.000	-.386	-9.194	<.001
	JAN	.047	.007	.095	6.681	<.001
	FEB	.011	.007	.021	1.499	***.134***
	MAR	-.045	.007	-.091	-6.423	<.001
	APR	-.139	.007	-.275	-19.479	<.001
	MAY	-.158	.007	-.319	-22.407	<.001
	JUN	-.024	.007	-.047	-3.304	<.001
	JUL	.165	.007	.333	23.448	<.001
	AUG	.099	.007	.200	14.080	<.001
	SEP	-.089	.007	-.177	-12.513	<.001
	OCT	-.178	.007	-.358	-25.203	<.001
	NOV	-.122	.007	-.243	-17.208	<.001
	MONDAY	.048	.005	.121	8.819	<.001
	TUESDAY	.062	.005	.156	11.331	<.001
	WEDNESDAY	.063	.005	.159	11.566	<.001
	THURSDAY	.065	.005	.164	11.948	<.001
	FRIDAY	.058	.005	.148	10.762	<.001
	SATURDAY	.019	.005	.047	3.406	<.001
Dependent Variable: log total load 22:00 - 23:00						

Table 78: Coefficient summary of log total load 22:00 - 23:00

As it is can be observed from Table 78Table **78**, the conclusions from the regression results of the actual total load of time zone 22:00-23:00 for the significance of the independent variables are similar of the time zone 20:00-21:00.

- *23:00 – 24:00*

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	T	Sig.
1	(Constant)	8.543	.008		1127.979	<.001
	linear term	1.544E-5	.000	.102	2.481	.013
	Quadradic term	-1.493E-8	.000	-.334	-8.151	<.001
	JAN	.048	.007	.092	6.633	<.001
	FEB	.011	.007	.020	1.443	***.149***
	MAR	-.044	.007	-.084	-6.083	<.001
	APR	-.135	.007	-.256	-18.611	<.001
	MAY	-.147	.007	-.284	-20.465	<.001
	JUN	-.001	.007	-.002	-.147	***.884***
	JUL	.202	.007	.391	28.210	<.001
	AUG	.139	.007	.268	19.341	<.001
	SEP	-.062	.007	-.119	-8.635	<.001
	OCT	-.161	.007	-.311	-22.455	<.001
	NOV	-.116	.007	-.220	-16.017	<.001
	MONDAY	.045	.006	.110	8.187	<.001
	TUESDAY	.058	.006	.141	10.515	<.001
	WEDNESDAY	.059	.006	.143	10.700	<.001
	THURSDAY	.062	.006	.151	11.242	<.001
	FRIDAY	.064	.006	.156	11.650	<.001
	SATURDAY	.028	.006	.069	5.132	<.001
Dependent Variable: log total load 23:00 - 24:00						

Table 79: Coefficient summary of log total load 23:00 - 24:00

As it is can be concluded from Table 79 all independent variables expect of February and June have p-value lower than 0.05 indicating that they have statistically significant impact on the total load of electricity for the time zone 23:00 - 24:00 in Greece as the null hypotheses are rejected. As concerns the variables of February and June, their p-values are greater than 0.05 indicating that there is no sufficient evidence that the impact of each of these two variables is significant for the electricity demand in the time zone 23:00 – 24:00.

Appendix E: Figures and Tables of regression models' forecasting accuracy

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	1.065	.077		13.784	<.001
	Quadradic term	-9.340E-10	.000	-.017	-3.072	.002
	MAR	-.010	.003	-.020	-3.435	<.001
	APR	-.023	.003	-.046	-7.317	<.001
	MAY	-.019	.003	-.038	-5.820	<.001
	JUL	.027	.003	.054	7.962	<.001
	AUG	.011	.003	.021	3.284	.001
	SEP	-.015	.003	-.029	-4.942	<.001
	OCT	-.024	.003	-.048	-7.246	<.001
	NOV	-.015	.003	-.031	-4.878	<.001
	TUESDAY	.074	.002	.187	29.712	<.001
	WEDNESDAY	.045	.002	.115	18.492	<.001
	THURSDAY	.038	.002	.097	15.656	<.001
	FRIDAY	.039	.002	.100	16.096	<.001
	SATURDAY	.045	.002	.113	18.293	<.001
	lagged log total load 1st grade	.871	.009	.871	96.099	<.001

a. Dependent Variable: log total load 00:00 - 01:00

Table 80: Coefficient summary of log total load 00:00 - 01:00 2015-2022

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	1.103	.078		14.063	<.001
	Quadradic term	-9.964E-10	.000	-.019	-3.206	.001
	MAR	-.010	.003	-.021	-3.404	<.001
	APR	-.024	.003	-.049	-7.520	<.001
	MAY	-.022	.003	-.046	-6.645	<.001

	JUL	.024	.003	.049	7.349	<.001
	AUG	.008	.003	.017	2.598	.009
	SEP	-.017	.003	-.034	-5.598	<.001
	OCT	-.027	.003	-.055	-7.875	<.001
	NOV	-.016	.003	-.032	-4.887	<.001
	MONDAY	.008	.003	.020	2.730	.006
	TUESDAY	.083	.003	.211	27.917	<.001
	WEDNESDAY	.047	.003	.121	16.373	<.001
	THURSDAY	.042	.003	.108	14.549	<.001
	FRIDAY	.045	.003	.115	15.509	<.001
	SATURDAY	.050	.003	.128	17.273	<.001
	lagged log total load 1st grade	.866	.009	.866	94.008	<.001
a. Dependent Variable: log total load 01:00 - 02:00						

Table 81: Coefficient summary of log total load 01:00 - 02:00 2015-2022

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.227	.083		14.858	<.001
	Quadradic term	-9.698E-10	.000	-.019	-3.050	.002
	JAN	.009	.003	.019	2.779	.005
	MAR	-.008	.003	-.017	-2.584	.010
	APR	-.024	.003	-.049	-7.044	<.001
	MAY	-.021	.003	-.044	-6.082	<.001
	JUL	.029	.004	.061	8.108	<.001
	AUG	.013	.003	.027	3.721	<.001
	SEP	-.014	.003	-.029	-4.367	<.001
	OCT	-.025	.003	-.053	-7.279	<.001
	NOV	-.015	.003	-.031	-4.439	<.001
	MONDAY	.019	.003	.051	6.457	<.001
	TUESDAY	.089	.003	.234	29.402	<.001
	WEDNESDAY	.053	.003	.138	17.795	<.001
	THURSDAY	.046	.003	.121	15.541	<.001
	FRIDAY	.049	.003	.127	16.405	<.001
	SATURDAY	.051	.003	.134	17.224	<.001

		B	Std. Error	Beta	t	Sig.
	lagged log total load 1st grade	.850	.010	.850	87.091	<.001

a. Dependent Variable: log total load 02:00 - 03:00

Table 82: Coefficient summary of log total load 02:00 - 03:00 2015-2022

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	1.326	.089		14.841	<.001
	Quadradic term	-1.040E-9	.000	-.021	-3.114	.002
	MAR	-.012	.003	-.027	-3.825	<.001
	APR	-.028	.003	-.060	-7.992	<.001
	MAY	-.021	.004	-.046	-5.924	<.001
	JUL	.028	.004	.060	7.697	<.001
	AUG	.010	.003	.022	2.957	.003
	SEP	-.018	.003	-.038	-5.369	<.001
	OCT	-.027	.004	-.059	-7.607	<.001
	NOV	-.017	.003	-.035	-4.788	<.001
	MONDAY	.074	.003	.201	26.868	<.001
	TUESDAY	.046	.003	.125	15.260	<.001
	WEDNESDAY	.038	.003	.102	13.634	<.001
	THURSDAY	.039	.003	.106	14.160	<.001
	FRIDAY	.031	.003	.084	11.241	<.001
	lagged log total load 1st grade	.747	.018	.747	41.114	<.001
	lagged log total load 2st grade	.092	.018	.092	5.003	<.001

a. Dependent Variable: log total load 03:00 - 04:00

Table 83: Coefficient summary of log total load 03:00 - 04:00 2015-2022

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	1.255	.090		14.010	<.001
	Quadradic term	-8.136E-10	.000	-.017	-2.568	.010

	JAN	.009	.003	.020	2.762	.006
	MAR	-.007	.003	-.016	-2.272	.023
	APR	-.023	.003	-.051	-6.677	<.001
	MAY	-.019	.003	-.044	-5.596	<.001
	JUL	.027	.004	.061	7.555	<.001
	AUG	.010	.003	.024	3.074	.002
	SEP	-.013	.003	-.029	-4.051	<.001
	OCT	-.022	.003	-.050	-6.414	<.001
	NOV	-.013	.003	-.029	-3.846	<.001
	MONDAY	.060	.003	.172	19.561	<.001
	TUESDAY	.097	.003	.277	31.434	<.001
	WEDNESDAY	.069	.003	.199	21.839	<.001
	THURSDAY	.061	.003	.174	20.203	<.001
	FRIDAY	.061	.003	.174	20.344	<.001
	SATURDAY	.043	.003	.123	14.329	<.001
	lagged log total load 1st grade	.777	.019	.777	41.928	<.001
	lagged log total load 2st grade	.068	.018	.068	3.685	<.001
a. Dependent Variable: log total load 04:00 - 05:00						

Table 84: Coefficient summary of log total load 04:00 - 05:00 2015-2022

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.277	.092		13.961	<.001
	JAN	.013	.003	.030	3.964	<.001
	APR	-.024	.004	-.055	-6.832	<.001
	MAY	-.025	.004	-.056	-6.480	<.001
	JUL	.019	.003	.044	5.622	<.001
	SEP	-.013	.003	-.029	-3.764	<.001
	OCT	-.020	.004	-.045	-5.536	<.001
	NOV	-.009	.003	-.020	-2.553	.011
	MONDAY	.137	.003	.391	40.742	<.001
	TUESDAY	.130	.004	.371	31.795	<.001
	WEDNESDAY	.097	.004	.277	26.291	<.001

	THURSDAY	.091	.003	.259	26.179	<.001
	FRIDAY	.086	.003	.244	24.776	<.001
	SATURDAY	.031	.003	.088	8.943	<.001
	lagged log total load 1st grade	.720	.018	.720	39.099	<.001
	lagged log total load 2st grade	.120	.018	.120	6.544	<.001
a. Dependent Variable: log total load 05:00 - 06:00						

Table 85: Coefficient summary of log total load 05:00 - 06:00 2015-2022

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.475	.099		14.972	<.001
	Quadradic term	-8.619E-10	.000	-.016	-2.221	.026
	JAN	.019	.004	.038	5.059	<.001
	APR	-.029	.004	-.057	-7.288	<.001
	MAY	-.027	.004	-.054	-6.510	<.001
	JUL	.018	.004	.036	4.900	<.001
	SEP	-.018	.004	-.035	-4.611	<.001
	OCT	-.023	.004	-.045	-5.713	<.001
	NOV	-.009	.004	-.018	-2.401	.016
	MONDAY	.243	.004	.604	63.227	<.001
	TUESDAY	.169	.006	.420	27.846	<.001
	WEDNESDAY	.133	.005	.330	29.535	<.001
	THURSDAY	.129	.004	.320	30.518	<.001
	FRIDAY	.120	.004	.299	28.526	<.001
	SATURDAY	.015	.004	.037	3.560	<.001
	lagged log total load 1st grade	.735	.019	.735	39.709	<.001
	lagged log total load 2st grade	.080	.018	.080	4.361	<.001
a. Dependent Variable: log total load 06:00 - 07:00						

Table 86: Coefficient summary of log total load 06:00 - 07:00 2015-2022

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	1.515	.102		14.799	<.001
	Quadradic term	-9.102E-10	.000	-.016	-2.323	.020
	JAN	.016	.004	.031	4.099	<.001
	MAR	-.008	.004	-.015	-2.095	.036
	APR	-.032	.004	-.061	-7.643	<.001
	MAY	-.027	.004	-.052	-6.244	<.001
	JUL	.019	.004	.037	4.950	<.001
	SEP	-.019	.004	-.037	-4.858	<.001
	OCT	-.027	.004	-.052	-6.378	<.001
	NOV	-.014	.004	-.026	-3.391	<.001
	MONDAY	.284	.004	.692	72.591	<.001
	TUESDAY	.196	.006	.478	30.558	<.001
	WEDNESDAY	.158	.004	.386	35.498	<.001
	THURSDAY	.148	.004	.361	34.952	<.001
	FRIDAY	.142	.004	.346	33.969	<.001
	SATURDAY	.040	.004	.097	9.673	<.001
	lagged log total load 2st grade	.104	.018	.104	5.686	<.001
	lagged log total load 1st grade	.706	.018	.705	38.211	<.001
a. Dependent Variable: log total load 07:00 - 08:00						

Table 87: Coefficient summary of log total load 07:00 - 08:00 2015-2022

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	1.572	.105		15.009	<.001
	linear term	1.065E-5	.000	.063	2.249	.025
	Quadradic term	-4.390E-9	.000	-.078	-2.788	.005
	JAN	.017	.004	.033	4.281	<.001
	MAR	-.011	.004	-.022	-2.984	.003
	APR	-.035	.004	-.067	-8.129	<.001
	MAY	-.028	.004	-.054	-6.423	<.001

	JUL	.020	.004	.039	5.101	<.001
	SEP	-.020	.004	-.038	-5.040	<.001
	OCT	-.030	.004	-.059	-7.074	<.001
	NOV	-.017	.004	-.033	-4.232	<.001
	MONDAY	.271	.004	.663	68.956	<.001
	TUESDAY	.191	.006	.469	31.809	<.001
	WEDNESDAY	.154	.004	.377	35.867	<.001
	THURSDAY	.144	.004	.352	35.081	<.001
	FRIDAY	.135	.004	.332	33.482	<.001
	SATURDAY	.053	.004	.131	13.346	<.001
	lagged log total load 1st grade	.695	.018	.695	37.667	<.001
	lagged log total load 2st grade	.109	.018	.109	5.972	<.001
a. Dependent Variable: log total load 08:00 - 09:00						

Table 88: Coefficient summary of log total load 08:00 - 09:00 2015-2022

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.632	.105		15.551	<.001
	linear term	1.286E-5	.000	.079	2.744	.006
	Quadradic term	-5.015E-9	.000	-.093	-3.218	.001
	JAN	.015	.004	.031	3.965	<.001
	MAR	-.014	.004	-.029	-3.764	<.001
	APR	-.036	.004	-.072	-8.460	<.001
	MAY	-.028	.004	-.057	-6.593	<.001
	JUL	.022	.004	.044	5.534	<.001
	SEP	-.019	.004	-.038	-4.924	<.001
	OCT	-.032	.004	-.065	-7.603	<.001
	NOV	-.021	.004	-.041	-5.029	<.001
	MONDAY	.213	.004	.545	56.223	<.001
	TUESDAY	.150	.005	.384	28.880	<.001
	WEDNESDAY	.120	.004	.307	29.626	<.001
	THURSDAY	.112	.004	.288	28.833	<.001
	FRIDAY	.101	.004	.258	26.038	<.001

	SATURDAY	.042	.004	.107	10.948	<.001
	lagged log total load 1st grade	.720	.019	.720	38.891	<.001
	lagged log total load 2st grade	.082	.018	.082	4.463	<.001
a. Dependent Variable: log total load 09:00 - 10:00						

Table 89: Coefficient summary of log total load 09:00 - 10:00 2015-2022

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.710	.107		16.036	<.001
	linear term	1.408E-5	.000	.089	2.928	.003
	Quadradic term	-5.516E-9	.000	-.105	-3.448	<.001
	JAN	.013	.004	.027	3.344	<.001
	MAR	-.017	.004	-.035	-4.248	<.001
	APR	-.037	.004	-.076	-8.467	<.001
	MAY	-.028	.004	-.058	-6.482	<.001
	JUL	.024	.004	.051	6.045	<.001
	SEP	-.018	.004	-.037	-4.591	<.001
	OCT	-.033	.004	-.069	-7.673	<.001
	NOV	-.023	.004	-.047	-5.460	<.001
	MONDAY	.160	.004	.419	41.908	<.001
	TUESDAY	.119	.005	.310	25.366	<.001
	WEDNESDAY	.089	.004	.232	22.077	<.001
	THURSDAY	.089	.004	.232	22.804	<.001
	FRIDAY	.067	.004	.174	17.122	<.001
	SATURDAY	.029	.004	.076	7.672	<.001
	lagged log total load 1st grade	.726	.019	.726	39.196	<.001
	lagged log total load 2st grade	.070	.018	.070	3.812	<.001
a. Dependent Variable: log total load 10:00 - 11:00						

Table 90: Coefficient summary of log total load 10:00 - 11:00 2015-2022

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	1.759	.109		16.063	<.001
	linear term	1.424E-5	.000	.089	2.858	.004
	Quadradic term	-5.617E-9	.000	-.106	-3.389	<.001
	JAN	.017	.004	.035	4.175	<.001
	MAR	-.013	.004	-.026	-3.135	.002
	APR	-.032	.004	-.065	-7.326	<.001
	MAY	-.022	.004	-.046	-5.160	<.001
	JUL	.034	.004	.070	7.766	<.001
	AUG	.014	.004	.028	3.343	<.001
	OCT	-.028	.004	-.059	-6.581	<.001
	NOV	-.019	.004	-.038	-4.416	<.001
	MONDAY	.145	.004	.374	36.666	<.001
	TUESDAY	.107	.005	.277	23.514	<.001
	WEDNESDAY	.076	.004	.195	18.585	<.001
	THURSDAY	.084	.004	.217	21.294	<.001
	FRIDAY	.056	.004	.145	14.043	<.001
	SATURDAY	.032	.004	.084	8.302	<.001
	lagged log total load 1st grade	.736	.019	.735	39.636	<.001
	lagged log total load 2st grade	.056	.019	.056	3.017	.003
a. Dependent Variable: log total load 11:00 - 12:00						

Table 91: Coefficient summary of log total load 11:00 - 12:00 2015-2022

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	1.815	.111		16.323	<.001
	linear term	1.401E-5	.000	.083	2.670	.008
	Quadradic term	-5.489E-9	.000	-.098	-3.148	.002
	JAN	.020	.004	.039	4.454	<.001
	MAR	-.010	.004	-.020	-2.335	.020
	APR	-.030	.005	-.058	-6.406	<.001

	MAY	-.020	.005	-.039	-4.290	<.001
	JUN	.015	.004	.029	3.452	<.001
	JUL	.044	.005	.086	9.088	<.001
	AUG	.023	.005	.045	4.992	<.001
	OCT	-.027	.005	-.053	-5.807	<.001
	NOV	-.017	.005	-.032	-3.583	<.001
	MONDAY	.167	.004	.409	39.577	<.001
	TUESDAY	.119	.005	.292	24.885	<.001
	WEDNESDAY	.091	.004	.221	21.459	<.001
	THURSDAY	.100	.004	.244	24.146	<.001
	FRIDAY	.071	.004	.174	17.067	<.001
	SATURDAY	.055	.004	.134	13.358	<.001
	lagged log total load 1st grade	.725	.019	.725	39.122	<.001
	lagged log total load 2st grade	.058	.019	.058	3.107	.002
a. Dependent Variable: log total load 12:00 - 13:00						

Table 92: Coefficient summary of log total load 12:00 - 13:00 2015-2022

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.771	.112		15.846	<.001
	Quadradic term	-9.716E-10	.000	-.016	-2.060	.040
	JAN	.019	.005	.033	3.858	<.001
	MAR	-.012	.005	-.021	-2.462	.014
	APR	-.032	.005	-.056	-6.173	<.001
	MAY	-.021	.005	-.038	-4.243	<.001
	JUN	.017	.005	.030	3.597	<.001
	JUL	.050	.005	.088	9.307	<.001
	AUG	.028	.005	.049	5.461	<.001
	OCT	-.028	.005	-.050	-5.523	<.001
	NOV	-.016	.005	-.028	-3.141	.002
	MONDAY	.212	.005	.472	45.528	<.001
	TUESDAY	.143	.005	.319	26.110	<.001
	WEDNESDAY	.118	.005	.263	25.683	<.001

	THURSDAY	.118	.005	.263	26.042	<.001
	FRIDAY	.098	.005	.218	21.563	<.001
	SATURDAY	.069	.004	.153	15.311	<.001
	lagged log total load 1st grade	.703	.018	.702	37.987	<.001
	lagged log total load 2st grade	.083	.019	.083	4.472	<.001
a. Dependent Variable: log total load 13:00 - 14:00						

Table 93: Coefficient summary of log total load 13:00 - 14:00 2015-2022

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.645	.107		15.362	<.001
	Quadradic term	-9.708E-10	.000	-.015	-2.017	.044
	JAN	.012	.005	.020	2.477	.013
	MAR	-.019	.005	-.032	-3.889	<.001
	APR	-.043	.005	-.071	-8.109	<.001
	MAY	-.038	.005	-.063	-7.059	<.001
	JUL	.035	.005	.058	6.613	<.001
	AUG	.013	.005	.022	2.654	.008
	SEP	-.023	.005	-.038	-4.623	<.001
	OCT	-.042	.005	-.071	-7.890	<.001
	NOV	-.021	.005	-.034	-4.081	<.001
	MONDAY	.219	.005	.459	46.303	<.001
	TUESDAY	.142	.006	.297	25.079	<.001
	WEDNESDAY	.118	.005	.248	25.260	<.001
	THURSDAY	.120	.005	.251	25.812	<.001
	FRIDAY	.102	.005	.214	21.980	<.001
	SATURDAY	.066	.005	.139	14.410	<.001
	lagged log total load 1st grade	.721	.018	.721	38.970	<.001
	lagged log total load 2st grade	.080	.019	.080	4.300	<.001
a. Dependent Variable: log total load 14:00 - 15:00						

Table 94: Coefficient summary of log total load 14:00 - 15:00 2015-2022

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.425	.097		14.634	<.001
	MAR	-.023	.005	-.039	-5.079	<.001
	APR	-.046	.005	-.074	-8.751	<.001
	MAY	-.041	.005	-.067	-7.657	<.001
	JUL	.024	.005	.040	5.243	<.001
	SEP	-.029	.005	-.046	-6.120	<.001
	OCT	-.043	.005	-.071	-8.225	<.001
	NOV	-.020	.005	-.032	-4.097	<.001
	MONDAY	.206	.005	.424	44.666	<.001
	TUESDAY	.131	.005	.271	24.242	<.001
	WEDNESDAY	.109	.005	.225	23.829	<.001
	THURSDAY	.112	.005	.231	24.767	<.001
	FRIDAY	.095	.005	.196	20.920	<.001
	SATURDAY	.062	.004	.128	13.782	<.001
	lagged log total load 1st grade	.754	.018	.754	40.789	<.001
	lagged log total load 2st grade	.072	.018	.072	3.929	<.001
a. Dependent Variable: log total load 15:00 - 16:00						

Table 95: Coefficient summary of log total load 15:00 - 16:00 2015-2022

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.467	.102		14.401	<.001
	FEB	-.017	.005	-.027	-3.666	<.001
	MAR	-.035	.005	-.058	-7.218	<.001
	APR	-.058	.006	-.095	-10.023	<.001
	MAY	-.049	.006	-.081	-8.567	<.001
	JUN	-.014	.005	-.023	-2.886	.004
	JUL	.014	.004	.024	3.265	.001

	SEP	-.037	.005	-.060	-7.610	<.001
	OCT	-.048	.006	-.079	-8.511	<.001
	NOV	-.018	.005	-.029	-3.696	<.001
	MONDAY	.185	.004	.383	43.049	<.001
	TUESDAY	.124	.005	.256	24.451	<.001
	WEDNESDAY	.095	.004	.197	21.950	<.001
	THURSDAY	.105	.004	.217	24.799	<.001
	FRIDAY	.087	.004	.181	20.408	<.001
	SATURDAY	.052	.004	.109	12.482	<.001
	lagged log total load 1st grade	.765	.019	.765	41.257	<.001
	lagged log total load 2st grade	.059	.019	.059	3.167	.002
a. Dependent Variable: log total load 16:00 - 17:00						

Table 96: Coefficient summary of log total load 16:00 - 17:00 2015-2022

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.313	.097		13.534	<.001
	FEB	-.013	.004	-.021	-3.142	.002
	MAR	-.037	.004	-.061	-8.386	<.001
	APR	-.063	.006	-.102	-11.197	<.001
	MAY	-.053	.006	-.088	-9.539	<.001
	JUN	-.023	.005	-.038	-5.076	<.001
	AUG	-.017	.004	-.028	-4.233	<.001
	SEP	-.044	.005	-.071	-9.428	<.001
	OCT	-.046	.005	-.075	-8.728	<.001
	NOV	-.019	.004	-.031	-4.447	<.001
	MONDAY	.165	.004	.341	42.739	<.001
	TUESDAY	.113	.005	.233	24.677	<.001
	WEDNESDAY	.082	.004	.168	20.793	<.001
	THURSDAY	.098	.004	.202	25.617	<.001
	FRIDAY	.075	.004	.155	19.339	<.001
	SATURDAY	.045	.004	.093	11.895	<.001

	lagged log total load 1st grade	.778	.019	.778	41.994	<.001
	lagged log total load 2st grade	.066	.019	.066	3.541	<.001
a. Dependent Variable: log total load 17:00 - 18:00						

Table 97: Coefficient summary of log total load 17:00 - 18:00 2015-2022

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.299	.097		13.438	<.001
	Quadradic term	-9.450E-10	.000	-.016	-2.567	.010
	MAR	-.023	.004	-.042	-6.286	<.001
	APR	-.054	.005	-.098	-10.999	<.001
	MAY	-.049	.005	-.089	-9.609	<.001
	JUN	-.022	.004	-.040	-5.335	<.001
	AUG	-.016	.004	-.030	-4.580	<.001
	SEP	-.034	.004	-.062	-8.395	<.001
	OCT	-.032	.004	-.059	-7.608	<.001
	NOV	-.017	.004	-.030	-4.385	<.001
	MONDAY	.154	.004	.351	43.288	<.001
	TUESDAY	.105	.004	.239	25.121	<.001
	WEDNESDAY	.075	.004	.172	21.061	<.001
	THURSDAY	.089	.003	.203	25.475	<.001
	FRIDAY	.066	.004	.150	18.636	<.001
	SATURDAY	.044	.003	.100	12.704	<.001
	lagged log total load 1st grade	.787	.019	.787	42.435	<.001
	lagged log total load 2st grade	.059	.019	.059	3.153	.002
a. Dependent Variable: log total load 18:00 - 19:00						

Table 98: Coefficient summary of log total load 18:00 - 19:00 2015-2022

Coefficients[a]				
Model	Unstandardized Coefficients	Standardized Coefficients	t	Sig.

		B	Std. Error	Beta		
1	(Constant)	1.298	.095		13.594	<.001
	Quadradic term	-1.186E-9	.000	-.023	-3.486	<.001
	MAR	-.012	.003	-.027	-3.896	<.001
	APR	-.035	.004	-.075	-9.294	<.001
	MAY	-.037	.004	-.081	-8.875	<.001
	JUN	-.018	.004	-.038	-4.817	<.001
	SEP	-.022	.003	-.047	-6.443	<.001
	OCT	-.029	.004	-.062	-7.644	<.001
	NOV	-.015	.003	-.032	-4.283	<.001
	MONDAY	.132	.003	.358	41.397	<.001
	TUESDAY	.084	.004	.229	21.749	<.001
	WEDNESDAY	.058	.003	.157	17.445	<.001
	THURSDAY	.069	.003	.187	21.453	<.001
	FRIDAY	.045	.003	.121	13.690	<.001
	SATURDAY	.021	.003	.058	6.715	<.001
	lagged log total load 1st grade	.793	.019	.793	42.758	<.001
	lagged log total load 2st grade	.055	.019	.055	2.956	.003
a. Dependent Variable: log total load 19:00 - 20:00						

Table 99: Coefficient summary of log total load 19:00 - 20:00 2015-2022

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.176	.081		14.518	<.001
	Quadradic term	-1.290E-9	.000	-.027	-4.185	<.001
	MAR	-.010	.003	-.022	-3.377	<.001
	APR	-.023	.003	-.051	-7.239	<.001
	MAY	-.020	.003	-.047	-6.276	<.001
	JUL	.012	.003	.028	4.178	<.001
	SEP	-.021	.003	-.048	-6.985	<.001
	OCT	-.027	.003	-.061	-7.916	<.001
	NOV	-.013	.003	-.030	-4.250	<.001
	MONDAY	.092	.002	.267	37.217	<.001

	TUESDAY	.047	.002	.137	19.384	<.001
	WEDNESDAY	.035	.002	.102	14.369	<.001
	THURSDAY	.036	.002	.104	14.604	<.001
	FRIDAY	.018	.002	.052	7.322	<.001
	lagged log total load 1st grade	.864	.009	.864	94.321	<.001
a. Dependent Variable: log total load 20:00 - 21:00						

Table 100: Coefficient summary of log total load 20:00 - 21:00 2015-2022

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.034	.073		14.078	<.001
	Quadradic term	-1.169E-9	.000	-.023	-4.150	<.001
	MAR	-.010	.003	-.021	-3.699	<.001
	APR	-.022	.003	-.048	-7.756	<.001
	MAY	-.018	.003	-.040	-6.124	<.001
	JUL	.015	.003	.032	5.439	<.001
	SEP	-.021	.003	-.045	-7.469	<.001
	OCT	-.025	.003	-.055	-8.057	<.001
	NOV	-.013	.003	-.028	-4.563	<.001
	MONDAY	.063	.002	.172	28.259	<.001
	TUESDAY	.031	.003	.084	12.331	<.001
	WEDNESDAY	.024	.002	.066	10.577	<.001
	THURSDAY	.025	.002	.068	11.114	<.001
	FRIDAY	.011	.002	.030	4.887	<.001
	lagged log total load 1st grade	.970	.018	.970	52.774	<.001
	lagged log total load 2st grade	-.090	.018	-.090	-4.932	<.001
a. Dependent Variable: log total load 21:00 - 22:00						

Table 101: Coefficient summary of log total load 21:00 - 22:00 2015-2022

Coefficients[a]				
Model	Unstandardized Coefficients	Standardized Coefficients	t	Sig.

		B	Std. Error	Beta		
1	(Constant)	.959	.069		13.864	<.001
	Quadradic term	-9.449E-10	.000	-.018	-3.453	<.001
	MAR	-.010	.003	-.022	-4.024	<.001
	APR	-.023	.003	-.047	-7.999	<.001
	MAY	-.018	.003	-.038	-6.222	<.001
	JUL	.016	.003	.033	5.789	<.001
	SEP	-.020	.003	-.041	-7.300	<.001
	OCT	-.023	.003	-.048	-7.621	<.001
	NOV	-.014	.003	-.029	-4.882	<.001
	MONDAY	.063	.003	.166	24.732	<.001
	TUESDAY	.027	.003	.070	9.026	<.001
	WEDNESDAY	.021	.003	.054	7.638	<.001
	THURSDAY	.023	.003	.060	8.766	<.001
	FRIDAY	.015	.003	.038	5.519	<.001
	SATURDAY	-.018	.003	-.046	-6.798	<.001
	lagged log total load 1st grade	1.000	.018	1.000	54.241	<.001
	lagged log total load 2st grade	-.112	.018	-.112	-6.127	<.001
a. Dependent Variable: log total load 22:00 - 23:00						

Table 102: Coefficient summary of log total load 22:00 - 23:00 2015-2022

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.929	.072		12.901	<.001
	Quadradic term	-1.104E-9	.000	-.020	-3.892	<.001
	MAR	-.011	.003	-.021	-3.963	<.001
	APR	-.022	.003	-.044	-7.616	<.001
	MAY	-.017	.003	-.034	-5.744	<.001
	JUL	.020	.003	.040	6.634	<.001
	AUG	.006	.003	.011	2.005	.045
	SEP	-.018	.003	-.036	-6.557	<.001
	OCT	-.022	.003	-.044	-7.212	<.001
	NOV	-.013	.003	-.026	-4.530	<.001

	MONDAY	.073	.002	.184	32.240	<.001
	TUESDAY	.041	.002	.102	16.257	<.001
	WEDNESDAY	.034	.002	.084	14.654	<.001
	THURSDAY	.036	.002	.091	16.042	<.001
	FRIDAY	.035	.002	.088	15.554	<.001
	lagged log total load 1st grade	.949	.018	.949	53.003	<.001
	lagged log total load 2st grade	-.060	.018	-.060	-3.349	<.001
a. Dependent Variable: log total load 23:00 - 24:00						

Table 103: Coefficient summary of log total load 23:00 - 24:00 2015-2022

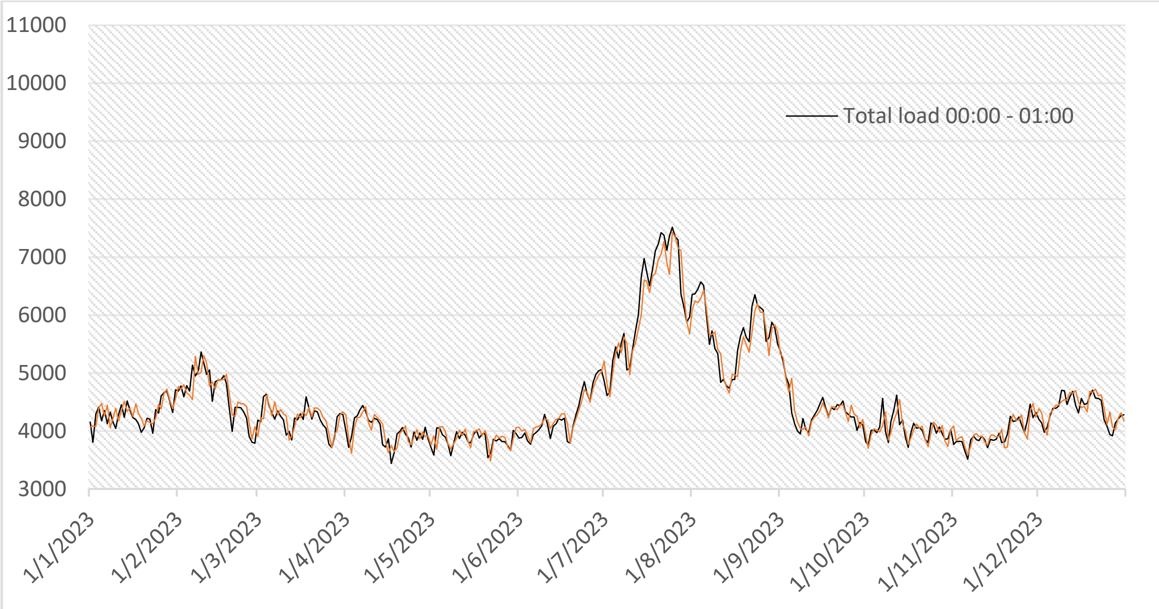

Figure 154: Forecasted total load vs Actual total load 00:00 - 01:00 2023

Figure 155: Forecasted total load vs Actual total load 01:00 - 02:00 2023

Figure 156: Forecasted total load vs Actual total load 02:00 - 03:00 2023

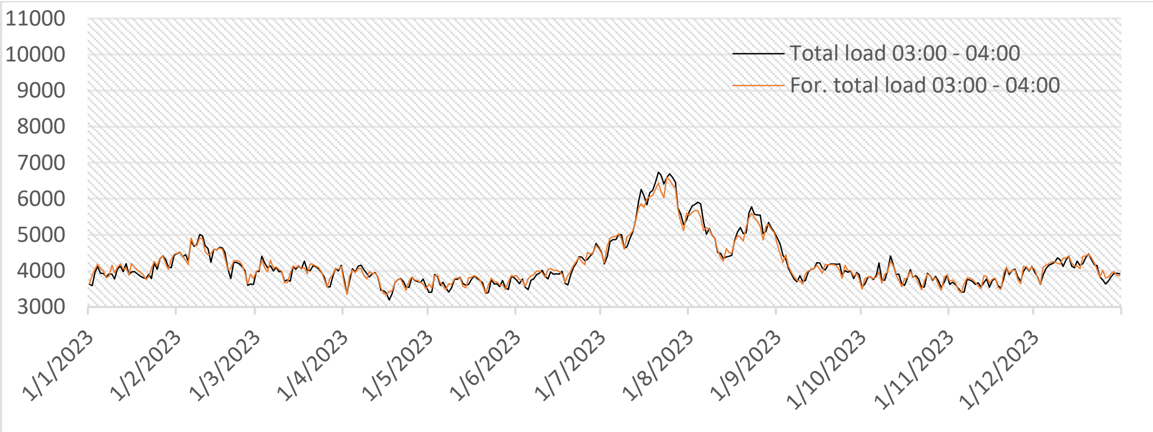

Figure 157: Forecasted total load vs Actual total load 03:00 - 04:00 2023

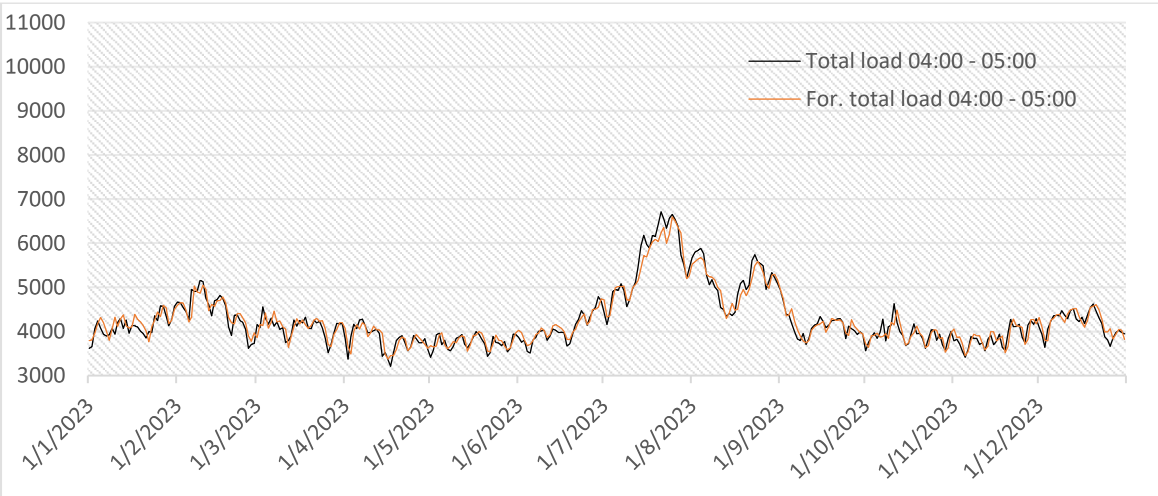

Figure 158: Forecasted total load vs Actual total load 04:00 - 05:00 2023

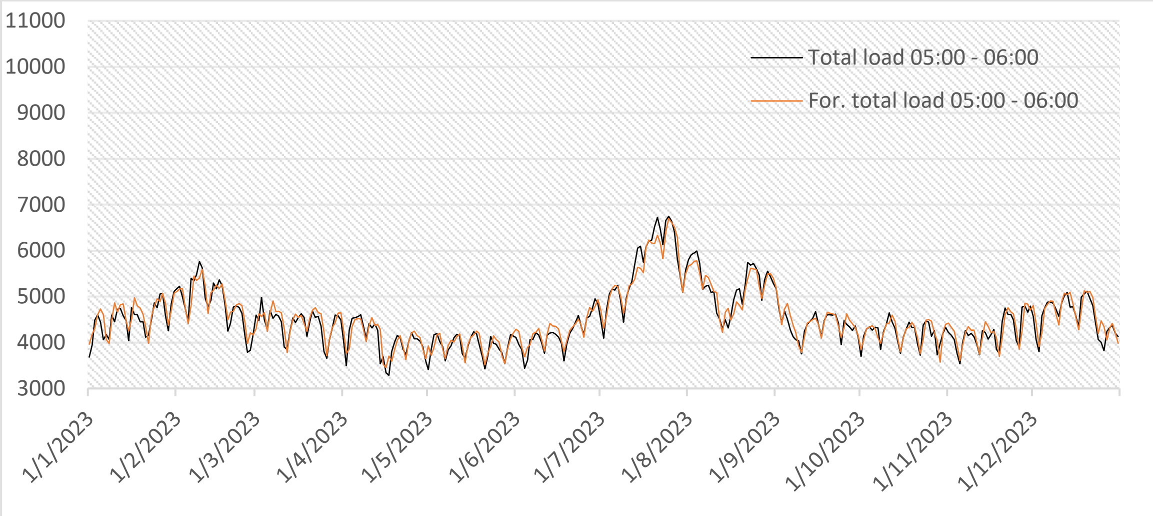

Figure 159: Forecasted total load vs Actual total load 05:00 - 06:00 2023

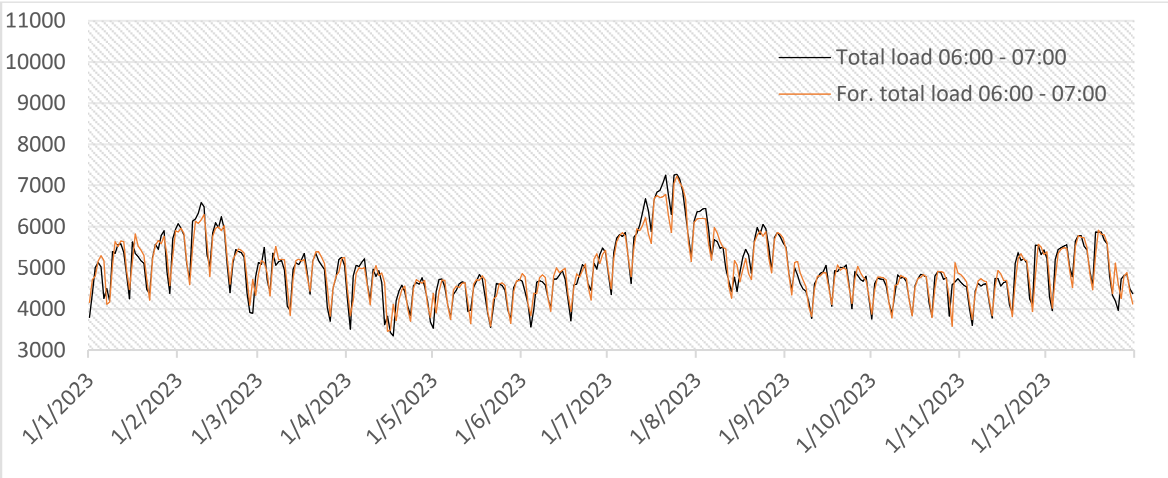

Figure 160: Forecasted total load vs Actual total load 06:00 - 07:00 2023

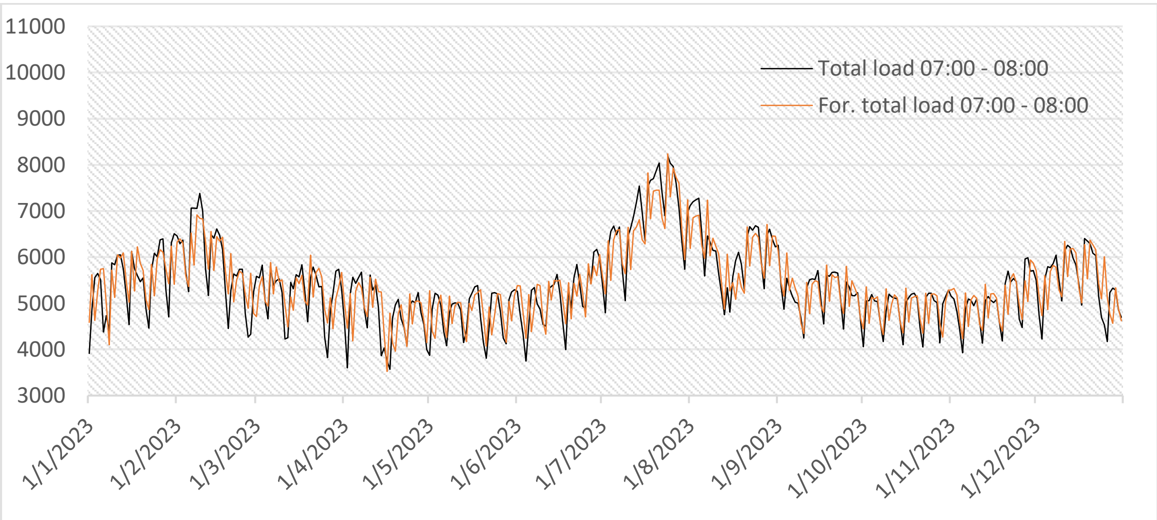

Figure 161: Forecasted total load vs Actual total load 07:00 - 08:00 2023

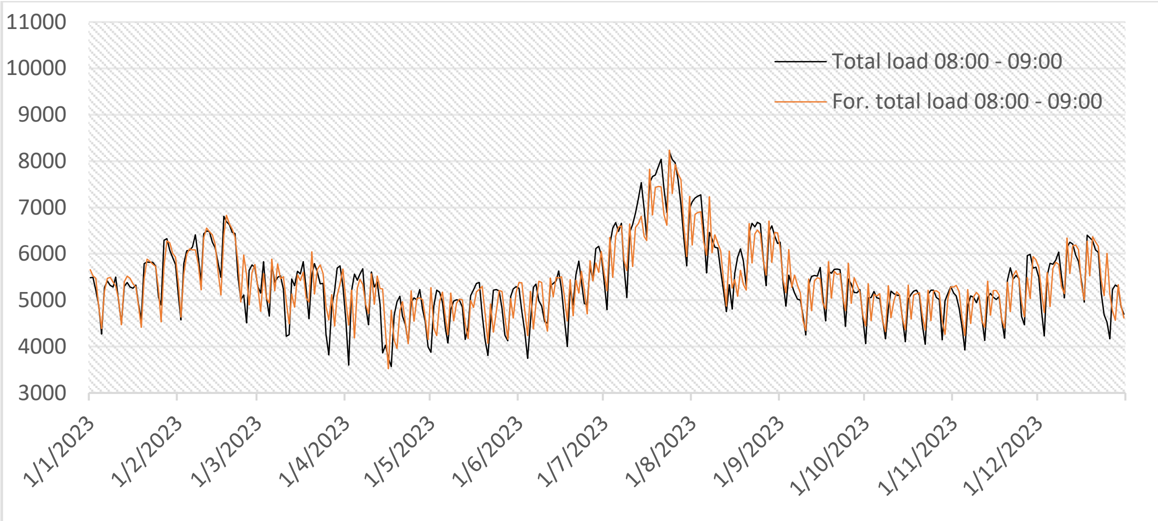

Figure 162: Forecasted total load vs Actual total load 08:00 - 09:00 2023

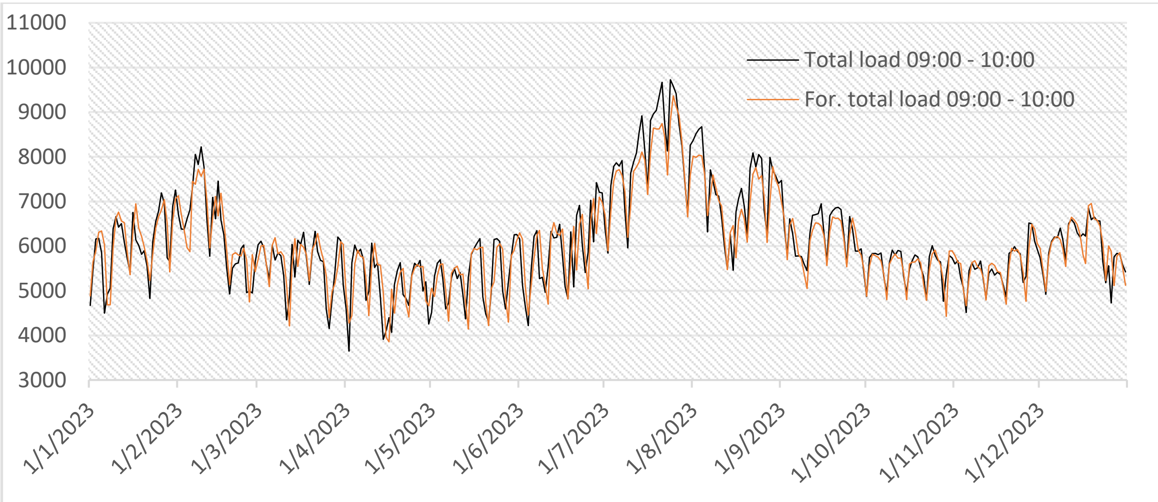

Figure 163: Forecasted total load vs Actual total load 09:00 - 10:00 2023

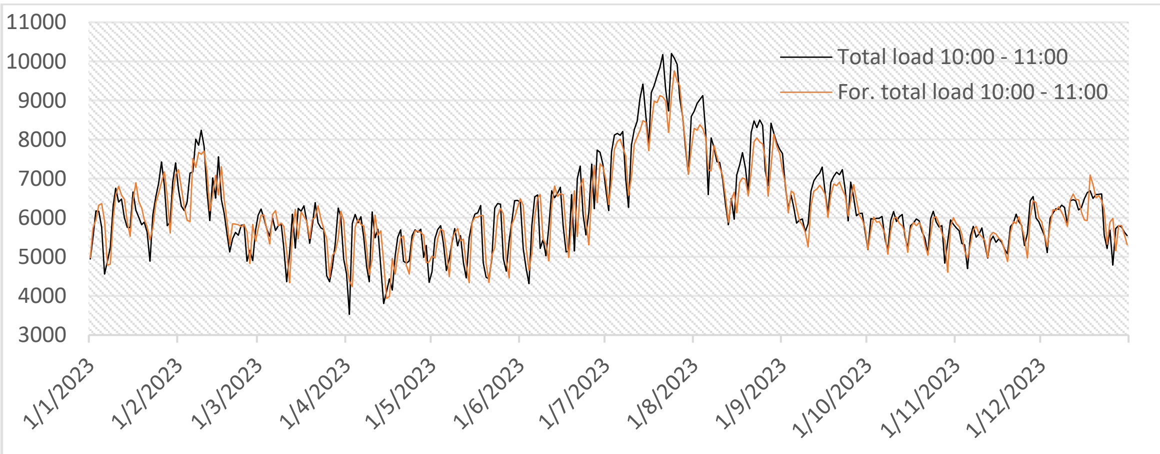

Figure 164: Forecasted total load vs Actual total load 10:00 - 11:00 2023

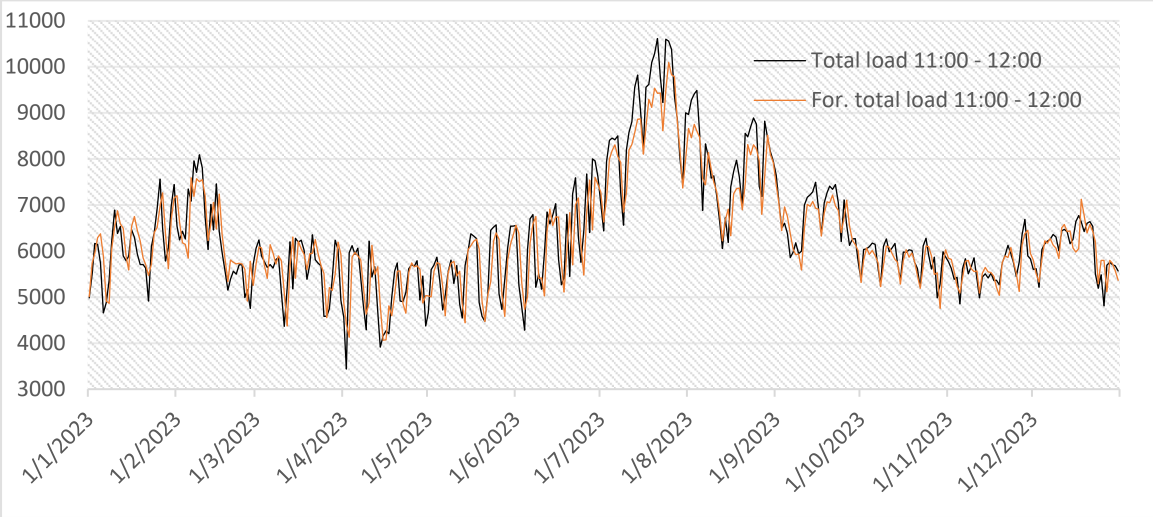

Figure 165: Forecasted total load vs Actual total load 11:00 - 12:00 2023

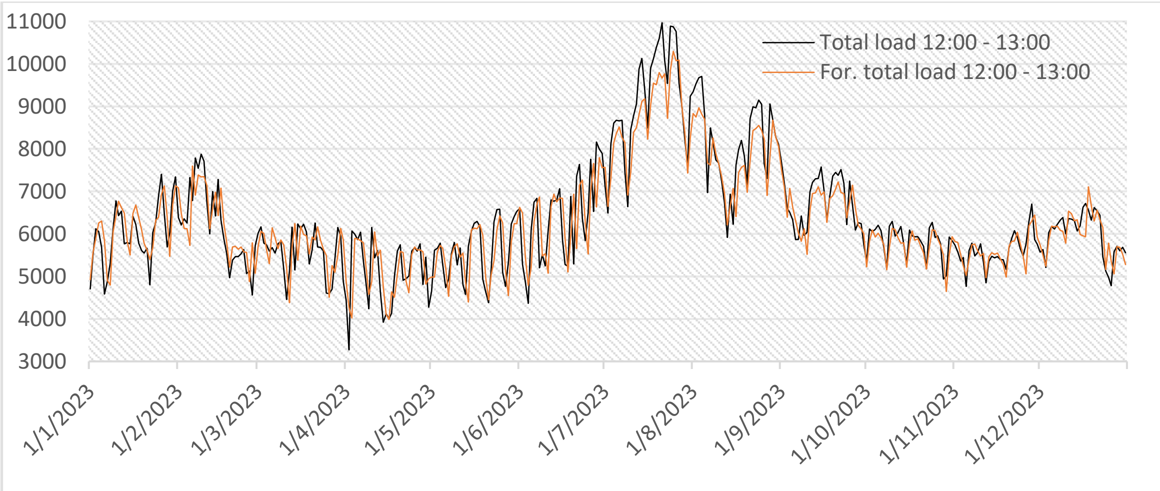

Figure 166: Forecasted total load vs Actual total load 12:00 - 13:00 2023

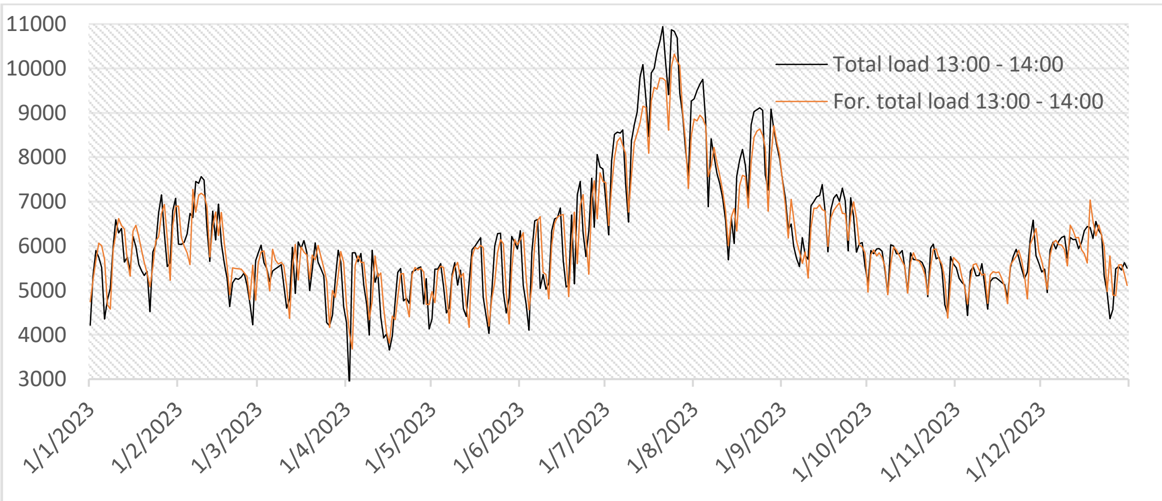

Figure 167: Forecasted total load vs Actual total load 13:00 - 14:00 2023

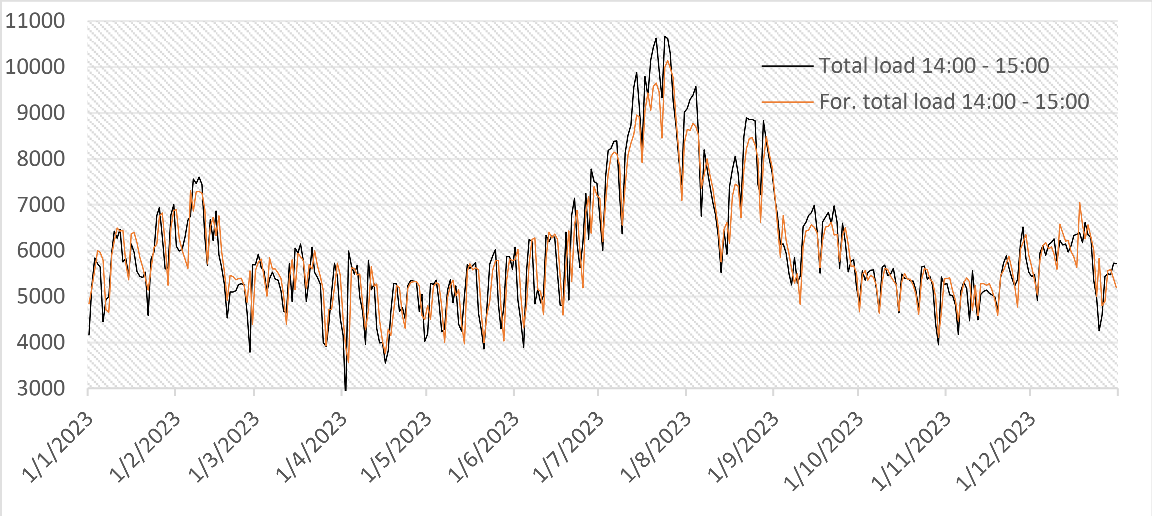

Figure 168: Forecasted total load vs Actual total load 14:00 - 15:00 2023

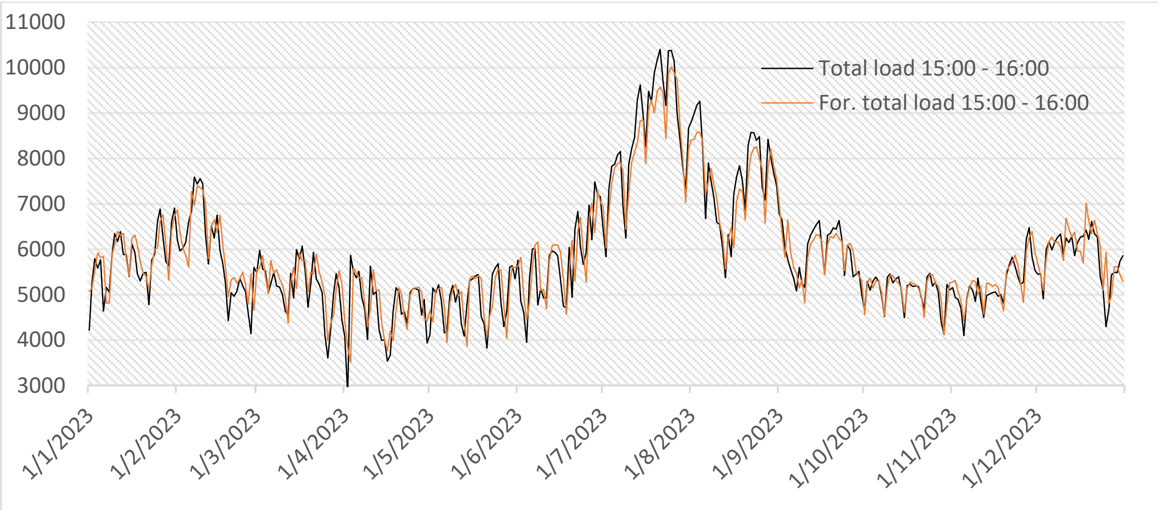

Figure 169: Forecasted total load vs Actual total load 15:00 - 16:00 2023

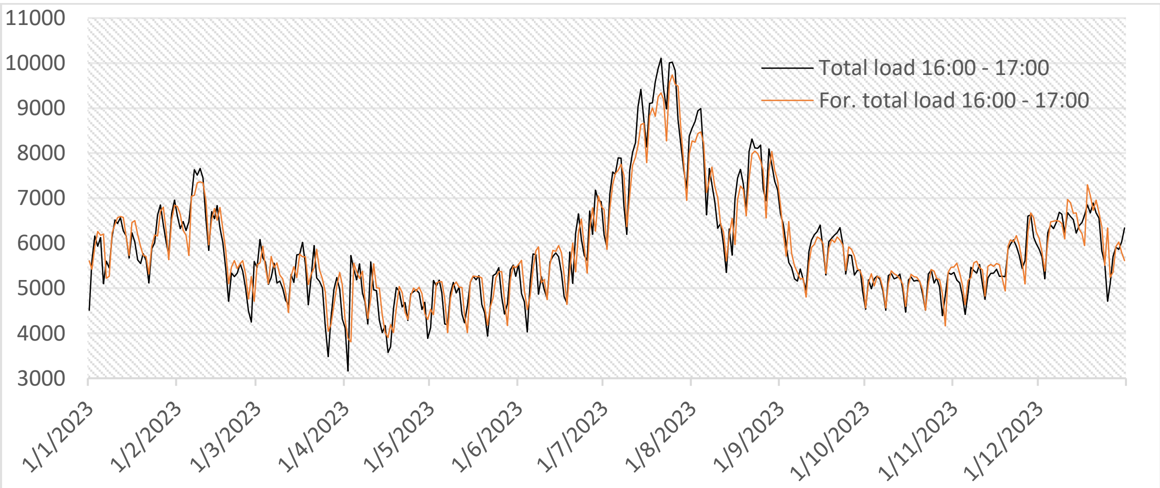

Figure 170: Forecasted total load vs Actual total load 16:00 - 17:00 2023

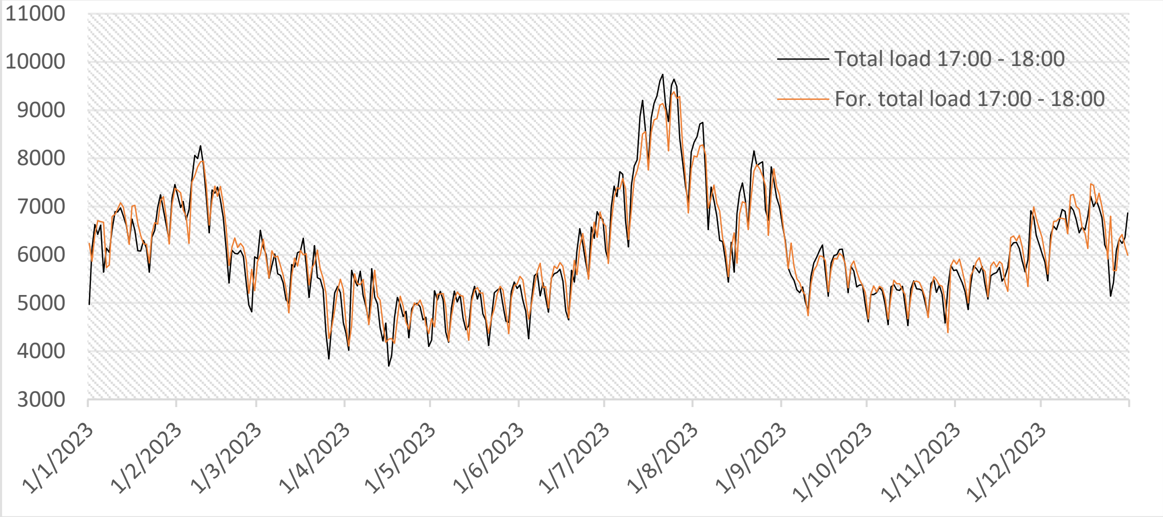

Figure 171: Forecasted total load vs Actual total load 17:00 - 18:00 2023

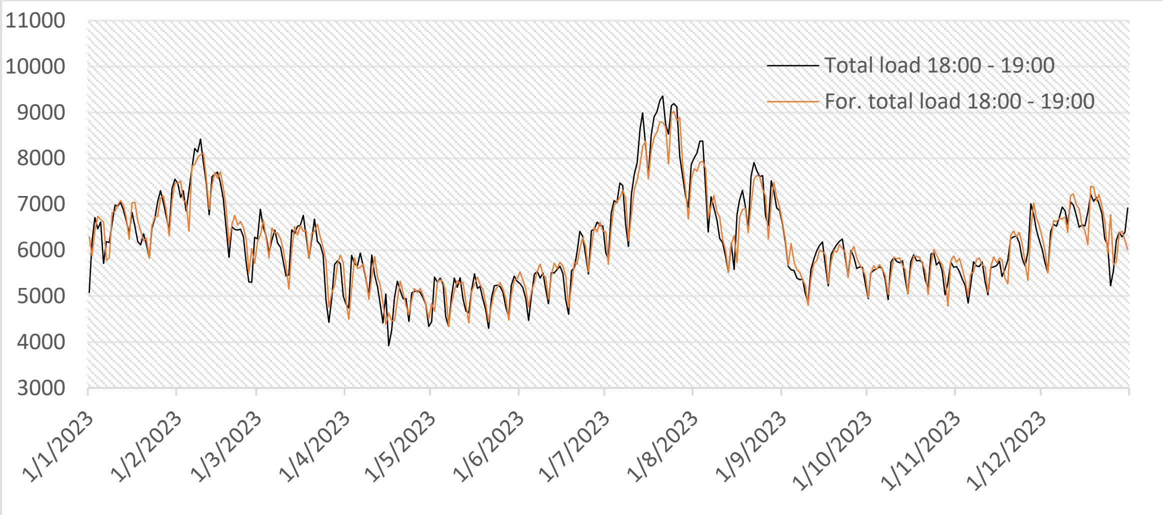

Figure 172: Forecasted total load vs Actual total load 18:00 - 19:00 2023

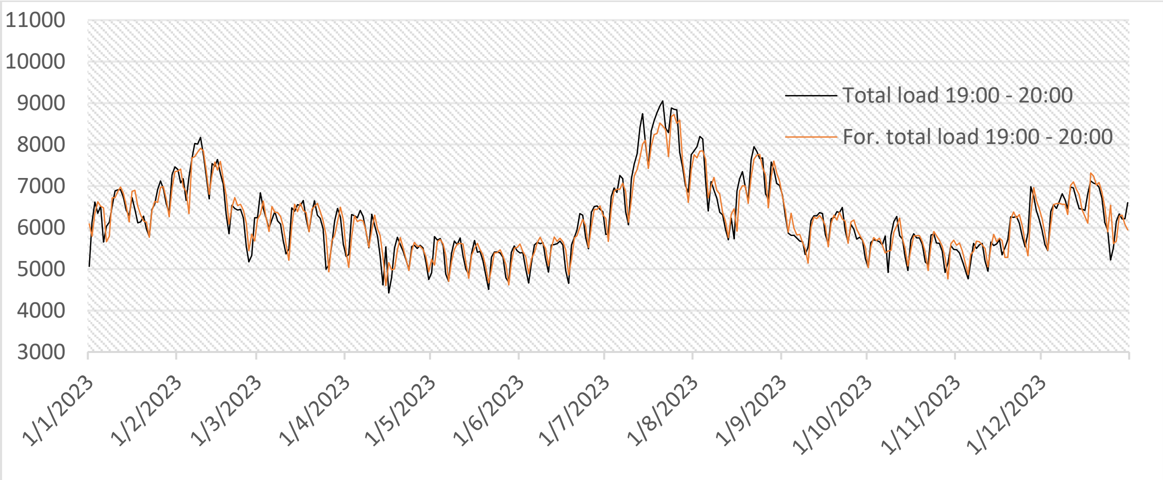

Figure 173: Forecasted total load vs Actual total load 19:00 - 20:00 2023

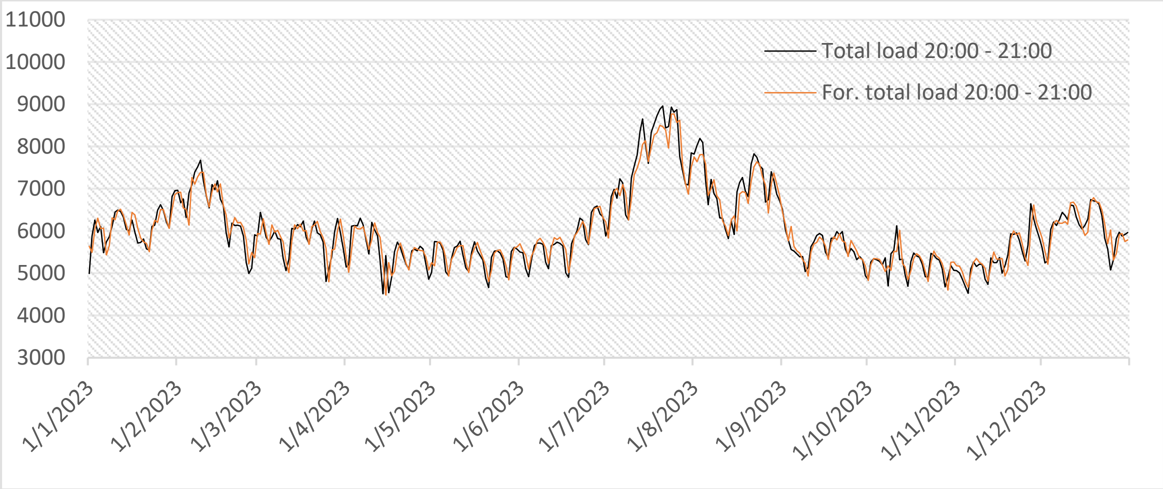

Figure 174: Forecasted total load vs Actual total load 20:00 - 21:00 2023

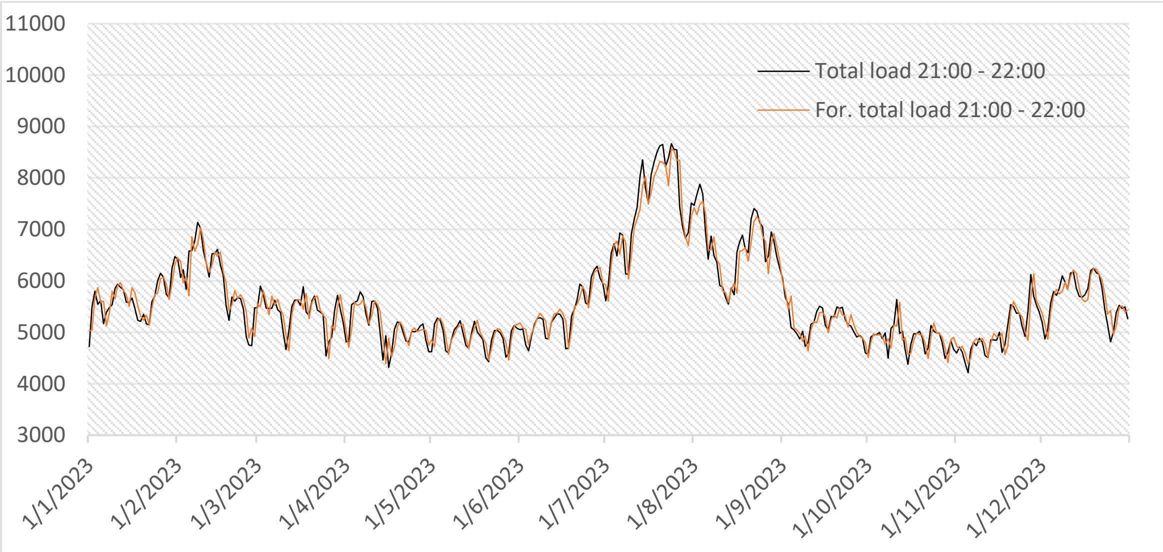

Figure 175: Forecasted total load vs Actual total load 21:00 - 22:00 2023

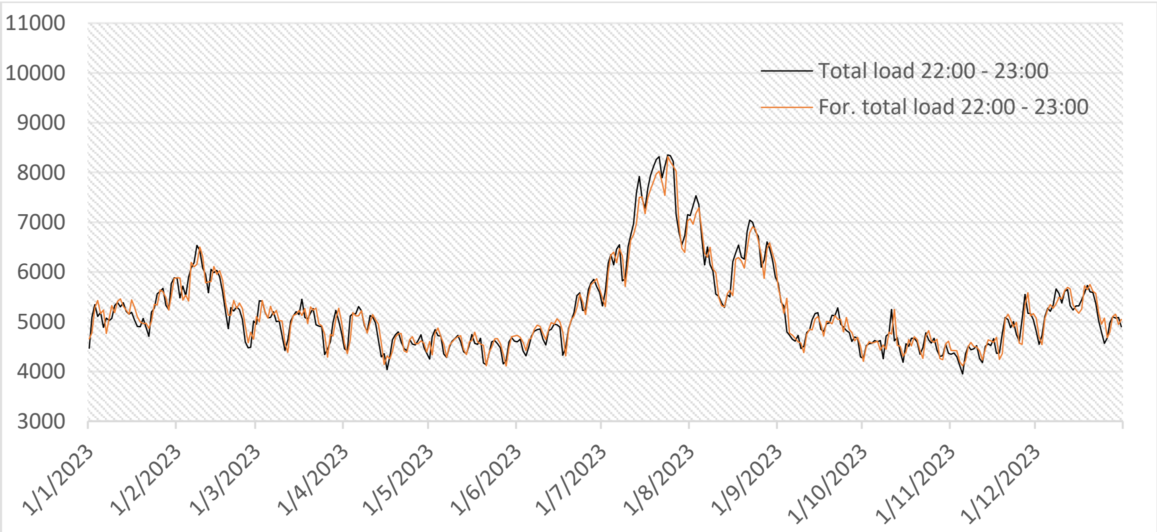

Figure 176: Forecasted total load vs Actual total load 22:00 - 23:00 2023

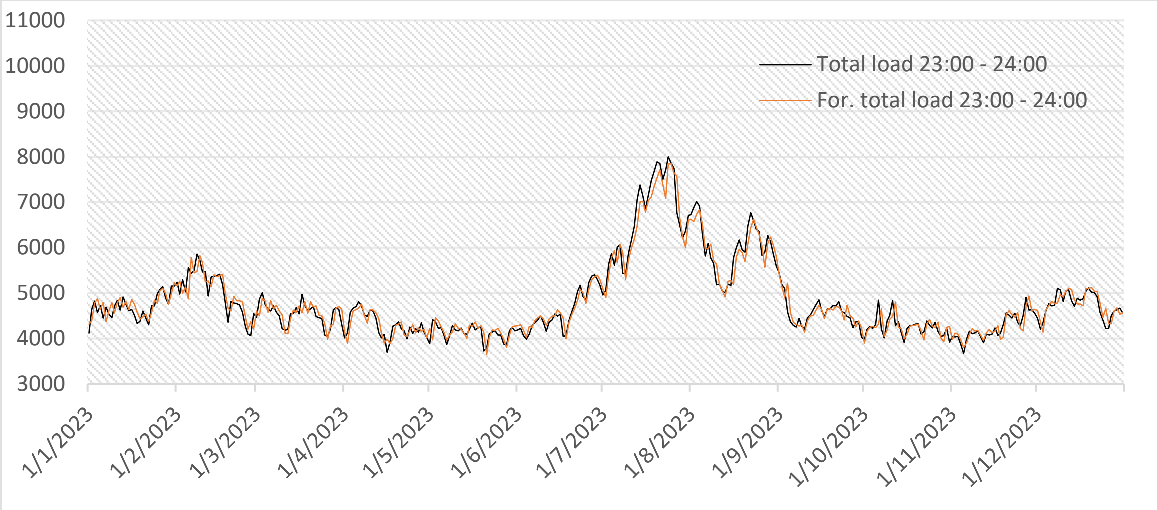

Figure 177: Forecasted total load vs Actual total load 23:00 - 24:00 2023

Appendix F: Tables comparing the performance metrics of the forecasting models

0000-0100			
	MAE	MAPE	RMSE
REGRESSION	134.30	**2.96%**	179.42
SMA (2)	186.90	4.13%	240.46
SMA (4)	212.28	4.64%	283.00
SMA (7)	236.89	5.09%	328.62
SMA (14)	297.53	6.27%	431.02
EWMA (λ=0.1)	165.68	3.68%	214.91
EWMA (λ=0.3)	172.70	3.82%	222.65
EWMA (λ=0.6)	191.03	4.18%	255.98
EWMA (λ=0.9)	291.30	6.16%	420.38

Table 104: Comparison of Performance Metrics for the models of time zone 00:00-01:00

0100-0200			
	MAE	MAPE	RMSE
REGRESSION	130.81	2.99%	173.31
SMA (2)	178.90	4.11%	229.53
SMA (4)	205.19	4.66%	270.66
SMA (7)	228.75	5.10%	314.09
SMA (14)	287.09	6.29%	410.57
EWMA (λ=0.1)	159.02	3.67%	205.14
EWMA (λ=0.3)	165.23	3.80%	212.64
EWMA (λ=0.6)	184.41	4.19%	244.60
EWMA (λ=0.9)	279.69	6.15%	398.53

Table 105: Comparison of Performance Metrics for the models of time zone 01:00-02:00

0200-0300			
	MAE	MAPE	RMSE
REGRESSION	130.38	3.06%	172.73
SMA (2)	174.04	4.10%	224.02
SMA (4)	199.29	4.64%	262.66
SMA (7)	221.29	5.06%	302.10

SMA (14)	274.87	6.18%	392.67
EWMA (λ=0.1)	155.32	3.67%	202.04
EWMA (λ=0.3)	160.87	3.80%	208.32
EWMA (λ=0.6)	179.65	4.19%	237.40
EWMA (λ=0.9)	267.55	6.04%	380.54

Table 106: Comparison of Performance Metrics for the models of time zone 02:00-03:00

0300-0400			
	MAE	MAPE	RMSE
REGRESSION	93.47	2.21%	123.95
SMA (2)	174.77	4.17%	221.64
SMA (4)	199.70	4.73%	258.46
SMA (7)	219.15	5.10%	292.89
SMA (14)	270.34	6.19%	378.26
EWMA (λ=0.1)	152.60	3.65%	196.36
EWMA (λ=0.3)	158.75	3.79%	203.87
EWMA (λ=0.6)	179.42	4.25%	232.37
EWMA (λ=0.9)	261.70	6.01%	366.07

Table 107: Comparison of Performance Metrics for the models of time zone 03:00-04:00

0400-0500			
	MAE	MAPE	RMSE
REGRESSION	124.38	2.92%	165.11
SMA (2)	188.25	4.44%	236.41
SMA (4)	216.95	5.09%	275.53
SMA (7)	227.49	5.25%	298.83
SMA (14)	275.07	6.25%	377.05
EWMA (λ=0.1)	166.51	3.94%	208.40
EWMA (λ=0.3)	172.02	4.06%	216.79
EWMA (λ=0.6)	191.09	4.48%	244.10
EWMA (λ=0.9)	266.55	6.07%	365.77

Table 108: Comparison of Performance Metrics for the models of time zone 04:00-05:00

0500-0600			
	MAE	MAPE	RMSE
REGRESSION	139.24	3.14%	185.46

SMA (2)	266.91	6.05%	326.06
SMA (4)	304.35	6.89%	365.38
SMA (7)	278.20	6.23%	351.03
SMA (14)	324.32	7.16%	416.80
EWMA (λ=0.1)	229.89	5.21%	286.57
EWMA (λ=0.3)	241.54	5.47%	295.89
EWMA (λ=0.6)	262.34	5.94%	317.74
EWMA (λ=0.9)	316.34	6.99%	409.07

Table 109: Comparison of Performance Metrics for the models of time zone 05:00-06:00

0600-0700			
	MAE	MAPE	RMSE
REGRESSION	177.93	3.72%	247.53
SMA (2)	431.24	9.08%	529.77
SMA (4)	482.84	10.21%	563.82
SMA (7)	405.16	8.56%	495.72
SMA (14)	454.13	9.47%	553.53
EWMA (λ=0.1)	360.34	7.56%	471.82
EWMA (λ=0.3)	385.24	8.11%	479.31
EWMA (λ=0.6)	415.38	8.78%	492.48
EWMA (λ=0.9)	452.38	9.44%	553.01

Table 110: Comparison of Performance Metrics for the models of time zone 06:00-07:00

0700-0800			
	MAE	MAPE	RMSE
REGRESSION	332.81	6.37%	440.66
SMA (2)	513.84	9.90%	627.47
SMA (4)	568.47	11.04%	664.35
SMA (7)	476.21	9.23%	577.98
SMA (14)	519.30	9.95%	637.03
EWMA (λ=0.1)	431.33	8.28%	566.67
EWMA (λ=0.3)	460.39	8.87%	571.66
EWMA (λ=0.6)	489.41	9.49%	581.89
EWMA (λ=0.9)	520.82	9.97%	639.68

Table 111: Comparison of Performance Metrics for the models of time zone 07:00-08:00

0800-0900			
	MAE	MAPE	RMSE
REGRESSION	292.40	5.60%	397.25
SMA (2)	554.07	9.83%	678.52
SMA (4)	608.51	10.90%	720.78
SMA (7)	522.00	9.30%	637.61
SMA (14)	569.39	10.05%	703.10
EWMA (λ=0.1)	474.02	8.37%	616.83
EWMA (λ=0.3)	499.95	8.87%	621.01
EWMA (λ=0.6)	529.65	9.46%	632.95
EWMA (λ=0.9)	567.99	10.02%	702.98

Table 112: Comparison of Performance Metrics for the models of time zone 08:00-09:00

0900-1000			
	MAE	MAPE	RMSE
REGRESSION	312.82	5.31%	425.04
SMA (2)	543.27	9.21%	673.98
SMA (4)	597.50	10.21%	721.84
SMA (7)	530.04	8.99%	652.58
SMA (14)	583.63	9.80%	727.21
EWMA (λ=0.1)	475.59	8.05%	614.98
EWMA (λ=0.3)	493.80	8.38%	619.20
EWMA (λ=0.6)	521.14	8.86%	634.47
EWMA (λ=0.9)	579.20	9.72%	723.50

Table 113: Comparison of Performance Metrics for the models of time zone 09:00-10:00

1000-1100			
	MAE	MAPE	RMSE
REGRESSION	356.84	5.89%	480.01
SMA (2)	539.28	8.93%	677.37
SMA (4)	596.77	9.94%	731.19
SMA (7)	542.71	8.95%	672.62
SMA (14)	601.67	9.82%	755.77
EWMA (λ=0.1)	475.01	7.87%	619.34
EWMA (λ=0.3)	493.46	8.18%	623.99
EWMA (λ=0.6)	523.06	8.67%	642.83

EWMA (λ=0.9)	595.34	9.72%	749.16

Table 114: Comparison of Performance Metrics for the models of time zone 10:00-11:00

1100-1200			
	MAE	MAPE	RMSE
REGRESSION	380.30	6.14%	509.78
SMA (2)	539.25	8.75%	682.60
SMA (4)	600.55	9.80%	738.66
SMA (7)	556.14	8.99%	688.69
SMA (14)	618.37	9.90%	779.43
EWMA (λ=0.1)	476.34	7.74%	629.06
EWMA (λ=0.3)	493.24	8.01%	632.08
EWMA (λ=0.6)	530.92	8.63%	651.62
EWMA (λ=0.9)	611.76	9.78%	772.20

Table 115: Comparison of Performance Metrics for the models of time zone 11:00-12:00

1200-1300			
	MAE	MAPE	RMSE
REGRESSION	393.87	6.33%	527.26
SMA (2)	551.02	8.93%	699.30
SMA (4)	617.46	10.07%	755.84
SMA (7)	572.69	9.25%	712.74
SMA (14)	635.52	10.14%	812.15
EWMA (λ=0.1)	486.92	7.89%	650.25
EWMA (λ=0.3)	506.54	8.21%	650.85
EWMA (λ=0.6)	546.61	8.87%	670.08
EWMA (λ=0.9)	629.25	10.03%	803.31

Table 116: Comparison of Performance Metrics for the models of time zone 12:00-13:00

1300-1400			
	MAE	MAPE	RMSE
REGRESSION	383.26	6.46%	508.11
SMA (2)	571.92	9.63%	722.22
SMA (4)	641.21	10.89%	779.78
SMA (7)	589.21	9.89%	734.85
SMA (14)	655.95	10.87%	840.36

EWMA (λ=0.1)	502.89	8.47%	674.27
EWMA (λ=0.3)	523.56	8.83%	673.51
EWMA (λ=0.6)	565.46	9.54%	692.15
EWMA (λ=0.9)	647.32	10.72%	830.33

Table 117: Comparison of Performance Metrics for the models of time zone 13:00-14:00

1400-1500			
	MAE	MAPE	RMSE
REGRESSION	373.54	6.49%	499.80
SMA (2)	591.60	9.77%	742.74
SMA (4)	661.17	11.00%	797.56
SMA (7)	623.24	10.24%	760.24
SMA (14)	685.82	11.14%	863.96
EWMA (λ=0.1)	527.10	8.73%	697.32
EWMA (λ=0.3)	551.45	9.11%	697.47
EWMA (λ=0.6)	589.60	9.73%	716.77
EWMA (λ=0.9)	667.99	10.80%	850.53

Table 118: Comparison of Performance Metrics for the models of time zone 14:00-15:00

1500-1600			
	MAE	MAPE	RMSE
REGRESSION	329.18	5.84%	440.97
SMA (2)	500.54	8.84%	627.27
SMA (4)	561.43	9.98%	687.03
SMA (7)	534.28	9.36%	673.43
SMA (14)	606.90	10.51%	791.02
EWMA (λ=0.1)	445.30	7.87%	585.13
EWMA (λ=0.3)	460.98	8.15%	586.17
EWMA (λ=0.6)	495.42	8.76%	611.66
EWMA (λ=0.9)	596.32	10.32%	775.34

Table 119: Comparison of Performance Metrics for the models of time zone 15:00-16:00

1600-1700			
	MAE	MAPE	RMSE
REGRESSION	283.83	5.00%	379.22
SMA (2)	448.74	7.87%	561.71

SMA (4)	506.36	8.92%	618.75
SMA (7)	487.61	8.48%	614.57
SMA (14)	560.96	9.64%	732.36
EWMA (λ=0.1)	399.81	7.03%	517.09
EWMA (λ=0.3)	413.11	7.26%	521.43
EWMA (λ=0.6)	443.70	7.79%	550.34
EWMA (λ=0.9)	549.94	9.45%	719.87

Table 120: Comparison of Performance Metrics for the models of time zone 16:00-17:00

1700-1800			
	MAE	MAPE	RMSE
REGRESSION	254.33	4.31%	335.75
SMA (2)	417.02	7.09%	516.65
SMA (4)	470.39	8.01%	567.79
SMA (7)	453.43	7.64%	567.79
SMA (14)	518.89	8.66%	681.01
EWMA (λ=0.1)	366.82	6.24%	468.63
EWMA (λ=0.3)	380.70	6.48%	475.37
EWMA (λ=0.6)	413.93	7.04%	505.18
EWMA (λ=0.9)	514.29	8.59%	672.68

Table 121: Comparison of Performance Metrics for the models of time zone 17:00-18:00

1800-1900			
	MAE	MAPE	RMSE
REGRESSION	225.48	3.71%	305.82
SMA (2)	388.30	6.45%	480.87
SMA (4)	441.94	7.36%	531.33
SMA (7)	423.33	6.98%	529.20
SMA (14)	485.45	7.94%	633.60
EWMA (λ=0.1)	335.03	5.58%	432.38
EWMA (λ=0.3)	352.29	5.86%	440.79
EWMA (λ=0.6)	387.64	6.44%	470.56
EWMA (λ=0.9)	477.14	7.80%	623.27

Table 122: Comparison of Performance Metrics for the models of time zone 18:00-19:00

1900-2000

	MAE	MAPE	RMSE
REGRESSION	215.84	3.53%	290.19
SMA (2)	380.15	6.24%	468.20
SMA (4)	432.83	7.12%	518.16
SMA (7)	408.24	6.66%	503.91
SMA (14)	461.82	7.47%	592.56
EWMA (λ=0.1)	320.41	5.27%	416.64
EWMA (λ=0.3)	341.23	5.61%	426.76
EWMA (λ=0.6)	376.91	6.19%	454.77
EWMA (λ=0.9)	452.78	7.32%	581.93

Table 123: Comparison of Performance Metrics for the models of time zone 19:00-20:00

2000-2100			
	MAE	MAPE	RMSE
REGRESSION	193.58	3.25%	260.31
SMA (2)	325.26	5.47%	404.10
SMA (4)	381.62	6.43%	459.52
SMA (7)	368.67	6.16%	458.93
SMA (14)	427.09	7.06%	551.86
EWMA (λ=0.1)	274.56	4.63%	357.35
EWMA (λ=0.3)	292.50	4.93%	369.12
EWMA (λ=0.6)	329.01	5.54%	401.29
EWMA (λ=0.9)	419.89	6.94%	542.00

Table 124: Comparison of Performance Metrics for the models of time zone 20:00-21:00

2100-2200			
	MAE	MAPE	RMSE
REGRESSION	174.82	3.13%	235.11
SMA (2)	275.84	4.94%	342.11
SMA (4)	325.25	5.82%	399.01
SMA (7)	328.25	5.81%	420.06
SMA (14)	392.97	6.86%	521.97
EWMA (λ=0.1)	230.81	4.14%	297.19
EWMA (λ=0.3)	247.84	4.44%	311.22
EWMA (λ=0.6)	281.16	5.02%	349.21
EWMA (λ=0.9)	385.45	6.73%	512.45

Table 125: Comparison of Performance Metrics for the models of time zone 21:00-22:00

2200-2300			
	MAE	MAPE	RMSE
REGRESSION	149.18	2.85%	199.43
SMA (2)	236.64	4.51%	294.05
SMA (4)	276.60	5.26%	348.03
SMA (7)	292.54	5.49%	383.60
SMA (14)	357.91	6.62%	489.04
EWMA (λ=0.1)	199.12	3.80%	255.69
EWMA (λ=0.3)	213.28	4.07%	268.58
EWMA (λ=0.6)	242.33	4.60%	307.51
EWMA (λ=0.9)	352.21	6.52%	480.58

Table 126: Comparison of Performance Metrics for the models of time zone 22:00-23:00

2300-2400			
	MAE	MAPE	RMSE
REGRESSION	142.25	2.93%	190.86
SMA (2)	206.12	4.25%	262.13
SMA (4)	236.01	4.83%	308.84
SMA (7)	259.27	5.22%	352.89
SMA (14)	324.41	6.43%	458.28
EWMA (λ=0.1)	179.94	3.72%	232.32
EWMA (λ=0.3)	188.70	3.89%	241.66
EWMA (λ=0.6)	210.72	4.31%	277.29
EWMA (λ=0.9)	318.51	6.33%	449.38

Table 127: Comparison of Performance Metrics for the models of time zone 23:00-24:00

Author's Statement:

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