

Optimal Integration of RES in Distribution System using Monarch Butterfly Optimization Technique

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Abstract - In this article we have used an optimization technique which is proposed by Wang et al. named as MBO optimization technique. It is used for solving an optimal deployment problem of RES in distribution systems. The objective is to minimize annual energy loss and node voltage deviation of the system. WTS and PV are considered and formulated for benchmark 33-bus distribution systems. MBO has proven to be a very effective technique for solving various kinds of optimization difficulties.

Key Words: RES (renewable energy resources), MBO (monarch butterfly optimization), DG (distributed generation)

1. INTRODUCTION

DG is very significant in today's generation system and expected to become more significant in future generation system. Currently there is no consistent term for DG. In general the DG can be defined as electric power generation within distribution network or on the customer side of the network.

DG is an affordable, efficient, clean and reliable piece of puzzle for meeting energy needs, reduce power cost, reduce security vulnerabilities, improve reliability, power quality, cut greenhouse gas emission and other pollutants.

There is distinction between transmission and distribution based on voltage levels eg. 220 KV and more than this is considered as transmission and below as distribution, is not very useful as distribution companies sometimes own and operate 220 KV lines and transmission companies operate 110KV lines.

The technology uses RES. According to the IEA (International Energy Agency) RES is explained as resources that are not subjected to depletion, such as wind and solar. These RES based technology consist of a small module, which are collected in very less space. These modules can be installed in a very less time at the final power station location and the generation requires very less time than for large centralized power station.

They are more ecofriendly as compared to centralized generation

Solar and wind are used in this optimization, solar energy is one of the fast developing industry India

The current status of solar energy and wind energy is, **solar installed** capacity reached **31.696GW**, 31 October 2019 and **wind installed** capacity reached **36.625GW**, 31 March 2019.

Monarch butterfly or simple monarch (*Danaus plexipus*) is a milkweed butterfly (subfamily Danaine) in the family Nymphalidae they have a unique life cycle yearly in which they produce their offspring.

MBO, it is inspired by the migration behavior of monarch butterflies in nature (found in North America). The monarch butterflies flutter migrate from Area1 to Area2 in month of April and from Area2 to Area1 in month of September by this process they produce their offspring which replace their parents.

Due to the intimidation to the wide variety of habitats that monarch butterflies require to surviving, coupled with public allure of their yearly migration.

MBO has been successfully utilizes for solving real world problems. MBO uses fixed no. of butterfly in the Area1 and Area2 and all the new offspring produce by the migration are accepted.

2. PROPOSED ALGORITHM

MBO algorithm:

There are two updating operators are there in this technique (1) migration operator and (MO) (2) butterfly adjustment operator (BAO)

In migration, monarch butterfly follows the following process:

- 1: complete monarch flutter lies in both Area1 and Area2;
- 2: the new butterflies are produce in Area1 and Area2 only;
- 3: Monarch flutter size remains constant and
- 4: Few monarch butterflies are not upgraded by upgrading operators.

(1) Migration operators:

Let, the population of monarch flutter remains in Area1, that is subpopulation-1 (N_{p1}), is determined as ceil ($P_r \times N_p$). Similarly, subpopulation-2 (N_{p2}) can be considered for Area-2 and calculated as $N_p - N_{p1}$.

Here N_p and P_r are representing the complete monarch butterfly population and ration of monarch butterfly in Area1.

The migration operator expressed as-

$$A_x^{t+1,k} = \begin{cases} A_{r1}^t, k & , r \leq P \\ A_{r2}^t, k & , r \leq P \end{cases} \quad [1]$$

The total no. of monarch butterfly is NP and the no. of monarch butterflies in Area 1 and Area 2 are NP1=ceil ($P \times NP$) and NP2=NP-NP1 respectively

P =migration rate of monarch butterflies with $P=0.416$ in MBO.

The subpopulation of Area 1 is denoted as subpopulation1 and subpopulation of area 2 is denoted as subpopulation 2.

$A_x^{t+1,k}$ is the k_{th} element of A_x in generation $t+1$;

Similarly

A_r^t, k denotes the k_{th} element of A_r^t in generation t and A_{r2}^t, k is the k_{th} element of A_{r2}^t in generation t

The current generation no. is t and the monarch butterflies $r1$ and $r2$ are randomly selected from subpopulation 1 and subpopulation 2 respectively.

Here $r = \text{rand} \times \text{peri}$

Peri=period of migration which is equal to 1.2 in MBO and rand is a random no. in subpopulation2 is done in this operator.

This is expressed as-

$$\begin{cases} A_{best}^t, k & \text{rand} \leq P \\ A_{r3}^t, k & \text{rand} > P \text{ and } \text{rand} \leq \text{BAR} \\ A_x^{t+1,k} + \alpha \times \left(dA_k - \frac{1}{2} \right), & \text{rand} > P \text{ and } \text{rand} > \text{BAR} \end{cases} \quad [2]$$

$A_y^{t+1,k}$ = k_{th} element of A_y in generation $t + 1$

Similarly $A_{best}^t, k =$

k_{th} element of A_{best} This is the best location for monarch butterflies in Area1 and Area2, in generation t

$A_{r3}^t, k = k_{th}$ element of A_{r3} in generation t ,

The monarch butterfly $r3$ is randomly selected from subpopulation 2 and BAR is the adjustment rate, the $\text{BAR} < \text{rand}$ the random no. rand . the k_{th} element of A_y at $t+1$ is updated

Where α =weighting factor and $\alpha = S_{maximum} / t^2$

$S_{maximum}$ =maximum walk steps

In (2) dx is the walk steps of butterflies y that can be calculated by the Levy Flight such that $dx = \text{Levy}(A_y^t)$

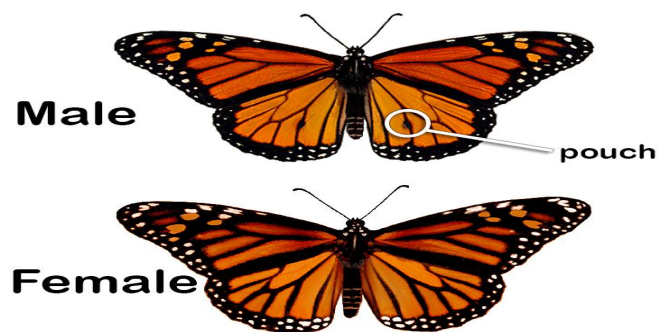


Figure: 1 Monarch butterfly of North America

3. EXPERIMENT AND RESULT:

Table -1: Simulation results of different DGs and annual energy loss for optimal allocations.

| Case | DG type, site(sizes in kW) | Annual energy loss(MWh) |
|-----------------------|--|-------------------------|
| Case-1 (Base case) | - | 3493.27 |
| Case-2 | @5(2000) ^{WT} @14(1250) ^{WT} @30(1500) ^{WT} | 1.6589 |
| Case-3 | @30(2000) ^{WT} @13(1500) ^{WT} @7(2985.2) ^{PV} | 1.577 |

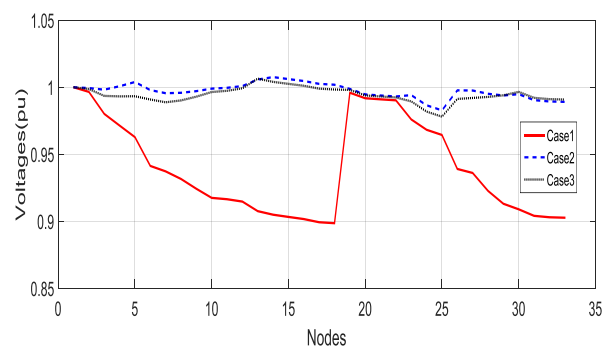


Figure-1: For all cases mean node voltages of the system

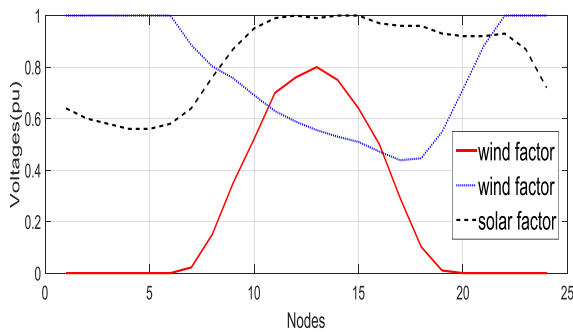


Figure-2: For wind and solar factor

For a benchmark 33 bus test distribution system, an existing power loss minimization problem is solved for demonstrating the capability of this optimization technique for solving dispatchable DG integration problems.

The parameters used, base voltage=12.66Kv, real power demand=3.715, reactive power demand=2.300 respectively.

For obtaining the fair results, all the implementation is done under the same conditions. We have used same parameter for MBO method:

S maximum (maximum step) = 1.0, BAO (butterfly adjustment rate)=0.416, migration period (peri=1.2) and the migration ratio (P=0.416)

There are 3 cases which are used for investigating the effect of every renewable technology and their operation. The cases which are solved by MBO are as follows :

Case1: base case (no DG); the annual energy loss 3493.27MWh with maximum voltage 1.0(pu) and minimum voltage 0.8986(pu)

Case2: operating at unity power factor (OPF), only WTs are used in this case for the optimal integration; the best location analysed by MBO for three DGs placement at bus no. 5,14,30 that reduces active power losses, the annual energy loss 1.6589MWh with maximum voltage 1.0076(pu) and minimum voltage 0.9827(pu).

Case3: operating at unity power factor (OPF), WTs and PV is used for the optimal mixed Integration; the best location analysed by MBO for three DGs placement at bus no. 30,13,7 that reduces active power loss, the annual energy loss 1.577MWh with maximum voltage 1.0064(pu) and minimum voltage 0.97805(pu)

3. CONCLUSIONS

In this paper a new kind of optimization technique is obtained by solving the migration behaviour of monarch butterfly in nature for continuous optimization problems.

In this optimization all the monarch butterflies are migrate and located in two areas:

South Canada and the northern USA (Area1) and Mexico (Area2), the updating of the position of the butterflies are in two ways:

- (1) Migration operator and
- (2) Butterfly adjustment operator.

In first the new butterflies are produced (position updating) by migration operator, and the migration ratio is used for adjustment. And then for other butterflies, the butterfly adjusting operator are used for tuning their position.

The methodology is simple and has no complicated operation and calculations. This makes the implementation of this methodology simple and faster.

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