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*Article*

# Modeling a Smart Greenhouse Using Energy from Solar Panels with Labview Software

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**Abstract:** The renewable energy sources have gained more and more acceptance in the world due to the economic challenges that have come about as a result of the world oil prices increasing. The adoption of solar photovoltaics (PV) has increased exponentially since the early 2000s, with installed capacity around the world surpassing 222 GW in 2015 and this figure starting to rise to 4500 GW by 2050. The present polycrystalline PV panels have efficiencies of 22.7%. Nevertheless, during summer where the temperatures are between 3545 C, the PV panels are less efficient. This gap thus necessitates the use of efficient Maximum Power Point Tracking (MPPT) controllers. This paper was done by experimental means at the city of Samarkand where a solar photovoltaic simulator was built and operated under the LabVIEW software. How the changes in temperature, irradiation, series resistance, shunt resistance, and ideality factor affect the performance of PV panel were examined.

**Keywords:** Solar Simulator, Arduino, Labview, Solar Collector

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## 1. Introduction

The solar radiation is one of the most promising and non-renewable energy sources. Its use can be maximized with the help of artificial intelligence. Light-emitting diodes and electronic DC motors will be incorporated with solar panels to provide direct conversion of sunlight into electricity which can consequently lower the energy consumption by up to 50 percent. The solar energy is one of the most promising alternative renewable sources in future. The figure of CO2 emissions into the atmosphere of the world will reduce by 75 percent by 2050 due to the use of more efficient energy-saving technologies and mass adoption of renewable energy technologies [1].

The technologies that are incurred in renewable energy have been crucial in addressing the global issues of carbon exhaustion, global warming and the necessity of raising the demand of energy. One of the most promising and sustainable energy sources, solar energy, in particular, is gaining more and more applications all over the world as the number of its applications increases at a high pace. The creation of photovoltaics (PV), artificial intelligence, and automation in the modern world has enabled the labor of solar-based systems, thus simplifying and stabilizing it. One of the new applications to which solar energy has become more scientifically and practically interesting due to the possibility of reducing energy consumption, improving the crop yield, and making agriculture sustainable is the introduction of solar energy into smart agricultural systems such as automated greenhouses [2].

The recent studies have introduced intelligent monitoring and control systems in the agricultural context as significant aspect in the farming environment.

Laboratory software like LabVIEW and Arduino microcontrollers and Maximum Power Point Tracking (MPPT) algorithm have been used to streamline the process of energy generation and automation of key processes. Theoretical models of energy conversion of renewable sources, sensor-mediated automation, and intelligent environmental control indicate that real-time environmental conditions of temperature, irradiation, and resistance have a strong effect on the performance of the system. Nevertheless, it is evident that there is still a very large gap in knowledge on modeling, experimental validation and performance analysis of solar-powered smart greenhouses, particularly in areas that experience drastic changes in temperature [3].

Past studies have discussed virtual instrumentation of solar simulators, MPPT algorithm performance and the behaviour of PV modules under varying environmental conditions. Virtual laboratories, GUI based monitoring and automated measurement systems have also been studied using LabVIEW. However, very little has been done to apply these techniques to fully operational smart green house prototypes especially those that are meant to be autonomously irrigated, real time environmental monitored and to manage energy optimization. To resolve this gap, a combined methodological approach that is based on simulation, hardware interfacing, and experimental testing is necessary [4].

This paper has developed a prototype of a smart greenhouse that is completely solar-powered with a photovoltaic system modeled and tested with the help of LabVIEW software and Arduino hardware. The study design involved the fabrication of a prototype of a 2 m greenhouse, a combination of humidity and temperature probe, a LabVIEW-based PV simulator, and the Perturb and Observe (P&O) MPPT algorithm to maximize the power efficiency. Effects of temperature, irradiation, resistance, and ideality factor on PV performance came under the analysis of the simulation and the role of the system stability, automated irrigation, and environmental monitoring, was tested through the experimental tests [5].

The results have shown that the P&O algorithm has greatly enhanced the power output and working steadiness of the solar panels and the built-in LabVIEW Arduino control system has shown the power to manage the water and less involvement by human beings. Such findings demonstrate the possibilities of solar-powered intelligent greenhouse systems in the area of sustainable agriculture. Its implications include the energy-efficient farming methods, the digitalization of farming, and the creation of the technologies that would be fully autonomous in greenhouse farming. Future studies are needed on remote monitoring with IoTs, artificial intelligence to control the environment in advance, and long-term monitoring of performance in various climatic conditions [6].

## 2. Methodology

This research utilized an experimental and simulation-based methodology in the development and testing of a solar-powered model of a smart greenhouse. One 2 m 2 prototype greenhouse was built and fitted with an LM393 soil moisture sensor attached to an Arduino UNO microcontroller that runs on 3.3 5 V. The microcontroller was coded in such a way as to constantly detect the moisture content of the soil via analog and digital circuits, automatically turn on irrigation, whenever the soil became dry, and to indicate real time data on an LCD display screen. A 50 W polycrystalline solar panel was chosen to provide renewable energy to operate the greenhouse and a photovoltaic simulator was created in the LabVIEW to investigate the behavior of the PV at different environmental conditions [7].

Temperature, irradiation, series resistance, shunt resistance and ideality factor have been varied methodically using the simulation environment to determine their effects on power generation. Perturb and Observe (P&O) Maximum Power Point Tracking algorithm was designed in LabVIEW to optimize working of the PV system and the performance of the algorithm was measured by monitoring the stability and responsiveness of the operating point in changing conditions [8].

The system was fitted with LED indicators to have an ideal view of the greenhouse temperature variations and automated irrigation programs were experimented using multiple wet dry cycles. The simulation outcomes were contrasted with the experimental results to support the reliability of LabVIEW model and prove the efficiency of the integrated hardware software system. This hybrid solution was enough to warrant proper examination of solar energy usage and automated performance of green house management [9].

## 3. Results and Discussion

For instance, Germany aims to increase its renewable energy share to 80% by 2030 and to achieve 100% by 2035. Uruguay generated 98% of its electricity from renewable sources in 2021, while Denmark produces more than half of its electricity from wind and solar energy [10].

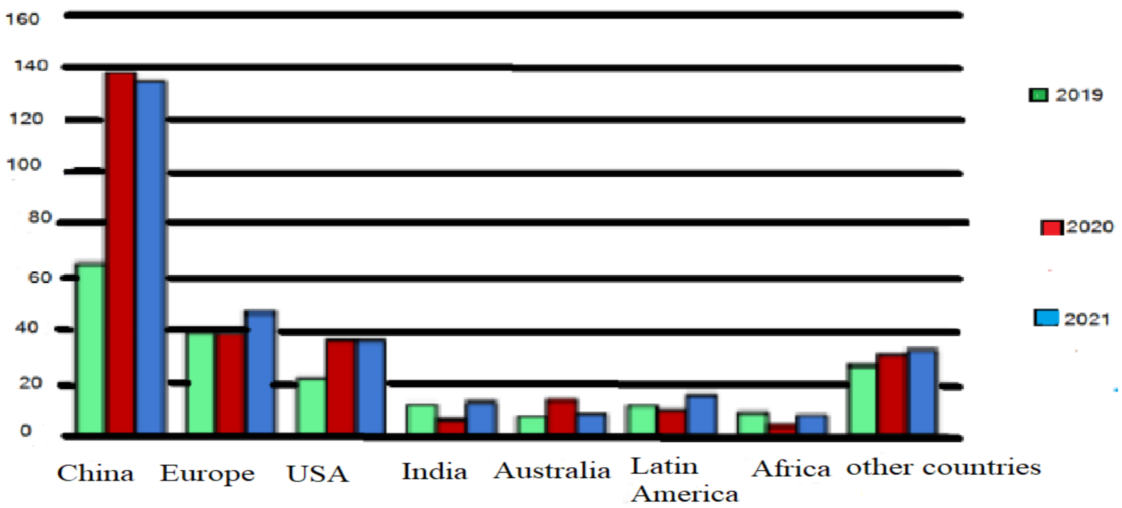


**Figure 1.** Statistics of leading countries utilizing solar energy.

China is currently the world leader in renewable energy production, aiming to generate one-third of its electricity from renewables by 2025. The country is also one of the largest global investors in renewable energy projects [11].

The effective use of solar radiation allows for the development of smart greenhouse models capable of monitoring soil moisture levels, ambient temperature, and reducing human labor. When physical processes become difficult to replicate manually, LabVIEW software provides accurate modeling capabilities. Today, LabVIEW-based simulations are widely applied for testing external devices, conducting measurements, managing control systems, and generating reports. The software enables the modulation of electromagnetic signals, design of traffic light systems, and implementation of virtual assembly processes. We can obtain the graphs of the resulting volt-ampere characteristics using graphical languages in C and C++.

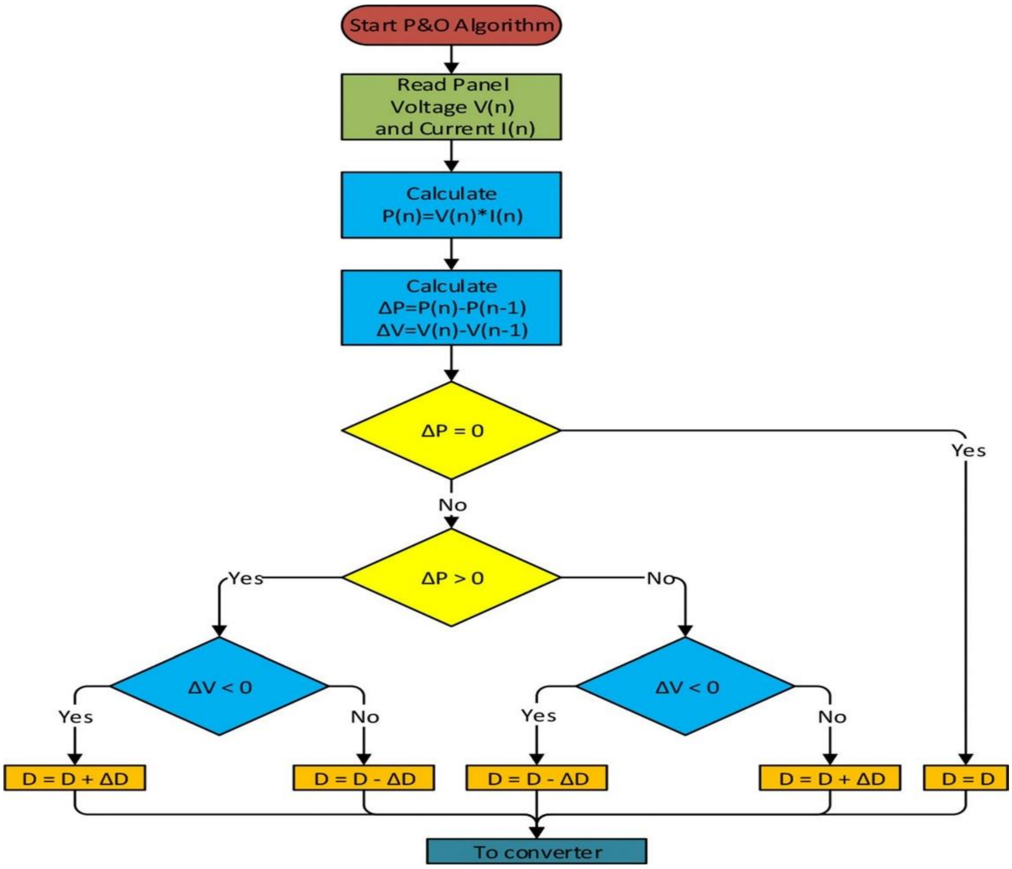


**Figure 2.** Flowchart of the P&O algorithm.

For the purpose of conducting the research, a greenhouse with an area of 2 m² was constructed. The LM393 humidity sensor was connected to the Arduino UNO microcontroller through a 3.3–5V voltage port. In order to power the "smart" greenhouse by means of solar panels, a photovoltaic (PV) simulator was designed in LabVIEW simulations. The necessary power to run the green house was obtained using a 50 W polycrystalline solar panel [12].

The smart greenhouse model developed ensured that the temperature inside the house did not exceed 25C to 45C. There was also an LCD display, which kept showing the humidity level in real time and when the soil was identified as dry then automatically the irrigation system was turned on. The irrigation process was automatically controlled with the help of analog and digital signals to sustain the moisture in the soil at the optimum level. Moreover, through the assistance of LabVIEW software, the Perturb and Observe (P&O) algorithm was created to increase the efficiency of solar panel harvested energy and guarantee efficient use of the energy acquired [13].

The algorithm makes the operating point of the PV module vary and assists in determining the criterion of maximum power. Solar power, resistance and illumination are automatically regulated in LabVIEW environment. They were equipped with LED indicators that showed the changes in the temperature of the greenhouse. The temperature of the green houses can be checked according to the color of these indicators. The experimental and simulation findings showed that the the LabVIEW-based methodology is dependable [14].

The results indicated that the P&O algorithm improved the functionality of solar panels by reducing the losses due to variation in temperature and illumination, which prevented stability in the system of operations. Arduino and LabVIEW integration made it possible to optimize the use of water in the greenhouse. Semi-automatic irrigation minimized human activities and conserved water. Moreover, it was established that the

LabVIEW program is a successful platform that allows managing and monitoring several parameters at the same time.

Smart Greenhouse Model. One prototype of a smart greenhouse of 2 m of surface area was constructed. The moisture level of the soil was measured with a hygrometer moisture sensor (LM393) and connected to an Arduino UNO controller. The sensor has a working voltage of 3.3 5V DC and a current of 35mA with analog and digital signals being transmitted to automatically control the irrigation. The values of resistance and voltages were not constant, which relied on the soil conditions, so the soil was dry, moderately moist, or oversaturated. Arduino UNO was coded to measure and show real time moisture on an LCD screen that was used to automatically monitor the greenhouse [15].

## 4. Conclusion

The LabVIEW software worked well in modeling, designing and simulating solar panel utilization systems. The results of simulations proved that the changes in temperature and irradiation have a significant effect on the PV panel output. Resistance was also noticed to have significant effect. The P&O MPPT algorithm demonstrated efficiency and stability in the production of power. Future research will be aimed at the full control of the smart greenhouse processes, which will be powered by solar panels, with the help of advanced data collection and analysis of how the output performance depends on the changes in irradiation levels.

The operation of Laboratory View LabView in modeling, implementation of the MPPT algorithm, and experimental analysis were all performed successfully in order to increase solar panel efficiency. These findings ensured the system was effective. Greenhouse processes will be automated completely in the future, and embedded with IoT technologies and artificial intelligence algorithms**.**

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