NETWORK DEVELOPMENT IN A FAST CHANGING SOCIETY – EXAMPLE TRIPOLI IN LIBYA

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ABSTRACT

Growing international acceptance of Libya in the last years led to an amazing economic development which poses high pressure on the electrical energy supply to follow the fast load growth. The paper describes the process of network planning and the resulting master plan for the subtransmission network of Tripoli for the year 2020 and the implementation strategy to realise a network evolution which is able to meet the defined requirements and the predicted high load growth.

INTRODUCTION

Growing international acceptance of Libya in the last years led to an amazing economic development which increases the standard of living of the Libyan people. Today the networks in Libya face a strikingly fast and large increase in the power demand with high requirements in the reliability of supply.

As Tripoli will develop as economical centre of Libya, for the city a load growth of approximately 12 % per year (compared to approximately 8 % in the rest of the country) is predicted in the near future with some lower growth rates later. Up to the year 2020 the load is expected to grow from now approximately 850 MW in the greater Tripoli area to nearly 2500 MW which means a growth by a factor of three. In such phases of revolutionary changes a master plan is very important to set the direction of the network development.

As it was originally designed to meet the requirements of the past, the electrical network has to be completely redesigned to enable it to cope with that high load growth.

DATA COLLECTION

To start with the planning the state of the existing network had to be documented and clarified. It is important to create one defined database containing all elements in the network. From experience it was found to be very important to have defined and unique names for all stations and substations. This point is especially fundamental as there is no defined transcription between Arabic and English names resulting in very different notations for the same station. Therefore a table has to be created containing the names of all stations in one defined English version, in one Arabic version and as defined abbreviation. The importance of that seemingly trivial point cannot be stressed enough as a disregard will cause many confusion, which could be observed in other developing networks, too.

The creation of one common and definitive database collecting all the data of all important equipment in one place simplifies data maintenance significantly. It also avoids the development of different and inconsistent databases in one enterprise. Such a database has to be maintained by one department being responsible. All changes in the network have to be incorporated into that database and everyone who needs it has to get access to it.

For planning purposes it is necessary to represent the data in a geographical representation in a network calculation program like PSS™Sincal together with a map of the city containing all the streets and building structures.

In the past the network was built to be able to handle the load requirements and to ensure the supply with a good reliability. Considering the high load growth the network will not be able to handle the loads in the next future. Weak points will occur decreasing the reliability of the network.

MASTERPLAN

The main content of a masterplan is the strategic development of a target network for the far future (the year 2020). This target network in future is then used as a guideline for every day decisions, like network extensions, removal of weak points and changes in the network.

Usually for existing networks several options exist to decide on network development and weak point removal (see figure 1). In operational short term planning it is often not possible to take a profound decision which option to choose.

Long term planning means that for a given area with a predicted future load distribution a target network is developed. Having created that target network for the future then changes and improvements in the existing network are proposed considering an intended mitigation in the direction of the designed future network. With that guideline in mind the intermediate networks for the year 2010 and the year 2015 were planned. From these steps an investment strategy was derived. For the given example in figure 2 the optimal decision based on the guidance of the masterplan will be the installation of line C-D.

As the boundary conditions will develop differently as planned, in the long run the target network as described in the masterplan will not be built exactly as it is proposed. It is just a hypothetical network. Therefore the network modelled for the original masterplan will not show the exact network configuration and the exact loading of the lines in the year 2020. The final network in 2020 probably will look similar to the one planned in the masterplan. Especially in dynamically developing networks an update of the masterplan at least every 2 years to the new boundary conditions is necessary to keep the masterplan close to reality.

The intermediate network for the year 2010 acts as guideline to decide on urgent actions to mitigate actual weak points in the existing network.

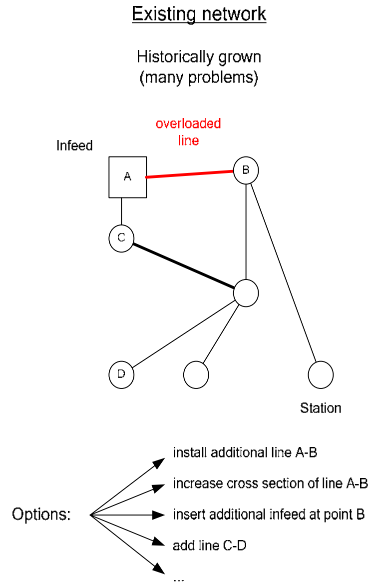

Figure 1 Motivation of Masterplan

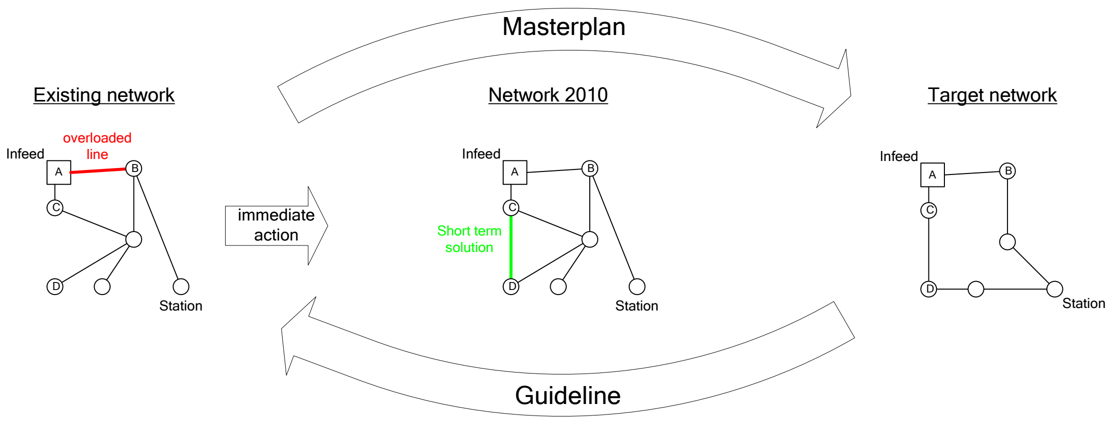

Figure 2 Benefit of Masterplan

LOAD DEVELOPMENT

The main goal of an electrical network is to supply the loads with electrical power. Therefore the development of the size and position of the loads has to be the main boundary condition for network planning. Prediction of loads for a longer time span in future is not a trivial task.

The city of Tripoli was divided into 11 load growth zones (see figure 3). For each of the zones the expected type of customers was defined (like residential, industrial, touristical, commercial). It is possible that in one zone several types of customers can be identified. For each customer type a prediction of the load development was defined. For example for touristical areas a load growth of 10 % per year up to the year 2015 and from that year onwards to the year 2020 a load growth of 6 % per year is expected.

For zones containing more than one customer type the average of the load growth factors of the different customer types was applied as the geographical distribution of the loads (concentrated loads at the 11 kV side of the 30/11 kV transformers) gives an impression of the load density distribution in that area.

For the planning of the masterplan it is necessary to know the future load density distribution. An approximation can be found by using the existing subtransmission station loads as representation of the existing geographical load density distribution. To that existing load density distribution the load growth factors are applied to define the future load density distribution. Known large customers in present and future are integrated in addition to that procedure.

By applying the load growth factors to the existing station loads the resulting loads will in many cases become higher than the capacity of a station. By assuming the concentrated loads as representation of the load density in that area, the loads can be distributed on neighbouring or newly placed stations in that area to make sure that no station is asked to supply more power than their firm capacity. The principle of that procedure is illustrated in figure 4. For that example a firm capacity of each station of 20 MVA was assumed. To reach that firm capacity 2 transformers 20 MVA each are needed to supply the power even if one transformer fails.

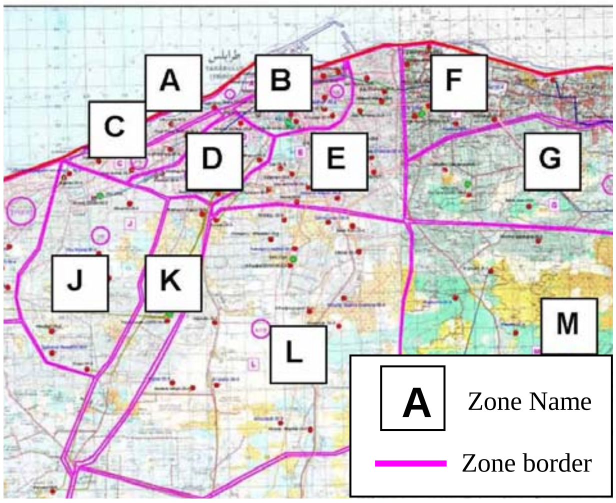

Figure 3 Load growth zones in central Tripoli

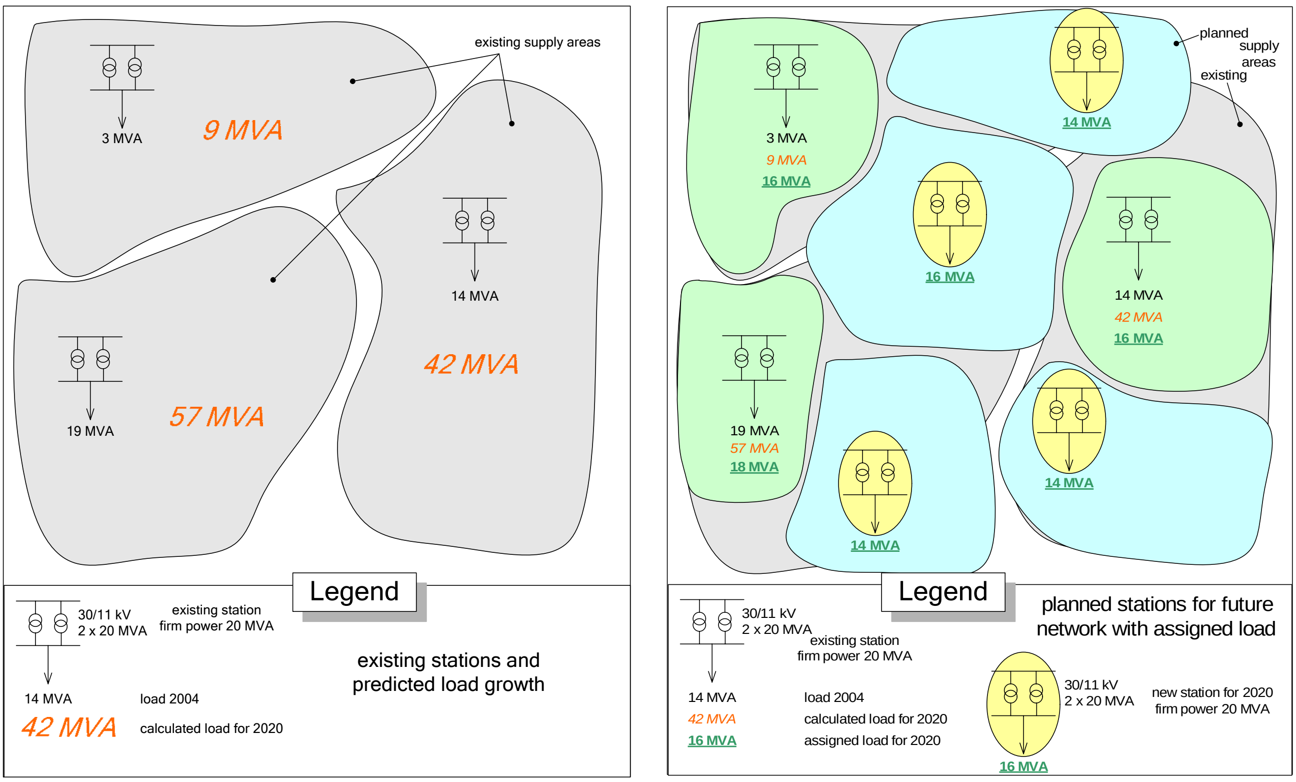

Figure 4 Principle load assignment

PLANNING CRITERIA

There are many possibilities to supply a given load distribution, which have different properties concerning economy, reliability, operability and other factors. Hence it is important to define criteria which the network should meet. The definition of these criteria is a very important part of the planning task as they influence the structure of the future network. These criteria are determined partly by the philosophy of the network operator which often results from historical experience, a deep insight into the economical, political and other boundary conditions of the specific region, the expectations of the customers and knowledge about the asset management strategies.

For the Tripoli area amongst others the following planning criteria were defined:

- Voltage levels: 220/30/11/0,4 kV
- Reserve strategy in 30 kV network:
  - instantaneous reserve for failure of one cable or overhead line circuit
  - switching reserve for failure of one station or common mode failure of lines
  - switching reserve for failure of one complete 220/30 kV station
- Simple and easy to operate network structure
- Standard equipment types have to be used

The requirements of the faults which have to be handled are quite strict and will lead to a network with a high reliability of supply. By using the defined standard equipment types the basic network structure routes to adjacent stations was chosen (see figure 5).

The planning of the network has to be embedded into a total view of the system considering also protection systems, control systems and other factors as the performance of the power supply will be influenced by the total of all factors.

APPLICATION OF STANDARD STRUCTURE ON LOAD DENSITY

This standard network structure was then applied to the station distribution which results from the load density development. Existing routes were taken into consideration as well as the position of new infeeding stations from the high voltage network. To fulfil the criteria standardised structure and simple operation, this structure is applied throughout the full network for the year 2020. The planned network was verified by load flow and short circuit calculations and contingency analysis.

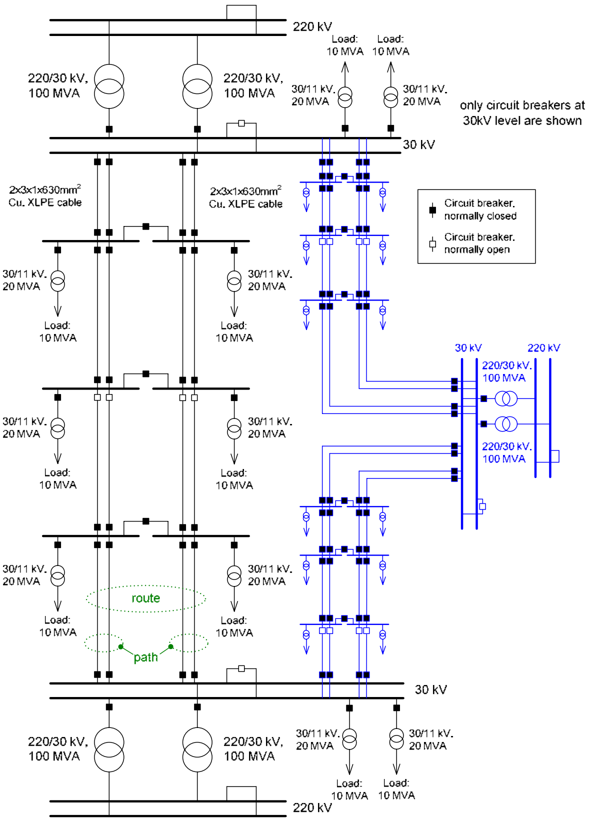

Figure 5 Basic network structure

ROADMAP TO FUTURE NETWORK

The master plan defines the network in a far future state (15 years ahead). For the network development it is necessary to have guidelines how to develop the network into the direction of the master plan. To illustrate these guidelines, intermediate network stages for the year 2010 and 2015 were planned.

To identify areas which need urgent attention and to prioritise the expansion works the existing network was analysed to identify actual weak points and to determine urgent action to remove these weak points not interfering with the future network development.

For the planning of the intermediate stages the principle of the superimposition was applied (see figure 6). That means, the previous and the following network are superimposed. By taking into consideration the existing and the planned lines, weak lines, stations of the previous and the following network as well as the actual load density, the intermediate network is planned as a transitional state between the two “boundary” stages.

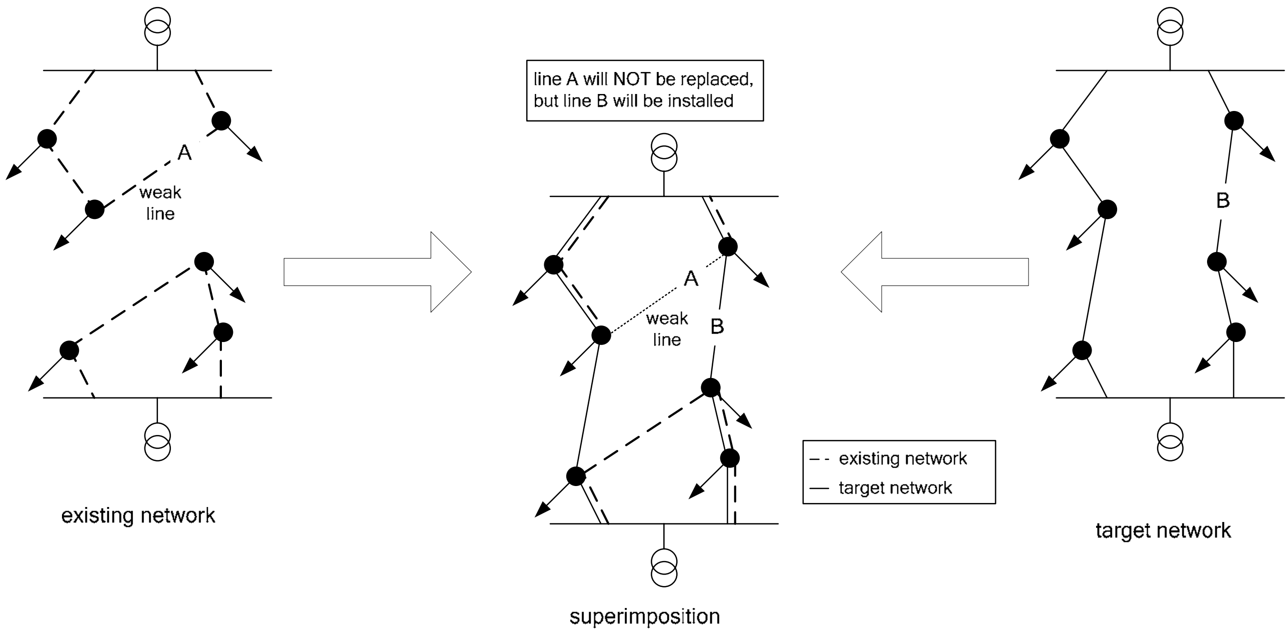

Figure 6 Principle of superimposition

CONCLUSION

The paper describes the planning process which is necessary to develop a masterplan for a dynamically developing network at the example of the subtransmission network of Tripoli. The main steps data collection and verification, investigation of load development, definition of planning criteria, development of standard structures, application to load density distribution which are necessary to develop the masterplan are described in detail.

The planning of new stations and the load allocation between stations in future based on the load density distribution is presented as a planning principle.

The principle of superimposition to develop intermediate networks which act as guidelines to solve urgent problems in the existing network and to develop the network into the direction of the target network is presented.

During the planning process many problems were identified, described and solved, which might occur similarly in analogue situations.