© IJEDR 2018 | Volume 6, Issue 2 | ISSN: 2321-9939

Optimal Energy Management of Greenhouse in Smart Grid

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Abstract— The paper presents the greenhouse ecological control approach, which can minimize the usage of energy same time keeping climatic variables under control. In greenhouse, simulated lighting, CO_2 generation and atmosphere control system expand significant energy. The principle target for this paper is to control and monitor the greenhouse system, for this purpose we have choose the set points for day and night for controlling the inside parameters of the greenhouse, and these set points are vary depending upon the type of plants inside the greenhouse. Smart grid is use to manage energy source, in this application smart grid is use to control and monitor three different types of energy sources. Given energy sources are wind energy, solar energy and regular energy from electricity board. In smart grid algorithm each energy source has priority to serve consumer. Solar energy have top most priority, wind energy have lowest priority than solar energy and higher than paid energy from electricity board and the proposed system is used to regulate the operation of greenhouse with respect to Smart Grid, which include Energy Management System and Automated Control System. The system can be extended to detect fungicides of various plants in the greenhouse for future use also the automated sprinklers of pesticides can be implemented for future work.

Index Terms— Greenhouse Energy System, Automated Control System (ACS), Energy Management System (EMS), Smart Grid

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I. INTRODUCTION

India economy will be basically subject to the farming worker result. Agribusiness is the fundamental part occupation done in India. Expansion that nourishment processing engineering organization done in India may be critical in these circumstances. But because of isotropic environmental states absence of water reservoir, wind and excessive solar radiation reduce the agriculture product quite a few energy and water also wasted by agriculture purpose.

In USA 16% of the energy is conserved by greenhouse and poultry forms. Energy consumption in greenhouse and improvement in the quality of crop production has main role in India. Plants are grown in greenhouse like a building or complex. This structure varies from small size to big sized buildings. Cold frame is a mini reproduction model of greenhouse. Greenhouse is like a structural building which has roofs and walls [1].

Roofs and walls are made up of glass or plastics. Plastics greenhouses are mostly used polyethylene film and several sheets of polycarbonate material. Glass greenhouses are mostly used acrylic glass material. Now a day's semiautomatic nurseries are present, and it requires lot of man power. But in this proposed system is automatic and does not require man power. The moderately closed environment of a greenhouse has its own particular kind of management necessities, compared with open air irrigation reproduction system [1].

A. Energy Management System (*EMS*):

The recommended framework might be promptly incorporated under Energy Management System (EMS) and implemented as an ongoing control previously existing greenhouse controllers, along these lines empowering greenhouses with successfully deal with. Their general vitality demand, production, and stockpiling progressively.

The main objective is to minimize the aggregate energy cost and request charges same time recognizing vital parameters of greenhouse; in particular, inside temperature and humidity, CO_2 generation and lighting levels if make kept inside satisfactory ranges [2].

All growing phases of crops can be modified by the control of temperature, humidity, light, and CO2 in a greenhouse.

In Greenhouse physical devices such as maximum window opening, flow rate of fans, rate of fogging systems, and temperature of hot water tubes are limiting features which need to be considered in these control systems.

In greenhouses, transpiration of a crop can be controlled by manipulating the temperature ventilation rate of the greenhouse, photosynthesis and CO2 Concentration [2].

B. Automated control systems (ACS):

In most greenhouses automated control system consist of central computers, sensors, and a data acquisition system connected through communication protocols such as RS-232 and Mod Bus.
These ACS coordinate and integrate the control of greenhouse equipment and systems such as heaters, coolers, motors for windows opening and closing, Pumps and irrigation systems in real time [2].

II . LITERATURE SURVEY

In 2016 Dr. Suresh D S, Deepa K, Rajendra C J has studied Energy optimization of Greenhouse by using ARM LPC1768. Also explains the Plants are grown in greenhouse like a building or complex. This structure varies from small size to big sized buildings. The moderately closed environment of a greenhouse has its own particular kind of management necessities, compared with open air irrigation reproduction system [1].

In 2015 Mohammad Chehreghani Bozchalui and Claudio A. Canizares has studied Energy Management System (EMS)
The main objective of this paper is to minimize the aggregate energy cost and request charges same time recognizing vital parameters of greenhouse; in particular, inside temperature and humidity, CO_2 generation and lighting levels if make kept inside satisfactory ranges [2].

In 2010 Qiuying Zou, Jianwei ji has studied a greenhouse environmental controller, which could minimize the utilization of energy by keeping those climatic temperature variables under control.
A Nonlinear Model Predicative Control (MPC) algorithm based on Particle Swarm Optimization (PSO) is suggested in this paper, As MPC may be exceptionally adaptable in selecting the control targets to solve the cost minimization issue. Joining MPC with PSO not only state the energy cost capacity flexibly, but also solve the streamlining issues of the nonlinear forms.
The energy balance is affected by the energy contribution of the heating system, the energy losses caused by the air exchange through transmission between the cover and the outside environment, as well as through the ventilation provided by the windows, and the energy contribution of the solar radiation [3].

In 1992 C. Stanghellini and W. T. M. Van Meurs has propose an application of the control for crop transpiration in the natural administration of a greenhouse tomato crop.
The climate control algorithm is not based on prescribed day or night set points for temperature and humidity within a greenhouse but on a set point for crop transpiration. The set points for temperature and humidity corresponding to the transpiration set point can be deduced from within the algorithm. These values are used as set point values for the climate control in the next 2 min. The procedure is based on a model of the transpiration of greenhouse crops, whereby the transpiration is calculated from the effects of the microclimate on the canopy. In this particular instance the microclimate is assumed to be determined by the temperature and humidity of the air surrounding the canopy and the amount of incoming global radiation. The canopy itself is assumed to be totally defined by the efficiency with which it is able to exchange energy [4].

Xiaoli Luan, Peng Shi and F.Liu present a general framework for robust adaptive neural network (NN)-based feedback linearization controller design for greenhouse climate system.
The controller may be In light of the well-known reaction. Linearization, consolidated for spiral foundation works NNs, which permits those sentiment linearization system will be utilized within a versatile route. Over addition, an strong sliding mode control is joined to manage the limited disturbances and the close estimation errors for NNs [5].

M. E. Ghoumari, H. J .Tantau and J. Serrano studied the appliance of Model Predictive Control (MPC) for temperature adjustment in agronomical processes. The main objective is to achieve temperature control of a greenhouse built in the Institute for Horticultural and Agricultural Engineering (ITG) at the University of Hannover [6].

In 2003 G.D. Pasgianos, K.G. Arvanitis and P. Polycarpou has studied the nonlinear feedback technique for greenhouse environmental control.
Climate control for protected crops brings the added dimension of a biological system into a physical system control situation. The plants in a greenhouse impose their own needs, significantly affect their ambient conditions in a nonlinear way, and add long-time constants to the system response.
This paper presents a feedback, feed forward approach to system linearization and decoupling for climate control of greenhouses and more specifically for the operation of ventilation/cooling and moisturizing [7].

III . PROPOSED SYSTEM

Figure.1. shows an overview of a greenhouse energy system. All growing phases of crops can be modified by the control of temperature, humidity, light, and CO2 in a greenhouse.
The Temperature and Humidity sensor is used to measure the appropriate temperature and Humidity, and depending upon this the decision regarding the heating or cooling, Air vent system and exhaust system can be taken.
The CO_2 sensor will detect the amount of carbon present in air, and the amount of carbon may get reduced due to internal constraints and it will lead into the reduction in the process of photosynthesis.
The light sensor will be using LDR and whenever the intensity of light will get reduce beyond a specific level, the lights will turn ON/OFF. RS 232 is used so as to send data serially to some computer device wired or wirelessly.

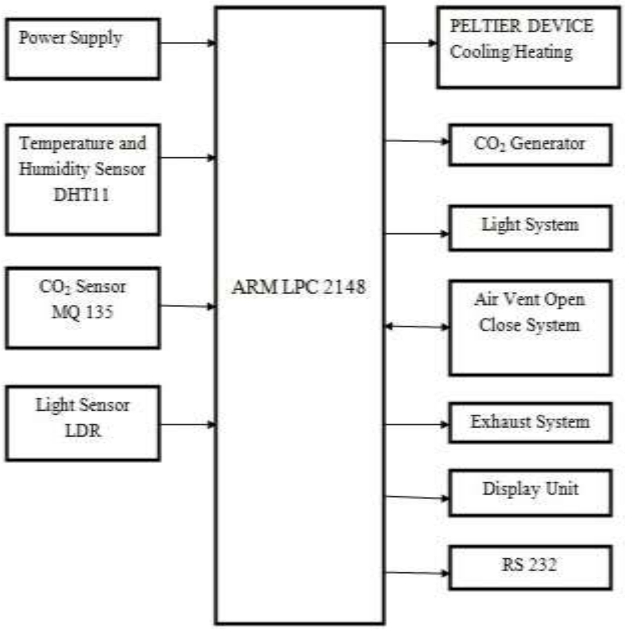

Figure 1: Overview of Greenhouse Energy System

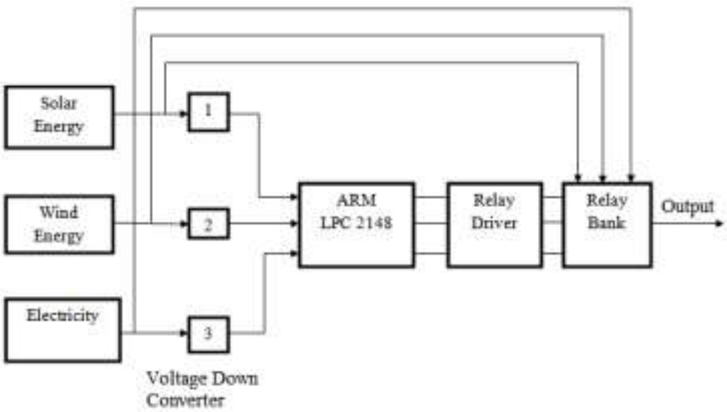

Figure 2: Block Diagram of Smart Grid

In Figure 2. Smart grid is use to manage energy source. in this application smart grid is use to control and monitor three different types of energy sources. given energy sources are wind energy, solar energy and regular energy from electricity board. In smart grid algorithm each energy source having priority to serve consumer. Solar energy have top most priority, wind energy have lowest priority than solar energy and higher than paid energy from electricity board.

SR NO	Solar	Wind	AC Mains	Priority
1	1	1	1	Solar
2	1	1	0	Solar
3	1	0	1	Solar
4	1	0	0	Solar
5	0	1	1	Wind
6	0	1	0	Wind
7	0	0	1	Wind
8	0	0	0	No Priority

Table 1. Priority Table for Smart Grid

In morning slot when sun light is available and generated solar energy is at sufficient level at this point energy source is select as solar energy.
When sun light is not available or generated solar energy is not sufficient at that time prime source of energy is selected as wind energy.
When generated wind energy is not sufficient at that time prime source of energy is seated as paid energy from electricity board.
In this smart grid system input is 3 different types of energy sources and output is given to greenhouse system.

IV. RESULTS

The proposed system consists of greenhouse which is made up of cardboard and Greenhouse plastic. Cardboard is used for supporting purpose while the plastic is used to maintain the heat and humidity in the greenhouse.
Greenhouse plastics are mostly made up of different types of plastics in these project we have used polyethylene plastic, which is economically good and it sustains for longer duration.
To sense the various parameters we have used no. of sensors such as Temperature, Humidity, CO_2 and Light. For each sensor we have set a threshold value such as for temperature we set 33 $^{\circ}$C, for humidity we set 70%. As the values of the parameters raises above the threshold a respective action takes place. Additional peltire device is used to increase or decrease the temperature of the greenhouse, also the Vent and Exhaust fan is used to control the temperature and humidity of the greenhouse. In response to increasing energy demand and automatic controlling of the system smart grid is used which aims to achieve a reliable and sustainable energy supply.
Smart grid is used to support data acquisition and automatic control of the distribution, hence the efficiency of the system is increase.

Figure 3. LCD Results of sensors

Figure 3. Shows the LCD results of Temp, Humidity, CO_2, and Light sensors. figure states that if humidity is greater than 70% at that time vent system is On else vent system is Off, If temperature is greater than 33 $^{\circ}$C at that time heating system is off and cooling system is On else heating system On and cooling system Off and If CO2 is detected then the CO2 valve gets On else it remains Off.

SR NO	Time	Solar	Wind	AC Mains	Priority
1	11.40 AM	1	1	0	Solar
2	11:55 AM	1	1	0	Solar
3	12:05 PM	1	1	0	Solar
4	12:15 PM	1	1	0	Solar
5	12:25 PM	1	1	0	Solar
6	12:35 PM	1	1	0	Solar
7	12: 45 PM	1	1	0	Solar
8	12:55 PM	1	1	0	Solar
9	1:05 PM	1	1	0	Solar
10	1:15 PM	1	1	0	Solar

Table 2. Output Table for Smart Grid

Table 2. States that at any instance of time when both the solar and wind is available with AC mains off the priority still to the solar energy with 100% accuracy.

V. CONCLUSION

A control approach is proposed for optimal operation of greenhouses in the context of smart grids, which includes Energy Management System, Automated control System for the optimal operation scheduling of greenhouse electricity, gas, and heat systems. The developed Systems incorporated electricity price advice and the end-user preferences to abbreviate absolute energy costs and peak demand charges while considering important parameters of greenhouses climate control.

The proposed system shows the accuracy of 100% while dealing with the priority and humidity and when temperature is consider the tolerance is noted as ± 2°C maintaining appropriate operational constraints of a greenhouse. The presented simulation results showed the capability of the proposed model to reduce absolute energy costs while.

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