International Journal of Advances in Engineering and Management (IJAEM)
Volume 6, Issue 04 Apr. 2024, pp: 04-11 www.ijaem.net ISSN: 2395-5252

Design and Development of an IOT using Power Sharing Control for Energy Management Systems

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Date of Submission: 25-03-2024 Date of Acceptance: 05-04-2024

ABSTRACT: Electricity is an important invention without which life on Earth is impossible. So obviously there is a need for measuring the consumed electricity. Accomplished by the wattmeter, but a person from TNEB has to visit each customer's house for measuring the power consumption and for calculating the bill amount of customers. So it requires much manual work and consumes time. We have intended to construct an IoT based energy meter to each customer of TNEB. So the proposed energy meter measures the amount of power consumed and uploads it to Thing speak cloud the concerned person can view the reading. The power reading is sent to the cloud using ESP 8266, a Wi-Fi module. The power reading from digital wattmeter is read using the opt coupler and transmitted digitally to the Arduino. So it automates the process of measuring the power consumption at homes using IoT and thereby enabling remote access and digitalization for each customer of TNEB.

KEYWORDS: Arduino UNO, Current sensor, Voltage sensor, Micro controller unit, Wi-Fi module, IOT Cloud, Wi-fi module ESP8266, TRIAC

I. INTRODUCTION

Electrical power has become indispensable to human survival and progress which leads to the enhancement of the people's standard of life by the introduction of automation in to energy distribution and management. With the constant development in technology, the need of automated meter reading systems is also increasing. The technology of e-metering (Electronic Metering) has gone through rapid technological advancements and there is increased demand for a reliable and efficient Automatic Meter Reading (AMR) system .The traditional meter reading process involves using the analog meters to collect the data of the energy consumed and display it either on a number dial or a digital display. The service provider person comes to the place of the meter and notes down the reading at the end of every billing cycle. But the traditional meter reading process not only wastes labor human power, but also is error prone. The procedures of sending the bills to customer are very laborious and cumbersome. The conventional process is time consuming as well. Another major problem in this system is that the readings cannot be taken if no one is available at the home or where the meter is located. The current system does not provide any scope for the user to conserve energy or does it provide energy consumption predictions for near future that enables the user to act in a more planned way. There are many such problems that cause inconvenience to the power provider as well as the consumers. Even though the conventional meters were replaced with more efficient electronic energy meters these problems still persists. Automatic meter reading system is a technology which is used to gather data from energy metering devices and transfer it to a central station in order to process it for billing purposes. Automatic meter reading system helps the customer and energy provider to access the accurate and updated data from the meters. AMR system can fetch energy consumption in a hourly, monthly, yearly basis on request or even in Real Time. This Real time energy usage can be seen by the users to control the use of power and be more economical. With the help of the collected data the service provider will be able to send energy saving ideas to the users. This kind of real time data collected from each of the individual houses is really a boon to data scientists, who use machine learning and data mining tools to build a predictive model over this valuable data to predict the future energy demands starting from every single house, area, city to the entire planet. Thus leading to sophisticated and predictive energy production, conservation and management.

- **ARDUINO UNO**

Arduino UNO is a low-cost, flexible, and easy-to-use programmable open-source microcontroller board that can be integrated into a variety of electronic papers. This board can be interfaced with other Arduino boards, Arduino shields, Raspberry Pi boards and can control relays, LEDs, servos, and motors as an output. The Arduino UNO is the best board to get started with electronics and coding. The UNO is the most used and documented board of the whole Arduino family. It is mostly used by the beginners that can use in electronics project and do programming in this board. The board has regular innovation and a bug fix in the design of the board to make the board suitable for the project's use. The Arduino UNO is an open-source microcontroller board based on the Microchip ATmega328P microcontroller (MCU) and developed by Arduino.cc and initially released in 2010. The microcontroller board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The board has 14 digital I/O pins (six capable of PWM output), 6 analog I/O pins, and is programmable with the Arduino IDE (Integrated Development Environment), via a type B USB cable. It can be powered by a USB cable or a barrel connector that accepts voltages between 7 and 20 volts, such as a rectangular 9 volt battery. It has the same microcontroller as the Arduino Nano board, and the same headers as the Leonardo board. The hardware reference design is distributed under a Creative Commons Attribution Share-Alike 2.5 license and is available on the Arduino website. Layout and production files for some versions of the hardware are also available. The word "uno" means "one" in Italian and was chosen to mark a major redesign of the Arduino hardware and software.

- **CURRENT SENSOR**

Current sensors are necessary for instrumentation as well as power systems. This is because it is essential to measure the current that is flowing through systems without having a detrimental impact on their performance. Throughout human history, the protection and management of electrical circuits have been the primary tasks of current sensing. Nevertheless, as a result of technological improvements, current sensing has evolved into a technique that may be utilized to examine and improve performance. A current sensor is a piece of equipment that can measure current and then change the measured current into a voltage that can be readily measured. The quantity of voltage that is being output is exactly proportional to the amount of current that is passing through the channel that is being monitored. This voltage signal is then used for control reasons, stored for further analysis in a system that collects data, or displayed on an ammeter to display the measured current to provide feedback to the user. All of these processes take place after the signal is collected. A current sensor's principal function is to carry out the operation of translating current into voltage to be used in various settings. This information can then be utilized in a variety of ways.

- **VOLTAGE SENSOR**

Voltage sensors can measure the voltage in various ways, from measuring high voltages to detecting low current levels. These devices are essential for many applications, including industrial controls and power systems. This type uses an electromagnetic field to detect changes in voltage. The sensor's exposure to an electric current generates a magnetic field. It induces currents in nearby conductors, such as wires or circuit boards, sensitive enough to detect these changes. This type of sensor is often used with microcontrollers since they can easily measure changes in electromagnetic fields around them with the help of built-in analog-to-digital converters (ADCs). method of measuring the load on a motor and adjusting its speed accordingly.

- **WIFI MODULE (ESP8266)**

Wi-Fi module is a device made up of a microcontroller, Medium Access Control, baseband and radio frequency front end. An ESP8266 Wi-Fi module is a SOC microchip mainly used for the development of end-point IoT (Internet of Things) applications. It is referred to as a standalone wireless transceiver, available at a very low price. It is used to enable the internet connection to various applications of embedded systems. Expressive systems designed the ESP8266 Wi-Fi module to support both the TCP/IP capability and

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the microcontroller access to any Wi-Fi network. It provides the solutions to meet the requirements of industries of IoT such as cost, power, performance, and design. It can work as either a slave or a standalone application. If the ESP8266 Wi-Fi runs as a slave to a microcontroller host, then it can be used as a Wi-Fi adaptor to any type of microcontroller using UART or SPI. If the module is used as a standalone application, then it provides the functions of the microcontroller and Wi-Fi network. The ESP8266 Wi-Fi module is highly integrated with RF frequency, power modules, RF transmitter and receiver, analog transmitter and receiver, amplifiers, filters, digital baseband, power modules, external circuitry, and other necessary components.

- **NODEMCU**

NodeMCU is an open source IoT platform. it includes firmware which runs on the ESP8266 Wi-Fi SoC from Expressive Systems, and hardware which is based on the ESP-12 module. The term "NodeMCU" by default refers to the firmware rather than the dev kits. The firmware uses the Lua scripting language. The programming code is being written for ESP8266 Wi-Fi chip using Arduino IDE, for which installation of ESP8266 library is required. We designed to make working with this chip super easy and a lot of fun. We took a certified module with an onboard antenna, and plenty of pins, and soldered it onto our designed breakout PCBs. While this chip has been very popular, it’s also been very difficult to use. Most of the low-cost modules.

- **ENERGY METER**

Energy Meter **or** Watt-Hour Meter is an electrical instrument that measures the amount of electrical energy used by the consumers. Utilities are one of the electrical departments, which install these instruments at every place like homes, industries and organizations, commercial buildings to charge for the electricity consumption by loads such as lights, fans, refrigerator, and other home appliances. The basic unit of power is watts and it is measured by using a watt meter. One thousand watts make one kilowatt. If one uses one kilowatt in one-hour duration, one unit of energy gets consumed. So energy meter measure the rapid voltage and currents, calculate their product and give instantaneous power. This power is integrated over a time interval, which gives the energy utilized over that time period.

- **TRIAC**

A Triac is defined as a three terminal AC switch which is different from the other silicon rectifier in the sense that it can conduct in both the directions that is whether the applied gate signal is positive or negative, it will conduct. Thus, this device can be used for AC systems as a switch. This is a three terminal, four layer, bi-directional semiconductor device that controls AC power. The triac of maximum rating of 16 kw is available in the market.

- **POWER SUPPLY**

A power supply is an electronic circuit designed to provide various ac and dc voltages for equipment operation. Proper operation of electronic equipment requires a number of source voltages. Low dc voltages are needed to operate ICs and transistors. High voltages are needed to operate CRTs and other devices. Batteries can provide all of these voltages. However, electricity for electrical and electronic devices are commonly supplied by the local power company. This power comes out of an outlet at 115-volt ac, with a frequency of 60 Hertz. Different voltages are needed to operate some equipment.

- **IOT CLOUD**

With the Arduino Cloud desktop or mobile platform, you can quickly connect, manage and monitor your devices from anywhere in the world. Arduino Cloud allows you to automatically create any code to program your device with - just add a couple of lines to customize it how you want. An IoT cloud is a massive network that supports IoT devices and applications. This includes the underlying infrastructure, servers and storage, needed for real-time operations and processing. Very simply explained, with the Arduino Cloud you can: Create a program for an Arduino based on a brilliant idea you just hatched. Upload the program to your board and synchronize any data you want to (most commonly through Wi-Fi).

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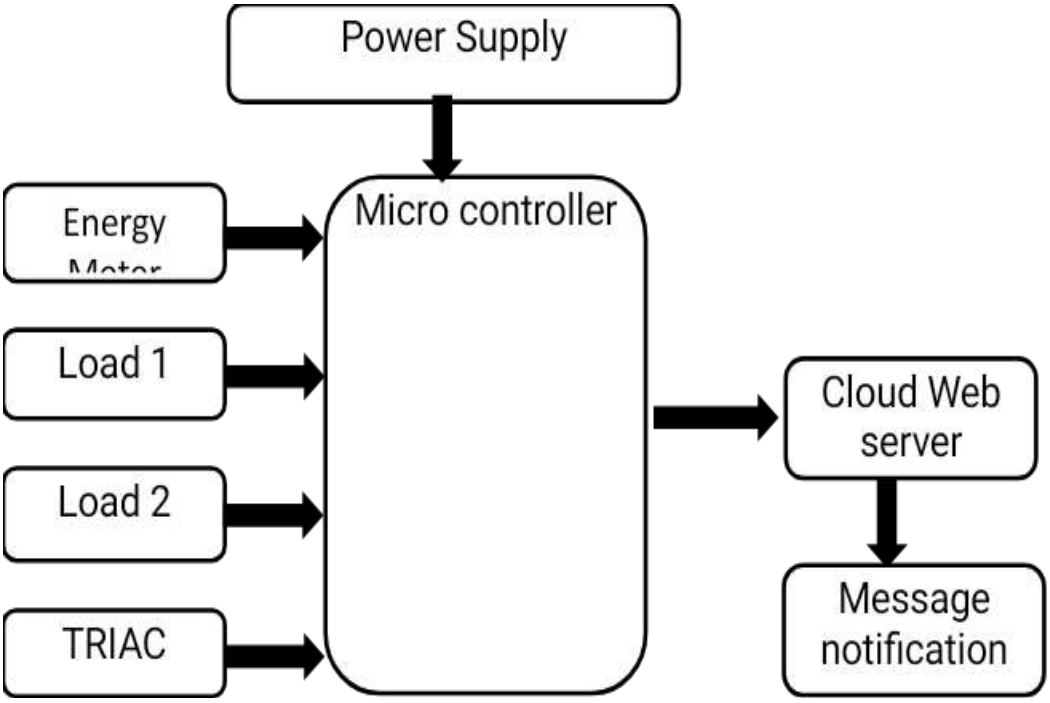
BLOCK DIAGRAM



- **IMPLEMENTATION**

In the present system the energy meter is using Power Line Carrier Communication. It is wired system and hence the performance is less compared to wireless systems. Power line communication (PLC) has seen a lot of interest in the past few years due to the almost omnipresent nature of the power line grid. One of the potential applications of power line communication is automatic reading of electric, gas and water meters. Even though automatic meter reading (AMR) is a low data rate application, it demands both high reliability and low computational complexity. Moreover, the power line channel proves unfavourable to reliable communication due to its multipath nature, frequency selective effects, narrowband interference and presence of strong impulse and colours background noises .the disadvantages are given below The interference in the power line cable that occurs between the electric signal and data signal is not overcome in this project, The data rate is low, The impulse response is large. Not suitable for real time billing system, Speed is too low, and two way communications between the user and EB is not efficient. In the expected system the parameter such as power, current, voltage is checked based on that the energy is calculated and the payment is generated to respective mail. If there are increases in load the power supply to the load is cut off and mail regarding power usage is sent to the electric board and display on the webpage. The advantages are given below . Low installation cost, Quick in action, Electricity theft is prevented, Better two way communications between the user and the Electricity Board, Low power consumption by the measureThe implementation of IOT-based power sharing and overload indication offers advantages such as enhanced energy efficiency, optimized resource utilization, and improved grid reliability by dynamically allocating power and preventing potential overloads. This technology finds applications across diverse sectors including smart cities, industrial automation, and residential areas, where efficient power management is crucial for sustainability and resilience. ring unit ,Upfront payment for electricity Lower overheads ,No billing hassle and No disconnection/ reconnection

II. RESULTS

The energy sharing results of ESP under different energy sharing models in different time slots are given in Fig. 1 and Fig. 2, respectively. The SOC variation of the BESS is given in Fig. 3

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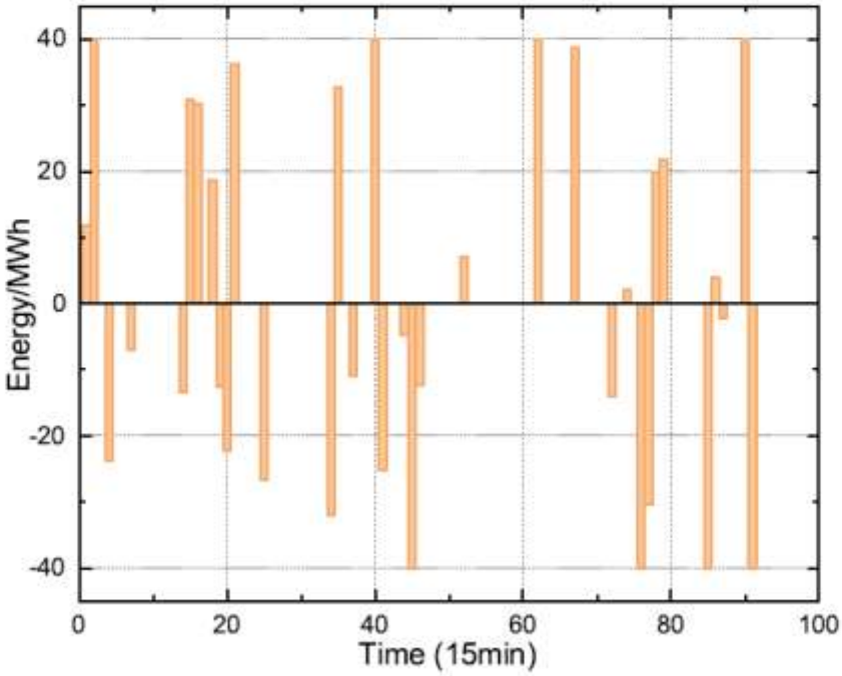

Fig. 1. Energy sharing results under energy storage sale model of ESP.

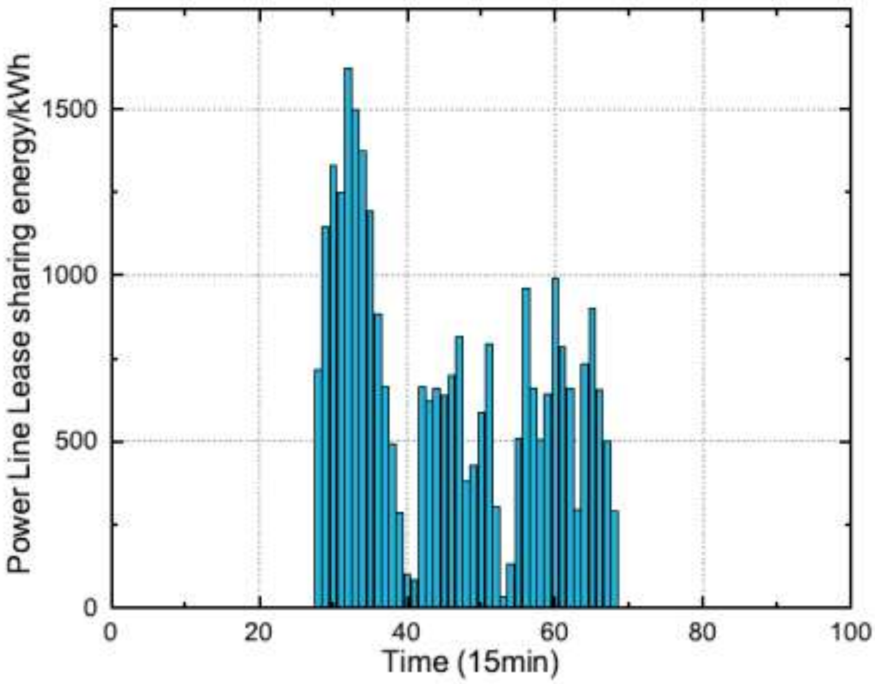

Fig. 2. Energy sharing results under power line lease model of ESP

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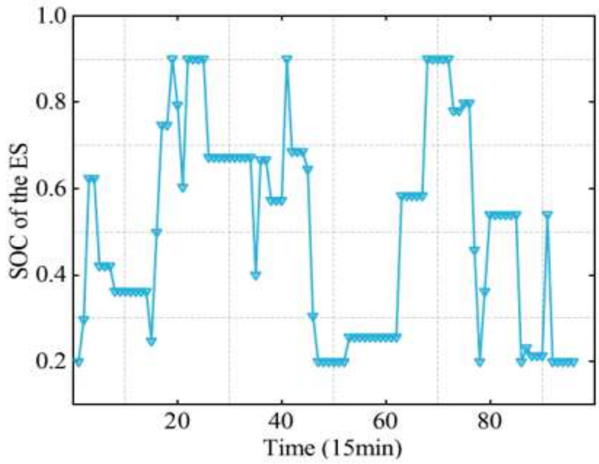

Fig. 8. SOC variation of BESS in different time slots.

The findings indicate that, with the objective of minimizing the economic cost of system energy management, the ESP operates in different sharing modes in different time slots, and both modes can coexist at the same time scale. From the period when the ESP is under energy storage sale model, it can be observed that the power balance requirement of the system is satisfied due to the participation of energy storage devices in the regulation. This is demonstrated by the fact that: during periods with low load demand or high wind power generation, such as 01:00-04:00, the BESS is charged, while during periods with high load demand, such as 10: 00-12: 00 and 18: 00-19: 00, the BESS is discharged to replace some of the output of carbon capture units and meet the load demand. When ESP shares its power lines, it can be observed from Fig. 7 that since the prosumer is a customer equipped with rooftop PV systems, the PV generation facilities cannot produce electricity during the periods of 01: 00-06: 00 and 19: 00-24: 00, the sharing activity cannot be implemented. So P2P transactions among the prosumers primarily occur during the period of 08:00-18:00. Figure 9 shows the net output of the thermal power units and the energy consumption of the carbon capture units. Due to the presence of the solvent storage tank in the carbon capture power plant, the energy consumption of carbon capture units can be adjusted by regulating the solvent inventory. Specifically, during peak-load periods, the energy consumption of carbon capture units is reduced, while during offpeak-load periods, it is increased. This can facilitate wind power integration and improve the flexibility of the system.

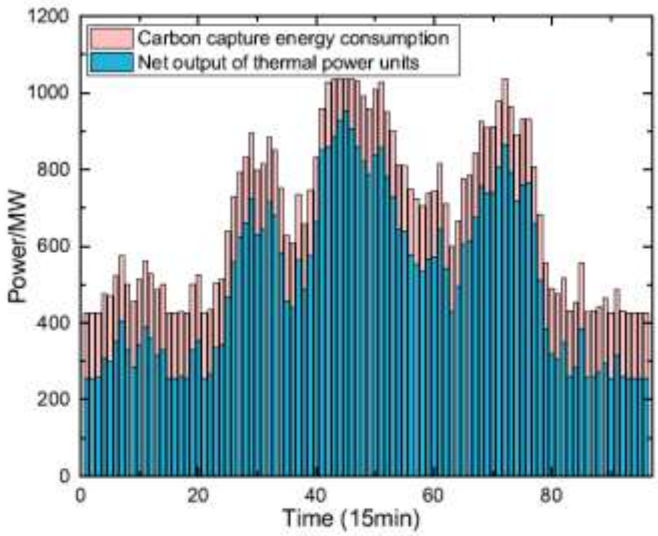

Fig. 3. Net output of thermal power units and energy consumption of car- bon capture units.

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Table I presents the system optimization results in different scenarios. Scenario 1 considers DRs and the installation of carbon capture power plants without shared energy storage devices. While Scenario 2 builds on Scenario 1 by inte- grating shared energy storage devices, resulting in a total cost reduction of $4328. The shared energy storage devices discharge during peak-load periods, and the surplus electricity is utilized by the carbon capture units for carbon capture, leading to a significant reduction of 46.6% in system carbon emissions. The inclusion of shared energy storage devices al- so decreases the wind curtailment rate and improves wind power integration. The ESP can profit from the charging and discharging activities as well as the leasing process, making it a profitable venture for the ESP. With known energy sharing results under power line lease model of ESP, Table II presents the real-time trading strategies between prosumers. Taking the energy sharing during the time period of 07:00-07:15 as an example, as shown in Fig. 7, there is a P2P trading between p1 and p3. The trans- action volume between them is 716 kWh. Based on the known volumes, the trading prices and volumes for both p1 and p3 at each 1-min time scale are shown in Table II , it can be observed that in time slots with higher trading power, the game-based electricity price is lower, while in time slots with lower trading power, the game-based electricity price is higher. Furthermore, P2P trading price of the prosumer 1 and prosumer 3 is always smaller than the electricity price in the real-time market, this is determined by the objective functions of the EP and IP. This greatly enhances the motivation of prosumers to participate in the shared energy storage framework, and improves the consumption of RESs.

TABLE I
SYSTEM OPTIMIZATION RESULTS IN DIFFERENT SCENARIOS

Scenario	Total cost ($)	Carbon emission (t)	Carbon trading cost ($)	Cost of P2P power trading ($)	Wind power consumption rate (%)	ESP profit ($)
1	247476	1067	-124678		89.2	0
2	243148	571	-131904	262	98.1	59375

TABLE II
REAL-TIME TRADING STRATEGIES BETWEEN PROSUMERS

Time slot	Power (kWh)	Price ($/ kWh)
1	60	0.11
2	67	0.09
3	9	0.26
4	68	0.09
5	47	0.16
6	7	0.28
7	21	0.21
8	41	0.15
9	71	0.08
10	72	0.08
11	12	0.25
12	72	0.08
13	71	0.08
14	36	0.17
15	60	0.11

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III. CONCLUSION

This project helps in continuously managing and monitoring the electricity usage of consumers and helps them to conserve the energy. Looking at the benefits the system provides, there is a need to give it a support and implement it on a large scale all across. A simplified tariff structure will make life much easier for the utilities, the supplier and the consumer. This project helps in continuously managing and monitoring the electricity usage of consumers and helps them to conserve the energy. Looking at the benefits the system provides, there is a need to give it a support and implement it on a large scale all across. A simplified tariff structure will make life much easier for the utilities, the supplier and the consumer. This involves creating a sophisticated communication infrastructure where IOT devices can seamlessly exchange information about their power needs, status, and priorities. This approach aligns with the global commitment to address climate change and build a greener future by harnessing technology. Motivated by environmental concerns and the desire to minimize our carbon footprint. This also holds the potential to mitigate environmental impact reduce operational costs, and enhance overall system resilience.

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