# DISTRIBUTION NETWORK PLANNING IN RESTRUCTURED EPS COMPANY

D. Jovanović
DP Elektrovojvodina d.o.o.
Novi Sad

## 1. ABSTRACT

After dividing republic Electric Power Company of Serbia into two separated company: EMS (company for transmit ion and monitoring) and EPS (company for producing and distribution), it was started with establishing new relationships between two companies. This dividing was only first step toward restructuring and deregulation in this two company.
Planning of building schedule for substation 110/x kV is product of distribution company needs, so accordingly Distribution Company makes this schedule. In the transmition company in network planning area, appearance of new substation is appearance of a new consumer.
Both, EMS and EPS has to make there own development plans, but it is necessary to harmonize it, for reaching optimal solution for both side in the case.
In ongoing changes both company will planning with constraint budget [1, 2, 3, 4] and this problem will be emphases (EMS will have constrained budget in spite is not on market). Competition will contribute to find some solution for this problem, but lasting of the transition period is not predictable, so there is need to prepare for coming changes.
In this paper is proposed solution for distribution company. There is proposed way for making decision in witch projects invest, and by witch schedule, all with constraint budget.
In EPS organization of Distribution Company with his separates, every separates make his own medium voltage network plans and proposals for substations building. In this way every separates make list of projects. These projects are mutually independent, so company administration (with constraint budget) has to make unique list of projects and objective function for making unique list of projects.
These companies' separates are partially independent in planning as are independent at all. This independence reach medium voltage (MV) network, while substations are in charge of administration. From the other hand, all parts of distribution area are not in the same level of medium voltage network quality (network structure, tension quality, etc), so, it should be

Dragoslav Jovanović, DP Elektrovojvodina d.o.o. Novi Sad,
Bul. Oslobodjenja 100, 21000 N. Sad, 021 528 556, dragoslav.jovanovic@ev.co.yu

opportune to equalize quality of network on the whole distribution territory as a rule in perspective. Additional problem is the fact that the projects for substations, MV network, and reconstructing substations should be taken as geographically and electrically independent (separates are geographically and electrically independent). Putting all projects in one view of planning it should make a decision in witch projects invest, and by witch schedule, all with constraint budget.

## 2. GENERAL APPROACH

In EPS organization of Distribution Company with his separates, every separates make his own medium voltage network plans and proposals for substations building. In this way every separates make list of projects. These projects are mutually independent, so company administration (with constraint budget) has to make unique list of projects and objective function for making unique list of projects.

These companies' separates are partially independent in planning as are independent at all. This independence reach medium voltage (MV) network, while substations are in charge of administration. From the other hand, all parts of distribution area are not in the same level of medium voltage network quality (network structure, tension quality, etc), so, it should be opportune to equalize quality of network on the whole distribution territory as a rule in perspective. Additional problem is the fact that the projects for substations, MV network, and reconstructing substations should be taken as geographically and electrically independent (separates are geographically and electrically independent). Putting all projects in one view of planning it should make a decision in witch projects invest, and by witch schedule, all with constraint budget.

## 3. PROPOSED METHOD

Until now, criterions for investment schedule [5], by separate group of projects (separate substations from MV network) were used. In this way we make clustering of budget into separate independent budgets for two main groups before planning analysis that should make overinvestment's or sub investments in some parts of network.

Distribution system planning need complete attitude so for avoiding this overinvestment's or sub investments, have to make unique criterion for investment schedule making before investments decision.

This unique criterion for investment schedule is very difficult to establish with satisfying technical and other constraints. Problem is more complicated with introducing reconstructing substation within observed problem.

For making clear position take first (knowing that are present two concepts: 110/35/10/0, 4 kV and 110/20/0, 4 kV) independently criterions for establishing schedules:

- Criterion for substations 110/x kV schedule
    - Load of TS 110/x kV,
    - Load of transformer 35/x kV (in existence of 10kV and 20kV tension),
    - Exploitation of TS 110/x kV is over 40 years,
    - criterion (n-1) for transformers, and possibilities of MV load supports from other substations 110/x kV,

- Criterion schedule for TS 35/10 kV
    - loading TS 35/10 kV,
    - Exploitation of TS 35/10 kV is over 40 years,
    - criterion (n-1) for transformers, and possibilities of MV load supports from other substations TS 35/10 kV,

- Criterion for MV network
  - Feeder load,
  - Loses in feeders,
  - Tension drops,
  - Time of exploitation,
  - Reserve posibilitéis,
  - Social constraints.

- Criterion schedule for reconstructing TS 110/x kV and TS 35/10 kV
  - Time of exploitation and equipment condition,
  - Equipment work interruption statistics,
  - Tension drops, MV network overloads, insufficient number of MV feeders,
  - energy not served.

By the ongoing proces of restructuring it is convinient to establish unique criterion according knowing principles of planning in deregulated systems. In purpose of equilazing network quality, uzing this factors we give new dimension of solution quality. This using of planning criterions should have lead to the solution with smallest investments by satisfying established criterions.
We started with fact that building substation and MV network are not expestable (even possible) at the same case, so it we have to associate quality measure for network to solutions at different locations. In this way solution with biger quality koefficient will take higher place on the list. Taking into account all all independent projects, it is neccesary submit it all to unique criterion and by this way made unique scedule of investments.
Using statements from [6, 7] for non dominated solutions it is possible to make different step in distribution planning, because there are the solutions that are not close and non dominant. Now we can't use classic risk analysis, but need to make decision under other parameters.
Applying penalty factor is solution that can make schedule with some order, but projects of reconstruction have advantage in space of energy not served, and in space of energy, advantage have projects of building MV network and substations.
One of possibilyties is that valorization factors should be reprezent of profit or annual investments cost with satisfying technical criterion. In the same time should have introduce penalty factors for technical criterion [8].

Investments costs, some can expres like:

- o Building substation TS 110/X kV,

Penalty factots cab be expresed:

1. Calculation load flows (or some other way) produce voltage drops and feeder loads, for all feeders from TS 110/X kV,
2. Find load of all TS 110/X kV.
3. (Find load of all TS 35/10 kV, if there is 10 kV and 20 kV network both.)

By the results one can make unbiased costs of substation with MV network connections, in the way of counting quality penalty factor for solution. This penalty factor take into account voltage drops and feeder loads influence in every feeder. By the way, all solution with violated voltage or termic criterion, was reject.

$$PF\,1 = \frac{1}{N_{iz}} \sum_{i=1}^{N_{iz}} \frac{\Delta U_i}{U_{nom}} + \frac{1}{N_{iz}} \sum_{i=1}^{N_{iz}} \frac{P_{iz\max}}{P_{iznom}} \quad (1)$$

Where:

$\Delta U_i$ – voltage drop in feeder „i“,

$U_{nom}$ – rated voltage,

$P_{iz\ max}$ – Max load of feeder „i“,

$P_{iz\ nom}$ – rated load of feeder „i“,

$N_{iz}$ – number of feeders from TS 110/X kV.

This coefficient shows the influence of load and voltage stage in all MV feeders after building substation.

$$PF2 = \frac{P_{inTS}}{P_{\max TS}} \quad (2)$$

Where:

$P_{inTS}$ – rate of TS 110/Dž kV,

$P_{maxTS}$ – max load of TS 110/X kV.

This coefficient express influence of substation load.

$$PF3 = \frac{\sum_{i=1}^{N_{izK}} P_{mizv}}{P_{konz}} \quad (3)$$

Where:

$P_{mizv}$ – feeder load „i“,

$P_{konz}$ – observed area (consume) load.

This coefficient express influence of loading and voltage drops in MV feeders before building substation.

Situation before building substation:

$$PFB = PFB1 + PFB3 \quad (4)$$

Situation after building substation:

$$PFA = PFA1 + PFA2 \quad (5)$$

$$QPF = \frac{PFA}{PFB} \quad (6)$$

Multiplying annual investment costs with sum of this coefficient some can get terms of objective. In this way, annual investments are pondered according with network function quality.

Relevant costs in this solution are sum of annual investments of substation, annual costs of connection MV feeders and reduction of energy not served.

$$IC = ICTS + ICCON - DENS \qquad (7)$$

Where:

IC – annual investments cost for solution,

ICTS – annual investments cost of substation,

ICCON – annual investments cost of connection MV feeders,

DENS – decrease of energy not served after bulding TS 110/X kV.

After that, objective function becomes:

$$F = QPF \cdot IC \qquad (8)$$

In the former relation first term of PF1 is measure of changing in every feeder from TS; second term of PF1 is measure of load changing in every feeder from TS; PF2 is measure of load TS influence; PF3 is measure of MV network situation before building TS and this is a sum for all observed area.

- o Building TS 35/10 kV,

Symilar as for  TS 110/X kV.

- o Reconstruction of TS 110/X kV or TS 35/10 kV,

In substation for reconstruction is M number of all equipment with relevant outages, N is number of exploitation years for equipment, $N_D$ is planned number of years for equipment.

$$PFR1_i = \frac{N}{N_D} \qquad (9)$$

$$PFR1 = \frac{1}{M}\sum_{i=1}^{M} PFR1_i \qquad (10)$$

$$M = \sum_{i=1}^{m} N_{TRi} + \sum_{i=m+1}^{n} N_{PRi} + \sum_{i=n+1}^{k} N_{Ri} + \ldots \qquad (11)$$

$$PFR2 = \frac{1}{M}\sum_{i=1}^{M} \lambda_i r_i \qquad (12)$$

$$ENS = (ENSB - ENSA) \qquad (13)$$

$$PFR3 = \frac{ENS}{E} \qquad (14)$$

$$QPF = PFR1 + PFR2 + PFR3 \quad (15)$$

Where:
$PFR1_i$ – using rate for equipment „i“,
$N_{Tri}$ – „i“-th transformer,
$N_{Pri}$ – „i“-th breaker,
$N_{Ri}$ – „i“-th interrupter,
$\lambda_i$ - average outage number of element „i“,
$r_i$ – average outage lasting of element „i“,
E – total energy,
ENS – energy not served,
ENSB – energy not served before reconstruction,
ENSA – energy not served after reconstruction,

In this case, depending on if it is reconstructed all substations or only some parts, investments can be rather different, but in spite this follow relation is written:

$$IC = ICR \quad (16)$$

Where:
ICR – annual reconstruction investment.

Objective function is:

$$F = QPF \cdot IC \quad (17)$$

In spite fast that substation reconstruction maybe not completely belong to the planning problem, it is placed in planning area because income budget.

- Building of MV network.

1. Based on analysis, establishing needed number of MV feeders.
2. Using load flow, or in the other way, counting of loading feeders and voltage drops, for all MV feeders.

Situation before building MV network:

$$PFNB = PFNB1 + PFNB3 \quad (18)$$

Situation after building MV network:

$$PFNA = PFNA1 + PFNA3 \quad (19)$$

Now, making analogy with building substation case we can write for MV consumes:

PFNB1 = PFB1 – for observed part of area

PFNA1 = PFA1 - for observed part of area,

PFNB3 = PFB3 - for observed part of area,

PFNA3 = PFA3 - for observed part of area,

$$QPFN = \frac{PFNA}{PFNB} \tag{20}$$

ICF – annual investments for MV network,

Where:
PFNA – penalty factor before building MV network,
PFNB – penalty factor before building MV network,

The objective is:

$$F = QPF \cdot ICF \tag{21}$$

Taking into account two spaces: loading, voltage drops and energy not served, solutions would be in two groups with three different attribute. In space of attribute, every solution group has dominant solution by group attribute. Non dominant solution can be only in the range of this two group. Following this, in the unique space (this is not non dominant group of solutions, as a rule for risk analysis) we introduce penalty factors.
In this way, instead of risk analysis we take penalty factors, so we have objective become:

$$\min_i F_i = \min_i QPF_i \cdot ICF_i \tag{22}$$

**4. CONCLUSION**

This way of solving problem is only one of possibilityes for establishing objective function, so it is introduced new way of solving problem. In this way we accept this attitude because the non dominante solutions make that risk analisys is not possible. Using penalty factors it is provide for solution with higher contribution for network quality to make higher place in list, and contribute for levelized network operation quality. Regulation of solvation is possible if at first some build emergency solutions, and after that make a list. This attitude, because prezence of two solvations gruop (substations and MV network), make only narrowing to unique criterion, but also can be a solid base for decision maker.
Implementing DMS (Distribution Management System) in distribution companies should make base for fast load flows, and voltage drops analysis and overbuilding tools for network planning and risk analysis.

**Key words:** planning, investments, scedule

**5. LITERATURE**

1. E. Van Geert: Towards New Challenges for Distribution System Planners, CIRED 97, June 1997.
2. N. Kagan & Co : A Quality Driven Software for Expansion Planning in an Open Regulated Electricity Market. CIRED 99, June 1999.
3. L. Philipson, H. Lee Willis: UNDERSTANDING ELECTRIC UTILITIES AND DE–REGULATION, Marcel Dekker, Inc. 1998.
4. H. Lee Willis: POWER DISTRIBUTION PLANNING REFERENCE BOOK, Marcel Dekker, Inc. 1997.
5. Uputstvo za Izradu srednjoročnog plana razvoja elektrodistributivne mreže preduzeća EVUP-EN-01, Elektrovojvodina, jul 2005.

6. Hyde M. Merrill, Allen J. Wood: Risk and Uncerainty in Power System Planning, 10$^{th}$ Power System Conference G, Austria, August 19-24, 1990.
7. V. Miranda, L. M. Proenca: Why Risk Analysis Outperform Probabilistic Choice as the Effective Decision Spport Paradigm for Power System Planning, IEEE trans. On Power Systems, vol.13, no.2. May 1998.
8. D. Jovanovic: Planning of Optimal Location and Sizes of Distribution Transformers Using Integer Programming, Electrical Power&Energy Systems, 25(2003), pp 717-723.

Dragoslav Jovanović, DP Elektrovojvodina d.o.o. Novi Sad,
Bul. Oslobodjenja 100, 21000 N. Sad, 021 528 556, dragoslav.jovanovic@ev.co.yu