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Enhanced Sizing Methodology for Renewable Sources and Battery System in a Nearly Zero Energy Building



Abstract: - This work aims to offer a new approach to determining the optimal amount of energy stored in batteries and other RES systems (BSS) for transforming a traditional residential building into a nearly-Zergy-Energy-structure (nZEB). This is accomplished by taking the building's location's weather history into account, as well as the efficiency of the building's appliances and mechanism for managing energy use. All of the above are parts of a cost function that takes into account the factors that have a major impact regarding the size and longevity of the RES and BSS in a nZEB. Some of these factors include the rate of feed-in and self-consumption, the influence of discharge power and measure of depth-of-discharge on the state-of-health (SoH) of the BSS, the rate of wear and tear on the original expenditure, and the simultaneous generation and consumption of energy. Thus, taking into account both the economic and efficacy aspects allows when it comes to the best RES and BSS sizes to be reached. Installing solar panels, making batteries, and buying power from the grid all work together to reduce the previously mentioned cost function. To make the model more adaptable on behalf of the building's desire to pay for environmental damages, we've introduced an adjustable parameter. For this, the genetic algorithm method is employed. A pilot nZEB has confirmed the practicality, ease of use, and efficacy of the suggested method.

Keywords: PIC 16F886 microcontroller, solar panel, battery, relay.

1. INTRODUCTION

By combining cutting-edge energy storage and management strategies with alternative power sources like solar and wind power, this article aims to create a sustainable energy system for almost zero-energy buildings [4]. By transferring electricity from renewable sources to the grid via wireless power transmission, the method lessens dependency on traditional energy infrastructures [5]. In order to control and maximize energy flow, it 3 integrates elements including solar panels, wind turbines, rechargeable batteries, and a microprocessor [6]. Utilizing wireless energy transfer, the study seeks to improve system performance, encourage environmentally friendly electricity options and help create a more sustainable and clean energy future.

2. LITERATURE SURVEY:

Developing an intense but scalable problem formulation for PV and BES optimum sizing in ZEBs is the most critical research demand, according to the literature evaluation [7]. The fact that BES and PV systems both have an effect on the environment, mostly during manufacturing, is an overlooked part of the research [8]. Moreover, the combination of power-supplying technologies (such as coal, nuclear, hydro, solar, wind, etc. determines whether grid electricity has negative environmental impacts [15]. Emissions of carbon dioxide as well as other types of greenhouse gases are the most often recorded lifecycle indicator in the European Union (EU) since reducing global warming is a primary environmental priority. Concerning material needs and land utilization in

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particular, decarbonizing the electricity industry may entail trade-offs [16, 17]. Additional investigation is required to determine how to account for the situation's impact on the environment. This study addresses two gaps in our knowledge: first, that prior writers solely central to BES optimum sizing with an emphasis on profit [10], and second, that this study takes environmental impacts into account when determining the ideal PV and BES system sizes [11]. The main innovation of this paper is an improved modeling the mathematical aspects of optimum PV and BES scaling issue [12] that can handle large-scale planning challenges while still meeting the ZEBs criterion. The current models might be enhanced if, instead of selling extra power to the grid, it was required to be stored in the battery. An interesting new feature is that it accounts for the environmental implications of generating PV and BES systems and grid power purchases using an adjustable parameter that statistically assesses the building owner's environmental concern-related willingness to pay. Using both business and residential buildings in India, the method's efficacy is quantified.

3. BLOCK DIAGRAM

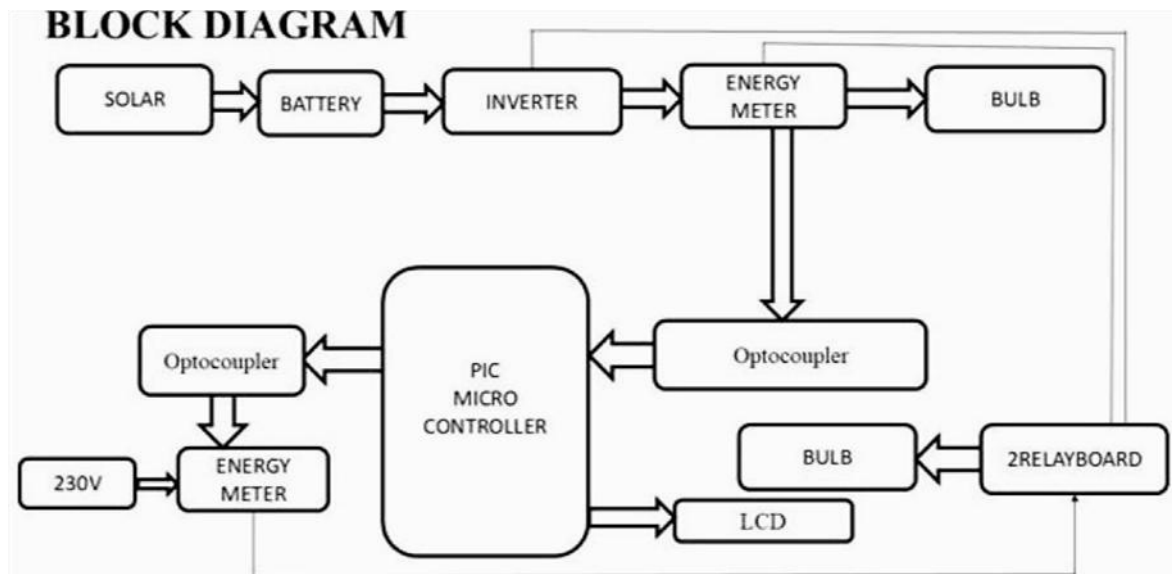


Fig.1 Block Diagram

4. PROBLEM FORMULATION

Figure 2 displays direction of electricity flow in the ideal PV and BES size model, which can simplify the issue formulation. To start, an issue involving mixed-integer nonlinear programming [13] represents the ideal PV and BES size. Then, to combine all nonlinear components into one bilinear time limitation period, the MINLP model is painstakingly and cleverly rebuilt. Lastly, paradigm that is scalable and uses mixed-integer linear programming is constructed by linearizing the McCormick relaxation applied to the bilinear rule approach.

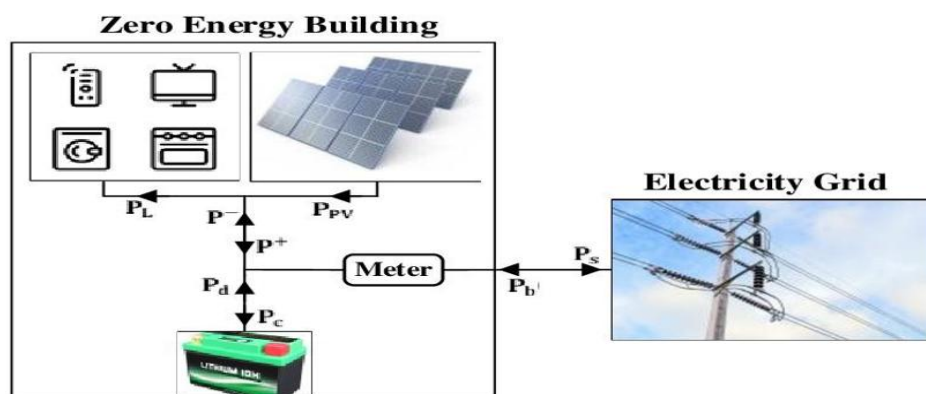


Fig.2 Zero energy building power flow directions

the desired outcome of solving the optimal PV and BES sizing equation. Profit from selling power to the grid, operating and maintaining the PV system, buying and maintaining battery storage, and how much it will cost to acquiring power from the grid are the four terms that make up this calculation [14].

The active power excess at time interval b may be represented as (3) and the deficit as (4), respectively, using binary variables. The PV output per unit and the electric power demand at time interval b are represented by parameters (b) and $RX(b)$, respectively. If there is an excess of active power at time interval b , the binary variable $I+(b)$ is equal to one; otherwise, it is equal to zero. Similarly, when there is an active power deficit at time interval b , the binary variable $I-(b)$ equals one, much as

$$\min \{ CRF(i, n). (I_{ninitial} + I). C_b + CRF(i, n). (I + I_{O\&M}). C_{pv} + \Delta t. (\sum P_b(t). EP(t) - \sum P_s(t). FIT(t)) \} \quad \forall t \quad (1)$$

Electrochemical changes, which are permanent, cause a battery's performance to decline with time. This includes an increase in internal resistance, a decrease in capacity, and an erosion of efficiency. Here, we take into account the performance degradations of PV and BES systems as operating and maintenance expenses, which change linearly on the optimal sizes. For instance, according to [19], a more comprehensive model of performance degradations grounded in physical principles could be required for model predictive control of Lithium-Ion batteries. It is anticipated that the interest will cover the initial investment cost of the PV and BES systems, including any converters that may be required [20].

In the same vein as the warranty periods for PV and BES systems, the rate is i for n years. Therefore, the capital recovery factor (CRF) is given by The second one is [21].

$$CRF(i, n) = \frac{i(1+i)^n}{(1+i)^n - 1} \quad (2)$$

Two binary variables, (3) and (4), are required to describe the surplus and deficit of active power at time interval b , respectively. The electric power demand at time interval b and the PV output per unit are denoted by parameters (b) and $PL(b)$, respectively. Assuming that an excess of active power at time interval b , the binary variable Unless a is 0, $I+(b)$ is one. Similarly, if there is an active power deficit at time interval b , the binary variable $I-(b)$ equals one; otherwise, it equals zero. The positivity of the continuous variables $P+(b)$ and $P-(b)$ is explained by constraints (5) and (6), while constraint (7) states that there can be no coexistence of excess and deficiency of active power at any time interval b .

$$P^+(t) = (\alpha(t). C_{PV} - P_L(t)). I^+(t); \quad \forall t \quad (3)$$

$$P^-(t) = (P_L(t) - \alpha(t). C_{PV}). I^-(t); \quad \forall t \quad (4)$$

$$P^+(t) \geq 0; \quad \forall t \quad (5)$$

$$P^-(t) \geq 0; \quad \forall t \quad (6)$$

$$I^+(t) + I^-(t) = 1; \quad \forall t \quad (7)$$

Table I lists the four potential statuses for each time interval. Four binary variables often yield $2^4 = 16$ possible outcomes. Constraint (7), however, eliminates eight impractical options. The remaining four impractical options are eliminated by constraints (8) and (9) and the feasibility area is established in accordance with Table I's intended state.

$$I_{max}(t) \leq 2 \times I^+(t); \quad \forall t \quad (8)$$

$$I_{min}(t) \leq 2 \times I^-(t); \quad \forall t \quad (9)$$

TABLE I MEANING OF THE FOUR POSSIBLE STATUSES FOR EACH TIME INTERVAL

Status	I+	I-	I _{max}	I _{min}
1	There is too much active power and the battery's capacity is not enough to hold it all.	0	1	0
2	Excess of active power exists and the available capacity of the battery is sufficient to fully store it.	0	0	0
3	Deficit of active power exists and the available energy of the battery is insufficient to fully supply it.	1	0	1
4	Deficit of active power exists and the available energy of the battery is sufficient to fully supply it.	1	0	0

Table 1: MEANING OF THE FOUR POSSIBLE STATUSES FOR EACH TIME INTERVAL

Two examples of linear constraints are the zero-energy restriction (constraint 8) and the limiting of environmental influences (constraint 9). As per (8), the annual power sold to the grid must be equal to or less than the annual electricity purchased from the system. The total environmental impact of producing BES and PV systems and utilizing grid electricity is constrained by constraint (9), where the parameter $aQ(e)$ represents the cost of environmental effect e in Pt/kWh. To find a middle ground between environmental impacts and economic goals, numerical case studies will reveal that EIM_{max} is a modifiable parameter. Think about how much the building owner is ready to pay to fix environmental issues before making a final decision.

This environmental restriction includes the so-called "midpoint" lifetime indicators, which include things like "land use," "eutrophication," "particulate matter emissions," "climate change," and "human toxicity." Use of a single-score indication to represent the environmental strain of different power production systems was made in a recent effort to include environmental indicators into system optimization issues [22].

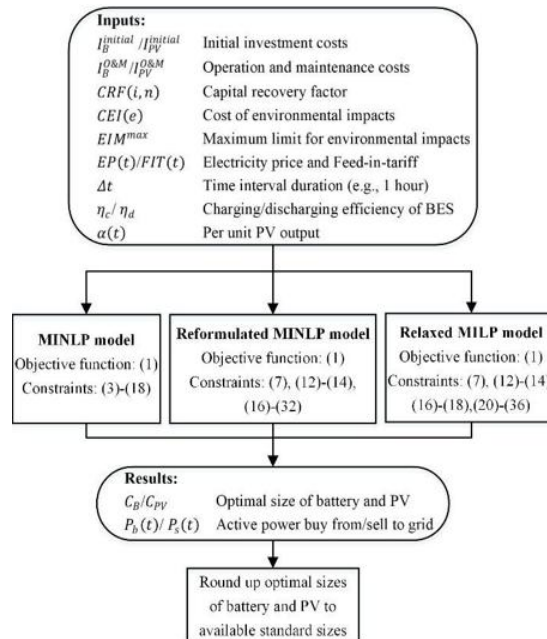


Fig. 3 A flowchart of the proposed models.

A. Quantitative Findings with Environmental Effects:

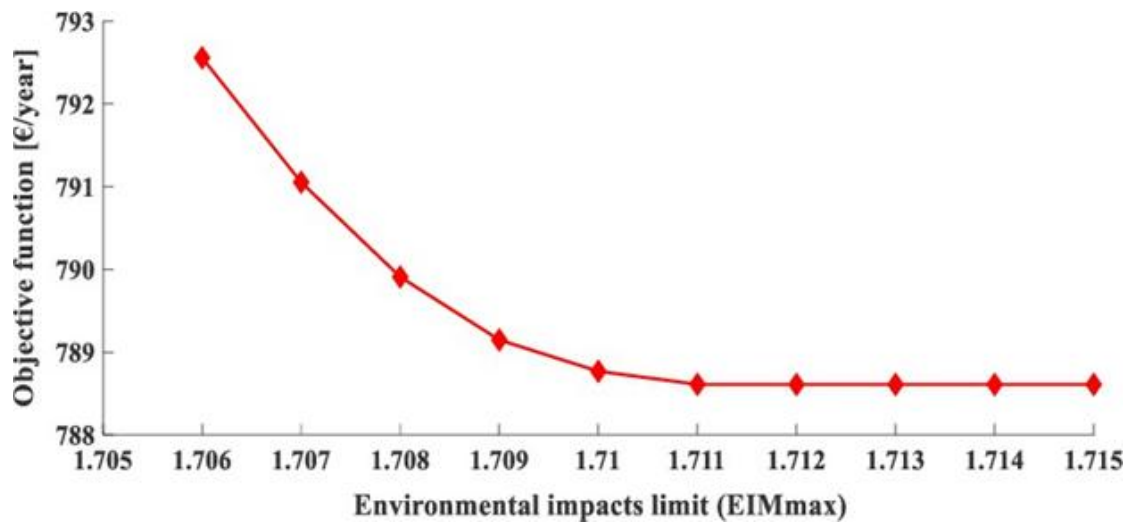


Figure 4 shows the suggested model's sensitivity to the environmental effect restriction for a scenario with 365 intervals.

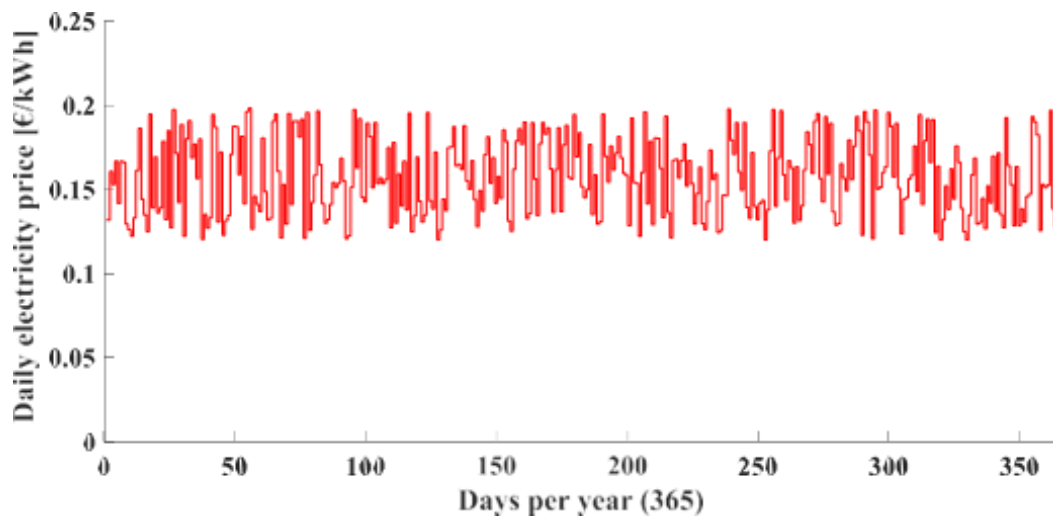


Fig.5 SOC of the battery for the case of 365 intervals.

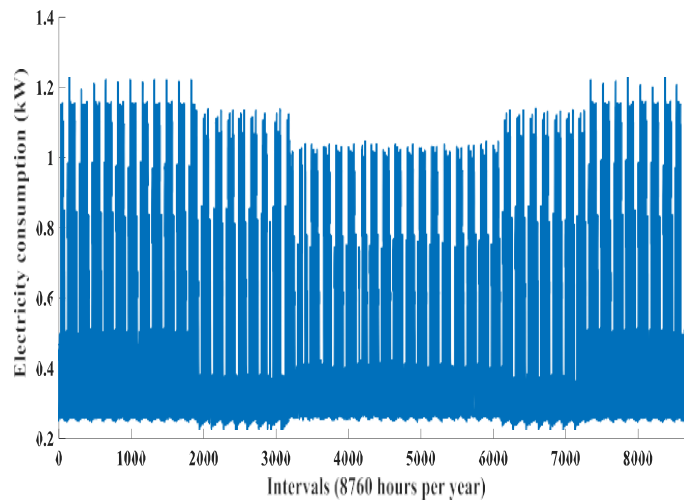


Fig.6 Hourly electricity consumption of the commercial building.

5. RESULT:

The paper's findings show how solar and wind energy may be successfully combined to produce power, which is then wirelessly delivered to the grid and effectively stored in rechargeable batteries. With real-time energy flow monitoring and control via the PIC microcontroller, the system runs smoothly. Without requiring physical hookups, wireless power transmission efficiently supplies energy to the grid, guaranteeing convenience and safety. Furthermore, when renewable output surpasses demand, excess energy is returned to the federal grid, promoting sustainability and energy efficiency. By developing a practically zero energy construction system, the article effectively lessens reliance on non-renewable energy sources.

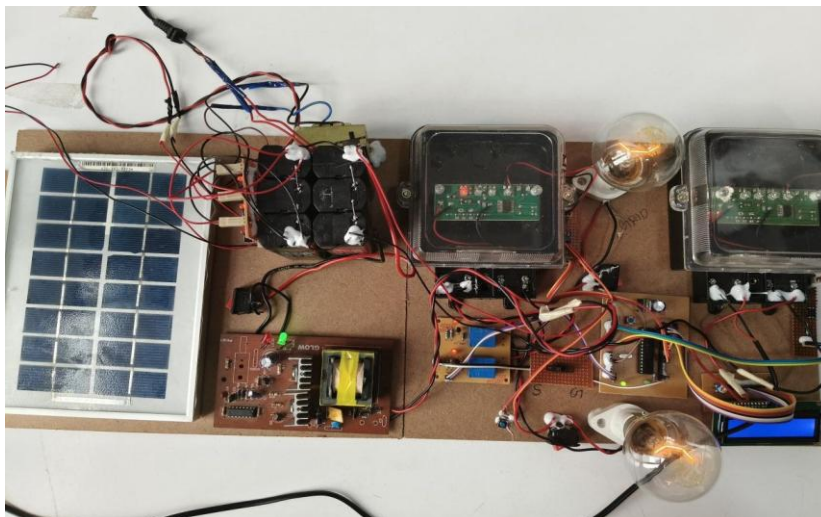


Fig.9 Prototype

6. CONCLUSION:

An efficient, economical, and sustainable way of energy management is offered by the creation of an improved sizing technique for battery storage and renewable energy sources in virtually zero energy buildings (nZEBs). The suggested methodology guarantees an ideal balance between energy generation, storage, and consumption while lowering grid reliance by combining sophisticated optimization techniques, real-time energy management tactics, and predictive control algorithms. The technique improves the overall performance, dependability, and economic viability of nZEBs through data-driven decision-making, intelligent demand-side management, and hybrid energy systems. Long-term sustainability, increased self-sufficiency, and a reduction in peak demand are made possible by the optimal size of battery storage and renewable energy systems. The feasibility of this strategy is further supported by the economic and environmental impact assessment, which shows a lower carbon footprint, cheaper operating expenses, and a higher return on investment (ROI). The usefulness of the suggested technique is validated by the outcomes of simulation and real-world case studies, demonstrating its potential for broad use in upcoming nZEB articles. To sum up, our study supports the worldwide shift to resilient, sustainable, and energy-efficient building systems, which is in line with the objectives of mitigating climate change. To sum up, this work supports the worldwide shift toward resilient, sustainable, and energy-efficient building systems, which is consistent with the decarbonization of the built environment due to climate change. To further improve system efficiency and flexibility, future studies can investigate the integration of cutting-edge technologies like AI-based energy forecasting, smart grid connection, and second-life battery applications. The implementation of the paper has been successful. As a result, the paper's design and testing were successful. e mitigation objectives and assisting in the built environment's decarbonization. Future studies can examine how cutting-edge technology like smart grid connection, AI-based energy forecasting, and uses for second-life batteries to increase system flexibility and efficiency. The implementation of the paper has been successful. As a result, the paper's design and testing were successful.

6.1 FUTURE SCOPE:

Expanding the use of wireless power transmission in larger-scale renewable energy systems, such as smart cities or industrial complexes, is part of this paper's future scope [21]. Energy loss might be further decreased and system dependability increased with improvements in wireless transmission efficiency and energy storage technology. Additional opportunities are provided by integration with electric car charging systems, which might charge EVs using excess renewable energy. Future advancements may also concentrate on enhancing the system's scalability, which would enable more adaptable and extensive usage across several industries. Furthermore, improvements in IoT-based monitoring and energy management software might maximize energy use [22] and improve grid and building sustainability.

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