EVERYDAY DECISIONS CONCERNING NETWORK DEVELOPMENT CAN BE OPTIMIZED

Edmond PETROSSIAN
Siemens AG – Germany
edmond.petrossian@siemens.com

Carsten BOESE
Siemens AG - Germany
carsten.boese@siemens.com

Eberhard OEHLER
Stadtwerke Ettlingen GmbH– Germany
eberhard.oehler@sw-ettlingen.de

Alfred ROTTONARA
Stadtwerke Brixen AG – Italy
rottonara.alfred@asmb.it

ABSTRACT

Planning of electrical networks can be divided into operative planning and strategic planning. Both methods are necessary to optimize and operate networks. Planning engineers of public utilities mostly focus the operative planning in its daily work. Therefore the long-term future concepts will not been recognized and local replacements of electrical equipment will be carried out without an analysis of the optimum for the whole system. Operative planning without any strategic planning will not lead to economical network structures.
Siemens AG network planning department received an order from several network operators to develop a process for the optimization of operative planning. This report presents and discusses the process that was worked out. The practical experience already gathered is also presented. The paper shows that a new method will support economic network planning in the daily work of planning departments for a German and Italian utility.

INTRODUCTION

Public electricity networks will be built and modernized to meet the requirements of customers today and in future. Those requirements have got a multiplicity of reasons:

- New houses and residential areas will be build
- Refurbishment of existing house will be carried out
- Change in the use of building (e.g. offices instead of apartments)
- Increasing or decreasing load demand.

Additionally the public power supply has to meet the increasing demands regarding reliability of supply. Not only interruptions but also voltage dips will lead to disturbances in modern offices, industries and households.
To adapt the distribution networks to the requirements of customers, necessary measures are assessed and implemented by the utilities on a daily basis within the scope of operative planning. Operative planning activities are cost-intensive and realization of measures also calls for high amounts of investment.
The knowledge derived from practice shows that the measures realized as a result of operative planning increase network and operating costs as time goes by and prove, to some extent, to be bad investments. Such measures can also turn out to be contrary to network optimization. This is because the lowest-cost expansion measures are generally worked out for and aimed at a short-term solution within the scope of operative planning.
According to the experience of the Siemens AG network planning department, networks can only be optimized if a long-term network concept within the scope of Greenfield planning is the basis for all short and medium-term decisions. Figure 1 elucidates the planning loop for strategic and operative decisions. The strategic network concept is basis for short term decisions. The medium term planning shows the transition from the existing network configuration to the target network [1].

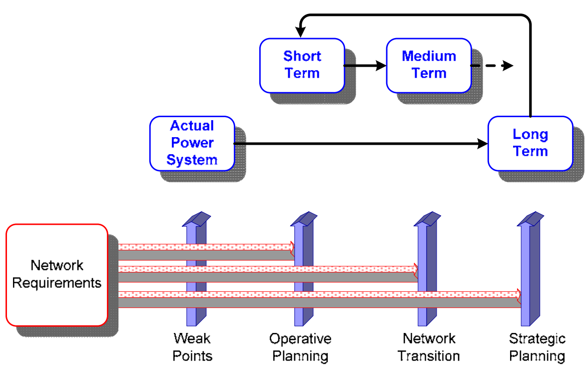

Figure 1: Planning Loop

NEW PLANNING CONCEPT

Preliminary investigations

Several networks that had grown historically were first analysed in order to develop the process for optimizing operative network planning.
The following operative planning measures were undertaken for these networks:

- Small-scale activity (connection of a new RMU)
- Medium-scale activity (renewing a substation), and
- Large-scale activity (boosting a network to power a commercial estate)

The operative planning activities were carried out by

- the power supply company's network planning department,
- the network planning department of Siemens AG, and
- jointly in groups

The results from the planning activities were then assessed and contrasted. As was to be expected, the results were approximately the same and were considered to be both technically and economically suitable. But: were they really the optimum?

In a further work step, one Greenfield planning operation was performed for the networks studied. Greenfield planning denotes strategic network planning, i.e. long-term orientation of the network. This means that only the loads will be taken and all other equipment will be neglected. Viewed from the point of view of Greenfield planning, the “optimum solutions” resulting from operative planning turned out to be no longer suitable in technical and/or economic terms.

Example

Ensuring the required supply reliability for a city called for renewal of an important 20 kV substation from the year 1959. This installation was in a critical state and caused high maintenance costs. Moreover, spare parts were difficult to come by or were no longer available at all and personnel were no longer at hand to maintain this installation. Several instances confirmed the need to renew it:

- the power supply company's employees
- an independent expert on switchgear safety, and
- the reliability calculations

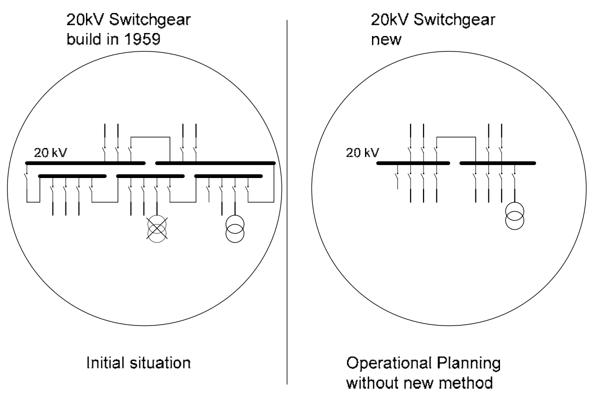

Figure 2: Switchgear configuration of the existing system and after operative planning

Within the scope of operative planning, the substation's design was conceived anew and it was possible to reduce the number of bays, which led to simplification of the installation (see figure 2). The estimated investment volume for the switchgear alone amounted to about € 325,000.

Construction of the substation would normally already be begun after a short-term decision to renew it. Then, planning at this stage now only involves implementation, for example routing the cables and continued operation during conversion. Then, as a result of the decision taken at short notice, the need for replacement is no longer scrutinized.

The **most important question**:

- Does this substation even have a function at all?

was no longer asked within the scope of operative planning. Why was this not scrutinized?

It was not possible to ask this question for the following two reasons:

- There were clear arguments and facts in favor of renewing the installation, i.e. it had been in operation for more than 45 years.
- Operative planning was carried out at isolated points, i.e. only the switchgear and the routing of the incoming cables had been considered.

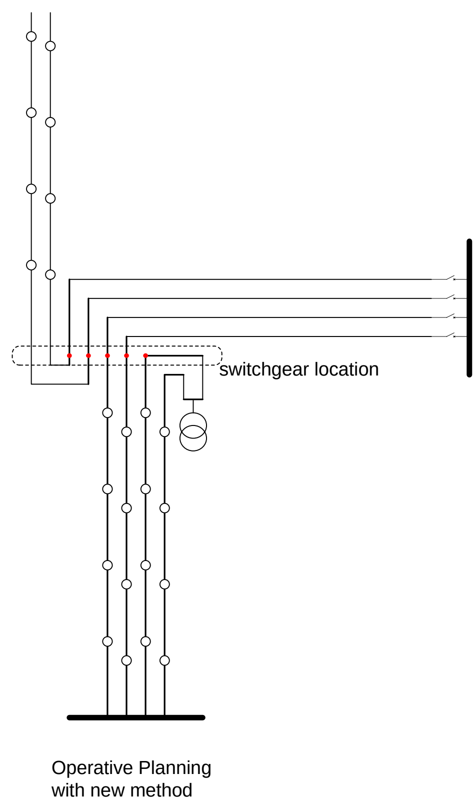

Figure 3: Elimination of switchgear with new method

It transpired from subsequent Greenfield planning that this substation no longer has any function in relation to the future power supply and was to be removed after jointing the cables. Figure 3 shows the final network design.

It has been found that Greenfield planning is the basic prerequisite for optimization of a network and thus of an investment. Extensive savings potentials cannot be identified without this step.

New process and its application

As already mentioned, Greenfield planning is the basic prerequisite for the new process. The suitable network voltages and types are defined in this process. For example, the network types for a municipal medium voltage network are:

- **Rings** that begin in a transformer substation and end in the same transformer substation, and
- **Lines between substations** that begin in a transformer substation and end in another one or in a remote station

Both types of networks are operated open in the medium voltage networks.
Initially, determining the **importance** of each individual network element for the supply of power is the basis of operative planning in accordance with the new method. This subdivision of network elements must be derived from the Greenfield planning.
The significance of some network elements is as follows, for example:

Cables

- Transport cables, distribution cables, reserve cables, etc.

Transformers

- Infeed transformers, reserve transformers, special transformers, etc.

Switchgear

- Transformer substation switchgear, infeed switchgear, network isolation switchgear, existing switchgear, remote station, customer switchgear, etc.

Changing requirements for the network, e.g. connection of an important consumer, are incorporated into the geographical network plan.
Neighboring cables, switchgear, recieving substations etc. are **considered in terms of their importance** when planning connection of the new load. The method most usually applied, i.e. "let's take the next best cable!", should no longer be used because the nearest running cable may have an important function. Equally, a customer should not simply be connected to the nearest substation without a precise definition of this substation's importance for the supply of power.
Therefore, the following documents and data are necessary for application of the new process:

- Simulation of the electrical networks belonging to the relevant voltage levels in a geographical representation
- The current capacity utilization of equipment
- The condition and/or age of equipment
- The future network concept from Greenfield planning, and
- The location and amount of the load to be connected

The necessary criteria and guidelines must be agreed for network planning. For instance, for municipal distribution networks these are

- (n-1) criterion
- Required supply reliability
- Simple network structure and operation
- Ability to adapt to changing loads
- Requirements posed by the regulating body
- Environmental conditions
- Cost-effectiveness
- etc.

The **advantages of the process** are:
Within the scope of the new process, an attempt is made to achieve high cost-effectiveness through usability of the newly deployed equipment over a period of time corresponding approximately to its useful life.

- Suitable connection of new customers because the functions and supply reliability of the lines are known
- Larger loads can also be optimally integrated in the network
- A defined adaptation of supply reliability to customers' wishes is possible
- Supply reliability is adjusted better to actual needs
- Suitable connection of dispersed power generation such as district heating power stations, bio-mass power stations, etc.
- More cost-effective cable renovation or partial cabling of overhead lines
- More cost-effective renewal of installations and of network protection
- Reduction of costs for operative planning
- There will no longer be networks "that have grown historically”
- It may be possible to reduce losses because you have an overview of the entire system
- Cutting operating costs thanks to simplified network structures
- Standardization of equipment sizes
- Technically, operationally and economically best solution for the overall network
- Avoidance of wrong investments
- etc.

Conclusions from example network analysis

The following conclusions were derived from the operative planning undertaken that had **not** been based on Greenfield planning:

- The operatively planned measures cement the “historically grown” networks and make restructuring difficult in the long term.
- Viewed individually, the operatively planned measures are cost-effective, but may entail

expensive network measures

- The operatively planned measures for network improvement can unnecessarily complicate the network
- In certain circumstances, the operatively planned measures can increase the costs of network operation, network losses and renovation
- The operatively planned adaptations or renewals of network protection and neutral point connection are highly complex
- The cost effectiveness of new measures must be assessed for the entire network
- Displacement of the load's focal point is not considered in operative planning

The following conclusions were derived from the operative planning undertaken that had been based on greenfield planning:

- Optimum deployment of investments
- In the course of operative planning, greenfield measures can be realized in steps
- To some extent, modernization, renewal and automation of a network are also possible
- The ring and line types of networks are not lost in the course of time
- Reduction of overall network costs is possible

The new process also pursues the aim of enabling continuous network renewal. Only when networks are renewed continuously can a wave of investments be avoided, which may lead to financial and logistics problems and may have a negative impact on supply reliability.

<u>Requirement: know your objective!</u>

SHORT-TERM EXPERIENCE

<u>Renewal of a 20 kV substation</u>

An 18-bay substation with 13 outgoing feeder and five busbar couplings in the city center was no longer suitable for operation because of its advanced age. It transpired from operative planning that the switchgear ought to be replaced. It also transpired from planning that it could not be replaced on a one-to-one basis, but could only be designed with 13 bays (see figure 2). The necessary investment costs amounted to approximately € 325,000.

As a result of the new process, it was found that a substation was no longer necessary when taking the Greenfield planning into account. The switchgear was removed after fitting of joints to a few cables and after setting up a simple network station (see figure 3).

The savings potentials achieved for the electrical equipment (Greenfield planning/operative planning) amounted to about € 300,000. Optimization of the network concept was also considerable.

<u>Connection of three ring main units</u>

In the supply area considered, three new stations were to be connected with one 20/0.4 kV transformer (400 kVA) each (estimated load approx. 250 kVA per transformer) (see figure 4).

It transpired from operative planning that the existing cable A should be used for the supply to the stations. The necessary investment cost for laying the cable amounted to about € 15,000.

It transpired from use of the new process that the cable B, a pure distribution cable, should assume the task of the infeed to the stations. Realization calls for higher investments of about € 45,000, however.

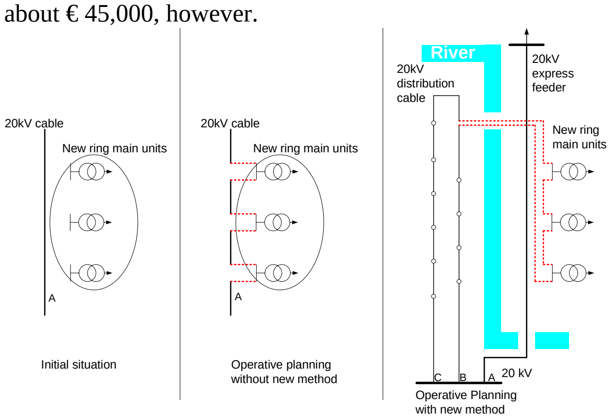

Figure 4: connection of three ring main units

Consideration of short and medium-term network development shows, however, that high savings potentials (up to € 200,000) can be achieved if the **express feeder A** is not used. These costs result from the need to lay a new unloaded supply cable between the transformer substation and the remote station in the long term.

LONG-TERM EXPERIENCE

<u>Experience in the past ten years</u>

The experience described below stems from a power supply company that had ordered Greenfield planning as early as 1993 [2]. Thanks to the new process, the operative planning was considerably simpler and faster.

Figure 3

Connection of a special consumer had to be devised after Greenfield planning in 1993. On the basis of the long-term strategies, it was possible to work out a fast and uncomplicated connection to the supply network. The information on load amount, required supply reliability and the deadline situation diverged greatly and were highly imprecise (see figure 5).

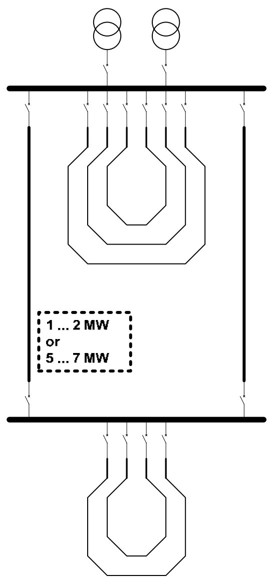

Figure 5: Initial network configuration with load growth

The prerequisites for connection of the special consumer were:

- Variant 1: load 1 to 2 MW, normal supply reliability
  Infeed from the municipal ring (see figure 6; Assumption A)
- Variant 2: load 1 to 2 MW, high supply reliability
  Infeed from the transformer substation via a new cable to be laid; reserve from the municipal ring (see figure 6; Assumption B)
- Variant 3: load 5 to 7 MW, high supply reliability
  Infeed from the transformer substation via two new cables to be laid (see figure 6; Assumption C)

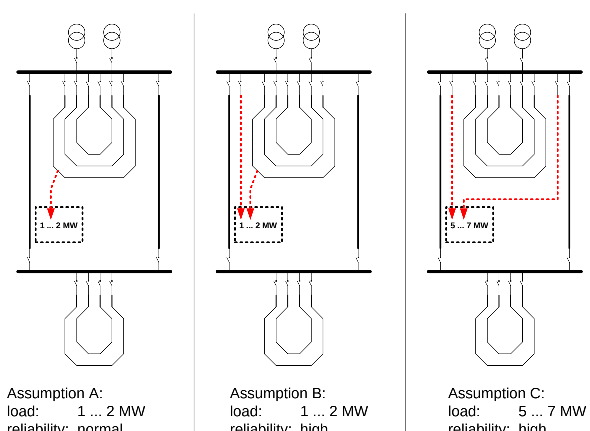

Figure 6: Network configurations for different load scenarios

After completion of operative network planning, the cable located close to the new special consumer was not touched because it has a feeding function for the network with two rings (three in future). The switchgear was also not considered because it has another function to fulfill.
Despite the imprecise data situation, it was possible to work out solutions for connection of the customer without much effort that involved various specifications for the power consumed and supply reliability.

CONCLUSION

It has been found that pending decisions can be reached faster on the basis of Greenfield planning. Security of investment has improved clearly in comparison with networks planned purely operatively. Operation has become simpler and more reliable. Faults have clearly decreased and this has therefore contributed to boosting supply reliability. Equipment capacity utilization shows a clearly improved distribution over the individual outgoing feeders. In more than ten years of use of the process, it has not been possible to identify any investment errors.

REFERENCES

[1] Guha, D.; Jain, V.; Connor, Th.; Böse, C., 2005, “Greenfield planning approach for the city of Mumbai leads to optimal future network development”, CIRED 2005, Turin, Paper 0455, Session 5

[2] Connor, Th.; Petrossian, E.; Oehler, E. Scherer, S., 2005, „Greenfield-Planung eines Verteilnetzes“, Elektrizitätswirtschaft, Heft 8/2005, Page 76 – 81