SCHOOL OF COMPUTING
Faculty of Engineering

Project Proposal Form MCSD 6215
Sem:…1… Session:…24/25…

SECTION A: Project Information.

Program Name:	**Masters of Science (Data Science)**
Subject Name:	**Project 1 (MCSD 6215)**
Student Name:	OSAMA GAMAL MAHMOUD IBRAHIM MOTIR
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Project Title:	Multivariate Time Series Analysis of Solar Irradiance for Photovoltaic Systems: The Hybridization of NARX and LSTM Models
Supervisor 1:	
Supervisor 2 / Industry Advisor(if any):	

SECTION B: Project Proposal

Introduction:

Problem Background:

The shift to renewable energy is a worldwide movement in the twenty-first century. Solar energy is driving this change because of its huge resource potential. Photovoltaic (PV) energy offers significant availability and extended longevity to stakeholders. As well as there are many technologies that had been developed in field of solar energy in terms of improving the power efficiency (PV cell) also the development reach to the storge system where it can help in improving the isolated system and the hybrid system. However, photovoltaic energy exhibits several constraints about inadequate power stability and subpar power quality. Photovoltaic plants are consistently affected by meteorological factors like cloud cover, wind velocity, and temperature fluctuations. Moreover, the primary impetus for energy production, namely irradiation, is only accessible during daylight hours. Consequently, forecasting models have been extensively used for photovoltaic systems to predict produced photovoltaic power on one hand and load demand on the other, so facilitating intelligent demand response and efficient energy management.

There are a number of limitations associated with photovoltaic energy, including poor power stability and substandard power quality characteristics. Meteorological elements such as cloud cover, wind velocity, and temperature changes are known to have a consistent impact on photovoltaic plants. Additionally, the fundamental incentive for energy generation, which is irradiation, is only available during the hours of daylight. For this reason, forecasting models have been used widely for solar systems. These models have been utilized to estimate the amount of photovoltaic power that is generated on the one hand, and load demand on the other hand. This has enabled intelligent demand response and effective energy management. However, models typically provide challenges when it comes to coping with the basic unpredictability of meteorological conditions. Extreme weather occurrences, such as cloud cover and storms, have the ability to significantly reduce the quantity of solar radiation, which makes it difficult to make accurate and consistent predictions.

The research on solar irradiance forecasting has gained significant attention, driven by the growing demand for renewable and environmentally friendly energy sources. Hence, the accurate prediction of solar irradiance is crucial for enhancing the effectiveness and reliability of solar power systems, and numerous techniques have been developed to meet this requirement. Statistical techniques like autoregressive integrated moving average (ARIMA) use past data to forecast future levels of irradiance, providing accurate predictions for short-term forecasts. Numerical weather prediction (NWP) models, which employ the principles of atmospheric physics to make accurate predictions, are well-suited for forecasting weather patterns over a time frame ranging from medium-term, particularly in regions with complex weather patterns. Additionally, support vector machines (SVMs), artificial neural networks (ANNs), and random forests (RFs) are machine learning approaches that have become popular because of their capacity to handle nonlinear relationships and adjust to various geographical situations. They have proven to be useful in both short-term and intra-day forecasting. Furthermore, recent studies have developed hybrid models that combine different forecasting techniques to take advantage of their strengths and minimize their weaknesses, resulting in improved accuracy and reliability of forecasts.

Problem Statement:

The total capacity of renewable energy sources around the globe reached 3,381 gigawatts in the year 2023. With a capacity of 1053 gigawatts (GW), solar energy has emerged as the second most widely adopted of these renewable sources for energy production. Malaysia is positioned as top four nations in Southeast Asia in terms of its significant solar energy capacity. In the present moment, renewable energy sources provide 13.3% of Malaysia's overall energy capacity, it is anticipated that Malaysia would attain 18.2% of its capacity to generate electricity from renewable sources by 2025, and 70% by 2050. Consequently, the amount of integration of the renewable energy with the main grid will increase exponentially which will increase the complexity in terms of gird management, and stability within the gird due to the difficulty in renewable energy forecasting. Therefore, to achieve the integration with RE, an accurate and strong forecasting model is require to predict the solar energy.

Aim of the Project:

The aim of the project is to present a hybrid Nonlinear Autoregressive Network with Exogenous Inputs Long Short-Term Memory (NARX-LSTM) model to meet the growing need for precise daily solar irradiance predictions, especially under volatile weather conditions in Malaysia.

Objectives of the Project:

1. To develop a hybrid machine learning model combining LSTM and NARX neural networks
2. To analyze the influence of various weather parameters, determining their individual and collective impact on the forecasting model's performance.
3. To develop a dashboard to display forecasts and analyze trends.

Scopes of the Project:

1. Python will be used as the main tool to develop and analyze the model evaluation.

2. The model performance will be evaluated by using historical weather data that had collected from Johor, Malaysia environments.

3. The project will focus on constructing a hybrid model that combines the strengths of Nonlinear Autoregressive with Exogenous Inputs (NARX) and Long Short-Term Memory (LSTM) networks to forecast solar irradiance.

4. The model will integrate various weather parameters which are Air Temperature, Cloud Attenuation, Precipitation Rate, Dewpoint Temperature, Surface Pressure, Precipitable Water, Relative Humidity, Wind Speed, Wind Direction

Expected Contribution of the Project:

1. Development of a Hybrid Forecasting Model

2. Enhanced Understanding of Weather Impacts

3. Improved Grid Management and Renewable Energy Integration

4. Advancement in Renewable Energy Forecasting Research

5. Environmental and Economic Benefits

Project Requirements:

Software: Libraries and Frameworks (Python), Data Collection and Processing (APIs, SQLite), Dashboard Development (Power Bi)

Hardware: Laptop

Technology/Technique/ Methodology/Algorithm: Data Collection and Preprocessing, AI Models, Evaluation Metrics (RMSE, MAE, R^2)

Visualization Techniques for presenting forecasts

Type of Project (Focusing on Data Science):

[/] Data Preparation and Modeling

[/] Data Analysis and Visualization

[ ] Business Intelligence and Analytics

[/] Machine Learning and Prediction

[/] Data Science Application in Business Domain

Status of Project:

[/] New

[ ] Continued

If continued, what is the previous title?

SECTION C: Declaration

I declare that this project is proposed by:

[/] Myself

[ ] Supervisor/Industry Advisor ( )

Student Name: .....

....

Signature **Date**

SECTION D: Supervisor Acknowledgement

The Supervisor(s) shall complete this section.

I/We agree to become the supervisor(s) for this student under aforesaid proposed title.

Name of Supervisor 1: .....

....

Signature **Date**

Name of Supervisor 2 (if any): .....

....

Signature **Date**

SECTION E: Evaluation Panel Approval

The Evaluator(s) shall complete this section.

Result:

[ ] FULL APPROVAL [ ] CONDITIONAL APPROVAL (Major)*

[ ] CONDITIONAL APPROVAL (Minor) [ ] FAIL*

***** Student has to submit new proposal form considering the evaluators' comments.

Comments:

Name of Evaluator 1:

Signature **Date**

Name of Evaluator 2:

Signature **Date**