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OPTIMAL PLACEMENT TECHNIQUE FOR DISTRIBUTED GENERATION USING CLOUD COMPUTING- A THEORETICAL APPROACH

Puneet Chawla [1], Saruti Arya [2]

[1]Asstt. Prof. Electrical Engg. Dept., [2]Programmer, Computer Sc. & Engg. Dept.,
Ch. Devi Lal State Institute of Engg. & Tech., Panniwala Mota (Sirsa)

ABSTRACT

India has made impressive progress in the field of electricity generation since independence. In terms, of generation, while new capacity has been added, by and large the gap between demand and supply had increased. Due to India's economic rise, the demand for energy has grown at an average of 3.6% per annum over the last 30 years. Our installed power generation capacity stands at 274.818 GW while our total demand for electricity is expected to cross 950,000MW by 2030. In order to meet India's need for rural electrification and to meet peak power demand, new areas of power generation had to develop as soon as possible. Since the electrical power is transmitted through the transmission systems from the central generating stations to end users using a series of distribution transformers and lines. As the electric utility industry continues to restructure, there is a renewed interest in small-scale electricity generation known as Distributed generation Small-scale generation is commonly called as Distributed generation (DG), embedded generation or decentralized generation. This paper presents general background, objectives, constraints and solution algorithm for the optimal placement of distributed generation (DG) and tried to implement the cloud computing technique in the field of electrical power generation.

Keywords: Distributed Generation, Micro-Turbines, Doubly-fed Induction Generator Wind Turbine, Squirrel Cage Induction Generator wind Turbine, Newton Raphson's Method, Optimal Allocation, Distributed Network Operator, Optimal DG Placement (ODGP).

I. INTRODUCTION

Distributed generation, defined as small scale (1kW to 50MW) electricity generation, is fairly a new concept in the economic literature about electricity market, but the idea behind it is not new at all. In the early days of electricity generation, DG was the rule, not the exception. The first power plants only supplied electricity to consumers to the closed neighbourhood of the generation plant. The first grids were DC based and so, the supply voltage was limited, as was the distance that could be used between generators and consumer. Balancing demand and supply partially done using local storage, i.e. batteries, which could be directly coupled with the DC grid. Distributed generation is a back-up electric power generating unit that is used in many industrial facilities, hospitals, campuses, commercial buildings and department stores. Most of these back-up units are used to provide emergency power during time when grid connected power is unavailable.

Distributed Generation (DG) or embedded generation (the European form) refers to generation applied at the distribution level. EPRI (1998) defines distributed generation as the "utilization of small (0 to 5MW), modular power generation technologies dispersed throughout a utility's distribution system in order to reduce T&D loading or load growth and thereby defer the upgrade of T&D facilities, reduce system losses, improve power quality and reliability [1]. A draft IEEE CIGRE standard (IEEE P1547-D11-2003) applies to generation under 10MW. Distribution substation generation is normally considered as distributed generation as DG. Related terms used are non-utility generation (NUG) and independent power producer (IPP)-refer to independent generation. A distributed resources (DR) encompasses distributed generation, back-up generation, energy storage and demand side management (DSM) technologies. Smaller-sized generators continue to improve in cost and efficiency, moving closer and closer to the performance of large power plants. At the same time, utilities face significant obstacles when building large utilities-both power plants and transmission lines. Utilities or end users can install modular distributed generation quickly. Distributed generation can allow utilities to defer large-scale utility projects. Also, DG reduces losses and improves voltage. With the right configuration, distributed generation can also improve customer reliability and power quality. Distributed generation includes the application of small generators utilizing the traditional power generation paradigms-diesel, combustion turbines, combined cycle turbine, low-head hydro or other rotating machines, but in addition, DH also includes methods such as wind, solar, fuel cell and renewable energy generators are often lumped into the DG category because their small sizes makes them convenient to connect to the lower voltage (distribution) levels of the electrical power system. The plant efficiency of modern exiting large central power units is in the range of 28% to 35%. By contrast, the efficiencies of 40% to 55% are attributed to small fuel cells and to various hi-technology gas turbine and combined cycle plants suitable for DG applications. Distributed generators are most cost effective if the customer has used for

- Cogeneration- Using the generator waste heat locally significantly improves the economics of many applications, such as steam, heating water, running air conditioners, facility heat etc.
- Reliability- Many locations need backup generation for reliability purposes, such as for peak loads.
  Utilities most need local generation with the following areas such as
- Overloaded circuits- Distributed generation can delay infrastructure upgrades for the utility and end uses purposes.
- Generation shortages- If a utility needs generation anywhere it can get it, the utility or end users can quickly install distributed generation.

Applying generation closer to the load benefits, the transmission and distribution infrastructure, local generation can relieve overburdened transmission and distribution facilities as well as reduce losses and voltage drop. While entering benefits and opportunities, generation is not always easy to integrate into existing distribution system [2]. Distributed systems were never designed to include generation, whereas they were designed for one-way power flow, from utility power generation to end users. One of the most critical situations is that a distribution interrupter may isolate a section of circuit, and the generator might continue supplying the load on that section in an island.

II. DG INTERCONNECTION TECHNOLOGIES BENEFITS & DRAWBACKS

Benefits: Distributed Generation technologies continue to advance cost comes down, performance improves. The idea behind connection of DG is to increase the reliability of supply of power to the end users and reduction losses in transmission and distribution systems. DG can also serve the growing demand for higher power quality than the one provided by the grid. Thus, DG is playing a vital and important role in electric power generation. The connection of DG to the power system improves voltage profile, power quality and support the voltage stability, allows the system to withstand higher loading conditions.

Projections of penetration of distributed generation into the electrical system vary widely. Since natural gas delivers energy at a cost that is roughly one fourth of the cost of the electric energy, if an efficient low-capital cost, and low-maintenance distributed generator becomes available. Compared to the conventional power plants DG has a shorter construction time and payback period. Some DG technologies are very flexible in operation, size and expandability.

Drawbacks: DG technologies have some negative impact on the environment as well as economic aspects. Wind turbines have visual, acoustic and bird-life impacts. Wind farms & PV systems need a large area compare to conventional technologies. Small hydro, tidal and wave power plants may influence the ecosystem and fishery. Biomass may produce unpleasant emissions in case of bad combustion. Bad planning may lead to deforestation or conflict over using land & water resources.

Small scale generators have a few direct cost disadvantages. First, the smaller generators cost more per kilowatt to build than large central power plants due to economy of scale. Second, the retail market prices of fuel delivery are normally higher compare to the whole sale price for central generation.

III. DISTRIBUTION GENERATION (DG) TECHNOLOGIES [3]

This section presents energy sources drive distributed generators including a table 1.1 listing different technologies in the distributed generation.

- Reciprocating engines.
- Combustion turbines.
- Micro-turbines.
- Wind turbines (Doubly-Fed induction generator, Squirrel cage induction generators)
- Fuel Cells.
- Photovolatics.
- Combined Heat and Power (CHP)

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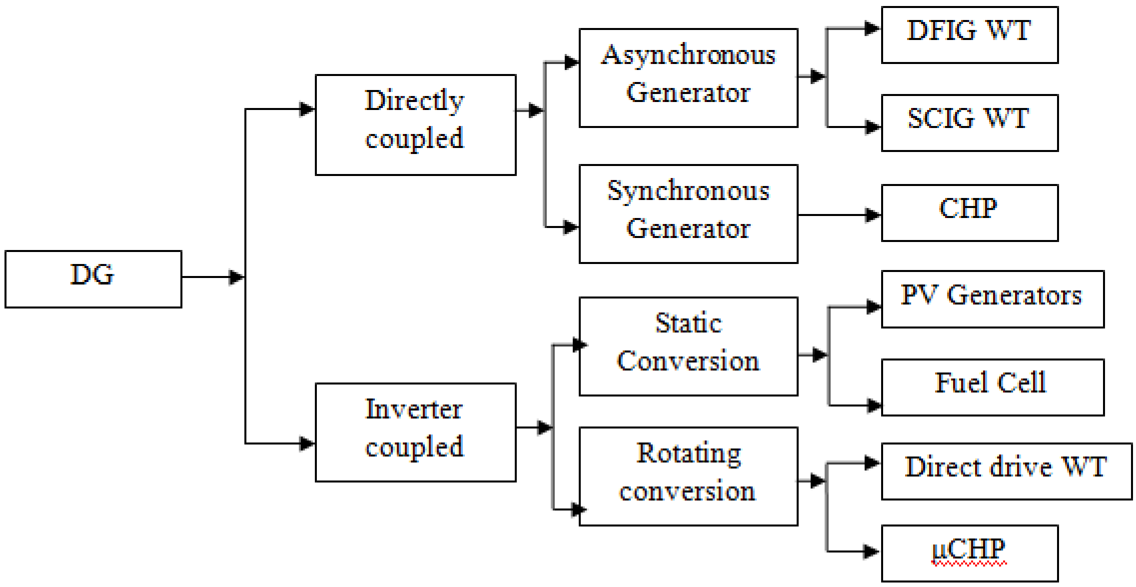
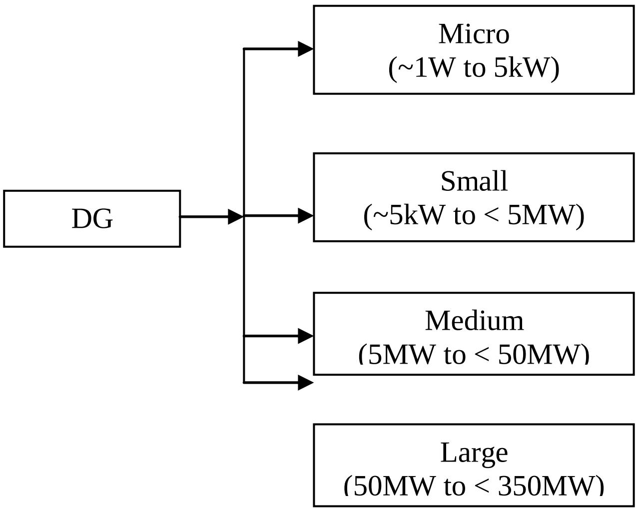


Technology	Capability	Utility integration
Solar PV	A few W to several 100KW	DC to AC converter
Wind	A few 100W to few MW	Asynchronous generator
I.C. Engine	A few 100KW to tens of MW	Syn. Generator/AC to AC converter
Combine cycle	A few MW to several 100MW	Synchronous generator
Micro Turbine	A few tens of KW to few MW	AC to AC converter
Fuel Cells	A few KW to tens of MW	DC to AC converter

Table 1.1 Distributed Generation techniques

Implementation of the different DG technologies is covering a wide range of applications according to load requirements, which is discussed as below:-

- **Standby:** DG can be considered as standby to supply the required power to sensitive load, such as process industries and hospitals during grid outages.
- **Stand-alone:** Usually isolated areas utilize DGs as a power provider instead of connecting to the grid. These areas have geographical obstacles, which make is more expensive to be connected to the grid.
- **Peak load sharing:** The electric power cost varies according to the load demand curves and the corresponding available generation at the same time. Hence, the DGs can be used to supply some loads at the peak periods.
- **Rural and remote locations:** DG can provide required power by the stand-alone remote applications. These applications include lighting, heating, cooling, communication and small industrial processes.
- **Base load:** Utility owned DGs are usually used as a based load to provide part the main required power and support the grid by enhancing the system voltage profile, reducing power losses and improving the system power quality.



Three power converters convert the power output of the energy source to interface with standard 50 or 60Hz systems [4].

- Synchronous generator.
- Induction generator.
- Inverter.

Normally reciprocating engines and combustion turbines interface through synchronous generators. Micro-turbines and wind turbines, fuel cells and photovoltaics interface through inverters.

Three factors are considerations for the energy source: the stability of the power source, the ability to follow change in load and the reliability (availability) of the source. In the reciprocating engines, combustion turbines and micro-turbines, the burn rate of the fuel-air mixture controls the power output. These combustion based generation are normally very stable sources. Wind turbines and photovoltaics produce variable output that is normally not controllable. One of the main concerns of wind turbines on distribution systems is the possibility of voltage controlling due to pulsating output due to blades of the wind turbines. Sunshine variability also causes variation to solar panel outputs, but the changes are normally slow enough to limit the flicker problems. Neither of these methods can follow load. Fuel cells have load-following capability, but it is significantly slower than combustion generators. Fuel cells and photovoltaics have no natural provision to provide the short-time overloads. DG capacities are not restrictedly defined as they depend on the user type and the used applications. Furthermore, the output electric power can be either direct or alternating. Fuel cell (FC), PV and batteries produce direct current. However, micro turbines, doubly-fed induction generators, squirrel cage induction generator wind turbines, provide an alternating current.

IV. DG PLACEMENT [5]

In literature, various objective functions have been considered and optimized, subject to different operating constraints, using conventional methods, intelligent searches and fuzzy set application for the placement of DG. A detailed study of the literature on DG placement (DGP) is summarized by the objective function model, mathematical algorithms to solve these objectives.

Objective and Constraint Functions In the DGP deals with the optimal allocation of distributed generation for minimizing the total real power loss in the system using second order method based on Newton Raphson's method. The basic formulation is that a sum of all nodal injections of power in a network represents losses, the impact of DG in power transfer capacity and voltage stability of power network. Thus overall impact is studied due to active power injection due to distributed generation and minimization of losses. The objective of optimal allocation of Distributed generation has been taken as maximization of DG capacity for constant load.

The objective is to maximize the amount of energy that can be harvested from DG by making best use of existing assets and available energy resources. To obtain most appropriate DG location, price variation at each bus and line loss sensitivity has been utilized in economical and operational criteria. The objective function is to minimize the fuel cost of conventional and DG sources as well as minimize the line losses of the network. In the maximum DG capacity has been determined by modelling DG as generators with negative cost coefficients. By minimizing the cost of these generators, the DG capacity benefits are maximized. In the problem is formulated with two distinct objective functions namely social welfare maximization and profit maximization.

In this, authors have considered the composite the total load sharing by switching the load to another DG system with appropriate overloading and with maximum utilization of DGs and optimized to reduce the voltage and frequency deviation.

4.1 Mathematical Algorithms

Analytical Methods: An analytical method, based on the exact loss formula, is proposed for a single DG optimal location and sizing. Analytical expressions for finding optimal size and power factor of different types of DGs are suggested in. An analytical method using a loss sensitivity factor that is based upon the equivalent current injection is developed in for find optimum size and location of a single DG. Two analytical methods for determining the optimal location of a fixed size DG is proposed in first method is applicable to radial and the second is to meshed power systems.

Conventional Optimization methods: An exhaustive search based method is proposed in evaluating DG placement for optimal power losses and reliability and a multi-objective performance index, taking into account the time-varying demand of supply. A discrete generation based model is reduced in deterministic model considering all possible conditions solved by Mixed Integer Non Linear Programming (MNLP) for optimal allocating either only one wind DG unit or other types of DG units. The optimal DG placement (ODGP) is formulated as a multi-period of optimal power flow. Optimal DG placement of various technologies considering electricity market price fluctuations employing MNLP is proposed. An integrated distribution planning model, containing optimal DG placement as an alternative option, is solved by MNLP. Power electronic devices interfaced with DG units are considered with an objective of improving the voltage stability margin for the placement and size of DG units. Dynamic programming based optimal DG placement model is proposed with maximizes the profit of the distribution network operator considering the nature and requirement of loads.

Intelligent Search based method [6]: The algorithm presented in uses artificial intelligent technique such as Genetic Algorithm (GA) as a technique to solve the problem of static planning of distribution system expansion considering possible commissioning of new feeders and distributors, substations. GA is used to solve the optimal DG placement requirement that considers variable power concentrated models, distributed loads and constant power concentrated loads. A GA is employed to solve optimal DG placement requirement that maximizes the profit of the Distributed Network operator. A GA methodology is implemented to optimally allocate the DG units in distribution networks to maximize the worth of local distribution system as well as customers connected to the system. A value-based approach considering the benefits and costs of DGs is developed and solved with GA that finds number, type, location and size of DGs. A GA-based method allocates simultaneously DGs and remote controlled switches for operation of DGs with power system operation in distribution systems. **A hybrid GA and fuzzy logic based programming is proposed for optimal DG placement. A fuzzy GA is employed to solve a weighted multi-objective optimal DG placement requirement model. A hybrid GA reduced the programming methodology and maximize the profit of the distributed network operator.** Placing a single DG based on the ranking of the power losses in the network or energy shutdown in the network lines. Heuristic methods for sizing wind farms based on modes of voltage stability and frequency deviations are proposed. A heuristic cost-benefit approach for optimal DG placement to serve peak demands is introduced. A heuristic value-based approach determines the optimum location of a single DG by minimizing the system reliability cost. So, a heuristic search technique is developed for that optimizes the objective function and maximizes the potential benefit by optimal DG placement. A heuristic approach calculates the regions of higher probability for location of DG plants in distribution network. The ODGP model for small distribution is solved by this method.

V. CLOUD COMPUTING TECHNIQUES [7]

“Cloud” computing – a relatively recent term, defines the paths ahead in computer science world. Being built on decades of research it utilizes all recent achievements in various fields. Cloud Computing has become a scalable services consumption and delivery platform in the field of Services Computing.. Cloud computing can help facilitate easier access and distribution of information among the various medical professionals who may come in contact with each individual patient. The name comes from the use of a cloud-shaped symbol as an abstraction for the complex infrastructure it contains in system diagrams.

Cloud computing means that instead of all the computer hardware and software you're using sitting on your desktop, or somewhere inside your company's network, it's provided for you as a service by another company and accessed over the Internet, usually in a completely seamless way. Exactly where the hardware and software is located and how it all works doesn't matter to you, the user—it's just somewhere up in the nebulous "cloud" that the Internet represents. Cloud computing is a buzzword that means different things to different people. For some, it's just another way of describing IT (information technology) "outsourcing"; others use it to mean any computing service provided over the Internet or a similar network; and some define it as any bought-in computer service you use that sits outside your firewall. However we define cloud computing, there's no doubt it makes most sense when we stop talking about abstract definitions and look at some simple, real examples—so let's do just that.

Simple examples of cloud computing Most of us use cloud computing all day long without realizing it. When you sit at your PC and type a query into Google, the computer on your desk isn't playing much part in finding the answers you need: it's no more than a messenger. The same applies to Web-based email. Once upon a time, email was something you could only send and receive using a program running on your PC (sometimes called a mail client). But then Web-based services such as Hotmail came along and carried email off into the cloud.

Preparing documents over the Net is a newer example of cloud computing. Simply log on to a web-based service such as Google Documents and you can create a document, spreadsheet, presentation, or whatever you like using Web-based software. Instead of typing your words into a program like Microsoft Word or OpenOffice, running on your computer, you're using similar software running on a PC at one of Google's world-wide data centres. Like an email drafted on Hotmail, the document you produce is stored remotely, on a Web server, so you can access it from any Internet-connected computer, anywhere in the world, any time you like. Using a Web-based service like this means you are "contracting out" or "outsourcing" some of your computing needs to a company such as Google: they pay the cost of developing the software and keeping it up-to-date.

Types of cloud computing IT people talk about three different kinds of cloud computing, where different services are being provided for you. Note that there's a certain amount of vagueness about how these things are defined and some overlap between them.

- Infrastructure as a Service (IaaS) means you're buying access to raw computing hardware over the Net, such as servers or storage. Since you buy what you need and pay-as-you-go, this is often referred to as utility computing.
- Software as a Service (SaaS) means you use a complete application running on someone else's system. Web-based email and Google Documents are perhaps the best-known examples.
- Platform as a Service (PaaS) means you develop applications using Web-based tools so they run on systems software and hardware provided by another company. So, for example, you might develop your own ecommerce website but have the whole thing, including the shopping cart, checkout, and payment mechanism running on a merchant's server. Force.com and the Google App Engine are examples of PaaS.

Advantages of Cloud Computing If used properly and to the extent necessary, working with data in the cloud can vastly benefit all types of businesses:

- **Cost Efficient** Cloud computing is probably the most cost efficient method to use, maintain and upgrade. Traditional desktop software costs companies a lot in terms of finance. Adding up the licensing fees for multiple users can prove to be very expensive for the establishment concerned. The cloud, on the other hand, is available at much cheaper rates and hence, can significantly lower the company's IT expenses.
- **Almost Unlimited Storage** Storing information in the cloud gives you almost unlimited storage capacity. Hence, you no more need to worry about running out of storage space or increasing your current storage space availability.
- **Backup and Recovery** Since all your data is stored in the cloud, backing it up and restoring the same is relatively much easier than storing the same on a physical device. Furthermore, most cloud service providers are usually competent enough to handle recovery of information. Hence, this makes the entire process of backup and recovery much simpler than other traditional methods of data storage.
- **Automatic Software Integration** In the cloud, software integration is usually something that occurs automatically. This means that you do not need to take additional efforts to customize and integrate your applications as per your preferences. This aspect usually takes care of itself.
- **Easy Access to Information** Once you register yourself in the cloud, you can access the information from anywhere, where there is an Internet connection. This convenient feature lets you move beyond time zone and geographic location issues.

- **Quick Deployment** Lastly and most importantly, cloud computing gives you the advantage of quick deployment. Once you opt for this method of functioning, your entire system can be fully functional in a matter of a few minutes. Of course, the amount of time taken here will depend on the exact kind of technology that you need for your business.

Disadvantages of Cloud Computing In spite of its many benefits, as mentioned above, cloud computing also has its disadvantages. Businesses, especially smaller ones, need to be aware of these cons before going in for this technology.

5.1 The Risks Involved in Cloud Computing

- **Technical Issues** Though it is true that information and data on the cloud can be accessed anytime and from anywhere at all, there are times when this system can have some serious dysfunction. You should be aware of the fact that this technology is always prone to outages and other technical issues. Even the best cloud service providers run into this kind of trouble, in spite of keeping up high standards of maintenance. Besides, you will need a very good Internet connection to be logged onto the server at all times. You will invariably be stuck in case of network and connectivity problems.
- **Security in the Cloud** The other major issue while in the cloud is that of security issues. Before adopting this technology, you should know that you will be surrendering all your company's sensitive information to a third-party cloud service provider. This could potentially put your company to great risk. Hence, you need to make absolutely sure that you choose the most reliable service provider, who will keep your information totally secure.
- **Prone to Attack** Storing information in the cloud could make your company vulnerable to external hack attacks and threats. As you are well aware, nothing on the Internet is completely secure and hence, there is always the lurking possibility of stealth of sensitive data.

Use of Cloud Computing in various Fields [8] Cloud Computing has become a scalable services consumption and delivery platform in the field of Services Computing. Cloud computing is the use of computing resources (hardware and software) that are delivered as a service over a network (typically the Internet). Cloud computing entrusts remote services with a user's data, software and computation. The technical foundations of Cloud Computing include Service-Oriented Architecture (SOA) and Virtualizations of hardware and software. The goal of Cloud Computing is to share resources among the cloud service consumers, cloud partners, and cloud vendors in the cloud value chain. The resource sharing at various levels results in various cloud offerings such as infrastructure cloud (e.g. hardware, IT infrastructure management), software cloud, application cloud and business cloud (e.g. business process as a service).

- Cloud Computing in Business
- Speed up Development in Cloud
- Cloud Computing in Medical Fields
- Cloud Computing in Education
- Marketing Companies
- Online Entertainment

- Online Gaming
- Online Personal media Store
- Online Media playback
- Information technology
- Finance and Banking
- Telecommunication
- Security
- Data Protection

VI. PROBLEM FORMULATION & ANALYSIS

The DG planning is basically a non-linear mixed integer optimization problem which finds the optimal DG placement and sizing that are to be located into the distribution networks subjected to various network operation constraints, DH operating constraints etc. The objective function may be single or multi-objective in order to maximize the benefit of DG satisfying various network constraints.

Objectives: The main objective functions that are being considered as:

- **Minimization of Power losses:**

  Min $\sum_{k=0}^{n}(Pk)$

where P_k is the power injection at k^{th} node and n is total no. of buses in the distribution system.

- **Maximizing the reliability:** Network reliability assessment contains two types of indices: load point and distribution network. Load point factor is calculated at each point of load connection and are used for the evaluation of distribution system performance. The distribution system factor that can be considered for reliability evaluation. These indices are System Average Interruption Frequency Index (SAIFI) and System Average Interruption Duration Index (SAIDI).

$$SAIDI = \frac{\Sigma\, u_k \times N_k}{\Sigma\, Nk}$$

$$SAIFI = \frac{\Sigma\, r_k \times N_k}{\Sigma\, Nk}$$

$$\text{Min. } W_1\,(SAIDI)_{DG} /(\,SAIDI)_{base} + W_2\,(SAIFI)_{DG} /(\,SAIFI)_{base}$$

where N_k is number of consumers at the load point, u_k is outage time and r_k is the failure time. The smaller the values of reliability index, the higher is the system reliability.

- **Maximization of DG capacity:**

  Max $\sum_{k=0}^{n}(PDGk)$

  where P_{DGk} is DG capacity at any k^{th} node and N is the set of all possible DG locations.

- **Maximizing the profit and social welfare:** Social welfare is defined as the difference between the total benefits to consumers minus total cost of production. The objective function for maximizing the social welfare is as defined:

$$\text{Max} \sum_{k=0}^{n} (Bk\ (PDk) - Ck\ (PDk) - C\ (PDGk))$$

where, $B_k(P_{Dk})$ is the cost function for buyers of electricity, $C_k(P_{Dk})$ is the cost function of seller (centralized generating plants) and $C(P_{DGk})$ is the cost function supplied for DG owner.

The profit maximization formulation is as follows:

$$\text{Max} \sum_{k=0}^{n} (\lambda k\ (PDk) - C\ (PDGk))$$

where, k is total no. of nodes in the system, $P(_{DGk})$ is the DG size at the node, λ_k is locational marginal price and $C(P_{DGk})$ is the cost characteristics of DG owner.

- **Maximizing the voltage stability margin:**

$V_l = (V_{P\ with\ DG}) / (V_{P\ base})$

$$\text{Max } Vkndex = \sum_{k=0}^{n} (Vk\ p\ rn\ )/\ 96$$

where n is total no. of nodes in the distribution system, $V_{P\ with\ DG}$ and $V_{P\ base}$ are voltage profile of system with DG and without DG. The highest value of voltage index implies the best location of DG in terms of improving the stability of the system.

Constraints: The main objective constraints in DG placement problem are as under:

- **Power Flow equality equations:**

$$P_k = P_{Gk} - P_{Dk} = \sum_{k=1}^{n} Vk\ Vq\ Ykq\ \cos\ (\delta k - \delta q - \theta kq)$$

$$Q_k = Q_{Gk} - Q_{Dk} = \sum_{k=1}^{n} Vk\ Vq\ Ykq\ \sin\ (\delta k - \delta q - \theta kq)$$

where, n is the total number of nodes in system. P_k and Q_k are the real and reactive power injections in the system at any bus, k. V_k is voltage magnitude of node, k. δ_k is the phase angle of complex power of node k. θ_{kq} is the angle of the k-q^{th} element and Y_{kq} is k-q^{th} element admittance.

- **Bus Voltage limitations:**

$V_k^{\ min} \leq V_k \leq V_k^{\ max}$

where min. and maximum limits of voltage of bus at distribution system is maintained.

- **DG generation limitation:**

$P_{DGk}^{\ min} \leq P_{DGk} \leq P_{DGk}^{\ max}$

$Q_{DGk}^{\ min} \leq Q_{DGk} \leq Q_{DGk}^{\ max}$

where minimum and maximum limits of DG power are required to be decided for each distribution network.

- **Feeder power Level:**

$S_k \leq S_k^{\ rated}$

The power carrying capacity of the distribution feeder is represented by MVA limits and it must be well within the limits and within the maximum thermal capacity of the lines.

- **Short Circuit power level:**

A short circuit calculation is carried out to ensure that fault current with DG should not be increase rated fault current ratings of currently installed protective devices SCL_{rated} as

$SCL_{DG} \leq SCLrated$

Design variables: There are three main design variables i.e. D.G. and load variables alongwith the proper computation of placement:-

- DG variables that are generally considered are location, size, type, number of DGs, location is fixed.
- Load profile of distribution network feeders as static load and time-varying loads which are considered as load variables.
- DG placement techniques are to be allocated in order to achieve the maximum utilization of feeder strength and DG capacity using various techniques including the current technique of Cloud Computing.

VII. SOLUTION TECHNIQUES INCLUDING CLOUD COMPUTING

The solution techniques for DG placement have been evolving an number of approaches have been developed, each with its particular mathematical and computational characteristics. The most of techniques discussed are classified into three categories:

- Analytical methods
- Conventional methods
- Intelligent search based methods

The conventional analytical methods include Linear Programming (LP), Non-Linear Programming (NLP) like Newton's Raphson Method, AC optimal power flow and continuous power flow method. The intelligent search-based methods include Simulated Annealing (SA), Evolutionary Algorithms (EAs), Particle Swarm Optimization (PSO), Genetic Algorithm (GA), Hybrid Fuzzy and Genetic Algorithm model approaches with optimum DG placement associated with DG generation, demand etc.

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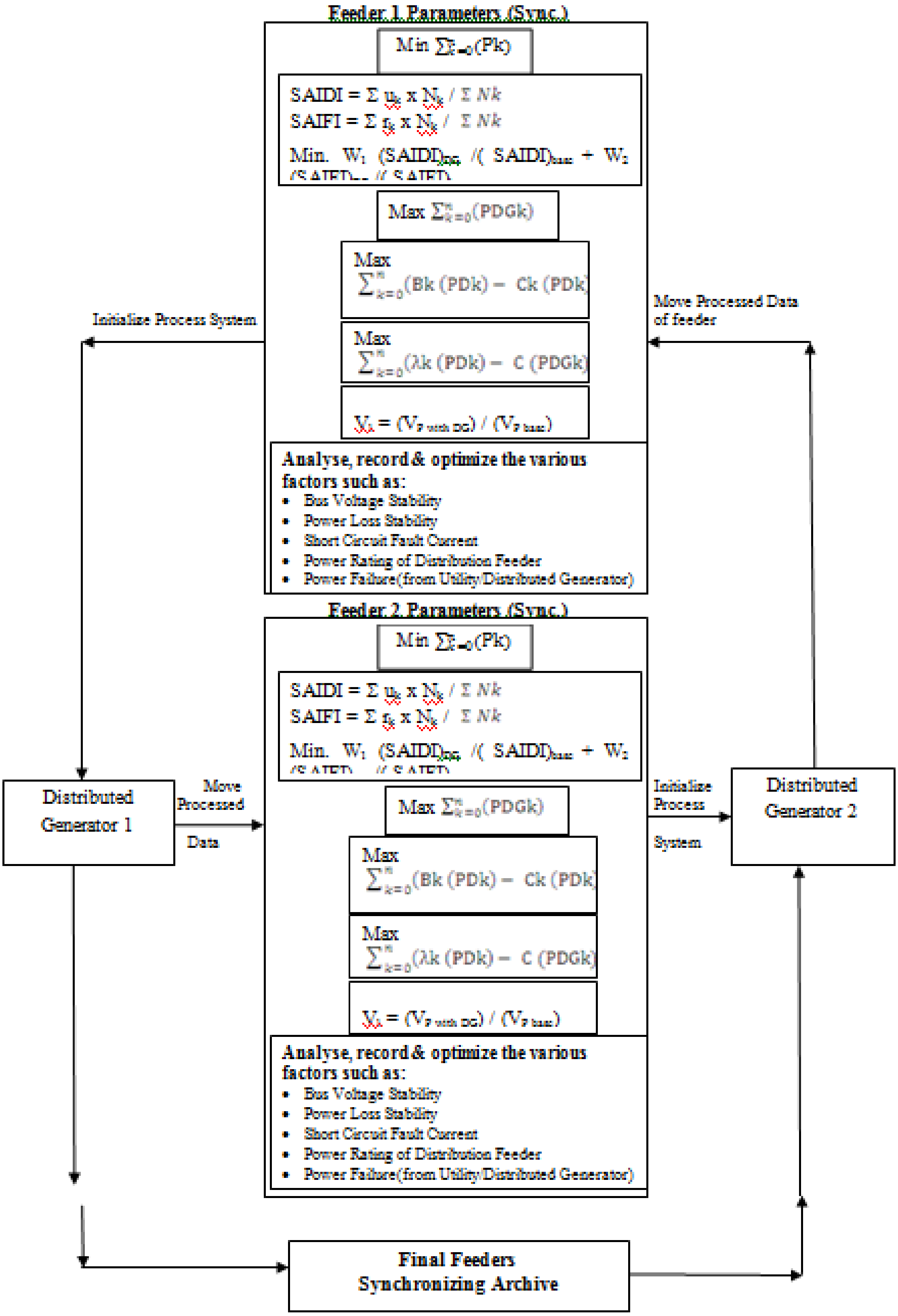
Flow Charts for Implementation of Cloud Computing for Distributed Generation:



VIII. CONCLUSION

Thus, the author started from the observed renewed interest in small scale electricity generation. Various DG Technologies are described and major benefits, issues of DG are discussed.

Small scale generation is commonly called as distributed generation and noted down various aspects. So, Distributed generation has implications for the control of voltage levels across the network. Various issues and methodologies have been discussed for the implementation of DG technologies for a potential increase in generation levels without the need of reinforcement. The objectives, constraints and solution algorithm alongwith the techniques for the optimal allocation of Distributed Generation (DG) have also been discussed in this paper. The objectives have been classified as single-objective or multi-objective functions and constraints. Interesting aspects of conventional and artificial intelligent methods alongwith heuristic optimization techniques and most importantly Fuzzy set theory to model the uncertainties in objective functions, load, generation, electricity price and constraints for better solutions using optimal placement, location and operation of distributed generation using Cloud Computing techniques.

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