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Electric Systems Planning

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Abstract

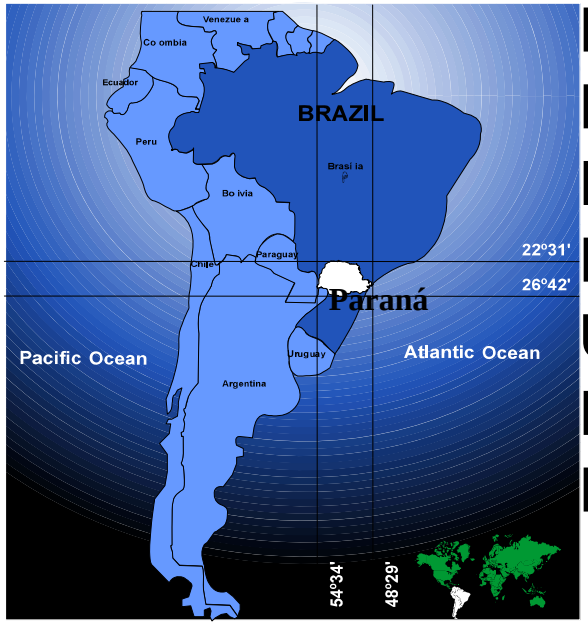
Distribution Planning is a very complex task in which the planners must ensure that the system will meet the demand regarding substation and feeder capacity.The basic goal of a distribution utility could be expressed as: Supply of electricity, Good economy and Good safety.

The implementation took two years of development. The solution is called GISPLAN, and can perform several types of analysis on existing and planned network: Fault Analysis, Load Flow, Technical Losses Calculations, Load Increase, Outage Management Studies, Reliability Studies, Cost Benefit Ratios Determination, Optimal Capacitor Placement, and others.

GISPLAN is a powerful tool to help planners creating scenarios studies and performing simulations to evaluate the impact of modifications in the network, current or future. All simulations can be easily visualized. The most important benefits were: reduced time to plan, better solutions, good performance of calculations, easy drawings and easy and fast input of data.

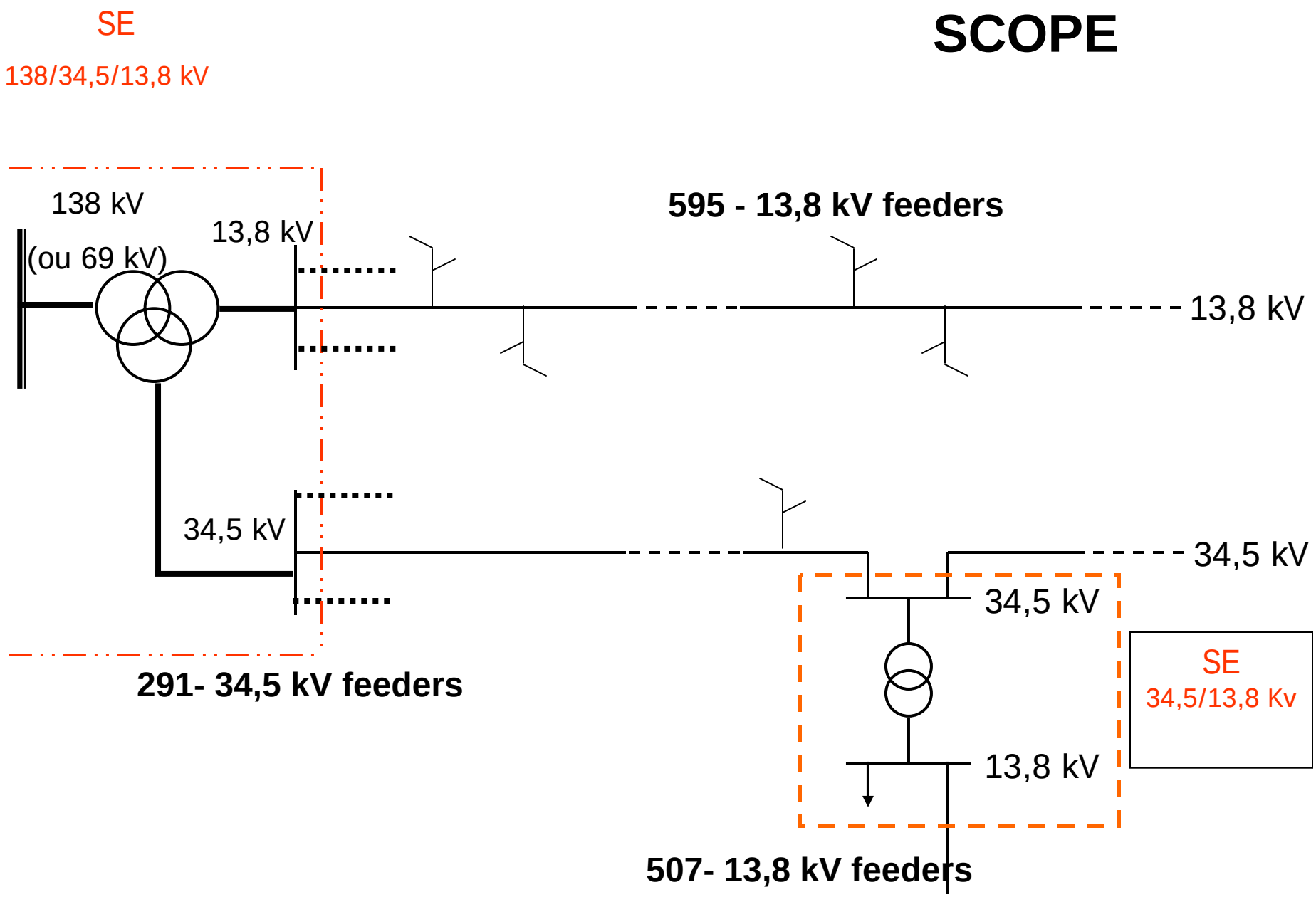
Main Figures

Concession Area : 194.548 km^2
47% of California

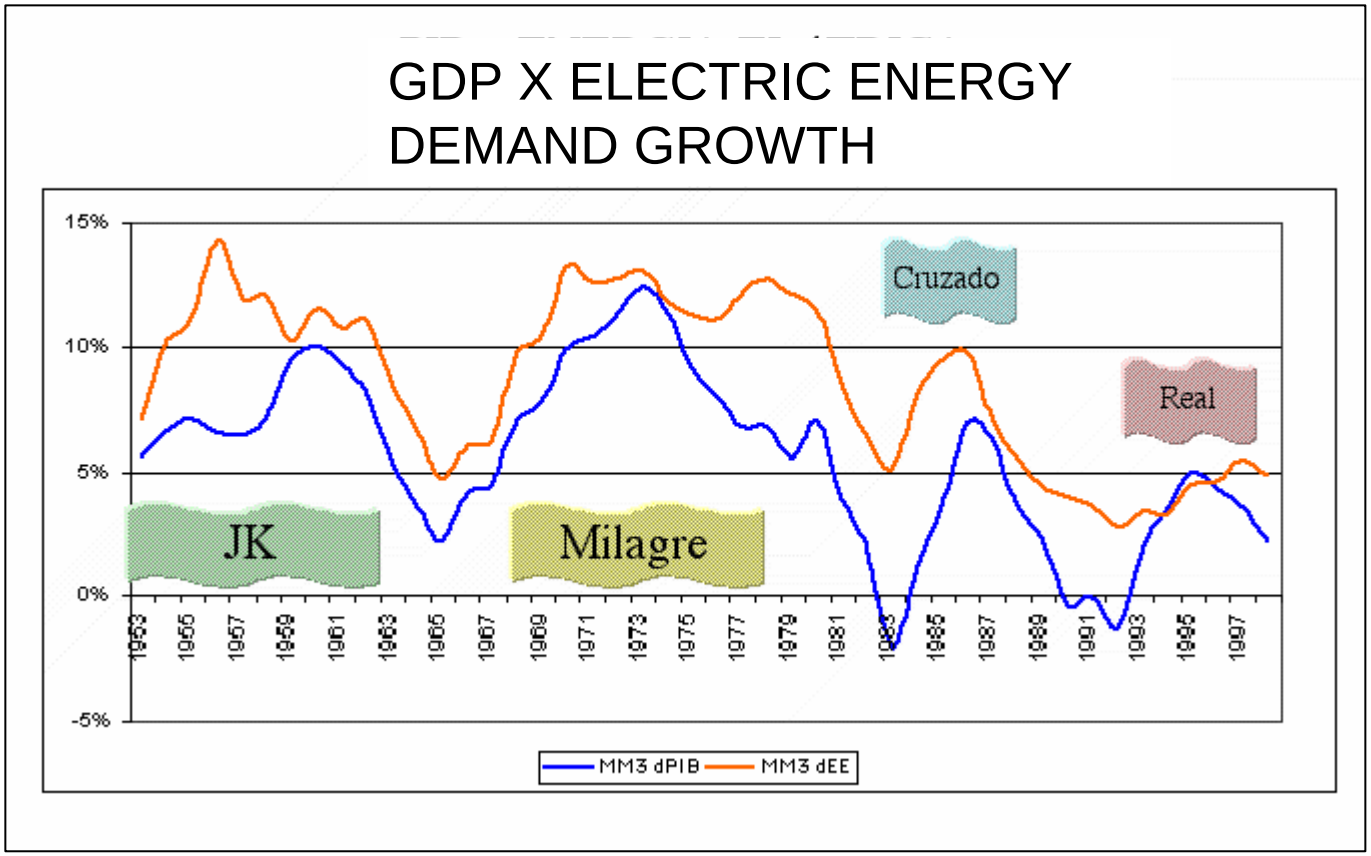


Municipalities served: 393.
Population: 10 millions.
Number of Customers: 3,3 millions.
Per Capita Consumption: 1900 kWh/year
Urban Area:98% of population served.
Rural Area: 85% of population served.
Losses: 6,0 %.

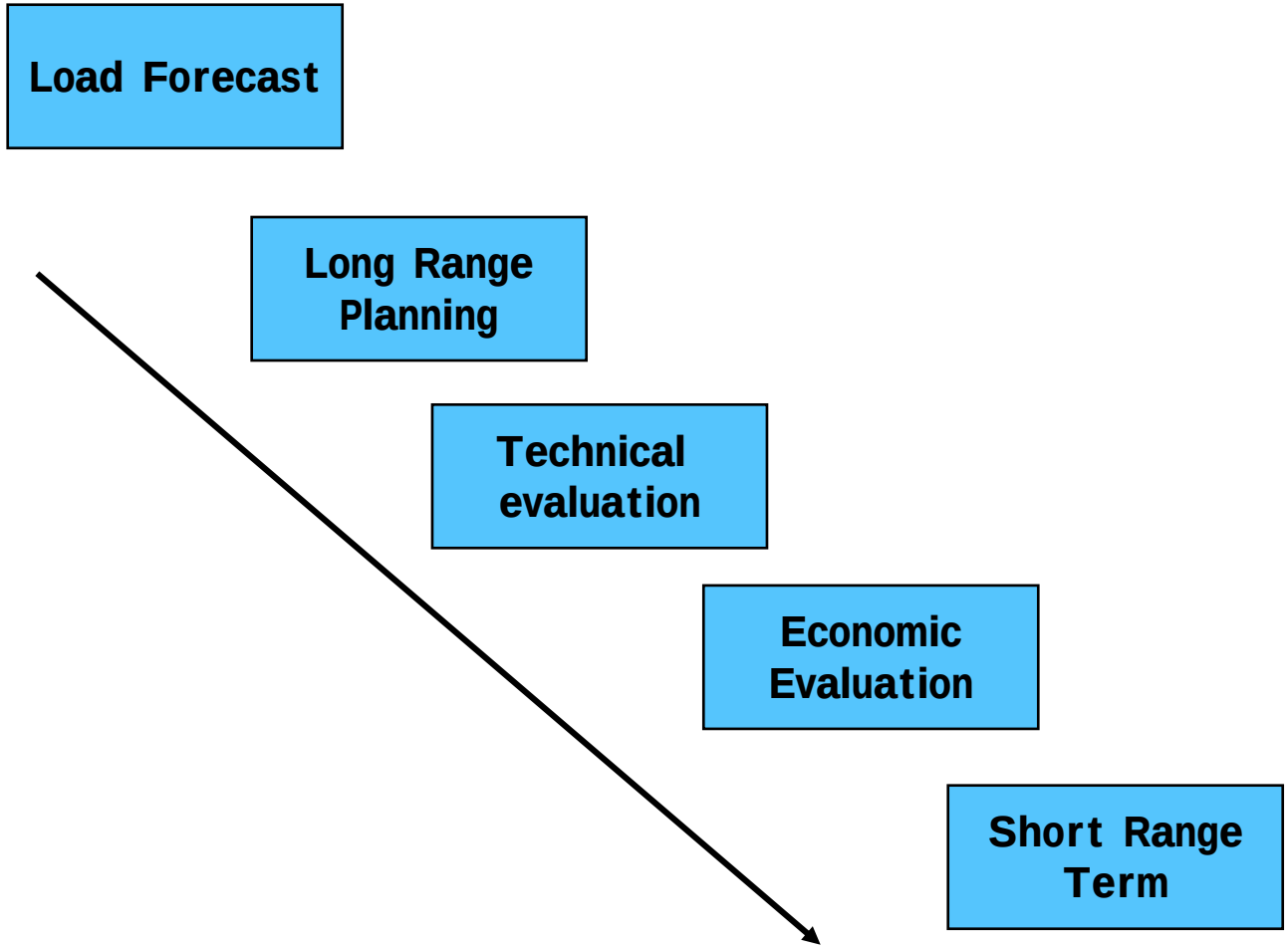
SCOPE

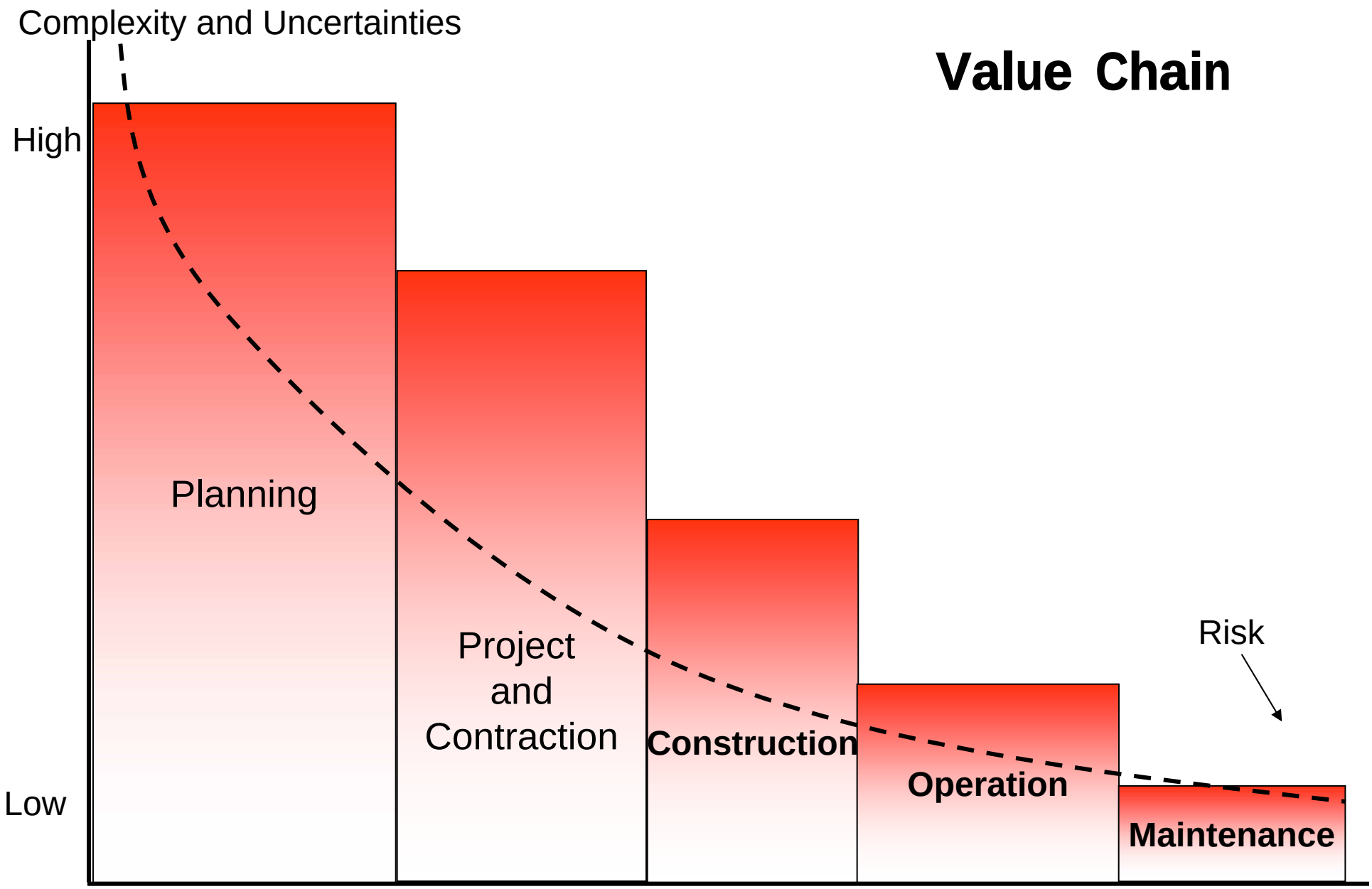

SE
138/34,5/13,8 kV
138 kV
(ou 69 kV)
13,8 kV
595 - 13,8 kV feeders
13,8 kV
34,5 kV
34,5 kV
34,5 kV
13,8 kV
SE
34,5/13,8 Kv
291- 34,5 kV feeders
507- 13,8 kV feeders

THE PLANNING DISTRIBUTION PROBLEM



PLANNING PROCESSES

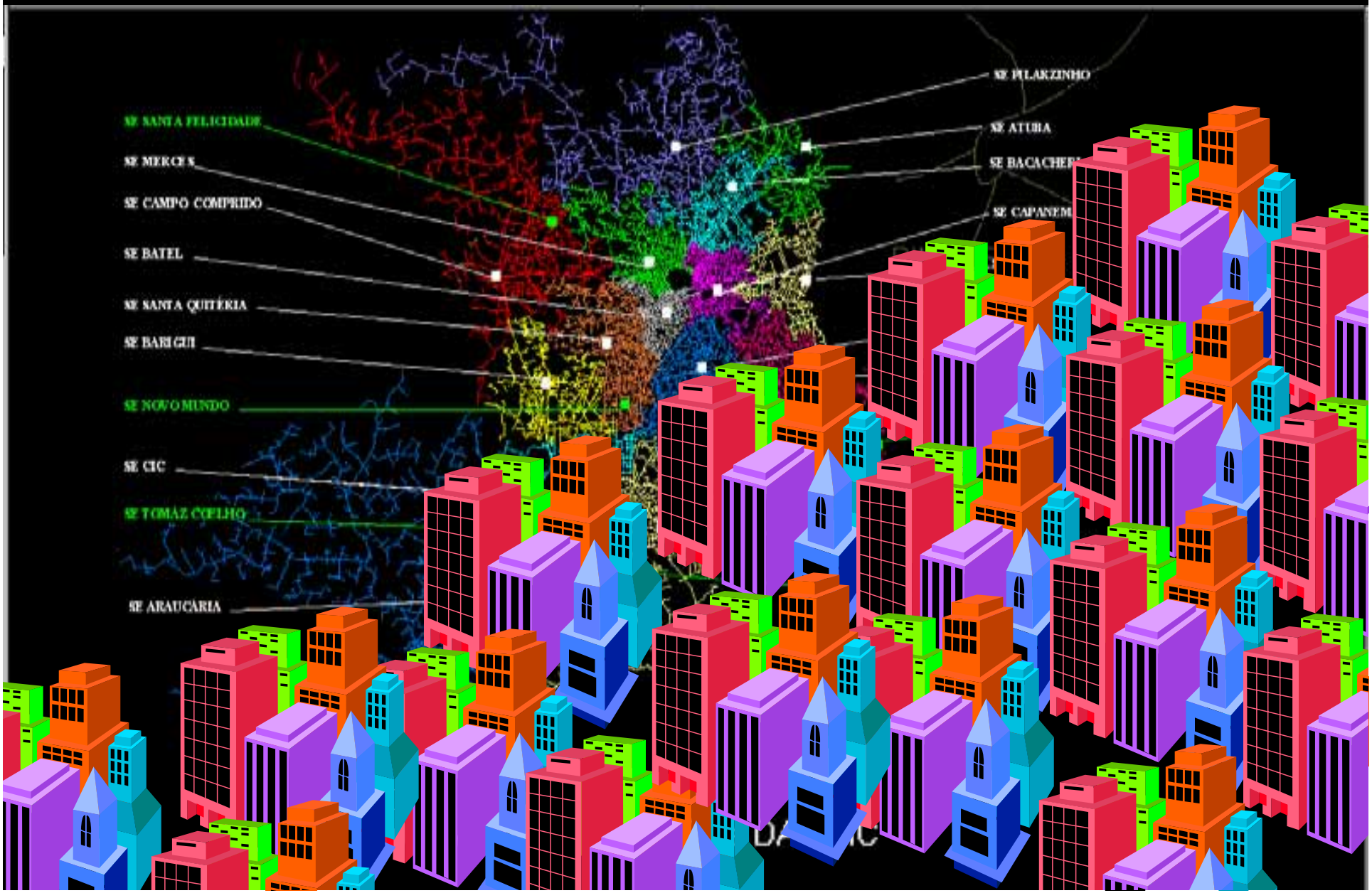



Complexity and Uncertainties
Value Chain
High
Low
Planning
Project
and
Contraction
Construction
Operation
Maintenance
Risk

Planning Programmes:

- Strategic Planning (long term)
- Tactic Planning (medium term)
- Operational Planning (short term)

LONG RANGE PLANNING
SUBSTATION LOCATION



Strategic Plan (Long Range)

20 years.

Substations:

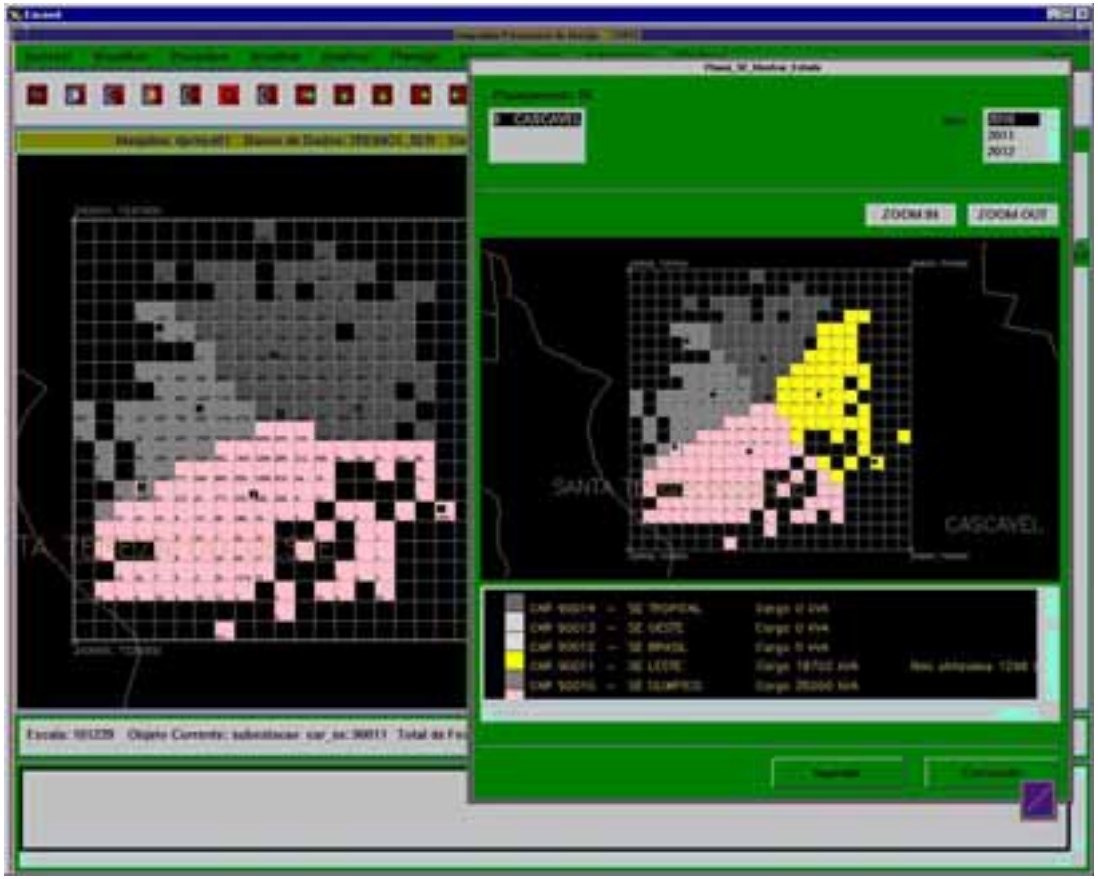
Transportation Models

-Load Forecasting (grids)

-Location .

-Size.

-Time.



Medium Range and Short Range

Migration Project

Distribution

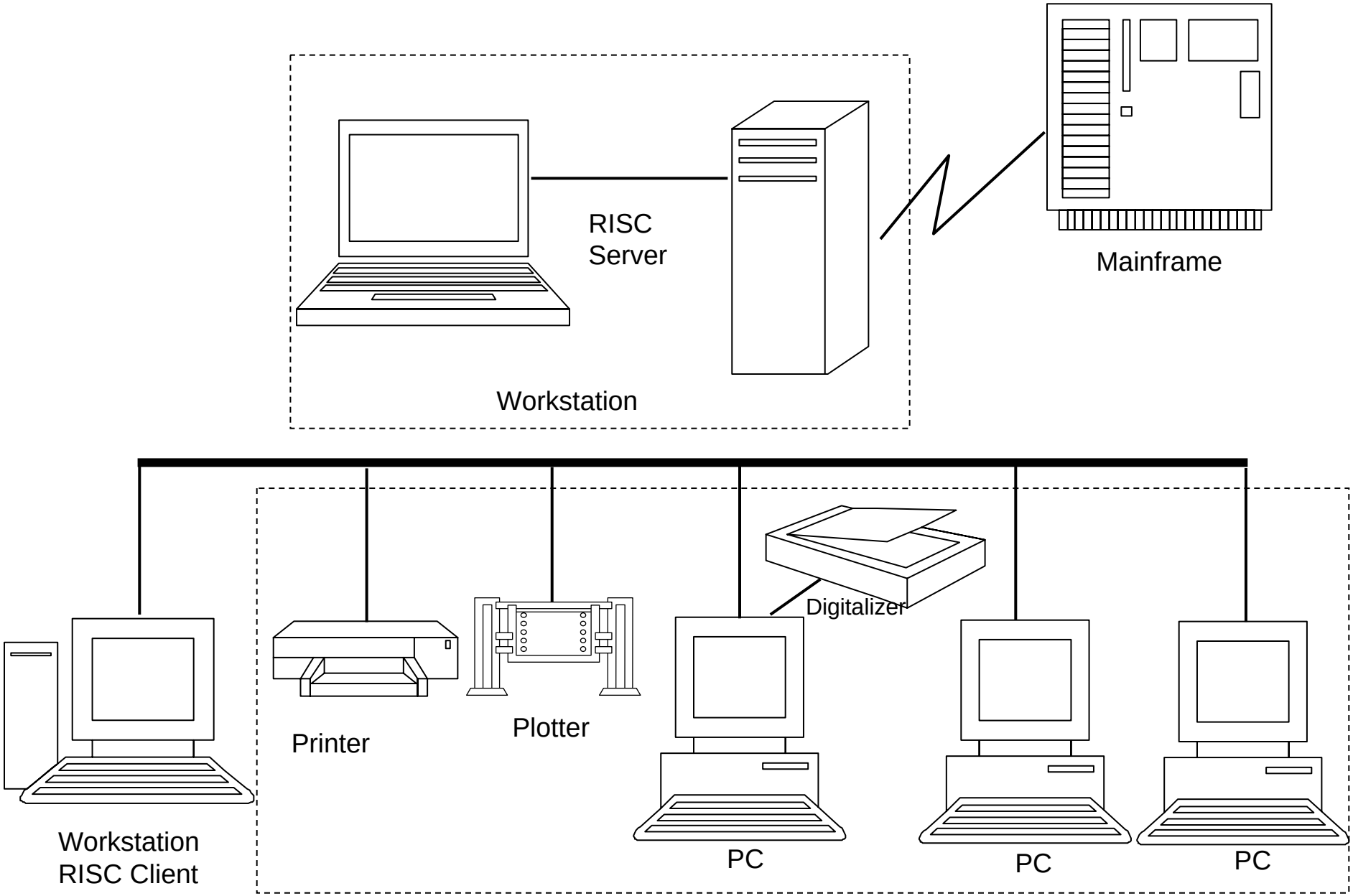
Migrageo
Migration Program for Vision System to ArcGis System.

21 aplications to be converted;
1.200.000 code lines (GML, C, PASCAL, JSP)

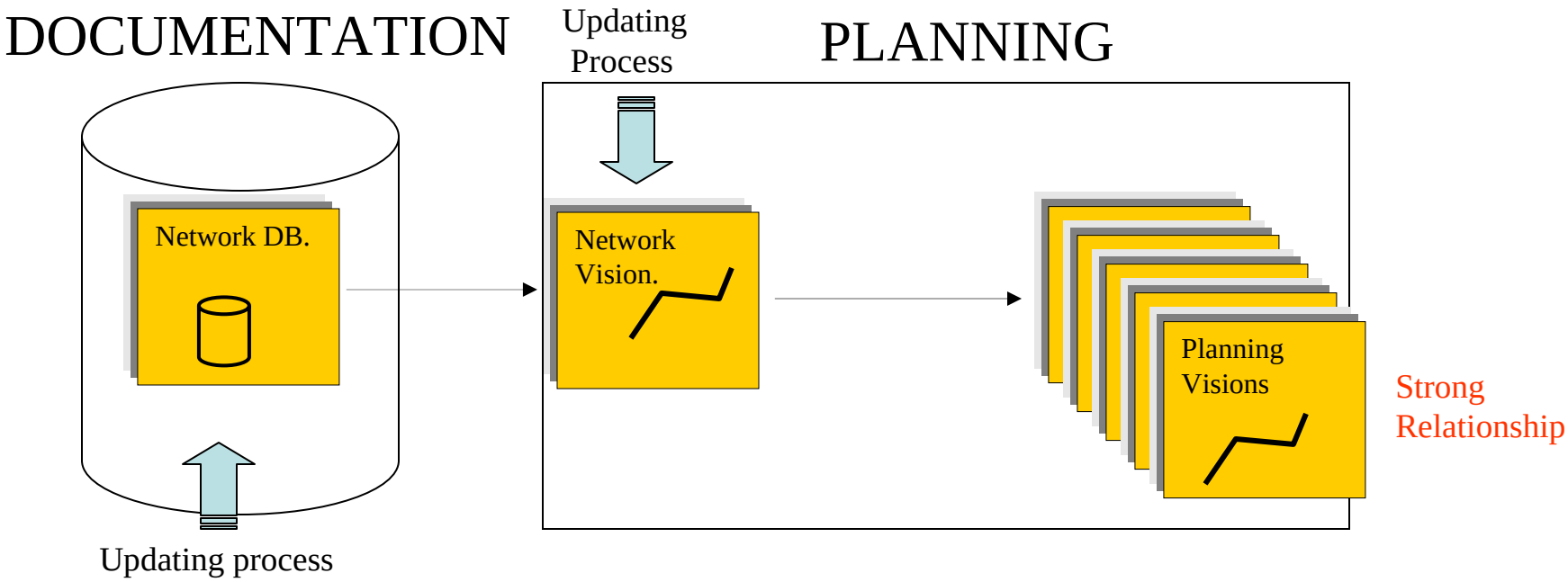
36 Projects
Estimated WorkForce: 120.000 IT mxh

Time Period: 4 to 5 years.

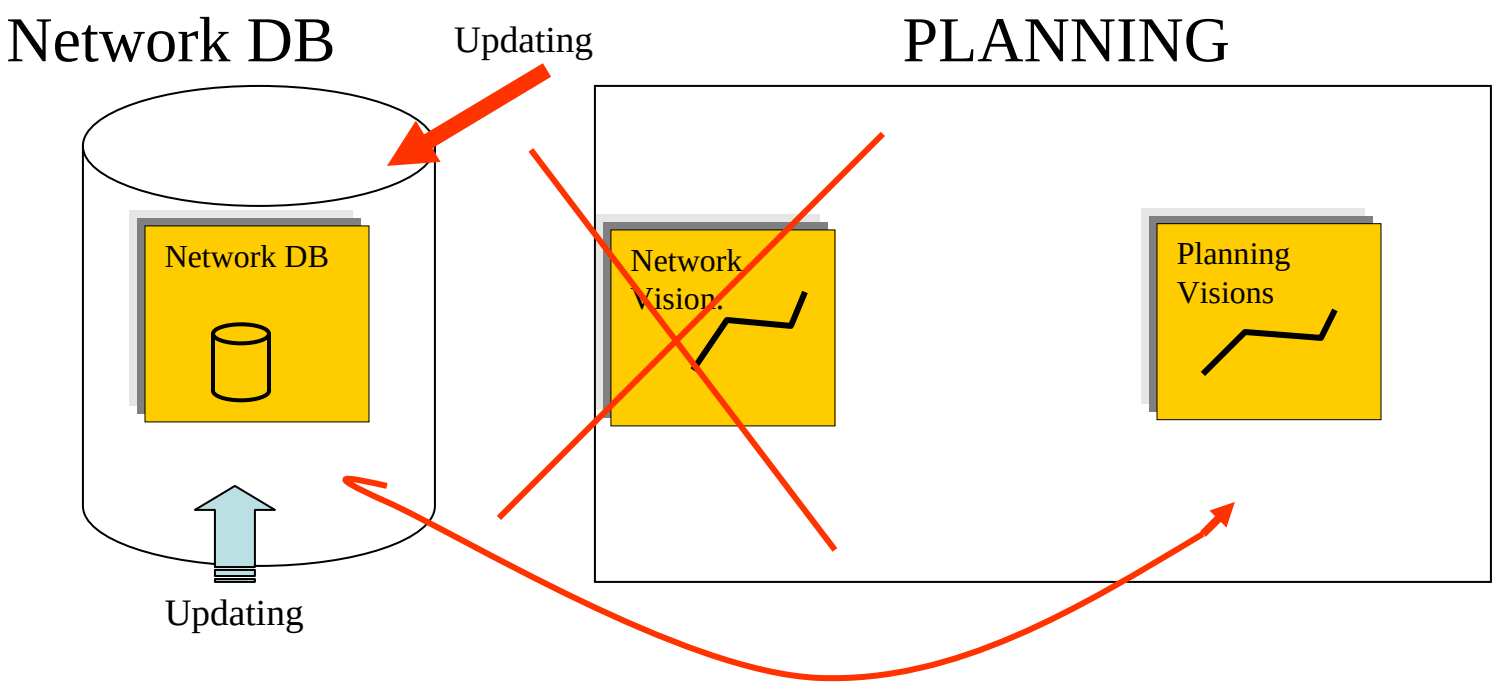
GIS Copel Old System



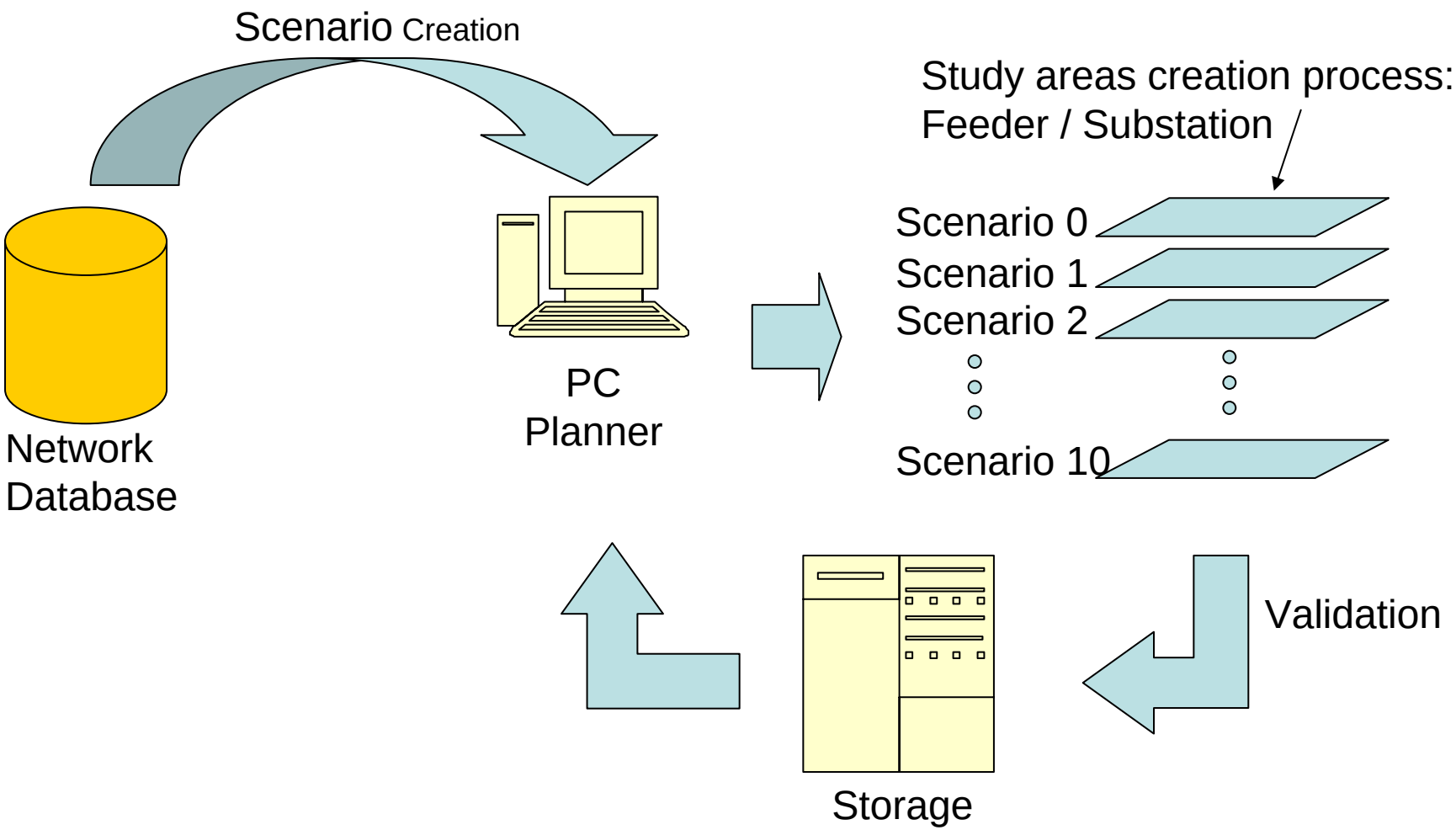
Old Architecture



New Architecture

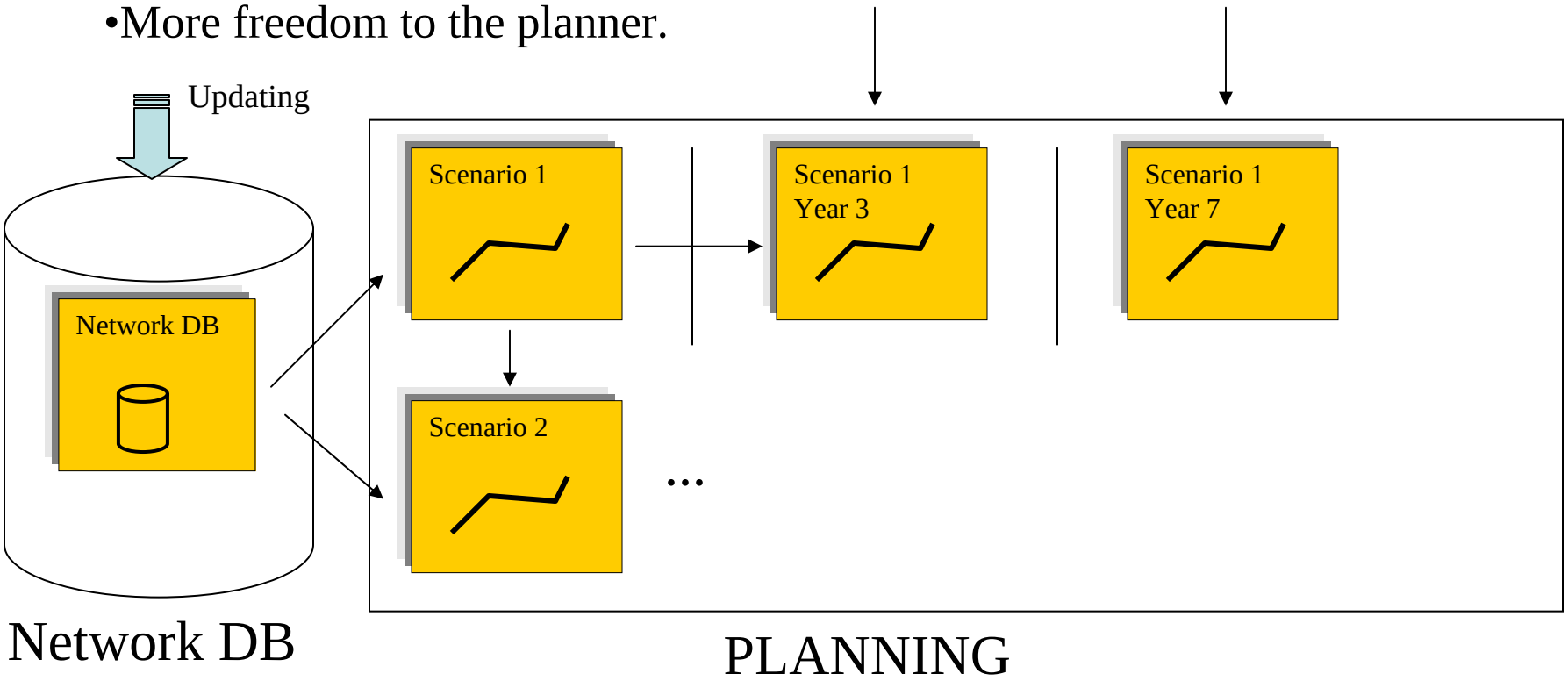


New Architecture



New Architecture

- Possibility to create different scenarios related to the same data-base.
- Easy to update.
- Less Work.
- More freedom to the planner.



Integrated System

AUTOMATION

DOCUMENTATION

MAPPING
AND
RASTER IMAGES

LOAD
FORECASTING

CONSTRUCTION

CUSTOMERS

OUTAGES

OTHER systems

FUNCTIONALITIES

SEARCH: elements search, network, diagrams, drawings geographic information...

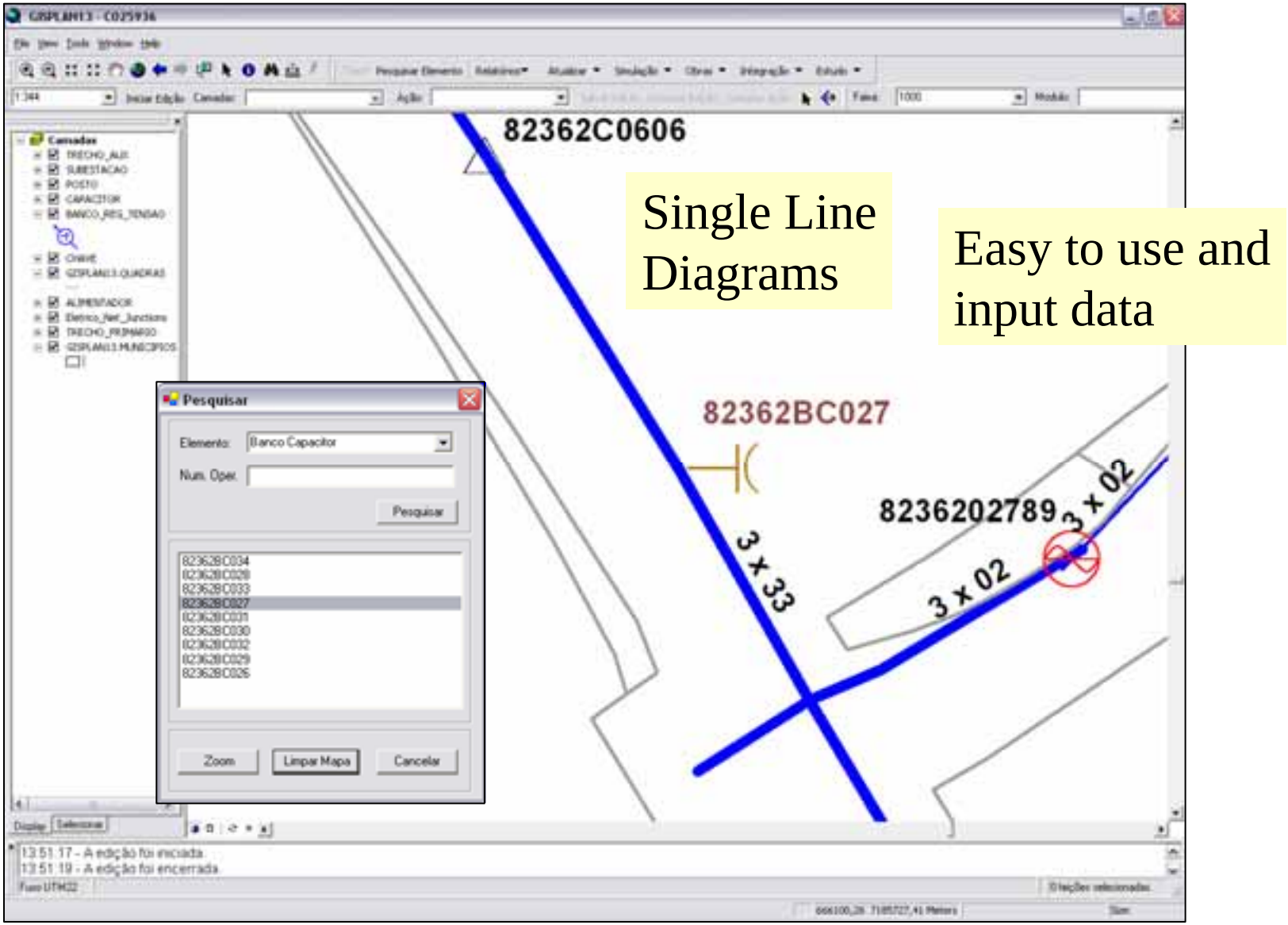
SIMULATIONS: load flow, current and voltage calculations, load curves, equipment adjusts.

ECONOMICS: Technical Losses, Non-delivered Energy and Voltage Deviation costs.

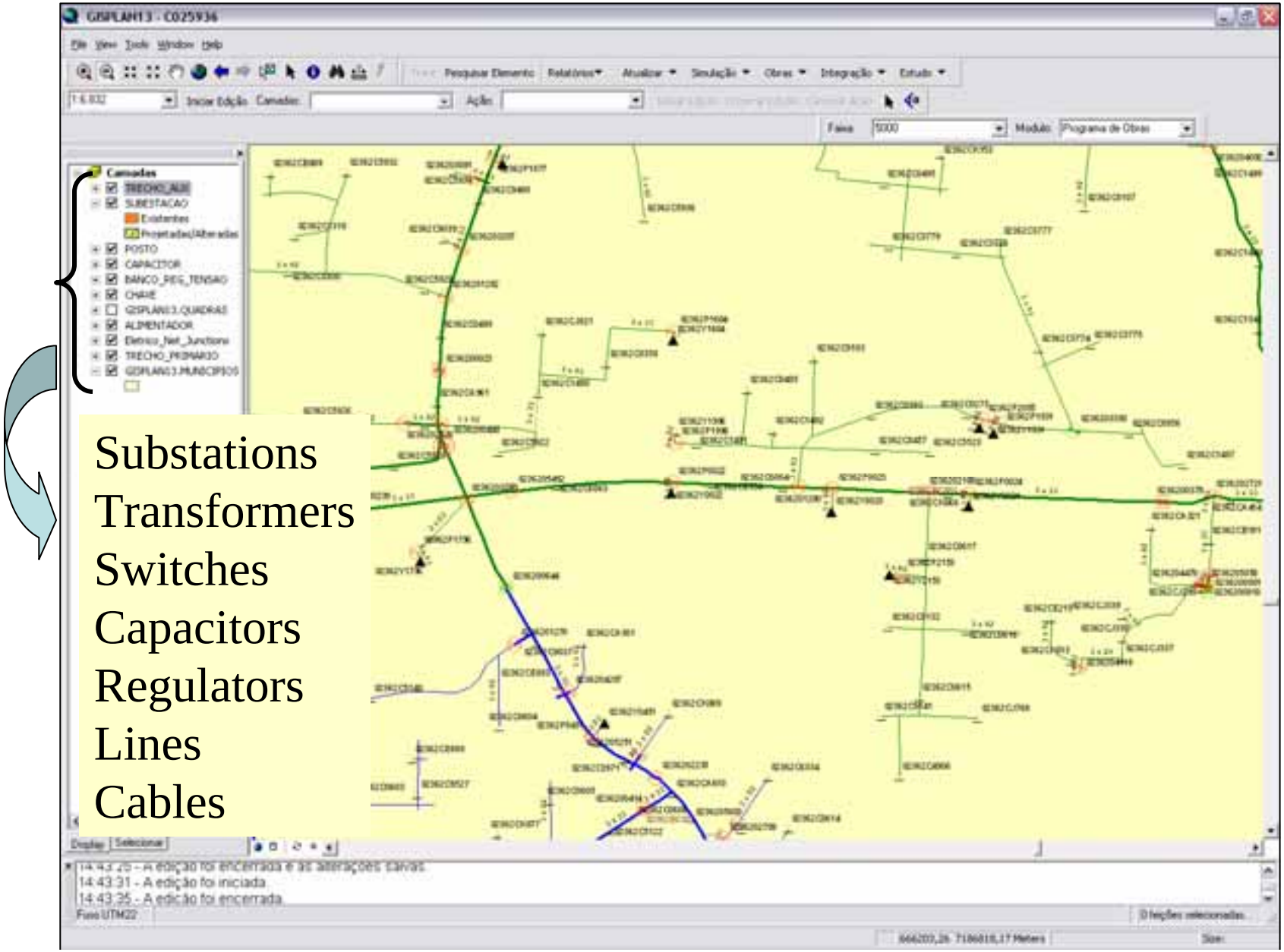
NETWORK OPTIMIZATION: equipment location, investment adviser, reliability planning.

NETWORK MANAGEMENT: integration, indexes, violations list.

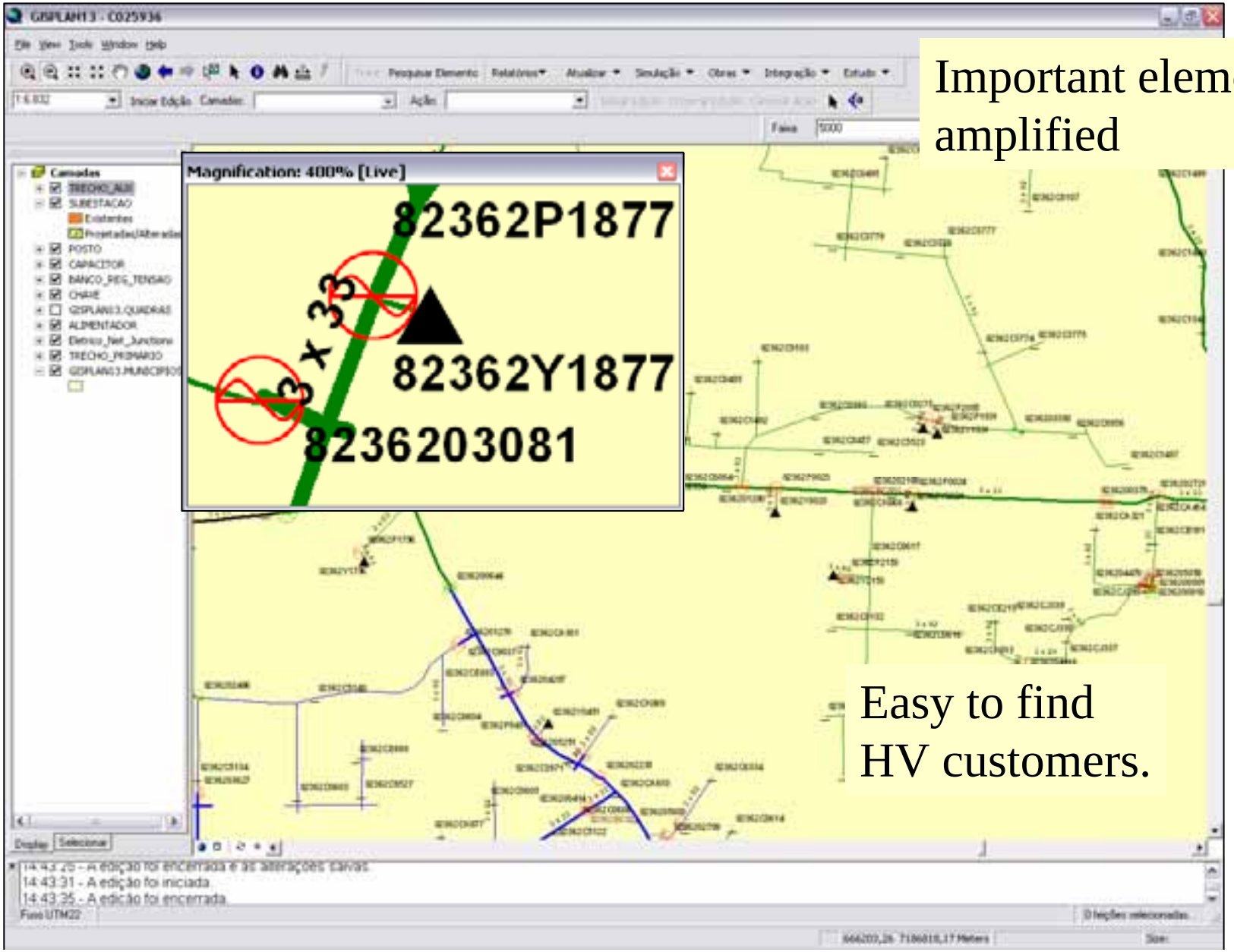
GISPLAN – Network Layout Drawings



GISPLAN – Network Layout Drawings



GISPLAN - VISUALIZATION



Important elements amplified

Easy to find HV customers.

GISPLAN - VISUALIZATION

Background Maps
Geographical maps
Rural Areas

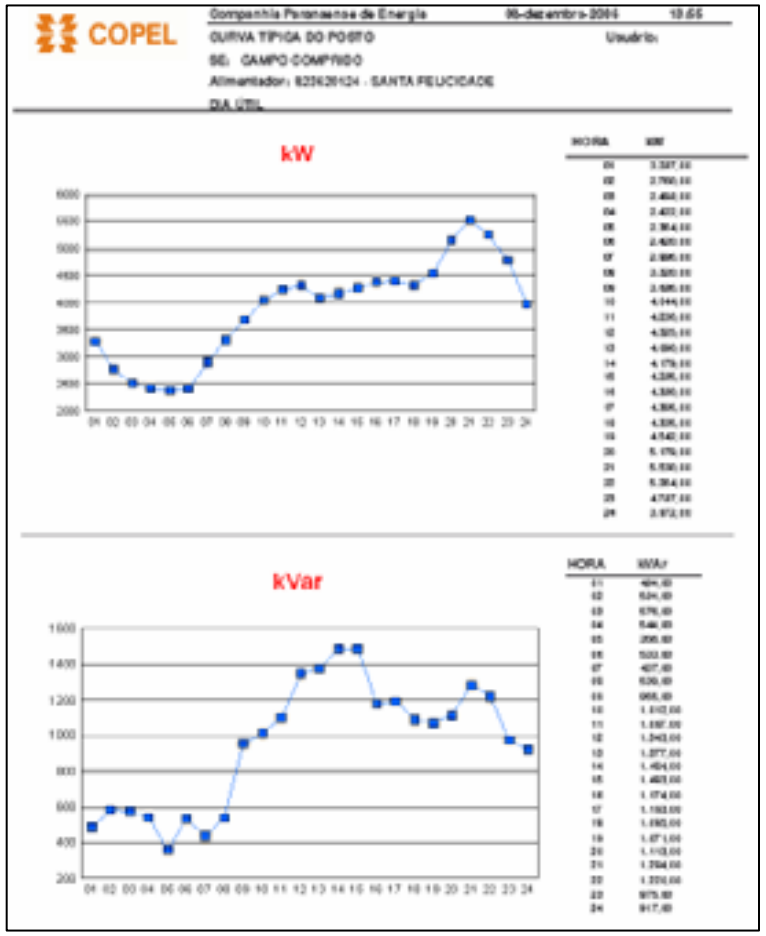
GISPLAN - SIMULATIONS

FEEDERS LOAD CURVE :

3 typical curves for each feeder: workday, saturday and sunday

The curves are generated automatically from metering feeders (automation) .

Curve Automatic Process of Selection and Choice – errors filtering



GISPLAN- SIMULATION

TRANSFORMERS LOAD CURVE:

Based on customer curves

Customer curve based on consumption and metering

Adjusted by the feeder curve.

High Voltage Customers:
Load Curve from meters

COPEL

Companhia Paranaense de Energia — 09-dezembro-2006 — 14:00

DADOS DE CONSUMIDORES — Usuário: C025936

SE: CAMPO COMPRIDO

Alimentador: 923620124 - SANTA FELICIDADE

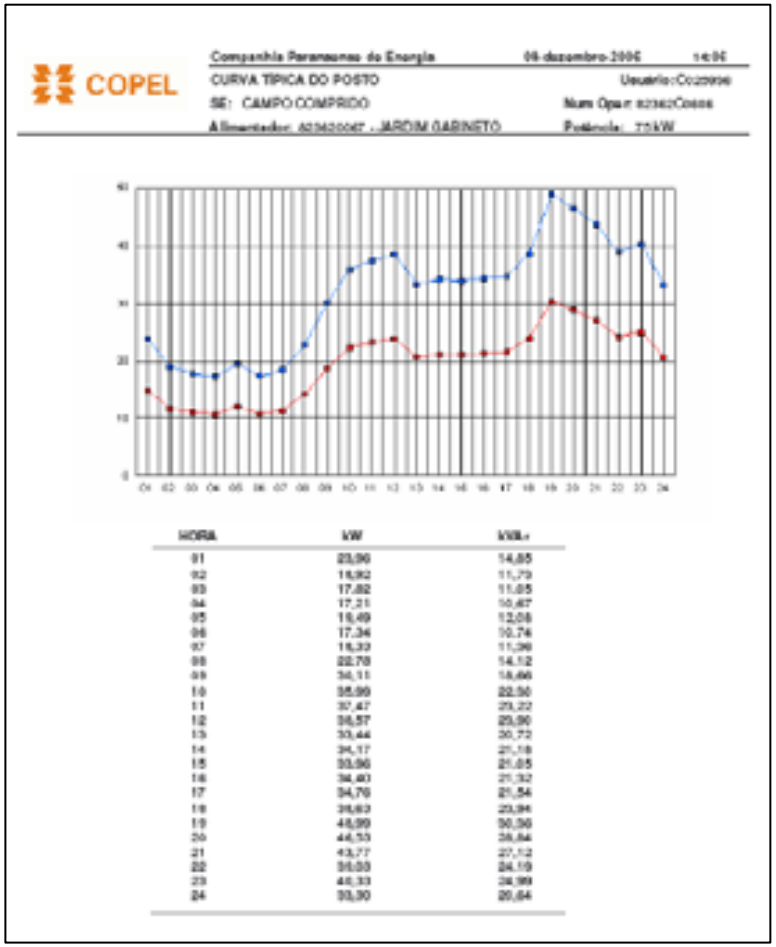
ALCABRAS INDUSTRIA E COMERCIO LTDA

DADOS GERAIS DO CONSUMIDOR:

ENDEREÇO	ROD DUZENTOS SETENTA SETE, 4500 Agua
CODIGO DE ATIVIDADE	0721600
CODIGO DO CONSUMIDOR - LZC	[illegible]
NUMERO OPERACIONAL	923627 1289
COORDENADA	[illegible]
POTÊNCIA INSTALADA	300
DEMANDA CONTRATADA PONTA	130
DEMANDA CONTRATADA FORA DA PONTA	130

DADOS DA MEDIÇÃO DO MÊS ATUAL

DEMANDA MÁXIMA	195,2347551442
FATOR DE CARGA	1
CONSUMO NA PONTA (kWh)	70664
CONSUMO NA PONTA (kVar)	27683
CONSUMO FORA DA PONTA (kWh)	70664
CONSUMO FORA DA PONTA (kVar)	27683
FATOR DE POTÊNCIA	0,95



COPEL

Companhia Paranaense de Energia — 09-dezembro-2006 — 14:00

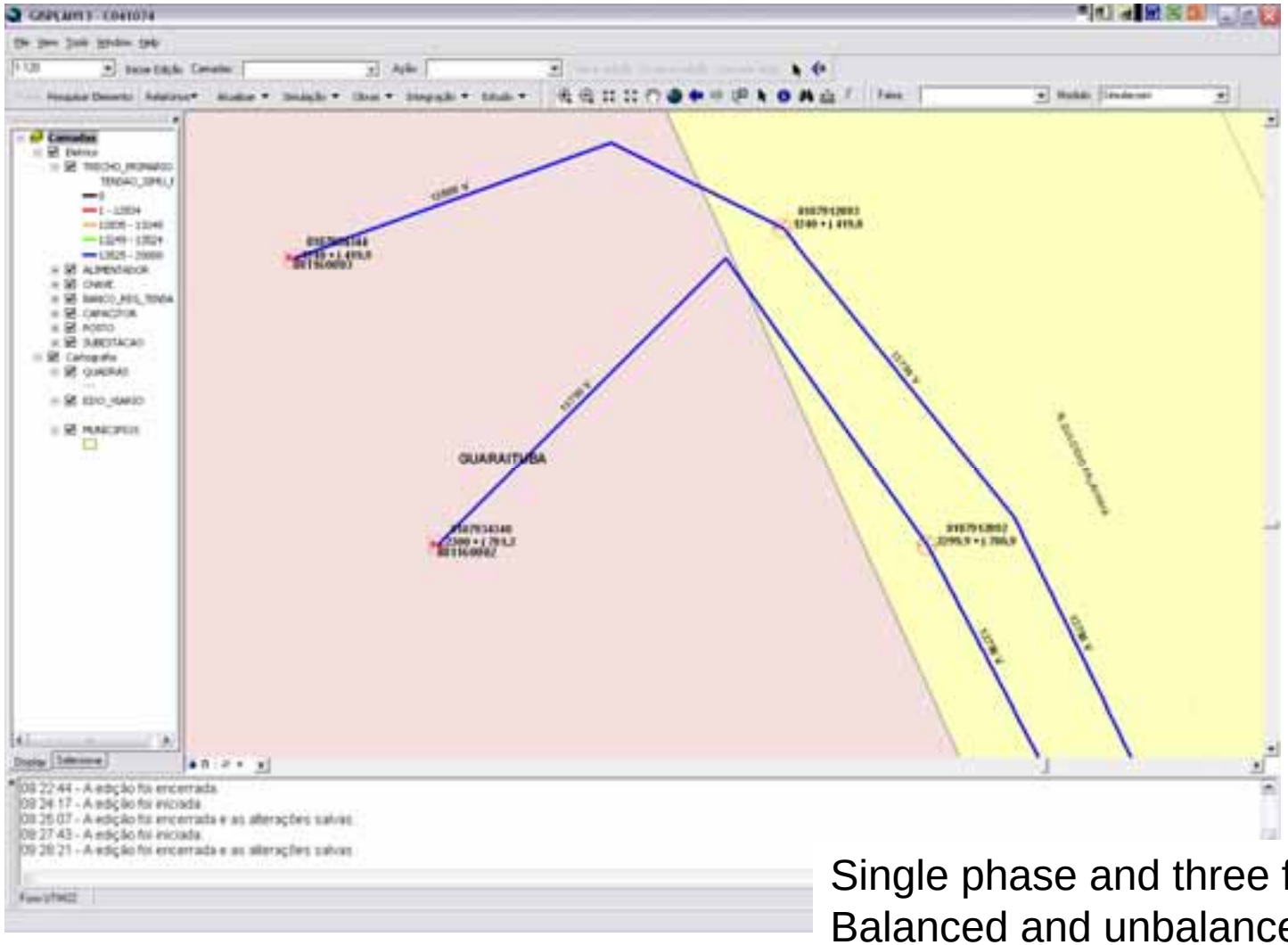
CURVA TIPICA DO POSTO — Usuário: C025936

SE: CAMPO COMPRIDO — Num Opar: 923620124

Alimentador: 923620087 - JARDIM GABINETO — Potência: 75kW

HORA	kW	kVAr
01	23,96	14,85
02	19,92	11,79
03	17,82	11,05
04	17,21	10,67
05	19,49	12,08
06	17,34	10,74
07	18,33	11,36
08	22,78	14,12
09	30,11	18,66
10	35,99	22,30
11	37,47	23,22
12	38,57	23,90
13	33,44	20,72
14	34,17	21,18
15	33,96	21,05
16	34,40	21,32
17	34,76	21,54
18	38,63	23,94
19	48,99	30,36
20	44,53	28,84
21	43,77	27,12
22	38,03	24,19
23	48,33	28,99
24	33,30	20,64

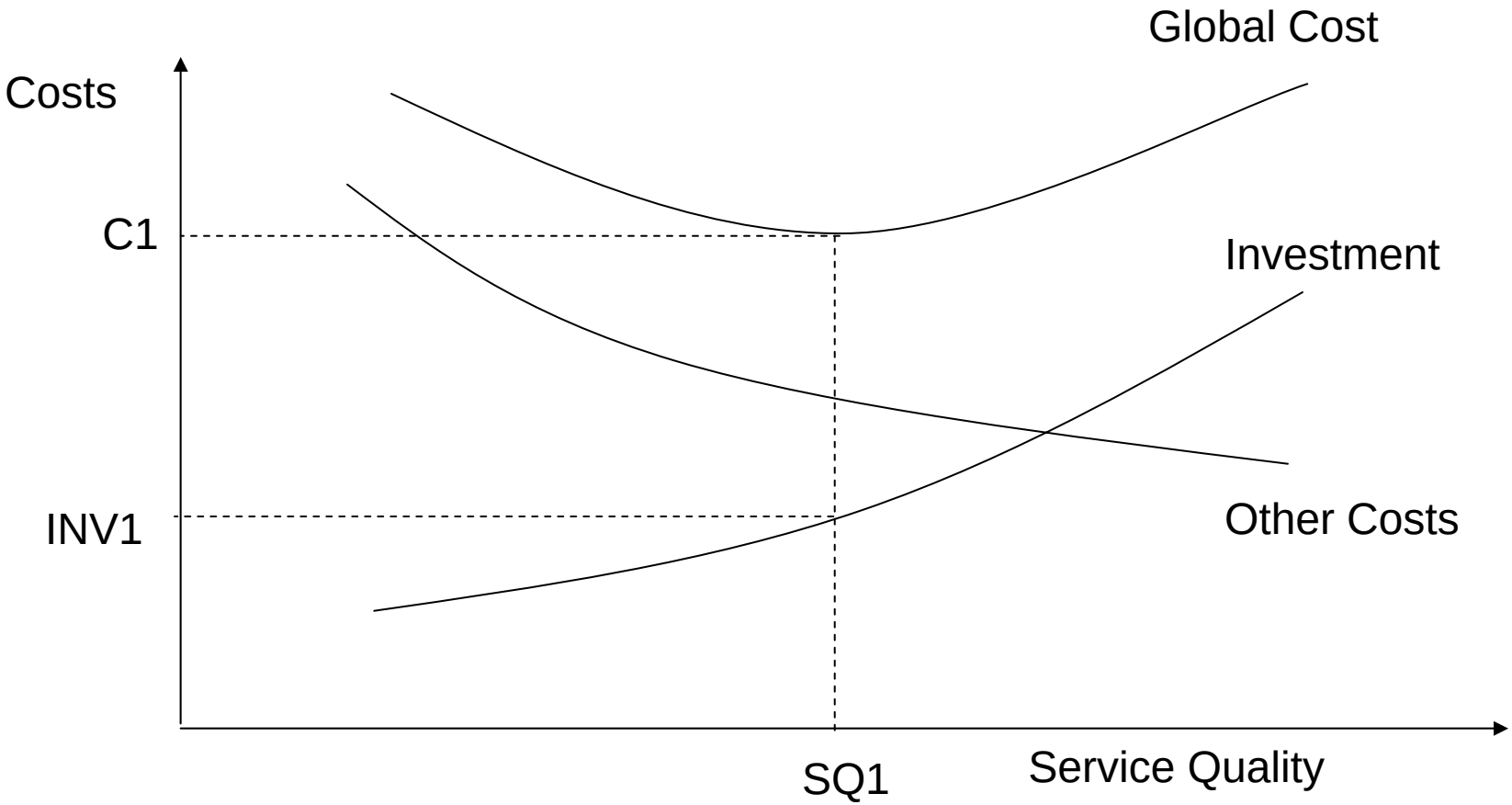
GISPLAN- SIMULATION



Single phase and three fase calculations
Balanced and unbalanced
Voltage Drop
Power Flow Analysis
Violations Information

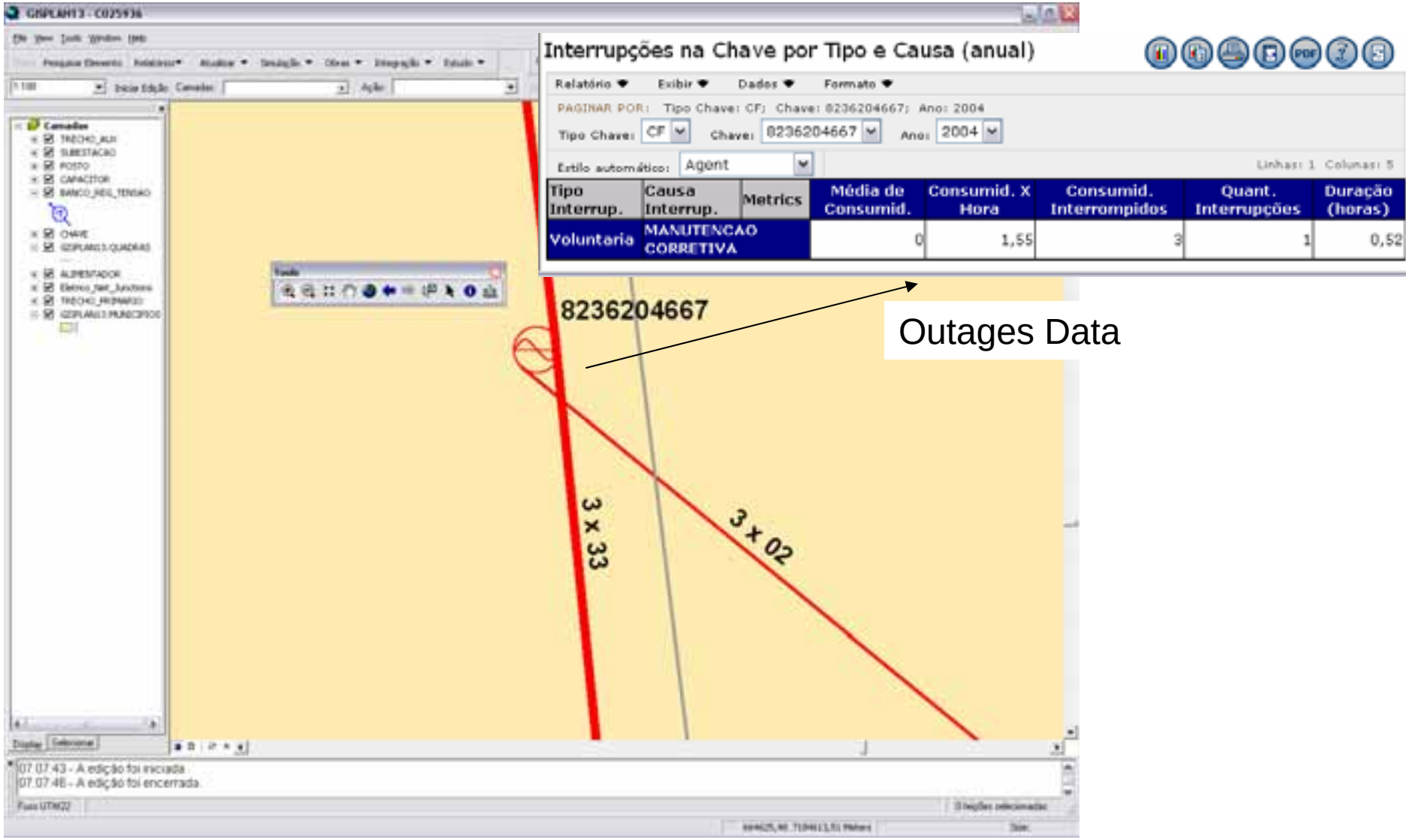
GISPLAN - ECONOMIC CONCEPTS

OPTIMIZATION



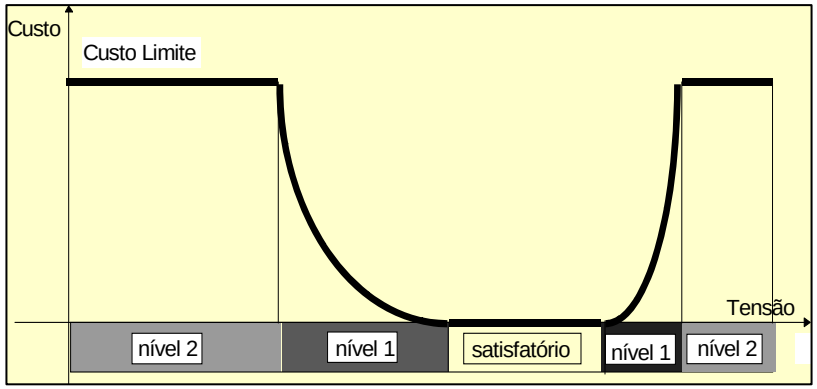
GISPLAN – Economics

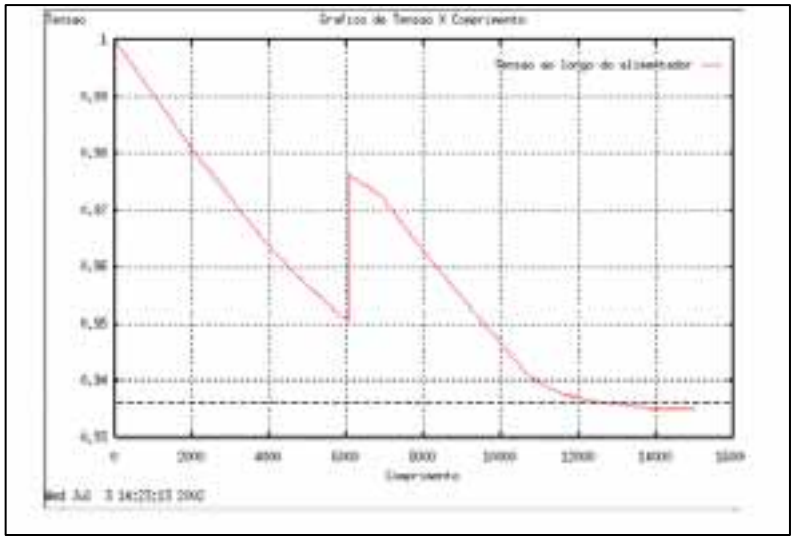
NDE Calculation – Non-Delivered Energy



GISPLAN – Economics

Voltage Deviation Calculation

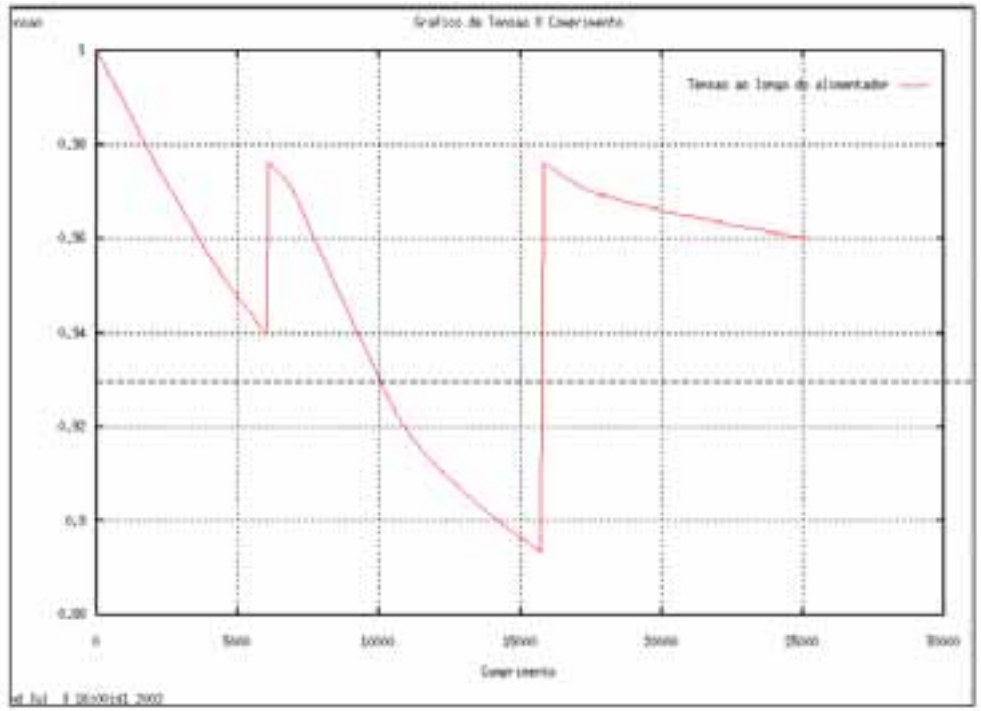




$$c_{DT} = 0{,}0044.(QT-4)^{1,45} \times \sum_{i=1}^{3}\sum_{j=1}^{24}\left(Dh_{ij} \times Nh_i\right) \quad [US\$]$$

GISPLAN - OPTMIZATION

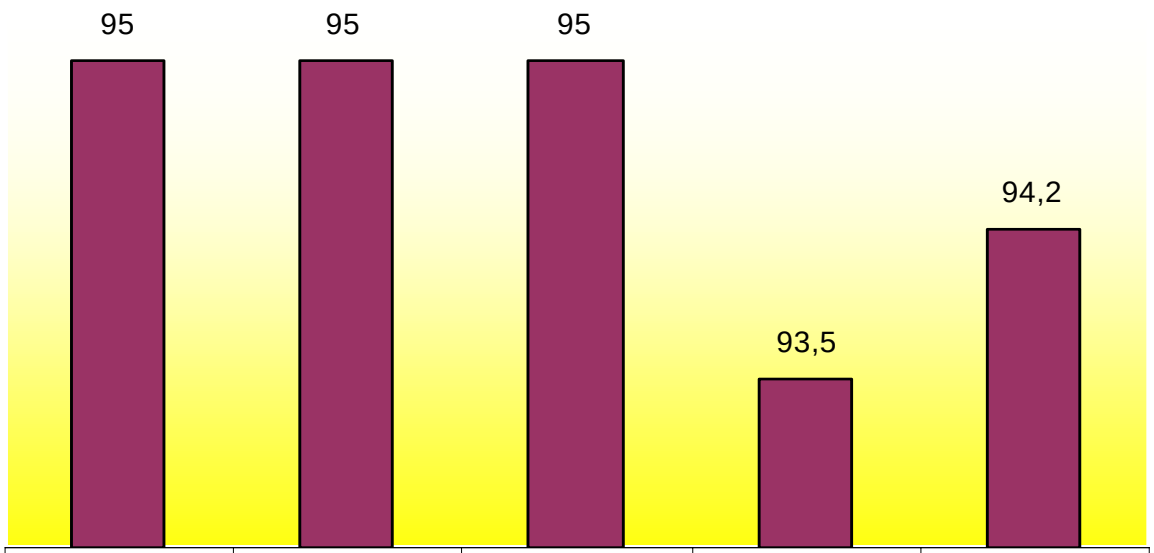
REGULATOR AND CAPACITORS AUTOMATIC LOCATION



GISPLAN – NETWORK MANAGEMENT

Automatic Generation of Indexes

% of Feeders that meets Loading Planning Criteria

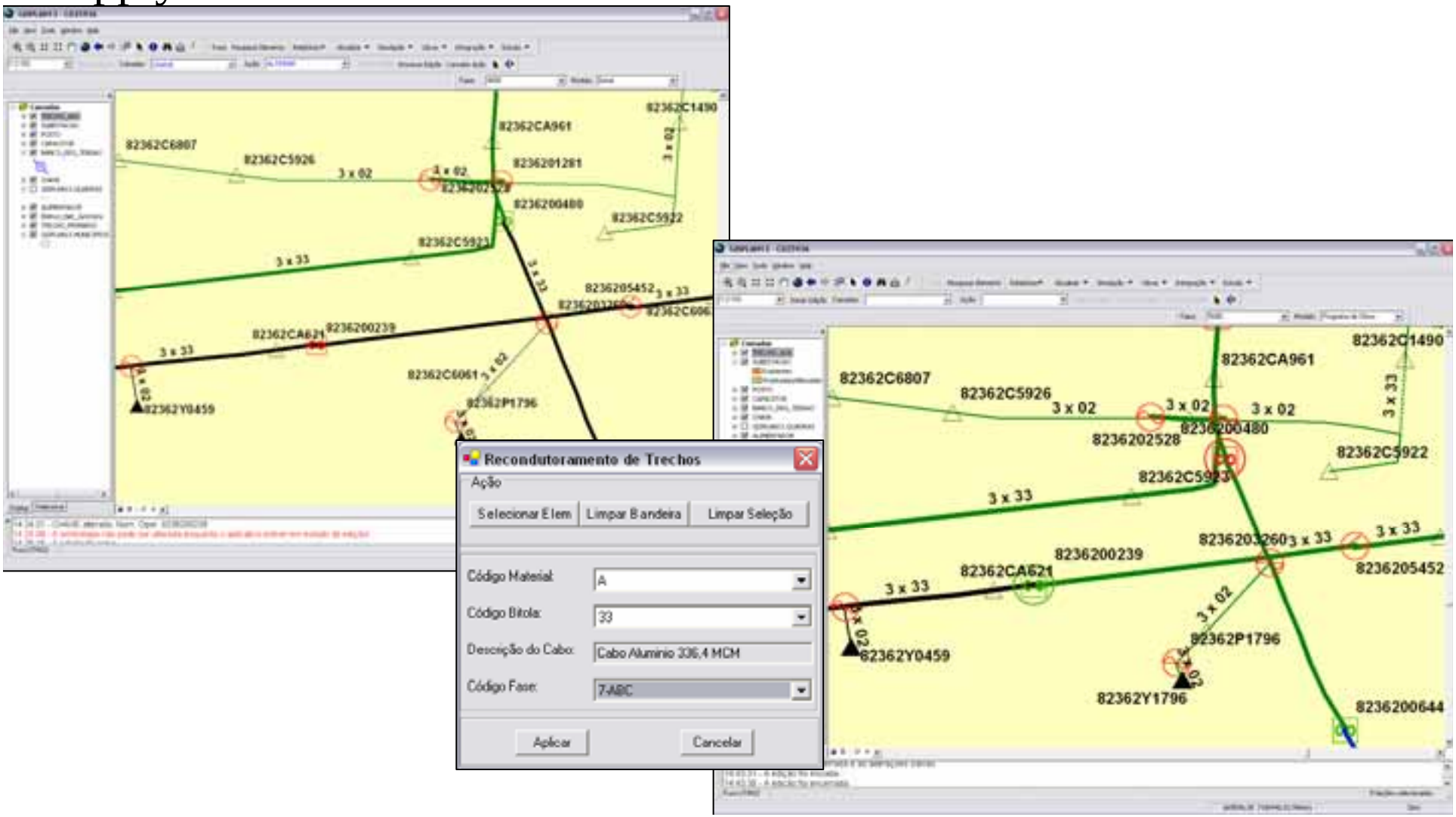


	2000	2001	2002	2003	2004
%	95	95	95	93,5	94,2

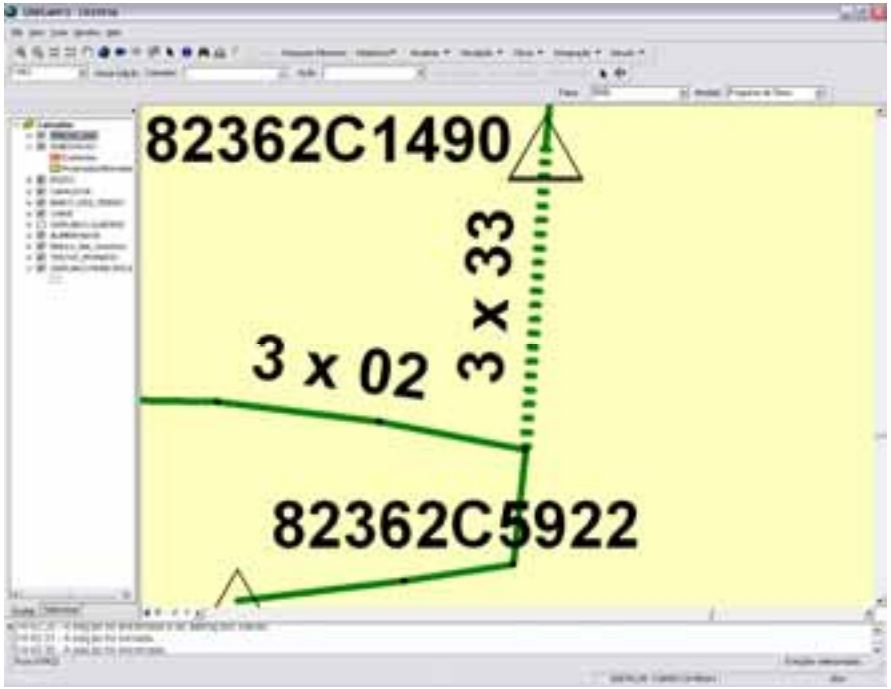
GISPLAN - OPTMIZATION

ADVISER HELP PLANNER TO BEST NETWORK INVESTMENT:

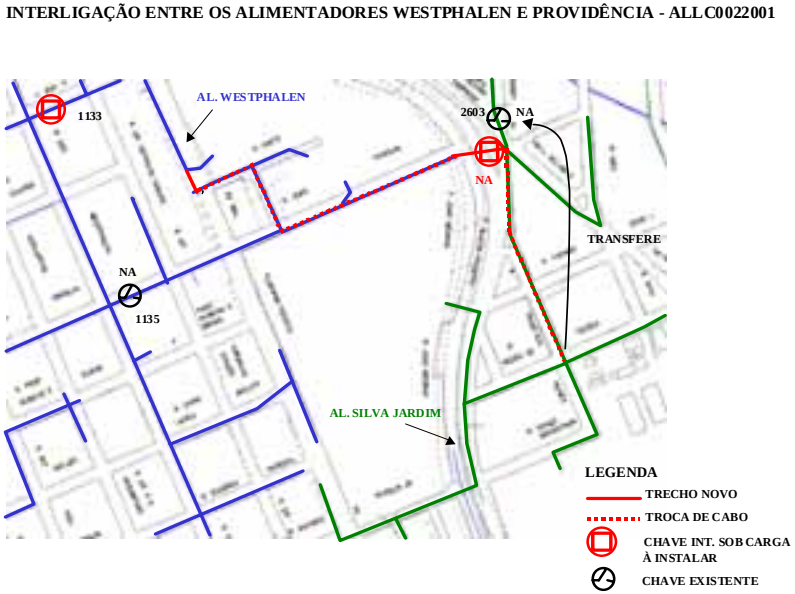
-Reconductoring, new feeders, extension from single to three phase supply.



GISPLAN - OPTMIZATION



Automatic Drawings
Projects List



CONCLUSIONS

- SYSTEMS BECAME MORE COMPLEX, SO OPTIMUM PLANNING IS IMMINENT FOR EFFICIENCY IMPROVEMENT.

- RESEARCH AND DEVELOPMENT PROJECTS ARE THE BASE OF SYSTEM INOVATION

- INTEGRATION IS FUNDAMENTAL.

- COPEL OPTION WAS FOR TAYLOR MADE SYSTEM.

- OPTIMIZATION GUARANTEE LOW TARIFFS.

REFERENCES

[1] Gruppelli, F.A. et all – An object oriented environment to redesign a 34,5 kV tranmission network under fault condition. VI INDUSCON, Joinville, 2004.

[2] Gruppelli, F.A. – Distribution Planning using geoprocessin technology. I Geoprocessing National Seminar in the Electric Sector, Brasília,2006.

[3] Gruppelli, F.A et all - The distribution system service restoration: an exact method and a heuristic search method. IV ALIO/EURO Workshop on applied combinatorial optimization, Chile, 2002.

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