SMART ENERGY HARVESTING AND SEVERE WEATHER ALERT SYSTEM

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Abstract

Life in the rural coastal communities in the Philippines depicts poverty. This poverty is due to the lack of direct energy access and frequent destruction of livelihood lead by severe weather such as storms and typhoons. To help these communities to become sustainable the researchers provided a solution to enable alternative energy access to these communities as well as severe weather early warning. This research implements a hybrid alternative energy harvesting system using an attachable solar and wind energy apparatus for community use;; farther--time early warning for severe weather through weather APIs with a real--time atmospheric analysis and prediction for a short--time early warning;; and a handheld lantern for fishermen that allows them to receive farther and short--time alerts. The system is integrated into The Things Network through LoraWAN™ which allows administrators to monitor the energy stored and weather conditions as well as communicating with the lanterns at a longer and more reliable network.

Keywords: Hybrid Alternative Energy, Offshore Wind Turbine, Optimizing Solar Panel, Severe Weather Alert, Time--Series Forecasting, Sustainable Engineering

1.0 INTRODUCTION

The Philippines is known to have 7,641 islands in its Economic Zone and has a coastline of 36,289 kilometers. The country enjoys a period of prosperity in terms of tourism which is highly contributed by the beach industries, even though with the temporary closure of Boracay Beach, there is still a steady influx of tourists coming in the country. Manila, Batangas, Puerto Princesa, Cebu and Dagupan, these are the most frequent destinations that any tourist would love to visit in the Philippines once in a while. The potential of the country lies not just with its plains for its agriculture but greatly on its coastlines, being the fifth longest coastline in the world. The Philippine coasts paved the way for better commerce before and during the colonization era which molded the modern day metropolitan areas such as Manila, Cebu and Cagayan de Oro are coastal cities. Although coastal communities enjoy prosperity in terms of trade and such as Batangas and Dagupan or tourism like Puerta Princessa and Cebu not all are urbanized, well--publicized nor self--sufficient. As per 2018 National Census around fifty--five percent of the populaton live in the rural areas of the country and most of which are coastal communities.

Rural coastal communities enjoy little to none of the priviliges of the urban coastal cities. Rural coastal communities have deficiencies in terms of basic needs such as food, electricity, clean water, proper medication, housing and financial security. The livelihood of rural coastal communities are coming from local fishing. Although around eighty per cent (80%) of the rural population has access to electricity and has proper housing they are posed with the biggest threat which is the Philippine weathers.

The Philippines is in the Pacific Ring of Fire, with this the country would face a number of typhoons, earthquakes and other meteorological disasters yearly and the country's vanguards to these natural disasters are the coastal communities. Even with increased commercial performance, urban coastal communities will still sustain damage from these natural calamities. But more damages will be afflicted to the rural communities as the structural integrity of the houses compared to urban communities are not as well--built and would take more time to rehabilitate since urban communities have more priority rather than those of rural communities.

Such rural communities have little to none communication means to for early warnings for an incoming typhoon and this might lead to the devastation of their homes, livelihood, power lines and water ways, and at the most, endangering the lives of the citizens.

The study covers a smart energy--harvesting system that can give early warning alerts through incoming storm prediction. Furthermore, the project includes a hybrid alternative energy harvesting system and severe weather alert system.

2.0 REVIEW OF LITERATURE

Weather Forecasting

Several of the state of the art for weather forecasting include development of numerical and statistical methods with Machine Learning specifically Artificial Neural Networks.

Collins and Tissot (2015) developeds several Artificial neural network model classifiers to generate predictions of thunderstorms within three 400--km2 domains to compare accuracy and performance. Results revealed improvement relative to ANN models from a previous study. Comparative results between the three sets of classifiers, NDFD, and MLR models for this study were integrated homogeneously, the best performers were a function of prediction hour, domain, and feature selection technique.

Krishna (2015) developed weather forecasting method using Data Mining and Forecasting Analysis. Weather data was considered with attributes comprising of wind pressure, humidity, Minimum and Maximum Temperature, Forecast and Type of Visakhapatnam city for a period of 97 days. The forecasting was carried out to evaluate, the weather condition for the next 15 days by enabling the ARIMA model prediction algorithm model to predict the forecasts.

Philippines' Department of Science and Technology developed an automated weather station (Espaldon, 2017a, 2017c, 2017b) (AWS) and crop forecasting entitled SARAI that would perform crop forecasts and planting calendars;; nutrient management support;; pest and diseases management;; water management protocols;; and early warning system for climate extremes. The project assesses the agricultural and meteorological measurements of the area including wind speed and direction, rainfall amount and intensity, pressure, relative humidity, temperature, solar radiation, sunshine duration, soil temperature, soil moisture for the benefit of rural agricultural areas.

Hybrid Alternative Energy Systems

The use of hybrid alternative energy systems are quite prevalent in modernized countries but they differ on the present resources and the geographic location. A. Fischer et al. discussed the feasibility of hybrid energy systems for coastal areas using Homer software noting that the details of the adaptation of Homer for description of current power plants and its inclusion in a PV wind biodiesel hybrid system already in operation (Fischer, Silva, Beluco, & Almeida, 2015). For coastal areas a hybrid wind--wave system was developed by Carlos P. that integrates an oscillating water column wave energy converter with an offshore wind turbine on a jacket – frame substructure. The main objective of this paper is to characterize the hydrodynamic response of the WEC sub--system of this hybrid energy converter (Perez-- Collazo & Iglesias, 2018).

Patented in 1988, US 4,779,006, a similar implementation was invented integrating solar energy and wind energy harvesting. It is a system for producing electrical energy including a stack shaped and positioned generally as the letter "J" and having an intake portion, an exhaust portion and a conveying portin there between together with a vacuum producing mechanism associated with the exhaust portion causing air to move through the stack whereby a generator responsive to the moving air generates electricity (4,779,006, 1988).

Nearest Prior Art
The system's nearest prior art a solar is US 20110049992 A1 (US 2011/0049992 A1, 2011) it pertains to an invention that can harvest and store solar, thermal, steam and wind energy and has a sensor system for monitoring weather conditions, monitoring and controlling the system, and communicating conditions of the system to a remote location.

The similarities of the invention to the current system that it harvests and stores solar and wind energy and it monitors weather conditions and displays it a remote station. The unique features of the current system to the invention is that the current systems includes a prediction system for long and short periods using two different methodologies one is making use of a commercial API and the other is analysis of weather parameters from the sensor system using a machine learning model as well as the utilization of an alert device that can alert users remotely off--shore as well as a remote monitoring station.

3.0 SYSTEM ARCHITECTURE

The current system architecture of the system comprises several subsystems such as the hybrid energy gathering module, weather forecast module and an offshore alert module.

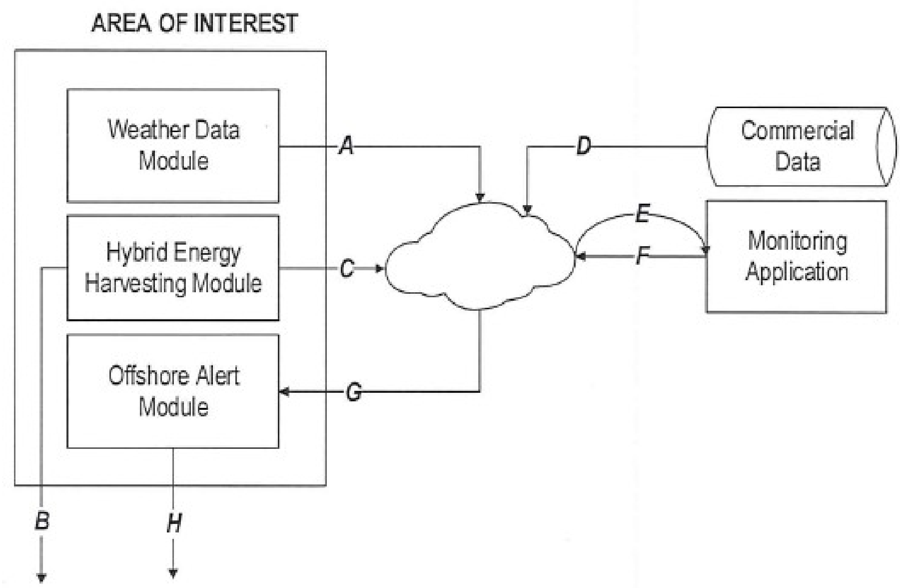

Figure 1: System Architecture

Figure 1 refers to the current system architecture. Several modules are deployed remotely at an Area of Interest such as coastlines or beaches. These modules comprise of a Weather Data Module which gathers information about the atmospheric parameters around the area denoted as A and is sent to the system network utilizing a LoRaWAN™ network. The system also has a hybrid energy harvesting module which gathers solar and wind energy from sun rays and wind respectively. The energy is then inverted for users to utilize (B). The readings of the energy are also sent to the network (C). The Monitoring displays the weather information and energy output at Areas of Interest. The weather information is also processed to determine the short--period weather alert for possible severe weather within 24 hours, commercial data on weather is also gathered by the application to determine long--period weather alerts for possible severe weather for 3 to 7 days of contact. If there is severe weather readings for short--period analysis this will produce a detection (F) and would send a flag (G) to the Offshore Alert module, this will prompt the said module to produce perceivable alerts (H).

Severe Weather Alert Module

The system's severe weather alert module comprises of a software program that has long--period severe weather alerts and short--period severe weather alerts.

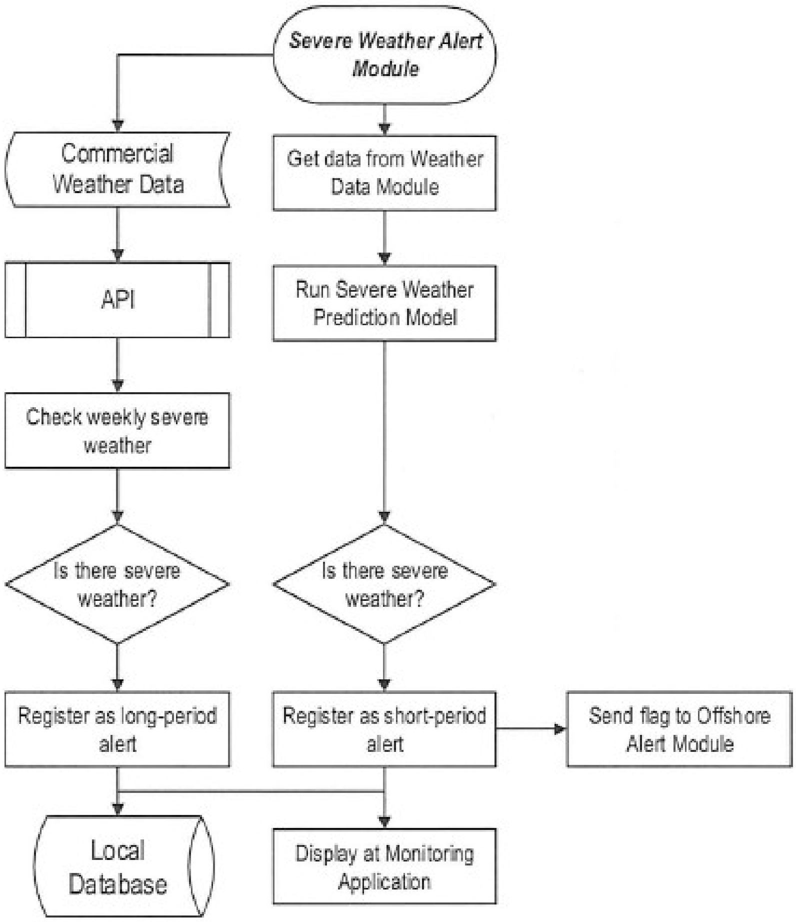

Figure 2: Severe Weather Alert Flowchart

Figure 2 refers to the severe weather alert program flow. Such that the program receives several weather parameters from the Area of Interest using barometric air pressure sensors, wind velocity sensors, humidity sensors, temperature sensors and lighting procimity sensors and will be used as input parameters for the prediction model and would produce a short--period severe weather prediction. The long--period prediction will be coming from the weather forecasts of the API that accesses the commercial weather database.

Hybrid Energy Harvesting Module

The hybrid energy harvesting module gathers, stores and makes alternative e nergy available to the users. It makes use of solar panels and wind turbines to gather alternative energy from the area of interest.

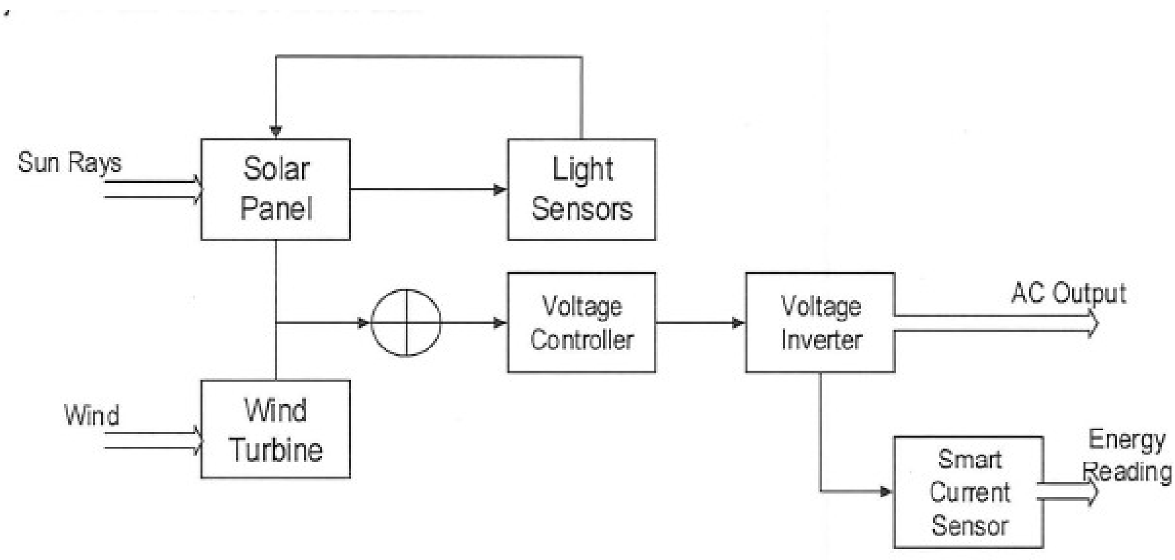

Figure 3: Hybrid Energy Harvesting Process Diagram

Figure 3 refers to the process of energy harvesting of the system. The module harnesses solar energy through solar panels which follow sun rays for optimized gathering using an assembly using light sensors and stepper motors. The energy outputs of the solar panel and wind turbine are combined at a voltage controller which is then passes through a voltage inverter to make the energy to users in the form of Alternating Current (AC) voltage. The readings of the combined energy output are read by the smart current sensor and sends it to the system network to be displayed at the monitoring application.

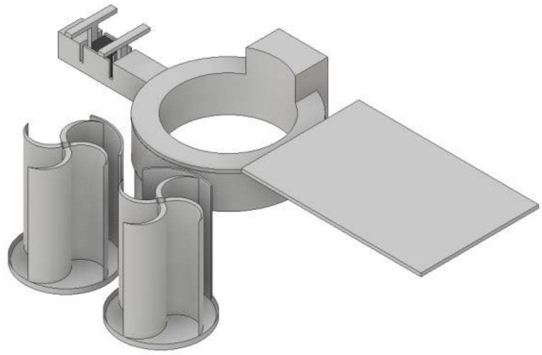

Figure 4: Energy Harvesting Device

Figure 4 shows the Energy Harvesting Device. The device includes pair of Vertical Axis Wind Turbines to harness wind energy and a pair of solar panel trays and armature to support and install the solar panels. The armature is connected to a stepper motor which actuates to position the tray to the direction of the sun rays.

Monitoring Application

The monitoring application of the system displays several information from the area of interest as well as displaying alerts regarding long and short period severe weather alerts. The monitoring application runs at terminal at a remote station or central station. The application connects to both the internet and the sensor network of the system. The application can also activate the off--shore alert devices via broadcasting an alert signal when there is a short--period severe weather alert.

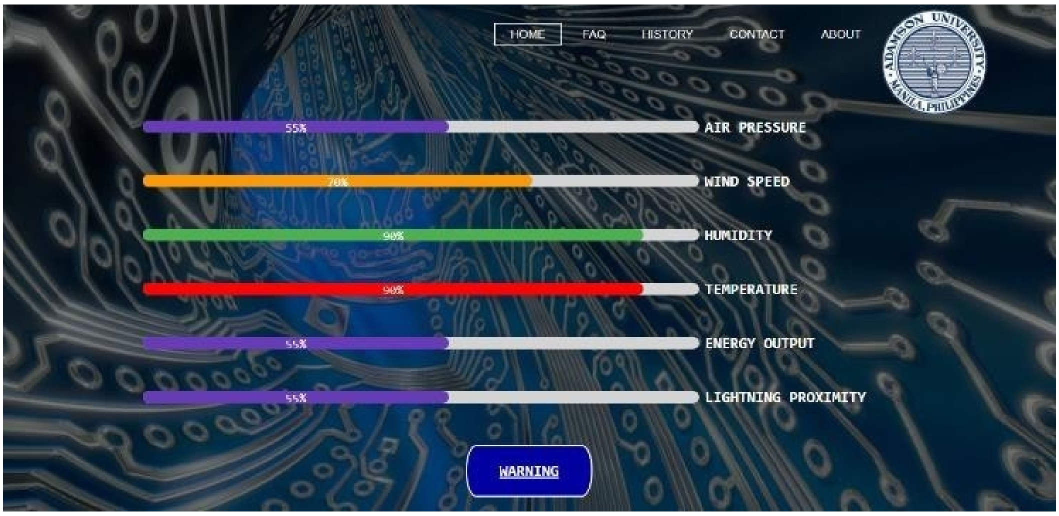

Figure 5: Monitoring Application Dashboard

Figure 5 refers to the dashboard of the monitoring application which displays the weather parameters collected by the sensors as well as the energy output of the devices deployed at the area of interest.

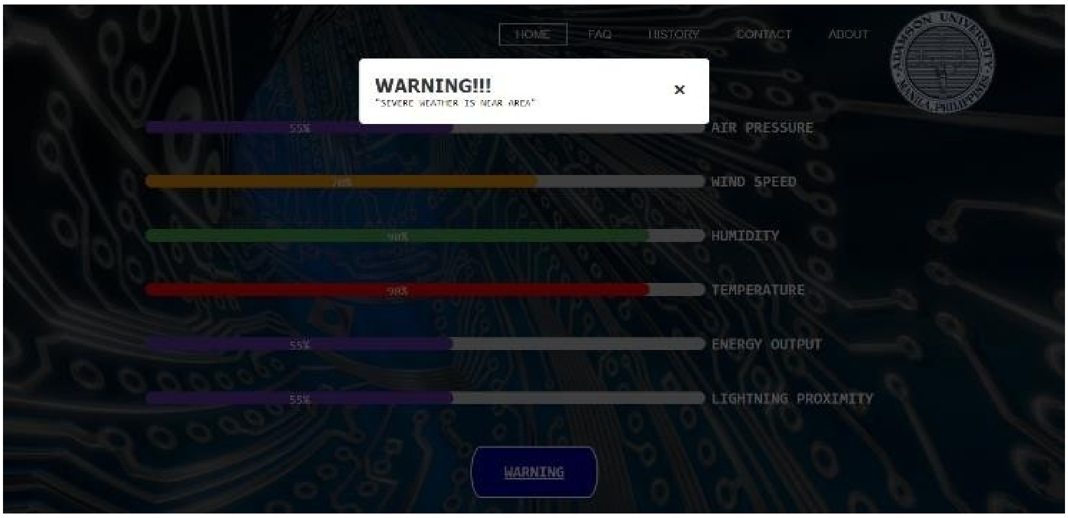

Figure 6: Monitoring Application Alert Screen

Figure 6 refers to the alert notification screen when there is a short--period and long period severe weather alert.

Alert Device

The alert device is deployed along with the user for off--shore remote activation. The device serves as a lamp for fishermen as well as a medium for perceivable alerts in the event of a short--period severe weather alert.

Figure 7: Alert Device

Figure 7 refers to the alert device that users will bring offshore. The device can act as a lamp as well as an alert device for short--period severe weather alerts.

4.0 CONCLUSION

The current system implements an alternative energy harvesting system specifically for solar and wind energy. It stores and converts the energy to AC voltage for consumption. The system also makes use monitoring application to display the energy readings and weather parameters at areas of interest. The monitoring application uses a commercial database, API and a machine learning model that enables the system to produce long-- period severe weather alerts from weather forecasts and short--period severe weather alerts form real--time weather parameter analytics. Lastly, the system also integrates an alert device for users that can be remotely activated offshore using the monitoring application. The system will be deployed at a coastal area in the province of Batangas in the Philippines.

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