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**HYBRID COMPOSITION OF DISTRUBUTED GENERATION BASED ON A NEW
STRATEGY USING GENETIC ALGORITHM**

YASHARKHANCHUPANI AHRANJANI¹, TOHID RAHIMI², SAEED AMANI-NIA³

¹Young Research And Elite Club, Urmia Branch, Islamic Azad University, Urmia, Iran

²Young Researchers And Elite club, Tabriz Branch, Islamic Azad University, Tabriz, Iran

³ Faculty of Electrical and Computer Engineering, University of Tabriz, Iran

ABSTRACT

In this paper, a new strategy is presented to determinate location and size of hybrid DGs (distributed generations) in distribution network (DN) by Genetic Algorithm in order to improve properties of DN and realize the desirable investment return period with respect to environment problems. The environment problem is entered when damaging aspect of greenhouse gases is important, so penalty cost for greenhouse gases emission is allocated. With respect to it, type of DGs is led to renewable or clean energies. But high primary investment of renewable and clean energies influence on investment return period can reduce their portions inside other DGs types. Therefore it is essential a new process to be introduced. The proposed processes consist of two steps. First step is locating hybrid DGs based on DN MWh requirement and regardless of the hybrid DGs combination. Second step is determination the portion of each available DG type in hybrid DGs based on desirable investment return period and with respect to environment problem.

**Keywords: DGs, Genetic Algorithm, Investment return period, Environment problem,
Renewable energy**

INTRODUCTION

It is becoming quickly distribution in power network especially distribution generations (DGs) resources are attentioned network. DGs can provide benefit to

distribution network such as: reducing line losses particularly in peak time (3), acting as a network service provider by causing delay new distribution reinforcement and providing auxiliary service. Improvement voltage profile with respect to different load model (9), noticeable maximum current flowing in distribution network lines are other benefits of DGs. The working group 37.23 of CIGRE (1999), has summarized some of reasons for an increasing share of DG in different country.

In recent years, a series of concerns about energy security have emerged. Fossil fuels are finishing, countries trying to reduce their dependence on fossil resources, especially oil. In development country a terrible imagine is created that if they don't move toward renewable sources one day will be arrived that they will not have any energy source (4) Problems associated with fossil fuels are not only related to energy security but increasing importance of emissions reduction is another human societies concern. About 80% of world pollutants result from burning of fossil fuel. In china, yearly costs of air pollutant are about 1.6 billion dollars (5). One important feature is reduction environmental pollution through electricity production process. For example, coal fuel power plants for every GW-h,

about 830-920 tons of carbon dioxide, 630-1370kgs phosphorus dioxide and other gases are releasing, while photovoltaic systems and wind energy have no pollution approximately (10). According to the mentioned fossil fuels problems, moving to renewable energies is essential. But because of high initial investment of renewable energies, there is a little tendency for investing in this section. So introducing effective solution for increasing renewable energies portion in electricity production and satisfying minimum financial expected investor looks essential.

Many approaches are discussed on optimal sizing and sitting of DGs. Placement of DG for reduced losses (7),(14) and analytical approaches (1) is done for placement DGs in distribution network. In reference (2) a multi objective performance index-based size and location determination of distributed generation in DN system with different model has been presented. In (13) an application of Firefly in determination the optimal and size of DG in DN is presented and the effectiveness of the Firefly Algorithm comparison with other method is shown. A method for optimal sizing renewable energy generations and combined heat and power (CHP) units in a hybrid energy micro grid based on hourly energy

balance and minimizing system annual cost, in (15) is presented but DN feature improvement is not considered. In (11) an Imperial competitive for optimal multiple DGs placement and sizing in DN based on minimizing the total real power losses and improve the voltage profile. But in (11) environment problem is not considered. All of former papers have discussed on sizing and sitting of DGs without consideration available DGs type, not based on desirable investment return period and without respect to environment problem. In the other words insufficient investigations on size of DGs with environment problems and economic issues are done. In this paper with attention to the DN system active power requirement and KW ability of investor company three type is proposed: 1)

1600 KW wind energy, 2) 1000 KW hybrid energy, 3) 2*200 KW hybrid energy. Wind, fuel cell, micro turbine and Internal Combustion Engine (diesel) are available DGs type. Defined DGs with Genetic Algorithm is placed in a distribution network to minimize fitness function.

NETWORK MODEL

The model for studying is KhodaBandlu feeder that is Part of the electricity distribution network in Tehran. Single linear diagram is shown in Figure 1. Impedance values per line based on the ohm are seen in Figure.1. The model has 13 buses. Type of the distribution network is radial. Base line voltage and power base are 20kv and 100kw respectively. Every node have consumer except node 1 that is slack bus.

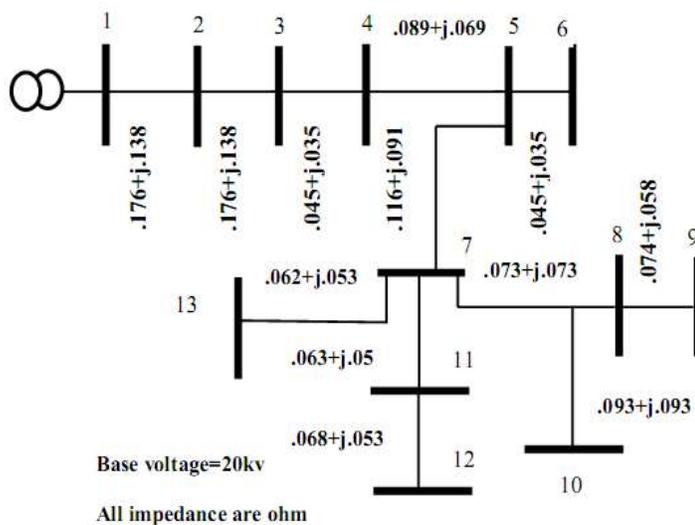


Figure 1: Single Linear Diagram of the Studied Network

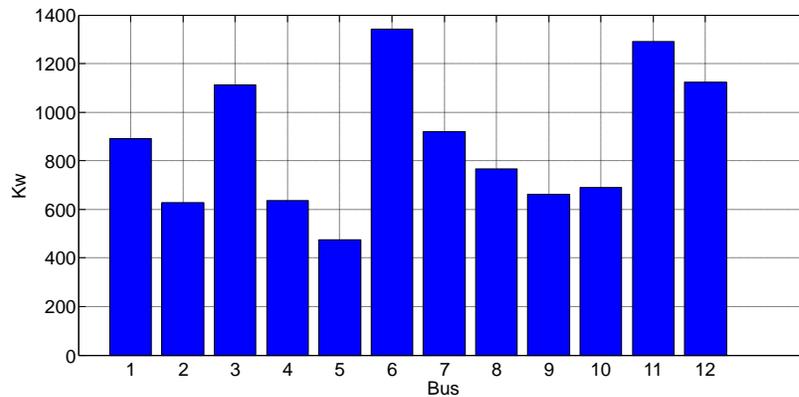


Figure 2. Active power of each node

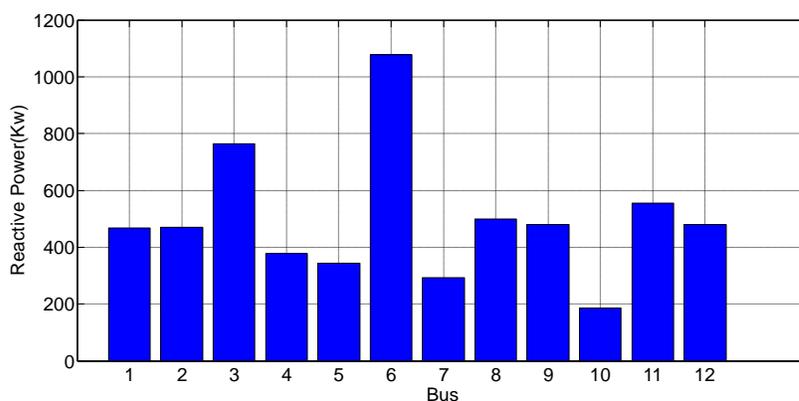


Figure 3. Reactive power of each node

Characteristic of Loads and DGs

Active and reactive power that each customer is consuming is shown in Figure.2, Figure.3 respectively. Note slack bus is emitted. Therefore real node number=node number+1.

According to requirement of the network, Climatic conditions, capacity of kind of DG sources sizes of possible hybrid distribution generation are 1600kw, 1000kw,2*200kw.

Types of DGs as is mentioned in previous section are wind, micro turbine, fuel cell and Internal Combustion Engine (diesel). Because of supportive policies of renewable energy, type of DG for 1600kw size, wind type is chosen. But types of other DGs are hybrid. Characteristic of any power unit are summarized in table I. Wind turbine consumes reactive power. However, hybrids DG produce reactive power.

Table 1: DGs characteristic

KW capacity	Type	Power Factor
1600kw	Wind Turbine	0.95
1000kw	Hybrid	0.95
100kw	Hybrid	0.95

LOAD FLOW ALGORITHM

$$i = A^T f \quad (1)$$

$$AV = -(r + jx) \cdot f \quad (2)$$

Where A is incident matrix lines-nodes defined as follow:

A/

$$A(L, K_{L,end}) = 1$$

$$A(L, K_{L,ini}) = -1 \quad (3)$$

$$A(L, K) = 0 \forall K \neq K_{L,ini}, K_{L,end}$$

i : node current matrix

f : line current matrix

r : Resistance of lines matrix

x : Reactance of lines matrix

k: member number of nodes

L= member number of lines

The notation $\square*$ indicates the operation element by element. For our particular case where the network is radial we have $n_{nod} = n_{lines} + 1$ and the slack bus ks is the PSP, where the

Distribution network connects to the transmission network. If slack bus is not entered in load flow:

$$v = (v_s, v_{ns}); i = (i_s, i_{ns}); A = (A_s, A_{ns})$$

"s" and "ns" are slack and no slack indicator. The additional description is brought in (Paul M,2006) Lastly can be written:

$$v_{ns} = -v_0 A_2^T A_s - A_2^T R A_2 i_{ns} \quad (4)$$

$$i_{ns} = (P_{ns} - jq_{ns}) / conj(v_{ns}) \quad (5)$$

The iterative algorithm used is as follows:

First step: Choose tolerance ε and set $v(k) = v_0 \forall k \in v_{ns}$

Iterative step:

Save in V^{old} the actual value of voltage vector v_{ns}

2) Calculate the current vector i_{ns} using 5

3) Calculate the voltage vector v_{ns} using 4

4) If $\|v_{ns} - v_{old}\| < \varepsilon$ the iteration is finished. In other case, go to 1).

SITING DGs in DN

In this section the mentioned DGs in table 1 using Genetic Algorithm subject to minimizing a defined fitness function, are replaced in three locations. The permitted locations in this paper are not the length of

lines but are buses. The most important step of each algorithm is defining fitness functions (FT). In order to define desirable FT in this paper, three parameters as expressed in equations 6-9 are defined. So FT is defined as shown in (10). Since in the

present of DGs, it is expecting that power losses decrease and voltage profile be better, so it is necessary to FT be minimum.

$$SAP = \sum_{i=1}^{12} P_{i \text{ without } DG} \quad (6)$$

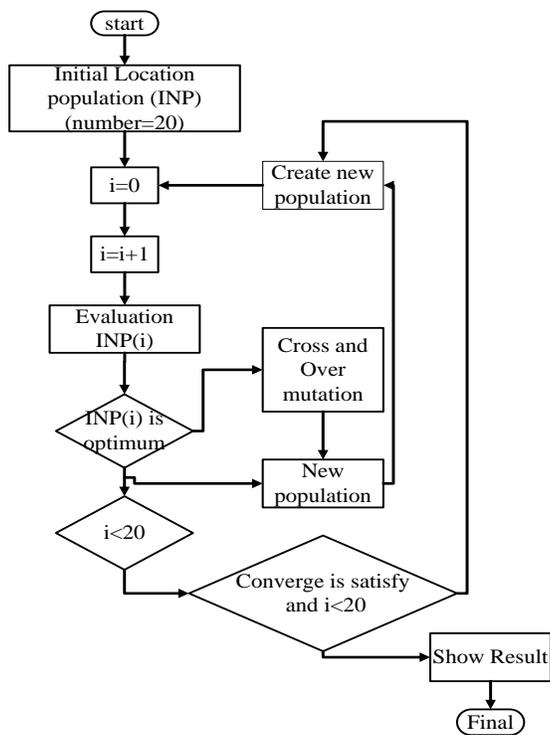
$$SRP = \sum_{i=1}^{12} Q_{i \text{ without } DG} \quad (7)$$

$$AVP = \frac{1}{12} \sum_{i=1}^{12} Voltage\%_{i \text{ without } DG} \quad (8)$$

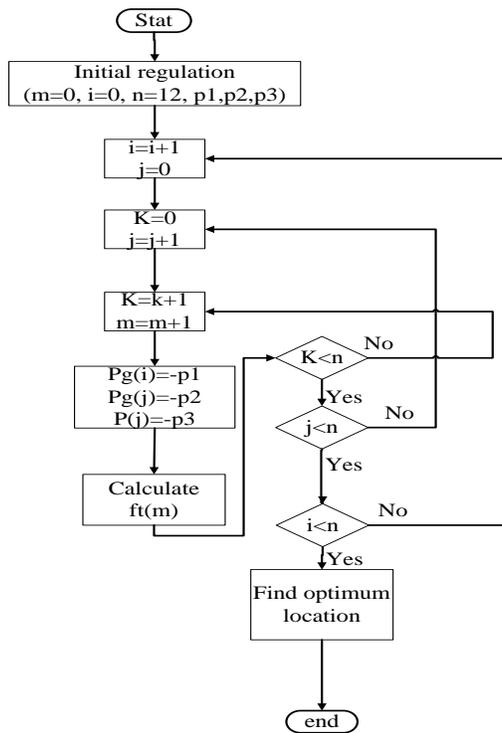
In the above equations, SAP (summation of active power), SRP (summation of reactive power losses), AVP (Average of voltage profile percent) are used to define FT as follow.

$$\begin{aligned} maxf = \frac{1000}{AVP} & \left\{ MAX \left[0, \left(\frac{1}{12} \sum_{i=1}^{12} Voltage\%_{i \text{ with } DG} \right) - AVP \right] \right\} \\ & + \frac{700}{SAP} \left\{ MAX \left[0, \left(SAP - \frac{1}{12} \sum_{i=1}^{12} P_{i \text{ with } DG} \right) \right] \right\} \\ & + \frac{300}{SRP} \left\{ MAX \left[0, \left(SRP - \frac{1}{12} \sum_{i=1}^{12} Q_{i \text{ with } DG} \right) \right] \right\} \end{aligned} \quad (9)$$

$$FT = \frac{1}{maxF} \quad (10)$$



(a)



(b)

Figure 4. The used algorithms for sitting DGs a) Genetic b) classical

According to above equation FT value for each chromosomes calculated. In (9) 1000,700 and 300 are Weighting coefficients for the maxF function. The used general Genetic Algorithm is shown in Figure 4(a). Initial population (INP) size is fixed and equals 20. In each stage FT is evaluated for each chromosome of populations. If FT is not optimum each stage, new population by using cross over and

mutation is producing. If the algorithm satisfies FT in each step, the algorithm stops. The used algorithm result can be seen in Figures 5, 6. Parameter numbers of 1000kw, 1600kw, and 2*200kw are 1, 2, and 3 respectively. Since slack bus is not considered in load flow analyze, one number must be add to obtained data to real found locations produce. So real locations are 10, 12, and 9.

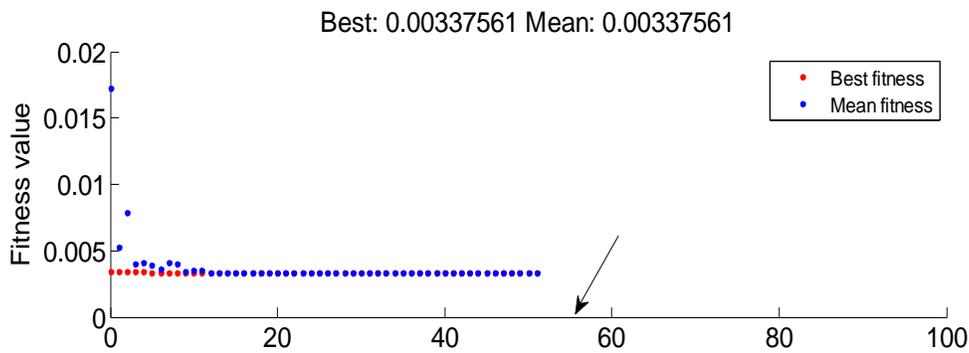


Figure 5. Convergence of the algorithm

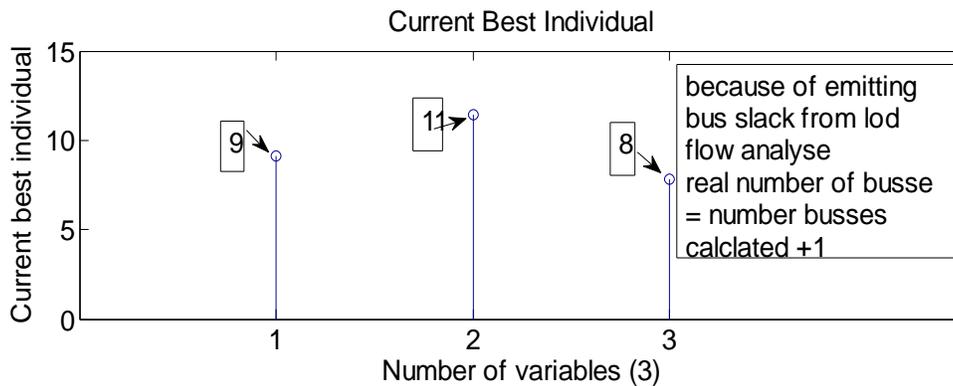


Figure 6. Found locations of DGs(raw data)

To show importance of FT, classical research method is implemented too. Since classical research method evaluate the whole of states, it's running will be long especially when Type of search parameters is continuous. Figure. 4 (b) shows classical research algorithm. Firstly initial conditions such as desirable size of DGs placed, so each DG sizes are examined for all buses. Lastly optimum locations of DGs with respected to

minimum FT search. Optimal DGs state occurs at 1544th step. There is a noticeable subject and it is that any DG is not permitted to place on slack bus, so n (== number of nodes) is equal 12. Importance of FT in optimum process and analytical result is seen in Figure 7. Comparing voltage profile in present DGs and without DGs is shown in Figure 8.

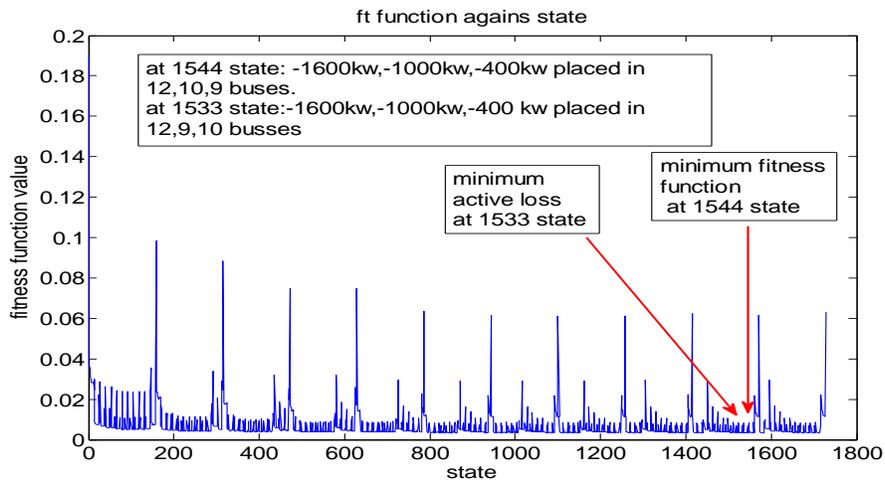


Figure 7. Importance of FT in placement DGs (Classical Algorithm)

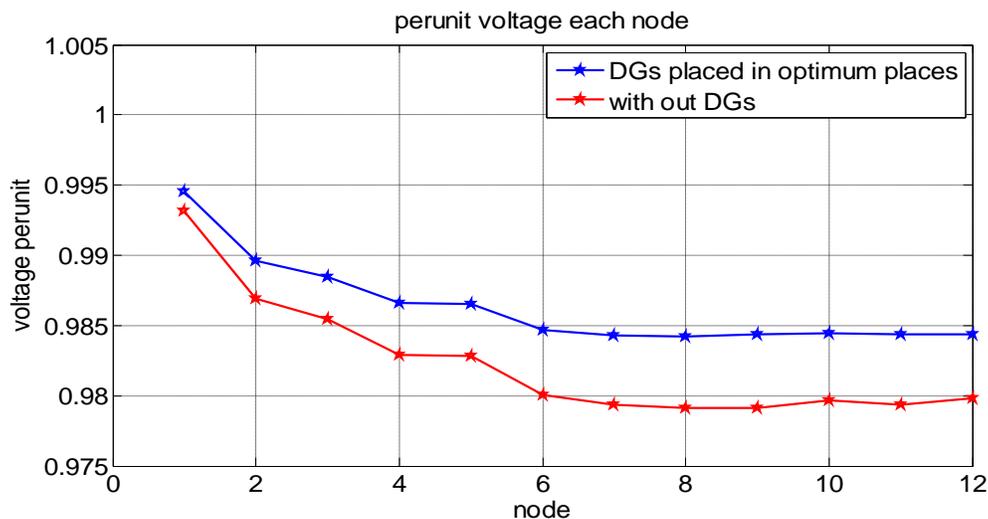


Figure 8. Improvement voltage profile in present DGs

DETERMINATION SHARE of EACH DG TYPE In HYBRID DG

In this sections, the goal is determining each available DG type (in first section is described about available DG type more) in hybrid DG to guarantee the defined investment return period. But environment problem is considering. Applying the environment problem cause renewable energies have more share in hybrid DG.

About 80 percent of the pollution caused by the burning of fossil fuels has been born. For example, in China, the annual cost of air pollution resulting is the 1.6 billion\$. The proposed indicators in order to assess the

environmental benefits of energy production and it is used to reduce air pollution seems necessary. The amount of annual emissions is a good indicator (K. Qian,2008) In order to reduce annual emission in electricity production part is moving to renewable energies. An important step to renewable energies is applying damage cost of environmental pollutant gases. According to Mohammad.Hosein(2011), Table II and Table III show emission characteristics of power generation technologies and cost of emitted cases related to their environment damage respectively.

Table 2: Emission characteristics of power generation technologies gr /kwh

Emission DG type	NOX	CO2	CO	SO2
Micro turbine	0.6188	184.08	0.1702	.000928
fuel cell	.0046	ND	ND	0.0371
Internal Combustion Engine	4.3314	232.04	2.3204	.4641

Table 3: Damage cost of environmental pollutant gases (\$/kg)

SO2	NOX	CO2	CO
0.131	0.28	0.0013	0.022

The purpose of the development of the electrical generation planning in power system from the perspective of an independent system producer (ISO) is providing customer's required electric power with the lowest cost and the highest quality. From the perspective of production and

investment companies, the main goals is maximizing profits in market participation and cover the lateral costs of producing the investment. On the other hand high investment cost of renewable energies so reluctance investors to invest in development of distributed generation sources especially

reduce noting to renewable energy sources. Table 4 shows investment and installation cost (Seyed Ali Mohammad Javadian, 2011)

High initial cost of renewable energies can be seen in Table 4.

Table 4: Investment cost

DG type	Fuel cell	Micro turbine	Wind Turbine	Internal Combustion
Initial cost(\$/kwh)	3500	1500	2500	500

According to the mentioned problem, it is important to choose an appropriate and econometric strategy to increase renewable energies share of DGs and guarantee minimum desirable investment period.

From the perspective of the investor Investment return at beginning decision must be ensured. Thus each of the investors in the manufacturing sector, simulate their presence on the market. In this section firstly

a investment return period is defining so using genetic algorithm, optimum combination according to the environment problem is determined. The environment problem is applying to increase renewable energies share in hybrid DG. A good genetic algorithm can be realized the paper goal. Algorithm flow chart can be seen in Figure 9.

FT for this section is as follow:

$$FT_{inv} = \frac{INC}{(selec - fuelc - emissionpc)_{year} - dyear} \quad (11)$$

FT_{inv}: Fitness function (= investment return/year)

INC: Initial investment cost

selec: sold electricity cost

fuelc: Fuel cost

emissionpc: Emission penalty cost

dyear: Desirable year for investment return period (in this paper its value equal 5.76 year)

It is assumed that fuel cost for micro turbine and internal combustion equals 0.001\$/kw.h.

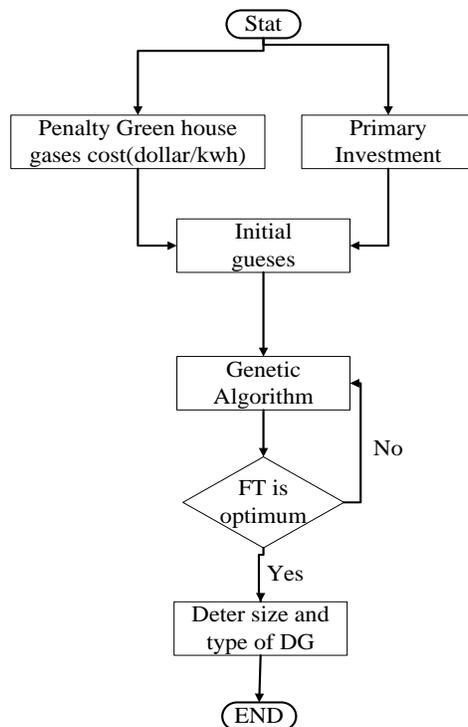
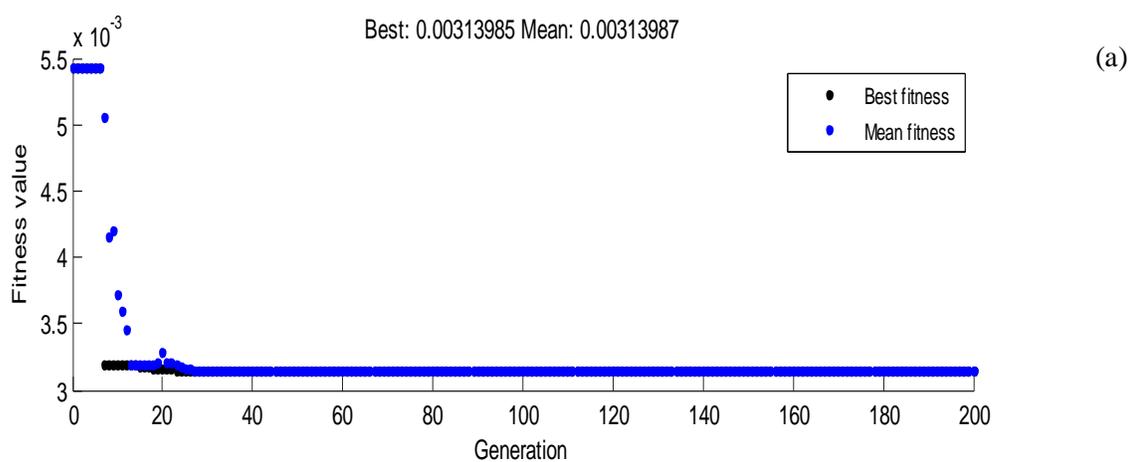


Figure 9. The used algorithms for determination hybrid DG combination

According to the used algorithm that is shown in Figure 9 initial condition that consisting initial investment cost of different kinds of DGs and penalty cost of greenhouse gasses, are determining. So genetic

algorithm is used to determine each hybrid DG combination is applying to satisfy minimum investment return period. In each step that FT is minimum value, the used algorithm stops.



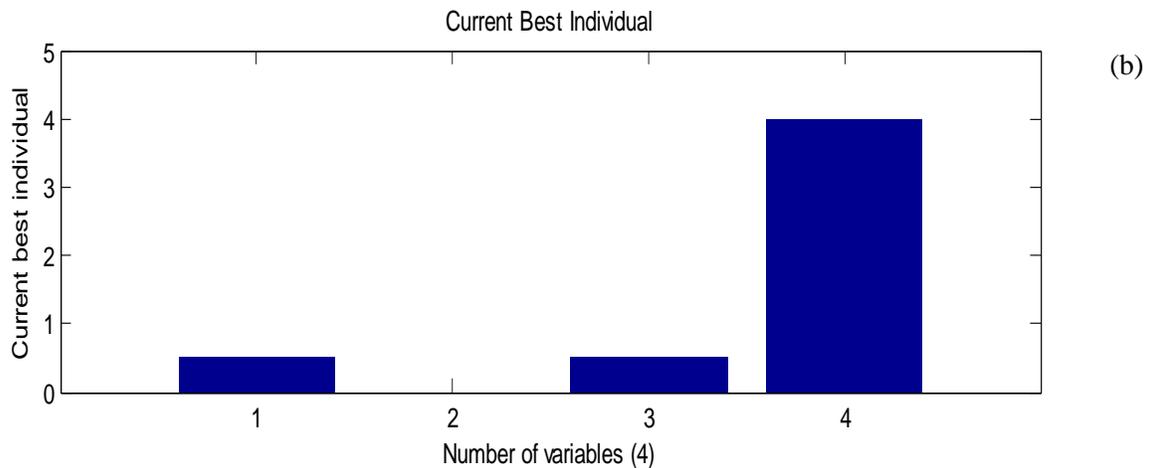
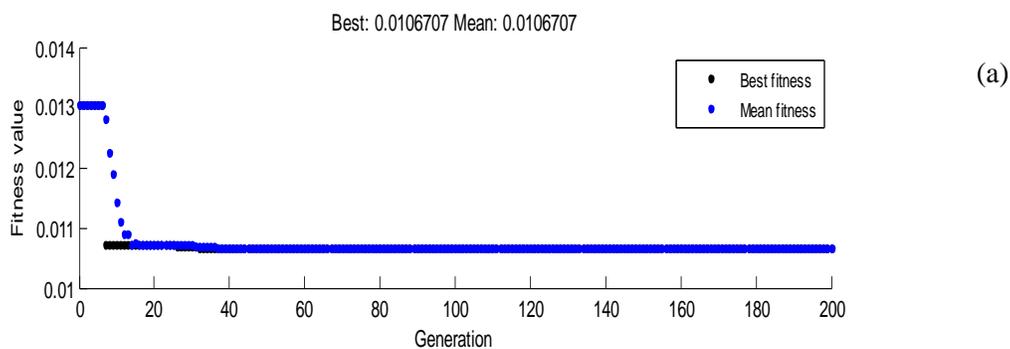


Figure 10. 1000 kw hybrid DG Result: a) Convergence of the algorithm, b) found size of each DG (*200KW)

Results of applied algorithm for 1000kw, 2*200 kw Hybrid DG are shown in Figure 10, 11 respectively. Variable 1, 2, 3, and 4 indicate wind turbine, fuel cell, micro turbine, and Internal Combustion Engine (diesel) respectively. Summarize of the applied algorithm resulting is brought in table V. since fuel cell source has high investment cost, does not have any portion in hybrid DG. In contrast because of damage cost of pollution applying, wind

turbine has 10% portion in electricity production by means of hybrid DG. Low investment cost of Internal Combustion Engine (diesel) cause to main contribution has resulted for it. Micro turbine has medium investment cost and medium emission so its contribution is similar to wind turbine. It is interesting that investment cost of wind turbine dose not let it to have any portion in 2*200kw hybrid DG combination



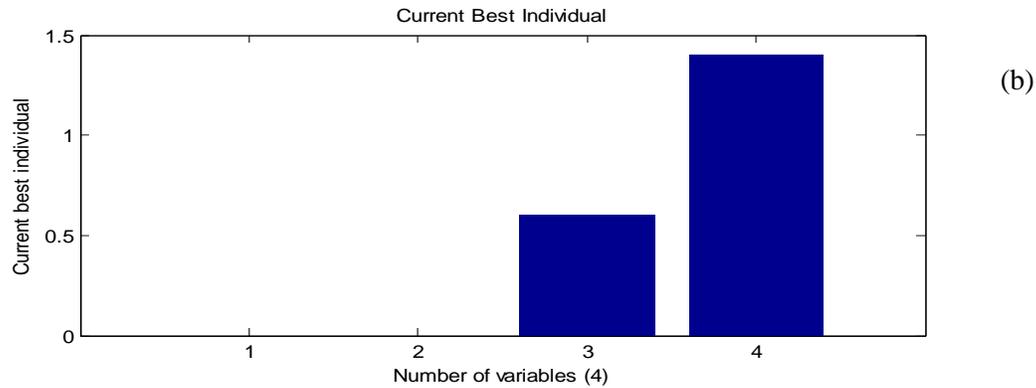


Figure 11. 200 kw hybrid DG Result: a) Convergence of the algorithm, b) Found size of each DG (*200KW)

Table 5: Each DG share of hybrid DG result (KW)

Variable state	1	2	3	4
100kw hybrid	100	0	100	800
200kw hybrid	0	0	60	140
2*200kw hybrid	0	0	120	280

CONCLUSION

A new strategy is presented to determinate location and size of hybrid DGs (distributed generations) in distribution network (DN) by Genetic Algorithm. For improvement characteristics of DN and satisfying desirable investment return based on environment problem, a new process is proposed. Firstly it is essential that DGs sitting in DN must be based on appropriate FT to improve general characteristics of DN. As has seen in section III depends on FT defining, different locations are obtaining. Simulation result by means of genetic algorithm and classical algorithm can be seen in section III. Voltage profile improvement is shown in sections III too. So according to the high investment cost of renewable energies and necessity of optimum

investment return period guarantee, to increase renewable energies application, must be noted to environment problem. Low emission of renewable energies is their advantage compared to other DG type. Applying penalty cost for greenhouse gasses can be important step to increase renewable energies share in electricity market. The obtained result in sections IV confirms the claim. Simulation result by means of genetic algorithm to determine combination each 1000kw and 2*200kw hybrid DG are obtained. Investment cost and applied penalty cost of greenhouse gasses effect on hybrid DG combination that can be seen in section IV. The used genetic algorithm increased renewable energies portion in hybrid DG

combination and also satisfy minimum investment return period.

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