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## An Economical Weather Monitoring System Based on GSM using Solar and Wind Energy

VAIJANATH V YERIGERI<sup>1</sup>, PRAMOD ARVIND KULKARNI<sup>2</sup>

**Abstract:** Renewable Energy is generally defined as energy that comes from resources which are naturally replenished on a human timescale such as sunlight, wind, rain, tides, waves and geothermal heat. Solar and wind Energy is a playing a key role in the 21st century as non-renewable sources are not much available to fulfill our energy needs. This is very important in a country like India, where supply to demand ratio is very limited. In this paper, we are interested to identify the geographical areas for solar and wind energy generations at a very low cost. It can be achieved by monitoring atmospheric Weather conditions such as temperature, humidity, wind speed and light intensity. This design is a remotely operated model with sensors, which gathers weather parameters information and transmits measured values to the control station. In our research, we have considered a number of options to device atmospheric weather monitoring system at low cost, long lasting and durable for extreme weather conditions. It is highly Sophisticated and deployable, and is very useful in developing country like India. This system can be easily installed at particular locations to continuously monitor changes in the climate.

**Keywords:** Study Of Weather Conditions At Low Cost, GSM-SMS Based Communications, Weather Monitoring Remotely, Wind Energy, Solar Energy And Renewable Energy Resource.

### I. INTRODUCTION

Weather monitoring model continuously monitors and records atmospheric conditions via sensors. Weather is determined by the basic factors, namely temperature, precipitation, humidity, cloudiness, visibility, pressure, and winds. Sun is the major contributor to the continuously changing climatic conditions. In our Solar System, energy from the sun creates so many imbalances in the temperature of flowing winds, which move from place to place creating wet, stormy or even sunny weather. The sea plays a major role in the regulating effect on the climate, due to which there is an enormous difference in the humidity, temperature and even pressure between the regions of the country and the also coastal regions. Weather is also affected by the natural dimensions of the earth and its rotator motion. The renewable energy (Wind and Solar) allows decentralized distribution of energy, particularly for meeting rural energy needs and empowering people at the grass root level. In

India, where alternative forms of energy are of the need of the hour, due to ever increasing pollution, industries and population, identifying places or locations which can generate renewable energy is very much important. The present existing model used by the Indian Meteorological Department [11] involves floating a weather monitoring device in a hydrogen balloon at every four hour intervals. This model is expensive and requires frequent manual efforts and is not practical for many places in India.

India has several geographical advantages for implementation of power plants based on renewable energy, such as solar and wind energy [13], [14], [15]. The Tropic of Cancer passes through Indian subcontinent, so the temperature factor is very much suitable to fit the needs of the generation of solar energy. Indian subcontinent is also close to the Equator which gives it a tropical climate and Monsoons [11], [12]. This type of climate is featured by strong and regular winds throughout the year across the country. In fact, temperature conditions are very good at certain states, like Gujarat, Madhya Pradesh, and Chhattisgarh. However, weather analysis in local regions are to be done for places within these states, to identify naturally cloudy or shadow regions, in which case the generated power output will be very low [11]. We propose a system, which can predict whether a particular place is suitable for establishing the solar power plant and/or wind power plant. We designed and implemented a low cost and reliable instrumentation system for remote wireless measurements of weather, with the help of various sensors. Our model is easily deployable by keeping it on top of a building, or being light in weight, it can be floated with a balloon. The device is made as a standalone data acquisition unit, from which data is sent via GSM based communication to the ground station. A number of power saving mechanisms are implemented to give maximum battery life for the sensor module.

Li Min et al. [1] introduced the system of embedded remote temperature measurement system within a building, which realized LAN by Wi-Fi connectivity. Data is read via a temperature sensor and stored in a shared file. This shared file is accessed via a single tasking HTTP server (which is embedded on Linux OS) stored on this remote sensing device and is then sent to the client via WiFi. Client may be a PC, a mobile device or any other device. Sankar et al. [2] uses an embedded system based on Atmega48

microcontroller for detecting humidity, temperature and pressure in the atmosphere for up to date weather monitoring. The observed values are communicated to the ground station via radio communication, which is limited by the short range of transmission. Wang Bao-qiang et al. [3] introduced an automatic meteorological data acquiring system based on embedded processor and implemented it in distributed control network. The microcontroller Mircea Popa et al. [4] presented a weather station made of temperature, humidity, luminosity and pressure sensors embedded in a microcontroller based board. Whenever the weather conditions are to be detected, a command is sent to the weather station in the form of an SMS, after which measured values are sent back to the mobile via SMS.

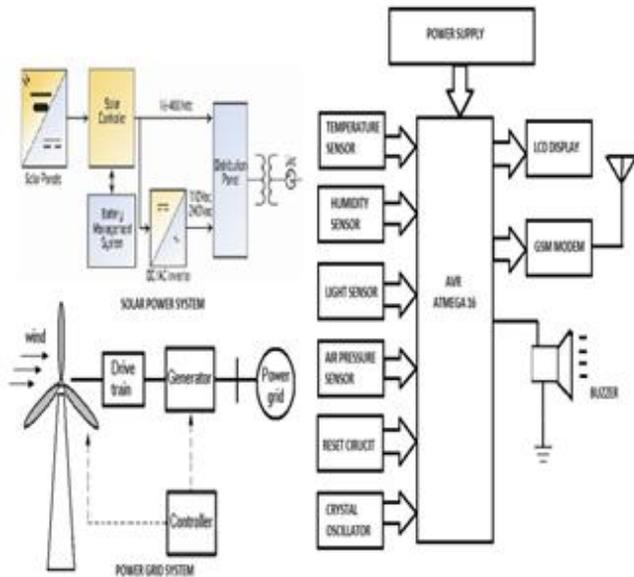


Fig.1. block diagram of our system.

TABLE I: The List of Components Used

COMPONENT NAME	COST(US \$)/WEIGHT (gm)
NTC THERMISTOR SENSOR	5.32 / 4
HSM 20G HUMIDITY SENSOR	5.5 / 10
TACHOMETER	1.3 / 10
8051 MICROCONTROLLER BOARD	4.1 / 50
ADC 0804	1.7 / 6
GSM DEVICE	12 / 9
PHOTO DIODE	0.1 / 1
IR LED	0.05 / 1
BATTERY	0.40 / 20
TOTAL	30.47 / 111

The major drawback of this system is that it is not easily deployable like our model. Another advantage of our system is that no command is sent through the client side, as our system autonomously decides when to send a data to ground station as shown in Fig.1. Darren Gould et al. [5] introduced modified approach towards condensation detection in a

system. This system uses humidity sensor, as well as remote and wirelessly powered temperature sensing system. The system is implemented using off-the-shelf components, and is designed separately around resonant tanks. It is costlier method and has no concerns about power consumption.

TABLE II: List of Components

COMPONENT NAME	SPECIFICATIONS
NTC THERMISTOR SENSOR	$\pm 0.5^{\circ}\text{C}$ or $\pm 1.5^{\circ}\text{C}$ of interchangeability tolerance, $1\text{mw}/^{\circ}\text{C}$ of dissipation constant, Thermal time constant of 1 second max.
HSM 20G HUMIDITY SENSOR	Input voltage range $\rightarrow$ DC $5.0 \pm 0.2\text{V}$ , Measurement accuracy $\rightarrow \pm 5\%$ RH
TACHOMETER	Input voltage range $\rightarrow$ DC $5.0 \pm 0.2\text{V}$
8051 MICROCONTROLLER BOARD	One Serial Port, 8 Interrupt Sources, 4K bytes On-Chip ROM, 256 bytes RAM, 2 Timers
ADC 0804	Eight channel multiplexer, 8-bit analog to digital (A/D) converter
GSM DEVICE	Adjustable serial baud rate (1200-115200) bps, 5 V D.C. supply
PHOTO DIODE	Response : 0.47 A/W (650

TABLE III: Specifications of Components of System

IR LED	nm ) Peak wavelength = 940nm, low forward voltage
BATTERY	+5V DC source, AA type

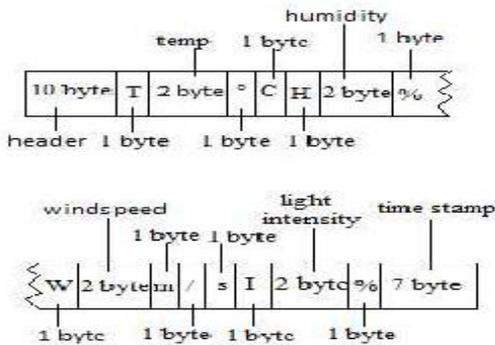
#### IV. IMPLEMENTATION

Our model mainly focuses on the following aspects: To Save maximum as much as possible to extend battery life, Send an SMS only when it is required (only when there is a significant change in the atmosphere parametric conditions), And, sample the data at regular intervals and send the averaged data from samples. Unlike mobile phones, a GSM modem doesn't have a keypad and display to interact with. It just accepts certain commands through a serial interface and acknowledges for those. These commands are called as AT commands. There are a list of AT commands to instruct the modem to perform its functions. Every command starts with "AT". That's why they are called as AT commands. AT stands for attention. As our system is aimed only on the feasibility study for solar power plant and wind energy generation, the system is tuned only for this function, and not as a general tool for weather monitoring. The sampling of sensor data happens only after every 30 second intervals. Between these periods, the system sleeps to save power. If any significant change is noticed by the system in any one of the readings, an SMS message is framed from all sensor data, and is transmitted to ground station via the GSM communication module.

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The structure of the SMS format is shown in fig.2. TP-data coding scheme defined in GSM 03.38 protocol is used for making SMS packet [8]. In this protocol the timestamp is divided as year, month, day, hour, minute, second and time zone, and each one of these take a byte in size (total 7 bytes). Values of temperature, humidity, light intensity and wind speed are considered as integers and each takes 2 bytes (total 8 bytes). The total SMS size, with other required fields, is only 36 bytes, as shown in fig.2. The microcontroller sends serial data to the GSM module. The GSM configures the SIM card present inside it via AT commands as shown in fig.3. These are short text strings which combine to give operational commands such as dialing, sending of data and ending of connection. For instance a command such as AT+CMGW sends a single SMS message [9]. Format is of the following form:-

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AT+CMGW="phone number"\n
> Type your message here.\z
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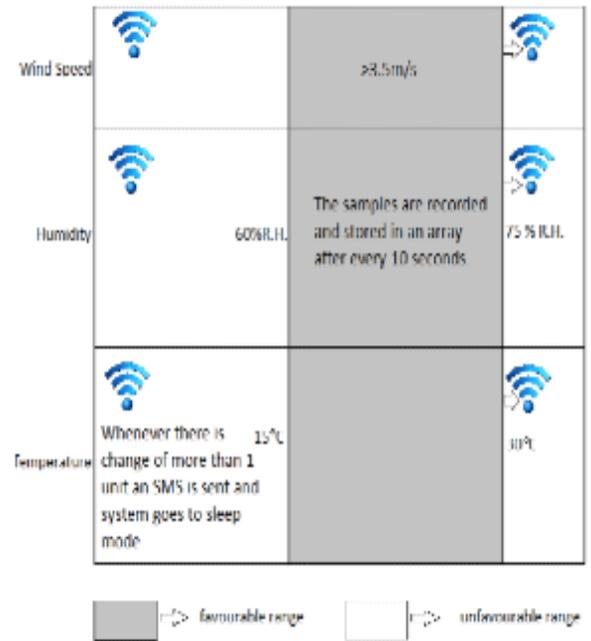


**Fig.2. GSM-SMS Format.**

**Phase 1:** In this phase the microcontroller samples and computes the reading of temperature, light intensity, humidity and wind speed. For this phase our area of concern is the favorable values (refer Tables 2, 3 and 4 for favorable ranges). If the conditions that system detects through monitoring are found out to be in the mentioned range, . This procedure continues till the monitored values don't exit the favorable range.

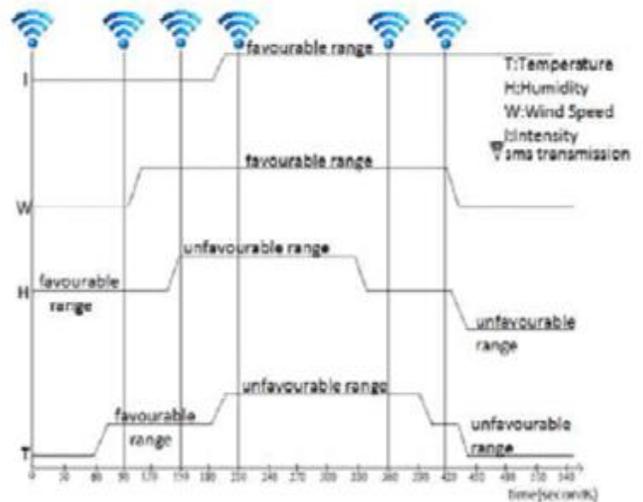
**Phase 2:** This phase is defined exclusively for sending SMS. The system has no fixed duration after which it must send an SMS. When the values are between the favorable ranges, values are input inside the array after interval of 10 seconds and if and when it goes in the unfavorable range,

the average of the values present inside the array is calculated and an SMS is sent to the ground station. Just after an SMS is sent, the system goes off to 'sleep mode' for 30 seconds whether or not a considerable change is still occurring.



**Fig.3. Humidity Format.**

Overall this two phased process saves the maximum amount of energy. Issuing one SMS requires a penalty of 1.25 J [8]. The system isn't required to send any SMS when it is in the favorable condition. As soon as it encounters the first unfavorable parameter, it calculates the average of the saved array elements and issues the SMS for it. So, if the system resides in the conditions which were favorable for a month then averaging the readings it issues a single SMS for the entire month, which saves a huge amount of energy.



**Fig.4.**

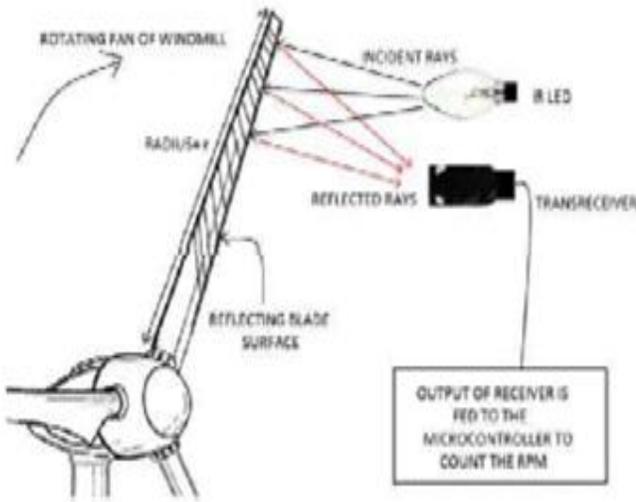


Fig.5. Speed and Wind Measurement.

the construction of the wind speed gauging device involves the use of a tachometer and a rotating shaft or disk contraption as shown in fig.5. As the blades of the fan rotate, the photodiode present inside the tachometer construction receives regular breaks in the light incident on it due to an IR LED. The blades of the fan introduce an obstruction in the propagation of light, and hence produce a low digital state, whenever light is incident on the photodiode its resistance becomes zero at that point of time. This generates periodic binary signals.

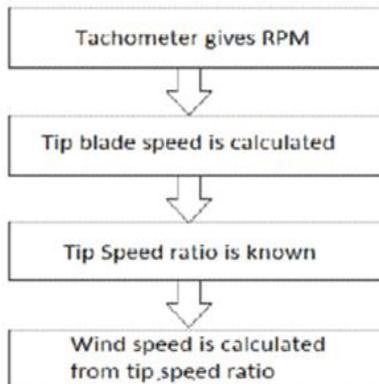


Fig.6.

Note the length of the blade of fan from center of the fan. Now take it as radius (r) and convert it into meters. Now calculate the circumference of the fan (circle) from formula,

$$\text{Circumference} = 2\pi r$$

Suppose RPM (Revolution per Minute) = 80 and r = 5 cm or 0.05m.

Converting to minutes, Tip Blade speed (TBS) =  $D/T = 25.12/60 = 0.419 \text{ m/s}$  or 1.58 km/hr.

Here, T is time period in seconds, and D is distance is travelled.

TSR (Tip Speed Ratio) =  $\frac{\text{TBS}}{\text{Wind speed}}$  Wind speed =  $\frac{\text{TBS}}{\text{TSR}}$

**A. Methods**

From the references Hanif M. et al. [6], E. B. Ettah et al.[7] and [10], we gathered information about optimal conditions for temperature, humidity and wind speed, in order to predict solar and wind energy generation.

TABLE IV: Relative Humidity Range for Power Output of a Solar Panel

Temp ( in °C)	Power output of a solar panel (watts)
Temp > 30	Decreases
15 <= Temp <=30	Maximum
Temp < 15	Decreases

Table III. Temperature range for power output of a solar panel [6]

Relative Humidity RH (%)	Power output of a solar panel (watts)
RH > 75	Decreases
60 <= RH <=75	Maximum
RH < 60	Decreases

TABLE V: Speed and Wind Comparisons

Wind Speed S (in m/s)	Power output of a wind turbine (watts)
S > cut-in speed (3.5 m/s)	Increases
S < cut-in speed	Nearly zero

**B. Testing**

Values for temperature, humidity, light intensity and wind speed are calculated for a random day and checked whether they are optimized or not.

**Temperature:** Solar panels show maximum power output when placed at an angle of 35° [6] with temperature ranging from 15 to 0 °C. Temperature was measured for a sample day and reading was taken after each hour. Here is the graph temperature (°C) Vs time (in Hours).

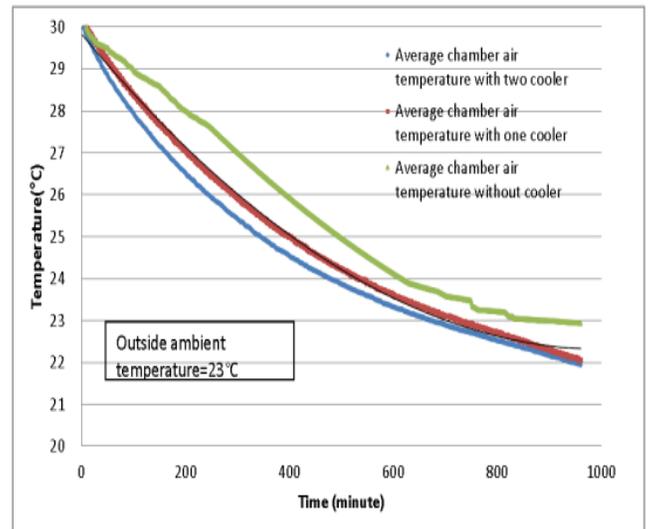


Fig.7. Air flow Variations.

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LM35 is a precision IC with its output proportional to the temperature (in °C). The sensor circuitry is sealed and therefore it is not subjected to oxidation and other processes. With LM35, temperature can be measured more accurately than with a thermistor. It also possess low self heating and does not cause more than 0.1 °C temperature rise in still air. The operating temperature range is from -55°C to 150°C. The output voltage varies by 10mV in response to every °C rise/fall in ambient temperature ,i.e., its scale factor is 0.01V/°C as shown in fig.7.

**Humidity:** Humidity is the presence of water in air. The amount of water vapour in air can affect human comfort as well as many manufacturing processes in industries. The presence of water vapour also influences various physical, chemical, and biological processes. Measurement of humidity in industries is very critical because it may affect the business cost of the product and the safety and health of the personnel. Hence, sensing of humidity is very important, mainly in the control systems for industries and human convenience. Relative humidity (RH) affects the performance and efficiency of solar system panels as it majorly affects the current/voltage ratings of solar panels. However, it has very little effect on output voltage. Increase in current is occurred when by relative humidity is 60% to 75%, as mentioned in [7]. The relative humidity is measured for every random sample of a day and reading was taken for every 1 hour. Here is the graph of relative humidity (%) VS time (in Hours).

**Wind Speed :** At very low wind speed, there is insufficient torque exerted by the wind on the turbine blades to make them rotate. However, as the speed increases, there is sufficient torque to produce electrical power. The speed at which the blades start rotating and electrical power is produced is called cut-in speed, which is 3.5 m/s [10]. Here is the graph of wind speed (m/s) Vs time (in Hours). The mapped values are at a peak during 16:00 hrs and maximum power is obtained at this point according to the formula:

$$1/2(\rho U^3 \left\{ \frac{\pi d^2}{4} \right\}) \quad (1)$$

The available power in a stream of wind of the same cross-sectional area as the wind turbine is calculated using the above mentioned formula, where the wind speed U is in m/s, the density is in kg/m<sup>3</sup> and the rotor diameter d is in m and the available power is in watts.

### V. RESULT

From graph 1, temperature is in range between 15 to 30°C. From graph 2, the average relative humidity is 72% which is in favor of optimized solar power generation. So, we can see that if light sensor detects enough day light, and temperature and humidity are in favor of solar power generation, then we can install solar power station at this place. Graph 3 indicates that wind speed in this area can be utilized efficiently for efficient harnessing of wind energy. Establishment of Solar and wind energy power plants was

successfully studied using a low cost, light weight, efficient and portable system which was deployable to detect weather information.

### VI. CONCLUSION

The main characteristic of this report is regular sampling of data at every 30 seconds from the deployed device, and communicates to the ground station via GSM cellular networks. Power generation feasibility is mapped frequently and optimal generation is checked for different values of, humidity, temperature, light Intensity and wind speed. In this way, for different values of above physical conditions, we can suggest the ways to establish solar and wind power generation stations wherever the conditions for establishment are favorable.

### VII. REFERENCES

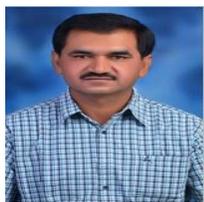
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### Author's Profile



**Vaijanath V. Yegeri**, B.E. (Electronics & Communication Engineering) Passed from Vijaya Nagar Engineering college Bellary (Gulbarga University) passed in the Year July 1995. M.E (Power Electronics) from P.D.A. Engineering college, Gulbarga (Gulbarga University) passed in the Year May 1999. Currently working as Professor & Head of the Department of Instrumentation Engineering, M.B.E. Society's College of Engineering Ambajogai-431517, Dist: BEED(MS) Teaching Experience: 19years, Email: vaijanatha\_y@rediffmail.com.

**VAIJANATH V YERIGERI, PRAMOD ARVIND KULKARNI**



**Pramod Arvind Kulkarni B.E.**

(Electronics & Communication Engineering) from P.D.A.Engineering college, Gulbarga (Gulbarga University) passed in the Year July 1988 (Gulbarga University) passed in the Year July 1995 M.E(Power

Electronics) from P.D.A.Engineering college Gulbarga Gulbarga University) passed in the Year April 2001 Currently working as Professor & Head of the Department of Electronics & Telecommunication Engineering, M.B.E.Society's College of Engineering AMBAJOGAI-431517, Dist: BEED(MS) Teaching Experience : 27years, Email ID: pakulkarni120@rediffmail.com.