POWER SHARING WITH INTERFACED MICRO SOURCES AMONG DISTRIBUTED GENERATION FOR RESILIENCE IN MICROGRID

Anurag S.D. Rai[1], Reeta Pawar[1], Dr. Anil Kurchania[1], Dr. C.S Rajeshwari[2],

[1]Department of Electrical and Electronics Engineering,
Rabindranath Tagore University, Bhopal- Chiklod Road, Raisen-464993, (M.P.)
[2]Department of Electrical and Electronics Engineering,
National Institute of Technical Teachers Training and Research, Shyamla Hills, Bhopal, (M.P.)

Abstract

Microgrid is integration of utility network along with the capability of localized power generation via distributed energy resources (DERs). Control and operation strategy of microgrid lead to selection of its optimal mode of operation. In this research work energy management system and central control unit operation is also introduced. Insight of microgrid architecture lead to selection of optimal selection of localized power generation and flow in the distributed network. Optimal selection of power flow via central controller improves resilience of microgrid by scheduling the system operation.

I. Microgrid

In the modern power systems smart grids are new buzz words, but this is possible by up-scaling of microgrids. In microgrids utility is integrated with distributed energy resources (DERs) which are controlled by the microgrid energy management system. With the development of microgrid both utility and end user is benefitted, as there is robust power supply which is assured to the end users, to enhance the resilience of system. DERs such as PV, Wind power, fuel cells, and energy storage systems are interconnected to create the microgrids, now a day the integration is also connected via-cyber physical layer which improves the decision making capability of the systems. Thus the cyber physical layer collects the data and feed to the central controller, this controller analyze the data with the existing set of information and take the decision. In figure 1. Interconnection of different physical components with cyber system is shown, control center will analyze the data, take the best decision which is best possible as per the present situation.

End User Perspective: Microgrid enhances the system reliability, robust operation and controlling, power quality and reduce system down-timing. Voltage and frequency stability of system remain intact.

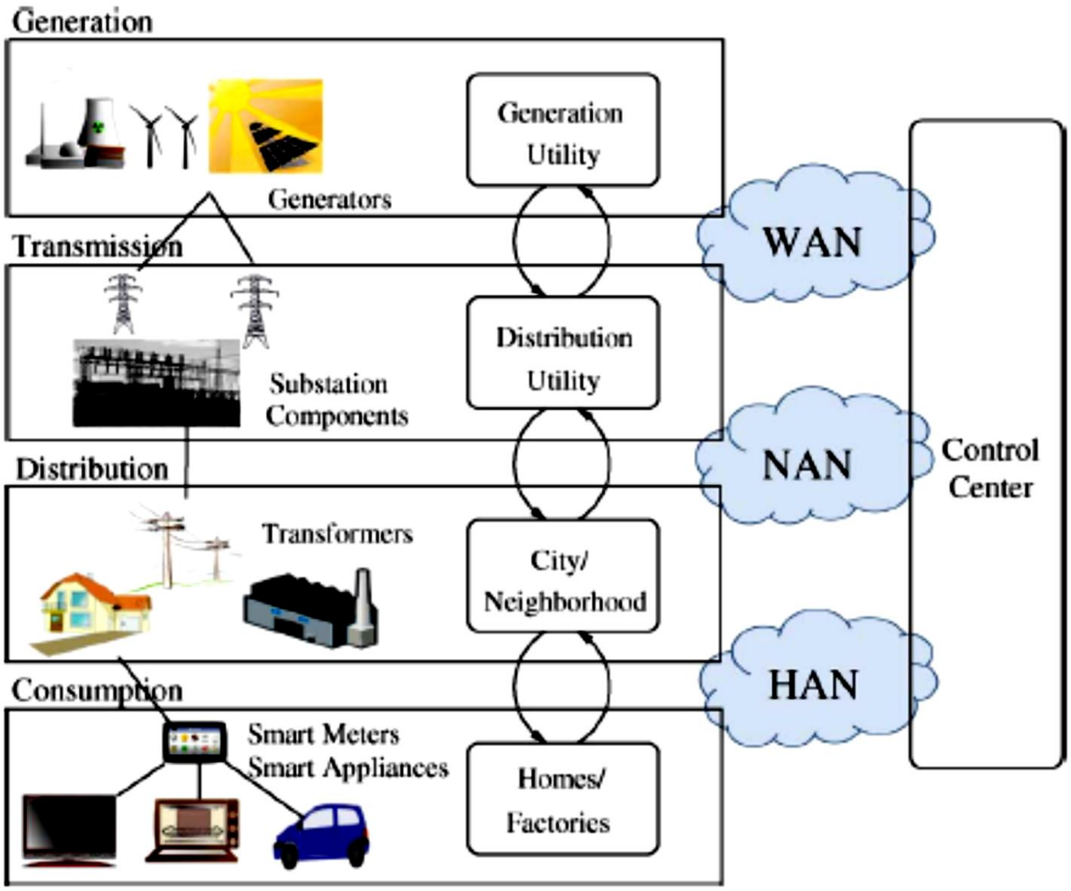

Figure 1: Cyber Physical Interconnections of Microgrid

Utility Perspective: microgrid is special integration to the distribution network, which have DERs and capability to control the power flow in the localized grid.

A. Strategy for Microgrid Operations:

A microgrid is integrated part of the localized distribution network, capability to generate power locally and control the power flow in the localized network make it different from normal distribution system. There are two modes of operation for microgrids, grid connected mode and islanded mode where local power generation along with grid power availability is adjust with the load demand. When microgrid is operating in grid connected mode it can take or provide power to utility grid as per the demand of the end-user and localized power availability. If any disturbances or catastrophic event occurs, microgrid isolates from main utility to operate as separate entity so that end-users are not impacted with the external events. This separation of microgrid and operate standalone is termed as Island mode of operation. When utility grid is recovered from external events microgrid is returned to grid connected mode, this elasticity of operation improves the resilience capability to bear the large impact without impacting end-users'. Optimal power flow in microgrid will depend on the Economics concern, Technical aspects, Environmental Aspects and based on the operational planning microgrid stake-holders are also benefited.

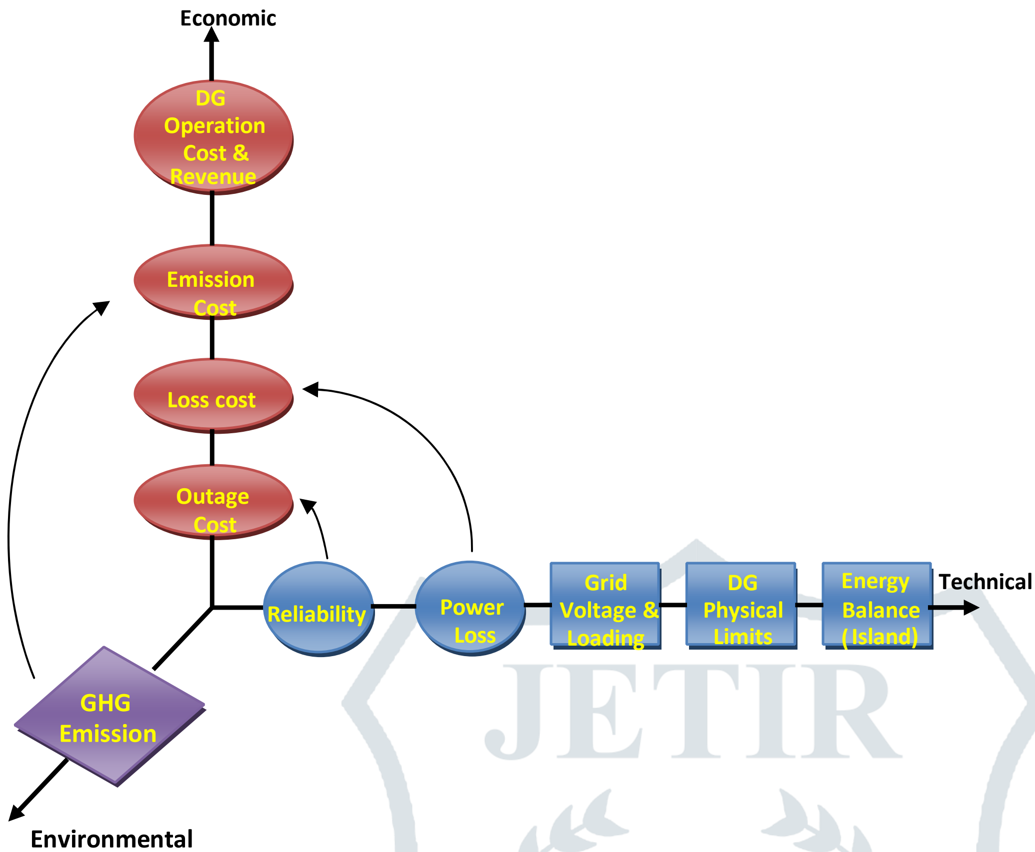

Figure 2: Strategy for Microgrid operation

Microgrid operation in islanded mode and grid connected mode, is adjusted by the coordinated control schemes. In coordinated control schemes, energy management system (EMS) is designed as shown in figure 3. In this objective variables along with different constraints are provided according to the present state situation EMS will take the decision of power flow in the network. Load forecast and generation variation are noted along with prizing for power generation between utility and DERs to determine optimal cost operation via selecting the generation source to be used for end-users. Controller is capable to regulate voltage and frequency of microgrid based on the normal operation or security state violation limits.

B. Energy Management System for Microgrid Operation

Microgrid is integration of utility network with DERs, due to presence of multiple sources and multiple end-users there is need of EMS. EMS will have different variable as input and scheduling decision as output. The optimal operation of system is decided on the basis of EMS objectives which are as follows:

1. Economic Constraints
2. Technical Constraints
3. Environmental Constraints
4. Combined objective constraints.

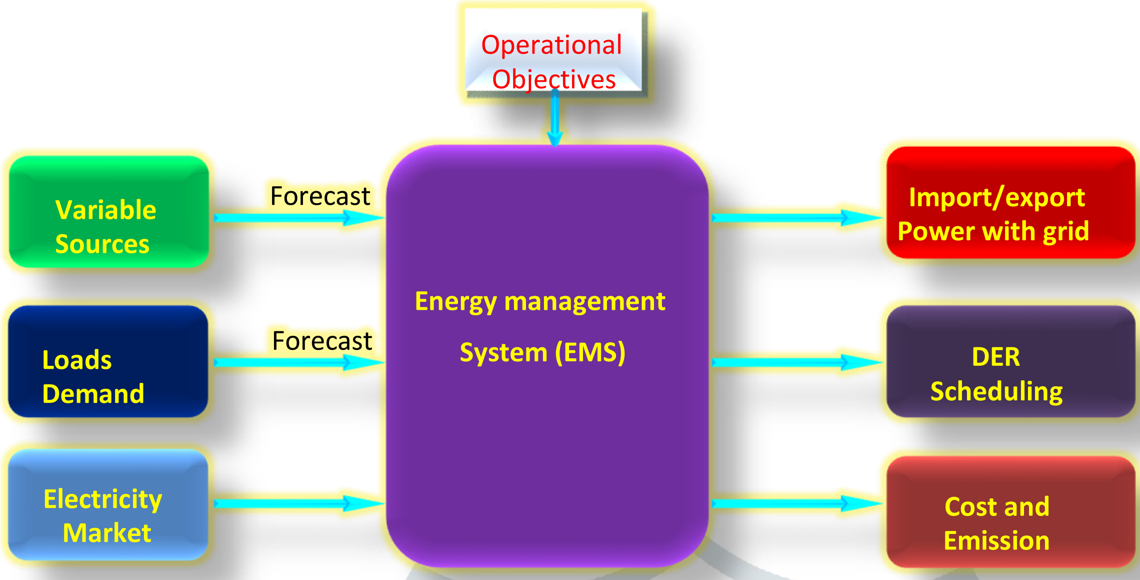

Figure 3: Energy Management System Control Scheme.

II Microgrid control

Control of microgrid is possible when the architecture is known, for this figure 4, represents it. With this it comes into action that the state of operation of microgrid and power system should be intact. Microgrid having capability to operate in grid-connected mode and island mode as per the situation of interconnected network security state. Microgrid contain different power sources, also connected to utility grid as depicted in the architecture along with storage devices. With the advent of technology power electronics control along with the cyber-physical connections to the controller for decision making have changed the operation methodology along with response time of the logical operation is improved. Prediction of the load forecast and demand side management analysis enhance the system efficiency.

The microgrid control includes:

- Micro Source Controllers (MC) and Load Controllers (LC)
- Microgrid System Central Controller (MGCC)
- Distribution Management System (DMS).

1. Micro Source Controller (MC):

This is power electronics analyzer for the system variables monitoring and providing information of DERs. This MC is cyber-physically connected to the central controller for logical decision making.

2. Microgrid System Central Controller (MGCC)

This is central decision making unit which act according to overall analysis, connected with each operator of the microgrid along with utility. Role of central controller is to enhance the system performance. Block diagram of centralized controller is shown in figure 5.

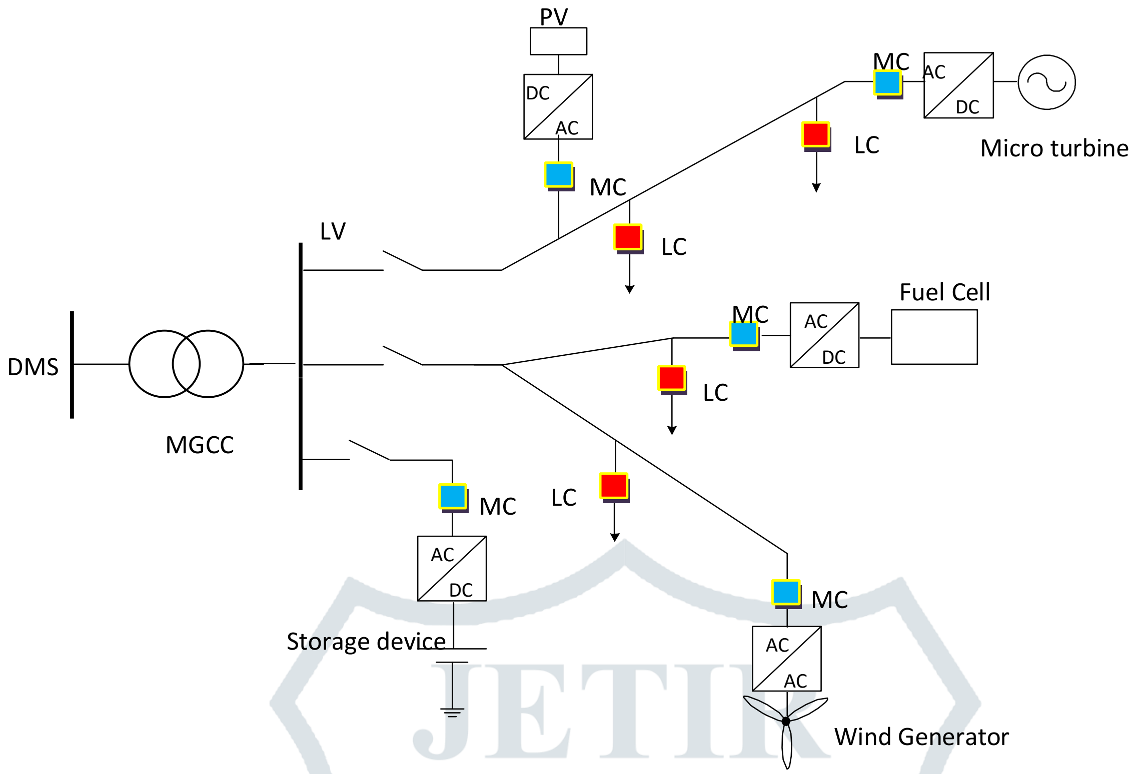

Figure 4: microgrid architecture

3. Distribution Management System (DMS).

This work like Energy Management System, having data and information about each operator of the system and feeding information via MC to MGCC this create the close loop monitoring system.

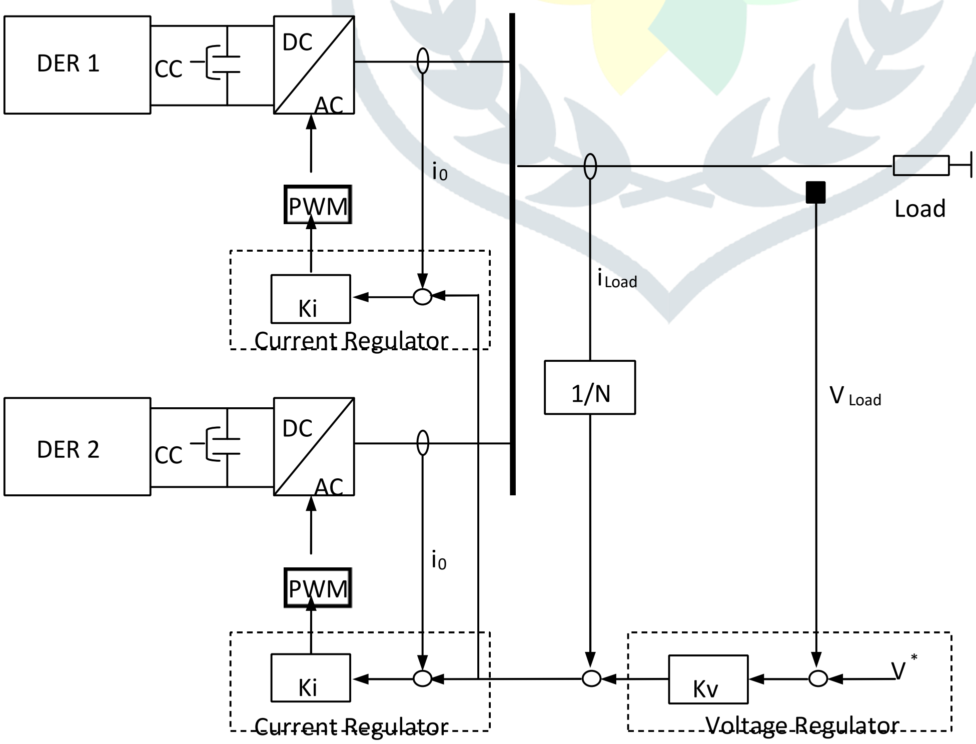

Figure 5: centralized control block diagram

III Factors Affecting Microgrid Control

Presence of different distributed energy sources (DERs) as a localized energy generation source affect the operation and control of the microgrid MGCC to adjust the mode of operation. Distributed Generation may be Wind Energy, Solar PV, Diesel Generator, Fuel Cell or combination of them, to control the demand side management and load side management characteristic should be known then only robust and resilient operation of grid can be adjusted. Selection of localized generation source depends on the economy of its affordability which decides its overall acceptability too, then only resilient and robust operation can be planned.

1. Solar PV as Localized Generation

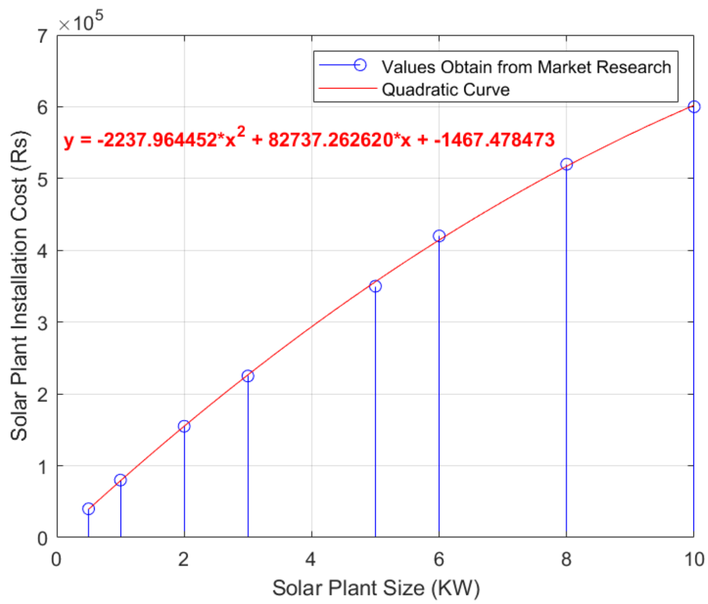

Figure 6: Solar PV Installation Economics.

Figure 6 shows the installation economics of solar pv this will show how the localized generation plant capacity and its capacity utilization based on Diversity factor to be decided in microgrid or multiple coordinated microgrids.

2. Wind Plants

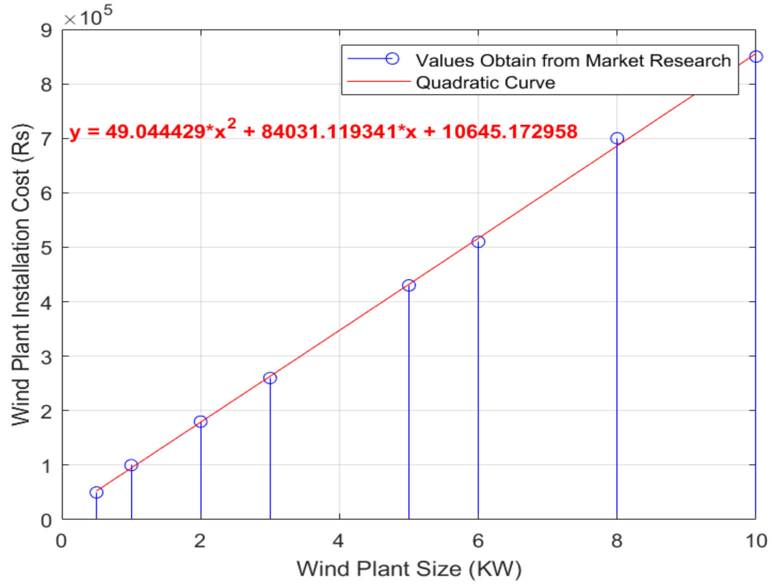

Figure 7: Wind Plant Installation Economics

3. DG Plant

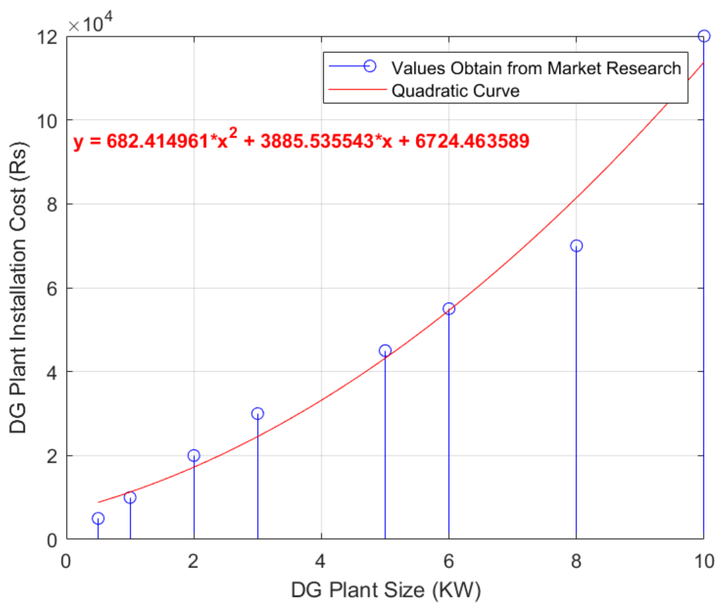

Figure 8: DG Plant Installation Economics.

4. FC Plant

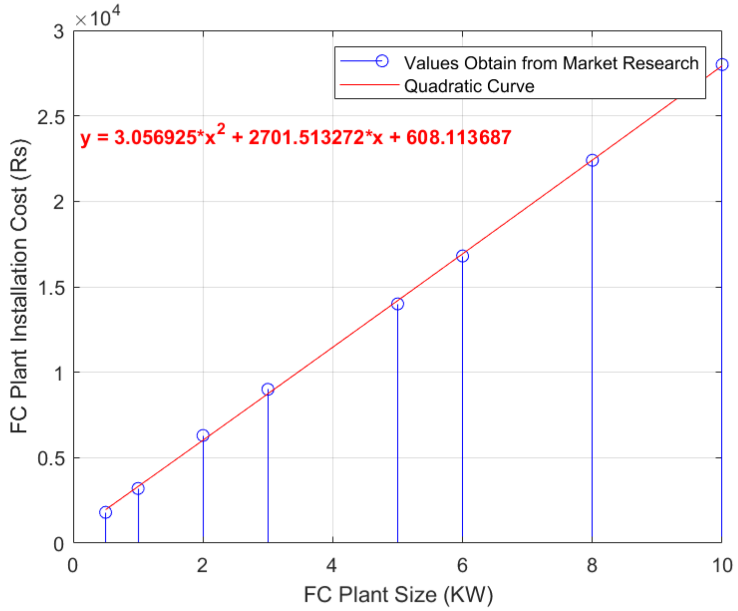

Figure 9: FC Plant Installation Economics

$$minimize:\ f_{obj} = \sqrt{\frac{1}{N\times 12}\sum_{i=1}^{N}\sum_{j=1}^{12}\left(D_j^i - G_j^i\right)^2} \ldots 1$$

Where,

N, is the number of MGs.

D_j^i and G_j^i are the demand from i^{th} MG for j^{th} month and power generated during j^{th} month from the plant of i^{th} MG respectively.

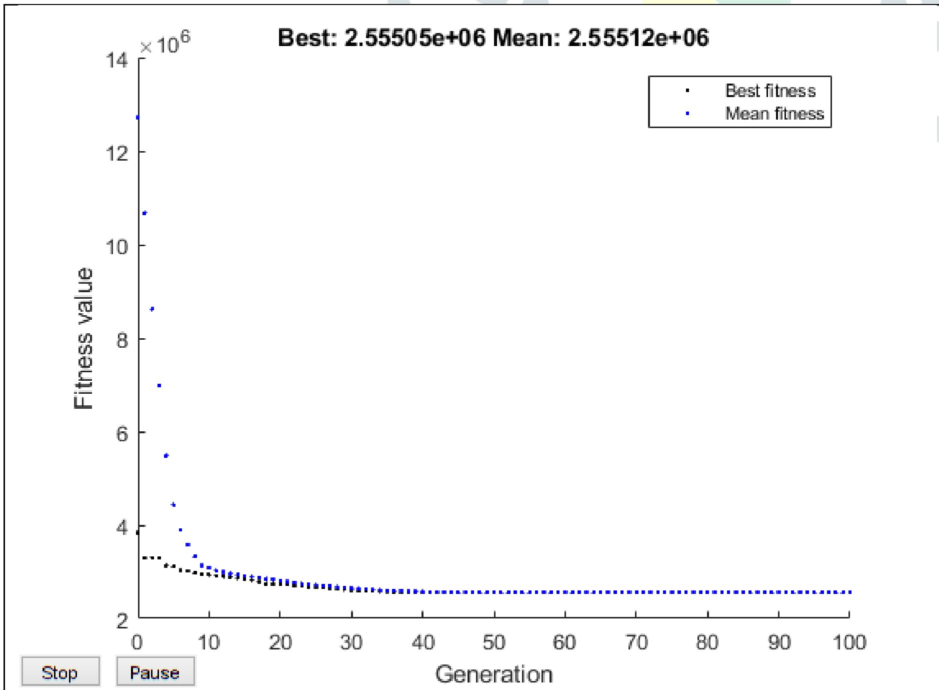

Figure 10: genetic algorithm convergence plot.

$$minimize:\ f_{obj}^{1} = \sqrt{\frac{1}{N\times 12}\sum_{i=1}^{N}\sum_{j=1}^{12}\left(D_j^i - G_j^i\right)^2} \ \ldots 2$$

$$minimize:\ f_{obj}^{2} = \sum_{i=1}^{N} U_i \ \ldots 3$$

Where, U_i, is the unit cost of electricity generated by i^{th} plant.

$$minimize:\ f_{obj}^{1} = \sqrt{\frac{1}{N\times 12}\sum_{i=1}^{N}\sum_{j=1}^{12}\left(DGP_j^i - GGP_j^i\right)^2} \ \ldots 4$$

Where,

N, is the number of MG groups.

DGP_j^i and GGP_j^i are the demand from i^{th} MG group for j^{th} month and power generated during j^{th} month from the plants of i^{th} MG group respectively.

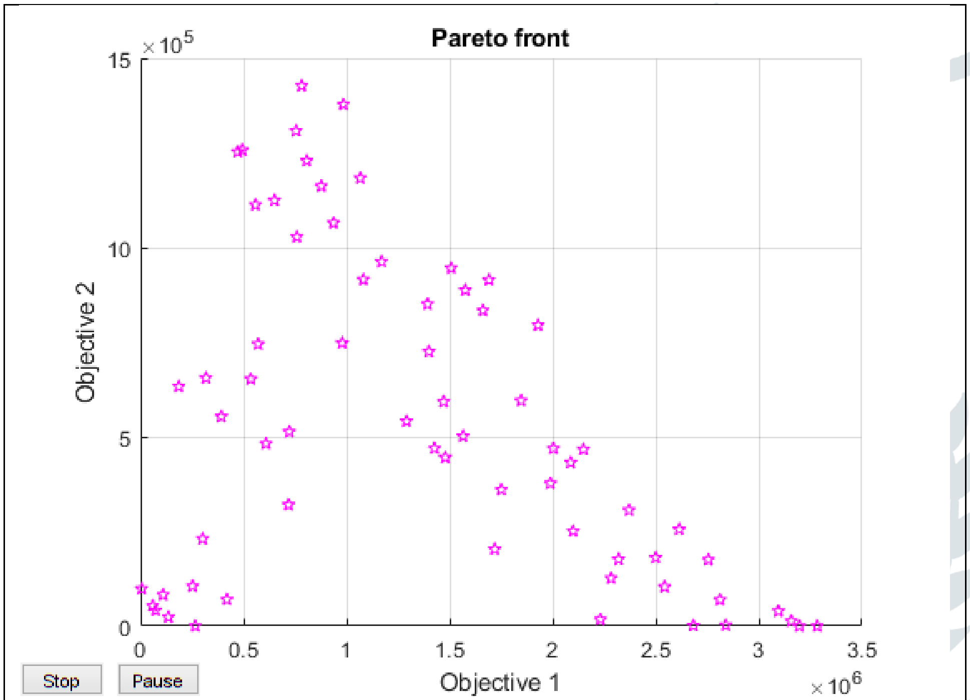

Figure 11: genetic algorithm convergence plot.

Cost estimation analysis of distributed renewable energy source help in optimization and scheduling of the power flow in distributed network system. Optimal selection of power generation system selects the priority of the source selection along with utility grid when operating in grid connected mode. Optimal power generation is scheduled as per the demand when operating in ISLAND mode.

IV CONCLUSION

In this research article strategy for selection of power flow in microgrid is defined. Detailed overview of economic selection of distributed power generation source are plotted. Microgrid architecture is also discussed which have different distributed renewable energy resources. Microgrid operation is controlled by central controller mechanism of central controller operation is also defined. This article also contain genetic optimization of power flow, when operating in islanding and grid-connected mode.

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