RETHINKING NETWORK PLANNING FOR INTEGRATION OF DISTRIBUTED GENERATION

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Summary
Investing in an electrical network is expensive. Voltage upgrading, replacing outdated components or increasing network capacity implies a considerable cost. This is why investment decisions are supported by extensive network planning processes. Network planning includes risk, as it is necessary to estimate load growth, future power needs and when equipment and components will fail. Risk can be handled with proper planning methodologies in order to reduce the uncertainty. Distributed generation brought new risk factors and uncertainties to the network planning. Therefore, it is important to determine if the existing methodologies for network planning can handle the uncertainty brought by distributed generation, in a satisfactory manner, or if new methodologies are needed.

1. INTRODUCTION

Distributed generation has taken an important role in fulfilling the national and international goals set for effective use of energy resources. National governments acknowledge this important role by subsidizing and giving incentives to installation and connection of distribution generation to the power network.

Small size distribution generation, often based on renewable resources, is connected at the distribution network level. A challenge in that respect is that renewable resources are usually located in remote places where the distribution network is characterized as weak and widely spread (long lines with considerable voltage drop effect). Also, the distribution network was designed to deliver power from the higher voltage levels to the lower voltage levels. The production of power at the low voltage side opens the possibility of power flowing “upstream”, from the low voltage side to the high voltage side, in some situations.

Due to this, the connection of distribution generation can bring several challenges like equipment overheating, system instability, voltage values oscillation to values outside the regulated limits, quality degradation of supplied power and others [1] [2] [3].

Like most of the problems, these can be solved after the problem comes up or prevented. After problem solutions almost always end up with grid reinforcements or upgrades (by increasing the local network voltage) which are very expensive (imply replacing of cables, overhead lines and voltage equipment like transformers). Prevention of the problems is done with proper and adequate planning. Although planning is always associated with uncertainty (due to the predictions made), present day planning techniques can deal and reduce this uncertainty considerably, helping to make the right decisions.

2. PLANNING

Network planning is an essential task when developing an electrical network. The difference between bad and good planning can be measured in the amount of future costs that the utility will need to spend in order to adapt the network to situations that should have been predicted at the planning stage.

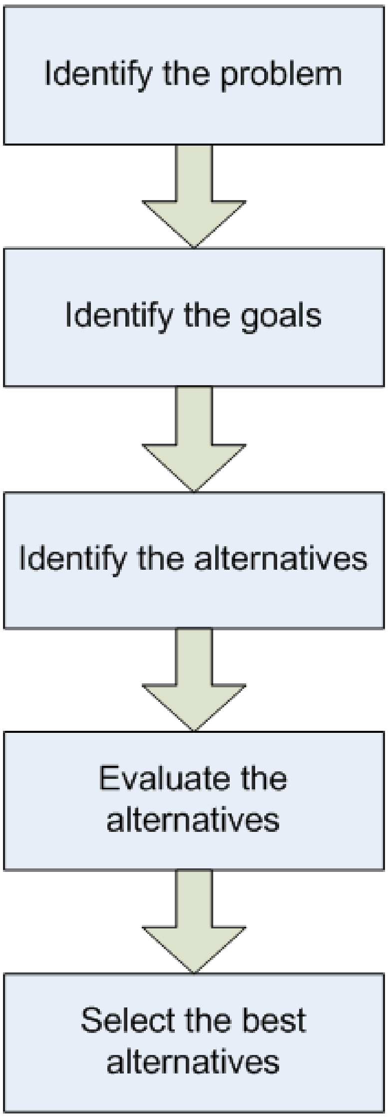

Figure 1: General steps in a planning process [4]

This importance recognized in good planning has led to the development of planning methodologies and techniques. Figure 1 shows the general steps that need to be taken in a general planning process.

The first step is to identify the problem that needs to be addressed. Without understanding what the problem is, the probability of reaching a successful solution will be minimal.

The second step is the identification of goals. Questions like "what do we want?" or "why are we doing this?" should always be answered in order to avoid dispersion and keep the work focus on the problem at hand.

The third step is to identify the available alternatives. Here, all possible solutions must be considered and excluding solutions by principle is not acceptable.

The fourth step is the evaluation of the identified alternatives. The evaluation should take into consideration all the normal and basic regulations of electrical networks and the planning objectives which need to be successfully fulfilled and accomplished.

The fifth and final step is the selection. Selecting the best solution can be difficult, especially when there are several solutions that might present themselves as good but relying on different approaches, but the best solution will be the one that best answer to the objectives set in the second step.

3. NETWORK PLANNING METHODOLOGY

The current network planning methodology is adapted to the electrical network needs that have dominated until now, which means it is adapted to the load increase.

The current planning methodology is shown the flow chart of Figure 2. This flow chart is used in the methodology description of this chapter (further detail and explanations on the current planning methodology can be found in [5]).
The challenges for integration of distributed generation and how it can change the existing planning methodology are discussed in chapter 4.

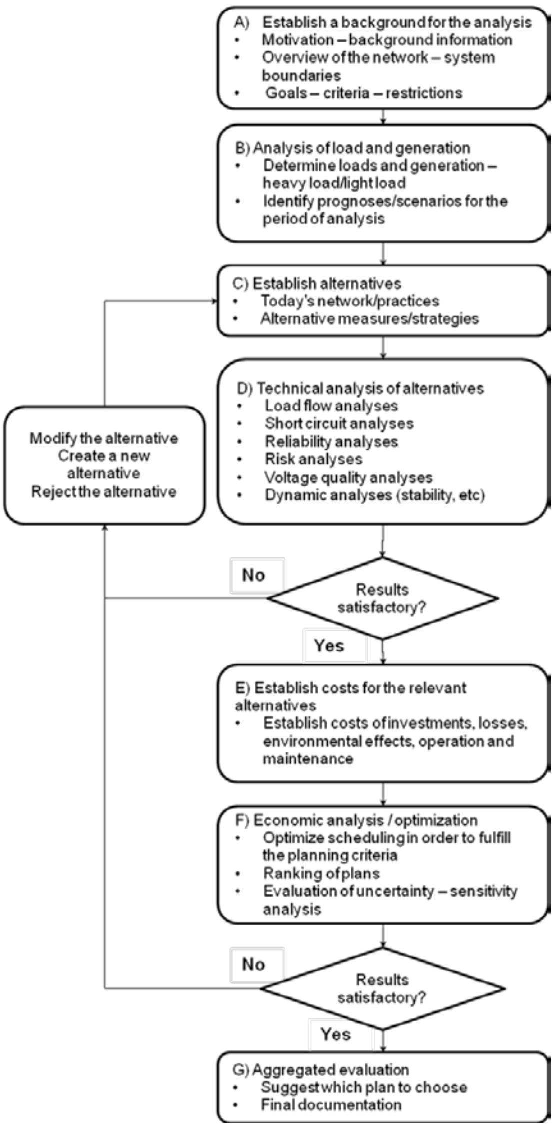

Figure 2: Planning methodology for electrical networks [5]

3.1 Establish a background for the analysis

As explained in chapter 2, the first steps in any planning process the definition of the problem and objectives. When planning an electrical network, it is important to first define the problem that needs to be addressed, the objectives that must be achieved at the end and how to evaluate the objectives.

The most important information at this stage is information on the area affected by the network planning, not only physical aspects, like terrain, vegetation, weather, but the existing electrical aspects should also be focused here, like substations nearby, types of load, type of network, which stakeholders are going to be affected (so that all of their costs can be also included in the planning process and solution evaluation) and the time horizon (longevity of the intervention and the planning objectives).

3.2 Analysis of load and generation

The main purpose of an electrical network is to connect the power generation to the power consumption. All network planning and design is based on balancing of the power supplied to that electrical network with its power consumption and losses.

Power system reports done for the electrical network provide important information, like future network conditions, expected actions and investments needed to fulfill the main network purpose.

These power system reports focuses on the energy production, distribution and consumption, from where the main parameters for a load and generation analysis /amount of produced and consumed energy, variation over a year and production and consumption evolution) are obtained.

3.3 Establish alternatives

It is likely that there are several alternatives to a network problem. Hence, it is important to understand the space of alternatives in order to restrain this space and reduce the number of possible alternatives.

Still, restraining the space of a possible solution should not be done without some basic analysis. As Figure 2 shows, the planning procedure is a dynamic process that modifies, creates or rejects alternatives through the use of proper analysis and simulation tools (see 3.4). Results from basic simulation and analysis will provide new ideas and new constrictions on the alternatives, limiting the possible alternatives space and reducing the alternatives available to the ones that are worth considering.

3.4 Technical analysis of alternatives

The alternatives must undergo technical and reliability analysis so that important parameters used on the solutions evaluation are identified. The results that come out of the technical analyses have three applications:

a) They provide a basis to check if the alternatives/solutions meet the required restrictions (government regulations on power quality – FOL [6]);
b) They provide a basis for establishing information on alternatives/solutions costs (costs on power losses);
c) They provide ideas for new alternatives/solutions (by adapting or changing initial alternatives as said before).

As shown in Figure 2, the analysis will include the use of tools that cover the necessary technical areas:

- Load flow analysis
- Short circuit analysis
- Reliability analysis
- Risk analysis
- Power quality analysis
- Dynamic analysis (stability, etc.)

3.5 Establish costs for the relevant alternatives

The economic characteristics of the different alternatives/solutions play a key role in a technical-economical analysis. Depending on the purpose of the economical analysis, the cost of the different elements can have different relevance for the end result. This means that some of the cost elements can be irrelevant and may not be considered at all.

3.6 Economic analysis/optimization

After determining the relevant costs for each alternative/solution, it is important to try to optimize them and determine the overall cost. The overall cost may reveal solutions that are economically better and exclude others that, although very good technically, are simply too expensive.

The overall cost of an alternative/solution will result from the sum of costs of all the years in the analysis period, considering all possible combinations of measures and timing of implementation.
The economic analysis and optimization will give a basis to determine what measures should be implemented and when those measures should be implemented.

3.7 Aggregated evaluation

At this stage, the number of possible solutions should have been reduced considerably through the technical and economical analysis.
In the evaluation, it is important to take in account:

- Uncertainty in the data base (preferably using sensitivity analysis) ;
- Conditions that are not represented directly in the economic analysis model;
- The robustness that the various plans have with respect to the uncertainty in the data base;
- Fulfillment of planning objectives

The result of this evaluation will be a proposal of solution with the measures that should be implemented and when they are to be implemented.

4. THE CHALLENGES OF TODAY

Distribution generation brings new challenges to network planning and development. Besides some of the challenges already mentioned in the beginning of this report, like bidirectional power flows, the new reality brought by distribution generation also brings the uncertainty of when, where and what distributed generation will be connected to a certain part of the distribution network.

Giving an answer to “when, where and how much” emphasizes the planning component for it creates the need to have answers on specific future situations that are usually outside the sphere of control of network operators. Information regarding distribution generation exploitation potential and trends in the area under planning becomes essential to the planning process.
For example, answering the “where” requires models of the network physical area in order to understand where the primary energy resources can be found and therefore, the future distributed generation units. Answering the “when” implies the understanding of energy market dynamics, distributed generation costs and current incentives since the appropriate time will be defined by the selling price that the distribution generation owner hopes to achieve in order to fulfill its profit expectations. Answering the “how much” question depends greatly on the technology available and local conditions, like weather.

This is the kind of information that network planning processes do not have today, not only because it increases the complexity of the problem but it is also difficult to include this information in the planning process. In order to be useful, this information must be modeled appropriately and undergo risk assessment and uncertainty analysis so it can be translated into numbers, values and criteria through the economical and technical analyses, so that can support decisions and point to the right decision to make.

5. REFERENCES

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