

Scalable IOT Application/ Infrastructure Approach in Solar Energy Farms



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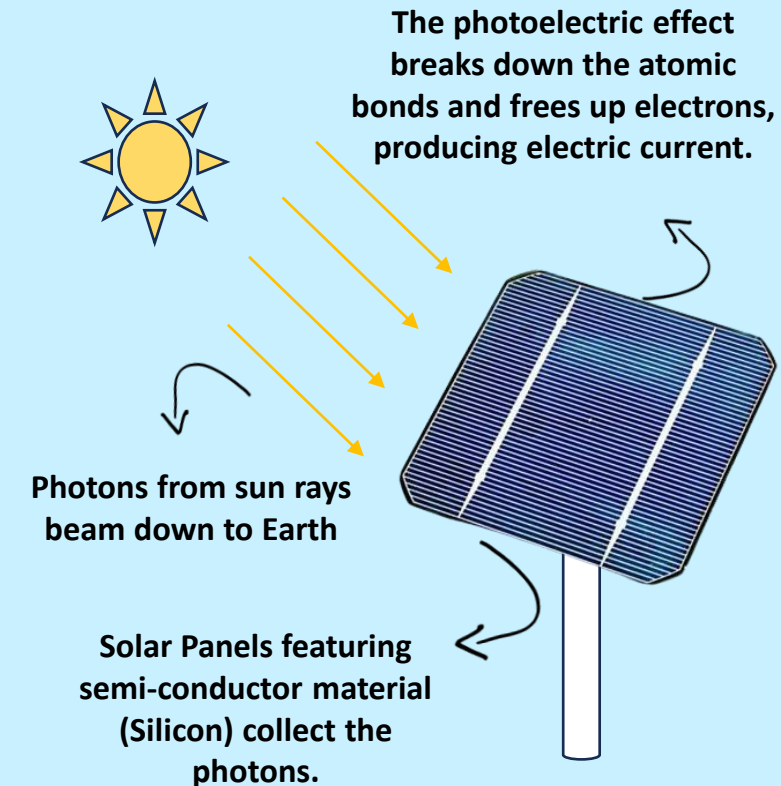
ABOUT ME



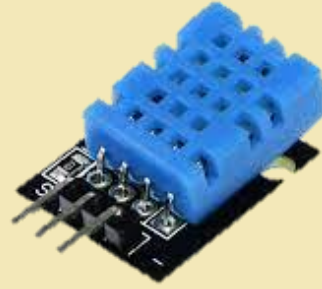
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Introduction

- IoT (Internet of Things) involves connecting everyday objects to the Internet using sensors, actuators, and connectivity protocols, enabling them to send and receive data.
- Solar farms harness solar energy through arrays of photovoltaic panels to generate electricity. They play a crucial role in sustainable energy production, offering clean and renewable power sources.
- Scalable IoT deployments in solar farms encompass sensor-equipped equipment, edge computing, and cloud-based analytics platforms. They empower predictive maintenance, fault detection, and optimization strategies enhancing operational efficiency and maximizing energy yield.



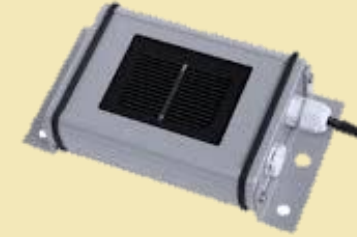
**Temperature-Humidity
Sensor**



**Voltage
Sensor**



**Solar Irradiance
Sensor**

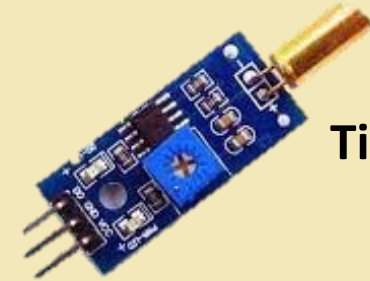


**Current
Sensor**



SENSORS

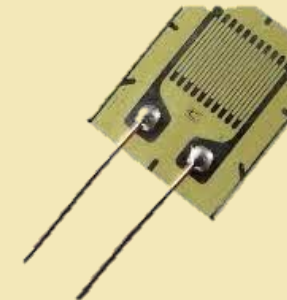
**Tilt & Orientation
Sensor**



Accelerometer

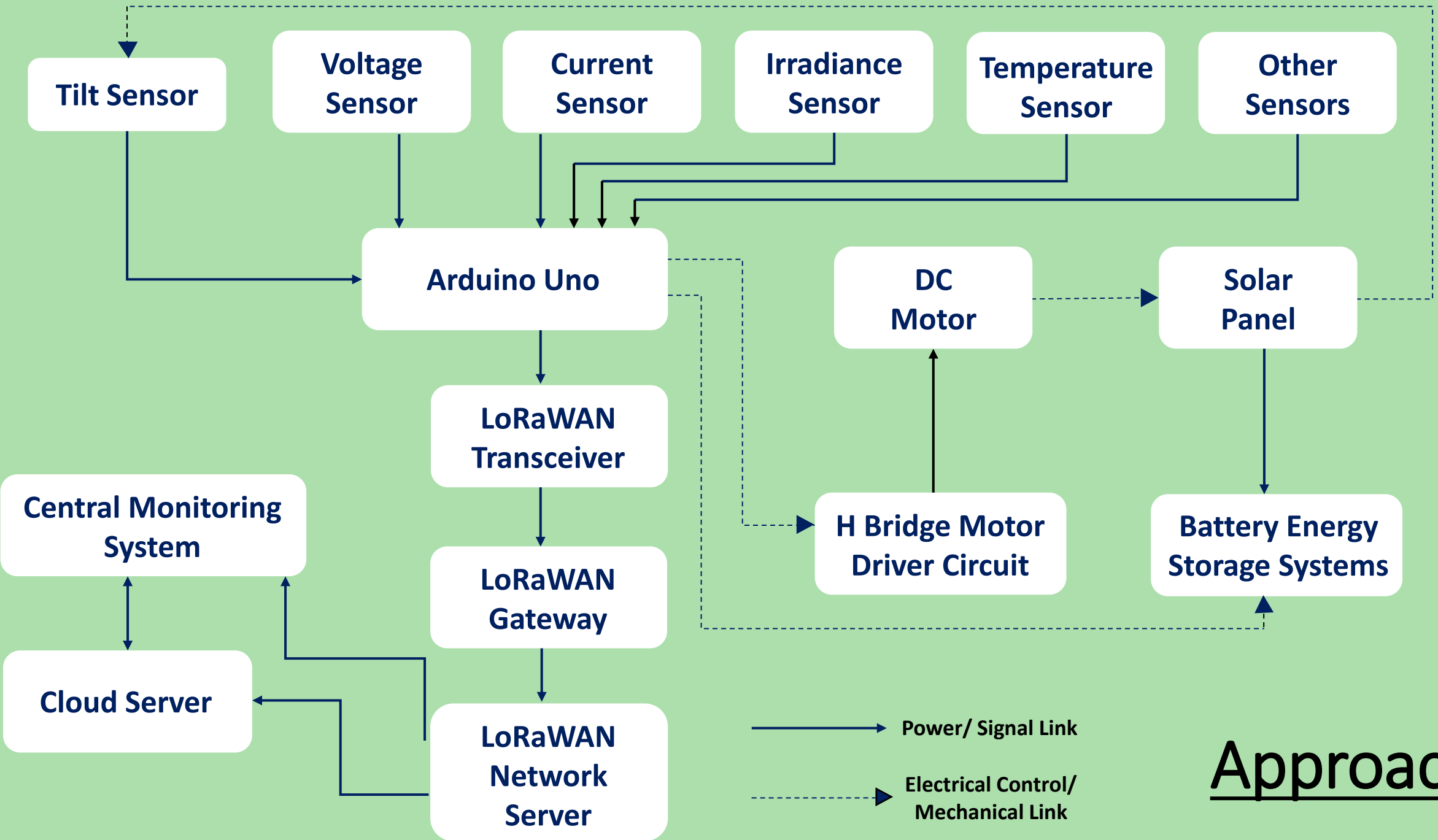


Strain Gauge



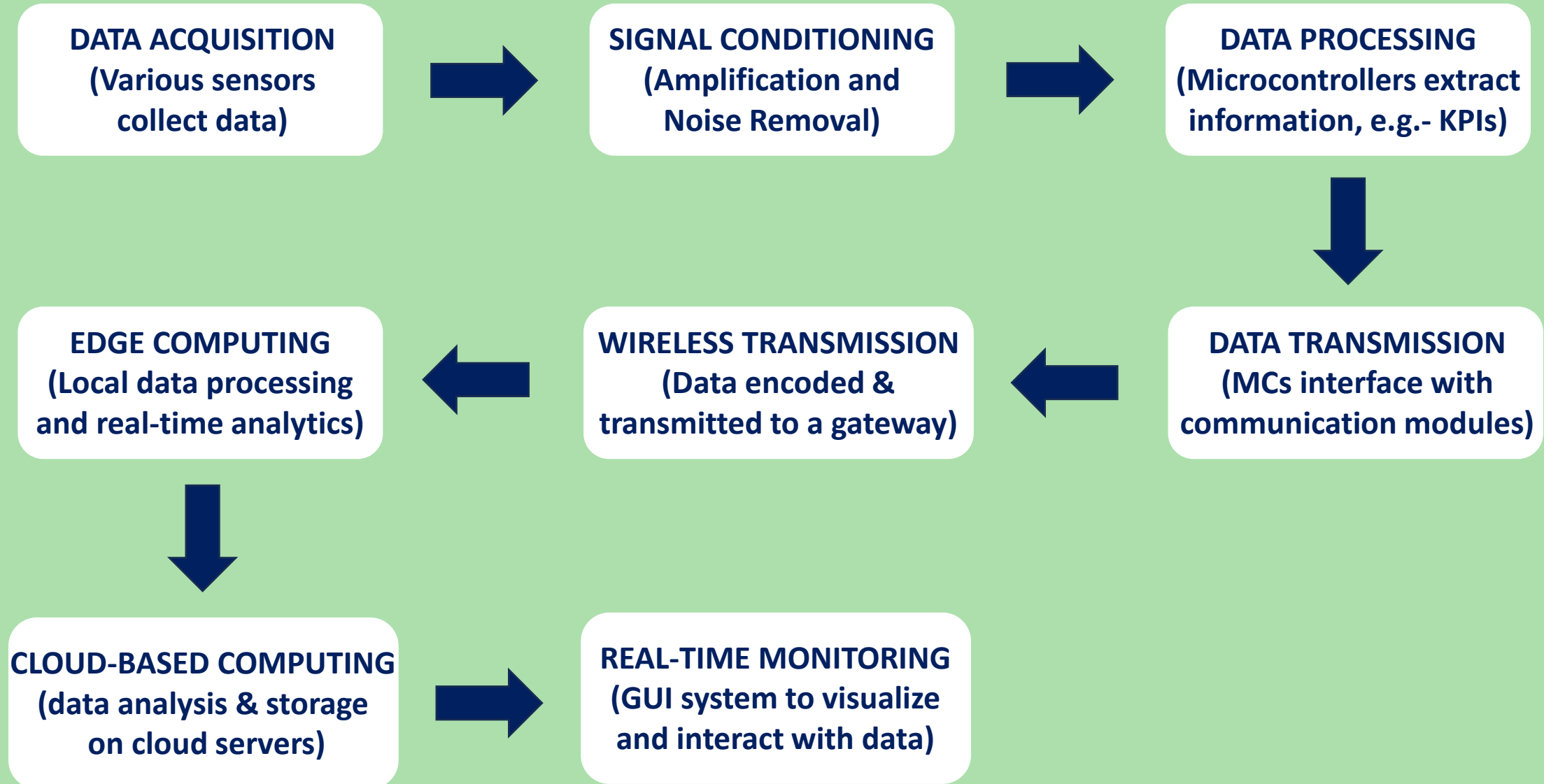
**Dust & Soiling
Detection Sensor**





Approach

Implementation



Wireless Communication Technologies

Wi-Fi (IEEE 802.11) :

- It operates in 2.4 GHz and 5 GHz frequency bands, offering high data rates with relatively short ranges.
- It boasts interoperability with existing infrastructure and devices.
- It covers up to 100 meters indoors and several hundred meters outdoors.
- It is efficient for medium-range communication, with bandwidth-intensive applications & high data rates.

LoRaWAN (Long Range Wide Area Network) :

- Low-power, wide-area protocol operating in sub-GHz bands, offering extensive coverage and minimal power usage.
- Ranges from several kilometers in urban settings to tens of kilometers in rural environments.
- It provides broad coverage within expansive solar farms with extended battery life, ideal for areas lacking cellular coverage.

Zigbee (IEEE 802.15.4) :

- It operates in the 2.4 GHz band, offering low-power, short-range communication with mesh networking support.
- It typically covers 10 to 100 meters indoors and 100 to 300 meters outdoors.
- Ideal for short-range communication within solar farms, Zigbee ensures efficient data transmission for low-power, battery-operated devices.

Cellular (3G/4G/5G) :

- It offers high-speed data transmission over licensed spectrum bands, with wide coverage.
- Ubiquitous coverage and high data rates cater to real-time transmission needs, with good interoperability.
- The range spans several kilometers to tens of kilometers

Key Features

1. Real-Time Monitoring-

Scalable IoT infrastructure allows for continuous real-time monitoring of solar panel performance metrics such as irradiance levels, energy production, voltage, and current output.

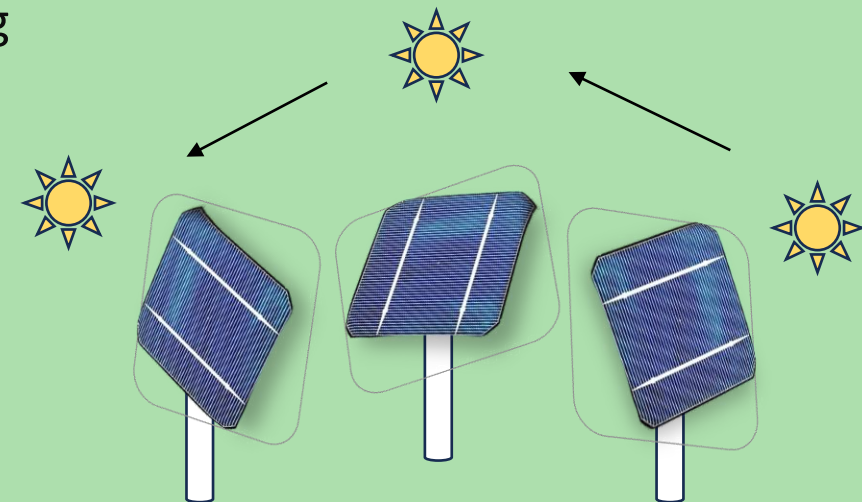
2. Predictive Analytics-

IoT platforms utilize predictive analytics algorithms to forecast the amount of energy reserve, potential issues based on historical data, and real-time trends to schedule maintenance.

3. Operational Ease-

- IoT sensors monitor various parameters of solar panels, including access to detailed diagnostic data of panel health and performance, facilitating quick identification of faulty panels or suboptimal performance areas.
- IoT dashboards provide intuitive interfaces for managers to monitor and control solar farm operations from a centralized location. Remote management capabilities enable adjustments to panel settings, tilt angles, or cleaning schedules with minimal effort, enhancing operational efficiency.

Application of Solar Irradiance tracker and Arduino, H-Bridge motor driver circuit, DC motor



4. Scalability-

Scalable IoT infrastructure facilitates the seamless integration of additional sensors and monitoring devices as solar farms expand.

5. Agrivoltaics-

- Agrivoltaics refers to the practice of installing solar panels above or alongside crops or agricultural fields, allowing for dual land use. This approach aims to optimize land productivity by simultaneously generating renewable energy while maintaining or enhancing agricultural output.
- IoT sensors can provide real-time data on environmental conditions, soil moisture levels, and crop health within the Agrivoltaic system. This data can be used to adjust irrigation schedules and solar panel tilt angles for maximum efficiency.



100% Crop Production



100% Solar Electricity



>180% Land Use Efficiency

Comparison

Parameters	Standalone System	IoT-based System
Energy Production Monitoring	Manual reading or periodic inspections	Real-time monitoring with detailed analytics
Maintenance	Reactive maintenance based on visual inspection	Predictive maintenance based on IoT sensor data
Fault Detection	Relies on visual inspection for fault identification	Early detection of faults through IoT sensors
Performance Optimization	Limited optimization capabilities based on experience	Dynamic optimization based on real-time data
Remote Monitoring	Not available	Remote monitoring and control via IoT connectivity
Connectivity	Independent operation	Connected to IoT network for data transmission
Cost	Lower upfront cost but higher maintenance expenses	Higher upfront investment with reduced long-term maintenance costs

A photograph of a solar farm. In the foreground, two rows of solar panels are visible, tilted at an angle. The panels are dark blue with white grid lines. They are mounted on metal frames in a lush green field. In the background, there is a line of trees and a hill under a sky filled with large, white, fluffy clouds. The sun is shining through the clouds, creating a bright, hazy effect.

Thank You