Optimal operation of a Microgrid in the Power Market Environment by PSO Algorithm

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Abstract- In this paper for optimal operation of a microgrid a model is represented including wind turbine, photo voltaic, generator diesel, battery bank, converter, critical load and controllable load. This Microgrid Management System (MMS) generates an optimum operation plan for a microgrid on next day. Modeled microgrid has ability of converting electric energy to main grid. At proposal model, uncertainty in predicting wind velocity is considered. Operation of this microgrid with purpose of reduction of cost is optimized. In this paper, the Particle Swarm Optimization Algorithm (PSO) is used for optimization. At the end of a model example for applying the results of the proposed model will be examined and analyzes the results. Results show that the model is an appropriate method for the operation of this microgrid.

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Introduction

Interconnection of small, modular generation and energy storage to low or medium voltage distribution systems forms a new type of power system, the microgrid (MG) [1]. Micrograds can be connected to the main power network or be operated autonomously, similar to power systems of physical islands. In other words, the microgrid concept assumes an aggregation of loads and micro sources (<500 kW) operating as a single system providing both power and heat.

Currently, power in the entire world leaded to construct changes in order to reach to power grid simultaneously and also use of Distributed Generation (DG) dispersed. Many years ago, electricity was produced in large power plant and generation, transmission, distribution and providing electricity were done at there. But today production and consume are in a competitive space and equipments of this industry should move to its functions and activities in order that electricity industry has efficacy commercially. As a result this power market expelled from exclusion of few counties and thousands producers will substitute it If they accomplish this, the consumer will have the opportunity to choose their electricity supplier. Main reasons of different countries refer to production references of DG include higher efficacy, little pollution, flexibility at consuming fuel and reduction of need to development of transmission and distribution system. Distributed Generation (DG) has been available, such as solar systems, wind turbines fuel cell, small-scale gas turbine units. DG use local energy source which are Renewable Energy Sources (RES), for electricity production. Amount of converted energy compared with produced values from large central power plant are little. So they are consumed at its installment place. Most of percent of electrical energy is consumed at place of production, as energy is consumed or microgrid is generated. Integration of little and modular productions and energy store at low-voltage systems, from a new type of power system called microgrid [1]. At recent years, different researches about shapes and sizes of micrgrid were done [2, 3]. Also a lot of proposals about fundamental relations of exploitation between different sources at microgrid for solving the problem of consumption optimization for fuel are available in papers [4]. In this paper a microgrid which includes wind turbine and photovoltaic unit and a diesel generator and battery and a converter and critical and controllable loads was modeled. Also this microgrid according uncertainty of power wind unit was made. Optimization of proposed model in this paper was done by means of Particle Swarm Optimization (PSO).

In the section 2 of this paper, we'll explain the structure and the direction of energy current in a suggestive model. In section 3 it is presented the uncertainty in forecasting wind energy production. In section 4, we'll explain suggestive model modeling and the extension of model by using the PSO algorithm. After that, a realistic case study is presented in section 5. Finally, concluding remarks are given in section 6.

Structure and direction of energy current in suggestive model

The suggestive model of the microgrid is like to fig. 1 in this paper.

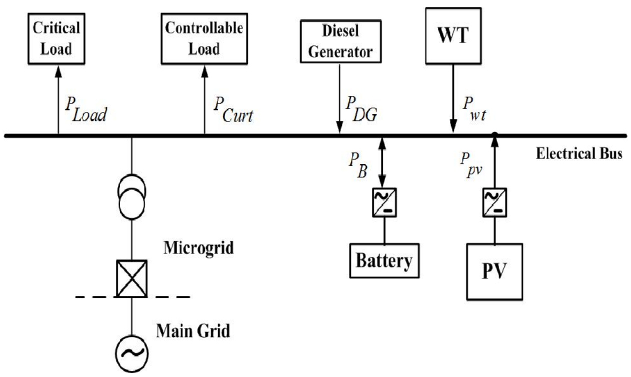

Fig. 1. Structure and direction of energy current

As it is observed in fig. 1, in this microgrid is a wind turbine (P_{wt}), photovoltaic system (P_{pv}), a diesel generator (P_{DG}), a battery bank (P_B) and converter DC/AC. In this microgrid output power from wind unit (P_{wt}), output power from photovoltaic (P_{pv}) as well as requested power provision are stored at batteries. In this model, batteries power (P_B) and diesel generator (P_{DG}) and requested power from controllable electrical loads (P_{curt}) covers emergency situation. Sizing this model was done by homer software and amounts and capacity of each unit, has been accounted. As we can see from fig.1, photovoltaic, wind unit and diesel generator provide power for critical (P_{load}) and controllable (P_{curt}) loads. In this microgrid is used a battery bank in order to store output energy of wind and photovoltaic. Microgrid with a main grid exchanges the power. Also microgrid has ability of selling and buying the electrical energy.

Wind turbine model

In order to account and amount of wind turbine output power according to different velocities of wind during 24 hours and Cut-in and Cut-out velocity of wind turbine we can use Eq (1) [5].

$$P_{wt}(t) = \begin{cases} a.V^3(t) - b.P_R & V_{c_i} < V < V_r \\ P_R & V_r < V < V_{co} \\ 0 & V < V_{c_i} \end{cases} \qquad (1)$$

Which for a, b we have:

$$a = P_r / (V_r^3 - V_{ci}^3) \qquad (2)$$

$$b = V_{ci}^3 / (V_r^3 - V_{ci}^3) \qquad (3)$$

At above equation, P_r is indicator of generator rated power, V_{ci} is cut-in velocity, V_{co} is cut-out and V_r is turbine rated velocity.

Curvy of power-velocity of wind turbine is shown at fig.2.

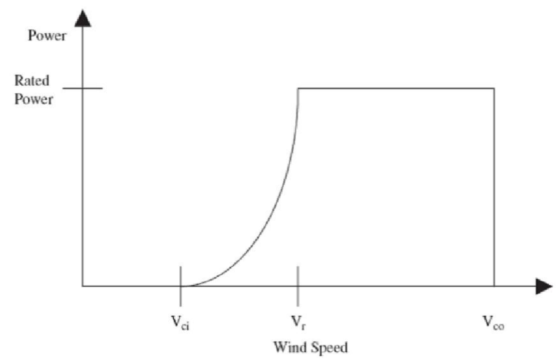

Fig. 2. Curvy of power-velocity of wind turbine

Model of photovoltaic panels

Output power of photovoltaic panel is accounted by their relation between amount of sunlight on the panels and environment temperature.

Output power from a photovoltaic panel is accounted by Eq(4).

$$P_{pv} = P_{stc} \frac{G_{ING}}{G_{STC}} (1 + k(T_c - T_r)) \qquad (4)$$

P_{pv} is output power from photovoltaic panels, P_{STC} is maximum power of panel at STG, G_{ING} is amount of sun radiations, G_{STC} is sun radiation at standard state ($1000\frac{w}{m^2}$), K is thermal coefficient, T_C is temperature of solar cell and T_r is environment temperature.

Model ling battery bank

For charging and de charging the batteries in a microgrid, amount of being charged of a battery is accounted by Eq (5) [5].

$$soc(t+\Delta t) = soc(t) + \eta_{bat}\left(p_B(t) \big/ U_{bus}\right).\Delta t \quad (5)$$

Δt is interval time or interval of two successive times at one hour, η_{bat} is efficiency of being charged in a battery and this value reach to 100% for de charge, u_{bus} is DC bus voltage of microgrid, $P_B(t)$ is batteries power, $SOC(t)$ is amount of charge in a battery at time (t) which its unit is ampere hour (Ah).

$$SOC_{\min} = (1-DOD).Soc_{\max} \quad (6)$$

Eq (6) show how a battery is de charged and $SOC_{\min}$, $Soc_{\max}$ is respective low limit and high limit of battery charge state. DOD is percent of battery charge.

Diesel generator model

In order to account the diesel generator cost, two important costs are considered [6].

1. Fuel cost, 2. Maintain and repairmen cost

$$C_{D_G}(t) = C_{o\&m}(t) + C_{fuel}(t) \quad (7)$$

$$C_{fuel}(t) = P_{r_{fuel}}.(A + B.P_{DG}(t) + C.P_{DG}{}^2(t)) \quad (8)$$

$C_{D_G}(t)$ is diesel generator (∉), $C_{o\&m}(t)$ is maintain and repairmen cost of diesel generator (∉), $C_{fuel}(t)$ is fuel cost at diesel generator (∉), $P_{r,fuel}$ is fuel price ($\frac{∉}{L}$), $P_{DG}(t)$ is output power of diesel generator (Kw) and coefficients A,B,C are respective diesel generator at account part and given numerical results.

Uncertainty in forecasting wind energy production

Uncertainty in wind energy production is the characteristic of this natural energy, so when the utilization of networks, including the type of units is considering the issue of uncertainty is essential. If the location of wind units are geographically dispersed set of output changes greatly reduced the units and of course still has the problem of uncertainty considered. Fluctuations in power output of wind turbines in wind speed changes to come there, not completely random and are not completely predictable. For a long period activity of a wind farm, the prediction error is similar to a normal distribution function. In order for risk prediction error at issue reduced the utilization of the combined system, we can predict the errors at different levels, we calculated reliability. Prediction error of wind energy production, known as risk. For example, 95% said the level of probability that the prediction error is greater than the amounts of production risk is less than 5%. This method of production for the proposed wind energy to a specific level of reliability in production planning gains. Wind energy minus the predicted rate of production risk that can issue operating system should be used. Since the operator more willing to overestimate the production of wind generators is therefore a unilateral distribution curve is considered as normal distribution curve. The operator to determine the issue of risk needs to determine the production of a certain confidence level. The following equation estimates the high error level unilateral normal distribution curve with confidence level (α-100) % [7].

$$P[e - \mu_e \geq Z_\alpha \sigma_e] = \frac{\alpha}{100} \quad (9)$$

$$\tilde{e} = \mu_e + Z_\alpha \sigma_e \quad (10)$$

$\tilde{e}$ represents the high-risk relationships, μ_e producing an average forecast wind error standard deviation and σ_e are the wind forecasting error. Below a graphic expression of these equations with the confidence is level (α-100) %.

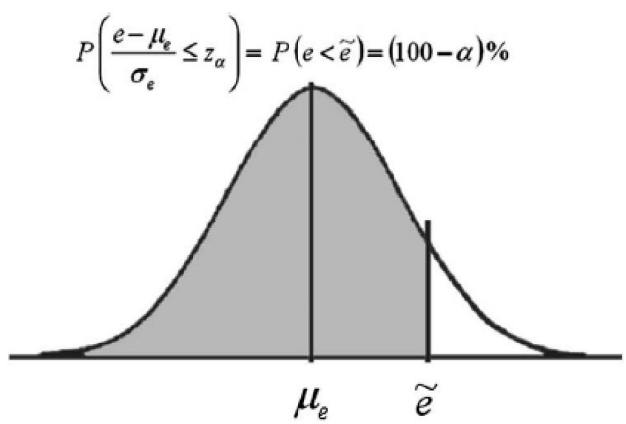

Fig. 3. Level of confidence level on a normal distribution curve

$\tilde{e}$ is some probability that states that the prediction error is higher than $\tilde{e}$ is less than% α.

$$P(e < \tilde{e}) = \alpha\% \qquad (11)$$

100% of the total area under the curve and the area eaten part hachure% (α-100) are. Z_α Value for the reliability levels of 90%, 95% and 99% in Table I is given.

TABLE I

Z_α VALUE FOR DIFFERENT CONFIDENCE LEVELS

Z_α	$P[e-\mu_e \ge Z_\alpha \sigma_e]$
1.285	90%
1.645	95%
2.329	99%

Mean error Mean error as a historical period is calculated. We have For N observation:

$$\mu_e = \frac{1}{N}\sum_{i=1}^{N} e_i \qquad (12)$$

$$\sigma_e = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(e_i - \mu_e)^2} \qquad (13)$$

The e_i prediction error rate in sample i, μ_e and σ_e mean wind forecast error standard deviation error of prediction are wind. To enter risk production in the utilization plan, planners should first determine what level of confidence they need. The mean error and standard deviation can be recorded from the previous authentication information and relationships (12) and (13) come get. Values using the error mean value, standard deviation, and risk production value of Z_α ($\tilde{e}$) relation (10) is calculated. Value obtained for ($\tilde{e}$) of the predicted value is low and this number as the output of wind generators will enter the optimization problem. Considering the above mentioned wind turbine output matching relationship (14) is considered.

$$P_{wt} = (1-\tilde{e}).P_{wt}^{forcs} \qquad (14)$$

The term P_{wt}^{forcs} represents an equivalent wind turbine production forecast and $\tilde{e}$ is the production risk.

modeling for optimal operation from microgrid

Objective function of microgrid with regard to uncertainty at velocity prediction is defined as Eq (15) to least cost.

$$\min\left\{\sum_{t=1}^{24} Cost(t)_i - Income(t)_i\right\} \qquad (15)$$

i is available units at grid.

$$\min\left\{\sum_{t=1}^{24} C_{pv}(t) + C_{wt}(t) + C_{bat}(t) + C_{DG}(t) + C(P_{curt}(t)) \pm P_{exch}(t).\rho_{exch}(t)\right\} \qquad (16)$$

At this objective function each parameter is defined as following:

$C_{pv}(t)$ is photovoltaic unit cost ($\notin$), $C_{wt}(t)$ wind turbine unit cost ($\notin$), $C_{bat}(t)$ is batteries bank cost($\notin$), $C_{DG}(t)$ is diesel generator unit cost ($\notin$), $C(P_{curt}(t))$ is cost of cut strategy at controllable loads ($\notin$), $P_{exch}(t)$ is amount of bought or sold power (kw) and $\rho_{exch}(t)$ is price of bought or sold power $(\frac{\notin}{kw})$.

Account of photovoltaic unit cost

Photovoltaic unit cost is accounted according to Eq (17):

$$C_{pv}(t) = C_{T,pv}(t) + C_{m,pv}(t) \qquad (17)$$

At above equation, $C_{T,PV}(t)$ is sum of panels buy cost and their installment cost at an hour ($\notin$), $C_{T,PV}(t)$ is account by means of Eq (18).

$$C_{T,pv}(t) = \frac{C_\circ(1+\alpha)^n}{20\times365\times20} \qquad (18)$$

At above, $C_\circ$ is cost of buy and installment of panels at beginning of the project, α is interest rate and n is age of project.

$C_{m,PV}(t)$ is repairmen and maintain of photovoltaic panels at interval of one hour ($\notin$) and is accounted according to Eq (19) [5].

$$C_{m,pv}(t)=\frac{(\frac{C_0}{100})\times 20}{20\times 365\times 24\times 20(kw)}\times P_{pv}(t)$$

(19)

Account of wind turbine unit cost

Wind unit cost is accounted according to Eq (20).

$$C_{wt}(t)=C_{T,wt}(t)+C_{m,wt}(t) \qquad (20)$$

At above equation, $C_{T,wt}(t)$ is sum of wind turbine sell cost and its installment cost at an hour (∉) and $C_{m,wt}(t)$ is repairman and maintain an hour (∉) of wind turbine, value of $C_{T,wt}(t)$ is accounted by Eq (21) [5].

$$C_{T,wt}(t)=\frac{C_{\circ}(1+\alpha)^n}{20\times 365\times 24} \qquad (21)$$

$C_{\circ}$ is buy and installment cost of wind turbine at beginning the project, α is interest rate and n is age of project.

Cost of wind turbine maintains and repairmen are accounted by Eq (22).

$$C_{m,wt}(t)=\frac{(\frac{C_0}{100})\times 20}{20\times 365\times 24\times 300(kw)}\times P_{wt}(t)$$

(22)

Account of battery bank cost

Cost of battery is considered by Eq (23).

$$C_{bat}(t)=C_{T,Bat}(t)+C_{m,Bat}(t) \qquad (23)$$

$C_{T,Bat}(t)$ is cost of battery bank buy and its installment at a hour (∉) and $C_{m,bat}(t)$ is buy and exchange cost.

$C_{T,Bat}(t)$ is accounted by Eq (24).

$$C_{T,bat}(t)=\frac{C_{\circ}(1+\alpha)^n}{20\times 365\times 24} \qquad (24)$$

Cost of charge and de charge is accounted by Eq (25).

$$C_{m,wt}(t)=\frac{(\frac{C_{\circ bat}}{100})\times 20}{20\times 365\times 24\times 228(kw)}\times P_B(t)$$

(25) $C_{\circ}$ is buy and installment cost of batteries at beginning the project, α is interest rate and n is age of project.

Cost of cut strategy in controllable loads

Cut strategy cost at controllable loads is accounted according to Eq (26) [9].

$$C(p_{curt}(t))=\beta.P_{curt}+\gamma\ .\ P_{curt}^2 \quad (\notin) \qquad (26)$$

β,γ are cost coefficients at cut strategy at controllable loads. $P_{curt}(t)$ is cutting power at controllable loads (Kw).

Constraints of objective function for optimal operation from microgrid

Constraints of objective function for optimal operation from microgrid are following:

1. Constraint related to battery bank: charge state of batteries bank between $SOC_{\min}$, $SOC_{\max}$ is changing [9].

$$SOC_{\min}\le SOC(t)\le SOC_{\max} \qquad (27)$$

2. Sum of photovoltaic unit power and wind turbine and exchange power with main grid and diesel generator power and batteries bank should be able to provide requested power from critical and controllable loads.

$$(P_{pv}(t)+P_B(t))\times\eta_{con}+P_{wt}(t)+P_{exch}(t)+P_{DG}(t)$$
$$=P_{LOAD}(t)+P_{curt}(t) \qquad (28)$$

$P_{pv}(t)$ is productive power by photovoltaic panels (Kw), $P_{wt}(t)$ is productive power by wind turbine (Kw), $P_{exch}(t)$ is bought or sold power amount (Kw), $P_{LOAD}(t)$ is requested power by critical loads (Kw), $P_{curt}(t)$ is requested power by controllable loads (Kw), η_{con} is converters outputs.

If $P_B(t)<0$, batteries are charging and if $P_B(t)>0$, batteries are de charging.

3. Limitations of maximum and minimum capacities of productive power of wind turbine unit and photovoltaic unit and diesel generator are the following, which:

$$P_{pv,\min}\le P_{pv}\le P_{pv,\max} \qquad (29)$$

$$P_{DG\min}\le P_{DG}\le P_{DG\max} \qquad (30)$$

$$P_{wt,\min} \le P_{wt} \le P_{wt,\max} \qquad (31)$$

$P_{pv,\min}$ and $P_{pv,\max}$ are low high limits of photovoltaic unit productive power. $P_{wt,\min}$ and $P_{wt,\max}$ are low and high limits of wind turbine unit productive power. $P_{DG,\min}$ and $P_{DG,\max}$ are low and high limits of diesel generator productive power.

4. Maximum limitation of microgrid power exchang with main grid is accounted by Eq (32) [10].

$$P_{exch}(t) \le P_{exch}^{\max} \quad : \forall t = 1{:}24 \qquad (32)$$

5. High and low limits of critical and controllable loads are accounted by Eq (33) [1].

$$0 \le P_{curt}(t) \le P_{curt}^{\max} \qquad (33)$$

The software development of suggestive model

According to objective functions and mentioned constraints for optimization as well as prediction of wind velocity, we need power plant units' features at microgrid, requested power amount, price of electricity buy and sell and bought and sold power amount.

At fig.4 flowchart of optimization program was shown.

As we can see at fig.4, at the first step according to wind speed and uncertainty at win production power and by environment temperature and sun radiation amount after the determination of initial input parameters and maximum production power of each source during 24 hours, after selecting the powers alternatively in each source, the cost function will be accounted and program is repeated until the best output power of each source be determined and the least cost be received.

Optimization of suggestive model by using of PSO algorithm

In this paper, the optimization of suggestive model is accepted by using PSO algorithm.

PSO algorithm is applied for optimization:

The first step:

1) The production of initial population of articles, all of the articles accidentally are produced in limit which provides the bridles.

2) Set the repetition number equal to 1.

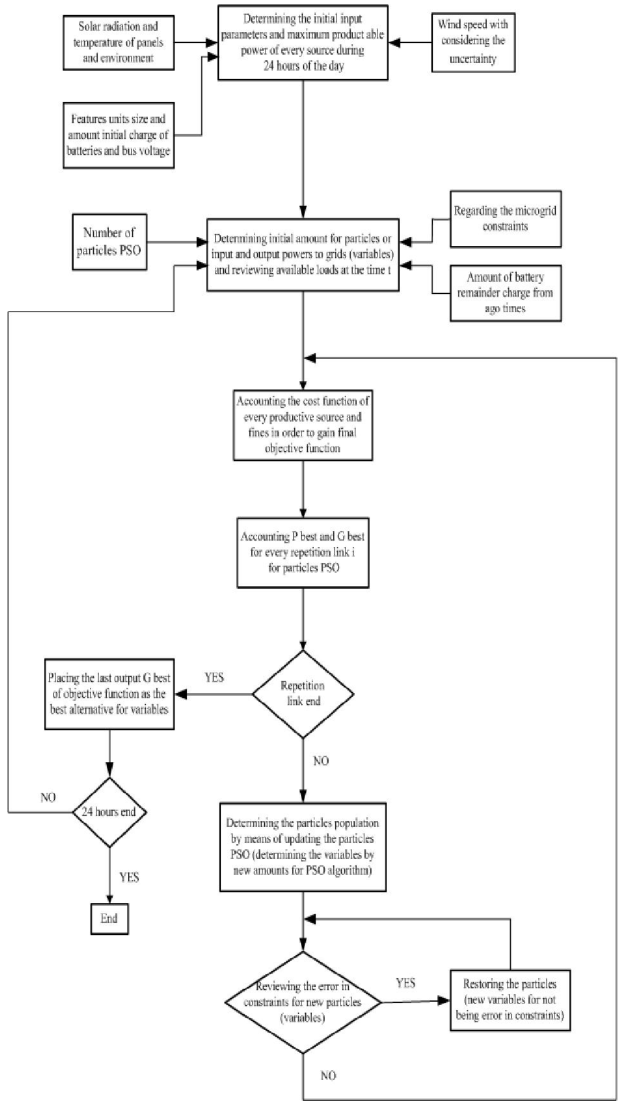

Fig 4. Flow chart optimization program

The second step:

1) Calculation of the value of objective function.

2) Calculation of the amount of sufficiency.

Third step: producing the new articles.

Fourth step:

1) Consideration the constraints: if constraints aren't provided by an article, that part of article, which over step from the free bridle is produced accidently than that constraint will be produce finally.

2) edit the repetition number: If the repetition number is smaller than its maximum, it goes to second step, if not, goes to fifth step.

Fifth step: the result of optimization.

Regarding to the explained stages, the flowchart of optimization by using PSO algorithm is as fig. 5[11].

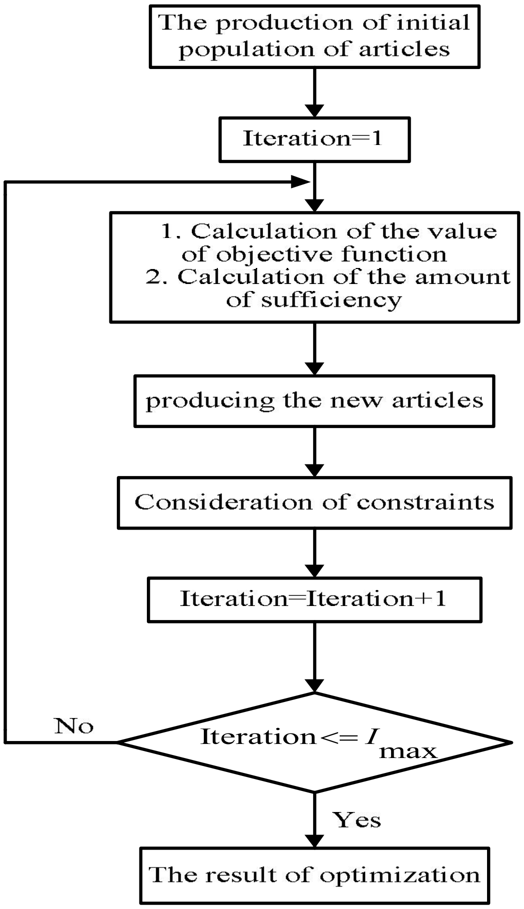

Fig. 5. Flowchart of optimization by using of PSO algorithm

CASE STUDY

In this section the optimum operation microgrid of suggestive model on a sample model is done for different parameters and the results of optimization are studied.

Also in this section, input information related to available units at microgrid and necessary amount for optimization according to objective function of Eq (16) and constraints of Eq (26) to (33) and with regard to uncertainty at prediction wind velocity in order to receive the least cost, is represented.

Input Data

In table II to V and fig. 6 to 12, the internal data are brought for program performance.

The used wind turbine in this model has the power 2MW, which it used 6 wind turbine 2MW that have the same features. The values of parameters of used wind turbine in this paper are brought in table II.

TABLE II. THE VALUES OF PARAMETERS WIND TURBINE

Parameter	Value
Rated power	200 Kw
V_r	13.8 (m/s)
V_{c_i}	3.1 (m/s)
V_{c_i}	25 (m/s)
$C_{\circ\, wt}$	190000 €

Predicted wind velocity at 24 hours is as fig. 6.

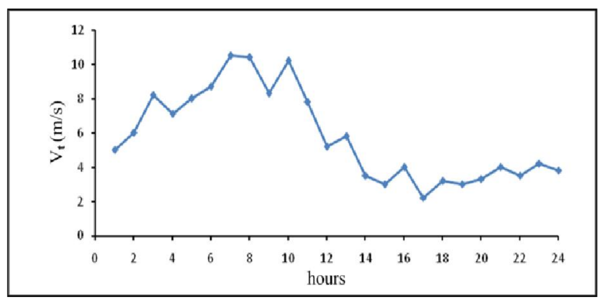

Fig. 6. The scenarios of predicted wind speed in 24 hours of market day

The uncertainty in forecasting wind energy production, the average error in predicting the 10% and standard deviation of the predicted 5% to be considered. Referencing Table (1) the amount of Z_α will be obtained, then using relation (10) the amount of production risk ($\tilde{e}$) will be obtained. Values of these parameters in Table III are given.

TABLE III
VALUES FOR THE PARAMETERS GIVEN THE UNCERTAINTY IN FORECASTING WIND ENERGY

σ_e	μ_e	Z_α	$P[e-\mu_e \geq Z_\alpha \sigma_e]$	$\tilde{e}$
5%	10%	1.645	95%	0.1822

Considering the amount of production risk ($\tilde{e}$) in

Table III, and using relationship (14) the amount of wind power production capacity with considering the uncertainty in predicting energy Wind is calculated.

Fig. 7 shows production power amount of wind power plant according to wind turbine parameters amount and uncertainty at predicting the wind energy.

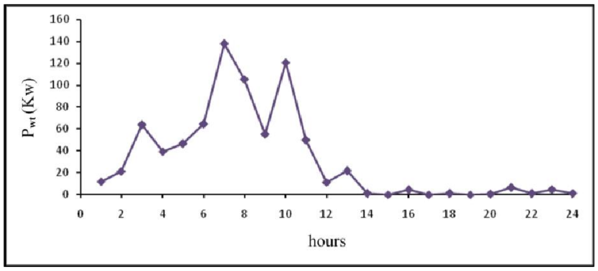

Fig. 7. Wind turbine output power in 24 hours

In order to account the photovoltaic panels output power amount by Eq (4), sun radiations and environment temperature at every hour of the day, is required [10]. The radiations amount and environment temperature shown at fig. 8 and 9. So received power amount by photovoltaic cells is according to fig. 8.

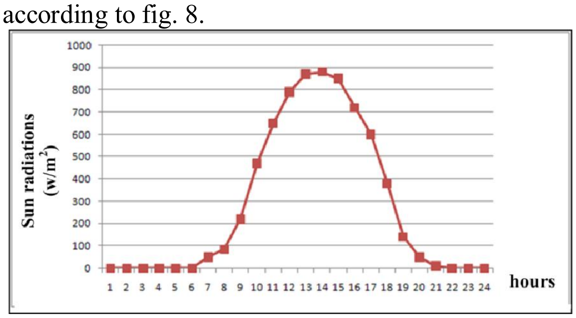

Fig. 8. Amount of sun radiations during 24 hours of the day

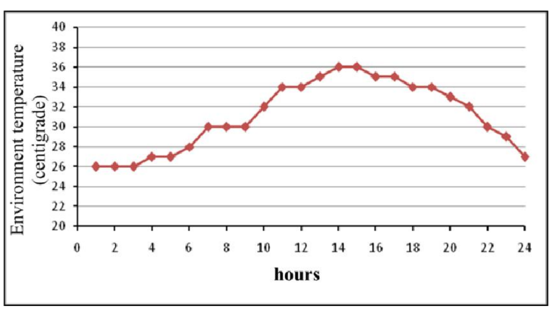

Fig. 9. Amount of environment temperature during 24 hours of the day

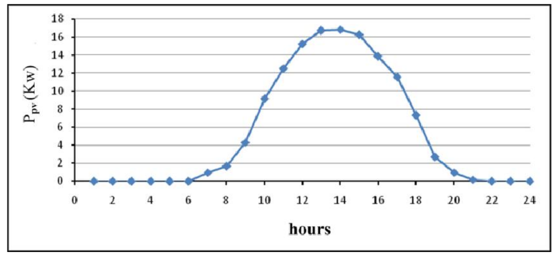

Fig. 10. Photovoltaic unit output power in 24 hours

Also numerical amounts related to photovoltaic panels features at the microgrid are represented at table IV.

TABLE IV. THE VALUES OF PARAMETERS PHOTOVOLTAIC UNIT

Parameter	Value
P_{STC}	20 Kw
G_{STC}	228 (w/m^2)
K	-0.004
T_r	25 ^{oc}
$C_{\circ\ pv}$ (112 number)	210000 €

At this microgrid in order to store energy, 30 batteries were used and numerical amounts related to battery bank features at this microgrid was shown at table V [5].

TABLE V. THE VALUES OF PARAMETERS BATTERY BANK

Parameter	Value
Rated capacity of 30 battery	1900 Ah
Productive energy	228 Kwh
Voltage every battery	4V

Parameter	Value
DOD	80%
η_{bat}	80%
$C_{\circ\, bat}$ *(30 number)*	448000 €

Amount of critical load for participants of microgrid during 24 hours of the day is as fig.11 [6].

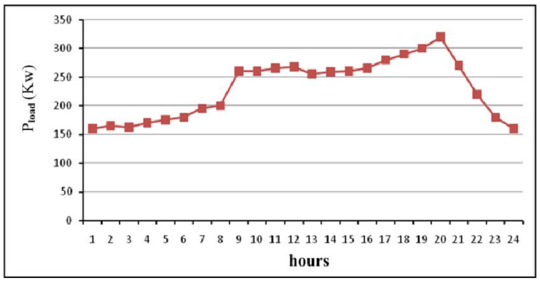

Fig. 11. Amount of critical load for participants of microgrid during 24 hours of the day

Amount of bought or sold electricity price with main grid (power market) during 24 hours of the day shown fig.12.

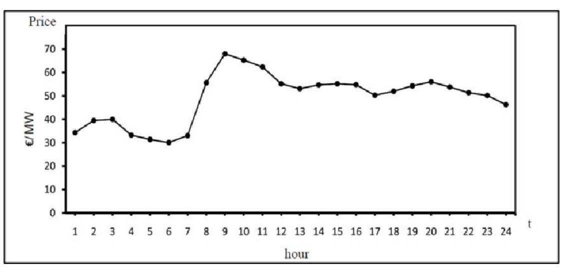

Fig. 12. Amount of bought or sold electricity price with main grid during 24 hours of the day

Features of controllable loads shown at table VI.

TABLE VI. THE VALUES OF PARAMETERS CONTROLLABLE LOADS

Parameter	Value
$P_{curt\ \min}$	0
$P_{curt\ \max}$	20 Kw

Parameter	Value
β	0.08
γ	0.001

Also amount of other parameters of model shown at table VII.

TABLE IV
THE VALUES OF THE OTHER PARAMETERS

Parameter	Value
$P_{pv,\min}\ (kw)$	0
$P_{pv,\max}\ (kw)$	20
$P_{wt,\min}\ (kw)$	0
$P_{wt,\max}\ (kw)$	300
$P_{DG,\min}\ (kw)$	0
$P_{DG,\max}\ (kw)$	400
$P_{exch}^{\max}\ (kw)$	30
η_{con}	80%
$n\,(years)$	20
α	0.06
A	0.3842
B	0.0466
C	0.0007

Price of diesel generator fuel is 0.9 €/Lit and cost of diesel generator repairmen and maintain is 0.2 € at an hour.

Applied to the parameter values for the PSO algorithm are in Table VII.

TABLE VII
THE PARAMETER VALUES FOR THE PSO ALGORITHM

Parameter	Value
Population size	350
Number of replications	1500
Acceleration coefficient C_1	2
Acceleration coefficient C_2	2
Retention Weight (W)	1

B. The program exit and analysis of results

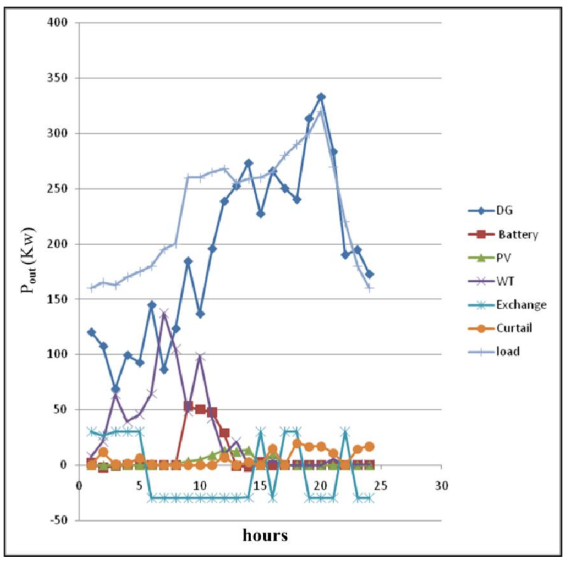

Fig.13. Programming of productive power from operation of microgrid

The results of microgrid optimization according to uncertainty at predicting the wind velocity for optimal operation of microgrid in order to receive the least cost are shown at following figures. Fig.13 shows the production power amounts of every unit and also amount of sale and buy of the power with main grid and amount of cutting load at critical loads and amount of charge and de charge of batteries during 24 hours of the day.

As shown at fig.13, amount of charging and de charging the batteries didn't become less than 20% maximum charge. At first the full charge was assumed in the batteries. Negative amounts at exchange power show that microgrid is selling power to main grid and positive amounts show that microgrid is buying the power from main grid.
At fig.14 the cost amount of every production unit for production power of fig.13 and penalty of cutting for controllable loads and buy and sale of microgrid power is represented.

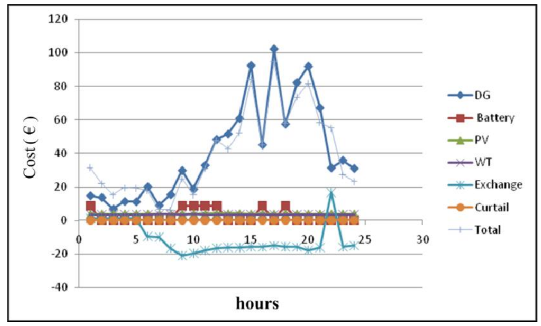

Fig.14. the cost amount of every production unit and cost of microgrid in 24 hours

At fig.14 the least operation cost of microgrid during 24 hours is represented. Negative amounts of fig.14 related to power exchange with main grid are for sale and regarded profit.

CONCLUSIONS

In this paper a model from microgrid is represented including wind power production units, photovoltaic unit, diesel generator, battery storage units, critical and controllable loads. In this microgrid, exchange with main grid is executed. In this model, the objective function expresses least cost of microgrid operation according to uncertainty at wind energy. Also for solving the optimization problem, different constraints were used such as constraints related to productive units, constraints related to microgrid and constraints related to critical and controllable loads. Using wind turbine units and photovoltaic units because of least cost at operation can be effective in microgrid and other pointes of power system. Diesel generator system is used as support in order to provide remainder power.

Also optimization was done by means of PSO algorithm. The results show efficiency of PSO algorithm.

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