# A review on IoT-based SCADA for renewable energy systems

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***Abstract*:** *With the new era of computing technology Internet of Things (IoT) finds its application in all industries. IoT is a network which has the ability to sense and collect data from anywhere in the world, and then share that data across the Internet where it can be processed and utilized for various purposes or things. The IoT is viewed as a network that includes smart objects with sensors, networks, and processing technologies that integrate and work together to provide an environment that provides smart services to end users. IoT brings many changes to human life where smart services are provided to use any activity anytime and anywhere. All of these services and facilities are communicated through various applications running in the IoT environment. The most important task performed by IoT applications is monitoring and, consequently, rapid decision-making for client management. The renewable energy sector is fast emerging as the alternative to conventional energy generation system. IoT based SCADA is the most rapidly implemented technology in the renewable energy sector for monitoring and control now. This paper presents a review of the implementation of IoT based SCADA in that sector.*

***Keywords*: IoT, SCADA, Wind Energy, Solar PV Systems, Hydro Generation.**

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## I. INTRODUCTION

Supervisory Control and Data Acquisition (SCADA) is a technology for monitoring systems and apply appropriate control action accordingly. It is used in almost all industrial systems to gain access to the entire plant from a centralized control room. For years, industries have been concerned with their operational cost and related expenses and are continuously trying to find solutions that are capable of providing stability, fault tolerance, flexibility and cost efficiency. To satisfy such requirements, one solution is the concept of Internet of Things (IoT) which involves cloud computing. With its emergence, IoT-cloud has brought multiple benefits like cost reductions, increase in redundancy and flexibility to the system. But since the system is integrated with the IoT they are exposed to a number of vulnerabilities also, that could possibly expose them to risks or threats that have negative impact on the performance of the system [1]. To ensure that threats are actively managed and reduced, risk assessment is employed. Risk assessment provides the foundation for the identified risks to be treated with care [2].

## II. SCADA AND IOT IN INDUSTRY

When SCADA systems first came into existence, standard protocols and wired communications were used and were solely aimed towards monitoring and controlling system processes. However, with computer technologies growing rapidly, these systems are exposed to the IoT environment, which incorporates cloud services with the conventional SCADA system for more robust monitoring and control [7].

Automation companies develop various sorts of SCADA hardware and software which they sell as solutions to end users. Currently, in addition to the huge initial capital costs of buying these SCADA systems, end users are made to pay for annual maintenance and support fees also, to use the SCADA system solutions. This has become a problem for

smaller companies, such as companies within running renewable generation systems, with low financial resources, compared to large companies where the value of owning these SCADA systems might be affordable. To make it more affordable, low-cost open-source SCADA systems using IoT are being developed. The open-source IoT based SCADA carry out the desired functions of a SCADA system, which include Data Acquisition, Networked Data Communication, Data Presentation, and Remote Monitoring and Supervisory Control. The entire system is found requiring low power for operation and at a reduced cost. This has made SCADA affordable for smaller companies also [8].

The main idea behind developing Industrial IoT was to make machines smarter and more efficient. For this purpose, industrial SCADA systems utilize IoT and cloud computing. There are still major security risks related to the industrial SCADA systems. Even though challenges are encountered, more research can be done in terms of security, protection mechanism and assurance approach to secure the SCADA system within and outside the IoT-cloud environment [9].

Figure 1 shows an IoT based SCADA system where RTUs are reporting to the Cloud Server, which is accessible by the mobile clients [1]. This makes the client terminals mobile and flexible. Also, the cost of setting up of server is considerably reduced. Such IoT based systems are in use currently in smaller industries and slowly such systems are going to be implemented in almost all processes.

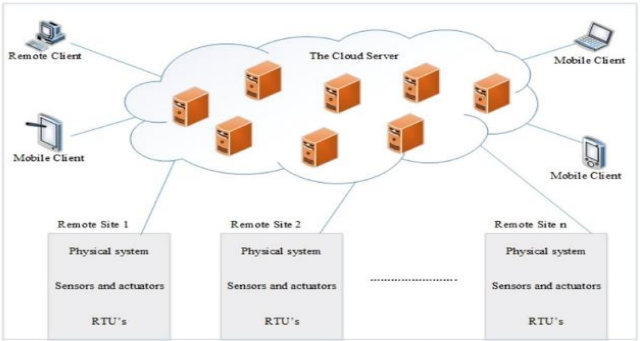


Fig 1: The general architecture of SCADA systems in an IoT-cloud [1]

## III. IoT based SCADA in Wind Energy System

With IoT applications specially designed for monitoring wind energy sources, the IoT-SCADA system gathers information such as technical failure in electrical equipment and transfers the information to the central system, generates an alert signaling the failure and conducts the analysis. After that the analysis results are evaluated by the program to determine if the failure is critical, and displays the information in a logical and organized manner [4].

With the rapid evolution of SCADA and cloud-based IoT, industry transformation will provide important solutions in wind energy technology like increasing lifetime of devices and reducing operating and maintenance costs in turbine technology. This can happen by controlled use of the components of the wind energy system, by monitoring their optimum requirement for a load demand. The continuous monitoring helps in deciding the control action. This technology provides real-time data storage and retrieval of wired or wireless information from the sensors. Real time monitoring of wind farms especially in harsh operating conditions provides pre-detection of faults and better understanding of operating behavior, so as to supply more economical solutions. Such systems are advantageous for renewable energy power plants like wind park environments that are robust and sparsely located [5].

With IoT-Cloud based SCADA systems, reliability of wind turbines has increased, due to the controlled operation of the components. It also plays a big role in selecting the foremost suitable location for installing wind turbines. Meteorological sensors monitor real-time weather and specific environmental parameters like wind speed and wind direction, which are essential for reliability studies as a graphical representation with time. Through IoT, automated historical data besides daily work reports are often obtained to reinforce long-term reliability, optimize operations in long-term and increase annual energy production. Future wind turbines are going to be self-organized owing to sensors and implementation control strategies using IoT based SCADA [6].

Due to long operation hours under challenging environments, wind turbines can meet with their main technological advancement through IoT, this may grant field operators the tools to make sure about the maintenance strategy development, reduce uncertainty, maintain system reliability as well as availability and enhance annual energy production.

SCADA has some limitations and by using IoT we get a broader perspective at implementing such a system. By using the flexibility of IoT technology, where the sensors and actuators have more intelligence embedded into them and the main control is free to implement more complex tasks such as security and surveillance, making small enterprises run more efficiently and with more reliability.

## IV. IoT based SCADA in solar energy system

Photovoltaic (PV) systems are important renewable energy sources. Also called solar energy system, PV systems are electronic devices that can convert sunlight directly into electricity. Despite their promising performance, PV systems have some limitations, like counting on factors like longitude, latitude, weather and being limited to daytime hours to generate power. SCADA system can monitor real-time electrical data measurements of solar module and batteries. The sun-tracker system has also used the IoT

based SCADA system to watch the solar insolation and movement of the sun [10].

The photovoltaic system used for power generation involves various components whose operational behavior varies. To be more precise, solar intensity is time varying and weather dependent. Hence constant power generation isn't possible throughout the system operation. It indirectly effects the working of other system components like power converter voltage levels, battery state of charge, energy demands by loads etc. Sometimes, the dust accumulation, and other environmental conditions can also end in poor performance of the photovoltaic system. However, these problems in longer terms results in the failure of the system. Monitoring such failures is difficult for humans, as they have to go to the plant site frequently and maintain the record of operational data. Here IoT comes as the rescue. A continuous monitoring system is to be equipped alongside the PV system, such that it might monitor the system parameters and store them in cloud platform. The stored data will help in understanding its performance and reasons for poor performance. This allows to make troubleshooting and maintenance operation when the performance is poor due to some faults [11].

## V. IoT BASED SCADA IN HYDRO GENERATING SYSTEM

SCADA system generally refers to industrial control systems: computer system that monitor and control industrial processes. A SCADA control center performs centralized monitoring and control of field devices over long-distance, including monitoring and processing of the data. The combination of PLC with PC based SCADA systems is used for plant control and data acquisition. This makes the system more economical and thus can be suitable for hydroelectric power plants for generation, control and automation. Based on information received from remote stations, automated or operator-driven supervisory commands can be pushed to remote station control devices, which are often referred to as field devices [12].

With the aim of monitoring the performance of several parameters, the system can monitor several parameters such as voltage, current, frequency, and turbine rotation, so that it can be accessed directly at one central location. This is done by taking into account the real parameters from the field. Some parameters that become the main target to monitor are voltage, current, frequency, and turbine rotation. The voltage generated by the alternator must be adjusted to the voltage supplied by State Electricity Company to the consumer, including the phase matching. The hydro source stream should also be monitored for power to be adjusted to the turbine spin. The generator frequency is kept stable according to the standard frequency of the State Electricity Company generator [13].

Generally, the system must be able to establish a link between the station and the field device for transferring information, transmitting data to the monitoring center, and for disconnection if there is any disturbance in the line or parameters. The Hydro power plant parameters that are monitored by the IoT based sensors in real time are:

1) Current- The current in the generator changes rapidly with the changes in the installed load, it is necessary to observe that these fluctuations do not cause damage to both the generator and the load.

2) Voltage- Voltage stability on the generator is required with a difference of tolerance of 10%.

3) Temperature-The temperature of the generator should be kept under normal conditions [13].

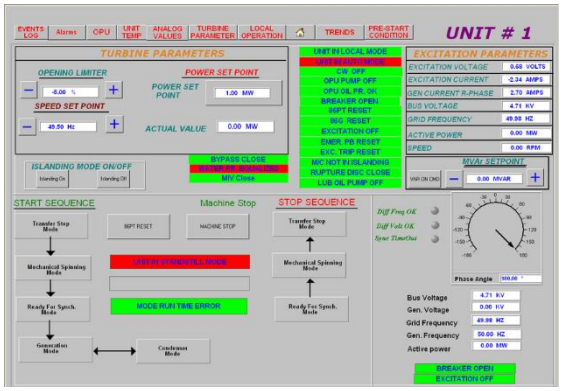


Fig 2: Screen-shot from an IoT based SCADA System for a hydro power plant [12]

As shown in Figure 2, the SCADA screen is divided into following 5 sections.

Section 1: Turbine parameter- from this section operator can monitor and change turbine parameters.

Section 2: Status display- This section displays the status of machine.

Section 3: Excitation Parameters- From this section operator can monitor analog value of important excitation parameters

Section 4: Command Section- This section is used to issue start and stop command for machine.

Section 5: Synchronizing section- From this section operator can monitor synchronizing condition of machine as well as related important electrical parameters [12].

## VI. CONCLUSION

SCADA has some limitations on its own. By using IoT, we get a broader perspective at implementing a SCADA system. By using the flexibility of IoT technology, where the sensors and actuators have more intelligence embedded into them and the main control is free to implement more complex tasks such as security and surveillance, making small enterprises run more efficiently and more reliably with

the usage of data. Applications of SCADA and IoT in renewable energy systems have brought about flexibility, ease of monitoring and quicker response capabilities. All future data acquisition, monitoring and control systems in the renewable energy sector are envisaged to have IoT based SCADA.

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