INTERACTIVE PLANNING TOOLS FOR STRATEGIC DEVELOPMENT OF MV NETWORKS IN GEOGRAPHICAL INFORMATION ENVIRONMENT

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SUMMARY

The paper presents a methodology of a systematic approach to the study of the long-term development of the Slovenian distribution network over regional distribution utilities. The method is of a heuristic type and is supported by an advanced software package named GREDOS which allows an analysis in a completely graphic environment supported by a commercial geographic information system program ArcView.

1. INTRODUCTION

Modern and effective distribution systems necessitate contemporary approaches to the planning of the electric power network. The new tasks and changes, such as the institutional arrangements, opening the electricity market, environmental restrictions, and adoption of new technologies, should by all means be in any respect taken into consideration at the strategic development planning of distribution companies. It is a prerequisite that the methodological and technological development of electric power systems is closely followed, and that program tools and EPS planning methods are constantly improved as foreseen on the basis of development studies. The probabilistic approach to the planning and the pertaining analysis have turned out to be of a paramount importance as far as the company's cost efficiency and achievement of the quality level of the consumer supply are concerned.

There are some countries in which the importance of long term development solutions is no longer so strongly felt as before as a result of the introduction of a higher level of competition. Considering the increasingly more rigorous environmental restrictions, it is reasonably believed that such approach will be in no time recognised as erroneous. Further, obtaining a site for the plant construction has become an extremely difficult and time-consuming procedure for both the distribution and transmission plants.

It has been noted through experience that there have been less difficulties accompanying procedures for obtaining site permits for new distribution plants when the decision for constructing such plants has been taken on the basis of long term planning. New solutions need, besides energy-economy approvals also higher technology levels to meet new environmental regulations. (The new Act on the Electromagnetic Radiation in the Natural and Living Environment [4] and the Regulatory on the First Measurements and Operational Monitoring of Electromagnetic Sources and Conditions for Their Implementation [5], which were enforced in Slovenia in 1996, very much pushed down limit values for the electric and magnetic fields (E and B).

It is an important task for planners of distribution network. The following are the factors that have a global impact on the planning process for the distribution system:

- Rise in the electricity consumption,
- Spatial and environmental restrictions,
- Organization of the electricity supply industry, market opening, and
- Reliability and quality criteria.

The Slovenian distribution system consists of five regional distribution utilities (shareholding societies with the majority ownership by the state) which in 1997 cover some 80% of the electricity consumption or some 7700 GWh. In the five utilities, there are currently 66 110/MV kV supply substations with 3200 MVA of the installed power. Within the middle voltage level, there are 14620 km of the network and 12100 MV of substations. In 1996/97 the consumption increase was 3.2%. The long-term studies (Project REDOS 2025 [1]) have foreseen that the average increase in the period 1995 - 2025 would be 2.3% annually or the doubling of the consumption in the period of 30 years.

Our last development studies were focused on the issue of flexibility of the distribution network over individual distribution utilities with regard to the possibility of the market opening. The analyses of the kind are made possible by means of the GREDOS program package as the planning tools that will be shown in a greater detail in the continuation.

2. PLANNING TOOLS AND PLANNING PROCEDURE IN SLOVENIA

The REDOS development project was implemented by five Slovenian distribution utilities. Their target was to provide the basis for a permanent study in the development of the distribution network and **software package tools**. With regard to the same planning criteria and external conditions governing the utility operations, a complete long-term development plan for one utility is made each year (Fig. 1). On the basis of such approach, each utility is being considered within a cycle of five subsequent years. A 30 years lasting period is being planned. The initial emphasize will be laid on investments to be considered in the first five years. The annual study for each utility contains up to seven

sub-regional studies. The planning system is decentralized with the criterion aimed at the optimal development of each utility. Advantages of the common project for five utilities are cost-effective financing, common development interests and common software development for the needs of the Slovenian distribution system.

The vital program tool is an advanced software package named **GREDOS** [2]. It is schematically shown in Fig. 2. It contains advanced calculation modules for power flows (the AC and DC version), optimal re-switching of the MV distribution network, any type of short-circuits, and reliability analyses. The development of the program package is the result of a several years lasting intensive involvement of the Electroinstitute Milan Vidmar in the use of various models for the analysis of the MV network. There is uniform database used for any analysis. It is based on the **GIS** platform. A connection is enabled with the common distribution information system in the old environment of the relation database (DB2) or the new GIS environment, depending on the distribution utility. It is hoped that by means of the presently available development project and the **GREDOS** software package an initiative will be evoked providing the basis for the setting up of the GIS database for all utilities operations in the rest of the distribution environment, too.

The employed mathematical modules were designed in accordance with the most recent achievements. The relevant calculations are extremely fast. There are no restrictions on the network size. All modifications and calculations are run in the graphic environment. The AC module for the power flow calculation enables modeling of generation sources in the distribution network, transformer voltage control evaluation and more useful options for planning process.

The optimal sectioning of the MV network follows the minimum loss criteria or the adequacy criteria on the most favorable network reliability structure. The program enables an interactive approach and analyses of alternative solutions over various criteria. In the fault analyses, data are automatically created from the PF network data and additional data from the database. Different fault types analyses are available.

The reliability analyses module enables calculation of reliability indices of distribution networks in the same graphic environment. Indices used to evaluate adequacy of the customer supply are:

- average interruptions frequency (F),
- average interruptions duration (T),
- expected annual interruptions time (H=FxT),
- interruptions cost.

The system index of adequacy E is defined as an expected average not supplied considering all failures, which might occur in the network.

Besides the capacity of network elements, the model considers constraints of the radial operation of meshed built networks. At each failure, the model eliminates the failure component and calculates a new radial state by switching. The new radial state can be sufficient or insufficient for a particular demand. So, with such calculation the reliability judgement and different investigations of the network development in a wide range of conditions are made possible.

The **GREDOS** program package is written in the C++ language. The database employs the commercial program named ArcView. The new version of GREDOS is based on Map Objects technology what enables running program as stand alone application without any commercial GIS software package.

The basic planning procedure is shown in Fig.2. It is divided in two phases. Due to the nature of the distribution network planning, the heuristic based approach was selected.

In the first phase, the operating states analysis considers:

- *Planning under normal conditions and*
- *Planning for emergency conditions.*

Technical standards for this phase [3] was used as follows:

- Allowed 7.5% voltage drop in normal conditions for the MV network and
- Allowed 12.5% voltage drop in emergency conditions for the MV network.
- OHL 50% ratings in normal conditions and 100% in emergency conditions.
- Cable 75% ratings in normal conditions and 100% in emergency conditions.
- Transformer ratings depend on the substation concept:
  - In substations with 2 units, it is 60% in normal conditions and 120% in emergency conditions,
  - In substations with 3 units, it is 80% in normal conditions and 120% in emergency conditions.

Adequacy planning standards are proposed as follows:

- 5 interruptions per year (of over 3 min. duration),
- 20 short interruptions per year (of less then 3 min. duration) and
- the duration of all interruptions per year is 20 hours.

Following the above criteria and planning procedure supported by the GREDOS software package, it is possible to set up adequate variants of the future network. In the second phase, the economy and environment factors are dealt with and tested. The final solution is then proposed for the development plan.

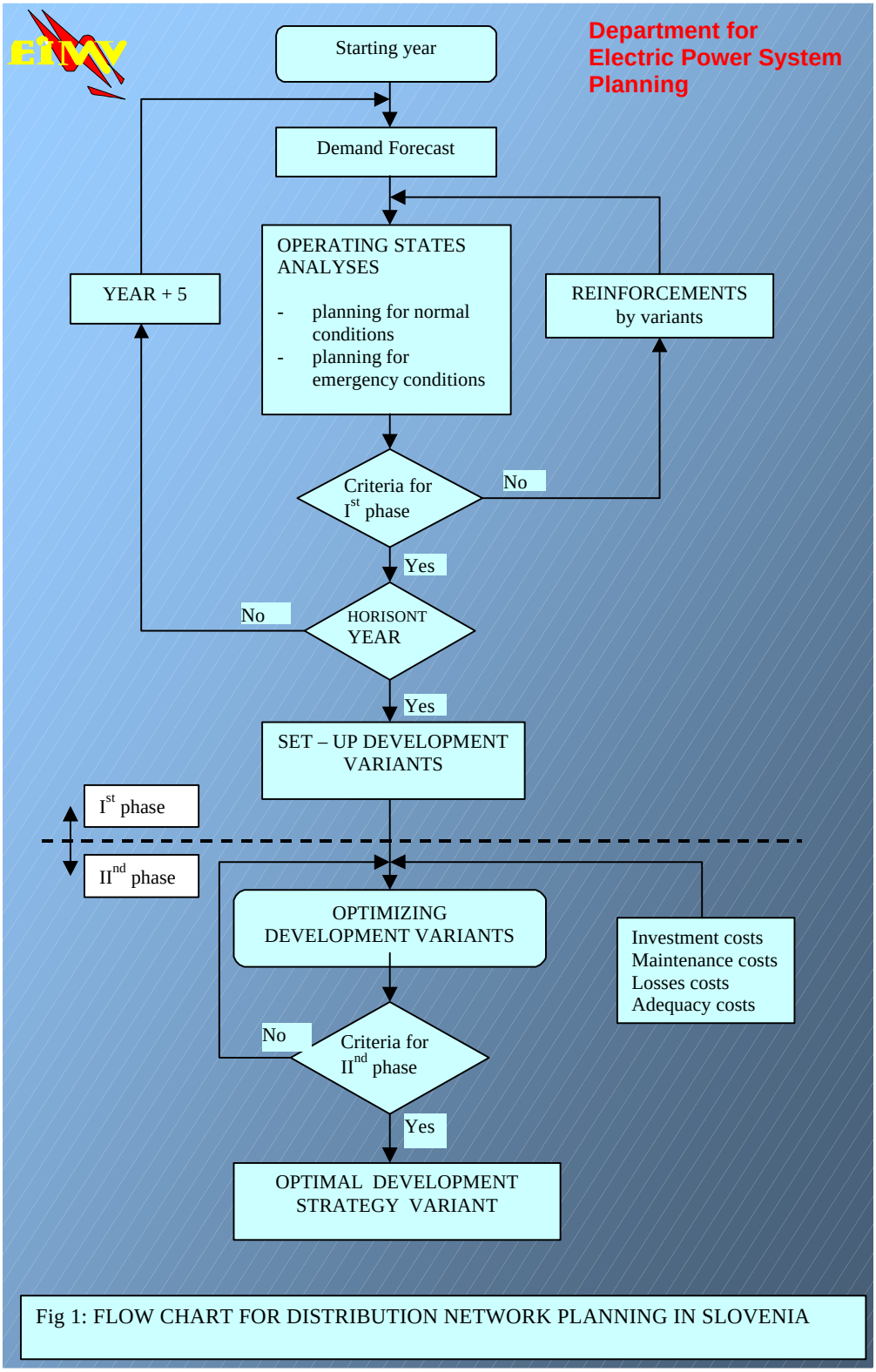

Fig 1: FLOW CHART FOR DISTRIBUTION NETWORK PLANNING IN SLOVENIA

3. GIS DATABASE PLATFORM

A geographic information system (GIS) is a computer-based tool for mapping and analyzing things that exist and events that happen on earth. It was chosen for graphical support for the GREDOS software package.

All the digitized cartographic platforms in various dimensions (from 1:750000 to 1:5000; source: the Slovenian Geodesic Administration) have already been made for Slovenia. Fast organizational-business changes in companies will require a higher level of transparency and prompt availability of various kinds of information and data for which adoption of efficient and standardized

technologies will be a prerequisite. With the consideration of this fact and by integrating the GIS technology in the software for the analysis and development of electric power networks, a long-term compatibility will be assured with other spatial data that already are or will be available from state institutions. Data acquisition is in this way considerably accelerated, thus stimulating electricity distribution utilities to speed up their utilization of the GIS technology.

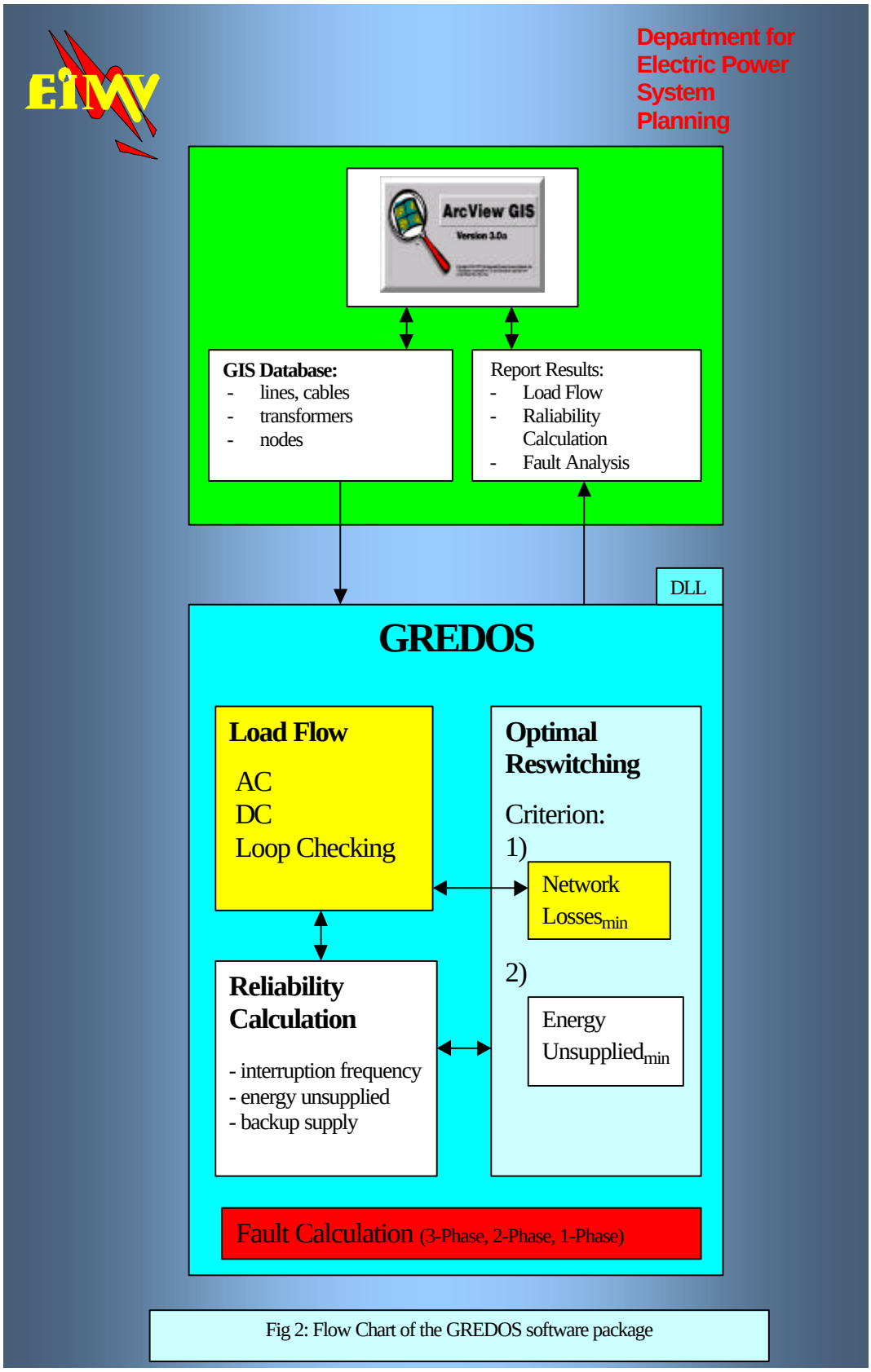

Fig 2: Flow Chart of the GREDOS software package

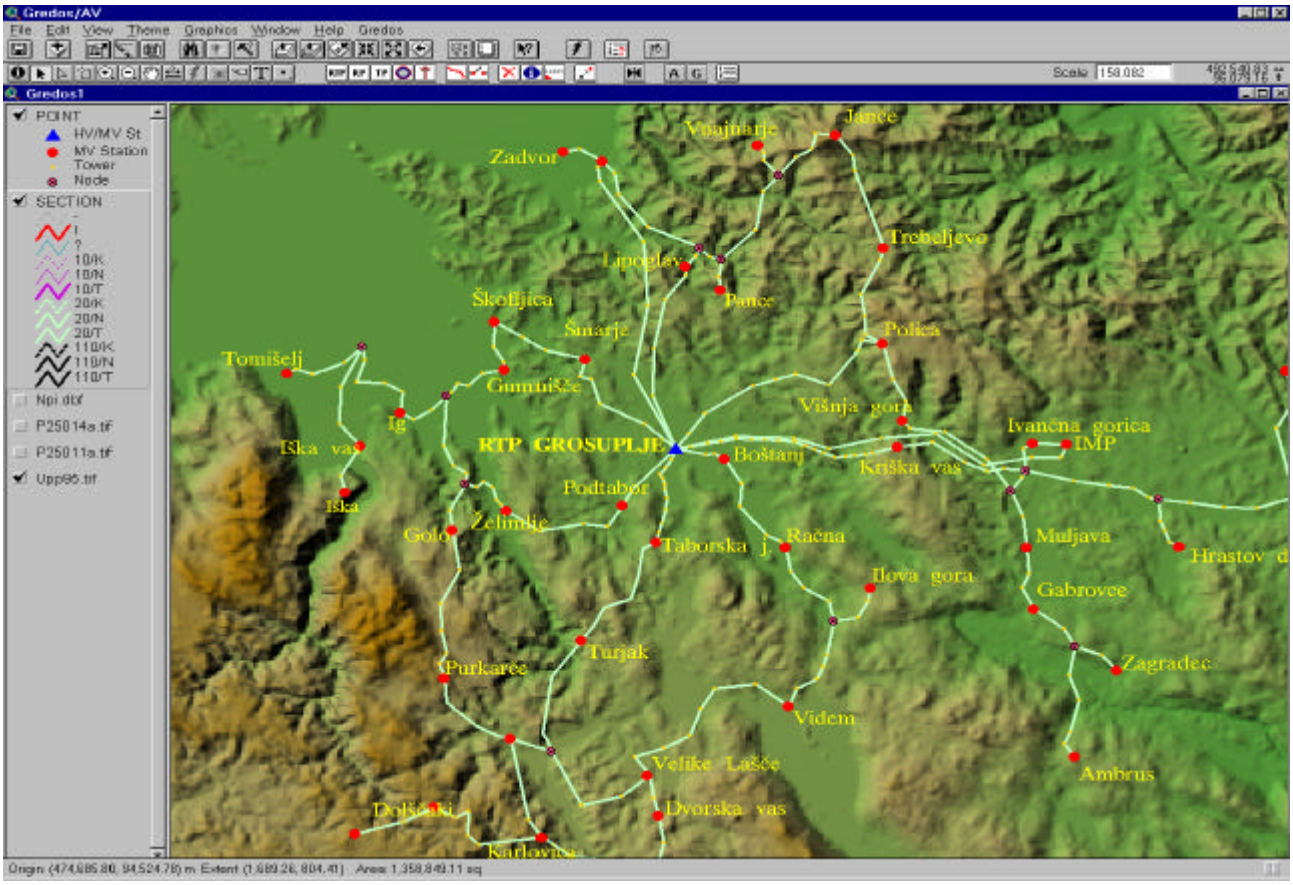

Fig 3: GREDOS topology data in the GIS ArcView [6]

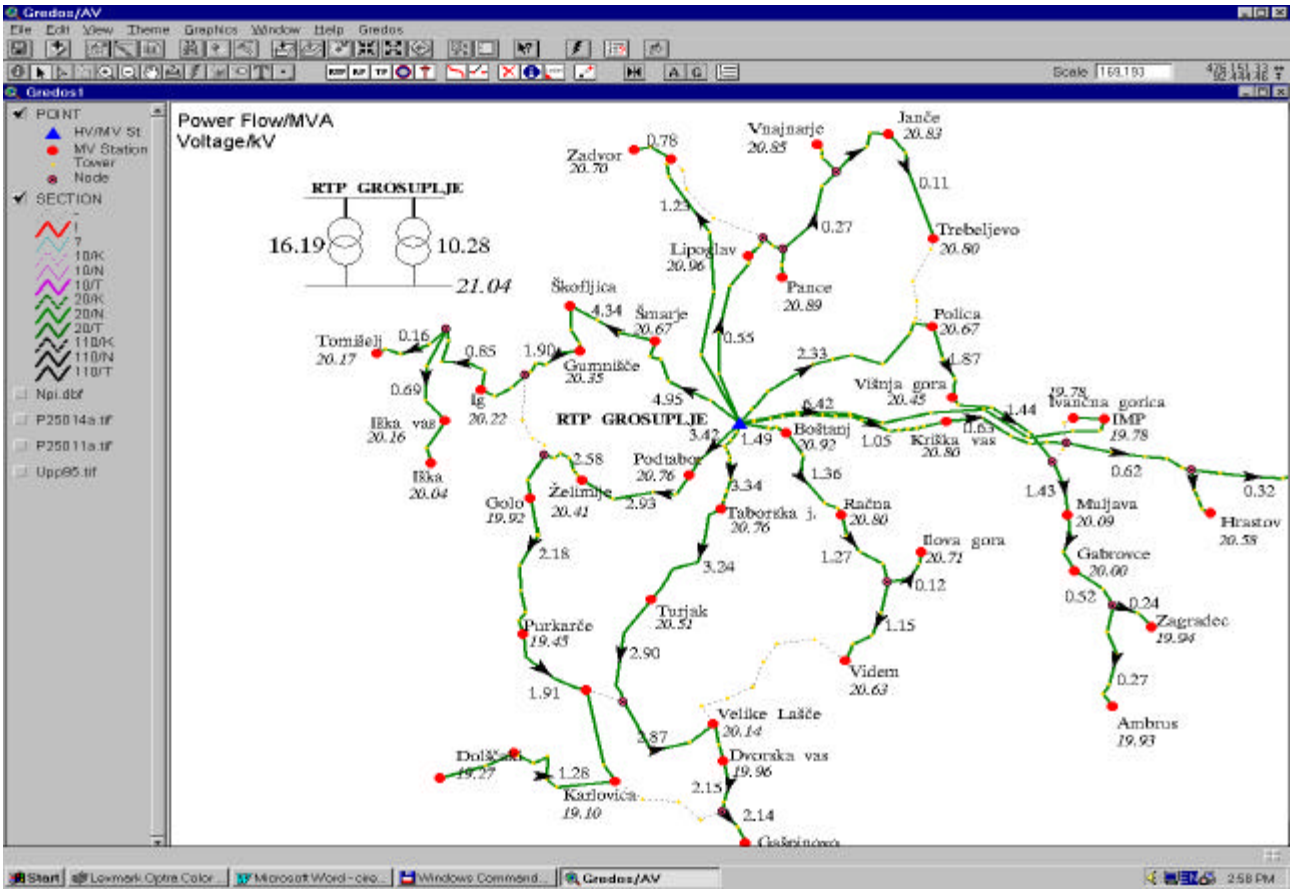

Fig 4: GREDOS Load Flow Results in the ArcView

In the analysis of the network development, most of the time has so far been consumed for the input data make up. The data have been stored in various sources. They have to be verified and adequately organized for their utilization in application programs. The introduction of the GIS technology in the preparation of input data has enormously decrease the time needed for the verification and preparation of data (200 - 300%). The time needed for preparing studies is consequently very much shortened and a greater attention can thus be paid to the network analysis and searching optimal development variants. The final result is a higher level of elaborated projects due to the fact that there can be more time consecrated to the consideration of new criteria of the network development, i.e. increase in the operational reliability, economy and environmental restrictions.

The topology data in the GIS ArcView environment for GREDOS processing are presented in Fig. 3. It is evident that the presentation of the network is very friendly and databases are easily achievable. This graphical database and the results of the power flow in the MV network are in the same graphical environment presented (Fig. 4). The results of other GREDOS calculating models can be shown in the same way

4. CONCLUSION

New challenges faced with in the development of distribution systems have required new modern and effective program tools and planning procedures assuring a greater consideration of the interactive work. In Slovenia the implemented GREDOS software package supported with the GIS database has enabled distribution utilities a quality strategic network planning.

The planning process aided with the possibility of an interactive approach in the same database environment offers enormous advantages. The obtained solutions are verifiable by means of several criteria (technical, reliability, economic). In the planning process, reliability analyses can analyze also the market opening, quality of the consumption supply, institutional changes, effects of distributed sources, etc.

Owing to the vital importance of spatial and environmental issues in the development of the Slovenian distribution network, it has been planned to upgrade the module so as to provide for EMF analyses within same software package. The support of the GIS environment will in this respect be very valuable.

The GREDOS software package is an important tool in the planning process of the Slovenian distribution system that is being permanently pursued. The GIS database platform has yielded very effective results.

Acknowledgments

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