INTERNATIONAL CONFERENCE ON
SCIENCE AND ENGINEERING
1st December 2015 DUBAI - UAE
علوم و مهندسی
کنفرانس بین المللی
١٠ آذرماه ١٣٩٤ دبی - امارات

Active Distribution Networks Expansion Planning Under Uncertainty In Generation In Presence Of Loss reduction And Improve Reliability In Electricity Market

Seyed Safa Seyed Mortezaei
Zanjan University
Safamortezaei@znu.ac.ir

Saeid Jalilzadeh
Zanjan University
Jalilzadeh@znu.ac.ir

Abstract

This paper is planning expansion an active network of uncertainty in production as a possible model for multi-objective function with dynamic time horizon considered that the purpose of this paper is to consider all uncertainties and constraints and achieve the best results in reducing losses and improving the reliability of systems that evaluate the best answer comes in various scenarios using genetic algorithm and making scenario from demand response program Which can reduce losses and increase profits as well as taking into account market power of innovation in this article can be named.

Keywords: Distribution networks, Expansion planning, Distribution generation, Multi objective, Uncertainty, Reliability, Genetic algorithm

Introduction

Expansion planning of distribution network generally static definitions, such as restructuring, reconfiguration, rewiring, installation of new feeders, installed new posts, install normal opened(NO) and normal closed(NC) switches and installing new distributed generation(DG) as well as issues related to the electricity market in energy sold to the grid and purchased energy from load growth can be named. In this paper, the assumption considering the uncertainty in generation model with a normal probability distribution function(PDF) and restrictions on the time horizon based dynamic multi-objective function while reducing losses and increase the reliability of the system to achieve the best solution and the most profitable (buy or sell to the grid) in obtained using genetic algorithm.

Dynamic programming to include different stages looking for the best time and place to strengthen the system to grow with the lowest cost and best quality done that’s why we have distribution networks in transition from passive network with unidirectional flow supplied by transmission grid to active distribution network with integration DG [١]. In previous works, based on pseudo-dynamic algorithm have been done [٢] on the basis of this algorithm was built dynamic method [٣] and using genetic algorithm interconnected [۴] shown, and without the control of sequential genetic algorithm for scheduling development is done in this paper to consider improving reliability and reducing cost efficient method genetic algorithm by backward and forward [١] used taking losses and market presence that is the power of innovation in this article we have tried to improve the situation with regard to the algorithm flowchart maximize profits and minimize losses, along with dynamic scheduling ۵ years ahead (based on [۱]) with genetic algorithm to develop new feeders and installation in distribution network, rewiring, reconfiguration and restructuring, change switch status and installation new switches and energy purchased from DG can be named.

Generation uncertainty are taken into account. Reinforcement of the network and expansion planning is based on the pseudo-dynamic [۲] simulation have been conducted in MATLAB and GAMS.

I. Definition of expansion planning

A. Objective function

Expansion planning model in this paper based on genetic algorithm is pseudo-dynamic multi-objective function with the aim of optimizing the objective function alongside the existing restrictions in the planning and development is taking uncertainties which the objective function can be expressed as follow:

$$OF = C_{Loss} + (C_{Grid} - C_{Pool}) + ECOST + C_{Inv} \qquad (۱)$$

Where C_{Loss} is annual cost of lost energy, C_{Grid} cost of buying from the grid, C_{Pool} cost of sales to pool market, $ECOST$ expected energy costs are not distributed, C_{Inv} annual investment cost of the system and $ECOST$,reliability index is calculated as:

$$ECOST = \sum C_i L_i U_i \qquad (۲)$$

Where C_i is the interruption cost, L_i is the medium load, U_i is the annual mean repair time.

The value of losses and energy imported from transmission system are calculated by non-linear optimal power flow (NLP) and power flow solved by the Newton-Raphson method. In active distribution networks operation, active management (AM) is applied with real time control and management of DG units and distribution network devices based on real time measurements of primary system parameters (voltage and current) [۵].

B. Constraints

Constraint in this article are as

- Active and reactive power balance

$$P_{g_i} - P_{l_i} - \sum_{j \in \Omega_i} p_{ij} = 0$$
$$Q_{g_i} - Q_{l_i} - \sum_{j \in \Omega_i} Q_{ij} = 0 \qquad (۳)$$

- Bus voltage limit

$$V_i^{min} \le V_i \le V_i^{max} \qquad (۴)$$

- Power flow limit

$$P_{ij}^{min} \le P_{ij} \le P_{ij}^{max} \qquad (۵)$$

- Line loading constraint

$$S_{ij}^{\min} \le S_{ij} \le S_{ij}^{\max} \qquad (۶)$$

- DG penetration level constraint

$$PL_i \le PL_i^{\max} \qquad (۷)$$

- Ramp up and ramp down limit
- Maximum-up time and minimum-down time

Where P_{g_i}, Q_{gi} are active and reactive generation at bus i, respectively; P_{l_i}, Q_{l_i} the active and reactive load at bus i, respectively; $V_i^{\min}$، $V_i^{\max}$ the minimum and maximum voltages at bus i, respectively; $P_{ij}^{\min}$، $P_{ij}^{\max}$ the minimum and maximum power flow at element i-j, respectively; $S_{ij}^{\min}$، $S_{ij}^{\max}$ the minimum and maximum MVA of line, respectively; PL_i the DG penetration level at bus i; $PL^{Max}{}_i$ the maximum DG penetration level at bus i.

C. Genetic algorithm

In this article optimization using genetic algorithm and binary editing and with chromosomal structure, each part of it is related to the objective function is checked that each chromosome is a part of the network, including the structure of the chromosomes this article in figure ۱.The algorithm that used in this paper is the same the genetic algorithm that used in [۱] but in this paper another part Add, modified in selection and mutation to reach better optimization solution, flowchart of this modified algorithm as shown in figure ۲

Topology changed (۱)	DG (۲)	Rewiring (۳)	New load point (۴)	Installation of new post (۵)

Figure ۱.chromosome structure

Chromosome structure is divided to five part, refers to changing throw status of switches and maneuver of switches (C_{recon}) and installation of new switches (C_{NSW}) But it is important to care of radial structure of network when the some switches is opened it's necessary to some switches should be closed. The second part of chromosome refers to possibility of installed DG unit and their capacities (Cost C_{DG}) and third part refers to possibility of rewiring lines (Cost C_{rew}) , the fourth part of chromosome refers to connection of new load points into the system (Cost C_{NCP}) which is calculated as follow:

$$C_{NCPij} = C_{Feeder} L_{ij}$$

Where C_{NCPij} is the cost of the connection of new load point i to the system bus j; C_{Feeder} is the cost per kilometer of feeder construction to connect new load point and L_{ij} is is the distance in km between the new load point of system where it will be connected at bus j. and the last part of chromosome refers to C_{INP} which is obtained from costs of land and equipments.

Table ۱. Genetic algorithm parameters

Selection	***Roulette wheel***
Crossover	۲ point
Mutation	۱
Crossover rate	۰,۷
Population size	۲۰۰

II. Modeling of expansion planning

Price of the $C_{Loss}, C_{Grid}, C_{Pool}$ modeled in simulated network OPF using NLP techniques have been calculated, loss in obtained in OPF results and we have modeled As retailer model in electricity market.

A. Uncertainty model

Uncertainty of this paper is to generate and load, according to the probabilities of each combination of the probability and possibility of load obtained several scenarios, each of model to be created, to allow the planner in order to have the best choice according to the plan. The possibility of a review in the optimization process so that the function of each mode is calculated by multiplying the probability of all cases and the possibilities to reach a final result.

- Generation uncertainty

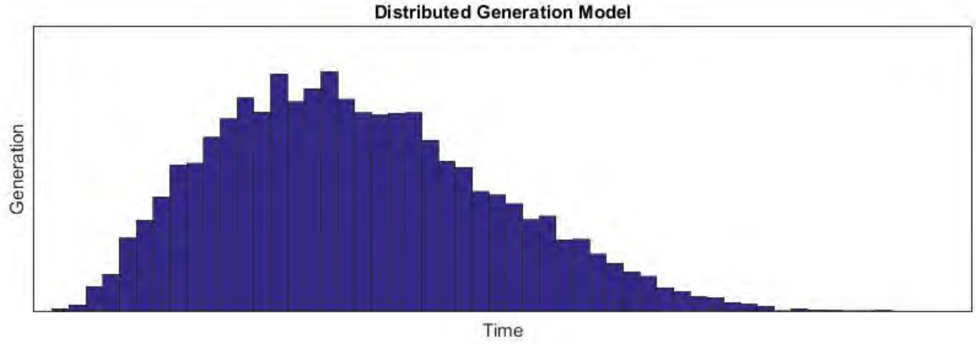

Figure ۲.DG model

- Load uncertainty

Uncertainties discussed in the network, according to Table ۲, three load scenarios and three production scenarios were considered , based on the different level of load factor catcher and production has been written, in [۱] ۹ scenarios obtained for this problem but in this article the same number of scenario obtained but with different IF and Prob. Which calculate from demand response program.

Table ۲.Gen. and load uncertainty model

Scenario	*IF*	*GF*	*Probability(%)*
۱	۱	۱	۲۲
۲	۱	۰,۸	۱۶
۳	۱	۰,۶	۱۲
۴	۱,۲	۱	۱۳
۵	۱,۲	۰,۸	۹
۶	۱,۲	۰,۶	۵
۷	۱,۴	۱	۱۰
۸	۱,۴	۰,۸	۷

۹	۱,۴	۰,۶	۶

Where IF and GF are Factors used to obtained different load and generation levels, respectively; as follows [۱]:

$$\frac{Pl_{ij}}{Pl_{i\,.nom}} = IF \qquad (۸)$$

$$\frac{Gl_{ij}}{Gl_{i\,.nom}} = GF \qquad (۹)$$

Where Pl_{ij} is load at bus i considering scenario j, $Pl_{i\,.nom}$ is the nominal load at bus i, Gl_{ij} is generation at bus i considering scenario j, $Gl_{i\,.nom}$ is the nominal generation at bus i.

B. Simulation model

The network planning developed in ۲ stage is intended for network, stage one ۱ year ahead and stage two ۵ years ahead which in ۱ year ahead there isn't load growth in gird and then in ۵ years ahead planning we have ۱۰۰٪ load growth in this network,
the backward path in presented from investment defined for stage one in the backward path, aiming at obtaining the best sequence of investment to be implemented respectively in stage two and forward path, considering the investments indicated for stage one , a GA in executed with the purpose of determining the investment to be implement stage two[۱].
Cost and objective function changed with these stages as follow:

$$COST_{K,I}^{PV} = COST_K \frac{1}{(1+r)^{K-1}} \qquad (۱۰)$$

$$Objective_i = \sum_{K=1}^{n_c} \rho_k \, objective_{i,K} \qquad (۱۱)$$

Where $COST_{K,I}^{PV}$ is cost of stage k; $COST_K$ the cost associated to stage k; r is annual interest ; $Objective_i$ value for objective function I ; $objective_{i,K}$ the value objective function I in scenario k; n_c number of scenarios considered; and ρ_k is the probability of occurrence of scenario k.

III. Results

The case study is a network has a substation , ۳۳ buses, ۳۵-line, ۳۲ NC-switches , ۳ NO-switches and ۱۲,۶۶ KV nominal system voltage, complete data are given in [۶] and all of the cost in R$ that is Brazil Real R۱,۰۰ corresponds to approximately US۰,۵۰.

a. Assumptions

- An annual interest rate of ۱۲٪ per year

- Upper and lower limits for bus voltage is ۱,۰۵ and ۰,۹۸ respectively
- Network reconfiguration by changing the status of NO switches installed in lines (۳۴),(۳۵),(۳۶)
- Installation of new switches in lines (۳۳) and (۳۷)
- Rewiring of lines (۵),(۶),(۷),(۱۶),(۱۷),(۲۰),(۲۱),(۲۲),(۲۳),(۲۴),(۲۸) (۲۹),(۳۰),(۳۱) and (۳۲)
- Installation of DG units with capacity ۳۰,۶۰,۹۰,۱۲۰,۱۵۰,۱۸۰ and ۲۱۰ at bus (۶),(۷),(۱۷),(۲۱),(۲۳),(۲۴),(۲۹),(۳۱) and (۳۲)
- On stage two, the necessary of attending three new load points represented by buses, (۳۴),(۳۵) and (۳۶)

Table ۳.Costs

	Costs
Losses	۰,۱۲۵ R$/KWH
New switches	R$ ۲۵۰۰,۰۰
Switch maneuver	R$ ۱۰۰,۰۰
DG	۱۶۱۰,۰۰ R$/KW
Rewiring	۱۲۰۰۰,۰۰ R$/KM
Transmission imported energy	۰,۰۱ R$.KWH
New feeders	۳۵۰۰۰,۰۰ R$/KM

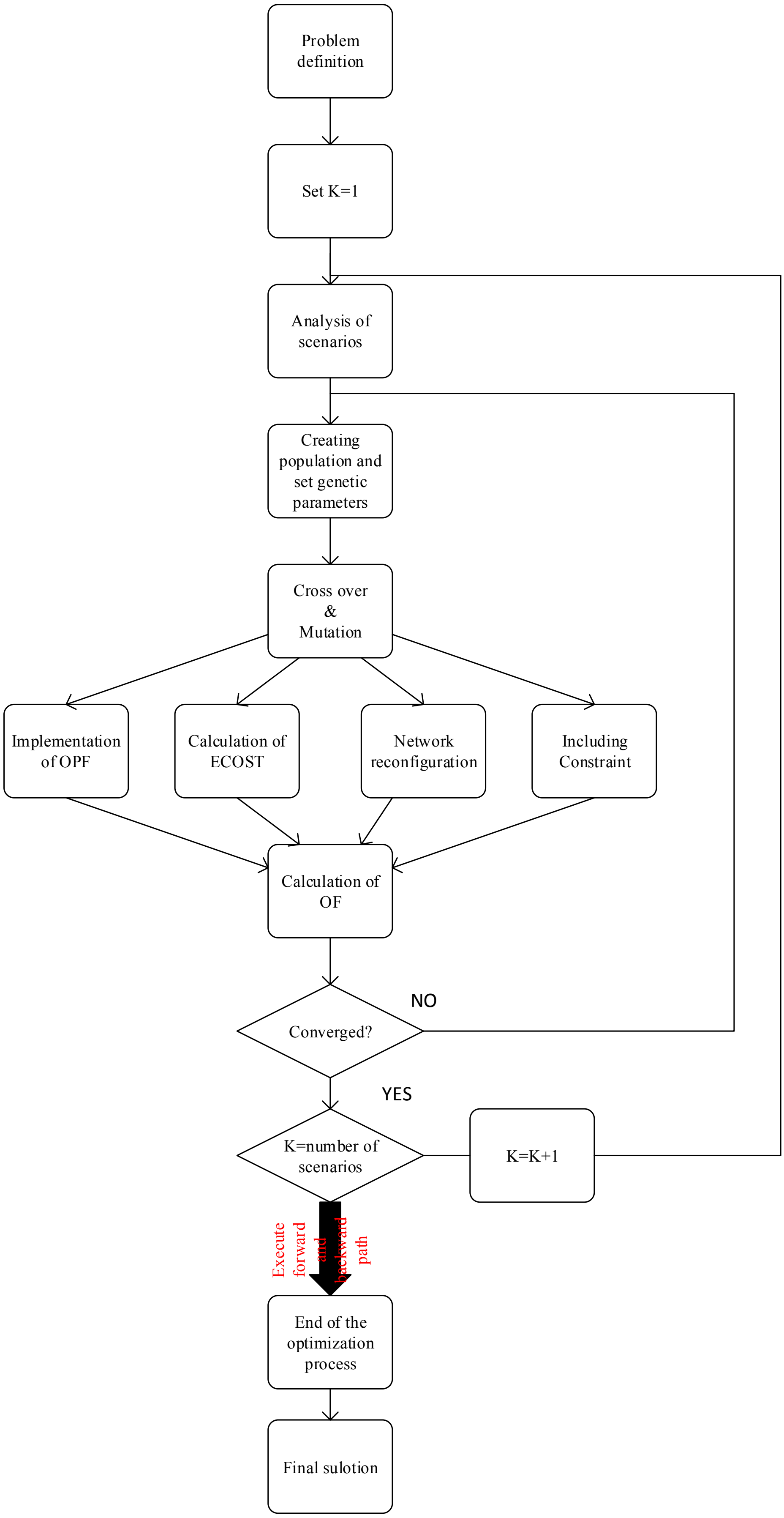

Figure 3.GA flowchart

b. schematic of network according to the following:

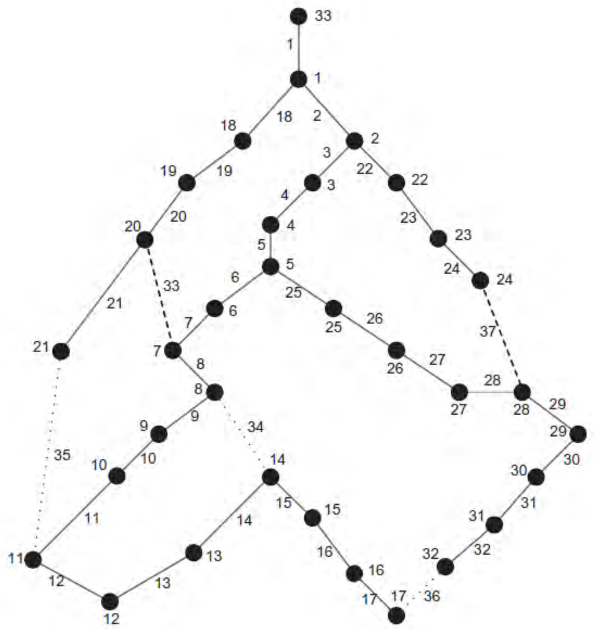

Figure ۴. ۳۳ buses test system [۱]

c. Simulation results

Table ۴. Simulation results (all in R$)

stage	*۱*	*۲*	*۱(this paper)*	*۲(this paper)*
Cost of losses	۴۰۲۹۷	۷۴۱۶۳	۳۶۸۷۱	۷۱۷۹۰
ECOST	۴۸۹۴۲۱	۶۶۱۱۱۳	۴۸۱۹۸۰	۶۶۹۱۲۱
Cost of investment	۵۸۸۵۸	۴۷۲۷۷	۵۶۳۰۱	۴۱۵۴۳
Cost of selling and buying from grid	۲۱۰۰۰۴	۲۸۴۲۲۲	۱۹۹۴۵۰	۲۶۲۳۴۰
Total cost	۷۹۸۵۸۰	۱۰۶۶۷۷۵	۷۷۴۶۰۲	۱۰۴۴۸۹۴

- ✓ In this simulation all of the cost are optimized from previous method but the ECOST of stage ۲ is more than same index of results because assumption off IF=۱,۲ need more reliability in the same way ECOST increase but total cost is optimized.

IV. Conclusion

This paper propused a modified GA algorithm based on GA algorithm to expansion planing active distribution network when the uncertainty of load and generation integration and pseudo-dynamic, multi objective function base method are developed to optimization the best solution of this problem.this optimization help to improve reliability and loss reduction and then simulate this method on ۳۳ busses case study.

V. References

Carmen Lucia Tancredo Borges and Vinivius Ferreira Martins”Multistage expansion planning for active distribution networks under demand and distributed generation uncertainties” Electrical Power and Energy Systems ۳۶ (۲۰۱۲) ۱۰۷-۱۱۶

Rosado RIJ, Gonen T. Pseudodynamic planning for expansion of power distribution systems. IEEE Trans Power Syst ۱۹۹۱;۶(۱):۲۴۵–۵۳.

Khalesi N, Rezaei N, Haghifam MR. DG allocation with application of dynamic programming for loss reduction and reliability improvement. IntJElectPowerEnergySyst۲۰۱۱;۳۳(۲):۲۸۸–۹۵.

Skok M, Krajcar S, Skrlec, D. Long Term Multi-Stage Planning of Open Loop Distribution Networks under Uncertainty. Proc Power Syst Comp Conf ۲۰۰۵; Liege

Shafiu A, Bopp T, Chilvers I. Active management and protection of distribution networks with distributed generation. Proc IEEE Power Eng Soc Gen Meet; ۲۰۰۴. p. ۱۰۹۸–۱۰۳.

Baran M, Wu F. Network reconfiguration in distribution systems for loss reduction and load balancing. IEEE Trans Power Syst ۱۹۸۹;۴(۲):۱۴۰۱ ۷.

Kersting WH. Distribution system modeling and analysis. CRC Press; ۲۰۰۲.

Gonen T. Electric power distribution system engineering. McGraw-Hill, Publication; ۱۹۸۶

Conejo, A.J., Carrion, M., Morales, J.M.: ‘Decision making under uncertainty in electricity markets’ (Springer, New York, ۲۰۱۰)

Deb, K.: ‘Multi objective optimization using evolutionary algorithms’ (John Wiley & Sons,۲۰۰۳)

Ramirez-Rosado IJ, Bernal-Agust?n JL. Reliability and costs optimization for distribution networks expansion using an evolutionary algorithm. IEEE Trans Power Syst ۲۰۰۱; ۱۶(۱):۱۱۱–۸.

Final solution