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HYBRID MICROGRID EFFICIENCY IMPROVEMENT THROUGH DISPATCHING OF RENEWABLE ENERGY RESOURCES USING GAEMPC

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Abstract

The collection of interlinked conventional and renewable energy resources that are connected to the users as well as controlled by the system for ensuring the efficiency of energy storage and usage is referred to as a hybrid microgrid. It will be separated from the interconnected or main utility grid. Different types of renewable energy resources like hydropower, solar radiation, geothermal energy, and wind energy forms the composition of energy mixture according to the particular location. In facing the energy crisis and fast depletion of fossil fuels renewable energy can be replaced for the protection of the environment. Hybrid microgrids dispatch renewable energy resources with distributed generators. The main scope of the study is the improvement of the efficiency of hybrid microgrid through the dispatching of renewable energy resources with unit commit-based Model Predictive Control (MPC), which produce energy in each power system-controlled input given by the MPC is named Economic MPC (EMPC). Genetic Optimization is an advanced method for complex inputs, that helps in minimizing the Battery Energy Storage System (BESS) as well as Total Harmonic Distortion (THD) with efficient Maximum Power Tracking power for overall cost minimization by increasing the efficiency of hybrid microgrid for reliable utilization and dispatching of renewable energies. Distributed energy-sharing programs in hybrid microgrid efficiency are improved using renewable energy resources.

Keywords: Hybrid Microgrid, Renewable energy, Dispatching, Battery Energy Storage System

1 Introduction

In order to electrify rural regions in India, hybrid microgrids and solar-micro-hydro-wind systems are reportedly the most efficient solution. The appropriate capacity for a hybrid wind-solar power system is proposed in this work, which focuses on battery storage technology [1] and offers a general EMPC strategy. The model examines battery backup, micro-hydro, wind, solar PV, and other power sources [2]. A case study is carried out in a typical rural neighborhood in the Eastern Ghats of Andhra Pradesh, India. The research results will be utilised to design and develop the optimal hybrid energy system [3], which will offer the village community a dependable and affordable power source [4]. This storage must be used to hold any extra energy generated by power plants using renewable energy sources. In this paper, the dynamic economic dispatch for the optimization issue may be used for hybrid microgrids with energy storage [5]. Results from simulations are obtained for the best capacities of the

BESS, converter, DG, WT, and PV as well as for the payback period taking into account seasonal load variation, the penalty for greenhouse gas emission, fuel cost, operation cost, initial cost, cost of energy, net present cost, state of charge, discharging, and charging pattern [6,7]. This paper presents a Genetic Algorithm-Based Economic Model Predictive Control (GAEMPC) based fundamental optimisation approach for complicated inputs and disturbances [8,9]. Numerous advantages of the proposed GAEMPC are highlighted and investigated throughout the study utilising simulations.

2 Methodology

The optimisation in this study will be completed with a dynamic Genetic Algorithm (GA) in an Economic Model Predictive Control (EMPC) style. As a result, this part also provides an overview of the theory underlying generic MPC and GA's and how they are used in this situation.

2.1 Economic model predictive control

In a hybrid microgrid, performance improvement is the main objective so to optimize the system model an optimization issue is solved using EMPC over a 24h horizon. The optimisation identifies the best choice variables for the full period divided into optimisation time steps of 1 h. The horizon for the optimisation is moved ahead by one hour and the process is restarted with only the choice variables from the first time step incorporated. Figure. 2.1 depicts the general layout of a GAEMPC process.

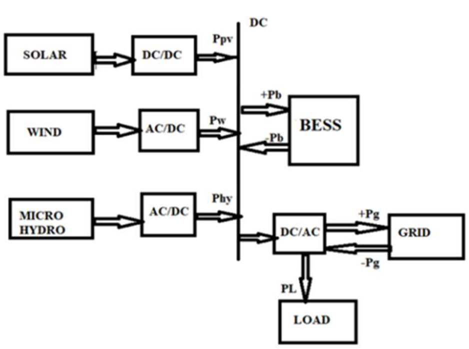


Figure 2.1. Block Diagram of microgrid

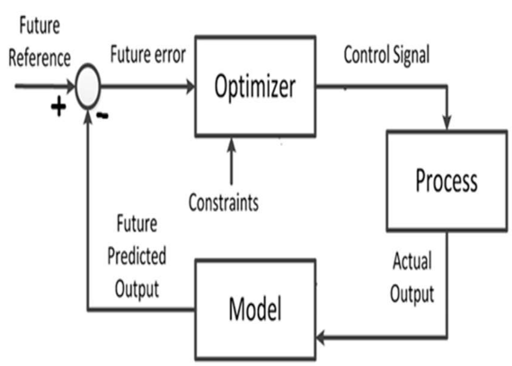


Figure 2.2 Block diagram of EMPC

The main objective of the EMPC technique is the guarantee of energy availability to satisfy load demands at any time while minimising production and distribution costs. To achieve these goals a) Economic cost b) Safety c) Smoothness.

Economic cost:

$f_E(k) = ((a)+b(k))\ u(k)$---(1)

a=S+W+H+B maintenance cost

b=time varying of power flow to transmission and distribution

BESS level:

$f_S(k) = S(k)^T S(k)$---(2)

S(k) is the degree of soft constraint infringement, S=0 means no offense

***Smoothness*:**

$f_{\Delta u}(k) = \Delta u(k)^T \Delta u(k)$---(3)
The rate change of control inputs should be decreased on the DC bus
This the quadratic expression that is used to penalise changing rates.
$\Delta u(k)=u(k)-u(k-1)$
$J_{EMPC}(k)=\sum_{i=0}^{H-1} (\alpha f_E (i \mid k) + \beta f_S (i \mid k) + \gamma f_{\Delta u} (i \mid k))$ ----------------(4)
α, β, γ are the prioritization weights
H is the prediction horizon
The EMPC The following is how the optimisation problem is put out:
min $J_{EMPC} (k)$ shows that
$x (i + 1| k) = Ax (i \mid k) + Bu (i \mid k) + Cd\, D (i \mid k)$ ------------------------(5)
$Eu\, u(i \mid k) + Ed\, D (i \mid k) = 0 \quad i = 0,..., H -1$-----(6)
Eu gives that RES power sources performance indices control unit losses
Ed gives load dispatch indices
$soc(i \mid k) >= \delta - \varepsilon \quad i = 1,..., Hp$--------------(7)
$u(i \mid k) \in [u_{min} (i \mid k), u_{max} (i \mid k)]$-------(8)
$soc(i \mid k) \in [soc_{min} , soc_{max}]$----(9)
$soc(0 \mid k) = soc(k)$ ----(10)

2.2 Genetic Algorithm

In the aforementioned general model GAEMPC, the Optimisation Technique employed a Genetic Algorithm. GAs is a subset of meta-heuristic algorithms that draw inspiration from the natural world's process of evolution. The algorithm consists of:

Step 1: Initialization: This phase takes into account all the information needed to launch the algorithm. The Profiles of available power from all energy sources including load demand power. The GA is parameterized with the length of the population and the maximum number of generations.

Step 2: Evaluate: To Evaluate the fitness function for individual chromosomes obtained at the end of the flow chart.

Step 3: Constraints handling: Perform a selection process to increase the likelihood that a person will survive to the following generation if they have higher fitness values.

Step 4: Evaluate min JEMPC (k) The sizing objective function min JEMPC (k) is evaluated for each individual chromosome.

Step 5: Stopping criterion check: The procedure described above is repeated until a stopping criterion is reached.

Step 6: Select the best solution: If the maximum allowed number of generations is reached, the best individual generation is chosen from min JEMPC (k) which is the lowest associated cost.

Step 7: Selection, crossover, and mutation: The selection operator chooses the best individuals of the current generation. Then this group of individuals is combined by the crossover operator to form a new set of individuals. The new generation is formed by combining both groups. It is possible to apply a mutation operator to avoid dropping to a local minimum.

2.3 Results and Discussion

This section presents a research study that is based on an examination of the proposed model suggested for enhancing hybrid microgrid performance by improving efficiency by dispatching renewable energy sources compared to BESS discharge and grid discharge. The models comprised of different Economic MPC and hybrid microgrid systems of solar energy micro hydro energy wind energy and BESS using MATLAB/Simulink software for calculation of the BESS level without EMPC, with GAEMPC, and the maximum power tracking error is calculated. The outputs are simulated by MATLAB R2021a

2.2 Simulation output of the proposed model

The graph Figure 3.1 shows the increased power of wind systems and hydropower for dispatching energy of renewable energy resources compared to solar and wind power to the microgrid. The optimal discharge of available RES power compared to the discharge of grid power and battery power is seen in the obtained graph and it proves the increased efficiency of the Microgrid system for dispatching energy of renewable resources to the grid.

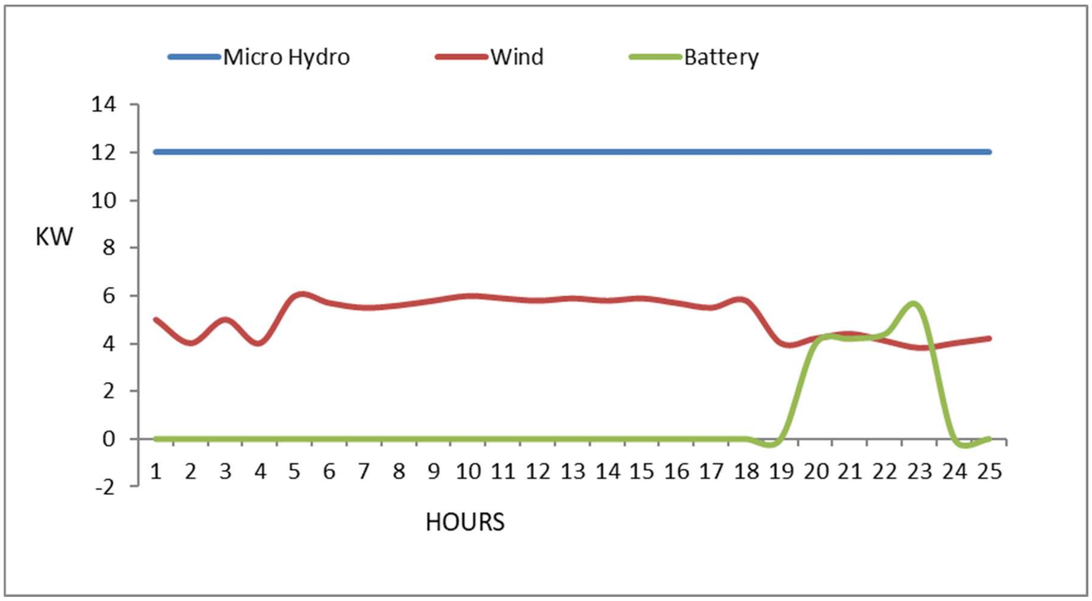


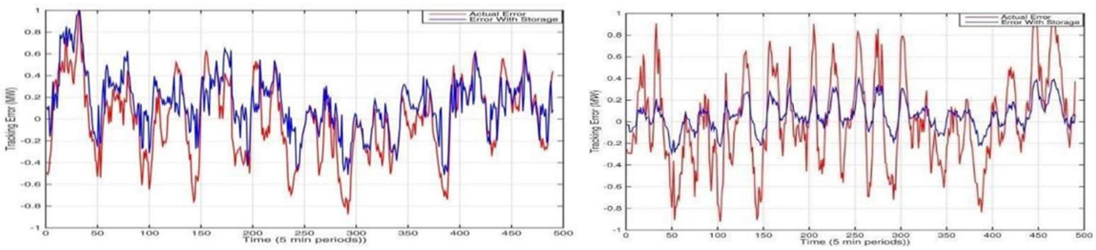
Fig. 3.1 Available Power dispatch meeting the load

The comparison of the BESS system using the GA optimization method for model EMPC is obtained as shown in Table 4.1. The number of hours of operation of BESS is 8 hours with EMPC and 4 hours with GAEMPC respectively. The economic unit cost of the hybrid microgrid with EMPC is 9.8 Rs/kwh but with GAEMPC is 9.5 Rs/kWh. for constant micro hydro dispatch unit. It shows that the life of operation of BESS is reduced with GAEMPC compared with the EMPC technique.

Table 3.1 Optimal Design Parameters

S.No	Parameter	EMPC	GAEMPC
01	With BESS hours of operation	8	4
02	Economic unit Cost of Hybrid Microgrid (Rs/kwh)	9.8	9.5

2.3 Maximum Power Demand Tracking Error



a. b

Fig 3.2 (a.) Maximum Power Demand tracking with EMPC, 3.2 (b.) Maximum Power Demand tracking by GAEMPC.

Table 3.2 Tracking Error Calculation

Parameter	With EMPC, MW	With GAEMPC, MW
Proposed Model	0.05	0.045

Table 3.2 shows the Maximum power demand tracking error for a hybrid microgrid. The proposed model shows the hybrid microgrid maximum power demand tracking error with GAEMPC and MW is 0.045 and the maximum power demand tracking error without EMPC and MW is 0.05.

3.3 THD level of the inverter and grid with proposed model EMPC

The total harmonics level is measured for unit commit-based Model Predictive Control (EMPC) design. THD with GAEMPC is 0.24%. The inverter system THD with GAEMPC is 0.27%. It is shown in Table 4.4

Table 3.4 THD level of the inverter and grid

System	THD With EMPC (%)	THD With GAEMPC (%)
Grid	0.37	0.24
Inverter	0.32	0.27

Figure 3.4 contains a graph that compares the effectiveness of a Hybrid microgrid. It demonstrates that, in comparison to the other two methods, the Proposed hybrid system exhibits greater efficiency with time.

3 Conclusion

The proposed research study concludes that improvement of efficiency of hybrid microgrids through the dispatching of renewable energy resources using the Genetic Algorithm Economic Model Predictive Control System (GAEMPC). The simulation model of solar, wind, micro-hydro, and battery hybrid microgrid for grid-connected shows greater efficiency than other models. Hybrid microgrid in an islanded state to increase the system's overall effectiveness in distributing renewable energy. By improving the effectiveness of hybrid microgrids for the dependable utilisation and distribution of renewable energy, the use of solar-wind-hydro battery hybrid systems helps to reduce battery storage in remote settlements as well as total costs. Distributed energy-sharing programs in hybrid microgrid efficiency are improved using renewable energy resources.

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