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Improvement and Planning for Utilization of Sparse Production Resources in Distribution Networks Using DP Dynamic Algorithm

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ABSTRACT: This paper proposes a microgrid distribution system with low voltage (LV) in the distribution network with multiple distributed generations (DG), including distributed and control loads. Here, for the presented network, with the aim of optimizing the network the performance of the during microgrids during 24 hours performance and management on the market price per day regarding the production costs (startup costs) with the cost of the consumer considered with regard to the market policy. In the studied LV network, different market policies assuming the form the market close reflected the operating expenses and the effects on microgrids and the distribution network has been discussed. The proposed approach using genetic and dynamic algorithm and demand-side bidding have been made.

Keywords: Microgrid, Distributed generation, markets, optimization, renewable energy sources, Demand-side bidding (DSB)

INTRODUCTION

Environmental energy has some policies, among other requirements, which penetrates the distributed generation (DG) and has the capacity of closing the resources to energy consumers at low or medium voltage (LV) in the distribution network. These resources include multiple technologies including diesel motors, micro-turbines (MTs), or fuel cells or combined heat and power (CHP) which are used solely to produce electricity, photovoltaics (PVs), small wind turbines (WTs), hydro turbines, etc. with resources of different DG in capacity from a few kilowatts to 1.2 megawatts.

Synchronization and controlling the DG resources is done by storage devices such as wind turbines, power capacitor, batteries and controllable loads such as water heaters, central air conditioners as microgrids (1) (2). Microgrids mainly have a close relationship with the main distribution network, but can be isolated in the case of an external fault. From the point of view of the network, Microgrid can be considered as a control entity within the power system which can have sole and compact load function, even as a small source of power or ancillary services supporting the network. From the customer's point of view, microgrids provide traditional LV distribution networks not only with heat and electricity needs, but also enhanced local reliability, reduced emissions, improved power quality by supporting voltage and reducing voltage drop, resulting in lower cost of energy supply. It is clear that, in order to achieve these benefits, it is important to provide a coordinated decision-making process, so that the future balance of supply and demand of both DG and medium-voltage (MV) resources of the distribution feeder can be obtained.

This paper focuses on the units used for energy planning, which is an important role in the optimization planning of daily operation of each power system plan that is typically used by system administrators. Planning energy resources include two phases: the unit commitment (uc) economic dispatch (ED). Unit commitment (3) (4) can be defined as ON/OFF Status of power generation units over a time horizon of daily or weekly, while valuing on other generators system limitations. Typically the aim is to minimize the problems associated with energy costs, and the costs for switching units on/off. As a result, the problem with large-scale nonlinear optimization, for which there is no exact solution method. The solution to this problem can be obtained by complete counting which often in costs is a prohibitively long computation time required for a true power. Therefore, research efforts are focused on efficient UC algorithms, which are used in modern power systems. Economic distribution and computing level of power agents per unit commitment cost of generators is sent to all generators regarding decision to distribution. (5)

The proposed method in this paper uses the sparse grid system including several compact thermal loads using genetic algorithm planning on continuing thermal units using the operation of unit commitment, dynamics algorithm in MATLAB software. The structure of the remaining part of the paper includes: in the second part, the genetic algorithm and UC have been investigated, in the third part the market policy and in the fourth part, Demand side bidding load in two in cases of load transfer and load cut; the results obtained are shown in section V and the results of economic optimization of this process has been shown in section VI as conclusion. The microgrid examined in the study included four thermal units, three wind turbines, three PV units and the major network (GRID).

Planning Based on Genetic Algorithm

Randomized, multi-purpose genetic algorithm and parallel search methods can be used as optimization methods. Close global optimum can be achieved by the GA. This algorithm is inspired by genetics, the theory of evolution and natural selection and the survival of the fittest. This repeated method in the population of chromosomes, support each chromosome using a candidate solution to the problem. Proportionality that depends on how well it solves the problem that is associated with each chromosome. The objective function includes fines and penalties for those which can not met the potential solution constraints of the problem. The objective function is translated to fitness that is the solution's ability to survive and reproduction. The new generation of solutions is obtained by a process of selection, crossover, and mutation. During the evolution process, a new generation is increasingly characterized by the evolution of solutions toward the optimal solution. (5)

UC Using Genetic Algorithm

To use GAS for UC problem, the simple binary alphabet was used for endocing solution. If N represents the number of H unit and the planned period in hour, then the assumption that at each hour a particular unit can be turned on or off, a H bit row is needed to describe the planning of single planning of the row. In such a row, '1' indicates that the active unit in a particular place per hour, while '0' indicates that the unit is not activated. With the incorporation of rows, N units of N'H bit row are consisted of the as shown in Figure 1.

The result of research in this space is extensive. For a system with 20 units and for 24 hour planning during writing genetic sequences, there are 24*20 = 480 bytes results in the time space for mode 10^{44}, there are 3.12 = 2^{480} different solutions.

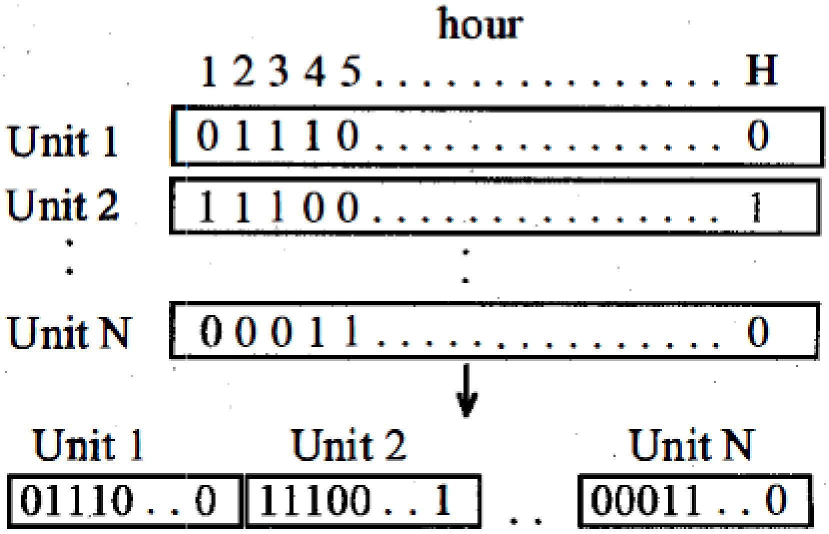

Figure 1. Unit commitment problem solution with binary representation

Formulation Problem for Solving the UC

The UC problem is to minimize total production costs during the planning horizon. Total costs include:

- Fuel costs
- Startup costs
- Outage costs

Fuel costs are calculated using the unit heat rate and fuel price information. The use of dual- fuels to stabilize flame when the output level of the unit is low, for example during the startup ramp, further complicated the fuel cost calculations. Startup costs are expressed as a function of the number of time units (exponential which is mild and linear). Outage costs are defined as a fixed dollar amount per unit of any outages.

Requirements that must be satisfied during the optimization process include:

(a) Balance of power system (demand + losses + exports).
(b) Storage system requirements.
(c) The initial conditions of the unit.
(d) The lower limit of the high mw (economic performance)
(e) The time of minimum at up of the unit.
(f) The time of minimum at the bottom of the unit.
(g) The constraints of the situation of the unit (forced move, fixed mw, available, unavailable).
(h) Restrictions on unit rates.
(i) The startup ramp of the unit.
(j) The shutdown ramp of the unit.
(k) Heat stabilization of unit combination fuel.
(l) Single or double use of alternative fuels.
(m) Fuel availability to the unit or units.
(n) Limitation of factory workers.

Limitations (a) and (b) are relevant to all units of the system or called system binding constraints. For multi-area unit commitment, system restrictions should be modified to take into account the exchange constraints and limitations of the nodes. In general, the system constraints must take into account constraints on the allocation of demand and supply and the bottlenecks that may be transferred to production units.

Constraints (c) through (m) are concerning the individual units and are called local constraints. Plant personnel constraints can also be classified along with local restrictions, but they cover all units of a power plant. (7)

Priority List (PL) Method

PL techniques imitate the planning ways following the system performance. Commitment units are in ascending order, with an average unit cost of fuel load so that the economic base load for the unit commitment is in first and last units to meet peak demand times. PL method is very smart and very fast timetable with relatively high production cost.

The Dynamic Programming (DP) Method

DP method decomposes the UC problem at time: starting in the first hour of planning, commitment unit to the process units an hour at a time, and mix of units is to be stored at any time. This is the path forward of the DP method. At the end of the path forward for each hour – each mode (mode is defined as a combination of ON/OFF status of all units) the data is stored as follows:

a) Minimum total production cost to reach the starting position of the first hour,
b) The optimal point of the link pointing back at the previous hour, which leads to the optimum transmission mode (minimum total cost), current hour, and
c) Arrayed elements represents a continuous UP (if positive) or below (if negative) of all units.

The latest information is in order to be able to maintain compliance with time-dependent constraints, such as minimum up and down time of unit, startup and time-dependent costs. Finally, the schedule is obtained from the most economical to shift mode (hybrid) with a minimum total cost of the final hour via return path to the desired link of the state in the early hours. The main problem of DP method is the disaster of dimension: all possible combinations of storage units (N, 2^{N-1}: number of units) per hour is impossible even for medium-sized systems, so intelligent techniques can be used to limit the number of combinations of search strategies that maintain per hour (8-9). These heuristics produce suboptimal solutions and sometimes may require some relaxation of some constraints in order to produce a solution. DP Approach is related to UC problem, however, other major problem are the time-dependent behavior constraints such as minimum load of up and down of units, time-dependent startup costs, startup ramps, and so on. This problem has been well recognized in the literature (9-10) and may lead to suboptimal solutions or no solution even in the case of CBC mode. The reason for this is that the definition of "state" in the DP solution of the UC problem is a combination of the status of all units 0-1 and is incorrect. The false choice of "state" leads to the need to keep some information about UP or DOWN continuous-time for all units have already been discussed. However, this information is incomplete because it is stored for transmission path optimization not only for paths, so that valuable information to determine the optimal (or in some cases, even a functional) solutions are lost. To overcome this problem, the DP mode should be defined as $(1,2,\dots \mathrm{n})$ where *i* is the UP time (if positive) or down time (if negative) of unit i. However, with this definition of the state, the complexity of the DP solution is prevented even for small size systems.

The Mathematical Formulation

A. Integrated Mode

Optimization problem is formulated and have been considered according to different market policies. The following is intended to optimize the active power, since reactive power markets are less developed in distribution level. And in this case, optimization of functions for taking bid reactive power is straightforward.

Market Policy

Cost minimization, where:

$$\text{cost} = \sum_{i=1}^{N} \text{active\_bid}\,(x_i) + AX + \sum_{j=1}^{L} \text{load\_bid}\,(y_j) \qquad (1)$$

Where bid-active (X_i) is the ith bid of DG source, X_i is active power generation of ith of the source DG, X is the power purchased from the grid, N is the number of DG sources bid of productive capacity, and A is the open market price of active power. If the DSB is considered, the proposed y_j refers to the jth load of L bid loads. In the proposed outage option, the customer is being compensated, the compensation of cost burden-bid (y_i) is added to operating costs.

Constraints for the optimization include:

1) Technical limitations of DG sources, also maximum and minimum performance constraints;

2) The active power balance in Microgrid (11). P- Demand is active power demand. (12)

$$X + \sum_{i=1}^{N} X_i + \sum_{j=1}^{L} y_j = P\_\text{Demand}. \qquad (2)$$

Demand-side bidding

It is assumed that both low and high priority load consumers allow submitting separate bids for each of their MGCC. In our application, it is assumed that each consumer places bids in two levels reflecting their priorities. Low priority loads can be lower than prices in the period (shift) or if the service were not all satisfied (curtailment). Similar approach can be used over two levels more accurately reflect the proposed use of the consumer. Two options were considered for the bid consumers.

1) Load transfer: consumers instead of two bids for the supply of high- and low -priority loads are the future period performance.
2) Load cut (Curtailment): low priority consumers to shed load in constant prices in the next active period.

In both options, MGCC:

1) informs consumers about the free market price ;
2) accepts bid of consumer per intervals for the next hour in meters per minute;
3) runs an optimization procedure;
4) sends a signal to the LC in accordance with the results of the optimization (12)

The Problem Formulation

Cost optimization problems in exploiting the micro-grid is formulated as follows (13)

5.1 Definition of the target cost function

In order to minimize the operating costs of microgrid following formula is used:

$$Min \;\; f(P) = \sum_{t=1}^{T} Cost^{t} = \sum_{t=1}^{T} \left\{ \sum_{i=1}^{N_g} \left[P_{Gi}(t) B_{Gi}(t) \right] + \sum_{j=1}^{N_s} \left[P_{sj}(t) B_{sj}(t) \right] + P_{Grid}(t) B_{Grid}(t) \right\} \qquad (١)$$

Where T represents the total hours of study, Ng and Ns are the number of production energy saving units respectively, G_i (t) and s_j (t) is the output of *i*th unit in *j*th at time t and finally P_{GRID} (t) and B_{GRID} (t) is the exchange rate at time t and the proposed price of market.

Studied system (simulation results)

The system studied here is the same system used in reference 12, which includes two thermal units, three wind turbines units and three PV units and the major network (Grid).

In order to study the system performance using the basic genetic algorithms (GA) where solution method described in the previous section, ode in order to optimize the proposed prices and loads within 24 hours based on the eight systems considered and presented in Table 1.

Table 1. The main loads for 24 including demand loads (PP-Demand)

Hour	Load	Hour	Load	Hour	Load
1	1000	9	1640	17	1650
2	1030	10	1700	18	1630
3	1050	11	1870	19	1550
4	1070	12	1870	20	1450
5	1090	13	1850	21	1350
6	1150	14	1800	22	1200
7	1300	15	1720	23	1150
8	1400	16	1700	24	1050

Table 2. Values of household, businesses and industry loads

Hour	Residential	Industrial	Commercial
1	34.581	22.4085	17.8306
2	29.7498	19.4712	15.949
3	25.6815	18.6592	15.5193
4	24.4101	16.9608	16.5591
5	18.8161	17.1043	17.1796
6	18.2774	19.2713	17.4813
7	28.6571	25.844	18.3889
8	39.0369	31.148	25.3951
9	52.7222	46.0362	37.3816
10	51.2973	55.8409	47.8318
11	49.3024	62.8738	56.3038
12	58.9919	59.876	64.0921
13	58.6733	54.289	68.5578
14	52.1796	64.1967	67.5537
15	53.3931	60.5424	68.0645
16	46.1122	60.3816	65.8462
17	48.8181	56.99	67.0219
18	69.2786	45.7493	67.9421
19	87.2264	37.3829	73.3207
20	94.7645	34.5513	59.3343
21	95.8776	29.7352	53.0073
22	86.6917	28.2759	46.2724
23	71.7647	27.4054	38.4099
24	52.818	24.6708	23.2004

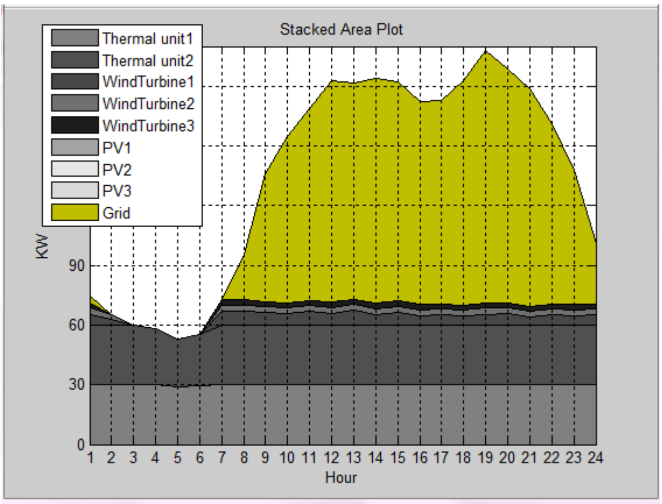

Figure 2. Output curves of loads within 24 hours based on bid loads and prices

The values used in the eight main units plus home network are as follows.

Table 3. Data used in the DG units

INSTALLED DG SOURCES			
Unit ID	Unit Type	Min Power (kw)	Max power (kw)
1	Thermal unit 1	6	30
2	Thermal unit2	3	30
3	Wind Turbin 1	0	15
4	Wind Turbin 2	0	3
5	Wind Turbin 3	0	2.5
6	Pv1	0	2.5
7	Pv2	0	2.5
8	Pv3	0	2.5
9	Grid	0	1000

The results of the simulation indicating the level of cost, average cost and cost reduction are as follows: In the initial state, the algorithm and in the case of dynamic constraints the demand constraints are also included.

Table 4: the level of cost, average cost and cost reduction

Cost in dollar	Average price($/Kwh)	Cost reduction
…………………..	………………..	………………………
5.293243e+002	1.645279e+001	-1.218538e+001

Table 5. Output values price based on genetic algorithm optimization within 24 hours

DP_input_data				
Parameters	Unit1	Unit2	Unit3	Unit4
PMIN(kw)	100	100	50	50
PMAX (kw)	410	410	270	270
GINC(btu/kwh)	1040	9000	8730	11900
GNLC(£/h)	213	585.6	684.7	252
GSC(£)	1100	1000	900	920
GFC(£/MBTU)	2	2	2	2
GMINUP(h)	5	5	3	3
GMINDOWN(h)	5	5	3	3
GSTATINI(+h)	5	5	3	3
GSH(£)	550	500	450	460
GCSTIME(h)	3	3	2	2
GRAMPUP(mw/h)	50	80	100	80
GRAMPDOWN(mw/h)	75	120	150	120
COEF_A(£)	65	60	45	41
COEF_B(£/mwh)	15.2	15.3	16.6	16.5
COEF_C(£/(MW^2)h	5.2	6.1	21	21.1
GSDC(£)	0	0	0	0
TAU(£)	NAN	NAN	NAN	NAN

In what follows, using the UC method and dynamic algorithm the initial level of thermal units with initial reference startup values (5) are shown in Table 5.

Table 6. Information of thermal units

State No.	MW Min.	MW Max.	UNIT1	UNIT2	UNIT3	UNIT4
1	0	0	0	0	0	0
2	50	270	0	0	0	1
3	50	270	0	0	1	0
4	100	410	0	1	0	0
5	100	410	1	0	0	0
6	100	540	0	0	1	1
7	150	680	0	1	0	1
8	150	680	0	1	1	0
9	150	680	1	0	0	1
10	150	680	1	0	1	0
11	200	820	1	1	0	0
12	200	950	0	1	1	1
13	200	950	1	0	1	1
14	250	1090	1	1	0	1
15	250	1090	1	1	1	0
16	300	1360	1	1	1	1

Here the values of the four units in four states have been calculated for four hours. 1 and 0 status of each unit is shown in Table 6 below.

Table 7. Data output per unit in each state after calculating UC

Cost in Euro	Average price(Ect/Kwh)	Cost reduction	load shed(kwh)
…………………..	………………..	………………………	
3.101194+002	1.038846ee+001	3.427307e+001	232

Table 8. Output values at load transfer state

Cost in Euro	Average price(Ect/Kwh)	Cost reduction	load shed(kwh)
…………………..	………………..	………………………	
3.233522+002	1.0473866ee+001	3.146851e+001	130

Table 9. Output values at load cut state

revenue in Euro	Average price(Ect/Kwh)	Percent of revenue
…………………..	………………..	………………………
1.026223+002	1.476274ee+001	2.160690ee+001

Bu comparing the output values we see in the output results from demand side include the income of 1.026223 euro, which is improved compared with cut and transfer state but obtained with no dramatic increase of average cost and the of value 1.476274 (Ect/Kwh). The purpose of calculating the values on demand side is to improve the price for the customer and then load cut and transfer.

As the figure 3 indicates, due to demand side price see and considering the best state for the customer, the values of sparse networks is brought to peak demand in peak hours.

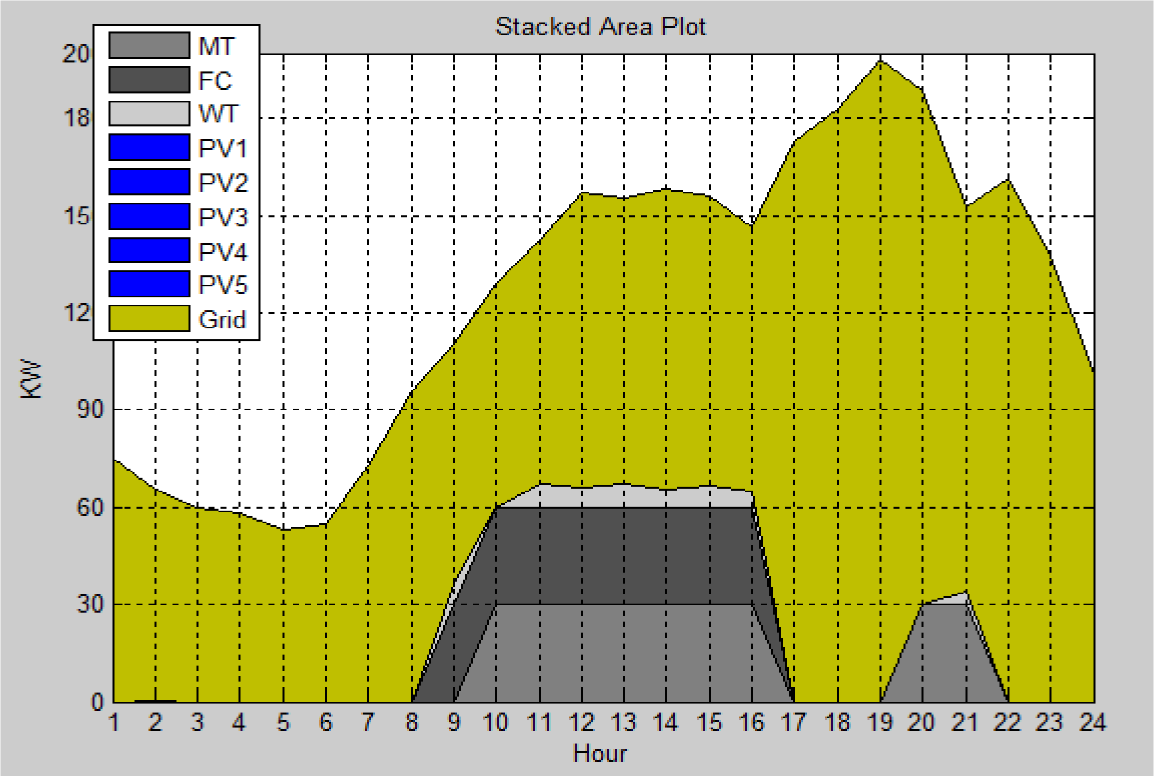

Figure 3. output curves obtained from demand-side bid

CONCLUSION

This paper tries to improve, optimize and consider the best state during a 24 hour forecast of production, regarding the amount of energy produced during this period, and finally the best state for the consumer to purchase his of energy in ideal situation. This paper deals conventional economic evaluation with microgrid in a real market with a variety of different policies. Bids from DG resources and other loads are considered. The actual value of the bid, the actual market price, and the profile of conventional load and renewable products are simulated. It has been shown that under simulated conditions, microgrid economic operations are useful, reduce energy prices for consumers and increase revenue collection. In addition, it can be concluded that the accumulation of DG resources as a microgrid under a central controller can provide optimum collaboration.

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