Optimization of Hybrid Renewable Energy Systems (HRES) Using PSO

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Abstract- Present paper aims to discuss scope and limitations of photovoltaic solar water pumping system. Components and functioning of PV solar pumping system are described. In addition, review of research works of previous noteworthy researchers has also been done. Irrigation is well established procedure on many farms in world and is practiced on various levels around the world. It allows diversification of crops, while increasing crop yields. However, typical irrigation systems consume a great amount of conventional energy through the use of electric motors and generators powered by fuel. Photovoltaic energy can find many applications in agriculture, providing electrical energy in various cases, particularly in areas without an electric grid. This thesis proposes a single stage grid interactive solar powered switched reluctance motor (SRM) driven water pumping system with an efficient control technique. The control of proposed system provides the proficient maximum power point technique (MPPT) tracking and motor drive control with bidirectional power flow between the photovoltaic (PV) array and single phase grid. It has harmonics components elimination, improved dynamic performance and a DC offset rejection capability compared to other control. A PV feedforward term is also incorporated in developed control to enhance the dynamic performance of the system and to minimize the size of DC link capacitor with improved MPPT performance. The novel scheme of fundamental switching of SRM drive over its maximum operational time (when the grid is present) makes system efficient and reliable. An improved perturb and observe (P&O) based maximum power point tracking (MPPT) algorithm is used in this system to minimize the undesirable losses in a PV array specially under varying insolation levels. The proposed control is tested on a developed prototype and its suitability is authenticated through simulated and test results under various conditions.

Keywords- PSO, Wind, Solar, Battery, Load.

I. INTRODUCTION

World electricity demand is rising steadily at twice the rate of overall energy usage. The challenge is to meet the rising demand with decelerating fossil fuels and rising fuel prices. As reported by the World Energy Council, the world primary energy demand increased about 26% in the past decade and the electricity demand alone is predicted to rise about 81% with 40000 TWh of electric energy by 2040. About 70% of this growing energy demand will be from the developing countries like India and China.

This huge power and energy requirement cannot be met by conventional sources alone. Coal and Natural Gas reservoirs are facing rapid depletion and are also less favorable for environmental health.

Thermal power generation using coal is a major contributor to carbon-di-oxide and other greenhouse gas emissions which contribute to global warming and ozone depletion. Nuclear power provides about 11% of the world's electricity and is also proclaimed to be a benign source of electricity with cheaper operating costs.

However, dangers of exposure to radioactive fuel and wastage disposals are serious issues that need to be addressed. Hazardous emissions occurring due to accidental meltdown, poor handling of radioactive waste, improper cooling etc. may lead to devastating effects on plant, animal and human life in the surroundings.

Oil is still a limited energy source with prices rising day by day. Also a majority of oil reserves is concentrated only in certain regions and large scale energy dependence on fuel imports cripples a nation's energy strategy.

As economic development of countries is fueled by their energy reserves, developed and developing countries alike will be competing for limited sources of energy. Conventional method of production of electricity included energy delivery from the point of generation to consumers through a centralized system.

These centralized power stations are usually major sources of water and air pollution. Moreover, when situated at long distances from the target consumers, the system needs to bear heavy losses in transmission and distribution of electric power.

All these factors have urged the world governments to look for alternative sources of energy to meet future demands and combat environmental degradation. Many government policy measures and financial motivations are being provided to drive down the investment and operation costs of renewable.

Abundant availability of renewable sources in India enables to strengthen its energy portfolio by reducing the dependence on imported fossil fuels. Hydro, Solar and Wind are the three prime pillars of renewable energy generation in the world today.

Hence, more focus is on development of Solar and Wind power generation in India to power up the increasing energy demands. Both these technologies have witnessed tremendous developments across the globe and are characteristic of abundant availability, distributed as well as local generation and low/no emissions. They are explored in detail in the following sections.

With its geographical location India is bestowed with immense solar power which can be harnessed extensively to generate electric power for domestic and industrial applications. India is one of the leading investors in development of solar energy. By 2005, India was generating 6.40 MW per year and since then additions have been made to the installed capacity and the generation is increased to 7.5 GW in 2016. In January 2015, the Indian Government imposed new plans targeting investments of about $100 billion for 100 GW of solar energy capacity by 2022.

With the introduction of Jawaharlal Nehru Solar Mission which is a part of National Action Plan on Climate Change, several allotments for Independent Power Producers are being planned which is expected to boost up development of solar power projects all over the country.

Remote Indian villages are still villages are still deprives of power and hence form an excellent platform to implement solar power for energizing these parts and avoiding additional costs of establishing new transmission networks. With Indian climate being a boon to develop solar energy, the country is expected to lead the world in PV installations.

Today India is the leading country in terms of solar power generated per watt installed. Moreover government has also taken many initiatives like Renewable Energy Certificates, accelerated depreciation, capital subsidies etc. [7-10]

II. RELATED WORK

Su Xiang Jing Su sns. (2020) In order to improve the performance of unbalanced energy distribution networks and solve the battery power system design (BESS) and the integration of rooftop solar (PV) systems, the research proposed a follow-up strategy. Two-step optimum control, combined with advanced BESS control and real -time control. Specifically, multiple goal improvement models for the previous day were first proposed.

Their targets are power loss, power reduction, load curve deviation and VOF deviation. The direct current method (DLF) and the particle optimization (PSO) algorithm together solve the BESS configuration problem mentioned above. For this reason, given the shortage of BESS and PV converted power, real-time QV monitoring is carried out to deal with local power outages caused by load-bearing faults. and prophecy.

Zeng Xiaohua et al. (2019), Compared to batteries, such as power storage devices for mixed electric vehicles (HEVs), supercapacitors have higher density and longer lifespan. However, when supercapacitors with power levels rather than batteries are used, fuel consumption becomes more susceptible to particle changes because the power supercapacitors store less energy and the state (SOC) is now more sensitive. In this article, the control parameters of a hybrid vehicle with supercapacitors are verified to obtain better fuel economy.

First, a mixed-power vehicle model and similar control strategies are implemented in the MATLAB scripting environment to facilitate the analysis and implementation of the optimization algorithm. Second, depending on the characteristics of the SOC, there are three main control parameters, and the effect on fuel consumption will be verified. Third, a proposed energy efficiency optimization (IPSO) algorithm has been developed, which overcomes the shortcomings of optimizing the plot that belongs to "local optimization" and improves the efficiency of the optimization. In order to fully exploit the fuel economy of a mixed car, the fuel distribution is also considered.

IPSO is used to improve the three major control parameters during the cycle of a passing vehicle. Finally, the best results are applied to hardware-in-the-loop testing to verify the effectiveness of the proposed optimization method. Compared to fuel consumption before the upgrade, urban fuel storage reached 9.20%, vehicle parts fuel storage reached 6.40%, and car parts reached 5.40%. Instead, the fuel storage system of the road section [1-10]\

III. PROPOSED METHOD

The plan takes into account the power fluctuations during grid-connected operation of the microgrid and quantifies the economic benefits of hybrid energy storage. A multi-

objective function with the aim of minimizing the power fluctuations of the DC bus in the Microgrid and optimizing the capacity ratio for each energy storage system in the hybrid energy storage system (HESS) is established.

The enhanced particle swarm optimization (PSO) is used to solve the objective function, and the solution is used on microgrid's experimental platform. By comparing current fluctuations from batteries and supercapacitors in HESS, it directly reflects the current distribution. Compared to the traditional hybrid energy storage management strategy, the optimized hybrid energy storage management strategy.

This work proposes an energy storage system based on a hybrid energy storage system to smooth out the fluctuations in wind and solar energy. The main objective of the proposed method is to find the power and energy capacity of the hybrid energy storage system in order to minimize the total daily costs for all systems. The energy management strategy used in this work is designed as a two-level energy distribution scheme: the first level is responsible for setting the output power of the hybrid energy storage system, and the second level controls the current between the battery and the utility point connection.

Taking the micro-lattice island model as a research object, a mathematical model is established for optimizing hybrid energy storage. For the control parameter problem of energy management strategy, a hybrid parallel particle swarm optimization algorithm is proposed. In addition, the proposed method uses a piecewise adjustment function to describe battery life. The results obtained show that the hybrid energy storage system, which uses the proposed energy management strategy, can provide the best performance of the wind power system in terms of cost and service life.

Renewable energy sources such as wind and solar cells can be added to some buses to solve the voltage collapse in the electrical system caused by the increase in load. This option can reduce electricity generation costs and improve system efficiency and reliability. This article introduces an enhanced smart technology using Particle Swarm Optimization (PSO) to select the best hourly trend for renewable energy [15]

Renewable energy sources such as wind power and solar energy have strong volatility and intermittency, and hybrid energy storage plays an important role in the flow balance of microbalances and the stable current fluctuations of renewable energy.

With regard to the isolated mode of operation of the microgrid, such as wind power, photovoltaic systems, variable load, etc., a method for optimal allocation of hybrid energy storage capacity is proposed. A mathematical multi-objective optimization model is proposed based on the charging and discharging power and state of charge (SOC) of the energy storage medium with the lowest average annual cost of renewable energy and least fluctuations.

A power correction strategy designed for the situation where the remaining capacity of the energy storage medium is too low or too high. Finally, the rationality and efficiency of the proposed method are verified by MATLAB programming.
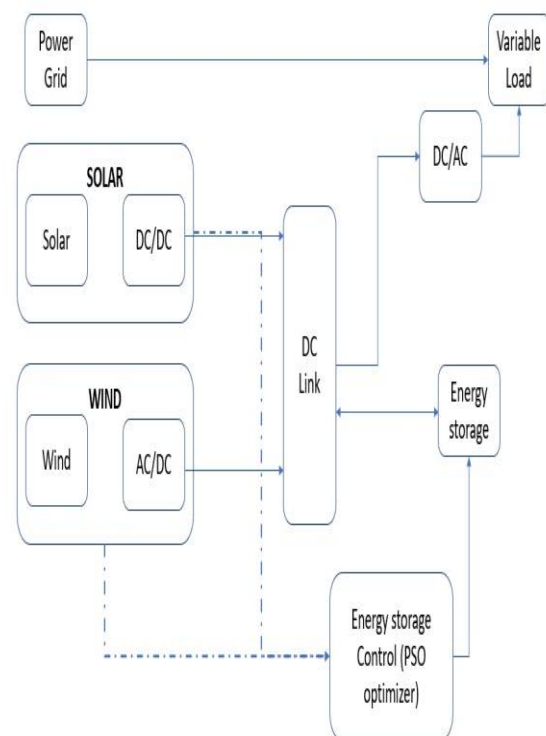

Fig 1. Flow chart.

IV. SIMULATION RESULT

1. With optimization:
The energy storage system makes it more stable on the time scale and the power scale. The high frequency oscillating power is compensated by the Supercapacitor and the low frequency oscillating power is compensated by the lithium battery. However, the coincidence of hybrid energy storage and emissions caused by the intermittent electricity production of wind and solar energy may cause the SOC to approach the limit, leading to insufficient charging and emission capacity available for the next time.

Therefore, the power command value must be corrected. This section uses composite energy storage in island mode to stabilize wind power fluctuations as an example. The current distribution and correction structure of the composite energy storage system is shown in Figure 4.2**.**
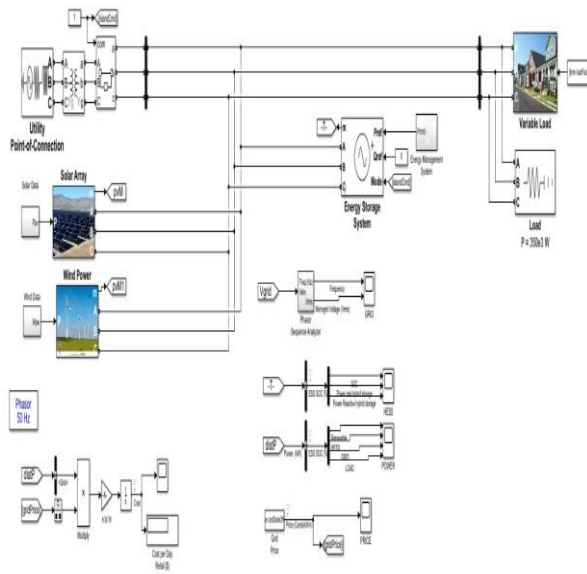
Fig 2. Proposed Simulink Model with Optimization.

2. Grid-Connected Solar Array:

This block models a grid-connected solar array using the Three-Phase Dynamic Load block. This is a system-level model that does not contain any power electronics, but is useful for load flow, phasor, and hybrid phasor-EMT simulations. The input to this block is the power output of the grid connected PV array, not irradiance.

For more detailed PV models, consider the PV Array block in the Renewable library. Consider using this PQ Model to perform load flow studies and switch to a more detailed model when full EMT studies are required.

Table 1. Simulink Parameter For Solar System.

Nominal L-L Voltage [Vrms]	5000
Nominal Frequency [Hz]	60
Initial Power [W]	500_e3

Table 2. Simulink Parameter For Solar System.

Phase-to-phase voltage (Vrms)	(13800)*1.00243
Phase angle of phase A (degrees):	0.071468
Frequency (Hz):	50
3-phase short-circuit level at base voltage(VA)	250e6
Base voltage (Vrms ph-ph):	13.8e3

3. Energy Storage Block:

The power storage block models a generic grid-connected energy storage system (ESS), most normally a battery system. This is a system-level model that does not contain any power electronics, but is useful for load flow, phasor, and hybrid phasor-EMT replication. The effort to this block is the commanded active or reactive power of the ESS.

The ESS is assumed to have operations. The Mode Input dictates what high-level operation the ESS has: current control (Mode = 1) or voltage control (Mode = 0). Current control is ideal for a grid connected system where you need to specify P,Q commands. Voltage control is necessary if the ESS will be the only system supporting the microgrid in islanded mode. For more detailed ESS models, consider the battery block in the Drives library. Consider using this PQ Model to perform load flow studies and switch to a more detailed model when full EMT studies or more advanced controls are required.

Table 3. Simulink Parameter For Solar System.

Nominal L-L Voltage [Vrms]	5000
Nominal Frequency [Hz]	60
Rated Power [kW]	400
Rated Capacity [kWh]	2500
Overall System Efficiency [%]	96%
Upper/Lower Charge Limits [%]	[85 19]
SOC to Recharge [%]	11
Recharge Rate [% of Rated Power]	50

Table 4. Simulink Parameter for Solar System a three-phase series RLC load.

Nominal phase-to-phase voltage Vn (Vrms	5000
Nominal frequency fn (Hz):	60
Active power P (W):	350e3

The Variable Load block is a lumped approximation for a distribution feeder. For non-unity power factor loads, the input (active power) is range accordingly to produce a beloved load.
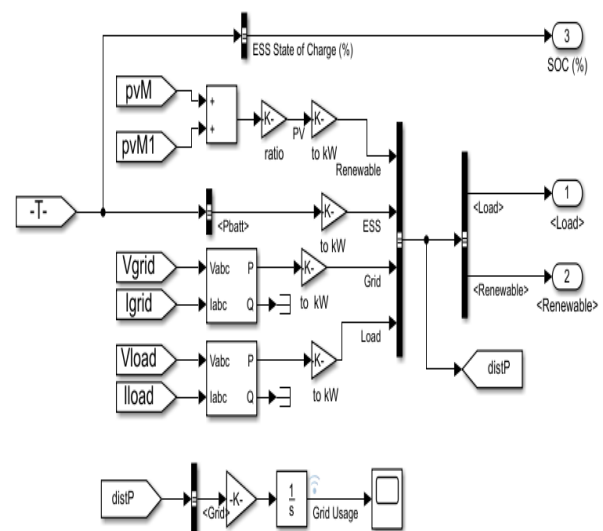

Fig 3. Optimization control.

4. Mathematical Model for Optimal Configuration of Composite Energy Storage System:

Optimal allocation target function Capacity optimization targets include economic targets and technical targets. The hybrid energy storage optimization targets proposed in this paper mainly include the lowest average annual costs throughout the life cycle and the fluctuations in renewable energy during the dispatch period.

4.1. Objective functions: After fitting, an improved particle swarm algorithm is used to solve the objective function. The calculation process is as follows:

- **Step 1:** Initialize the algorithm, enter the constraint conditions according to the mounted objective function, and calculate the suitability of the multi-objective function of each particle;
- **Step 2:** Determine the suitability of each particle's multi-objective function within the range of possible solutions, and find g best and p best according to the initial value;
- **Step 3:** Calculate the position and velocity of each particle in the next iteration according to the particle velocity and position update formula, and recalculate the suitability of each particle;
- **Step 4:** Find out if the conditions for stopping iteration are met, such as reaching the accuracy requirements or reaching the number of iterations. If it is not reached, select a new p best, g best is selected from it, and step 3n is performed again. If it reaches the stop iteration mode, stop the loop;
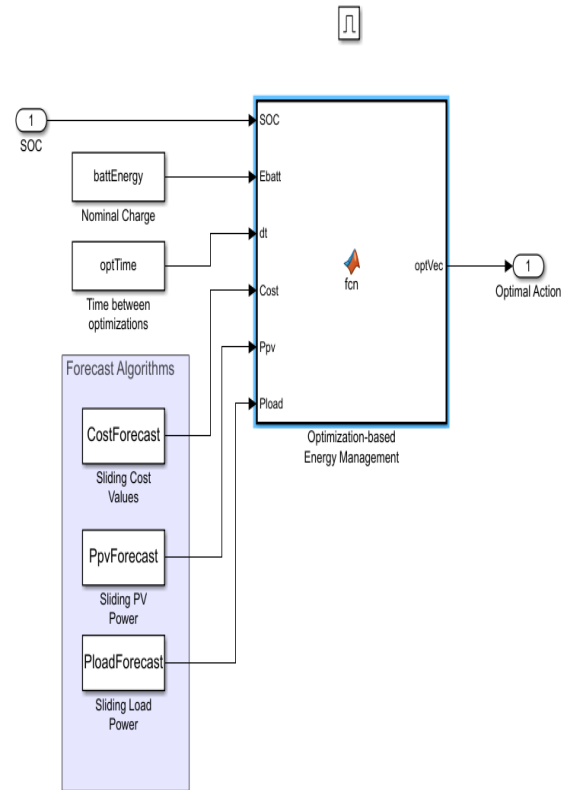
4.2 Optimization function:

It can also run without storage system, that is not in this process Optimizer is not activate in without optimizer, check the block optimizer mode is 0 in without with optimizer it will be 1.

Fig 5. Optimization based Energy Management.

5. Power Allocation and Correction Strategy for Composite Energy Storage System:

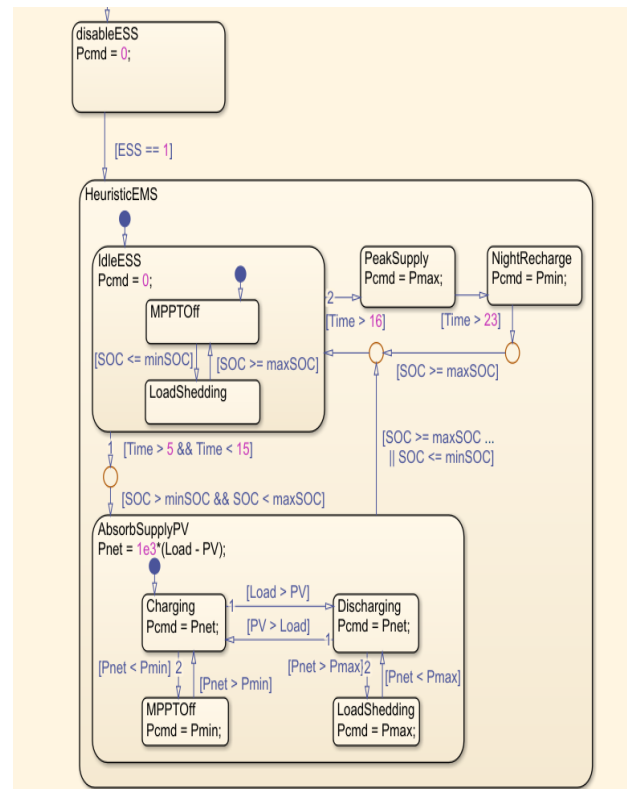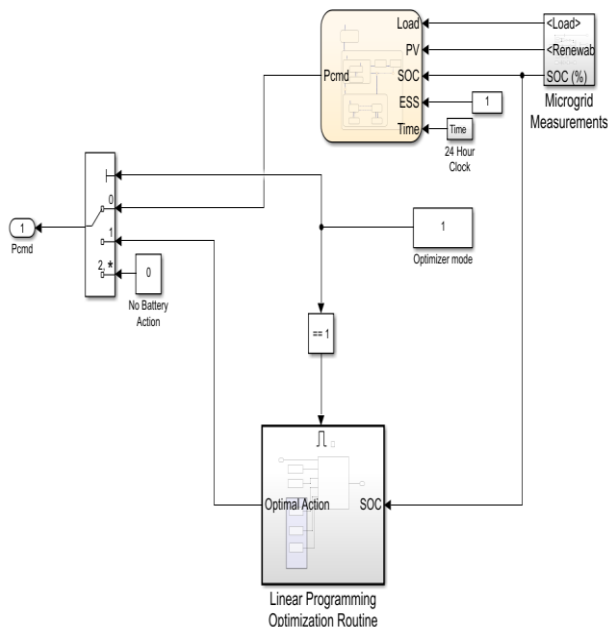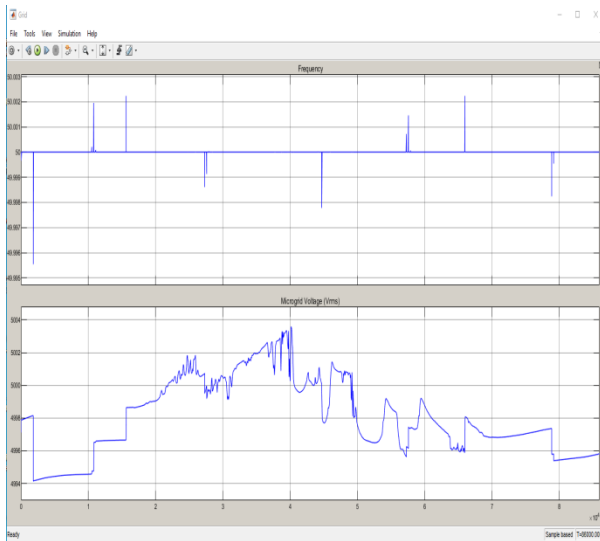Fig 6. Energy Storage System Flow.

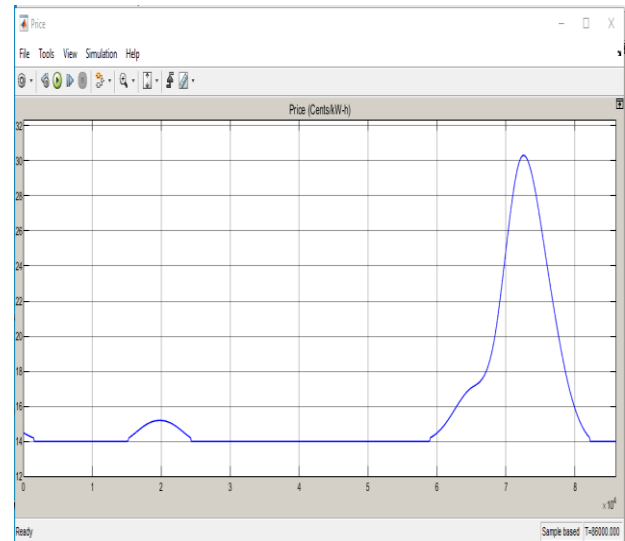Fig 7. 50 H$_z$ frequency, micro grid voltage (vms).
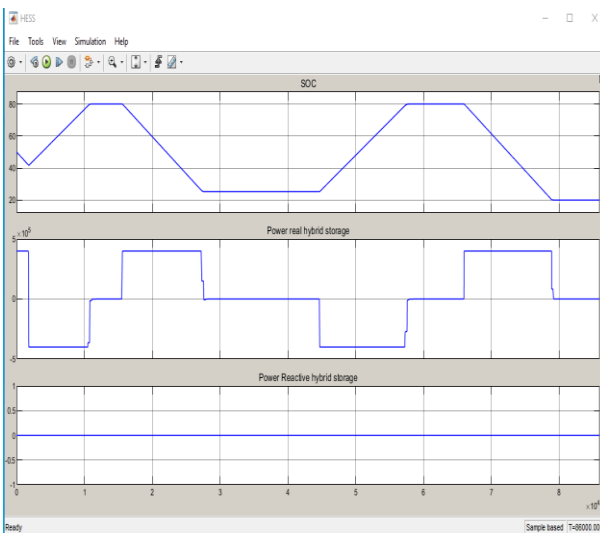

Fig 10. Fig Price after optimizer.

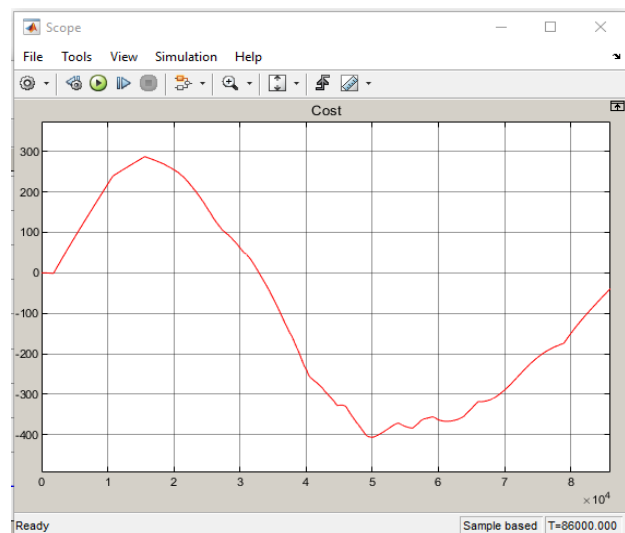Fig 8. Energy storage performance.

Fig 11. Fig Price after optimizer.

6. Without Optimization:
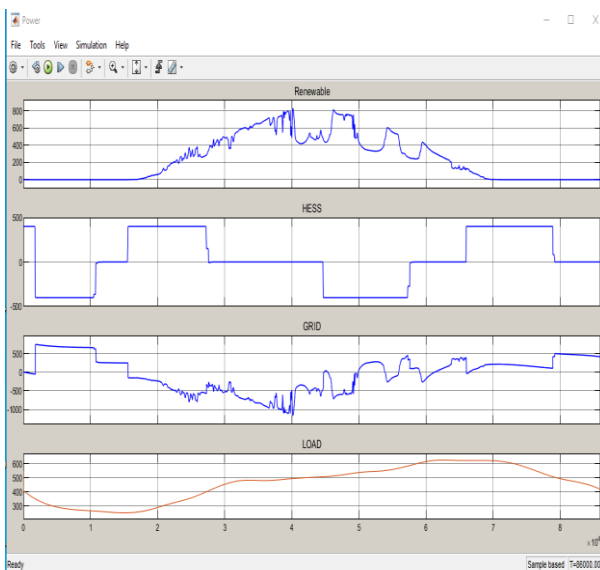

Fig 9. Grid, HESS, Grid, Load Voltage.
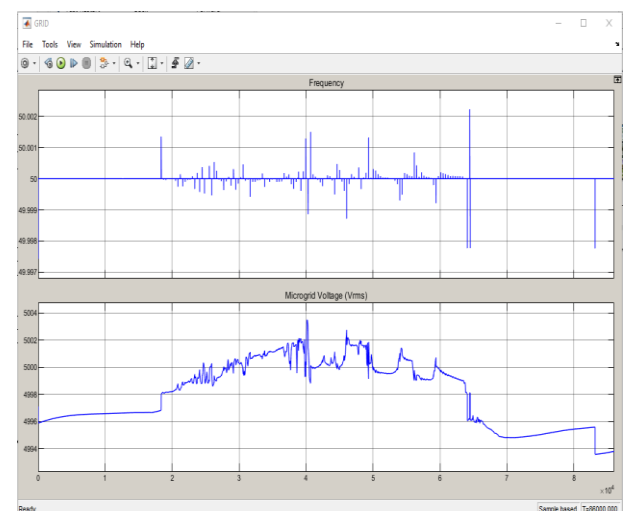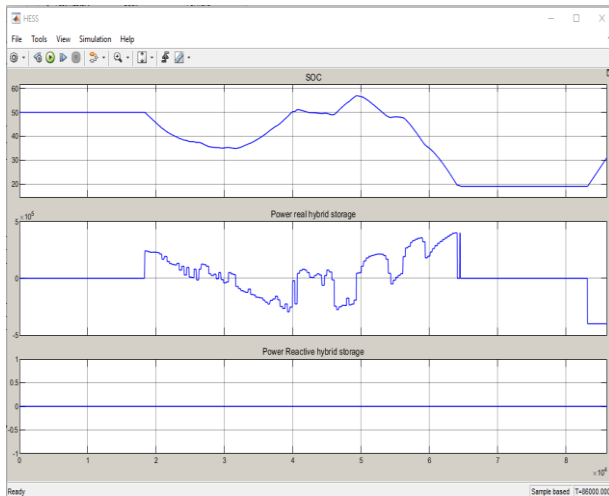

Fig 12. Micro grid voltage.
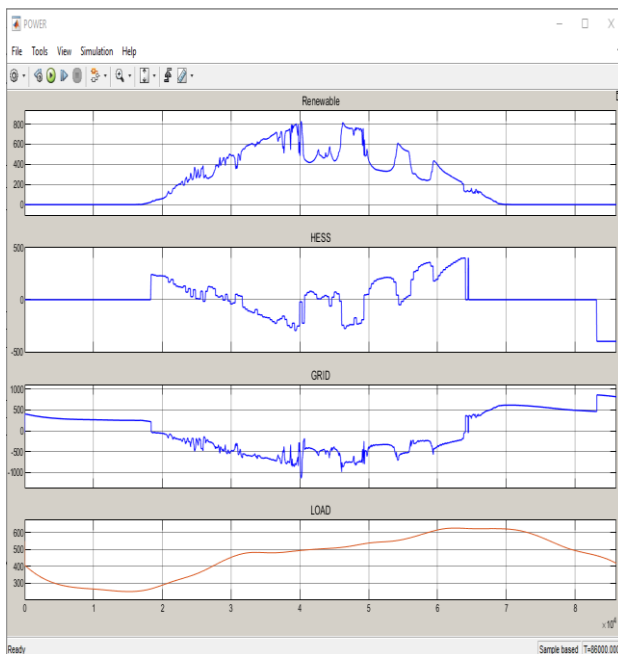
Fig 13. Energy storage performance.

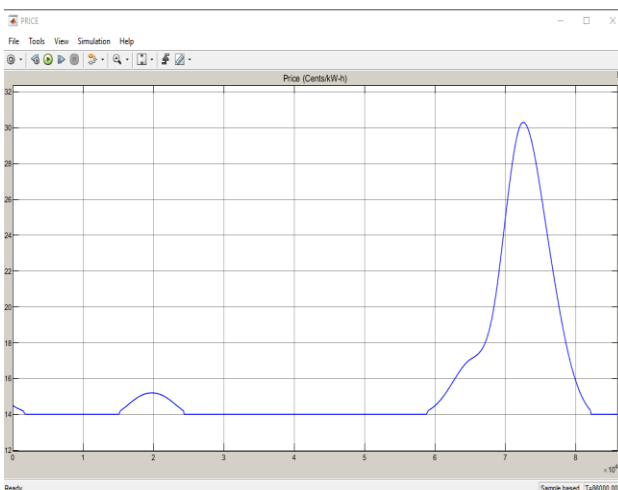Fig 14. Grid, HESS, grid, Load Voltage.

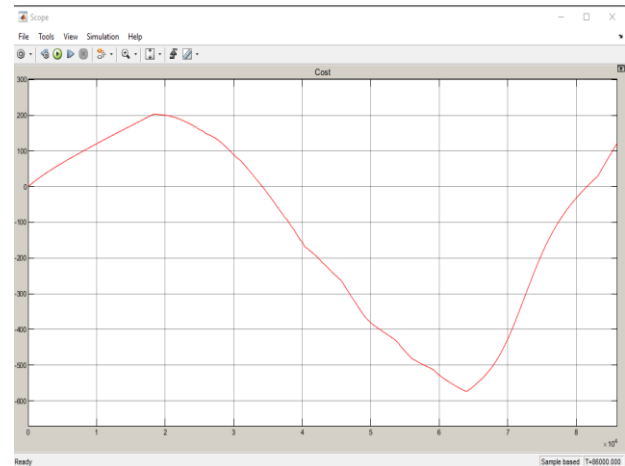
Fig 15. Fig Price after optimizer.

Fig 16. Fig Price after optimizer.

IV. CONCLUSION

Given economic and technical requirements, a mathematical model and solution algorithm for multi-objective optimization of microgrid's hybrid energy storage capacity is proposed. Current distribution and correction are realized based on low-pass filtering algorithm and unclear control rules. Finally, the adaptive weighted particle swarm optimization algorithm is used to solve the mathematical model through MATLAB.

Examples show that the proposed method can achieve better economy and higher technical.Hybrid electricity generation system is a better and more efficient electricity generation solution than traditional energy. It has higher efficiency. It can be delivered to remote areas that the government cannot reach. So that electricity can be used where it is generated, thereby reducing transmission losses and costs.

The cost can be reduced by increasing the output of the equipment. People must actively use unconventional energy. It is very safe for the environment because it does not generate any emissions and hazardous waste like traditional energy sources. This is a cost-effective solution for electricity production. It only requires an initial investment. Its lifespan is also very long. All in all, it is a good, reliable and economical solution for electricity production

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