International Science and Technology Journal
المجلة الدولية للعلوم والتقنية

عدد خاص بالمؤتمر الليبي الدولي للعلوم التطبيقية و الهندسية دورته الثانية
LICASE -2
2024 / 10 / 30-29

المجلة الدولية للعلوم والتقنية
ISTJ

تم استلام الورقة بتاريخ: 29/ 9/2024م
وتم نشرها على الموقع بتاريخ: 30/ 10/2024م

Machine learning methods for medium-term load forecasting

Study on the North Benghazi stations of the General Electricity Company in eastern Libya

http://www.doi.org/10.62341/licase2067

Hend M. Farkash
College of Electrical and Electronics Technology
Benghazi, Libya
Hend.mf_ceet@ceet.edu.ly

Mona A. El. Zuway
College of Electrical and Electronics Technology
Benghazi, Libya
mona.elzuway@ceet.edu.ly

Hana A. Mohammed
General Electricity Company of Libya (GECOL)
hana.abdulkarimgecol@gmail.com

Asma Agaal
Department of artificial intelligence, Faculty of Technical Sciences, Sebhau
asma.agaal@sebhau.edu.ly

Mansour Essgaer
Department of artificial intelligence, Faculty of Information Technology, Sebhau
man.essgaer@sebhau.edu.ly

Abstract

The General Electricity Company of Libya ***(GECOL)*** has experienced a surge in electricity demand in recent years, leading to power shortages, particularly during peak summer months. These shortages, often exacerbated by system outages caused by large generating unit failures or transmission line disruptions, have significantly impacted the country's stability. This is further compounded by the ongoing political instability in Libya, which, coupled with electricity supply issues, has negatively affected oil and gas production in some of the country's largest fields. This research addresses the challenge of electricity load demand forecasting by employing Machine Learning ***(ML)*** techniques, specifically focusing on Medium Term Load Forecasting ***(MTLF)*** based artificial intelligence algorithms. The study compares the accuracy and convergence of different ML methods against actual consumption data, aiming to identify the most effective approach. Accurate load forecasting is crucial for electrical utilities like *GECOL* to effectively meet customer demands and optimize power generation and transmission. Focusing on Benghazi, this research pioneers the application of Machine learning techniques to predict total energy consumption and demand. The study's findings are validated against real-world data obtained from GECOL's Benghazi Regional Control Center ***(BRCC)***, demonstrating the potential of ***ML*** for improving electricity load forecasting in Libya. The study concluded with the following results: The Extra Trees Regressor algorithm produced the best results for pregnancy as a target, with an accuracy value of 85%. The Huber Regressor algorithm produced the best results for deficit

International Science and Technology Journal
المجلة الدولية للعلوم والتقنية

عدد خاص بالمؤتمر الليبي الدولي للعلوم التطبيقية و الهندسية دورته الثانية
LICASE -2
2024 / 10 / 30-29

المجلة الدولية للعلوم والتقنية
ISTJ

تم استلام الورقة بتاريخ: 29/ 9/2024م
وتم نشرها على الموقع بتاريخ: 30/ 10/2024م

quantity as a target, with an accuracy value of 77%.
Keywords: GECOL, Machine Learning, Load Forecasting, Medium Term Load Forecasting, MTLF.

طرق التعلم الآلي للتنبؤ بالأحمال متوسطة المدى: دراسة على محطات شمال بنغازي التابعة للشركة العامة للكهرباء في شرق ليبيا

هند منصور فركاش
كلية التقنية الكهربائية والإلكترونية
بنغازي، ليبيا
Hend.mf_ceet@ceet.edu.ly

منى عبد الكريم الزوي
كلية التقنية الكهربائية والإلكترونية
بنغازي، ليبيا
mona.elzuway@ceet.edu.ly

هناء عبد الكريم محمد
الشركة العامة للكهرباء في ليبيا
hana.abdulkarimgecol@gmail.com

اسمه اعجال
قسم الذكاء الاصطناعي، كلية
العلوم التقنية، سبها
asma.agaal@sebhau.edu.ly

منصور علي الصغير
قسم الذكاء الاصطناعي، كلية تقنية
المعلومات، سبها
man.essgaer@sebhau.edu.ly

الملخص

شهدت الشركة العامة للكهرباء الليبية (GECOL) طفرة في الطلب على الكهرباء في السنوات الأخيرة، مما أدى إلى نقص الطاقة، خاصة خلال أشهر الصيف. وقد أثر هذا النقص، الذي غالبًا ما يتفاقم بسبب انقطاع النظام بسبب فشل وحدات توليد كبيرة أو تعطل خطوط النقل، بشكل كبير على استقرار البلاد. ومما يزيد من تفاقم هذا الوضع عدم الاستقرار السياسي المستمر في ليبيا، والذي، إلى جانب مشاكل إمدادات الكهرباء، أثر سلبًا على إنتاج النفط والغاز في بعض أكبر الحقول في البلاد. يتناول هذا البحث التحدي المتمثل في التنبؤ بالطلب على الأحمال الكهربائية من خلال استخدام تقنيات التعلم الآلي (*ML*)، مع التركيز بشكل خاص على التنبؤ بالأحمال متوسطة المدى (*MTLF*) باستخدام خوارزميات الذكاء الاصطناعي. تقارن الدراسة دقة وتقارب طرق تعلم الآلة المختلفة مع بيانات الاستهلاك الفعلي، بهدف تحديد النهج الأكثر فعالية. يعد التنبؤ الدقيق بالأحمال أمرًا بالغ الأهمية للمرافق الكهربائية مثل GECOL لتلبية متطلبات العملاء بشكل فعال وتحسين توليد الطاقة ونقلها. بالتركيز على بنغازي، يعد هذا البحث رائدًا في تطبيق **تقنيات التعلم الالي للتنبؤ** بإجمالي استهلاك الطاقة والطلب عليها. تم التحقق من صحة نتائج الدراسة مقارنة ببيانات العالم الحقيقي التي تم الحصول عليها من مركز التحكم الوطني التابع للشركة العامة للكهرباء، مما يدل على إمكانات التعلم الآلي لتحسين التنبؤ بأحمال الكهرباء في ليبيا.

International Science and Technology Journal
المجلة الدولية للعلوم والتقنية

عدد خاص بالمؤتمر الليبي الدولي للعلوم التطبيقية و الهندسية دورته الثانية
LICASE -2
2024 / 10 / 30-29

المجلة الدولية للعلوم والتقنية
ISTJ

تم استلام الورقة بتاريخ: 29/ 9/2024م وتم نشرها على الموقع بتاريخ: 30/ 10/2024م

الكلمات المفتاحية: GECOL، التعلم الآلي، التنبؤ بالأحمال الكهربائية، التنبؤ بالحمل متوسط المدى، MTLF.

I. INTRODUCTION

Electricity, a cornerstone of modern society and a critical driver of economic growth, requires meticulous planning and management to ensure reliable supply. Load forecasting, the practice of predicting future electricity demand, plays a vital role in the design, planning, and operation of robust and efficient power grids. In Libya, the General Electricity Company of Libya ***(GECOL)*** faces significant challenges in meeting the nation's growing energy needs. The current infrastructure suffers from insufficient generation capacity, resulting in a persistent electricity deficit, particularly during peak seasons. This deficit manifests as frequent and prolonged outages across various regions, impacting daily life and hindering economic activities. These challenges are further compounded by system instability due to large generating unit failures, transmission line disruptions, and the ongoing political climate, which has negatively impacted oil and gas production – key sectors for the Libyan economy.

The residential sector constitutes a major consumer group, accounting for 32.3% of Libya's total electricity consumption in 2004 [12]. With projected population, growth driving an anticipated 80% increase in residential demand, accurate energy consumption forecasting becomes crucial for optimizing resource allocation and ensuring reliable electricity supply.

The electricity crisis in Libya transcends mere inconvenience, impacting critical services such as banking, government offices, businesses, and educational institutions. Despite backup power solutions, shortages in diesel fuel often render these inadequate, further exacerbating the challenges faced by citizens.

Nowadays, the problem of power outages is serious, especially in critical places such as hospitals, sewage treatment plants, and mines, in addition to its great impact on government institutions and the systems operating in them, which may result in large financial losses; In particular, the problem of power outages and varying load rates affect the work Electricity stations and their long-term level of performance, which leads to their complete failure. This requires conducting several studies to develop and repair electrical systems and deal with the current situation and current problems, and this is what study was addressed by using artificial intelligence techniques to reduce these problems. The scope of the research is simple power system network of General Electricity Company in Libya illustrated as shown in Figure 1.

International Science and Technology Journal
المجلة الدولية للعلوم والتقنية
عدد خاص بالمؤتمر الليبي الدولي للعلوم التطبيقية و الهندسية دورته الثانية
LICASE -2
2024 / 10 / 30-29
المجلة الدولية للعلوم والتقنية
ISTJ
تم استلام الورقة بتاريخ: 29/ 9/2024م
وتم نشرها على الموقع بتاريخ: 30/ 10/2024م

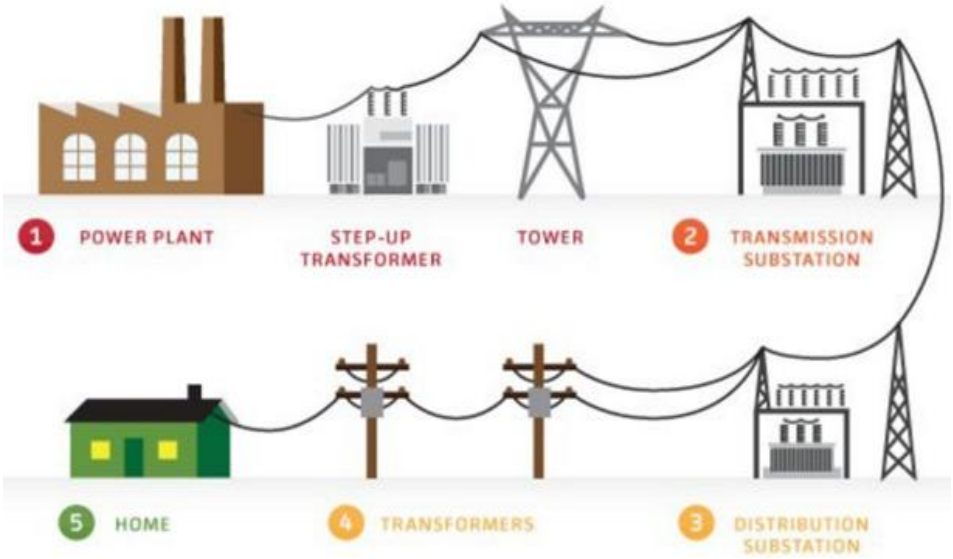

Figure 1. Scope of Research [10]

One of the main reasons for developing models to predict electrical load in medium and long term is to ensure the security of supply; It is important to have insight into how the projected demand will grow. In this sense, predicting load is vital for our society, as it ensures the proper functioning of the supply in the long run.

- **The general population of Libya:** who should be aware of the impact of energy consumption behavior on energy issues and those who have the right to a stable and affordable energy supply.
- **Energy consumption:** Libya has a typical example of the consumption of several provinces in the Middle East. For sustainable energy production and export, it is important to solve the problem of local consumption.
- **Domestic Consumption :** Reducing domestic consumption can save energy and carbon.
- **General energy control:** Effects of energy consumption behavior on general energy control.

A major problem facing the current electricity situation in Libya is that supply is still behind demand. Libya is experiencing unscheduled and scheduled power outages. Outages are most common in peak demand periods in summer, when demand for electric cooling is highest. This situation became critical after the Libyan revolution in 2011, during which energy infrastructure, including power plants and transmission lines, were damaged and destroyed [13]. Moreover, the population is growing, and new development projects including houses, building complexes, industries, and agricultural projects are currently being undertaken making the need to increase the energy production capacity, while that the current capacity of the installed power plants is insufficient to meet the demands of the Libyan society.

تم استلام الورقة بتاريخ: 29/ 9/2024م وتم نشرها على الموقع بتاريخ: 30/ 10/2024م

This research leverages advancements in artificial intelligence, specifically machine learning, to address the pressing need for accurate electricity load forecasting. By employing machine learning algorithms, this study aims to improve load prediction accuracy, optimize power system operation, and ultimately contribute towards alleviating Libya's energy challenges.

II. LITERATURE REVIEW

Since machine learning has undergone a revolution and a number of tools and applications, such as PyCaret, have emerged, this study explores the efficacy of progressive regression algorithms in the field. This section contrasts the methods and models employed in the current study with those that were derived from earlier research and focuses on those ideas [9].

The first study was in 2014, where Ahmed Al-Kilani from Sebha collected data from 40 power plants in the south, and the data was for the years 2009 and 2010, where he used machine learning methods with the k mean algorithm [1].

The next study was in 2018, where Mahmoud Khmeira collected data for 2016 to predict a short pregnancy, where he used the statistical methods that he applied on Matlab using a multiparameter regression method to predict by week [2].

In 2018, the same researcher made another prediction, but it was a long-term prediction, as he collected data between 2000 and 2017 in order to be able to predict the next seven years. In this work, he used simple regression [3].

In the year 2021, Ali Al-Arabi and others worked on predicting the loads, but the work was divided into two parts: he first used the CREST tool, where this tool generated dummy data, which is the one that was covered in this study, where the data was for five houses, and each house contained 30 devices All of them were connected to the network and home monitoring in that if any device consumed a higher load, it would be lowered by the network [4].

Finally in 2023, hend farkash and others worked on deep learning is used for the first time to forecast overall energy demand and consumption in Benghazi. The real data acquired by the Benghazi Regional Control Center ***(BRCC)*** of GECOL supports the results that were achieved. The goal of this study is to develop an ANN-based model that can forecast peak loads spanning days and hours. Applying The NARX Model to Forecasting Data by the Bayesian algorithm utilized in this study for daily and hourly prediction. The time series of electrical loads has a non-linear and periodic behavior. After several experiments with data and daily hours, it became clear that the most accurate results for forecasting electrical loads are obtained [16].

This study was distinguished in that it examined many progressive regression algorithms in the field of machine learning and extracted the best information from them by looking at the results of previous studies and comparing them with the methodology used in the current study.

International Science and Technology Journal
المجلة الدولية للعلوم والتقنية
عدد خاص بالمؤتمر الليبي الدولي للعلوم التطبيقية و الهندسية دورته الثانية
LICASE -2
2024 / 10 / 30-29
المجلة الدولية للعلوم والتقنية ISTJ
تم استلام الورقة بتاريخ: 29/ 9/2024م
وتم نشرها على الموقع بتاريخ: 30/ 10/2024م

III. METHODOLOGY

The rapid development of artificial intelligence, especially machine learning techniques, offers promising alternatives to traditional data-driven approaches, while providing exceptional ability to deal with complex nonlinear relationships.

In this study, a model was designed that inputs data from a specific power station to be trained on the proposed platform PyCaret, which is open source package that contains a large number of classifiers and regressors, to quickly select the best performing algorithms, using data analyzes received from the station to predict loads. Therefore, machine learning techniques will be better compared to traditional methods in terms of saving time and effort and the accuracy of expected results, the following Figure 2. Shows the PyCaret steps used in this paper.

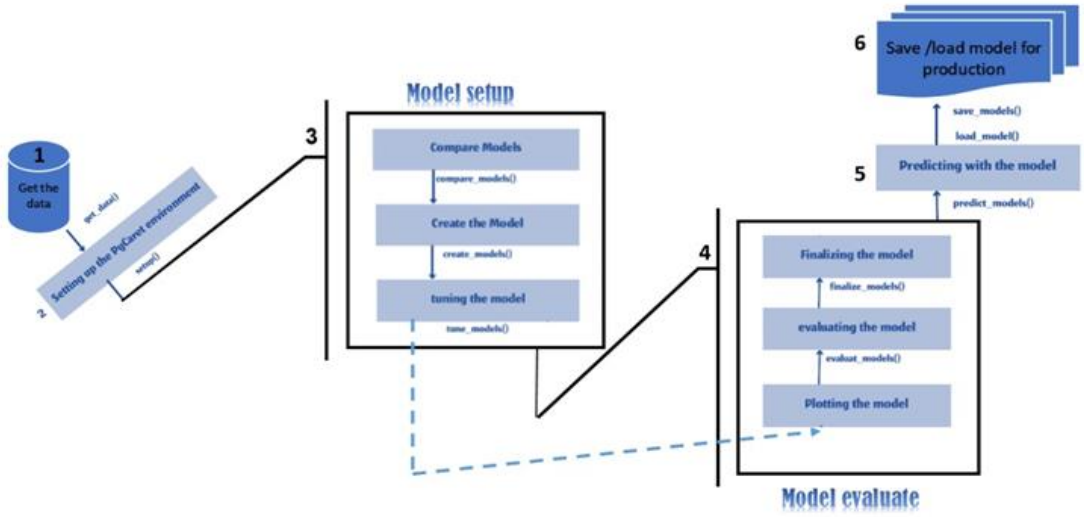

Figure 2. PyCaret Steps

- **Data Acquisition:**

The data was collected from Benghazi Regional Control Center (***BRCC)*** of GECOL, which represents the actual data for the month of May in three years. It is a daily time series representing the daily network loads.

- **Dataset Description:** The dataset features and description are listed in Table 1, which comprises 11 features.

The main objective of this research is to forecast medium-term electricity demand for the city of Benghazi. The objectives of the project are: Design a deep learning model using artificial neural networks to predict the expected electrical load of a given power station based on data of a certain period, all using artificial intelligence techniques. Study of the methods used in the design of the proposed model in relation to the software components and hardware components of the system. Reducing errors in predicting expected pregnancy by providing an artificial neural network model

that provides highly accurate results. In addition, comparison of the results of the new system with the traditional results of the station.

TABLE 1. Dataset Characteristics

Feature	description
Real loads	**Daily real loads**
Evening load	**Daily loads in the evening period**
Amount of deficit	**The amount of deficit in the electrical network**
Saloam	**Saloam connection lines**
Day	**Day**
Temperature	**Temperature**
Humidity	**Humidity**
Peak load	**Peak time load**
Ser220	**connection lines220 in the city of Sirte**
Ser400	**connection lines400 in the city of Sirte**
Max load	**the Maximum load**

Data were collected from Benghazi Regional Control Center ***(BRCC)*** of GECOL to predict the medium term, because the amount of load in all Benghazi stations is frequent without identifying a specific area the area that consumed the most load will not be identified, which led to a deficit.

Load forecasting is one of the most important applications in the field of forecasting, as it helps in giving an accurate result that helps in solving the problem of expected loads and calculating energy consumption rates, which in turn contributes to reducing the electricity problem, maintaining network stability, and helping power plants to make decisions related to power and load. It also helps control voltage, reconfigure the network and improve revenue.

IV.RESULTS AND DISCUSSION

The experiments were conducted by designing a machine learning model using the Pycaret platform. and the algorithms are as follows in Table 2.

The data was analysis, experiments were conducted on it in two cases: The first case considering the target is the loads, The second case considering the target is the amount of the deficit. Several regression models were used to evaluate the algorithm and determine the lowest error rate and best performance,

– The best results for load target is algorithmic *Extra Trees Regressor* where the accuracy R^2 value was 85%, where R-squared shows how well the data fit the regression model.

– The best results for amount of deficit target is algorithmic *Huber Regressor* where the accuracy R^2 value was 77%.

The following results were obtained during the evaluate model stage, which represents the learning level of the regression algorithm:

TABLE 2. Pycaret Algorithms

Models		Models	
huber	**Huber Regressor**	**rf**	**Random Forest Regressor**
br	**Bayesian Ridge**	**omp**	**Orthogonal Matching Pursuit**
et	**Extra Trees Regressor**	**gbr**	**Gradient Boosting Regressor**
en	**Elastic Net**	**ada**	**AdaBoost Regressor**
lasso	**Lasso Regression**	**lightgbm**	**Light Gradient Boosting Machine**
ridge	**Ridge Regression**	**dt**	**Decision Tree Regressor**
lr	**Linear Regression**	**par**	**Passive Aggressive Regressor**
llar	**Lasso Least Angle Regression**	**dummy**	**Dummy Regressor**
knn	**K Neighbors Regressor**	**lar**	**Least Angle Regression**

Features selection and Feature importance

To determine the appropriate features for the model used, one of the common methods was used to select features based on their importance to the model used which is *(RFECV)*Recursive feature elimination with cross-validation to select features is a feature selection method that fits a model and removes the weakest features until the specified number of features is reached [17].

- The best selection of features for load target are Real loads, Evening load, Morning load, Amount of deficit, Minimum load, and Saloam connection lines.
- The best selection of features for amount of deficit target are Real loads, Evening load, Amount of deficit, Saloam connection lines, Day, Temperature, Humidity, Peak load, Ser220, Ser400 and Max load.
  Select features and features importance show in the following Figures (3) (4) (5) (6).

International Science and Technology Journal
المجلة الدولية للعلوم والتقنية
عدد خاص بالمؤتمر الليبي الدولي للعلوم التطبيقية و الهندسية دورته الثانية
LICASE -2
2024 / 10 / 30-29
المجلة الدولية للعلوم والتقنية
ISTJ
تم استلام الورقة بتاريخ: 29/ 9/2024م
وتم نشرها على الموقع بتاريخ: 30/ 10/2024م

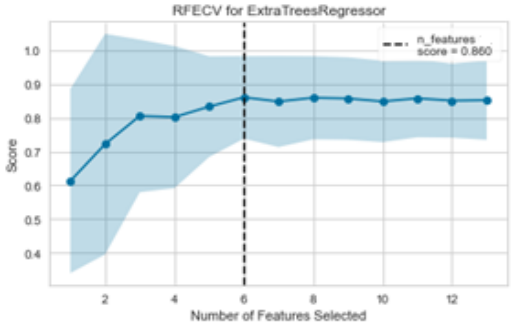

Figure 3. Select features (Where load is the target)

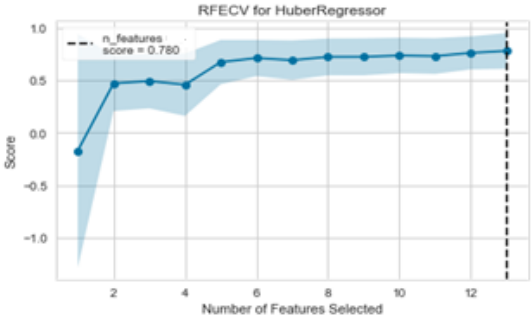

Figure 4. Select features (Where Amount of deficit is the target)

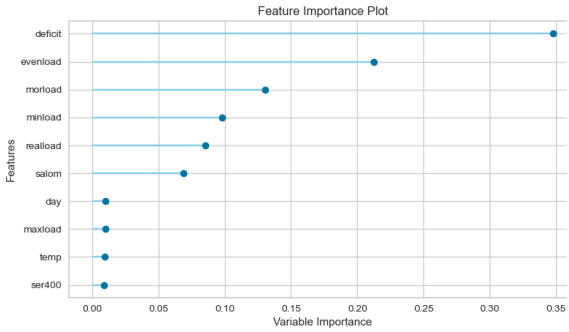

Figure 5. features importance (Where load is the target)

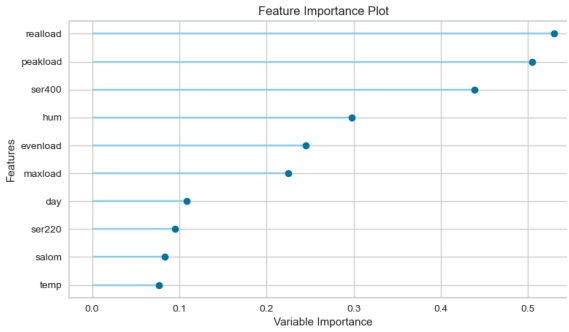

Figure 6. features importance (Where Amount of deficit is the target)

1. Learning curve

Learning curves are plots used to display the level of learning and show the performance of the model. In this study, the learning curve was as show in the following Figures (7) (8).

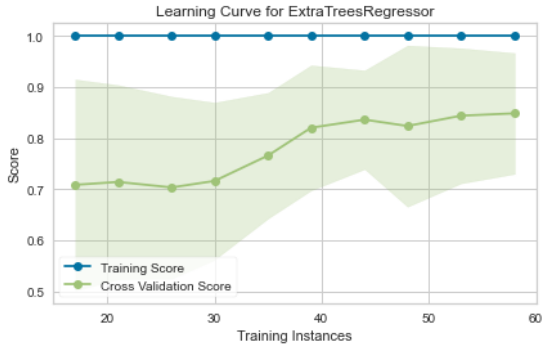

Figure 7. Learning curve (Where load is the target)

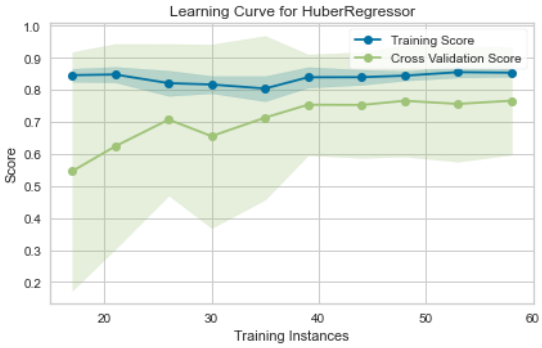

Figure 8. Learning curve (Where Amount of deficit is the target)

Finally, the model was tested for prediction using a new set of data(May 2023) in both cases, while the accuracy percentage in the case of the output is the loads was (41.19 %), while in the case of the output is the amount of deficit, the percentage was (-49.11 %) , It is noted that the accuracy rate was a negative value, and it is likely that the reason for this is due to the model not being appropriate to the data, as most of the deficit values for the year 2023 were equal to zero, the following Tables (3) (4)show the results.

TABLE 3. Predict model (target load)

Model	MAE	MSE	RMSE	R2	RMSLE	MAPE
Extra Trees Regressor	71.3735	9602.3594	97.9916	41.19	0.0817	0.0595

TABLE 4. Predict model (target Amount of deficit)

Model	MAE	MSE	RMSE	R2	RMSLE	MAPE
Huber Regressor	36.8542	2503.3607	50.0336	-49.11	3.3492	0.4410

V. CONCLUSIONS

In this paper, worked on real daily data for Benghazi Regional Control Center ***(BRCC)*** of GECOL, where several experiments were conducted and compared to approximately 18 algorithms representing different machine learning techniques. The results showed that both Huber Regressor and Extra Trees Regressor algorithms outperformed in the evaluation results, Where the percentages of these techniques were as follows: The best results for load as target is Extra Trees Regressor algorithm where the accuracy value was 85%, The best results for amount of deficit as target is Huber Regressor algorithm where the accuracy value was 77%.

After the model was tested to perform the prediction process with new data, the results were as follows :the accuracy percentage in the case of the output is the loads was (41.19 %), while in the case of the output is the amount of deficit, the percentage was (-49.11 %)

In view of the importance of this study and the results it reached, the authors recommend several future studies, including the possibility of publishing the model on one of the famous platforms so that it is accessible to users, expanding the scope of the data used for several years and different months during the year and comparing the results.

Reference

[1] Alkilany, A., et al. Application of the k-means clustering algorithm to predict load shedding of the southern electrical grid of Libya. in Fourth edition of the International Conference on the Innovative Computing Technology (INTECH 2014). 2014. IEEE.

[2] Khamaira, M.Y., et al., Modeling and Forecasting Short-Term Electricity Demand for Libyan Electric Network. 2018.
[3] Khamaira, M., A. Krzma, and A. Alnass, Long term peak load forecasting for the libyan network. 2018.
[4] Alarbi, Ali A A; Blanchard, Richard; Strickland, Dani. Communication 9: Minimising the Electricity Interruptions Using Artificial Intelligence and Demand Side Management Approach to Achieve SDGs, De Montfort University. Conference contribution.2021 https://doi.org/10.21253/DMU.14179904.v1.
[5] . Negnevitsky, M., Artificial intelligence: a guide to intelligent systems. 2005: Pearson education.
[6] Introduction to artificial intelligence. Available from: https://www.edraak.org/programs/course-v1:Edraak+ARIN+T3_2018/.
[7] Madsen, H., Time series analysis. 2007: Chapman and Hall/CRC.
[8] [8].J.Nashat,T.Hadi, "Building a load forecasting system in Baghdad",v:1/9,Journal ,2017
[9] .https://www.python.org. Accessed :31/1/2024.
[10] M.A. Shoeb “Integration of Wind Power into Electricity Markets”, Master thesis, Eindhoven University of Technology, EES.13.A0002, 2013.
[11] https://www.e-education.psu.edu/eme810/node/592. Accessed:14/3/2024.
[12] Saleh, S.H., 2014. Forecasting of the electricity demand in Libya using time series stochastic method for long-term from 2011-2022 (Doctoral dissertation, UNS (Sebelas Maret University)).
[13] Sayah, G.A., 2017. The Use of Renewable Energy Technologies in the Libyan Energy System. Case Study: Brak City Region. Technische Universitaet Berlin (Germany).
[14] Khamaira, M., A. Krzma, and A. Alnass, Long term peak load forecasting for the libyan network. 2018.
[15] He, W., Load forecasting via deep neural networks. Procedia Computer Science, 2017. 122: p. 308-314.
[16] Farkash, H., M. Sahly, E., A. El-werfalli, A., A. El-agori, R., Medium-Term Load Forecasting for The City of Benghazi Using an Artificial Neural Network Based Time Series Approach, IEEE, 2023.
[17]https://www.scikit-yb.org/en/latest/api/model_selection/rfecv.html, Accessed:1/4/2024