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Smart industrial fan monitoring system for the implementation of sustainable development goals

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Abstract

The development of the Fourth Industry is driving the manufacturing industry towards the era of smart manufacturing. In this transformation, various existing equipment, machines, processes, or devices are reinstalled with various sensors, computing, and other cyber-physical systems. In the current era of Industry 4.0, the automotive manufacturing industry continues to move towards sustainable development in a digital process framework so that real-time control and monitoring can be carried out. This study aims to reduce energy consumption and carbon emissions in the automotive manufacturing industry through the implementation of a PLC-based control and monitoring system. This system uses PLC and HMI for Industrial Fan control automation. The methodology used includes collecting energy consumption data through a power meter before and after system implementation, then analyzing the data to evaluate energy savings. The results of the study show that the system is able to reduce energy consumption by 20%, equivalent to savings of 122.66496 kWh per year, and reduce carbon emissions by 10.672 TCO2 per year. The implementation of this system supports energy efficiency and contributes to the achievement of the Sustainable Development Goals target.

Keywords: carbon emissions, energy efficiency, monitoring system, SDGs.

1. Introduction

Originating from the United Nations (UN) policy established in 2015, the Sustainable Development Goals (SDGs) program was agreed upon, comprising 17 goals to achieve a better and more sustainable future. This initiative has been adopted by Indonesia, with the manufacturing industry focusing primarily on SDGs goal number 7 (affordable and clean energy), 12 (responsible consumption and production), and 13 (climate action). In line with this, the Indonesian government has set a policy to accelerate carbon reduction by 31.89% by the year 2030. Industrial Fans are classified as indirect equipment with the highest energy consumption, using 1.1 kW (1100 Watts) per unit, with a total of 140 units in the manufacturing area. This results in total energy consumption of 613,324.80 kWh/year, which is equivalent to 533.59 tCO2/year. As an effort to reduce electrical energy consumption, an improvement has been made by developing an automatic control and energy monitoring system. The objective is to automate the usage time of Industrial Fans and monitor the energy consumption to ensure more efficient energy usage, consistent with the SDGs goal 12 (responsible consumption and production). The manufacturing industry, especially in the welding area, continues to experience a significant increase in energy consumption. The automotive industry's welding division contributes carbon emissions of up to 149 tCO_2 per year. One effective measure to reduce these emissions is to improve energy efficiency, particularly in the use of indirect energy equipment such as Industrial Fans. Based on observations, these Industrial Fans are one of the main contributors to energy consumption in the welding area. This study aims to develop a PLC-based automatic control system connected to an HMI to monitor and control the use of Industrial Fans more efficiently and in real time. This system can minimize energy waste and reduce dependency on human intervention, which is often a source of inefficiency in energy usage. With the implementation of this system, energy savings and reduced carbon emissions can be achieved, aligning with efforts to meet SDGs targets focused on energy efficiency and carbon emission reduction.

2. Methodology

This study employs a quantitative approach through the measurement of energy consumption and the collection of electric current data from Industrial Fans in the welding area. The system consists of a PLC, a ME110SSR-MB power meter, and Node-RED software. The Node-RED software is used to collect real-time data and store it in a MySQL database.

The research was conducted over six months, from January to June, in the welding area of an automotive manufacturing industry. This improvement also ensures energy savings that align with the SDGs targets, particularly SDG 12 (Responsible Consumption and Production). The specific hypotheses proposed are:

1. Reducing energy consumption in Industrial Fans will contribute significantly to achieving the carbon reduction target of 30% by 2030, in accordance with Indonesian government policies.
2. A real-time control and monitoring system based on production hours will ensure more efficient energy usage, aligning with SDG 12 (Responsible Consumption and Production).

Given this, the study holds urgency in designing a PLC-based control and monitoring system for Industrial Fans in the automotive manufacturing industry. The measurement of tCO_2 will be further explained in the results and discussion section (4).

The stages of this study include:

1. Collecting energy data before and after system implementation.
2. Creating and testing programs for PLC and HMI.
3. Testing automatic control systems and real-time monitoring.

3. Result and Discussion

The PLC-based control system implemented in the welding division has succeeded in providing significant energy savings, especially in the use of Industrial Fans. This system works automatically to monitor and control energy usage more efficiently, thus minimizing energy waste and reducing dependence on human error.

Energy Savings

After the implementation of the control system, data shows energy savings of 122,66496 kWh per year or equivalent to 20%. Before this system was implemented, energy consumption in the welding division was quite high, with carbon emissions reaching 149 TCO_2 per year. With the new system, these emissions can be reduced by up to 10,672 TCO_2 per year, resulting in significant carbon reductions. Table 1 shows energy and carbon emissions used by industrial fans. Table 2 shows improvement benefits during 5 year project life time. Table shows material used for improvement. The following can be seen in Table 1.

Table 1. Energy and carbon emissions used by industrial fans

No	Details	Before Improvement	After Improvement	Percentage (%)
1	Amount of energy used	148,685 kWh per year	74,432 kWh per year	50%
2	Amount of carbon emissions	129,4 Tco^2 per year	64,677 Tco^2 per year	50%

Table 2. Improvement benefits during 5 year project life time

No	Item	Amount
1	*Lost Time*	8 jam x 2 *Shift*
2	*Maintenance Industrial Fan*	Once every 2 months (before improvement) Once every 4 months (after Improvement)
3	*Manpower* for *Maintenance*	4 Manpower (before improvement) 2 Manpower (after Improvement)

Table 3. Materials used for improvement

No	Device	Amount
1	MCB 2Phase	1 Pcs
2	Selector Switch	1 Pcs
3	Relay NO	8 Pcs
4	Noise Filter	1 Pcs
5	Power Meter digital	1 Pcs
6	Base Unit PLC	1 Pcs
7	PLC Mitsubishi	1 Pcs
8	Input Module	1 Pcs
9	Output Module	2 Pcs
10	Modul Ethernet	1 Pcs
11	Modul Serial	1 Pcs
12	Power Supply Unit	1 Pcs
13	HMI Mitsubishi + Ethernet Cable	1 Pcs
14	Relay MY4N + Socket	1 Pcs

Reduce TON CO_2

Power 1 unit = 1.1 kW
Current 1 unit = 2.75 A
Usage time one day = 16 hours
Number of Industrial Fans = 16 Unit

Energy consumption per day = Power x Time x Number of Industrial Fan (1)
= 1.1 x 16 x 16
= 281.6 kWh

Energy consumption per year = 281.6 x working days per year (2)
= 281.6 x 255
= 71,808 kWh

Energy consumption per 5 year = 71,808 kWh x working days per 5 year (3)
= 71,808 kWh x 1.275
= 91,555,200 kWh

tCO^2 which is reduced, namely:

$$\text{Emission } (tCO^2) = \frac{\text{Total energy usage (kWh)}}{1000} \times 0.87\,(tCO^2/kWh) \quad (4)$$

=91,555,200 / 1000 x 0,87 = 79,653.024 tCO^2 per 5 years.

So, the carbon emissions that are reduced in five years are: 79,653.024 tCO^2.

4. Conclusion

Smart Manufacture Industrial Fan can be designed and implemented using a PLC scheme or topology integrated with HMI. Development and modification of control on the existing panel has been carried out to add several necessary components. This system allows control in accordance with the specified production time and real-time monitoring of industrial fan energy usage in the pilot research project area. Ultimately, this system can increase energy savings, reduce carbon emissions, and is in line with efforts to achieve SDGs targets that focus on energy efficiency and carbon emission reduction.

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