# TECHNO-ECONOMIC ASSESSMENT STUDY FOR ROGUN HYDROELECTRIC CONSTRUCTION PROJECT

## PHASE II: PROJECT DEFINITION OPTIONS

## Volume 3: Engineering and design

## Chapter 6: Transmission system

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|---|---|---|---|---|---|
| E | 07/08/2014 | Final Comments from WB incorporated | SFE | LCO | LCO |
| D | 31/03/2014 | Final | SFE | NSA | NSA |
| C | 20/09/2013 | Final Report following WB comments | SFE | GPA/LCO | LCO |
| B | 01/07/2013 | Final Report | SFE | GPA/LCO | LCO |
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# 1 SUBJECT AND SCOPE

Scope of the present report is the analysis of the impact of the new Hydro Power Plant of Rogun on the High Voltage Transmission System of Tajikistan.

Objective of these studies is the evaluation of the system export capabilities and the identification of the most adequate network expansion solution; more in detail the aim of the performed analyses is:

- to verify if the total power produced by the new power plant, in the various stages of Project implementation, can be reliably transferred by the Tajik Transmission System towards the load centres, based on the calculation of transfer capabilities of the planned HV network to the selected destinations under various operation conditions;
- to detect the grid bottlenecks and to evaluate the need to reinforce the Transmission System identifying the most appropriate new reinforcements, duplicating the lines circuits, increasing the transformers rated power and, in a few case, adopting capacitor banks to sustain the voltage profiles. These reinforcement actions have been designed with the criteria of increasing the size of lines and transformers only when strictly necessary (loading of the above elements growing to more than 100%);
- to estimate the yearly transmission losses in the target years with the various solutions, in order to allow a better economic evaluation among them.

These calculations have been performed on the base of the Tajik transmission system data provided by many data sources, that have been analysed and merged in order to obtain the most complete and coherent network representation. With the aim of properly calibrating the model, preliminary models of the Tajik Transmission System as it is nowadays have been issued and submitted to the Client and the corresponding comments have been taken into account in the preparation of the final version. It is thus deemed that the simulations finally obtained are as accurate as possible and results can be used with confidence for the purpose of the studies.

# 2 REFERENCE DOCUMENTS

The following table reports the list of the reference documents. Many other ones were available with minor data; this list reports only the most important and significant ones.

| [n.] | Company | Identification Code/File | Rev | Date | Title |
|---|---|---|---|---|---|
| [01] | | Parameters of TL-220- 500 kV.doc | | | 1. Technical parameters of overhead transmission lines 220-500 kV of power system of the Republic of Tajikistan |
| [02] | | Scheme of networks 220-500 kV with a glance of perspective.BMP | | | |
| [03] | | Technical parameters of power stations 220.doc | | | Technical parameters of electric power substations 220-500 kV of power system of the Republic of Tajikistan |
| [04] | | Information on intersystem TL.doc | | | REGIONAL PROJECT “CONSTRUCTION OF INTERSYSTEM TRANSMISSION LINE” |
| [05] | | PROJECT CASA-1000.doc | | | PROJECT “CASA – 1000. CONSTRUCTION OF TRANSMISSION LINES AMONG THE CENTRAL ASIAN AND SOUTH ASIAN |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | COUNTRIES” |
| [06] | Department of intergovern-mental flow | Actual power inter. 12 months 2010.doc | | | Information on actual power interchange among the republics For 12 months of 2010 |
| [07] | | Perspective.doc | | | The final plan for expansion of energy power system |
| [08] | | Information.doc | | | Necessary data through Tajikistan |
| [09] | OSHPC “BARKI TOJIK” | Capacity of generation of TJK.doc | | | |
| [10] | OSHPC “BARKI TOJIK” | Information on modernization 12 01 2011.doc | | | Information |
| [11] | | Daily and annual load demands.doc | | | Daily load demands |
| [12] | | Installed capacity and annual output. Heat Station.doc | | | Installed capacity and annual output Of electric power by heat stations |
| [13] | TEAS Consultant | CHAP8.pdf | A | Apr 2011 | TEAS for Rogun HPP Construction Project, Inception Report |
| [14] | | Table of loads to Transmission Lines-220-500.doc | | | Table loads on transmission lines in the normal mode |
| [15] | | Scope of Works & Methodology.pdf | | | TEAS for Rogun Hydroelectric Power Plant Construction Project - Terms of Reference of the Main Agreement |
| [16] | SNC-LAVALIN | SA_Energy_CrossBorder.pdf | | Feb 2011 | CENTRAL ASIA - SOUTH ASIA ELECTRICITY TRANSMISSION AND TRADE (CASA-1000) PROJECT FEASIBILITY STUDY UPDATE |
| [17] | FICHTNER | FICHT-8537801-v1-Interim_Report_v21.pdf | | Apr 2012 | Assessment of Tajikistan Power Supply Options - Interim Report |
| [18] | | Table transmission line loads in normal mode (eng).pdf | | | Table transmission line loads in normal mode |
| [19] | | Date on generators.xls | | | Date on generators |
| [20] | | TajikSystemDataCollection.xls | | | TajikSystemDataCollection |
| [21] | | Technical parameters of transformer stations.xls | | | Technical parameters of transformer stations |
| [22] | | Data on generators.xls | | | |
| [23] | | Rogun HPP capacity output.bmp | | | |
| [24] | | Technical parameters of the power lines 220 - 500 kV.xls | | | |
| [25] | | Data on generators (TPP PP) 09.2012.xls | | | |
| [26] | | Loads for Substations 09.2012.docx | | | Loads on substations 220-500kV |
| [27] | | TajikSystemDataCollection 09.2012.xls | | | |
| [28] | OSHPC “BARKI TOJIK” | Comments to the questions of Coyne.doc | | | Comments to the questions of Consortium «Coyne et Bellier» on Tajikistan Power Networks Simulation |
| [29] | | Perspective Scheme of 220-500 kV networks.BMP | | | |
| [30] | | Scheme of 35-500kV North Networks.png | | | |
| [31] | | Scheme of 35-500kV South Networks.png | | | |
| [32] | OSHPC “BARKI TOJIK” | Comments on the issues of load and power flow at Tajik energy system.pdf | | | |
| [33] | OSHPC “BARKI TOJIK” | Comments on the issues of load and power flow at Tajik energy system_copy.pdf | | | Clarifications to the discussions on the "Comments on the issues of load and power flow at Tajik energy system" |
| [34] | OSHPC “BARKI TOJIK” | Comments by the Government of the Republic of Tajikistan to the Report RP37.pdf | | | Comments to the Report № P.002378 RP37 rev.0 «Electrical transmission network studies" of the Consortium «Coyne et Bellier» |
| [35] | OSHPC “BARKI TOJIK” | OSHC Barki Tojik response.doc | | | OSHC “Barki Tojik” response to the Consortium “Coyne et Bellier” questions |
| [36] | OSHPC | Comments to the final revisions of | | | Comments to the final revisions of electric |

| | | | | |
|---|---|---|---|---|
| | "BARKI TOJIK" | electric network study.pdf | | network study |
| [37] | TEAS | spr-pr kk-Note Tajik (v2)-2012-05-08.doc | 06 May 2013 | Notes on Tajik System for the revision of the Electrical Studies |
| [38] | TEAS | doc-pr-Tajik Demand Forecast-2013-06-03.doc | 03 June 2013 | Notes on Tajik System for the revision of the Electrical Studies |

**Table 2.1: the list of reference documents**

# 3 SYSTEM DESCRIPTION

The Tajik transmission system is composed of:

- 4 500 kV substations (7 in year 2016);
- 31 220 kV substations (31 in year 2016);
- 8 lines at 500 kV (17 in year 2031);
- 60 lines at 220 kV (64 in year 2016);
- 63 load transformers in 31 substations, for a foreseen total peak of approx. 3,816 MW (5,948 MW in year 2031), according to 75$^{th}$ percentile peak demand forecast of doc. [38];
- 14 power plants for a total of 49 generation groups, 5,100 MW of installed power (8,700 MW in year 2031).

System data are reported in Chapter 9.

# 4 METHODS AND SOFTWARE TOOLS USED FOR THE STUDIES

## 4.1 Used software

The calculations are performed using the software simulator DIGSILENT PowerFactory, version 14.1. Detailed information on this tool is available with the Consultant and can be conveniently shared.

Some data pre-processing and results post-processing have been performed using Microsoft™ Excel™.

## 4.2 Used methods: the load-flow

Load-Flow calculations have been performed using the complete Newton-Raphson method. The tolerances are equal to 1 kVA or to 0.1% of the power flowing in each node.

The shunt parameters of the lines (capacitance) and of the transformers (no load current, no load losses) have been fully considered, by means of $\Pi$ (lines) or T (transformers) representation.

The generators and the "external grids" that represent the neighbouring countries can be represented as "PV" or "PQ" sources, or slack sources. Also, they can be controlled by means of secondary voltage/reactive power controllers (Power Plant controllers, Area controllers) and by means of secondary frequency/active power controllers that allow sharing automatically the reactive and active power in order to obtain proper voltage levels in pilot busbars and a proper power sharing among the entire system. These devices have been used for all (u/Q) or the most important (f/P) generators of the Tajik system, while the "external grids" have been set in PQ mode.

Following the calculations, the results below indicated were obtained:

- bus results (voltages in kV and per unit, phase angle in degrees);
- for each branch, the active and reactive power and current at each side, the loading with respect to the maximum current capability, the losses with the detail of load and no load losses;
- for the shunt elements (generators, motors[1], loads), the produced or absorbed active and reactive power and current and the loading with respect to the maximum current capability.

### 4.3 Reinforcements

Among the results of the load-flow calculations, the possible branches overload and/or the excessive voltage drops are the most significant. These violations, if any, allow assessing the needs of network reinforcements, sufficient to avoid overloads and under-voltage.

It is to be noted that the reinforcements assessment has been based on the peak load and generation values for each horizon year. In fact, the sizing of an electrical transmission system must be done on the peak, and not on the average values. In case of approach based on average values, the peak load request could not be satisfied and some load shedding is required.

Some of the reinforcements indicated in the study are already scheduled by Tajik transmission system operator T.S.O., as well as some new power plants completion. We assume these expansions as really available in the corresponding forecasted years.

## 5 CONFIGURATIONS AND CASES

### 5.1 Horizon years

The study starts from the year 2013, and considers the time horizons of years 2020, 2025, 2027, 2028 and 2031.

With reference to Rogun dam and HPP (Hydro Power Plant), according to the construction schedule of the project alternatives:

- in year 2020, “End of stage 1 dam” in case of dam FSL 1290 m, 2 generators are foreseen to be in operation with a power of 200 MW each one (400 MW total power);

1 *No motors have been represented explicitly in this study.*

- in year 2025, “End of Main Dam Construction” for dam FSL 1220 m, all six units are foreseen to be in operation, for a total of 2000 MW;
- in year 2027, “All Units (1 to 6)” in case of dam FSL 1290 m, 6 generators are foreseen to be in operation with a total power of 2160 MW;
- in year 2028, “End of Main Dam Construction” for dam FSL 1255 m and capacity of 2800 MW, all six units are foreseen to be in operation, for a total of 2800 MW;
- finally, in year 2031, all the 6 generators will arrive at the full power of 600 MW each one, for a total of 3600 MW, for dam FSL 1290 m.

During these years, some reinforcements actions are expected on the 500 kV Tajik transmission system, with some new transmission links that are shown in the table here in after:

| Name | Line Type | Station 1 | Station 2 | Vn [kV] | Length [km] | Irated [kA] | In Service since |
|---|---|---|---|---|---|---|---|
| L-S-I | Line_220 kV AC-400 bis | SUGHD | T_Shahristan | 220 | 90 | 0.825 | 2011 |
| L-S-I(1) | Line_220 kV AC-400 bis | T_Shahristan | AINI | 220 | 28 | 0.825 | 2011 |
| L-D-O-1 | Line_500 3x kV AC-400 | DUSHANBE | OBIGARM | 500 | 100 | 2 | 2014 |
| L-D-O-2 | Line_500 3x kV AC-400 | DUSHANBE | OBIGARM | 500 | 100 | 2 | 2014 |
| L-G-R | Line_220 kV AC-400 | GERAN | RUMI | 220 | 75 | 0.705 | 2014 |
| L-K-A | Line_220 kV AC-400 | ASHT | KAYROKUM | 220 | 70 | 0.705 | 2014 |
| L-24-KB/1 | Line_220 kV AC-400 | T-Shurob-1 | KAYROKUM | 220 | 52 | 0.69 | 2016 |
| L-24-KB/2 | Line_220 kV AC-300 | T-Shurob-2 | KANIBADAM | 220 | 15 | 0.69 | 2016 |
| L-KAN-S | Line_220 kV AC-400 | T-Shurob-2 | SHUROBSKAYA | 220 | 15 | 0.705 | 2016 |
| L-KAY-S | Line_220 kV AC-400 | T-Shurob-1 | SHUROBSKAYA | 220 | 15 | 0.705 | 2016 |
| L-Regar-Sangtuda1 | Line_500 3x kV AC-400 | REGAR | SANGTUDA-1 | 500 | 115 | 2 | 2016 |
| L-Obi-Rogun HPP/1 | Line_500 3x kV AC-400 | OBIGARM | ROGUN HPP | 500 | 8 | 2 | 2016 |
| L-Obi-Rogun HPP/2 | Line_500 3x kV AC-400 | OBIGARM | ROGUN HPP | 500 | 8 | 2 | 2016 |
| L-Obi-Rogun HPP/3 | Line_500 3x kV AC-400 | OBIGARM | ROGUN HPP | 500 | 8 | 2 | 2016 |
| L-O-S | Line_500 3x kV AC-400 | OBIGARM | SUGHD | 500 | 285 | 2 | 2020 |
| L-Obi-Sangtuda | Line_500 3x kV AC-400 | OBIGARM | SANGTUDA-1 | 500 | 126 | 2 | 2020 |
| L-O-Y | Line_500 3x kV AC-400 | OBIGARM | YUZHNAYA | 500 | 216 | 2 | 2028 |
| L-S-Y | Line_500 3x kV AC-400 | SANGTUDA-1 | YUZHNAYA | 500 | 90 | 2 | 2028 |

**Table 5.1: the scheduled new 500 kV connections**

The study considers export cases. Although some documents state that nowadays the Tajik system is not connected to Uzbekistan, the export studies consider, among others, also the possibility of connection with this country, in order to explore anyway this possible future situation.

## 5.2 Load levels and load yearly growth

The initial load conditions are based on year 2013 forecast reported in doc. [38], where a peak load of 3,816 MW is foreseen for that year. This document, anyway, reports an overall figure only. The sharing of these 3,816 MW among the various loads has been obtained using the doc. [26], “***Loads for Substations 09.2012.docx***”, where a total load for year 2011/2012 of 2,790 MW was expected. All the local load values of file [26] has been increased in the same measure, excluding the load of TALCO (“Regar”), that remains constant, in order to arrive to 3,816 MW. The obtained starting year results as follows.

| Load / Substation | Pmax MW | Qmax Mvar |
|---|---|---|
| AINI | 7.55 | 2.72 |
| ASHT | 2.87 | 0.60 |
| BUSTON | 63.38 | 25.66 |
| DJANGAL | 530.08 | 126.77 |
| GERAN | 81.49 | 40.75 |
| KANIBADAM | 135.82 | 46.78 |
| KHATLON | 185.62 | 81.49 |
| KHUJAND | 190.15 | 42.26 |
| KNS1 | 0.00 | 0.00 |
| KNS2 | 70.93 | 39.24 |
| KOLKHOZABAD | 83.00 | 33.20 |
| LOLAZAR | 140.35 | 99.60 |
| NOVAYA | 525.18 | 125.26 |
| NUREK | 48.29 | 21.13 |
| ORJABAD-2 | 312.09 | 54.48 |
| PRYADILNAYA | 73.95 | 46.78 |
| RAVSHAN | 87.53 | 39.24 |
| REGAR | 803.24 | 381.42 |
| ROGHUN | 81.49 | 27.16 |
| RUDAKI | 66.40 | 20.22 |
| RUMI | 70.93 | 33.20 |
| SEBISTAN | 20.22 | 4.83 |
| SHAHRISTAN | 1.96 | 0.60 |
| SHARSHAR | 5.28 | 2.41 |
| UZLOVAYA | 147.89 | 89.04 |
| YAVAN | 80.29 | 31.39 |
| | **3,816.00** | **1,416.24** |

**Table 5.2: Maximum active and reactive power load in each substation, year 2013**

The same file [26] also reported a minimum value for the years 2011/2012, that is about 41% of the peak, while doc. [38] reports also the yearly energy. Using these values, an estimation of the hourly loading has been done, and it has been found that, assuming that the peak value is valid for 760 hours per year (about 2 h per day), with the minimum for 3,860 hours and an average value ((min+max)/2) for the remaining 4,140 hours, the energy indicated in doc. [38] is almost perfectly obtained. This load profile has been used for the estimation of the losses.

The file [11] "***Daily and annual load demands.doc***" reports daily and monthly values that allow to compute the yearly energy absorbed by the loads as 2,069 MW x 8,760 h (the year 2010 table has been extrapolated to year 2012 assuming a growth factor of 4.5% per year).

The exact calculation of the losses requires knowing the detailed load profile along the year (hourly load value in MW for each one of the 8760 hours of year). This information is not available; available data are only the maximum (peak) load, the minimum load and the yearly load energy. An equivalent yearly load profile has therefore been estimated, as explained above: maximum load for 760 h, average load for 4,140 h and minimum load for 3,860 h, leading to the expected yearly energy. These 3 cases, each multiplied by its number of hours, are used for the estimation of the yearly losses.

2010 was the last year with available detailed load demand. No more recent detailed data are available. Anyway, year 2010 has been used only for the sharing of the demand, while for the overall value more recent data and the forecast have been used. It must be noted that these data are used only for the calculation of the yearly losses and not for the sizing of the equipment.

The sharing (percentage values referred to the total of the year) would not change substantially from year 2010 to year 2012. On the other hand, it could be expected that this sharing would change along the longer period of about 20 years (as considered in the analysis), but no forecast data are available for the monthly sharing on such a long period, and no forecast data are available for what attains the sharing among the various load substation. The study is thus based on the information nowadays available. Whenever in future reliable forecast about the load sharing among the various locations will be available, further studies can be carried out.

For what attains the load growth rate, the values of doc [38] have been used, considering the case named as "75$^{th}$". The following table reports the expected yearly energy and peak power:

**Table 1: IPA annual demand forecast (GWh)**

| | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Min.** | 16,220 | 16,634 | 17,266 | 17,216 | 17,166 | 16,315 | 16,139 | 15,963 | 15,703 | 15,571 | 15,441 | 16,169 | 17,541 | 19,085 | 20,824 | 22,782 | 24,987 |
| **25th** | 16,220 | 16,816 | 17,560 | 18,031 | 18,543 | 18,224 | 18,552 | 18,845 | 19,059 | 19,376 | 19,722 | 21,784 | 23,974 | 26,991 | 30,307 | 34,415 | 38,567 |
| **Median** | 17,220 | 17,816 | 18,570 | 19,020 | 19,492 | 19,162 | 19,536 | 19,943 | 20,240 | 20,664 | 21,096 | 23,842 | 26,717 | 30,575 | 35,283 | 41,217 | 48,052 |
| **75th** | 18,220 | 18,805 | 19,557 | 19,987 | 20,400 | 20,096 | 20,589 | 21,029 | 21,412 | 21,985 | 22,566 | 26,147 | 30,075 | 35,472 | 42,125 | 50,646 | 60,265 |
| **Max.** | 18,220 | 19,025 | 19,912 | 20,799 | 21,744 | 21,950 | 22,898 | 23,916 | 24,824 | 25,918 | 27,073 | 33,889 | 41,093 | 50,635 | 63,168 | 79,163 | 99,577 |

**Table 1: IPA peak demand forecast (MW)**

| | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Min.** | 3,097 | 3,176 | 3,296 | 3,287 | 3,277 | 3,115 | 3,081 | 3,048 | 2,998 | 2,973 | 2,948 | 3,087 | 3,349 | 3,644 | 3,976 | 4,350 | 4,771 |
| **25th** | 3,097 | 3,211 | 3,353 | 3,443 | 3,540 | 3,479 | 3,542 | 3,598 | 3,639 | 3,699 | 3,765 | 4,159 | 4,577 | 5,153 | 5,786 | 6,571 | 7,363 |
| **Median** | 3,288 | 3,402 | 3,545 | 3,631 | 3,722 | 3,659 | 3,730 | 3,808 | 3,864 | 3,945 | 4,028 | 4,552 | 5,101 | 5,838 | 6,736 | 7,869 | 9,174 |
| **75th** | 3,479 | 3,590 | 3,734 | 3,816 | 3,895 | 3,837 | 3,931 | 4,015 | 4,088 | 4,198 | 4,308 | 4,992 | 5,742 | 6,772 | 8,043 | 9,670 | 11,506 |
| **Max.** | 3,479 | 3,632 | 3,802 | 3,971 | 4,152 | 4,191 | 4,372 | 4,566 | 4,740 | 4,948 | 5,169 | 6,470 | 7,846 | 9,667 | 12,060 | 15,114 | 19,012 |

There is no information about possible redistribution of the load on the territory along these 18 years. Therefore, it has been assumed that the same growth occurs in all the load stations, excluding TALCO load, for which a constant value is expected. It has also been assumed that no new load locations are created, or no old ones are dismissed.

This growth, which varies between 1.8% and 3% per year (with a small decrease in year 2015), requires a significant reinforcement of the entire 220 kV Tajik transmission network and also of the load transformers etc.

A detailed analysis would require knowing the true territorial redistribution of the load and other information (possible new line paths, etc.) that are not available. Anyway, in order to obtain running load-flow cases for what attains the 500 kV system aimed at verifying the export capability, some basic reinforcements have been done on the 220 kV system. The modifications are reported in the following chapters.

## 5.3 Existing power plants

The Tajik system nowadays includes some main HPP (Hydro Power Plant) and TPP (Thermal Power Plant) namely:

| Power Station | Sub-Station | Pn [MW] | In Service since |
|---|---|---|---|
| Gen VARZOB-HPP1 | NOVAYA | 9.5 | Existing |
| Gen VARZOB-HPP2 | NOVAYA | 14.4 | Existing |
| Gen VARZOB-HPP3 | NOVAYA | 3.52 | Existing |
| Gen-Centralnaya | KOLKHOZABAD | 15.1 | Existing |
| Gen-Perepadnaya | GOLOVNAYA | 29.95 | Existing |
| HPP11-SANGT1 | SANGTUDA-1 | 670 | Existing |
| HPP24-KAYR | KAYROKUM | 126 | Existing |
| HPP5-GOLOV | GOLOVNAYA | 240 | Existing |
| HPP7-NUREK | NUREKSKAYA | 3000 | Existing |
| HPP8-BAYPAZA | BAYPAZA | 600 | Existing |
| HPP12-SANGT2 | SANGTUDA-2 | 220 | Existing |
| TPP-DUSHANBE | DUSHANBE | 198 | Existing |
| TPP-DUSHANBE-2 | DUSHANBE | 100 | 2013 |
| HPP-Rogun-1 | OBIGARM | 600 | 2019 |
| HPP-Rogun-2 | OBIGARM | 600 | 2019 |
| HPP-Rogun-3 | OBIGARM | 600 | 2026 |
| HPP-Rogun-4 | OBIGARM | 600 | 2026 |
| HPP-Rogun-5 | OBIGARM | 600 | 2027 |
| HPP-Rogun-6 | OBIGARM | 600 | 2027 |
| TPP-Yavan | YAVAN | 120 | Existing |

**Table 5.3: Tajik Power Plant**

for a total of nearly 5,346 MW existing installed capacity; in future with Rogun Power Plant the installed capacity would be 8,946 MW for the highest installed capacity alternative (3,600 MW).

## 5.4 Connections to neighbouring countries and connection alternatives

The possible connections to the neighbouring systems have been described i.e. in chapter 8 of the Inception Report [13], SA_Energy_CrossBorder [16], TEAS Note [37] and they can be summarized as follows:

- 220 kV AC connection between SANGTUDA-2 S/S and Afghanistan KUNDUZ S/S (approx. 180 km);
- 500 kV AC connection between SUGHD S/S and Kirgizstan DATKA S/S (approx. 477 km);
- 500 kV AC connection between REGAR S/S and Uzbekistan SURKAN S/S (approx. 162 km);

- 500 kV AC connection between REGAR S/S and Uzbekistan GUZAR S/S (approx. 255 km);
- 500 kV DC connection between SANGTUDA-1 and KABUL S/S and PESHAWAR S/S (Afghanistan and Pakistan).

The AC lines have been represented in detail; the DC lines are simply represented as a static load at the location of the AC/DC converter device. A detailed representation is not necessary, since for the purpose of this study it is sufficient to demonstrate that the AC transmission system and the generators are able to transfer to the AC/DC converter the required active power to be exported.

## 5.5 N-1 safety

For the farthest time horizon, year 2031, the N-1 conditions on the 500 kV transmission system have been explored, first in the base case (with no Export) and then in the various Export cases. It has been found that the outage of some lines is anyway critical also in the base case, while for the other outages and for each Export case the required Export power reduction level has been found. The effect of the outages has been reported in detail and summarized in a final table.

## 5.6 Losses

The losses in the 500 and 220 kV transmission system have been found for each horizon year, each load level and each export condition, with the total equivalent energy lost in each year. The yearly losses are found, for each year, by multiplying the losses of 1 h in each one of the 3 sample conditions: max., average and min. load, for the corresponding equivalent no. of hours: 760, 4,140 and 3,860 respectively.

# 6 SUMMARY AND DISCUSSION OF RESULTS

## 6.1 Starting year 2013

Detailed results are shown in Sub-Chapter 8.1, figures 2.1 and following.

In this year, with a peak load demand of about 3,816 MW, the load flow calculation does not show specific problems in the 500 and 220 kV systems, except some cases of lines or transformers overload. Some network reinforcements are necessary to avoid such loading violations.

This table summarizes the proposed reinforcements for year 2013:

| Type | Name | Vn [kV] | From Station | To Station | n°Par | Rating |
|---|---|---|---|---|---|---|
| Line | L-11L-1 | 220 | LOLAZAR | SANGTUDA-1 | 1 -> 2 | |
| Line | L-11L-2 | 220 | LOLAZAR | SANGTUDA-1 | 1 -> 2 | |
| Line | L-24-KB/1 | 220 | KAYROKUM | T-Shurob-1 | 1 -> 2 | |
| Line | L-24-KB/2 | 220 | T-Shurob-2 | KANIBADAM | 1 -> 2 | |
| Line | L-7-02 | 220 | ORJABAD-2 | T_NUREK | 1 -> 2 | |
| Line | L-7-02(1) | 220 | T_NUREK | NUREKSKAYA | 1 -> 2 | |
| Line | L-7-L | 220 | NUREKSKAYA | SEBISTAN | 1 -> 2 | |
| Line | L-7L | 220 | SEBISTAN | LOLAZAR | 1 -> 2 | |
| Line | L-8D | 220 | DJANGAL | BAYPAZA | 1 -> 2 | |
| 3 Wind. Transf. | TR-BUSTON-2 | 230 | BUSTON | | 1 | 133% |
| 3 Wind. Transf. | TR-DJANGAL-1 | 230 | DJANGAL | | 1 -> 2 | |
| 3 Wind. Transf. | TR-DJANGAL-2 | 230 | DJANGAL | | 1 -> 2 | |
| 3 Wind. Transf. | TR-GOLOVNAYA-1 | 242 | GOLOVNAYA | | 1 -> 2 | |
| 3 Wind. Transf. | TR-GOLOVNAYA-2 | 242 | GOLOVNAYA | | 1 -> 2 | |
| 3 Wind. Transf. | TR-NOVAYA-1 | 230 | NOVAYA | | 1 | 133% |
| 3 Wind. Transf. | TR-NOVAYA-2 | 230 | NOVAYA | | 1 | 133% |
| 3 Wind. Transf. | TR-ORJABAD-2-1 | 230 | ORJABAD-2 | | 1 -> 2 | |
| 3 Wind. Transf. | TR-ORJABAD-2-2 | 230 | ORJABAD-2 | | 1 -> 2 | |

**Table 6.1: 2013 Network reinforcement**

## 6.2 Horizon year 2020

In this year the load flow calculation does not show specific problems in the 500 and 220 kV systems. Detailed results are shown in Sub-Chapter 8.2, figures 3.1 and following.

In this year, the peak load demand is expected to be about 4,308 MW; considering also the losses and a possible power export of 1,000 MW (in case of complete availability of all the generators), the generation is about 5,440 MW, whilst the total installed capacity is about 5,500 MW.

This table summarizes the proposed reinforcements for year 2020 (in addition to the ones of the former years):

| Type | Name | Vn [kV] | From Station | To Station | n°Par | Rating |
|---|---|---|---|---|---|---|
| Line | L-10D | 220 | YATEC | DJANGAL | 1 -> 2 | |
| Line | L-KAN-S | 220 | T-Shurob-2 | SHUROBSKAYA | 1 -> 2 | |
| Line | L-KAY-S | 220 | T-Shurob-1 | SHUROBSKAYA | 1 -> 2 | |
| 3 Wind. Transf. | TR-BUSTON-2 | 230 | BUSTON | | 1 -> 2 | |
| 3 Wind. Transf. | TR-GERAN-1 | 230 | GERAN | | 1 | 133% |
| 3 Wind. Transf. | TR-GERAN-2 | 230 | GERAN | | 1 | 133% |
| 3 Wind. Transf. | TR-KHATLON-1 | 230 | KHATLON | | 1 | 133% |
| 3 Wind. Transf. | TR-KHATLON-2 | 230 | KHATLON | | 1 | 133% |
| 3 Wind. Transf. | TR-KHUJAND-1 | 230 | KHUJAND | | 1 | 133% |
| 3 Wind. Transf. | TR-KHUJAND-2 | 230 | KHUJAND | | 1 | 133% |
| 3 Wind. Transf. | TR-KOLKHOZABAD-1 | 230 | KOLKHOZABAD | | 1 | 133% |
| 3 Wind. Transf. | TR-SEBISTAN-1 | 230 | SEBISTAN | | 1 | 133% |

**Table 6.2: 2020 Network reinforcement**

## 6.3 Horizon year 2025

In this year the load flow calculation does not show specific problems in the 500 and 220 kV systems. Detailed results are shown in Sub-Chapter 8.3, figures 4.1 and following.

In this year, the peak load demand is expected to be about 4,992 MW; considering also the losses, the generation is about 6,760 MW, whilst the total installed capacity is about 7,099 MW; so in case of complete availability of all the generators, it could already be possible to export nearly 1,600 MW.

This table summarizes the proposed reinforcements for year 2025 (in addition to the ones of the former years):

| Type | Name | Vn [kV] | From Station | To Station | n°Par | Rating |
|---|---|---|---|---|---|---|
| Line | L-5K | 220 | GOLOVNAYA | KOLKHOZABAD | 1 -> 2 | |
| Line | L-5P | 220 | GOLOVNAYA | PRYADILNAYA | 1 -> 2 | |
| Line | L-7-10 | 220 | NUREKSKAYA | T_NUREK_2 | 1 -> 2 | |
| Line | L-HPP12-HPP5 | 220 | SANGTUDA-2 | GOLOVNAYA | 1 -> 2 | |
| Line | L-S-K | 220 | SUGHD | KHUJAND | 1 -> 2 | |
| 3 Wind. Transf. | TR-DJANGAL-1 | 230 | DJANGAL | | 2 | 133% |
| 3 Wind. Transf. | TR-DJANGAL-2 | 230 | DJANGAL | | 2 | 133% |
| 3 Wind. Transf. | TR-KHATLON-1 | 230 | KHATLON | | 1 -> 2 | |
| 3 Wind. Transf. | TR-KHATLON-2 | 230 | KHATLON | | 1 -> 2 | |
| 3 Wind. Transf. | TR-KHUJAND-1 | 230 | KHUJAND | | 1 -> 2 | |
| 3 Wind. Transf. | TR-KHUJAND-2 | 230 | KHUJAND | | 1 -> 2 | |
| 3 Wind. Transf. | TR-LOLAZAR-1 | 230 | LOLAZAR | | 1 | 133% |
| 3 Wind. Transf. | TR-LOLAZAR-2 | 230 | LOLAZAR | | 1 | 133% |
| 3 Wind. Transf. | TR-NOVAYA-1 | 230 | NOVAYA | | 1 -> 2 | |
| 3 Wind. Transf. | TR-NOVAYA-2 | 230 | NOVAYA | | 1 -> 2 | |
| 3 Wind. Transf. | TR-PRYADILNAYA-1 | 230 | PRYADILNAYA | | 1 | 133% |
| 3 Wind. Transf. | TR-RUMI-1 | 230 | RUMI | | 1 | 133% |
| 3 Wind. Transf. | TR-SUGHD-1 | 500 | SUGHD | | 1 | 133% |
| 3 Wind. Transf. | TR-SUGHD-2 | 500 | SUGHD | | 1 | 133% |
| 3 Wind. Transf. | TR-UZLOVAYA-2 | 230 | UZLOVAYA | | 1 | 133% |
| Capacitor | Cap_Kanib/1 | 10 | KANIBADAM | | | 50 MVAr |
| Capacitor | Cap_Kanib/2 | 10 | KANIBADAM | | | 50 MVAr |

**Table 6.3: 2025 Network reinforcement**

## 6.4 Horizon year 2027

In this year the load flow calculation does not show specific problems in the 500 and 220 kV systems. Detailed results are shown in Sub-Chapter 8.4, figures 5.1 and following.

In this year, the peak load demand is expected to be about 5,292 MW; considering also the losses and the export, the generation is about 7,070 MW, whilst the total installed capacity is about 7,261 MW. In case of complete availability of all the generators, it could already be possible to export about 1,600 MW.

This table summarizes the proposed reinforcements for year 2027 (in addition to the ones of the former years):

| Type | Name | Vn [kV] | From Station | To Station | n°Par | Rating |
|---|---|---|---|---|---|---|
| Line | L-7-02 | 220 | ORJABAD-2 | T_NUREK | 2 -> 3 | |
| Line | L-7-02(1) | 220 | T_NUREK | NUREKSKAYA | 2 -> 3 | |
| Line | L-8D | 220 | DJANGAL | BAYPAZA | 2 -> 3 | |
| Line | L-S-24/1 | 220 | SUGHD | T_Sughd | 1 -> 2 | |
| Line | L-S-24/2 | 220 | T_Sughd | T_Buston | 1 -> 2 | |
| 3 Wind. Transf. | TR-NUREK-1 | 230 | NUREK | | 1 | 133% |
| 3 Wind. Transf. | TR-NUREK-2 | 230 | NUREK | | 1 | 133% |
| 3 Wind. Transf. | TR-ORJABAD-2-1 | 230 | ORJABAD-2 | | 2 | 133% |
| 3 Wind. Transf. | TR-ORJABAD-2-2 | 230 | ORJABAD-2 | | 2 | 133% |
| 3 Wind. Transf. | TR-SEBISTAN-1 | 230 | SEBISTAN | | 1 -> 2 | |
| 3 Wind. Transf. | TR-YAVAN-1 | 230 | YAVAN | | 1 | 133% |
| 3 Wind. Transf. | TR-YAVAN-2 | 230 | YAVAN | | 1 | 133% |
| Capacitor | Cap_Geran/1 | 11 | GERAN | | | 30 MVAr |
| Capacitor | Cap_Geran/2 | 11 | GERAN | | | 30 MVAr |
| Capacitor | Cap_Rumi | 10 | RUMI | | | 50 MVAr |

**Table 6.4: 2027 Network reinforcement**

## 6.5 Horizon year 2028

In this year the load flow calculation does not show specific problems in the 500 and 220 kV systems. Detailed results are shown in Sub-Chapter 8.5, figures 5.1 and following.

In this year, the peak load demand is expected to be about 5,442 MW; considering also the losses and the export, the generation is about 7,441 MW, whilst the total installed capacity is about 7,901 MW. In case of complete availability of all the generators, it could already be possible to export about 1,800 MW.

This table summarizes the proposed reinforcements for year 2028 (in addition to the ones of the former years):

| Type | Name | Vn [kV] | From Station | To Station | n°Par | Rating |
|---|---|---|---|---|---|---|
| 3 Wind. Transf. | TR-NUREK-1 | 230 | NUREKSKAYA | | 1 | 133% |

**Table 6.5: 2028 Network reinforcement**

## 6.6 Horizon year 2031 and Rogun HPP with 3600 MW rated power and network reinforcement

Detailed results are shown in Sub-Chapter 8.6, figures 6.1 and following.

In order to have load flows without loading violations in the branches and severe voltages violations, it necessary to perform some reinforcements on the 220 kV and distribution system.

The proposed and most urgent and significant actions are:

| Type | Name | Vn [kV] | From Station | To Station | n°Par | Rating |
|---|---|---|---|---|---|---|
| Line | L-7-10(1) | 220 | T_NUREK_2 | YATEC | 1 -> 2 | |
| Line | L-S-K2/B | 220 | SUGHD | T_KNS-2 | 1 -> 2 | |
| 3 Wind. Transf. | TR-DUSHANBE-1 | 500 | DUSHANBE | | 1 | 133% |
| 3 Wind. Transf. | TR-GERAN-1 | 230 | GERAN | | 2 | 133% |
| 3 Wind. Transf. | TR-GERAN-2 | 230 | GERAN | | 2 | 133% |
| 3 Wind. Transf. | TR-KANIBADAM-1 | 230 | KANIBADAM | | 1 | 133% |
| 3 Wind. Transf. | TR-KANIBADAM-2 | 230 | KANIBADAM | | 1 | 133% |
| 3 Wind. Transf. | TR-KOLKHOZABAD-2 | 230 | KOLKHOZABAD | | 1 | 133% |
| 3 Wind. Transf. | TR-RUDAKI-2 | 230 | RUDAKI | | 1 | 133% |
| Capacitor | Cap_Djangal/1 | 10 | DJANGAL | | | 50 MVAr |
| Capacitor | Cap_Djangal/2 | 10 | DJANGAL | | | 50 MVAr |
| Capacitor | Cap_Geran/3 | 11 | GERAN | | | 30 MVAr |
| Capacitor | Cap_Geran/4 | 11 | GERAN | | | 30 MVAr |
| Capacitor | Cap_Khatlon/1 | 10 | KHATLON | | | 50 MVAr |
| Capacitor | Cap_Khatlon/2 | 10 | KHATLON | | | 50 MVAr |

**Table 6.6: 2031 Network reinforcement**

In year 2031, the peak load demand is expected to be about 5,948 MW; considering also the losses, the generation is about 6,116 MW, whilst the total installed capacity is about 8,701 MW. In case of complete availability of all the generators, it could already be possible to export about 2,450 MW.

The following pictures show that it could really be possible and that the 500 kV transmission grid is adequate for these export activities. The following pictures of fig. 6.1 to fig. 6.5 show the cases of 1,300 MW export to Afghanistan (with DC system), 550 MW export to Kirgizstan, 1,500 MW export to Uzbekistan through the two different solutions and a “global” case where a total of 2,450 MW are exported to these countries (1,350, 400 and 700 MW respectively).

In all the cases the transmission is fully possible, even if the Tajik 500 kV system is overloaded or the voltage values of the busbars go beyond ±5% of the rated voltage or, in a few busbar, are above the latter value but without exceeding ±10%.

An optimal reactive power calculation should be performed to improve the voltage profiles and to reduce the losses, but this is meaningful only with true and final data of all the connections.

This is normally part of a detailed study on the operation of the transmission system and it can be performed with significant results only when the operational conditions are defined with sufficient detail. The study at hands anyway assesses the minimum needs of reacted power compensation, which are listed in the “Reinforcement Actions” table (see par. 6.9 Reinforcements summary) as additional capacitors.

The following possible critical aspects should be taken into account, about the reactive power situation.

In particular, the SUGHD-DAKTA (Kirgizstan) connection – that is also the longest one (477 km) of the entire AC transmission system - is the most critical, also because it is located in an area far from the power plants and with limited reactive power resources. Although this line produces a huge amount of reactive power, in order to obtain feasible operational condition it is necessary:

- ✓ not to load excessively this line, in order to avoid to drag off too much reactive power;
- ✓ to produce other reactive power by means of the capacitor banks in Sughd;
- ✓ to disconnect the shunt reactors of the 500 kV line L-518 from Dushanbe to Sughd.

The export of active power to Datka is therefore limited due to the weakness of the Tajik transmission system in this area.

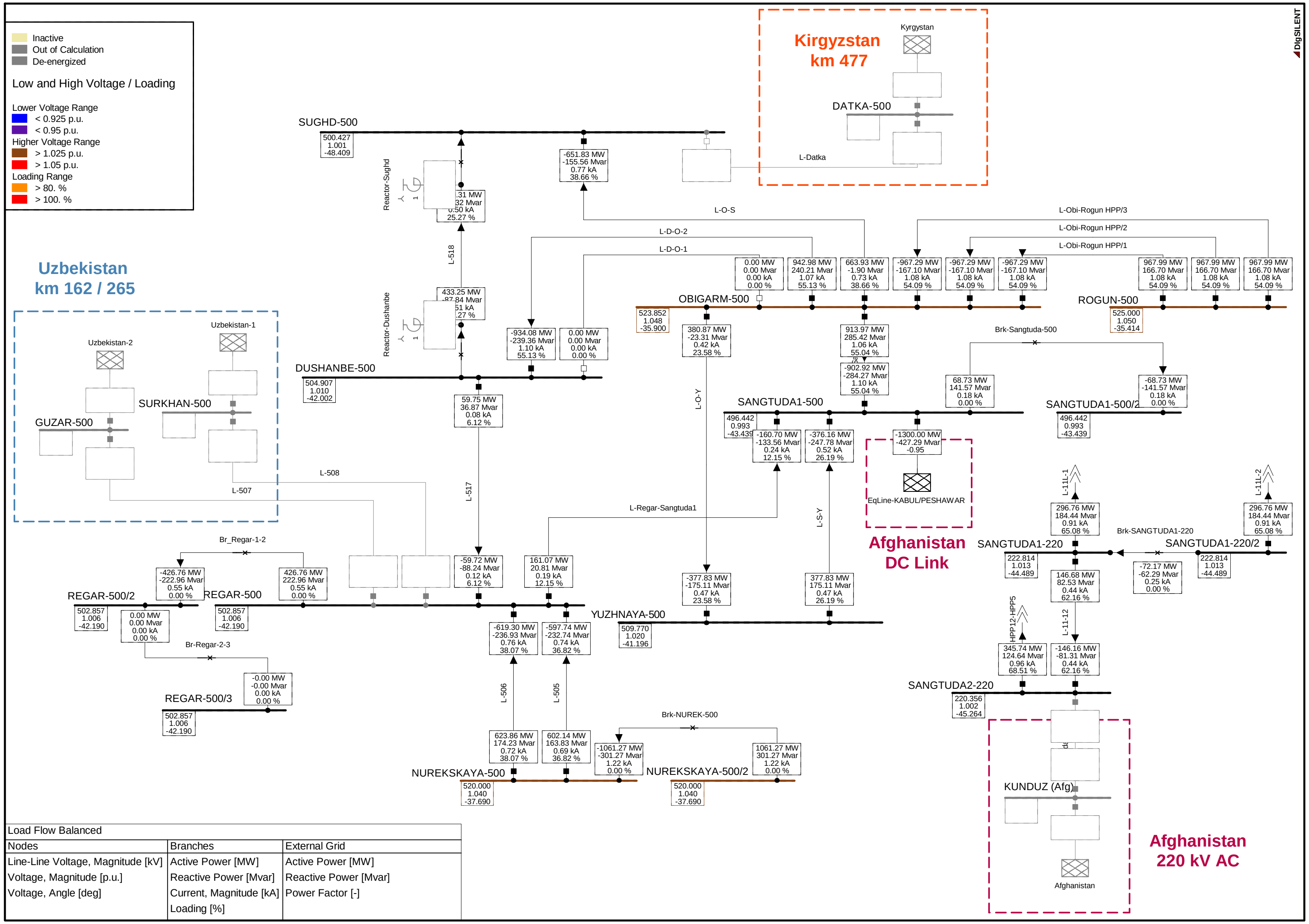



**fig. 6.1: horizon year 2031, peak load, ROGUN HPP at full rated power, export of 1300 MW to Afghanistan**

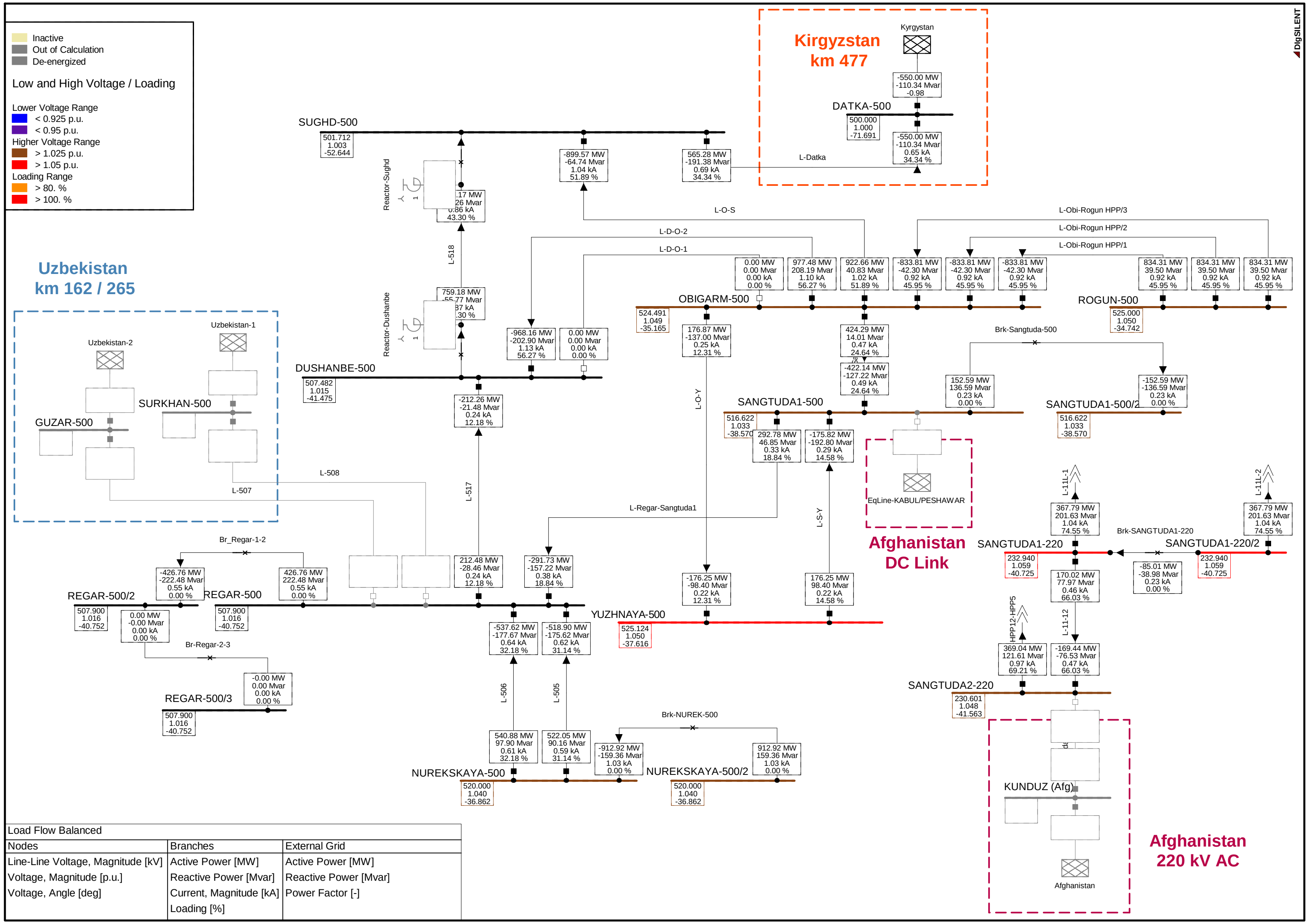



**fig. 6.2: horizon year 2031, peak load, ROGUN HPP at full rated power, export of 550 MW to Kirgizstan**

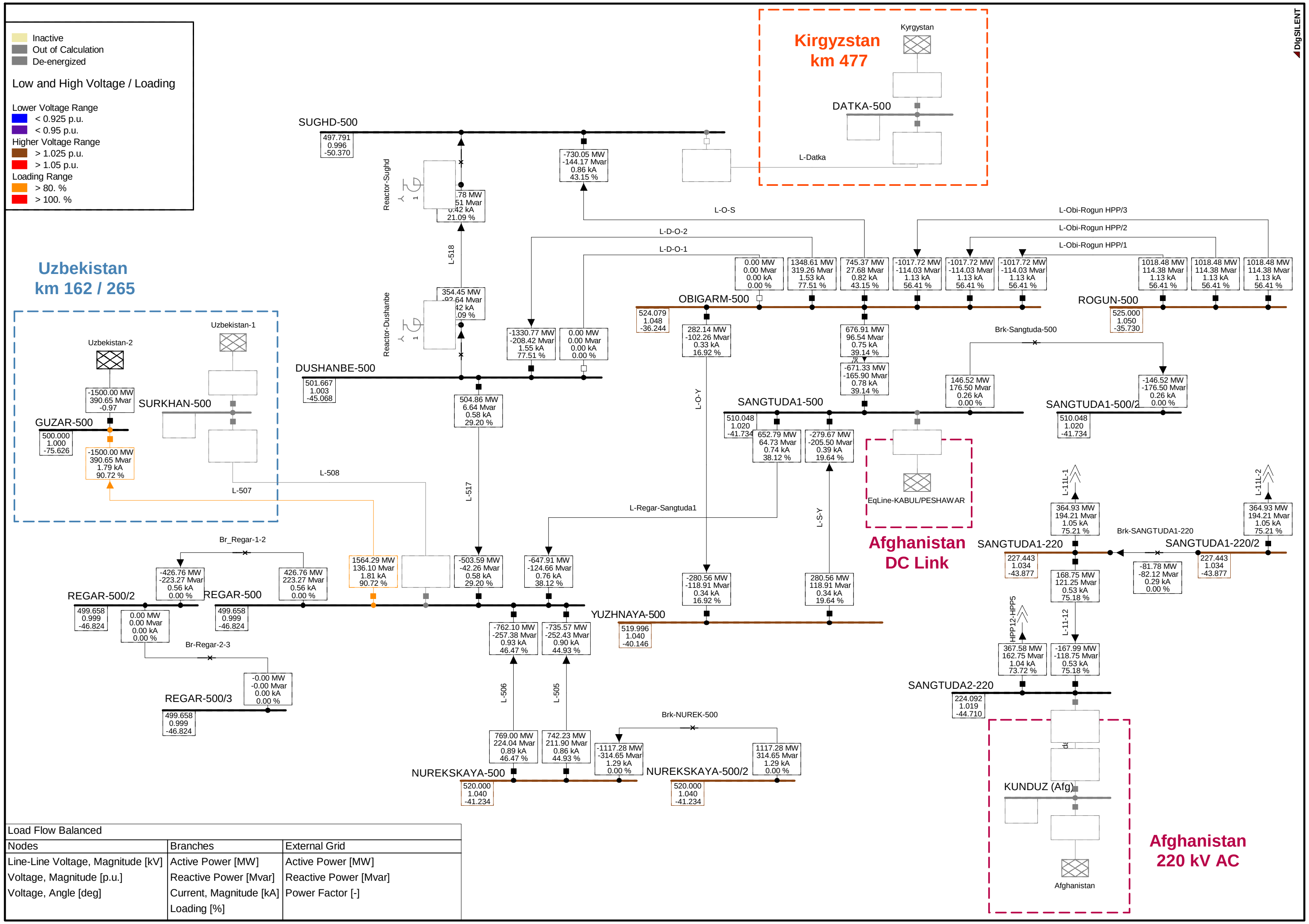



**fig. 6.3: horizon year 2031, peak load, ROGUN HPP at full rated power, export of 1500 MW to Uzbekistan (sol. 1)**

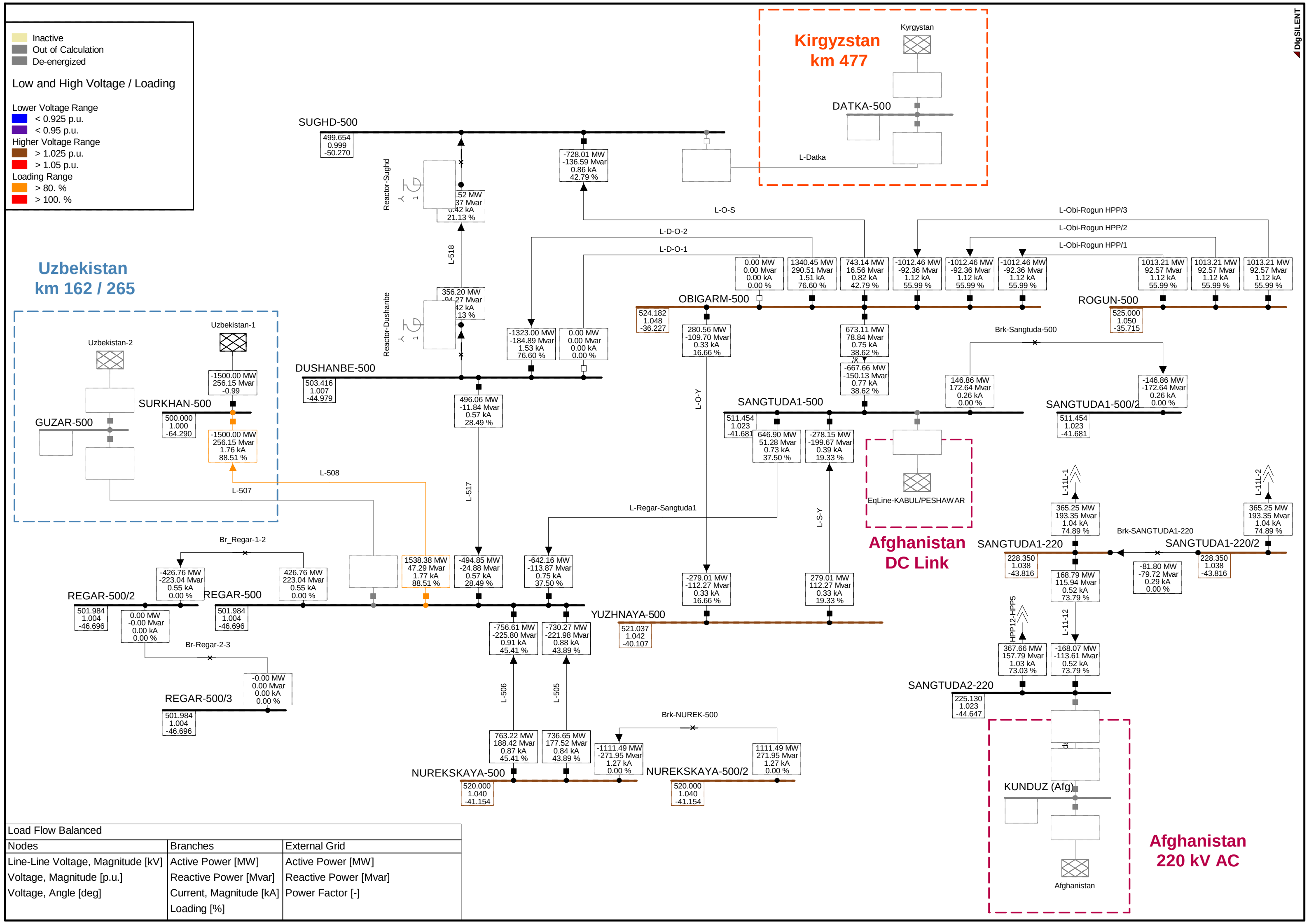



**fig. 6.4: horizon year 2031, peak load, ROGUN HPP at full rated power, export of 1500 MW to Uzbekistan (sol. 2)**

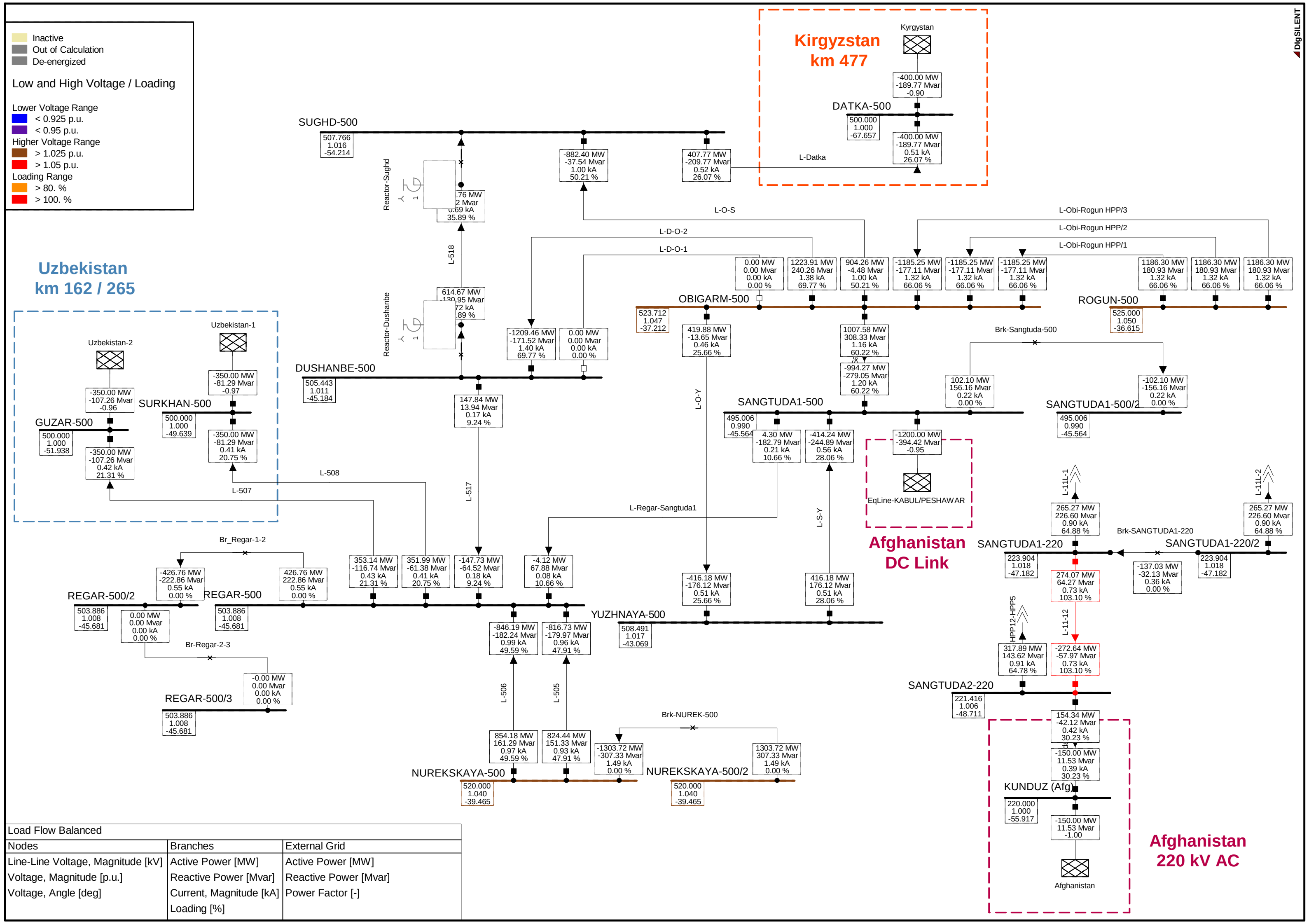



**fig. 6.5: horizon year 2031, peak load, ROGUN HPP at full rated power, export of 2450 MW to the neighbouring countries**

In the other cases of single-country export the reactive power situation is as follows:

- with Afghanistan: no reactive power is required from Afghan side. Tajik system can provide the needed 427 Mvar in SANGTUDA-1, with an assumed cosphi equal to 0.95 for the AC/DC converter.
- with Kirgizstan, to Datka: Kirgizstan will receive about 190 Mvar from the connection line, while other 210 Mvar will be provided from the line to the Tajik system (that needs this reactive power support).
- with Uzbekistan, to SURKHAN: Uzbekistan is requested to produce 256 Mvar, the other needed 47 Mvar are provided from the Tajik system.
- with Uzbekistan, to GUZAR: Uzbekistan is requested to produce 390 Mvar, the other needed 136 Mvar are provided from theTajik system.

### *6.6.1 N-1 analysis without Export connections*

In the base condition of year 2031, maximum load, without any export connection to the neighbouring countries, the outage simulation (N-1 analysis) on the 500 kV transmission system has been performed. The results are reported in the following picture. Then, the same analysis has been performed for the export cases.

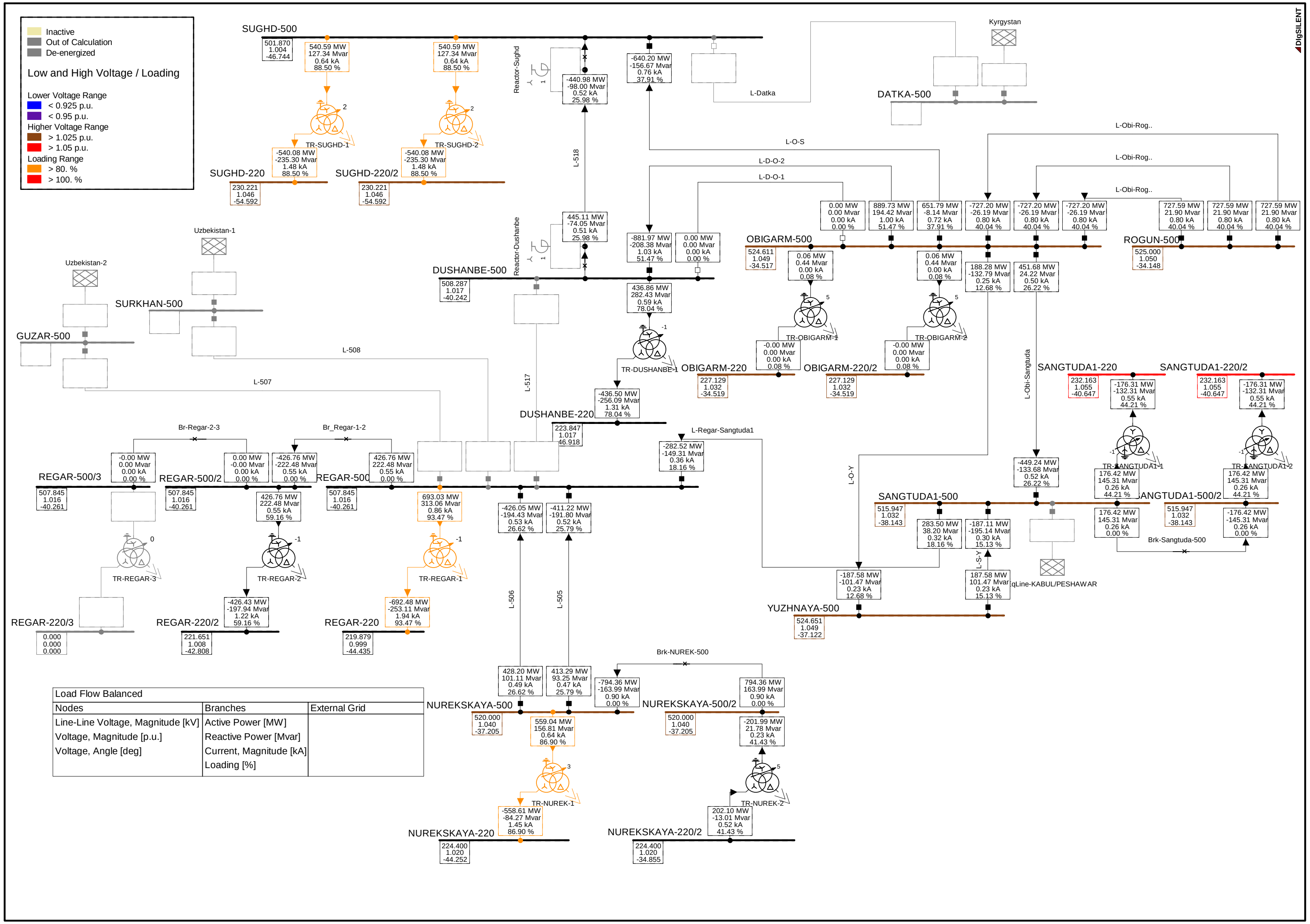



**fig. 6.6: horizon year 2031, peak load, no export: outage of 500 kV line L-517 REGAR - DUSHANBE**

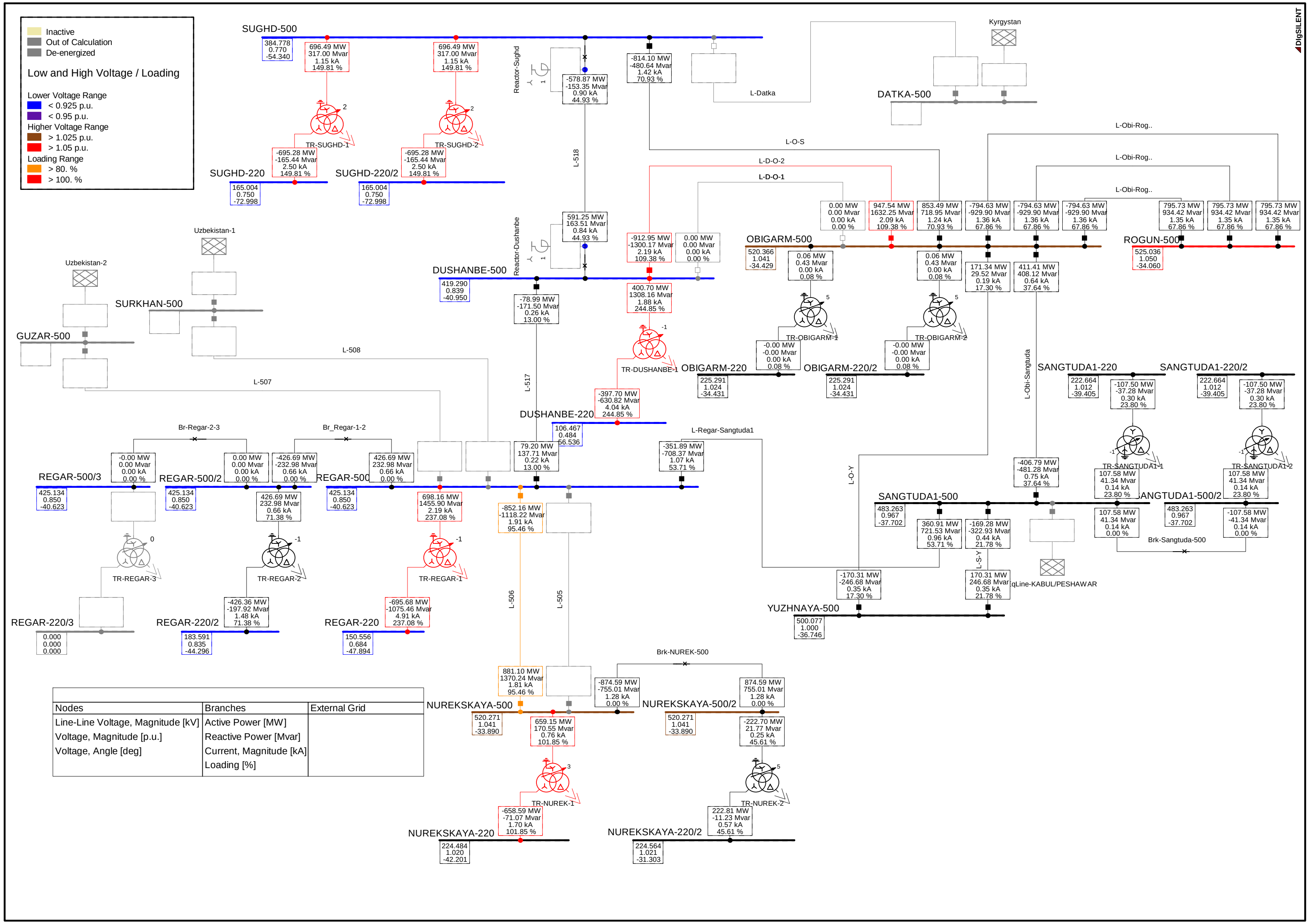



**fig. 6.7: horizon year 2031, peak load, no export: outage of 500 kV line L-505 REGAR - NUREKSKAYA**

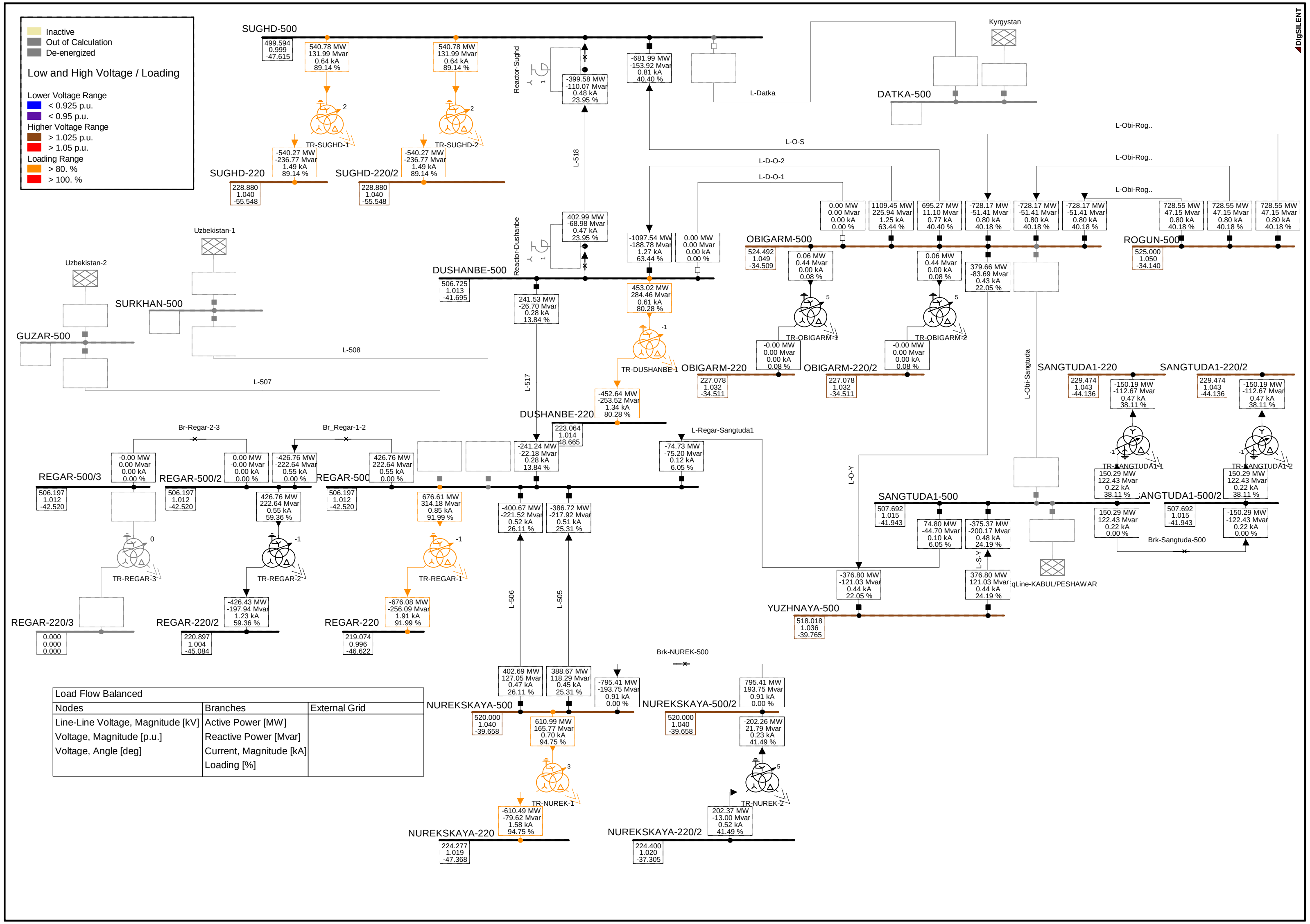



**fig. 6.8: horizon year 2031, peak load, no export: outage of 500 kV line L-Obi-Sangt. OBIGARM - SANGTUDA-1**

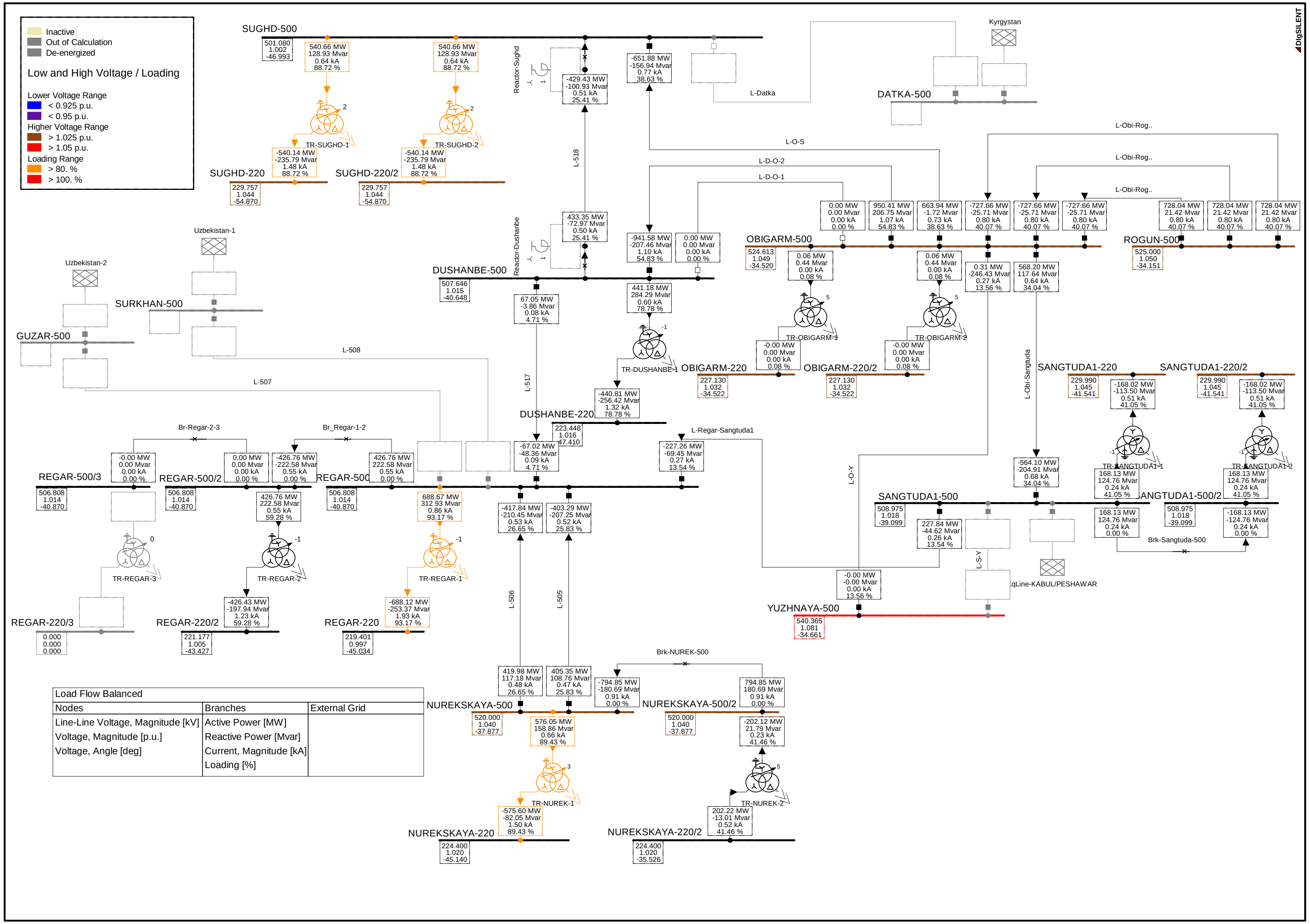



**fig. 6.9: horizon year 2031, peak load, no export: outage of 500 kV line L-S-Y SANGTUDA-1 - YUZHNAYA**

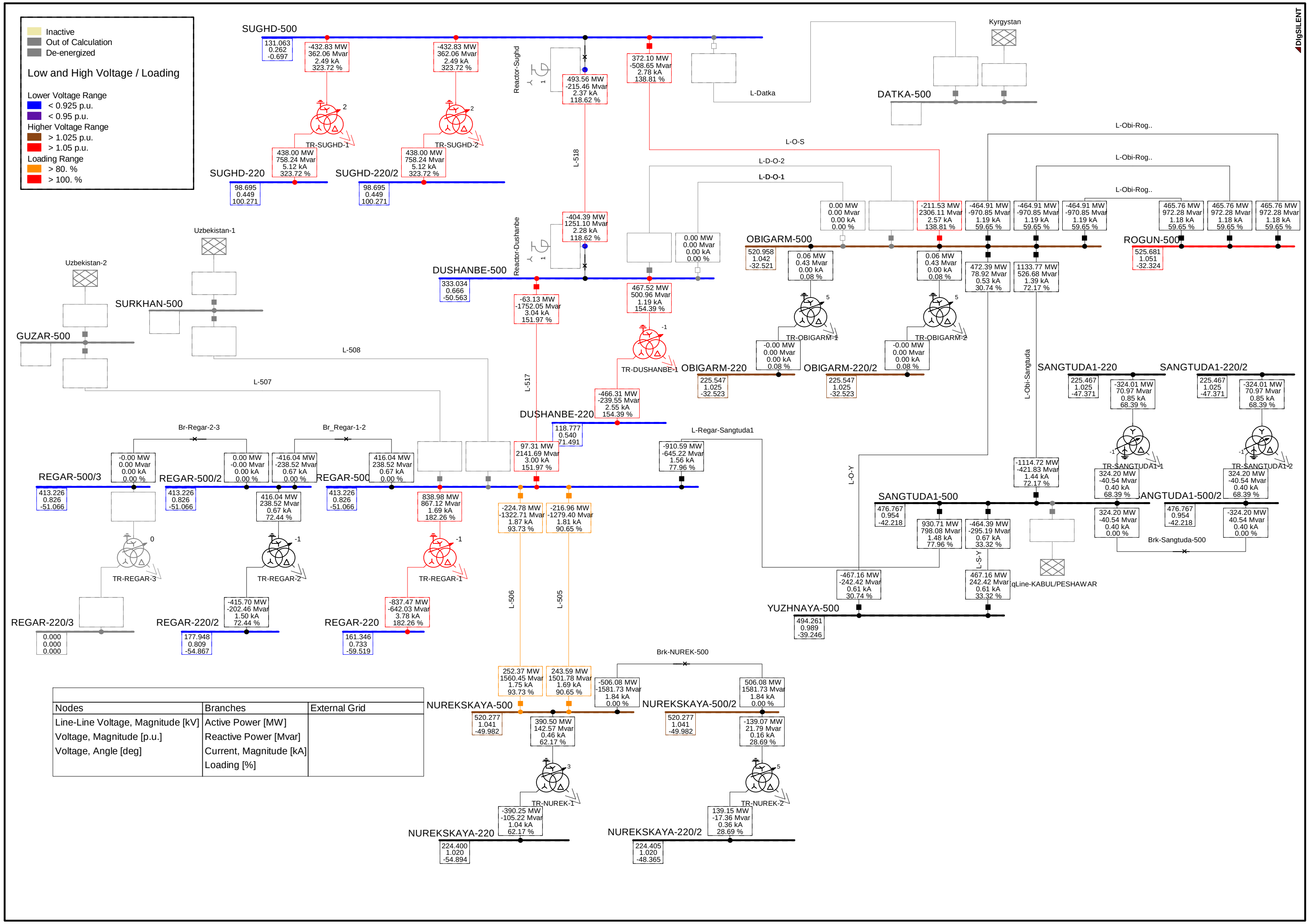



**fig. 6.10: horizon year 2031, peak load, no export: outage of 500 kV line L-D-O-2 DUSHANBE - OBIGARM**

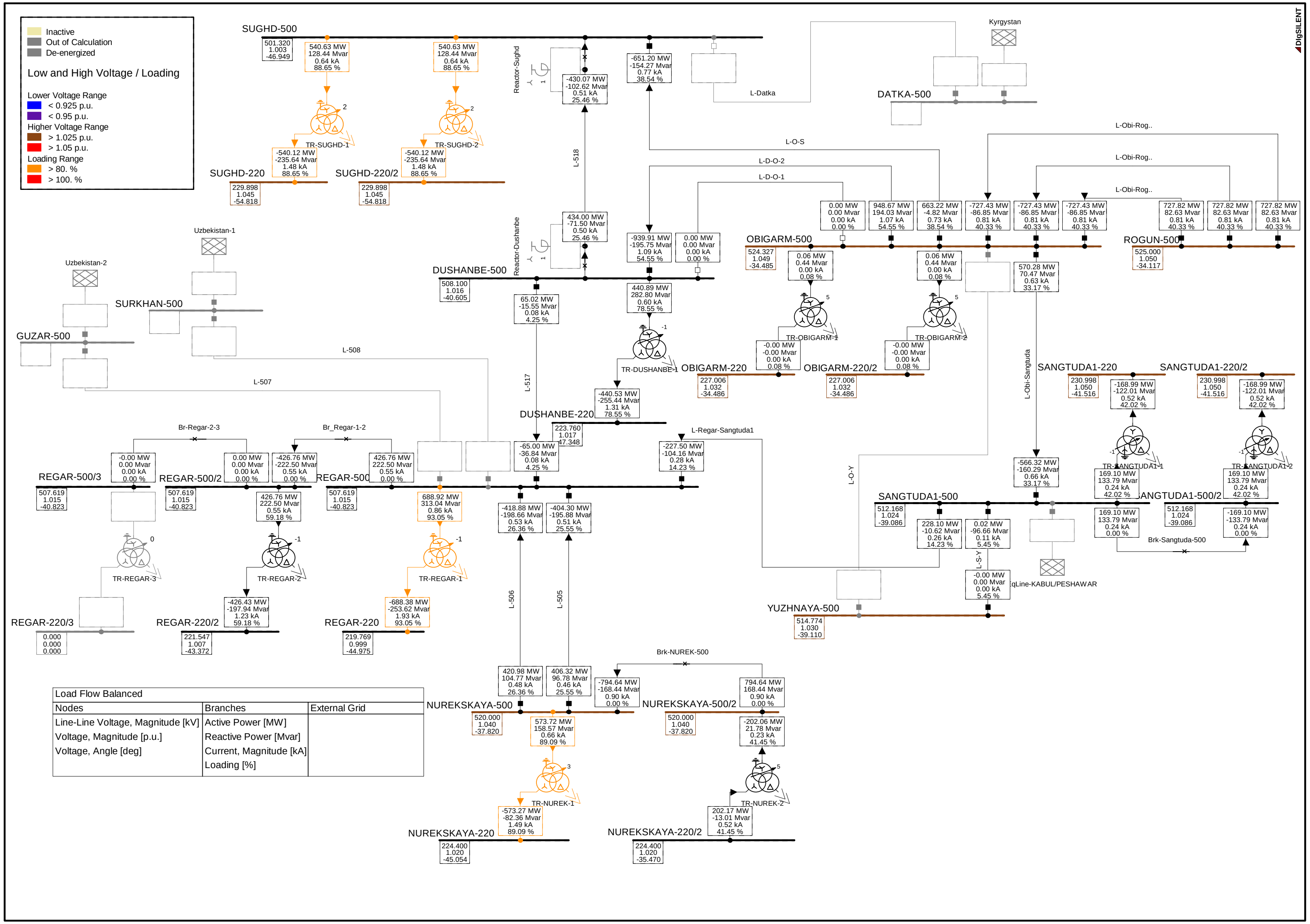



**fig. 6.11: horizon year 2031, peak load, no export: outage of 500 kV line L-O-Y OBIGARM - YUZHNAYA**

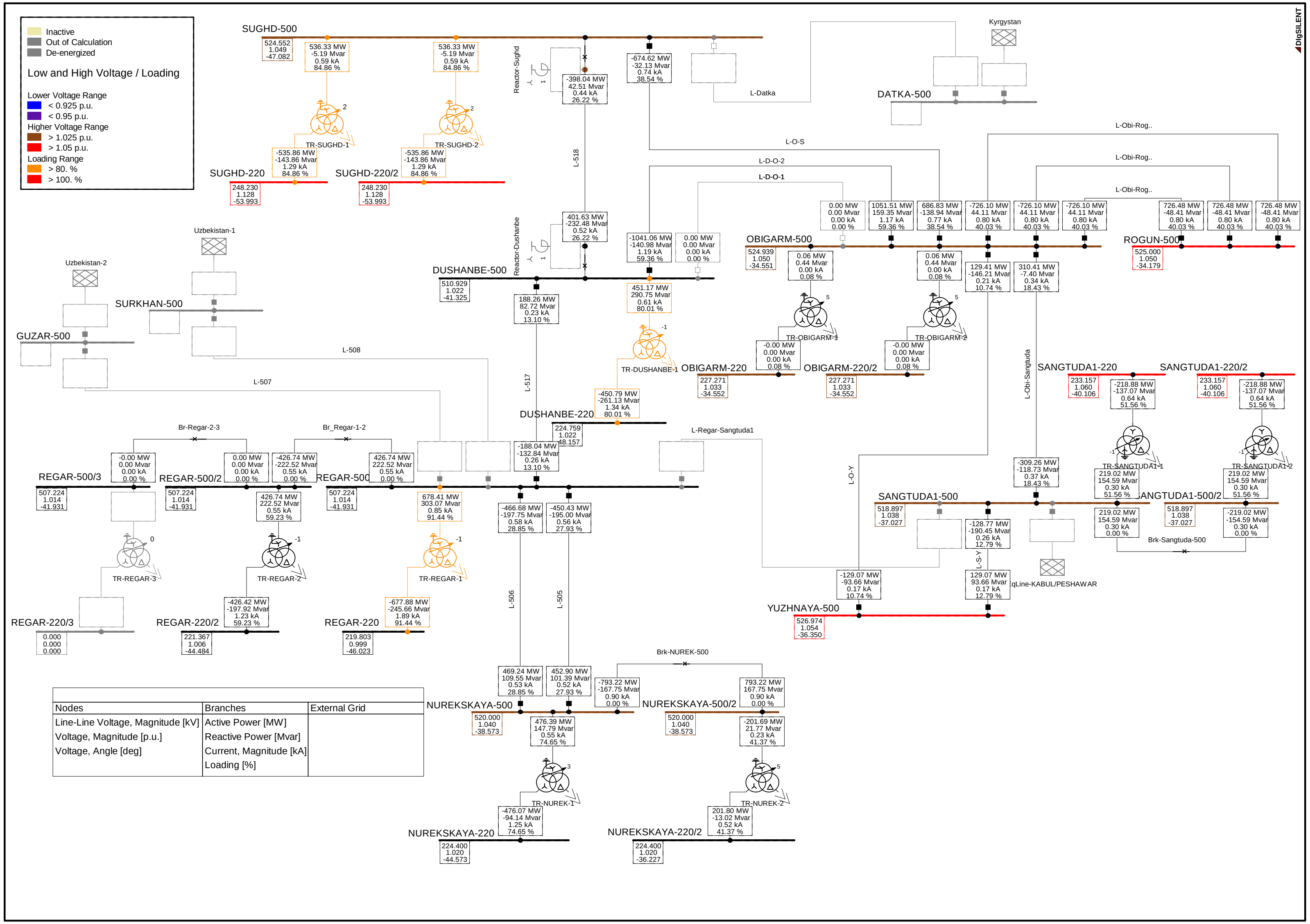



**fig. 6.12: horizon year 2031, peak load, no export: outage of 500 kV line L-Regar-Sangt. REGAR – SANGTUDA-1**

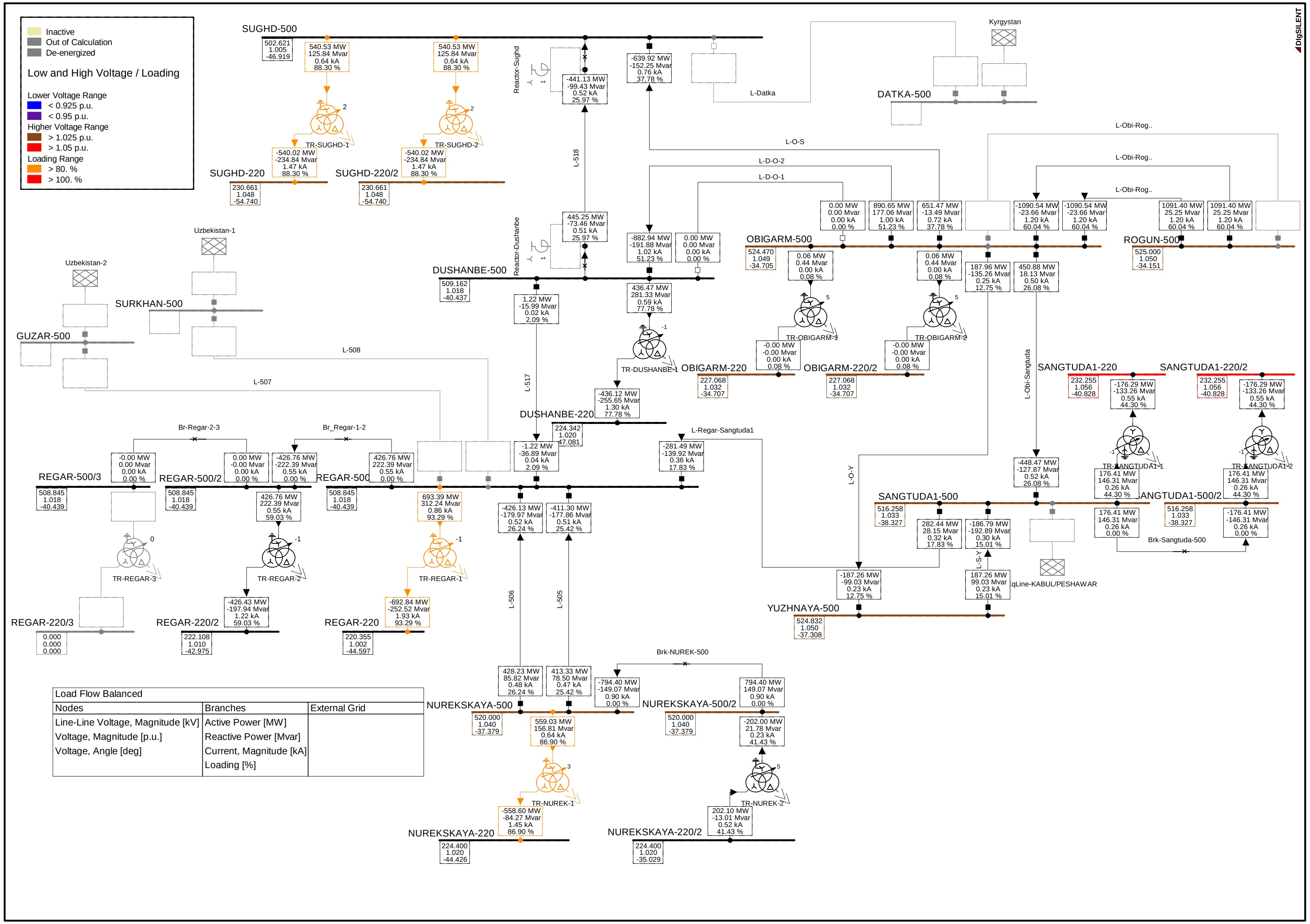



**fig. 6.13: horizon year 2031, peak load, no export: outage of 500 kV line L-Obi-Rogun OBIGARM – ROGUN HPP**

The outages results can be summarized as follows:

- the outage of the lines L-518 DUSHANBE – SUGHD, L-506 REGAR – NUREKSKAYA, L-O-S OBIGARM - SUGHD leads to the complete collapse of the system (load flow calculation failed);
- the outage of the lines L-505 REGAR – NUREKSKAYA, L-D-O-2 DUSHANBE - OBIGARM leads to huge voltage drops (50% or more) that of course are not acceptable;
- the outages of the lines REGAR - SANTUDA-1 lead to non-dramatic violation of loading of some 500-220 kV transformers: the violated loading values vary between 101 and 110% and could be avoided by a relatively small improvement of the ratings of these transformers (use of Forced Ventilation, when available, could be sufficient);
- the other cases do not produce significant consequences.

As already stated above, also this analysis shows that the critical part of the 500 kV transmission system is in the north area, mainly related to the connection of SUGHD substation to the other parts of the system.

It is therefore suggested to reinforce this part of the system, i.e. to create a 2nd line between OBIGARM and SUGHD.

### *6.6.2 N-1 analysis with Export connections*

The outage analysis has been performed also for the cases of Export to the neighbouring countries. The considered cases are: 1,300 MW export to Afghanistan, 550 MW export to Kirgizstan, 1,500 MW export to Uzbekistan via SURKHAN, 1,500 MW export to Uzbekistan via GUZAR.

Before performing this analysis, some network reinforcements have been adopted, according to the tables from 6.1 to 6.6.

Scope of the analysis is to determine if some outage case leads to the impossibility of export any power, or if an export power reduction could be sufficient to come back within acceptable working condition, without any overload.

The results can be summarized as follows:

#### *6.6.2.1 1300 MW export to Afghanistan*

In this case the outages of the lines DUSHANBE-SUGHD, OBIGARM-SUGHD and DUSAHNBE-OBIGARM lead to the complete collapse of the system.

The other outages can be withstood, with some reduction of the export power.

| Export connection from SANGTUDA-1 to Afghanistan DC link | | | | | |
|---|---|---|---|---|---|
| **Outage Line** | **Station 1** | **Station 2** | **Pexp** | **1: Violations** | **Reduction** |
| | | | **MW** | **0: No violations** | **MW** |
| L-517 | REGAR | DUSHANBE | 1100 | 0 | 200 |
| L-518 | DUSHANBE | SUGHD | LF Failed | | |
| L-505 | REGAR | NUREKSKAYA | 200 | 0 | 1100 |
| L-506 | REGAR | NUREKSKAYA | 150 | 0 | 1150 |
| L-Obi-Sangtuda | OBIGARM | SANGTUDA-1 | 350 | 0 | 950 |
| L-O-S | OBIGARM | SUGHD | LF Failed | | |
| L-O-Y | OBIGARM | YUZHNAYA | 750 | 0 | 550 |
| L-S-Y | SANGTUDA-1 | YUZHNAYA | 650 | 0 | 650 |
| L-Regar-Sangtuda1 | REGAR | SANGTUDA-1 | 900 | 0 | 400 |
| L-D-O-2 | DUSHANBE | OBIGARM | LF Failed | | |
| L-Obi-Rogun HPP/1 | OBIGARM | ROGUN HPP | 1100 | 0 | 200 |
| L-Obi-Rogun HPP/2 | OBIGARM | ROGUN HPP | 1100 | 0 | 200 |
| L-Obi-Rogun HPP/3 | OBIGARM | ROGUN HPP | 1100 | 0 | 200 |

**Table 6.7: export (to Afghanistan) power reductions in case of outages**

### *6.6.2.2 550 MW export to Kyrgyzstan*

In this case not all the outages require reduction of the export power.

In this case the outages of the lines DUSHANBE-SUGHD and OBIGARM-SUGHD lead to the complete collapse of the system.

In case of the loss of the line DUSHANBE-OBIGARM it is necessary to reduce the total export of 550 MW, but some lines or transformers violations are still present.

This table summarizes all the outages:

| Export connection from SUGHD to DATKA (Kyrgyzstan) | | | | | |
|---|---|---|---|---|---|
| **Outage Line** | **Station 1** | **Station 2** | **Pexp** | **1: Violations** | **Reduction** |
| | | | **MW** | **0: No violations** | **MW** |
| L-517 | REGAR | DUSHANBE | 400 | 0 | 150 |
| L-518 | DUSHANBE | SUGHD | LF Failed | | |
| L-505 | REGAR | NUREKSKAYA | 500 | 0 | 50 |
| L-506 | REGAR | NUREKSKAYA | 500 | 0 | 50 |
| L-Obi-Sangtuda | OBIGARM | SANGTUDA-1 | 550 | 0 | 0 |
| L-O-S | OBIGARM | SUGHD | LF Failed | | |
| L-O-Y | OBIGARM | YUZHNAYA | 550 | 0 | 0 |
| L-S-Y | SANGTUDA-1 | YUZHNAYA | 550 | 0 | 0 |
| L-Regar-Sangtuda1 | REGAR | SANGTUDA-1 | 500 | 0 | 50 |
| L-D-O-2 | DUSHANBE | OBIGARM | 0 | 1 | 550 |
| L-Obi-Rogun HPP/1 | OBIGARM | ROGUN HPP | 550 | 0 | 0 |

**Table 6.8: export (to Kyrgyzstan) power reductions in case of outages**

Again, this table shows that the connection to SUGHD is the weak part of the system.

#### *6.6.2.3 1500 MW export to Uzbekistan, via SURKHAN*

In this case some outages require some reduction of the export power, and there are three cases of system collapse, as in the base case (OBIGARM-SUGHD, DUSHANBE SUGHD and DUSHANBE-OBIGARM). This table summarizes all the outages:

| Export connection from REGAR to SURKAN (Uzbekistan) | | | | | |
|---|---|---|---|---|---|
| **Outage Line** | **Station 1** | **Station 2** | **Pexp** | **1: Violations** | **Reduction** |
| | | | **MW** | **0: No violations** | **MW** |
| L-517 | REGAR | DUSHANBE | 350 | 0 | 1150 |
| L-518 | DUSHANBE | SUGHD | LF Failed | | |
| L-505 | REGAR | NUREKSKAYA | 900 | 0 | 600 |
| L-506 | REGAR | NUREKSKAYA | 900 | 0 | 600 |
| L-508 | REGAR | SURKHAN | 1500 | 0 | 0 |
| L-Obi-Sangtuda | OBIGARM | SANGTUDA-1 | 650 | 0 | 850 |
| L-O-S | OBIGARM | SUGHD | LF Failed | | |
| L-O-Y | OBIGARM | YUZHNAYA | 1150 | 0 | 350 |
| L-S-Y | SANGTUDA-1 | YUZHNAYA | 1100 | 0 | 400 |
| L-Regar-Sangtuda1 | REGAR | SANGTUDA-1 | 600 | 0 | 900 |
| L-D-O-2 | DUSHANBE | OBIGARM | LF Failed | | |
| L-Obi-Rogun HPP/1 | OBIGARM | ROGUN HPP | 1400 | 0 | 100 |
| L-Obi-Rogun HPP/2 | OBIGARM | ROGUN HPP | 1400 | 0 | 100 |
| L-Obi-Rogun HPP/3 | OBIGARM | ROGUN HPP | 1400 | 0 | 100 |

**Table 6.9: export (to Uzbekistan/1) power reductions in case of outages**

Again, this table shows that the connection to SUGHD is the weak part of the system; for this particular case, also the loss of the line REGAR-DUSHANBE leads to a significant export power reduction.

#### *6.6.2.4 1500 MW export to Uzbekistan, via GUZAR*

In this case some outages require some reduction of the export power, and there is three case of system collapse, as in the base case (OBIGARM-SUGHD, DUSHANBE SUGHD and DUSHANBE-OBIGARM). This table summarizes all the outages:

| Export connection from REGAR to GUZAR (Uzbekistan) | | | | | |
|---|---|---|---|---|---|
| **Outage Line** | **Station 1** | **Station 2** | **Pexp** | **1: Violations** | **Reduction** |
| | | | **MW** | **0: No violations** | **MW** |
| L-517 | REGAR | DUSHANBE | 350 | 0 | 1150 |
| L-518 | DUSHANBE | SUGHD | LF Failed | | |
| L-505 | REGAR | NUREKSKAYA | 900 | 0 | 600 |
| L-506 | REGAR | NUREKSKAYA | 850 | 0 | 650 |
| L-507 | REGAR | GUZAR | 1500 | 0 | 0 |
| L-Obi-Sangtuda | OBIGARM | SANGTUDA-1 | 700 | 0 | 800 |
| L-O-S | OBIGARM | SUGHD | LF Failed | | |
| L-O-Y | OBIGARM | YUZHNAYA | 1100 | 0 | 400 |
| L-S-Y | SANGTUDA-1 | YUZHNAYA | 1050 | 0 | 450 |
| L-Regar-Sangtuda1 | REGAR | SANGTUDA-1 | 600 | 0 | 900 |
| L-D-O-2 | DUSHANBE | OBIGARM | LF Failed | | |

| Export connection from REGAR to GUZAR (Uzbekistan) | | | | | |
|---|---|---|---|---|---|
| **Outage Line** | **Station 1** | **Station 2** | **Pexp** | **1: Violations** | **Reduction** |
| | | | **MW** | **0: No violations** | **MW** |
| L-Obi-Rogun HPP/1 | OBIGARM | ROGUN HPP | 1300 | 0 | 200 |
| L-Obi-Rogun HPP/2 | OBIGARM | ROGUN HPP | 1300 | 0 | 200 |
| L-Obi-Rogun HPP/3 | OBIGARM | ROGUN HPP | 1300 | 0 | 200 |

**Table 6.10: export (to Uzbekistan/2) power reductions in case of outages**

Again, this table shows that the connection to SUGHD is the weak part of the system; for this particular case, also the loss of the line REGAR-DUSHANBE leads to a significant export power reduction.

## 6.7 Horizon year 2031 and Rogun HPP with 2800 MW rated power and network reinforcement

In this year, the peak load demand is expected to be about 5,948 MW; considering also the losses, the generation is about 6,113 MW, whilst the total installed capacity is about 7,901 MW. In case of complete availability of all the generators, it could already be possible to export about 1,650 MW.

The following pictures show that it is really possible to export such amounts, being the 500 kV transmission grid adequate for these export activities. The following pictures fig. 6.14 to fig. 6.18 show the cases of 1,300 MW export to Afghanistan, 500 MW export to Kyrgyzstan, 1,200 MW and 1,300 MW export to Uzbekistan through the two different solutions and a “global” case where a total of max 1,650 MW are exported to these countries (750, 400 and 500 MW respectively).

In all the cases the transmission is fully possible, even if the Tajik 500 kV system is overloaded or the voltage values of the busbars go beyond ±5% of the rated voltage or, in a few busbar, are above the latter value but without exceeding ±10%. An optimal reactive power calculation should be performed to improve the voltage profiles and to reduce the losses, but this is meaningful only with true and final data of all the connections.

The following possible critical aspect should be taken into account, about the reactive power exchange.

As already described above, the connection to Kyrgyzstan has limitations, due the weakness of the AC transmission system in that area of Tajikistan and its need of reactive power. The reactors of the 500 kV line L-518 from Dushanbe to Sughd have to be disconnected in order to obtain a feasible operational condition.

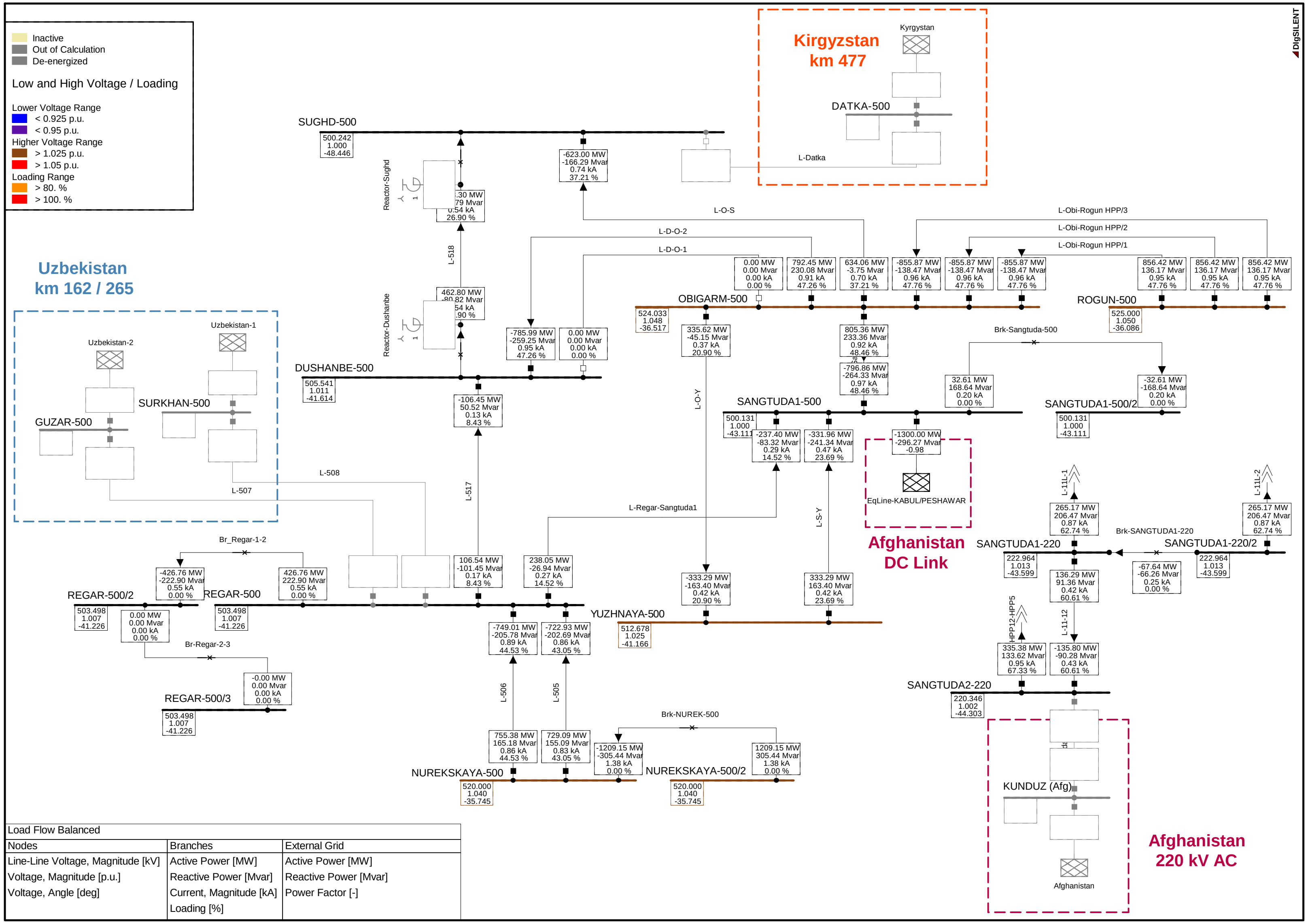



fig. 6.14: horizon year 2031, peak load, ROGUN HPP at max 2800 MW, export of 1300 MW to Afghanistan

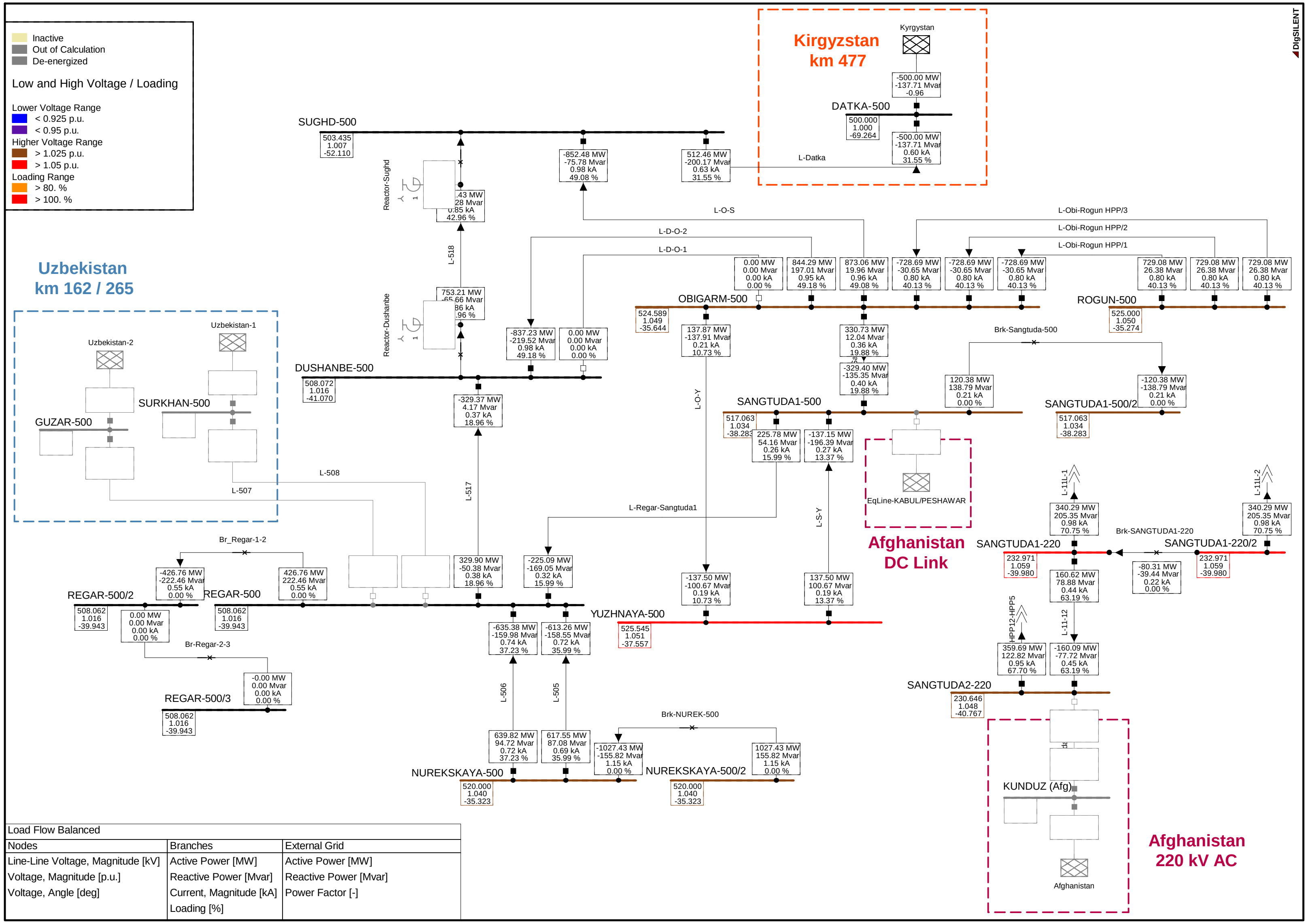



**fig. 6.15: horizon year 2031, peak load, ROGUN HPP at max 2800 MW, export of 500 MW to Kirgizstan**

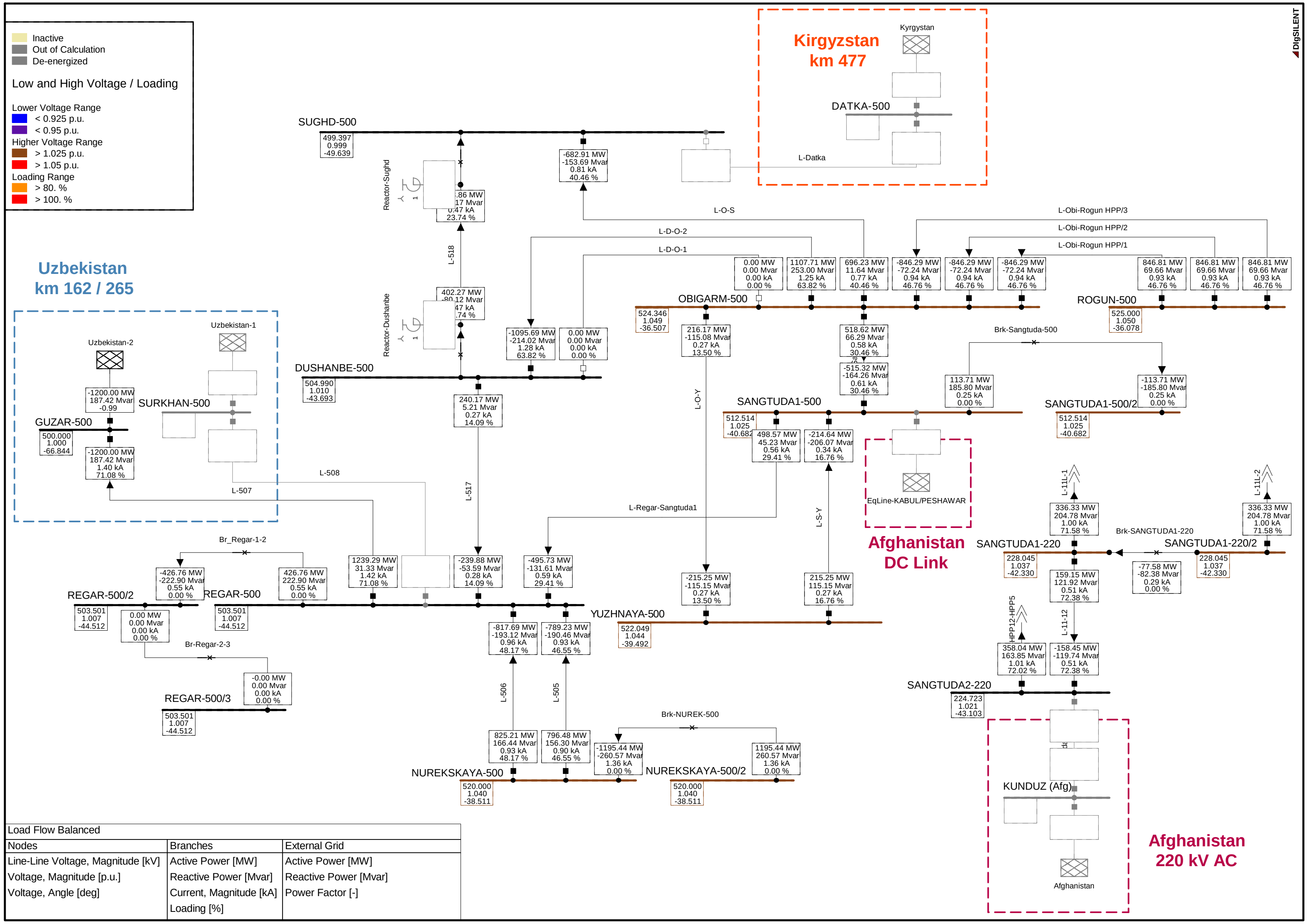



**fig. 6.16: horizon year 2031, peak load, ROGUN HPP at max 2800 MW, export of 1200 MW to Uzbekistan (sol. 1)**

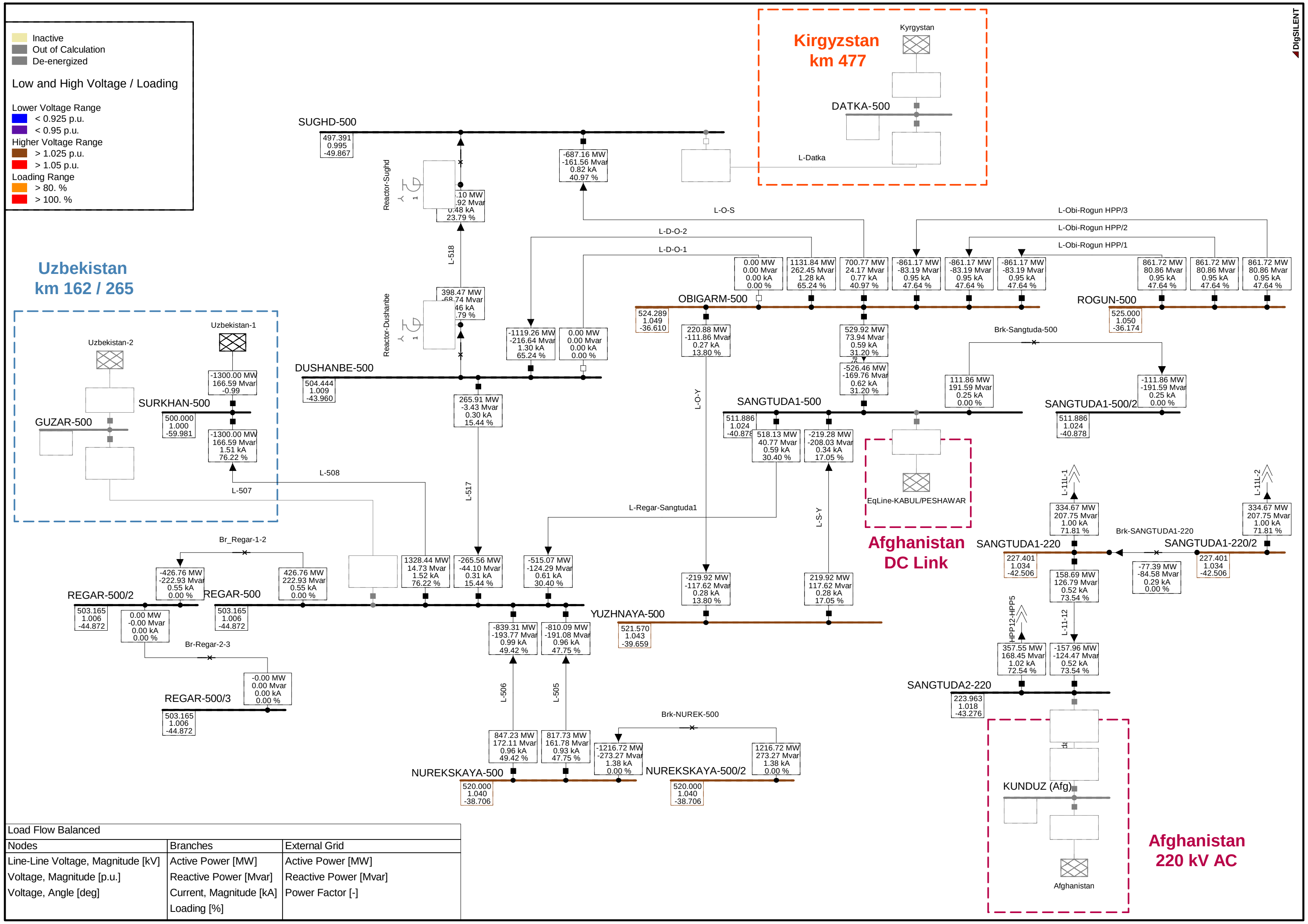



**fig. 6.17: horizon year 2031, peak load, ROGUN HPP at max 2800 MW, export of 1300 MW to Uzbekistan (sol. 2)**

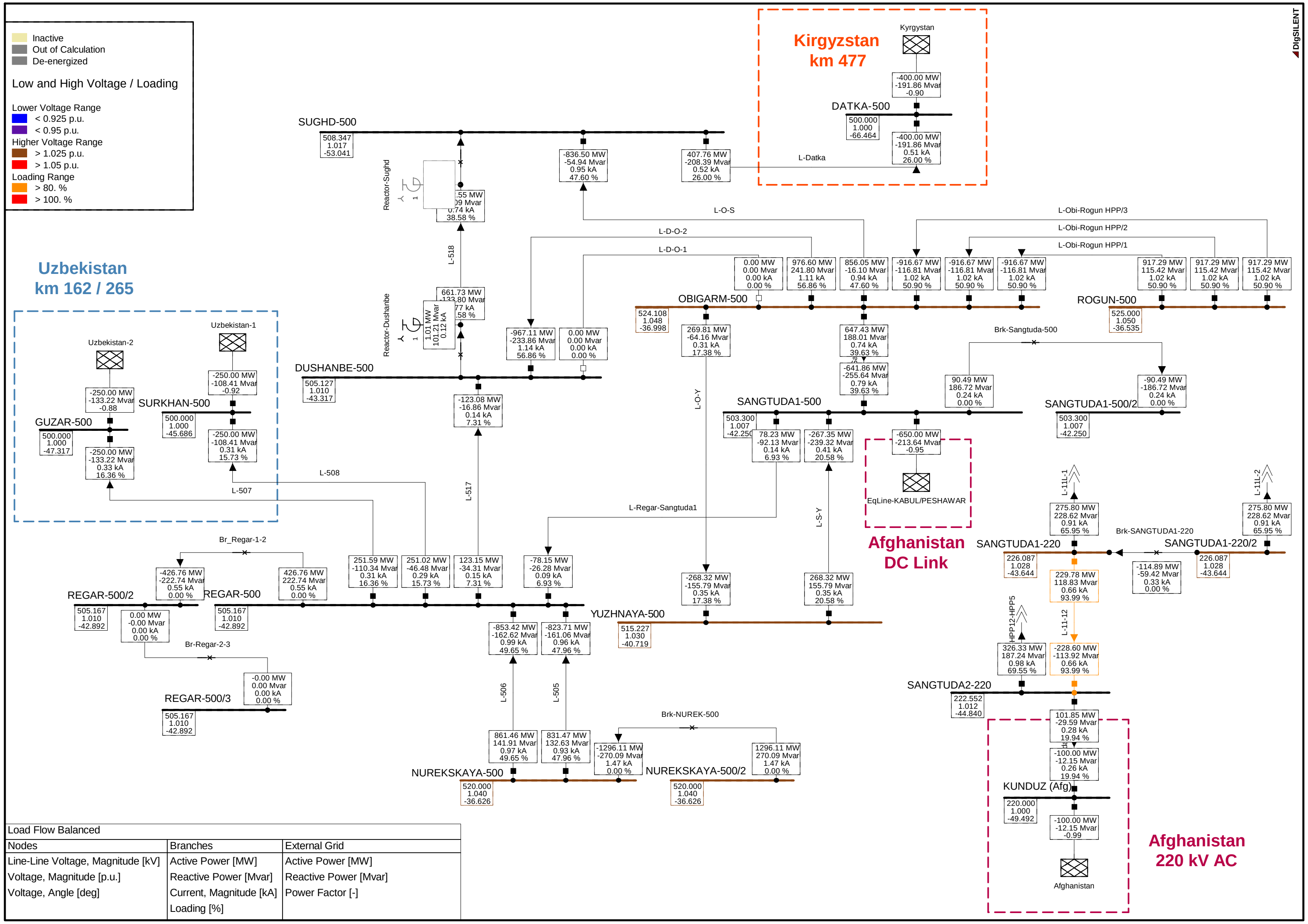



**fig. 6.18: horizon year 2031, peak load, ROGUN HPP at max 2800 MW, export of 2300 MW to the neighbouring countries**

In the other case of single-country export the reactive power situation is as follows:

- with Afghanistan: no reactive power is required from Afghan side. The Tajik system can provide the needed 296 Mvar in SANGTUDA-1, with an assumed cosphi equal to 0.95 for the AC/DC converter.
- with Kirgizstan, to Datka: Kirgizstan will receive about 137 Mvar from the connection line, while other 200 Mvar will be provided from the line to the Tajik system (that needs this reactive power support).
- with Uzbekistan, to SURKHAN: Uzbekistan is requested to produce 167 Mvar, the other needed 14 Mvar are provided from Tajik system.
- with Uzbekistan, to GUZAR: Uzbekistan is requested to produce 187 Mvar, the other needed 31 Mvar are provided from Tajik system.

As already described above, the connection to Kyrgyzstan has limitations, due the weakness of the AC transmission system in that area of Tajikistan and its need of reactive power. The reactors of the 500 kV line L-518 from Dushanbe to Sughd have to be disconnected in order to obtain a feasible operational condition.

### *6.7.1 N-1 analysis with Export connections*

In case of 2,800 MW max power of Rogun HPP, there are only minor differences in the outages on the 500 kV system when there is no export to other countries. In fact, the 500 kV system is just helping the 220 kV system to support the load, which is unchanged. Detailed results are not reported.

More interesting are the cases of outages in case of export to the neighbouring countries.

The considered cases are: 1,300 MW export to Afghanistan, 500 MW export to Kirgizstan, 1,300 MW export to Uzbekistan via SURKHAN, 1,200 MW export to Uzbekistan via GUZAR.

Scope of the analysis is to determine if some outage case lead to the impossibility of export any power, or if an export power reduction could be sufficient to come back within acceptable working condition, without any overload.

The results can be summarized as follows:

#### *6.7.1.1 1300 MW export to Afghanistan*

In this case the outages of the lines DUSHAMBE-SUGHD, OBIGARM-SUGHD and of the DUSHANBE-OBIGARM, lead to the complete collapse of the system.

Note: The outages of the lines L-505 and L-506 REGAR-NURESKAYA leads to the overload of the other line, also in case of reduced export.

| Export connection from SANGTUDA-1 to Afghanistan DC link | | | | | |
|---|---|---|---|---|---|
| **Outage Line** | **Station 1** | **Station 2** | **Pexp** | **1: Violations** | **Reduction** |
| | | | **MW** | **0: No violations** | **MW** |
| L-517 | REGAR | DUSHANBE | 900 | 0 | 400 |
| L-518 | DUSHANBE | SUGHD | LF Failed | | |
| L-505 | REGAR | NUREKSKAYA | 0 | 1 | 1300 |
| L-506 | REGAR | NUREKSKAYA | 0 | 1 | 1300 |
| L-Obi-Sangtuda | OBIGARM | SANGTUDA-1 | 350 | 0 | 950 |
| L-O-S | OBIGARM | SUGHD | LF Failed | | |
| L-O-Y | OBIGARM | YUZHNAYA | 750 | 0 | 550 |
| L-S-Y | SANGTUDA-1 | YUZHNAYA | 650 | 0 | 650 |
| L-Regar-Sangtuda1 | REGAR | SANGTUDA-1 | 850 | 0 | 450 |
| L-D-O-2 | DUSHANBE | OBIGARM | LF Failed | | |
| L-Obi-Rogun HPP/1 | OBIGARM | ROGUN HPP | 1050 | 0 | 250 |
| L-Obi-Rogun HPP/2 | OBIGARM | ROGUN HPP | 1050 | 0 | 250 |
| L-Obi-Rogun HPP/3 | OBIGARM | ROGUN HPP | 1050 | 0 | 250 |

**Table 6.11: export (to Afghanistan) power reductions in case of outages**

### *6.7.1.2 1500 MW export to Kirgizstan*

In this case almost all the outages require some reduction of the export power.

The outages of the lines DUSHAMBE-SUGHD and OBIGARM-SUGHD, lead to the complete collapse of the system.

In case of the loss of the line DUSHANBE-OBIGARM and REGAR-NUREKSKAYA, it is necessary to reduce the export to 0 MW (total reduction of 500 MW), but some elements are still in overload.

In all the other cases the reduction is much smaller. This table summarizes all the outages:

| Export connection from SUGHD to DATKA (Kyrgyzstan) | | | | | |
|---|---|---|---|---|---|
| **Outage Line** | **Station 1** | **Station 2** | **Pexp** | **1: Violations** | **Reduction** |
| | | | **MW** | **0: No violations** | **MW** |
| L-517 | REGAR | DUSHANBE | 150 | 0 | 350 |
| L-518 | DUSHANBE | SUGHD | LF Failed | | |
| L-505 | REGAR | NUREKSKAYA | 0 | 1 | 500 |
| L-506 | REGAR | NUREKSKAYA | 0 | 1 | 500 |
| L-Obi-Sangtuda | OBIGARM | SANGTUDA-1 | 500 | 0 | 0 |
| L-O-S | OBIGARM | SUGHD | LF Failed | | |
| L-O-Y | OBIGARM | YUZHNAYA | 500 | 0 | 0 |
| L-S-Y | SANGTUDA-1 | YUZHNAYA | 500 | 0 | 0 |
| L-Regar-Sangtuda1 | REGAR | SANGTUDA-1 | 450 | 0 | 50 |
| L-D-O-2 | DUSHANBE | OBIGARM | 0 | 1 | 500 |
| L-Obi-Rogun HPP/1 | OBIGARM | ROGUN HPP | 500 | 0 | 0 |
| L-Obi-Rogun HPP/2 | OBIGARM | ROGUN HPP | 500 | 0 | 0 |
| L-Obi-Rogun HPP/3 | OBIGARM | ROGUN HPP | 500 | 0 | 0 |

**Table 6.12: export (to Kyrgyzstan) power reductions in case of outages**

Again, this table shows that the connection to SUGHD is the weak part of the system.

### *6.7.1.3 1300 MW export to Uzbekistan, via SURKHAN*

In this case some outages require some reduction of the export power, and there are three cases of system collapse, as in the base case (DUSHANBE-SUGHD, OBIGARM-SUGHD and DUSHANBE-OBIGARM).

In case of the loss of the line L-506 REGAR-NUREKSKAYA, it is necessary to reduce the export to 0 MW (total reduction of 1300 MW), but some elements are still in overload.

This table summarizes all the outages:

| Export connection from REGAR to SURKAN (Uzbekistan) | | | | | |
|---|---|---|---|---|---|
| **Outage Line** | **Station 1** | **Station 2** | **Pexp** | **1: Violations** | **Reduction** |
| | | | **MW** | **0: No violations** | **MW** |
| L-517 | REGAR | DUSHANBE | 750 | 0 | 550 |
| L-518 | DUSHANBE | SUGHD | LF Failed | | |
| L-505 | REGAR | NUREKSKAYA | 450 | 0 | 850 |
| L-506 | REGAR | NUREKSKAYA | 0 | 1 | 1300 |
| L-508 | REGAR | SURKHAN | 1300 | 0 | 0 |
| L-Obi-Sangtuda | OBIGARM | SANGTUDA-1 | 650 | 0 | 650 |
| L-O-S | OBIGARM | SUGHD | LF Failed | | |
| L-O-Y | OBIGARM | YUZHNAYA | 1000 | 0 | 300 |
| L-S-Y | SANGTUDA-1 | YUZHNAYA | 950 | 0 | 350 |
| L-Regar-Sangtuda1 | REGAR | SANGTUDA-1 | 600 | 0 | 700 |
| L-D-O-2 | DUSHANBE | OBIGARM | LF Failed | | |
| L-Obi-Rogun HPP/1 | OBIGARM | ROGUN HPP | 1200 | 0 | 100 |
| L-Obi-Rogun HPP/2 | OBIGARM | ROGUN HPP | 1200 | 0 | 100 |
| L-Obi-Rogun HPP/3 | OBIGARM | ROGUN HPP | 1200 | 0 | 100 |

**Table 6.13: export (to Uzbekistan/1) power reductions in case of outages**

#### *6.7.1.4 1200 MW export to Uzbekistan, via GUZAR*

In this case some outages require some reduction of the export power, and there are three cases of system collapse, as in the base case (DUSHANBE-SUGHD, OBIGARM-SUGHD and DUSHANBE-OBIGARM). This table summarizes all the outages:

| Export connection from REGAR to GUZAR (Uzbekistan) | | | | | |
|---|---|---|---|---|---|
| **Outage Line** | **Station 1** | **Station 2** | **Pexp** | **1: Violations** | **Reduction** |
| | | | **MW** | **0: No violations** | **MW** |
| L-517 | REGAR | DUSHANBE | 750 | 0 | 450 |
| L-518 | DUSHANBE | SUGHD | LF Failed | | |
| L-505 | REGAR | NUREKSKAYA | 550 | 0 | 650 |
| L-506 | REGAR | NUREKSKAYA | 550 | 0 | 650 |
| L-507 | REGAR | GUZAR | 1200 | 0 | 0 |
| L-Obi-Sangtuda | OBIGARM | SANGTUDA-1 | 700 | 0 | 500 |
| L-O-S | OBIGARM | SUGHD | LF Failed | | |
| L-O-Y | OBIGARM | YUZHNAYA | 1000 | 0 | 200 |
| L-S-Y | SANGTUDA-1 | YUZHNAYA | 950 | 0 | 250 |
| L-Regar-Sangtuda1 | REGAR | SANGTUDA-1 | 650 | 0 | 550 |
| L-D-O-2 | DUSHANBE | OBIGARM | LF Failed | | |
| L-Obi-Rogun HPP/1 | OBIGARM | ROGUN HPP | 1150 | 0 | 50 |
| L-Obi-Rogun HPP/2 | OBIGARM | ROGUN HPP | 1150 | 0 | 50 |
| L-Obi-Rogun HPP/3 | OBIGARM | ROGUN HPP | 1150 | 0 | 50 |

**Table 6.14: export (to Uzbekistan/2) power reductions in case of outages**

## 6.8 Horizon year 2031 and Rogun HPP with 2000 MW rated power and network reinforcement

In this year, the peak load demand is expected to be about 5,948 MW; considering also the losses, the generation is about 6,111 MW, whilst the total installed capacity is about 7,099 MW. In case of complete availability of all the generators, it could already be possible to export about 900 MW.

The following pictures show that it is really possible to export such amounts, being the 500 kV transmission grid adequate for these export activities. The following pictures fig. 6.14 to fig. 6.18 show the cases of 700 MW export to Afghanistan, 500 MW export to Kirgizstan, 900 MW export to Uzbekistan through the two different solutions and a “global” case where a total of max 900 MW are exported to these countries (400, 200 and 300 MW respectively).

In all the cases the transmission is fully possible even if the Tajik 500 kV is overloaded or the voltage values of the busbars go beyond ±5% of the rated voltage.

The following possible critical aspect should be taken into account, about the reactive power exchange. As already described above, the connection to Kyrgyzstan has limitations, due the weakness of the AC transmission system in that area of Tajikistan and its need of reactive power. The reactors of the 500 kV line L-518 from Dushanbe to Sughd have to be disconnected in order to obtain a feasible operational condition.

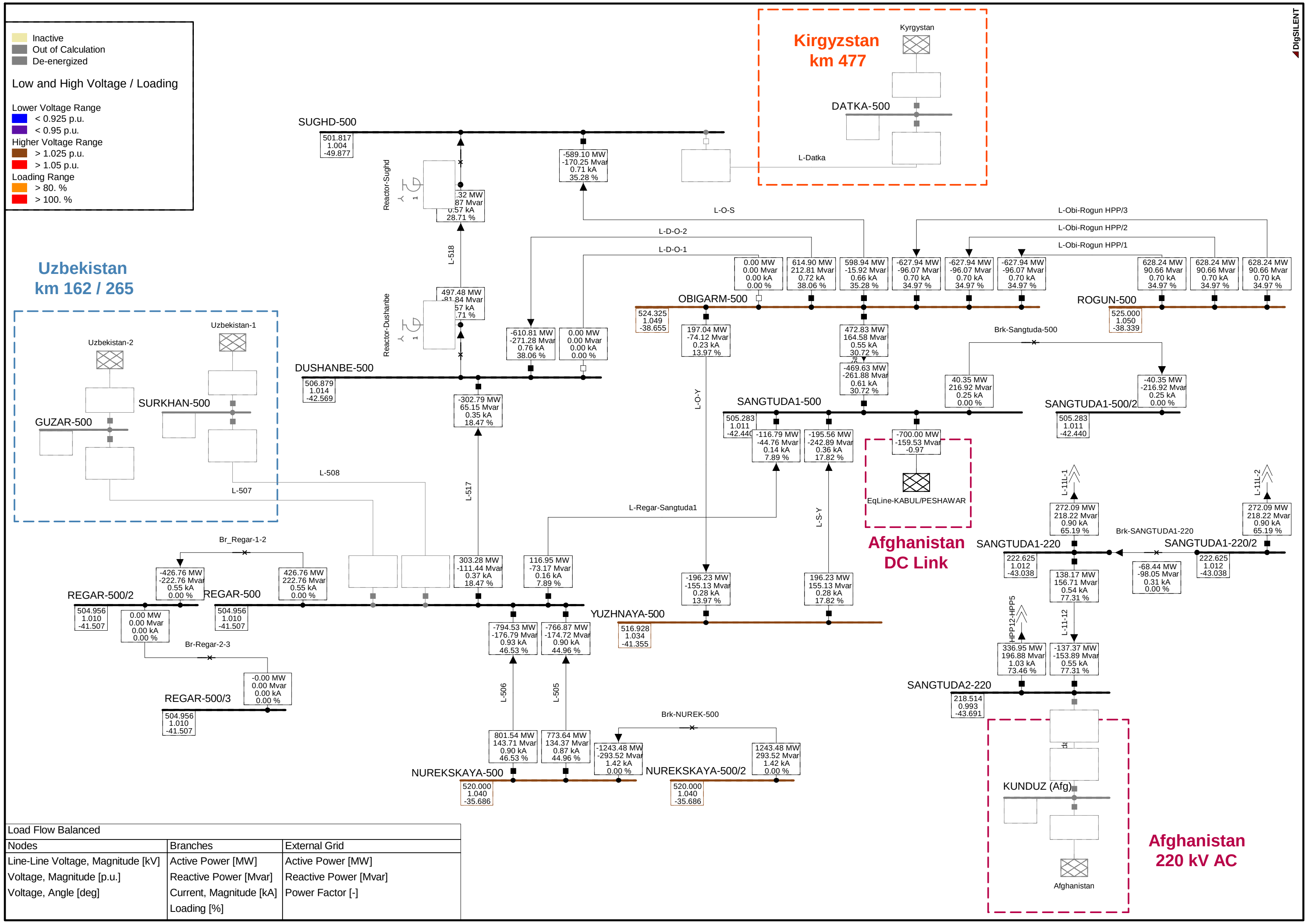


fig. 6.19: horizon year 2031, peak load, ROGUN HPP at max 2000 MW, export of 700 MW to Afghanistan

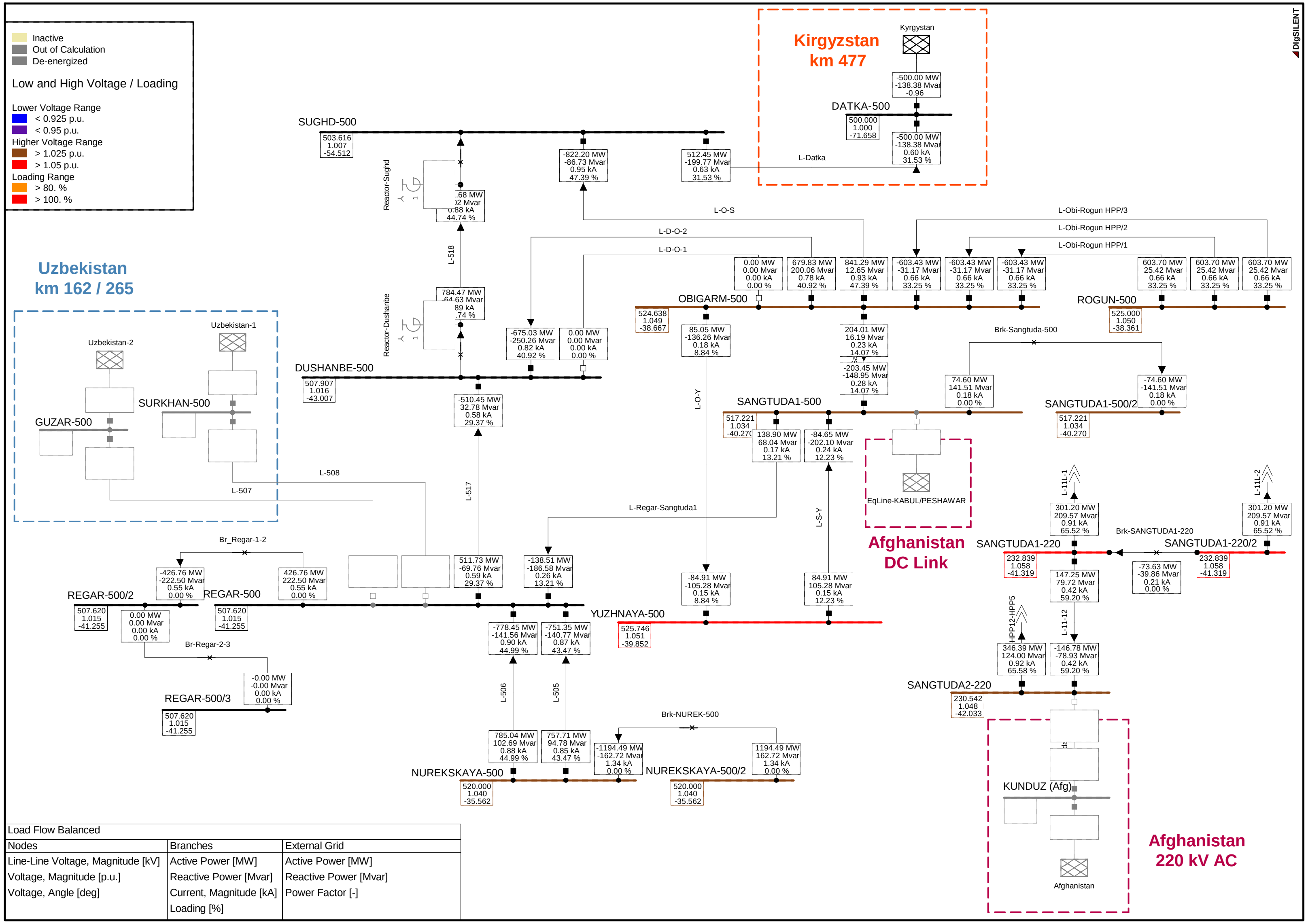



**fig. 6.20: horizon year 2031, peak load, ROGUN HPP at max 2000 MW, export of 500 MW to Kirgizstan**

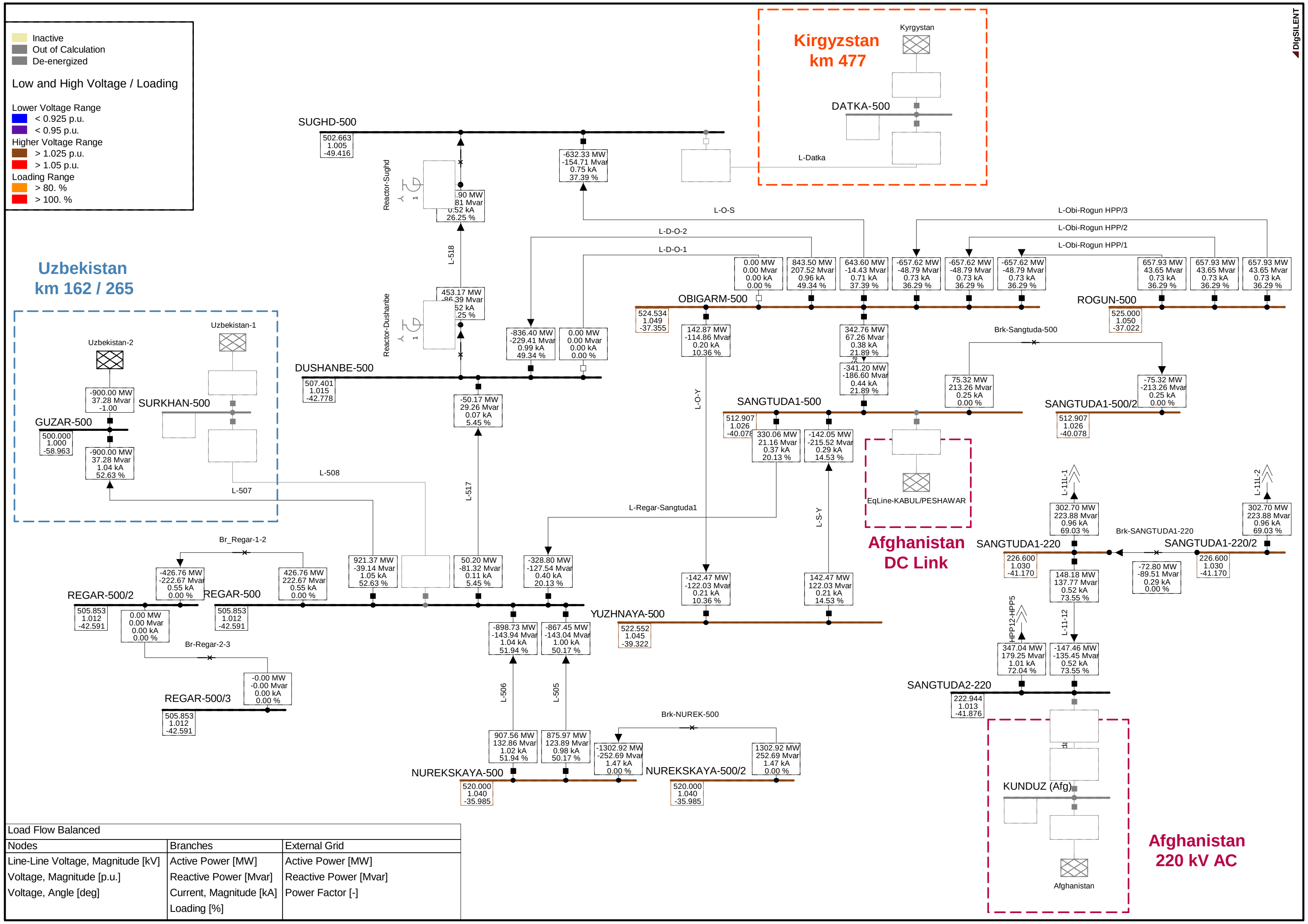



**fig. 6.21: horizon year 2031, peak load, ROGUN HPP at max 2000 MW, export of 900 MW to Uzbekistan (sol. 1)**

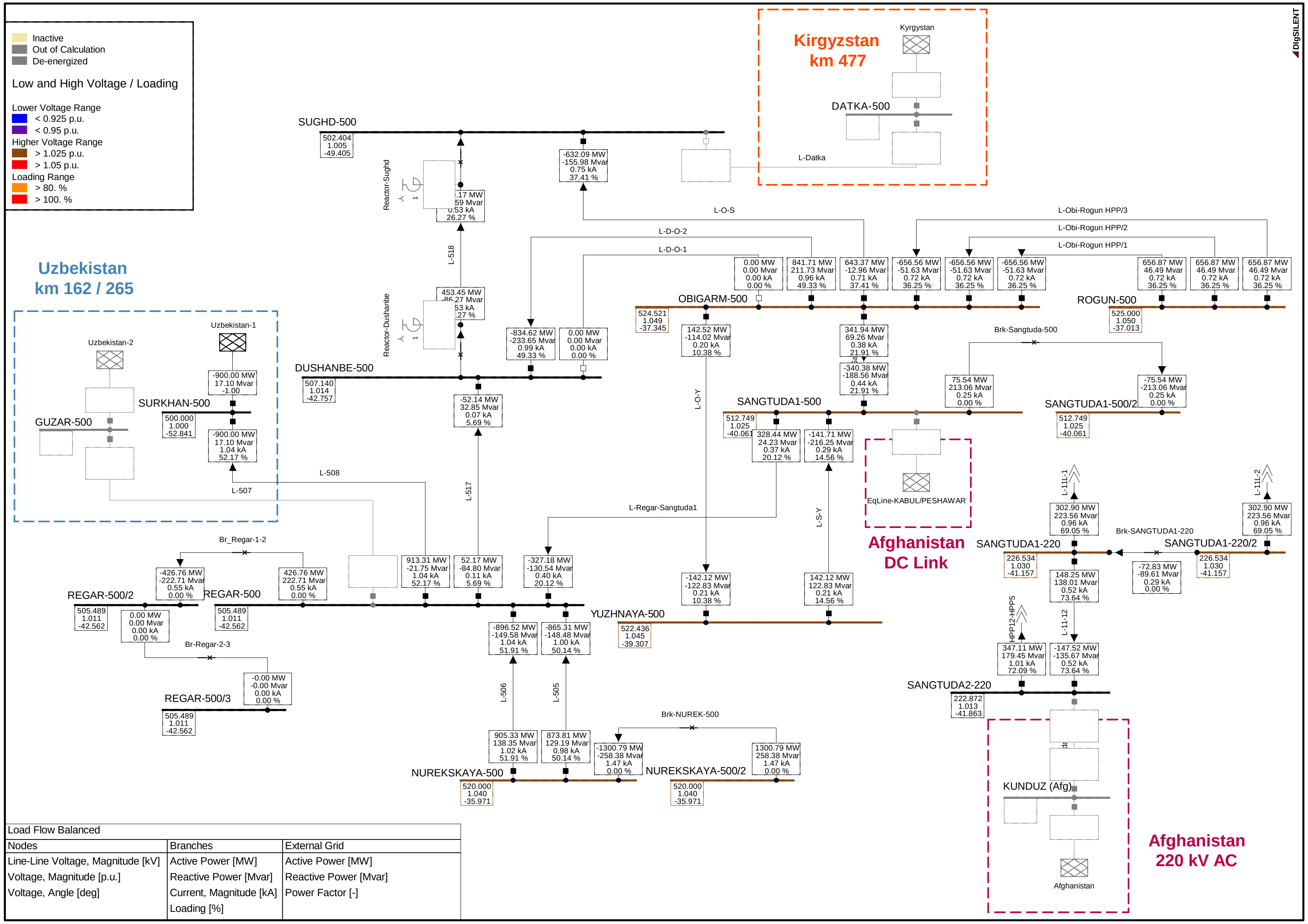



**fig. 6.22: horizon year 2031, peak load, ROGUN HPP at max 2000 MW, export of 900 MW to Uzbekistan (sol. 2)**

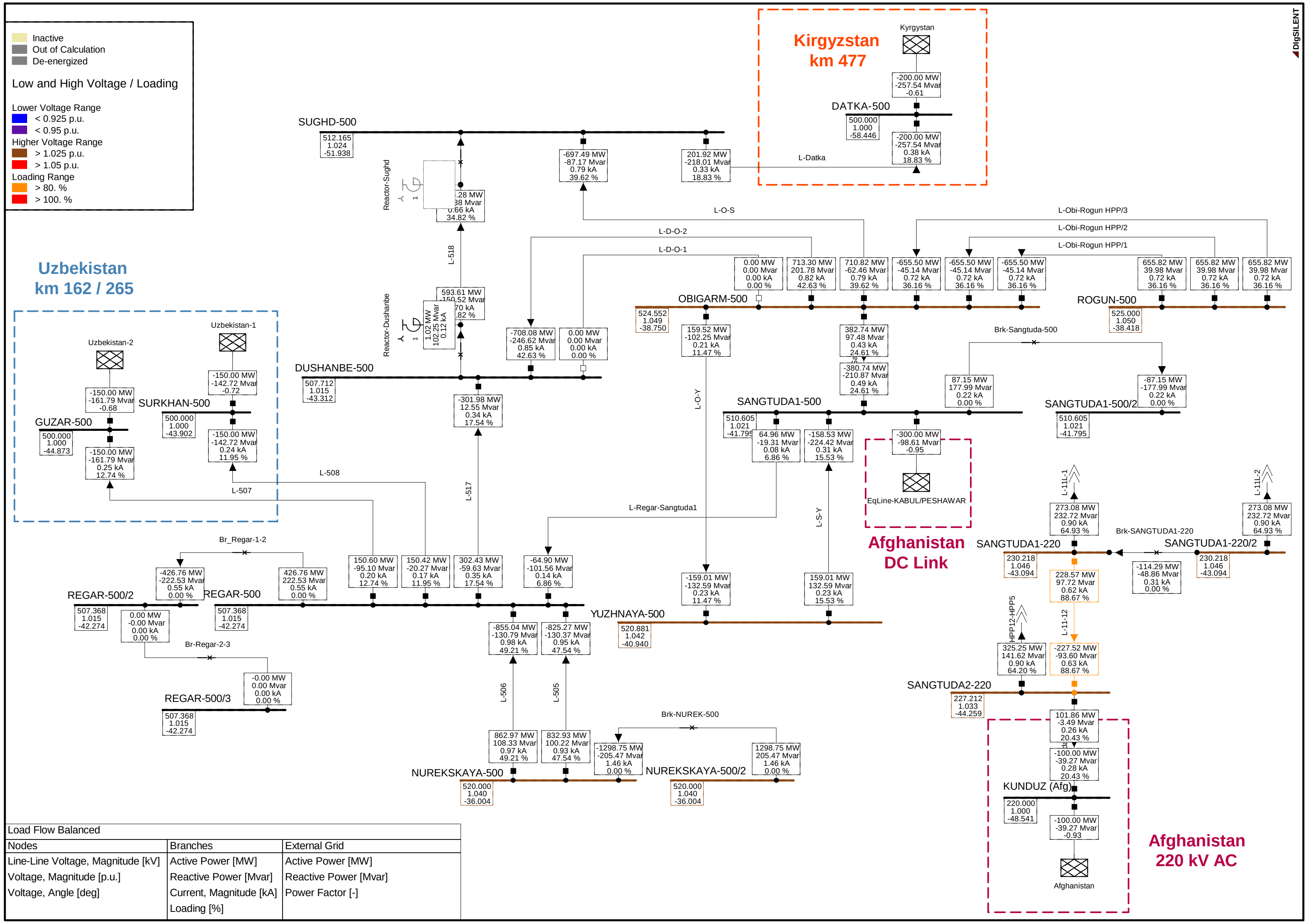



**fig. 6.23: horizon year 2031, peak load, ROGUN HPP at max 2000 MW, export of 900 MW to the neighbouring countries**

In the other case of single-country export the reactive power situation is as follows:

- with Afghanistan: no reactive power is required from Afghan side. The Tajik system can provide the needed 160 Mvar in SANGTUDA-1, with an assumed cosphi equal to 0.95 for the AC/DC converter.
- with Kirgizstan, to Datka: Kirgizstan will receive about 138 Mvar from the connection line, while other 200 Mvar will be provided from the line to the Tajik system (that needs this reactive power support).
- with Uzbekistan, to SURKHAN: Uzbekistan is requested to produce 17 Mvar.
- with Uzbekistan, to GUZAR: Uzbekistan is requested to produce 37 Mvar, the other 39 Mvar are absorbed from the Tajik system.

As already described above, the connection to Kyrgyzstan has limitations, due the weakness of the AC transmission system in that area of Tajikistan and its need of reactive power. The reactors of the 500 kV line L-518 from Dushanbe to Sughd have to be disconnected in order to obtain a feasible operational condition.

## 6.8.1 N-1 analysis with Export connections

In case of 2,000 MW max power of Rogun HPP, there are only minor differences in the outages on the 500 kV system when there is no export to other countries. In fact, the 500 kV system is just helping the 220 kV system to support the load, which is unchanged. Detailed results are not reported.

More interesting are the cases of outages in case of export to the neighbouring countries.

The considered cases are: 700 MW export to Afghanistan, 500 MW export to Kirgizstan, 900 MW export to Uzbekistan via SURKHAN, 900 MW export to Uzbekistan via GUZAR.

Scope of the analysis is to determine if some outage case leads to the impossibility of export any power, or if an export power reduction could be sufficient to come back within acceptable working condition, without any overload.

The results can be summarized as follows:

### 6.8.1.1 900 MW export to Afghanistan

In this case the outages of the lines DUSHAMBE-SUGHD, REGAR-NUEREKSKAYA, OBIGARM-SUGHD and DUSHANBE-OBIGARM, lead to the complete collapse of the system.

If the outage occurs on one of the lines REGAR-DUSHANBE, there are some overloads on the 220 kV transmission system, that are anyway not eliminated by the reduction of the export power, but that could be reduced by a re-scheduling of the active power production.

| Export connection from SANGTUDA-1 to Afghanistan DC link | | | | | |
|---|---|---|---|---|---|
| **Outage Line** | **Station 1** | **Station 2** | **Pexp** | **1: Violations** | **Reduction** |
| | | | **MW** | **0: No violations** | **MW** |
| L-517 | REGAR | DUSHANBE | 0 | 1 | 700 |
| L-518 | DUSHANBE | SUGHD | LF Failed | | |
| L-505 | REGAR | NUREKSKAYA | LF Failed | | |
| L-506 | REGAR | NUREKSKAYA | LF Failed | | |
| L-Obi-Sangtuda | OBIGARM | SANGTUDA-1 | 50 | 0 | 650 |
| L-O-S | OBIGARM | SUGHD | LF Failed | | |
| L-O-Y | OBIGARM | YUZHNAYA | 350 | 0 | 350 |
| L-S-Y | SANGTUDA-1 | YUZHNAYA | 200 | 0 | 500 |
| L-Regar-Sangtuda1 | REGAR | SANGTUDA-1 | 500 | 0 | 200 |
| L-D-O-2 | DUSHANBE | OBIGARM | LF Failed | | |
| L-Obi-Rogun HPP/1 | OBIGARM | ROGUN HPP | 550 | 0 | 150 |
| L-Obi-Rogun HPP/2 | OBIGARM | ROGUN HPP | 550 | 0 | 150 |
| L-Obi-Rogun HPP/3 | OBIGARM | ROGUN HPP | 550 | 0 | 150 |

**Table 6.15: export (to Afghanistan) power reductions in case of outages**

### *6.8.1.2 500 MW export to Kyrgyzstan*

The case of the loss of the lines DUSHANBE-SUGHD and OBIGARM-SUGHD leads to the complete collapse of the system.

If the outage occurs on the lines REGAR-DUSHANBE, REGAR-NUREKSKAYA, DUSHANBE-OBIGARM, there are some overloads on the 220 kV transmission system, that are anyway not eliminated by the reduction of the export power, but that could be reduced by a re-scheduling of the active power production.

| Export connection from SUGHD to DATKA (Kyrgyzstan) | | | | | |
|---|---|---|---|---|---|
| **Outage Line** | **Station 1** | **Station 2** | **Pexp** | **1: Violations** | **Reduction** |
| | | | **MW** | **0: No violations** | **MW** |
| L-517 | REGAR | DUSHANBE | 0 | 1 | 500 |
| L-518 | DUSHANBE | SUGHD | LF Failed | | |
| L-505 | REGAR | NUREKSKAYA | 0 | 1 | 500 |
| L-506 | REGAR | NUREKSKAYA | 0 | 1 | 500 |
| L-Obi-Sangtuda | OBIGARM | SANGTUDA-1 | 500 | 0 | 0 |
| L-O-S | OBIGARM | SUGHD | LF Failed | | |
| L-O-Y | OBIGARM | YUZHNAYA | 500 | 0 | 0 |
| L-S-Y | SANGTUDA-1 | YUZHNAYA | 500 | 0 | 0 |
| L-Regar-Sangtuda1 | REGAR | SANGTUDA-1 | 450 | 0 | 50 |
| L-D-O-2 | DUSHANBE | OBIGARM | 0 | 1 | 500 |
| L-Obi-Rogun HPP/1 | OBIGARM | ROGUN HPP | 500 | 0 | 0 |
| L-Obi-Rogun HPP/2 | OBIGARM | ROGUN HPP | 500 | 0 | 0 |
| L-Obi-Rogun HPP/3 | OBIGARM | ROGUN HPP | 500 | 0 | 0 |

**Table 6.16: export (to Kyrgyzstan) power reductions in case of outages**

### *6.8.1.3 900 MW export to Uzbekistan, via SURKHAN*

In this case there are three cases of system collapse, as in the base case (OBIGARM-SUGHD, DUSHANBE-SUGHD and DUSHANBE-OBIGARM).

If the outage occurs on line L-505 or L-506 REGAR-NUREKSKAYA, there are some overloads on the 500 kV and 220 kV transmission systems, that are anyway not eliminated by the reduction of the export power, but that could be reduced by a re-scheduling of the active power production.

| Export connection from REGAR to SURKAN (Uzbekistan) | | | | | |
|---|---|---|---|---|---|
| **Outage Line** | **Station 1** | **Station 2** | **Pexp** | **1: Violations** | **Reduction** |
| | | | **MW** | **0: No violations** | **MW** |
| L-517 | REGAR | DUSHANBE | 900 | 0 | 0 |
| L-518 | DUSHANBE | SUGHD | LF Failed | | |
| L-505 | REGAR | NUREKSKAYA | 0 | 1 | 900 |
| L-506 | REGAR | NUREKSKAYA | 0 | 1 | 900 |
| L-508 | REGAR | SURKHAN | 900 | 0 | 0 |
| L-Obi-Sangtuda | OBIGARM | SANGTUDA-1 | 250 | 0 | 650 |
| L-O-S | OBIGARM | SUGHD | LF Failed | | |
| L-O-Y | OBIGARM | YUZHNAYA | 800 | 0 | 100 |
| L-S-Y | SANGTUDA-1 | YUZHNAYA | 550 | 0 | 350 |
| L-Regar-Sangtuda1 | REGAR | SANGTUDA-1 | 800 | 0 | 100 |
| L-D-O-2 | DUSHANBE | OBIGARM | LF Failed | | |
| L-Obi-Rogun HPP/1 | OBIGARM | ROGUN HPP | 900 | 0 | 0 |
| L-Obi-Rogun HPP/2 | OBIGARM | ROGUN HPP | 900 | 0 | 0 |
| L-Obi-Rogun HPP/3 | OBIGARM | ROGUN HPP | 900 | 0 | 0 |

**Table 6.17: export (to Uzbekistan/1) power reductions in case of outages**

#### *6.8.1.4 900 MW export to Uzbekistan, via GUZAR*

In this case there are three cases of system collapse, as in the base case (OBIGARM-SUGHD, DUSHANBE-SUGHD and DUSHANBE-OBIGARM).

If the outage occurs on line L-505 or L-506 REGAR-NUREKSKAYA, there are some overloads on the 500 kV and 220 kV transmission systems, that are anyway not eliminated by the reduction of the export power, but that could be reduced by a re-scheduling of the active power production.

| Export connection from REGAR to GUZAR (Uzbekistan) | | | | | |
|---|---|---|---|---|---|
| **Outage Line** | **Station 1** | **Station 2** | **Pexp** | **1: Violations** | **Reduction** |
| | | | **MW** | **0: No violations** | **MW** |
| L-517 | REGAR | DUSHANBE | 900 | 0 | 0 |
| L-518 | DUSHANBE | SUGHD | LF Failed | | |
| L-505 | REGAR | NUREKSKAYA | 0 | 1 | 900 |
| L-506 | REGAR | NUREKSKAYA | 0 | 1 | 900 |
| L-507 | REGAR | GUZAR | 900 | 0 | 0 |
| L-Obi-Sangtuda | OBIGARM | SANGTUDA-1 | 300 | 0 | 600 |
| L-O-S | OBIGARM | SUGHD | LF Failed | | |
| L-O-Y | OBIGARM | YUZHNAYA | 800 | 0 | 100 |
| L-S-Y | SANGTUDA-1 | YUZHNAYA | 600 | 0 | 300 |
| L-Regar-Sangtuda1 | REGAR | SANGTUDA-1 | 850 | 0 | 50 |
| L-D-O-2 | DUSHANBE | OBIGARM | LF Failed | | |
| L-Obi-Rogun HPP/1 | OBIGARM | ROGUN HPP | 900 | 0 | 0 |
| L-Obi-Rogun HPP/2 | OBIGARM | ROGUN HPP | 900 | 0 | 0 |
| L-Obi-Rogun HPP/3 | OBIGARM | ROGUN HPP | 900 | 0 | 0 |

**Table 6.18: export (to Uzbekistan/2) power reductions in case of outages**

## 6.9 Reinforcements summary

As described above, the growth load requires the reinforcement of the existing Tajik 220 kV transmission system. The most adequate reinforcement choices would require to know the exact sharing of the load growth among the various load centers, the location of possible new load centers (that are probably not yet foreseen nowadays) and the activation of true network planning studies, to be updated frequently, including OPF/ORPF studies (Optimal Active/Reactive Power Flows), that are possible only when the above information were available.

The reinforcements actions adopted in this study are therefore an approximation of what would be really required, implemented with the purpose of having proper load-flow cases running without violation, based on the information nowadays available. The mentioned violations refer to the lines and transformers loading and bus voltages.

The following table reports the already programmed (by Barki Tojik) and additionally proposed (from the results of this study) reinforcements for the 220 kV system, the load transformers plus some 500/220 kV transformer.

The proposed reinforcements are basically related to the growth of the load demand within the Country. In the case of Rogun capacity lower than the maximum, the effect is principally a reduction of the export.

| Year | Item | Rogun Power [MW] | Identification | Vn [kV] | From Station | To Station | Reinforcement action |
|---|---|---|---|---|---|---|---|
| 2011 | Line | - | L-S-I | 220 | SUGHD | T_Shahristan | Programmed (*) |
| 2011 | Line | - | L-S-I(1) | 220 | T_Shahristan | AINI | Programmed (*) |
| 2013 | 3 W. Transf. | - | TR-BUSTON-2 | 230 | BUSTON | | capability increased of 33% |
| 2013 | 3 W. Transf. | - | TR-DJANGAL-1 | 230 | DJANGAL | | element duplicated |
| 2013 | 3 W. Transf. | - | TR-DJANGAL-2 | 230 | DJANGAL | | element duplicated |
| 2013 | 3 W. Transf. | - | TR-GOLOVNAYA-1 | 242 | GOLOVNAYA | | element duplicated |
| 2013 | 3 W. Transf. | - | TR-GOLOVNAYA-2 | 242 | GOLOVNAYA | | element duplicated |
| 2013 | 3 W. Transf. | - | TR-NOVAYA-1 | 230 | NOVAYA | | capability increased of 33% |
| 2013 | 3 W. Transf. | - | TR-NOVAYA-2 | 230 | NOVAYA | | capability increased of 33% |
| 2013 | 3 W. Transf. | - | TR-ORJABAD-2-1 | 230 | ORJABAD-2 | | element duplicated |
| 2013 | 3 W. Transf. | - | TR-ORJABAD-2-2 | 230 | ORJABAD-2 | | element duplicated |
| 2013 | Line | - | L-11L-1 | 220 | LOLAZAR | SANGTUDA-1 | element duplicated |
| 2013 | Line | - | L-11L-2 | 220 | LOLAZAR | SANGTUDA-1 | element duplicated |
| 2013 | Line | - | L-24-KB/1 | 220 | KAYROKUM | T-Shurob-1 | element duplicated |
| 2013 | Line | - | L-24-KB/2 | 220 | T-Shurob-2 | KANIBADAM | element duplicated |
| 2013 | Line | - | L-7-02 | 220 | ORJABAD-2 | T_NUREK | element duplicated |
| 2013 | Line | - | L-7-02(1) | 220 | T_NUREK | NUREKSKAYA | element duplicated |
| 2013 | Line | - | L-7L | 220 | SEBISTAN | LOLAZAR | element duplicated |
| 2013 | Line | - | L-7-L | 220 | NUREKSKAYA | SEBISTAN | element duplicated |
| 2013 | Line | - | L-8D | 220 | DJANGAL | BAYPAZA | element duplicated |
| 2014 | Line | - | L-G-R | 220 | GERAN | RUMI | Programmed (*) |
| 2014 | Line | - | L-K-A | 220 | ASHT | KAYROKUM | Programmed (*) |
| 2016 | Line | - | L-24-KB/1 | 220 | T-Shurob-1 | KAYROKUM | Programmed (*) |
| 2016 | Line | - | L-24-KB/2 | 220 | T-Shurob-2 | KANIBADAM | Programmed (*) |
| 2016 | Line | - | L-KAN-S | 220 | T-Shurob-2 | SHUROBSKAYA | Programmed (*) |
| 2016 | Line | - | L-KAY-S | 220 | T-Shurob-1 | SHUROBSKAYA | Programmed (*) |
| 2020 | 3 W. Transf. | 400 | TR-BUSTON-2 | 230 | BUSTON | | element duplicated |
| 2020 | 3 W. Transf. | 400 | TR-GERAN-1 | 230 | GERAN | | capability increased of 33% |
| 2020 | 3 W. Transf. | 400 | TR-GERAN-2 | 230 | GERAN | | capability increased of 33% |
| 2020 | 3 W. Transf. | 400 | TR-KHATLON-1 | 230 | KHATLON | | capability increased of 33% |
| 2020 | 3 W. Transf. | 400 | TR-KHATLON-2 | 230 | KHATLON | | capability increased of 33% |
| 2020 | 3 W. Transf. | 400 | TR-KHUJAND-1 | 230 | KHUJAND | | capability increased of 33% |
| 2020 | 3 W. Transf. | 400 | TR-KHUJAND-2 | 230 | KHUJAND | | capability increased of 33% |
| 2020 | 3 W. Transf. | 400 | TR-KOLKHOZAB.-1 | 230 | KOLKHOZABAD | | capability increased of 33% |
| 2020 | 3 W. Transf. | 400 | TR-SEBISTAN-1 | 230 | SEBISTAN | | capability increased of 33% |
| 2020 | Line | 400 | L-10D | 220 | YATEC | DJANGAL | element duplicated |
| 2020 | Line | 400 | L-KAN-S | 220 | T-Shurob-2 | SHUROBSKAYA | element duplicated |
| 2020 | Line | 400 | L-KAY-S | 220 | T-Shurob-1 | SHUROBSKAYA | element duplicated |
| 2025 | 3 W. Transf. | 2000 | TR-DJANGAL-1 | 230 | DJANGAL | | capability increased of 33% |
| 2025 | 3 W. Transf. | 2000 | TR-DJANGAL-2 | 230 | DJANGAL | | capability increased of 33% |
| 2025 | 3 W. Transf. | 2000 | TR-KHATLON-1 | 230 | KHATLON | | element duplicated |
| 2025 | 3 W. Transf. | 2000 | TR-KHATLON-2 | 230 | KHATLON | | element duplicated |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2025 | 3 W. Transf. | 2000 | TR-KHUJAND-1 | 230 | KHUJAND | | element duplicated |
| 2025 | 3 W. Transf. | 2000 | TR-KHUJAND-2 | 230 | KHUJAND | | element duplicated |
| 2025 | 3 W. Transf. | 2000 | TR-LOLAZAR-1 | 230 | LOLAZAR | | capability increased of 33% |
| 2025 | 3 W. Transf. | 2000 | TR-LOLAZAR-2 | 230 | LOLAZAR | | capability increased of 33% |
| 2025 | 3 W. Transf. | 2000 | TR-NOVAYA-1 | 230 | NOVAYA | | element duplicated |
| 2025 | 3 W. Transf. | 2000 | TR-NOVAYA-2 | 230 | NOVAYA | | element duplicated |
| 2025 | 3 W. Transf. | 2000 | TR-PRYADILN.-1 | 230 | PRYADILNAYA | | capability increased of 33% |
| 2025 | 3 W. Transf. | 2000 | TR-RUMI-1 | 230 | RUMI | | capability increased of 33% |
| 2025 | 3 W. Transf. | 2000 | TR-SUGHD-1 | 500 | SUGHD | | capability increased of 33% |
| 2025 | 3 W. Transf. | 2000 | TR-SUGHD-2 | 500 | SUGHD | | capability increased of 33% |
| 2025 | 3 W. Transf. | 2000 | TR-UZLOVAYA-2 | 230 | UZLOVAYA | | capability increased of 33% |
| 2025 | Capacitor | 2000 | Cap_Kanib/1 | 10 | KANIBADAM | | add capacitor of 50 MVAr |
| 2025 | Capacitor | 2000 | Cap_Kanib/2 | 10 | KANIBADAM | | add capacitor of 50 MVAr |
| 2025 | Line | 2000 | L-5K | 220 | GOLOVNAYA | KOLKHOZABAD | element duplicated |
| 2025 | Line | 2000 | L-5P | 220 | GOLOVNAYA | PRYADILNAYA | element duplicated |
| 2025 | Line | 2000 | L-7-10 | 220 | NUREKSKAYA | T_NUREK_2 | element duplicated |
| 2025 | Line | 2000 | L-HPP12-HPP5 | 220 | SANGTUDA-2 | GOLOVNAYA | element duplicated |
| 2025 | Line | 2000 | L-S-K | 220 | SUGHD | KHUJAND | element duplicated |
| 2027 | 3 W. Transf. | 2160 | TR-NUREK-1 | 230 | NUREK | | capability increased of 33% |
| 2027 | 3 W. Transf. | 2160 | TR-NUREK-2 | 230 | NUREK | | capability increased of 33% |
| 2027 | 3 W. Transf. | 2160 | TR-ORJABAD-2-1 | 230 | ORJABAD-2 | | capability increased of 33% |
| 2027 | 3 W. Transf. | 2160 | TR-ORJABAD-2-2 | 230 | ORJABAD-2 | | capability increased of 33% |
| 2027 | 3 W. Transf. | 2160 | TR-SEBISTAN-1 | 230 | SEBISTAN | | element duplicated |
| 2027 | 3 W. Transf. | 2160 | TR-YAVAN-1 | 230 | YAVAN | | capability increased of 33% |
| 2027 | 3 W. Transf. | 2160 | TR-YAVAN-2 | 230 | YAVAN | | capability increased of 33% |
| 2027 | Capacitor | 2160 | Cap_Geran/1 | 11 | GERAN | | add capacitor of 30 MVAr |
| 2027 | Capacitor | 2160 | Cap_Geran/2 | 11 | GERAN | | add capacitor of 30 MVAr |
| 2027 | Capacitor | 2160 | Cap_Rumi | 10 | RUMI | | add capacitor of 50 MVAr |
| 2027 | Line | 2160 | L-7-02 | 220 | ORJABAD-2 | T_NUREK | element triplicated |
| 2027 | Line | 2160 | L-7-02(1) | 220 | T_NUREK | NUREKSKAYA | element triplicated |
| 2027 | Line | 2160 | L-8D | 220 | DJANGAL | BAYPAZA | element triplicated |
| 2027 | Line | 2160 | L-S-24/1 | 220 | SUGHD | T_Sughd | element duplicated |
| 2027 | Line | 2160 | L-S-24/2 | 220 | T_Sughd | T_Buston | element duplicated |
| 2028 | 3 W. Transf. | 2800 | TR-NUREK-1 | 230 | NUREKSKAYA | | capability increased of 33% |
| 2031 | 3 W. Transf. | 3600 | TR-DUSHANBE-1 | 500 | DUSHANBE | | capability increased of 33% |
| 2031 | 3 W. Transf. | 3600 | TR-GERAN-1 | 230 | GERAN | | capability increased of 33% |
| 2031 | 3 W. Transf. | 3600 | TR-GERAN-2 | 230 | GERAN | | capability increased of 33% |
| 2031 | 3 W. Transf. | 3600 | TR-KANIBADAM-1 | 230 | KANIBADAM | | capability increased of 33% |
| 2031 | 3 W. Transf. | 3600 | TR-KANIBADAM-2 | 230 | KANIBADAM | | capability increased of 33% |
| 2031 | 3 W. Transf. | 3600 | TR-KOLKHOZAB.-2 | 230 | KOLKHOZABAD | | capability increased of 33% |
| 2031 | 3 W. Transf. | 3600 | TR-RUDAKI-2 | 230 | RUDAKI | | capability increased of 33% |
| 2031 | Capacitor | 3600 | Cap_Djangal/1 | 10 | DJANGAL | | add capacitor of 50 MVAr |
| 2031 | Capacitor | 3600 | Cap_Djangal/2 | 10 | DJANGAL | | add capacitor of 50 MVAr |
| 2031 | Capacitor | 3600 | Cap_Geran/3 | 11 | GERAN | | add capacitor of 30 MVAr |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2031 | Capacitor | 3600 | Cap_Geran/4 | 11 | GERAN | | add capacitor of 30 MVAr |
| 2031 | Capacitor | 3600 | Cap_Khatlon/1 | 10 | KHATLON | | add capacitor of 50 MVAr |
| 2031 | Capacitor | 3600 | Cap_Khatlon/2 | 10 | KHATLON | | add capacitor of 50 MVAr |
| 2031 | Line | 3600 | L-7-10(1) | 220 | T_NUREK_2 | YATEC | element duplicated |
| 2031 | Line | 3600 | L-S-K2/B | 220 | SUGHD | T_KNS-2 | element duplicated |

(*) the Reinforcement Actions indicated as "Programmed" were already scheduled by Barki Tajik. All the other Reinforcement Actions reported in this table were not originally included in that scheduling, but their need arises from the study.

**Table 6.19: reinforcement actions**

The next table reports the already programmed (by Barki Tojik) actions on the 500 kV transmission system, due to the new Rogun Hydro Power Plant and the needs of export to foreign countries. These actions are all already programmed by Barki Tojik, except for the short connections lines between Rogun Power Plant and Obigarm substation, that are of course necessary in order to connect the new plant to a strong node in the 500 kV system. The expected size of Rogun Power Plant is indicated beside the scheduled year.

| Year | Rogun Power [MW] | Item | Identification | Vn [kV] | From Station | To Station | Reinforcement action |
|---|---|---|---|---|---|---|---|
| 2014 | - | Line | L-D-O-1 | 500 | DUSHANBE | OBIGARM | Planned (*) |
| 2014 | - | Line | L-D-O-2 | 500 | DUSHANBE | OBIGARM | Planned (*) |
| 2016 | - | Line | L-Regar-Sangtuda1 | 500 | REGAR | SANGTUDA-1 | Planned (*) |
| (**) | - | Line | L-Obi-Rogun HPP/1 | 500 | OBIGARM | ROGUN HPP | Necessary |
| (**) | - | Line | L-Obi-Rogun HPP/2 | 500 | OBIGARM | ROGUN HPP | Necessary |
| (**) | - | Line | L-Obi-Rogun HPP/3 | 500 | OBIGARM | ROGUN HPP | Necessary (***) |
| 2020 | 400 | Line | L-O-S | 500 | OBIGARM | SUGHD | Planned (*) |
| 2020 | 400 | Line | L-Obi-Sangtuda | 500 | OBIGARM | SANGTUDA-1 | Planned (*) |
| 2028 | 2800 | Line | L-O-Y | 500 | OBIGARM | YUZHNAYA | Planned (*) |
| 2028 | 2800 | Line | L-S-Y | 500 | SANGTUDA-1 | YUZHNAYA | Planned (*) |

(*) the Reinforcement Actions indicated as "Planned" were already scheduled by Barki Tojik.

(**) Year depends upon the alternative under consideration.

(***) 3 lines from L-Obi-Rogun HPP/1 to OBIGARM are necessary in case the scheduled capacities of Rogun HPP were the maximum ones, 3600 MW, 3200 or 2800 MW. In case of smaller capacities, the 3rd line could be not strictly required. Anyway, it is necessary to take into account that this connection is a bottleneck and the availability of a 3rd line would improve substantially the reliability of the system.

**Table 6.20: 500 kV reinforcement actions**

We recommend the Tajik transmission system operator to update frequently the information and the forecast about the location of the load demand in the future years and its profile vs. time along the hours of the year. The proposed reinforcement plan on the 220 kV system and on the load transformers will have to be revised periodically, including reactive power compensation planning and indication to the operation for what attains reactive power management, congestion management, N-1 safety, etc.

## 6.10 Losses

The losses are summarized in the following tables:

| **Power losses** | **220 kV lines losses [MW]** | **interconn. transf. losses [MW]** | **500 kV lines losses [MW]** | **total losses in 500 and 220 kV syst. [MW]** | **total load, export excluded [MW]** | **total generation, exp. incl. [MW]** |
|---|---|---|---|---|---|---|
| Year-2013_1 max | 29.902 | *1.597* | 48.216 | 79.715 | 3813.149 | 3921.125 |
| Year-2013_2 ave | 14.236 | 1.051 | 20.624 | 35.910 | 2680.644 | 2735.912 |
| Year-2013_3 min | 4.598 | 0.777 | 6.565 | 11.941 | 1548.139 | 1574.145 |
| Year-2013_4 max Exp 960 MW AU | 48.037 | 1.600 | 55.692 | 105.328 | 3813.149 | 4910.230 |
| Year-2013_5 ave Exp 960 MW AU | 30.025 | 1.062 | 35.342 | 66.429 | 2680.644 | 3729.629 |
| Year-2013_6 min Exp 960 MW AU | 15.259 | 0.812 | 23.717 | 39.789 | 1548.139 | 2564.050 |
| Year-2020_1 max Exp 1000 MW AKU | 36.490 | 2.096 | 55.351 | 93.936 | 4308.166 | 5440.033 |
| Year-2020_2 ave Exp 1000 MW AKU | 23.746 | 1.519 | 28.209 | 53.474 | 3028.641 | 4107.587 |
| Year-2020_3 min Exp 1000 MW AKU | 13.153 | 1.132 | 11.777 | 26.061 | 1749.116 | 2793.755 |
| Year-2025_1 max Exp 1600 MW AKU | 47.782 | 2.388 | 71.198 | 121.368 | 4992.020 | 6759.918 |
| Year-2025_2 ave Exp 1600 MW AKU | 33.208 | 1.642 | 31.817 | 66.667 | 3509.390 | 5207.329 |
| Year-2025_3 min Exp 1600 MW AKU | 20.144 | 1.142 | 10.989 | 32.274 | 2026.760 | 3680.884 |
| Year-2027_1 max Exp 1600 MW AKU | 52.358 | 2.718 | 73.043 | 128.119 | 5292.076 | 7070.146 |
| Year-2027_2 ave Exp 1600 MW AKU | 35.162 | 1.778 | 32.355 | 69.295 | 3720.328 | 5422.450 |
| Year-2027_3 min Exp 1600 MW AKU | 20.620 | 1.184 | 10.876 | 32.681 | 2148.583 | 3804.040 |
| Year-2028_1 max Exp 1800 MW AKU | 59.494 | 2.788 | 84.165 | 146.447 | 5442.096 | 7441.266 |
| Year-2028_2 ave Exp 1800 MW AKU | 41.254 | 1.768 | 36.892 | 79.914 | 3825.794 | 5740.204 |
| Year-2028_3 min Exp 1800 MW AKU | 23.878 | 1.161 | 12.819 | 37.858 | 2209.491 | 4070.923 |
| 2031/2000_0a max Exp 0 | 34.582 | 3.126 | 82.496 | 120.204 | 5948.165 | 6111.693 |
| 2031/2000_0b ave Exp 0 | 21.474 | 1.982 | 40.644 | 64.099 | 4181.560 | 4273.063 |
| 2031/2000_0c min Exp 0 | 10.587 | 1.208 | 12.913 | 24.708 | 2414.955 | 2457.158 |
| 2031/2000_1 Exp 900 AKU | 48.862 | 3.240 | 87.959 | 140.061 | 5948.165 | 7041.208 |
| 2031/2000_2 Exp 700 Afg | 39.085 | 3.322 | 90.649 | 133.056 | 5948.165 | 6833.473 |
| 2031/2000_3 Exp 500 Kirg | 65.519 | 3.109 | 81.898 | 150.526 | 5948.165 | 6648.209 |
| 2031/2000_4 Exp 900 Uz-a | 65.989 | 3.167 | 87.341 | 156.498 | 5948.165 | 7057.196 |
| 2031/2000_5 Exp 900 Uz-b | 57.892 | 3.169 | 87.432 | 148.493 | 5948.165 | 7049.195 |
| 2031/2800_0a max Exp 0 | 35.166 | 3.119 | 83.573 | 121.858 | 5948.165 | 6113.056 |
| 2031/2800_0b ave Exp 0 | 20.860 | 1.973 | 41.263 | 64.096 | 4181.560 | 4272.814 |
| 2031/2800_0c min Exp 0 | 8.789 | 1.167 | 13.024 | 22.980 | 2414.955 | 2455.228 |
| 2031/2800_1 Exp 1650 AKU | 74.423 | 3.270 | 90.319 | 168.012 | 5948.165 | 7822.747 |
| 2031/2800_2 Exp 1300 Afg | 49.093 | 3.316 | 87.732 | 140.141 | 5948.165 | 7442.794 |
| 2031/2800_3 Exp 500 Kirg | 65.046 | 3.089 | 82.575 | 150.711 | 5948.165 | 6647.735 |
| 2031/2800_4 Exp 1200 Uz-a | 92.348 | 3.108 | 85.957 | 181.413 | 5948.165 | 7382.523 |

| Power losses | 220 kV lines losses [MW] | interconn. transf. losses [MW] | 500 kV lines losses [MW] | total losses in 500 and 220 kV syst. [MW] | total load, export excluded [MW] | total generation, exp. incl. [MW] |
|---|---|---|---|---|---|---|
| 2031/2800_5 Exp 1300 Uz-b | 83.643 | 3.126 | 87.076 | 173.845 | 5948.165 | 7475.630 |
| 2031/3600_0a max Exp 0 | 37.005 | 3.122 | 84.825 | 124.952 | 5948.165 | 6116.227 |
| 2031/3600_0b ave Exp 0 | 21.924 | 1.976 | 41.816 | 65.716 | 4181.560 | 4274.735 |
| 2031/3600_0c min Exp 0 | 8.983 | 1.166 | 13.031 | 23.180 | 2414.955 | 2455.976 |
| 2031/3600_1 Exp 2450 AKU | 95.207 | 3.319 | 93.912 | 192.438 | 5948.165 | 8650.119 |
| 2031/3600_2 Exp 1300 Afg | 52.155 | 3.266 | 86.658 | 142.079 | 5948.165 | 7444.042 |
| 2031/3600_3 Exp 550 Kirg | 72.099 | 3.081 | 83.456 | 158.636 | 5948.165 | 6705.718 |
| 2031/3600_4 Exp 1500 Uz-a | 130.165 | 3.089 | 87.071 | 220.325 | 5948.165 | 7722.675 |
| 2031/3600_5 Exp 1500 Uz-b | 102.696 | 3.069 | 85.909 | 191.674 | 5948.165 | 7693.484 |

**Table 6.21: power losses**

| Estimated Yearly Energy Losses | "max" hours losses [MWh] | "ave" hours losses [MWh] | "min" hours losses [MWh] | total losses [MWh] |
|---|---|---|---|---|
| **Year_2013** | 60 583 | 148 669 | 46 091 | **255 343** |
| **Year_2020** | 80 050 | 275 016 | 153 584 | **508 650** |
| **Year_2025** | 71 391 | 221 383 | 100 597 | **393 371** |
| **Year_2027** | 92 240 | 276 001 | 124 578 | **492 819** |
| **Year_2028** | 97 370 | 286 881 | 126 147 | **510 398** |
| **Year_2031 2000 MW** | 111 300 | 330 844 | 146 131 | **588 275** |
| **Year_2031 2800 MW** | 91 355 | 265 370 | 95 372 | **452 097** |
| **Year_2031 3600 MW** | 92 612 | 265 357 | 88 701 | **446 670** |

**Table 6.22: estimated yearly energy losses**

# 7 CONCLUSIONS

Before any conclusive discussion, it is necessary to remark that a heavy work of data merging and filtering, model fine-tuning, etc., has been necessary to arrive to a final and reliable model.
In the original data a true working load-flow showing the Tajik used approach for what attains reactive power management, transformer tap changers settings etc. has never been available, but this has been solved by proper adjustments of the model.

The forecast on energy demand indicated by document [38], along the duration of the horizon periods, leads to a significant growth (from a peak of about 3.8 GW in year 2013 to a peak of more than 5.9 GW in year 2031) with consequent overload of some elements of the transmission and distribution network. These problems can be solved with proper network reinforcements on the HV Tajik transmission system and the substations transformers.

The results of the study are therefore an indication of the capability and of the limits of the system for what attains the possibility to transport the exceeding power of the Hydro Power Plants (Rogun) to the neighbouring countries.

Further analyses with more complete information can be performed in the next phase of the studies, but the purpose of the present phase is anyway fulfilled with the analyses contained in this report.

These analyses show that the critical part of the 500 kV transmission system is located in the north area, mainly related to the connection of SUGHD substation to the other parts of the system. The weakness of this area is indicated by the fact that the export connection SUGHD to the Kyrgyz Republic needs to ***receive*** reactive power in SUGHD from the Kyrgyz Republic, although it is not a very long line (477 km), and by the fact that the outage of one single line connecting SUGHD to OBIGARM (Rogun HPP) or DUSHANBE leads to the system collapse. It is therefore suggested to reinforce this part of the system, i.e. to create a 2nd line between OBIGARM (Rogun HPP) and SUGHD.

In N conditions, year 2027, with Rogun HPP with rated power of 3,600 MW, also when the Tajik load is at its maximum, it is possible to export with a normal 500 kV line (2 kA rated current), 1,500 MW to Afghanistan (from YUJNAYA S/S), to the Kyrgyz Republic (from SUGHD) or to Uzbekistan (from REGAR and with 2 different alternatives); or a combination of all these destinations, up to a total of 3,000 MW (probably also a little more), i.e. 900 MW to Afghanistan, 900 MW to the Kyrgyz Republic and 1,200 MW to Uzbekistan.

With the peak flow of 1500 MW in each single line, for the longest connections (the ones to Uzbekistan) it is necessary to share between Tajikistan and the importing country the reactive power request of the line (reactive load losses are higher than reactive capacitive losses); for the connection from SUGHD to the Kyrgyz Republic, as already mentioned, SUGHD needs to ***receive*** reactive power in SUGHD from the Kyrgyz Republic, although the line is not very long (477 km), due to Tajik 500 kV system weakness in the connection of SUGHD.

In the case of Rogun HPP rated power of 2,800 MW, the export availability is reduced. The export cases of 1,500 MW for each single neighbouring country are still possible with no reductions, while the global maximum export in multiple countries is 2,300 MW.

In the case of Rogun HPP rated power of 2,000 MW, the export availability is further reduced. The export cases of 1,500 MW for each single neighbouring country are still possible with small reductions (1,350 or 1,400 MW export instead of 1,500 MW), while the global maximum export in multiple countries is about 1,500 MW.

The outages may require some export power reduction (see tables in subchapters 6.6.2, 6.7.1 and 6.8.1) for some of the possible outages cases, and again demonstrate the weakness of the north area 500 kV system. One possible choice would be that to increase the proposed reinforcement actions, in order to avoid any need of reduction with in N-1 condition. The results where some reductions were needed occur under very unfavourable conditions: loss of important lines, generation and export at peak or close to admissible peak. Such conditions may occur for a very limited number of hours per year, so the expected cost of this reductions could be, at the end, rather small, not enough to justify further investments.

The yearly estimated losses are reported in the corresponding table (sub-chap. 6.10) and, with the expected load growth year, they rise from 255 to 447 GWh/year from year 2013 to 2031, taking into account the assumed reinforcements that surely contribute to improve the system efficiency. For example, in the year 2025 the value of the losses is reduced with respect to former years, in spite of the load growth, thanks to the favourable impact of the proposed reinforcement.

(detailed results and system data follows)

# 8 DETAILED RESULTS

Scope of the studies is the analysis of the impact of the new Hydro Power Plant of Rogun, under construction, on the High Voltage Transmission System of Tajikistan in the frame of the TEAS.

## 8.1 The load-flow in year 2013

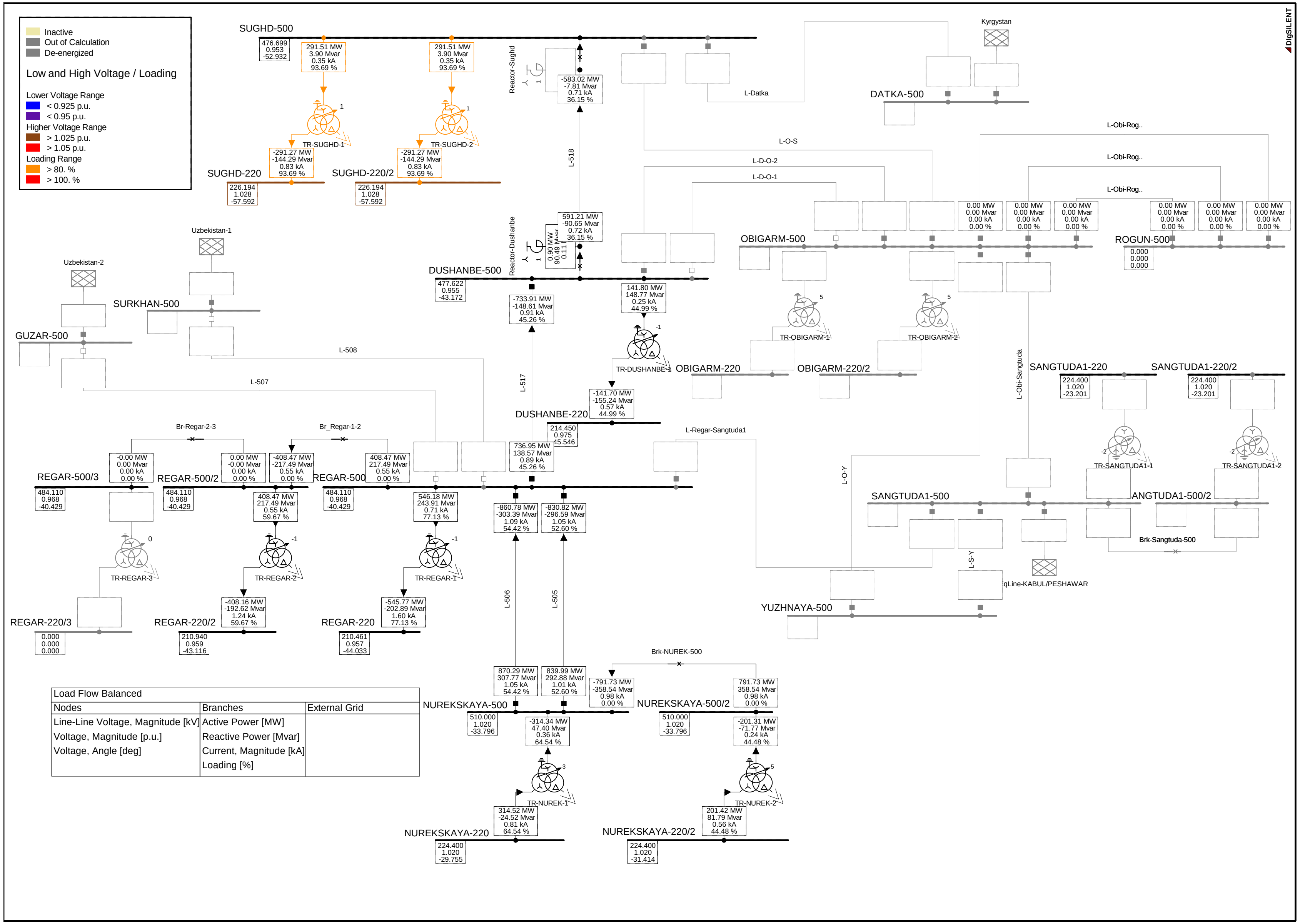



fig. 8.1: year 2013,maximum load, 500 kV system

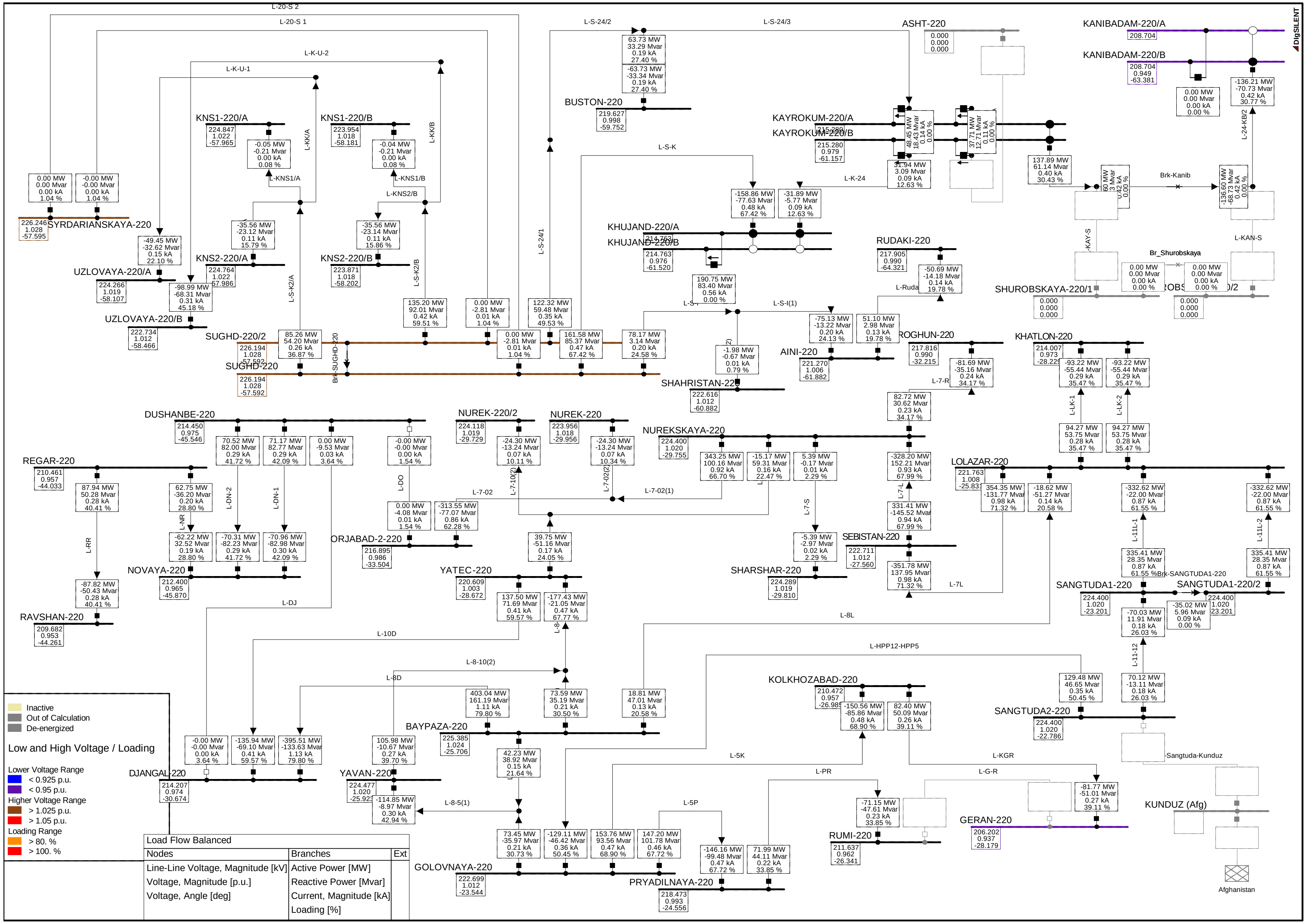
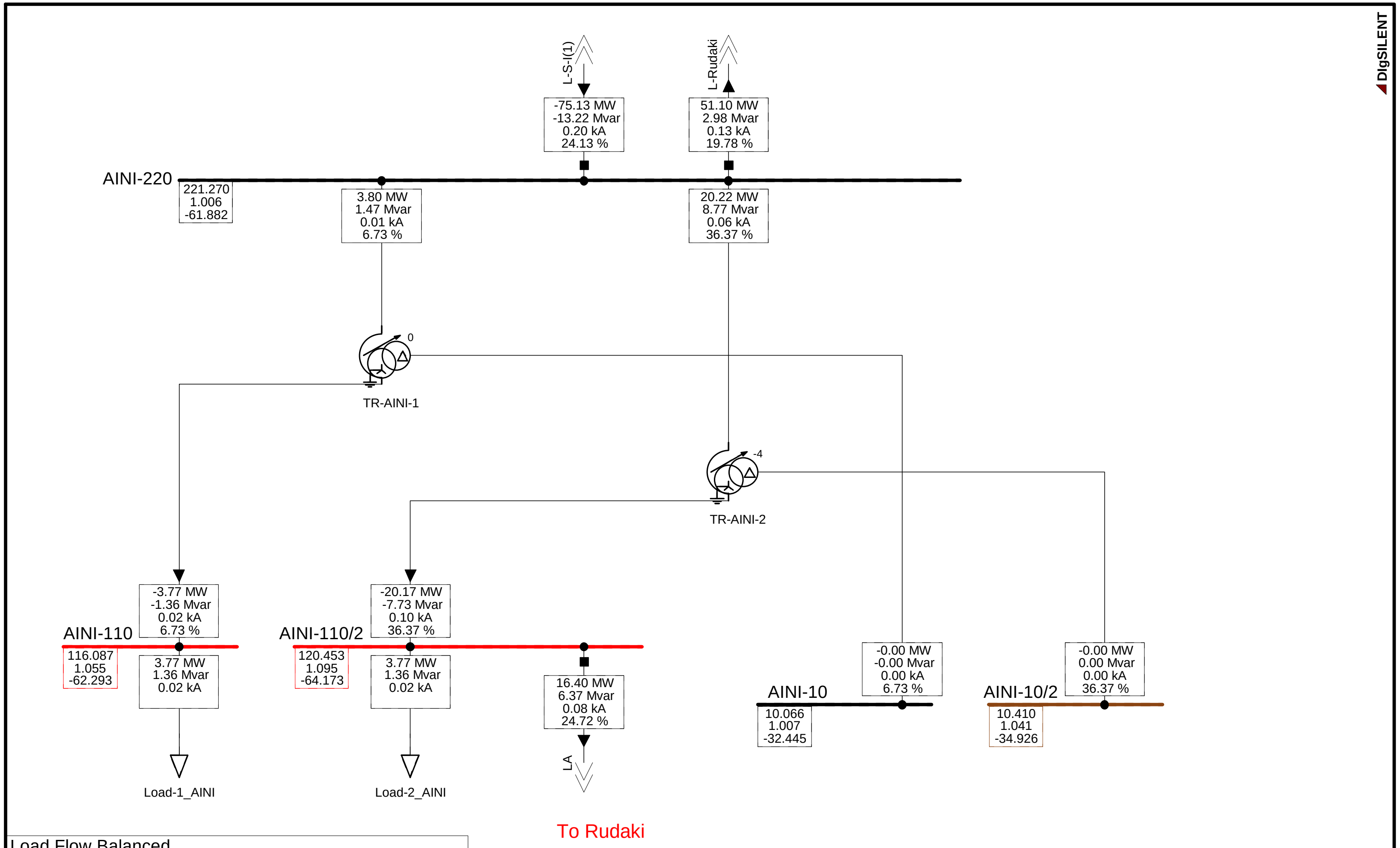
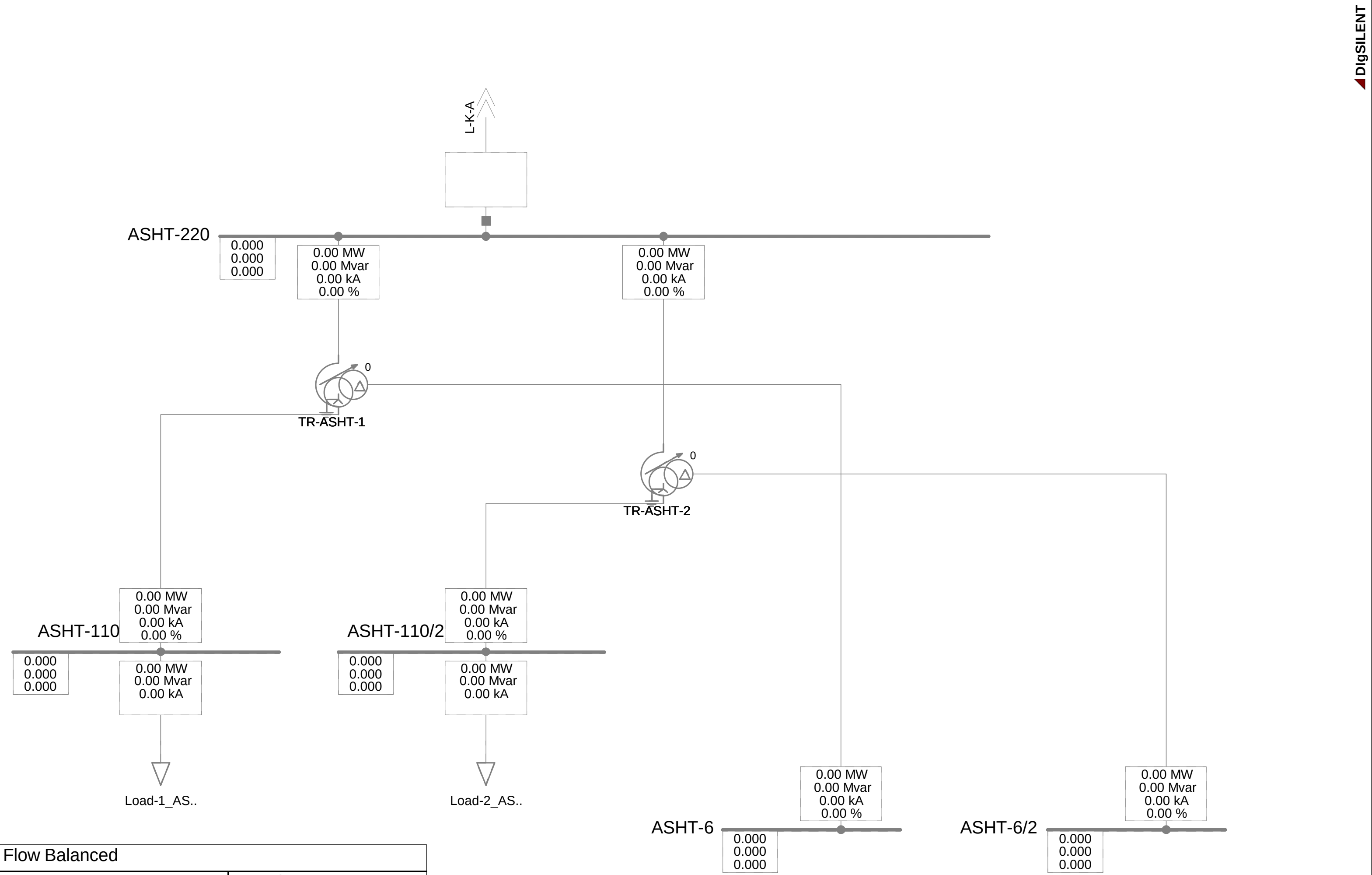



fig. 8.2: year 2013, maximum load, 220 kV system




| Load Flow Balanced | |
|---|---|
| Nodes | Branches |
| Line-Line Voltage, Magnitude [kV] | Active Power [MW] |
| Voltage, Magnitude [p.u.] | Reactive Power [Mvar] |
| Voltage, Angle [deg] | Current, Magnitude [kA] |
| | Maximum Loading [%] |

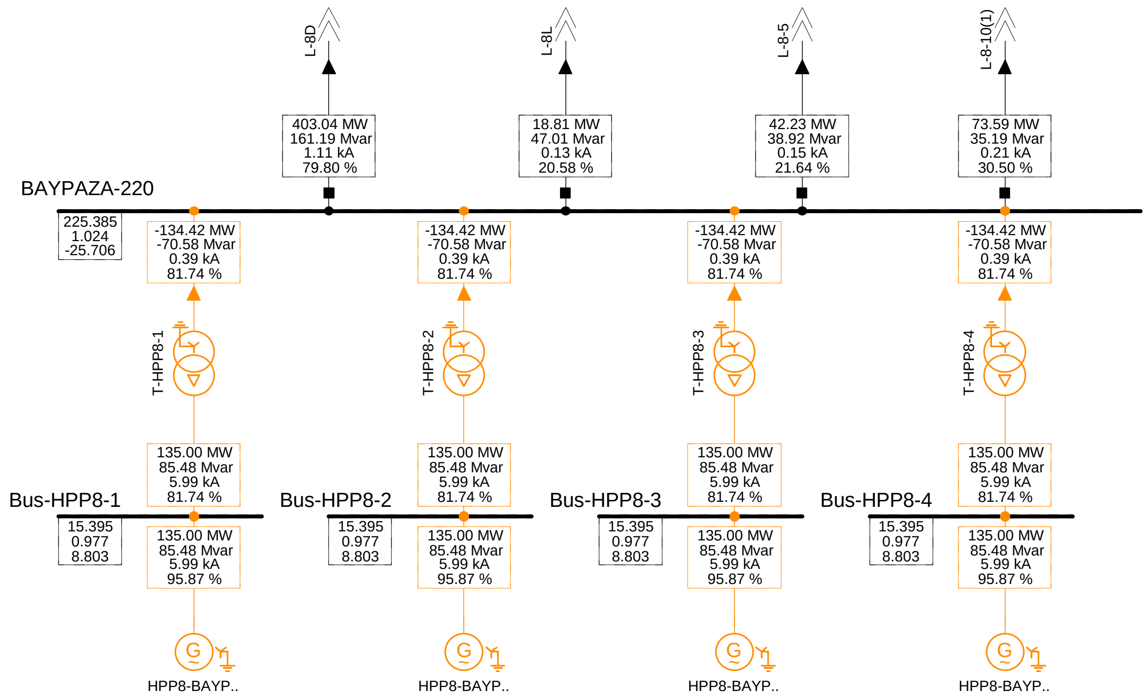
| | | |
|---|---|---|
| | | Project: |
| | | Graphic: AINI |
| | | Date: 26/06/2013 |
| PowerFactory 14.1.3 | | Annex: |




| Load Flow Balanced | |
|---|---|
| Nodes | Branches |
| Line-Line Voltage, Magnitude [kV] | Active Power [MW] |
| Voltage, Magnitude [p.u.] | Reactive Power [Mvar] |
| Voltage, Angle [deg] | Current, Magnitude [kA] |
| | Maximum Loading [%] |

| | | |
|---|---|---|
| | | Project: |
| | | Graphic: ASHT |
| | | Date: 26/06/2013 |
| PowerFactory 14.1.3 | | Annex: |

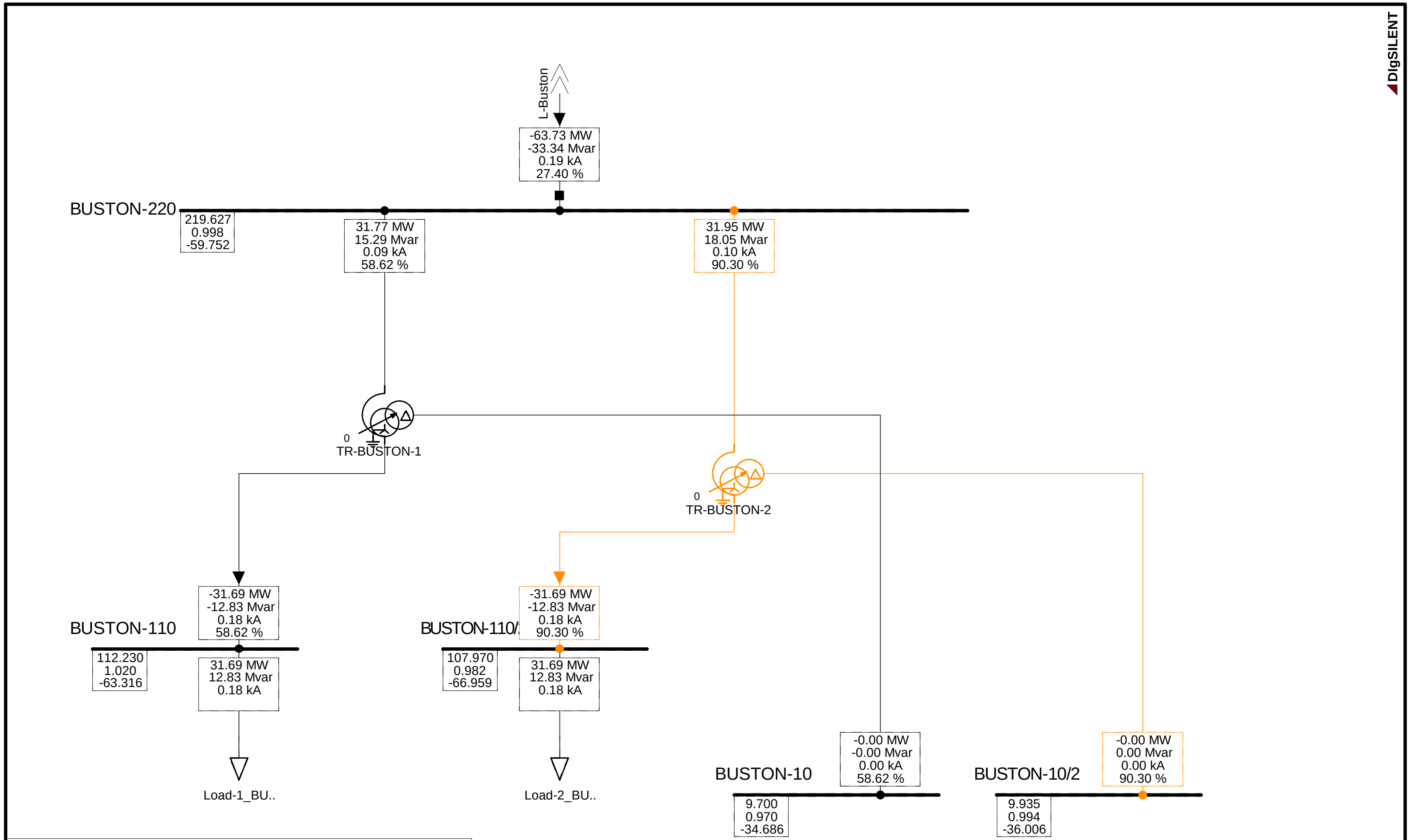
DIgSILENT




| Load Flow Balanced | |
|---|---|
| Nodes | Branches |
| Line-Line Voltage, Magnitude [kV] | Active Power [MW] |
| Voltage, Magnitude [p.u.] | Reactive Power [Mvar] |
| Voltage, Angle [deg] | Current, Magnitude [kA] |

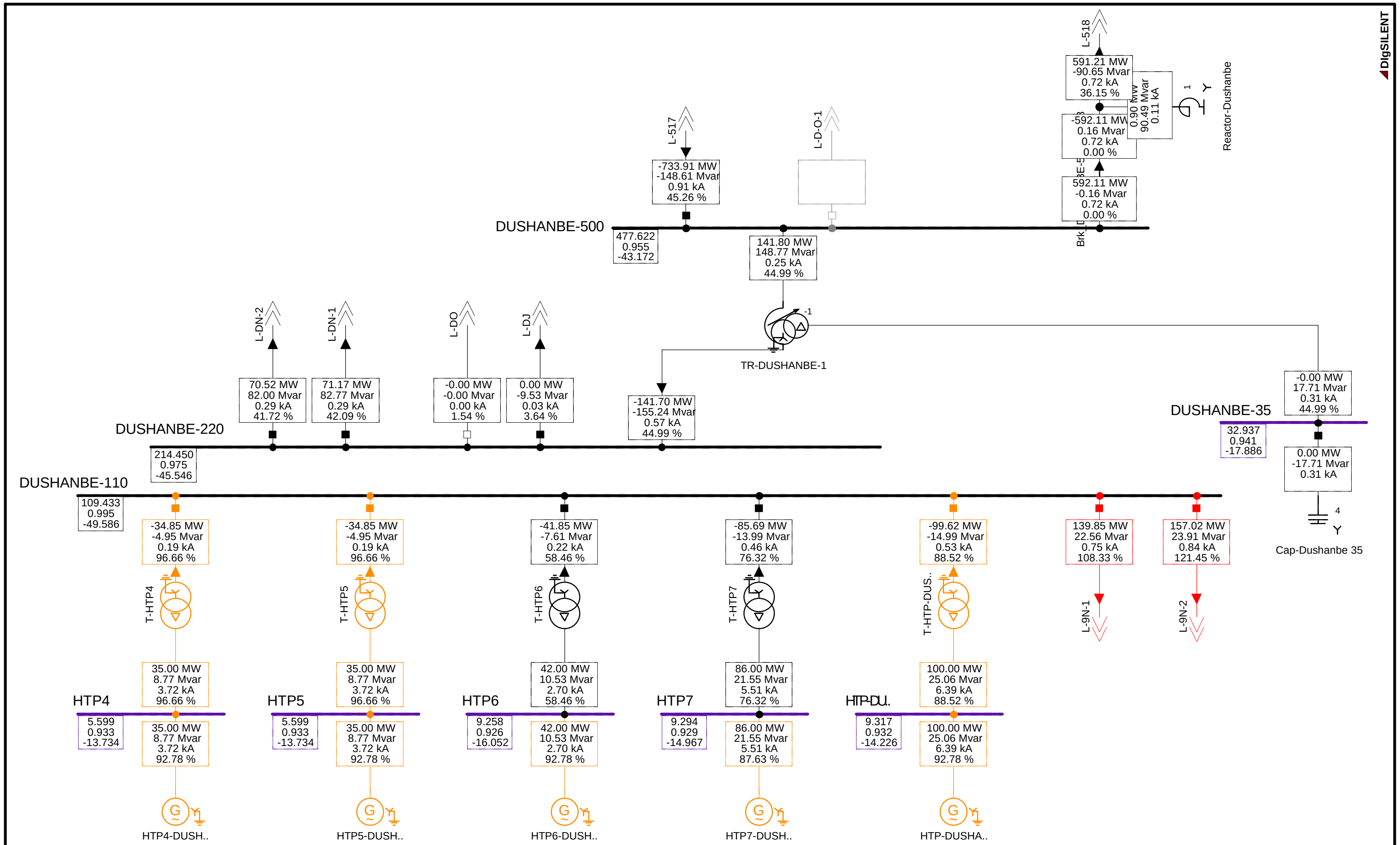
PowerFactory 14.1.3

Project:
Graphic: BAYPAZA
Date: 26/06/2013
Annex:



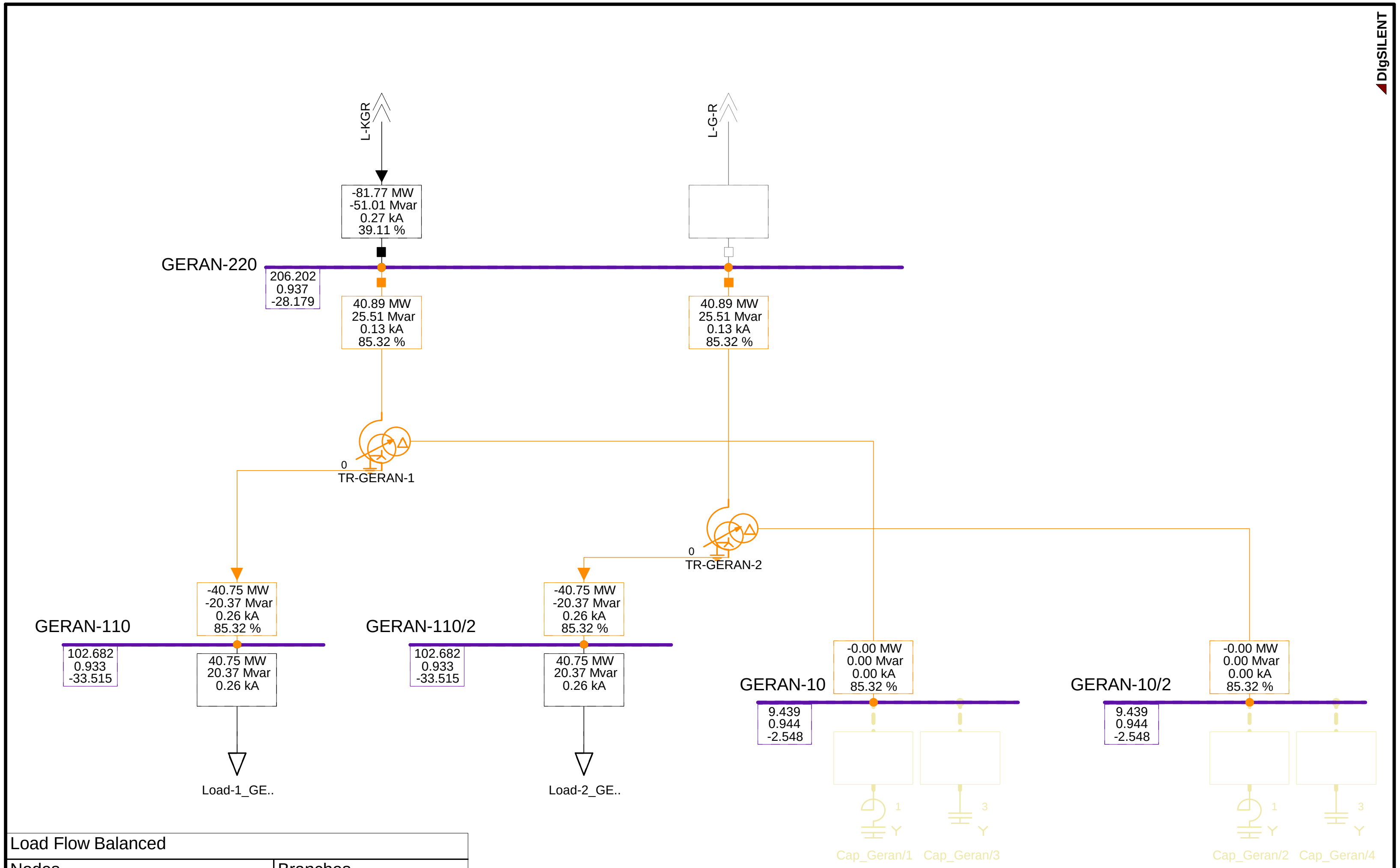

| Load Flow Balanced | |
|---|---|
| Nodes | Branches |
| Line-Line Voltage, Magnitude [kV] | Active Power [MW] |
| Voltage, Magnitude [p.u.] | Reactive Power [Mvar] |
| Voltage, Angle [deg] | Current, Magnitude [kA] |
| | Maximum Loading [%] |

| | | |
|---|---|---|
| PowerFactory 14.1.3 | | Project: |
| | | Graphic: BUSTON |
| | | Date: 26/06/2013 |
| | | Annex: |



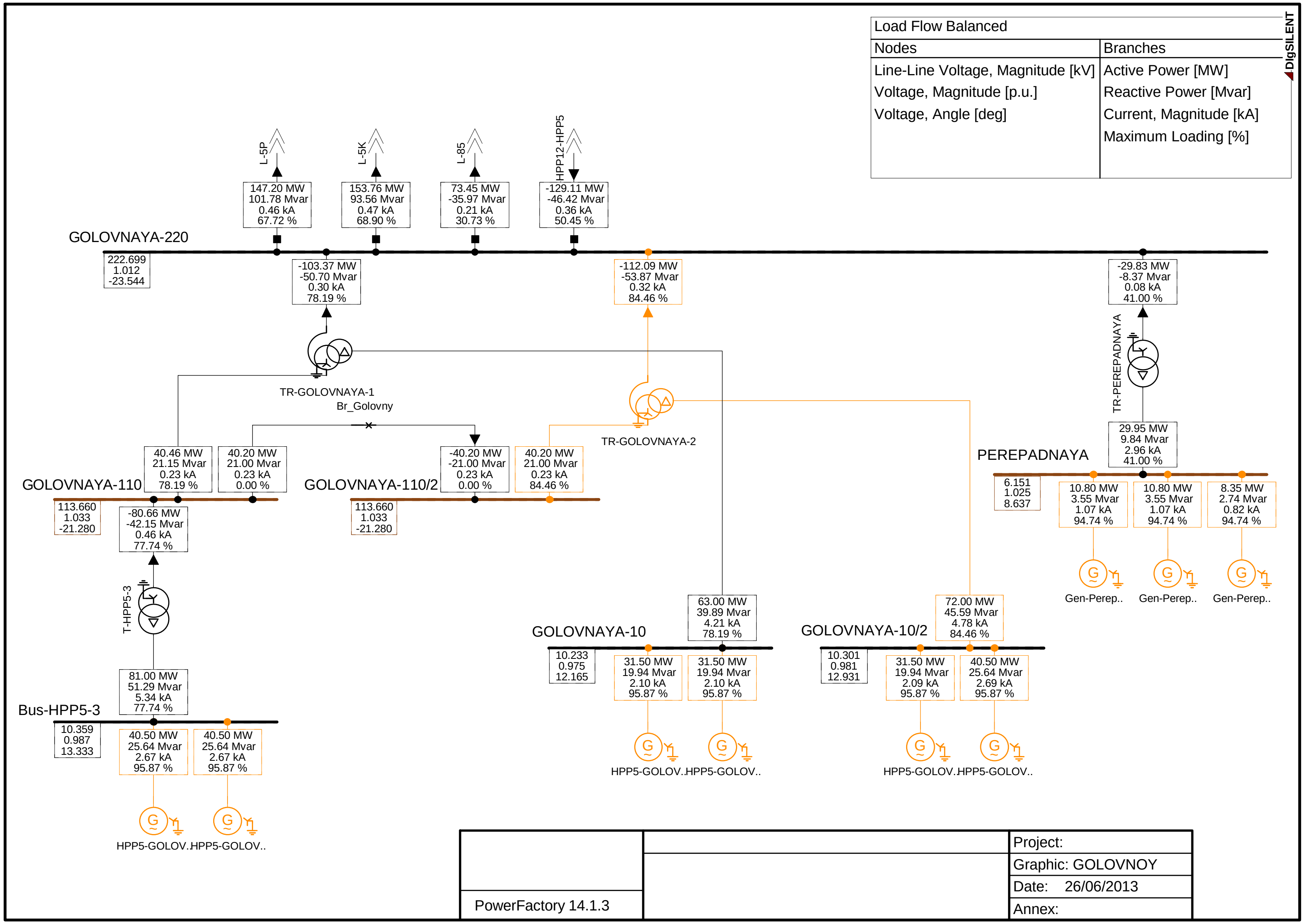

| Load Flow Balanced | |
|---|---|
| Nodes | Branches |
| Line-Line Voltage, Magnitude [kV] | Active Power [MW] |
| Voltage, Magnitude [p.u.] | Reactive Power [Mvar] |
| Voltage, Angle [deg] | Current, Magnitude [kA] |
| | Maximum Loading [%] |

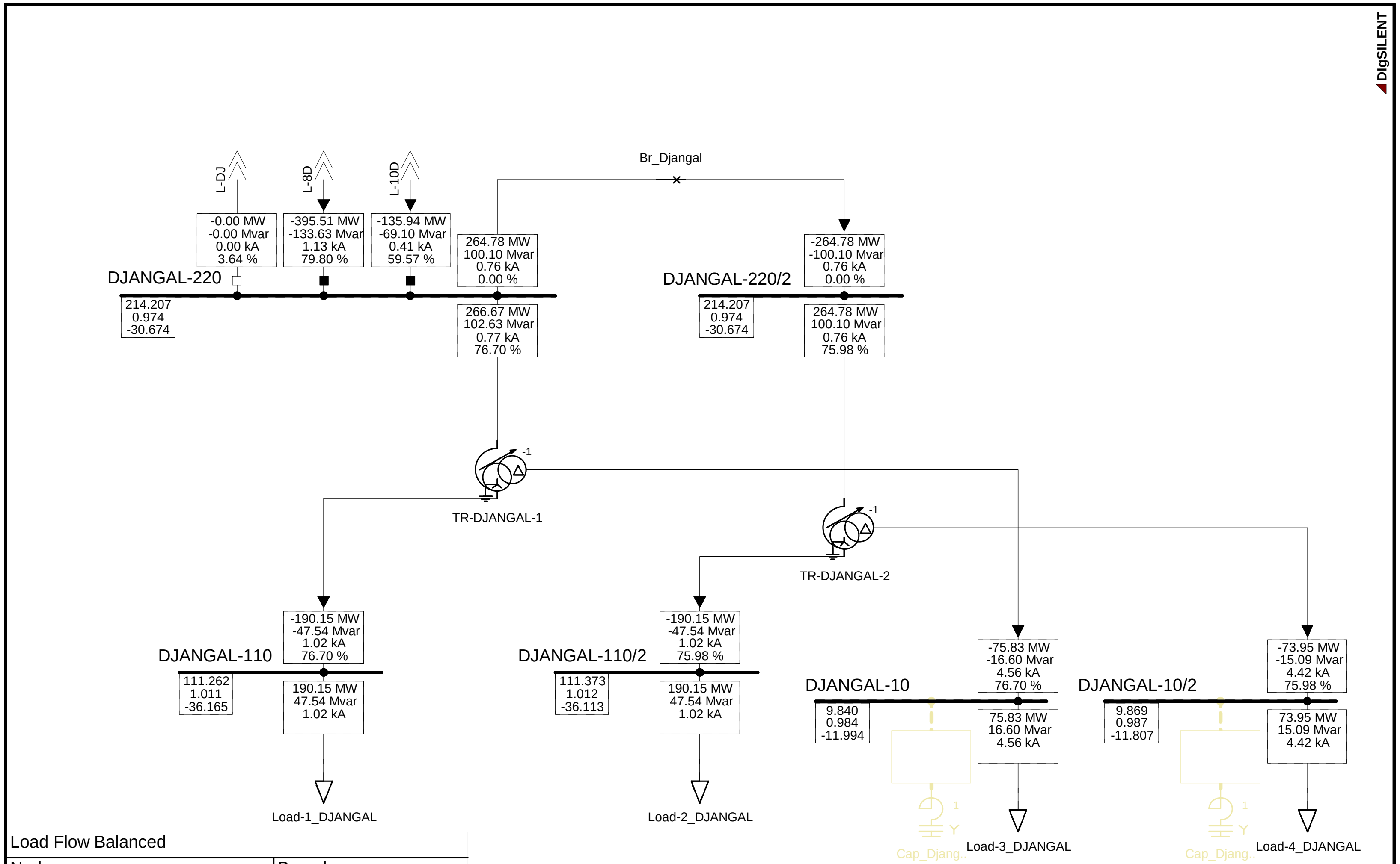
| | | |
|---|---|---|
| PowerFactory 14.1.3 | | Project: |
| | | Graphic: DUSHANBE |
| | | Date: 26/06/2013 |
| | | Annex: |




| Load Flow Balanced | |
|---|---|
| Nodes | Branches |
| Line-Line Voltage, Magnitude [kV] | Active Power [MW] |
| Voltage, Magnitude [p.u.] | Reactive Power [Mvar] |
| Voltage, Angle [deg] | Current, Magnitude [kA] |
| | Maximum Loading [%] |

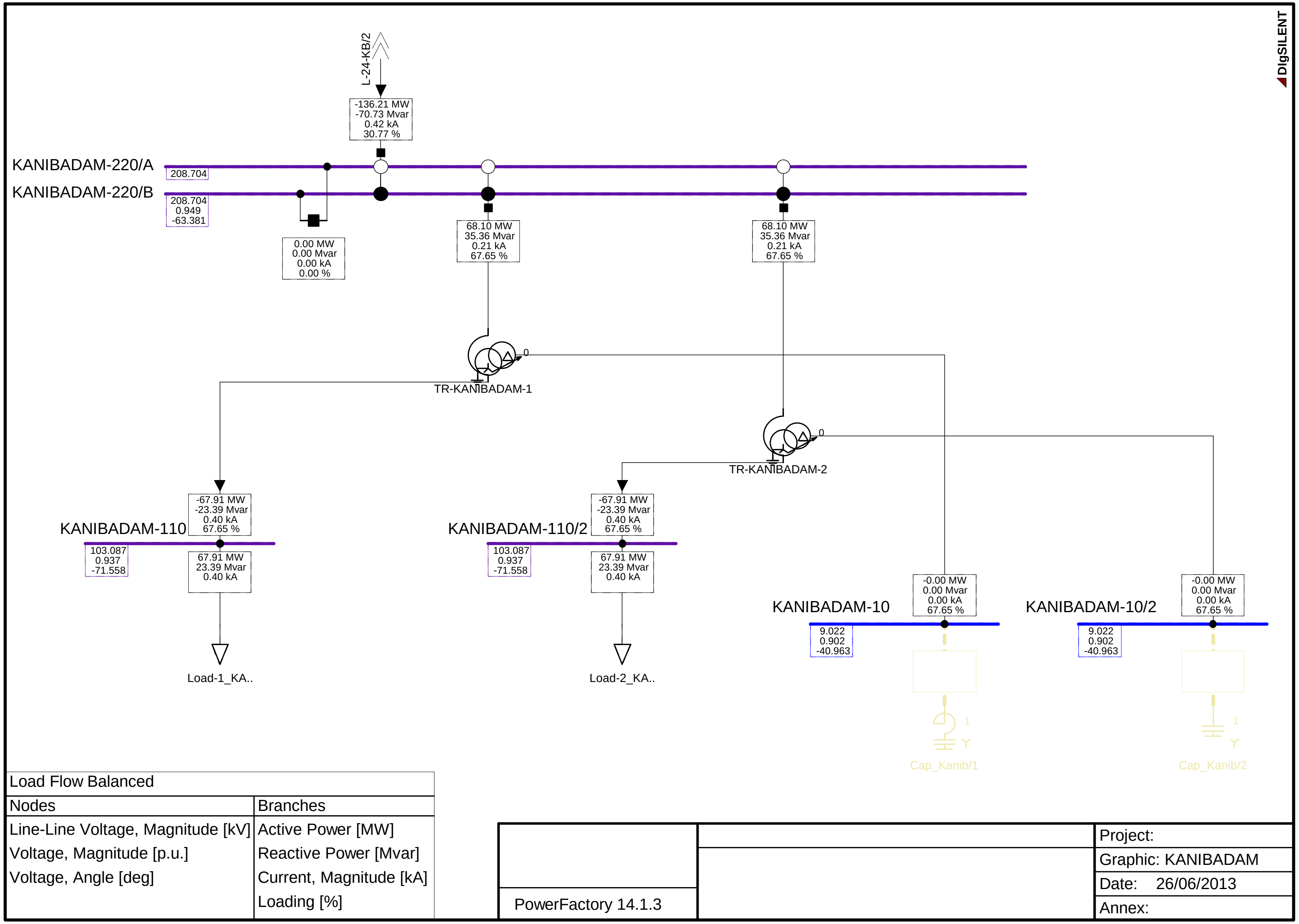
| | | |
|---|---|---|
| | | Project: |
| | | Graphic: GERAN |
| | | Date: 26/06/2013 |
| PowerFactory 14.1.3 | | Annex: |

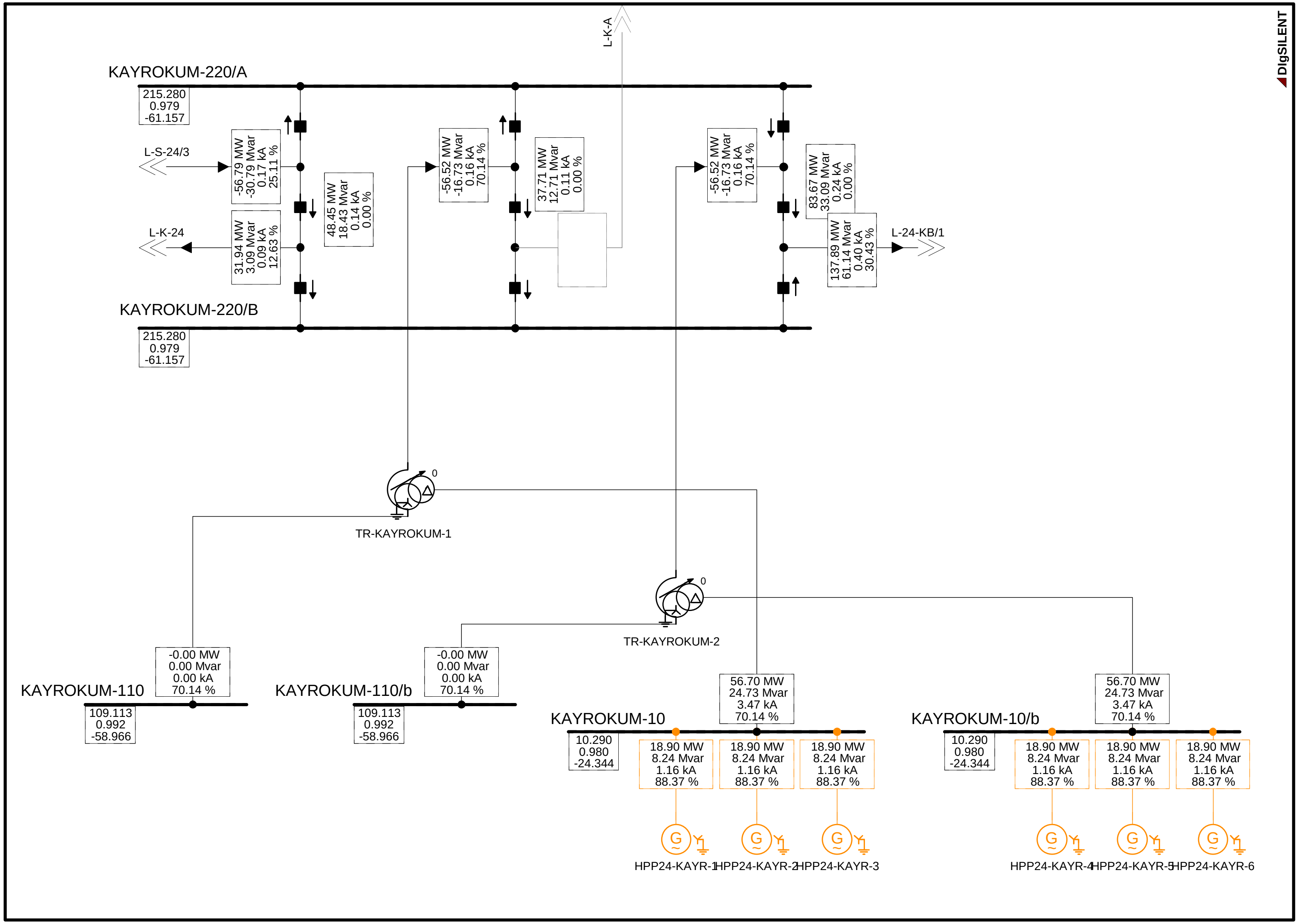

Load Flow Balanced
Nodes
Line-Line Voltage, Magnitude [kV]
Voltage, Magnitude [p.u.]
Voltage, Angle [deg]
Branches
Active Power [MW]
Reactive Power [Mvar]
Current, Magnitude [kA]
Maximum Loading [%]
DIgSILENT
L-5P
L-5K
L-85
HPP12-HPP5
147.20 MW 101.78 Mvar 0.46 kA 67.72 %
153.76 MW 93.56 Mvar 0.47 kA 68.90 %
73.45 MW -35.97 Mvar 0.21 kA 30.73 %
-129.11 MW -46.42 Mvar 0.36 kA 50.45 %
GOLOVNAYA-220
222.699 1.012 -23.544
-103.37 MW -50.70 Mvar 0.30 kA 78.19 %
-112.09 MW -53.87 Mvar 0.32 kA 84.46 %
-29.83 MW -8.37 Mvar 0.08 kA 41.00 %
TR-GOLOVNAYA-1
Br_Golovny
TR-GOLOVNAYA-2
TR-PEREPADNAYA
29.95 MW 9.84 Mvar 2.96 kA 41.00 %
PEREPADNAYA
6.151 1.025 8.637
10.80 MW 3.55 Mvar 1.07 kA 94.74 %
10.80 MW 3.55 Mvar 1.07 kA 94.74 %
8.35 MW 2.74 Mvar 0.82 kA 94.74 %
Gen-Perep..
Gen-Perep..
Gen-Perep..
GOLOVNAYA-110
40.46 MW 21.15 Mvar 0.23 kA 78.19 %
40.20 MW 21.00 Mvar 0.23 kA 0.00 %
113.660 1.033 -21.280
-80.66 MW -42.15 Mvar 0.46 kA 77.74 %
GOLOVNAYA-110/2
-40.20 MW -21.00 Mvar 0.23 kA 0.00 %
40.20 MW 21.00 Mvar 0.23 kA 84.46 %
113.660 1.033 -21.280
T-HPP5-3
81.00 MW 51.29 Mvar 5.34 kA 77.74 %
Bus-HPP5-3
10.359 0.987 13.333
40.50 MW 25.64 Mvar 2.67 kA 95.87 %
40.50 MW 25.64 Mvar 2.67 kA 95.87 %
HPP5-GOLOV..HPP5-GOLOV..
GOLOVNAYA-10
63.00 MW 39.89 Mvar 4.21 kA 78.19 %
10.233 0.975 12.165
31.50 MW 19.94 Mvar 2.10 kA 95.87 %
31.50 MW 19.94 Mvar 2.10 kA 95.87 %
HPP5-GOLOV..HPP5-GOLOV..
GOLOVNAYA-10/2
72.00 MW 45.59 Mvar 4.78 kA 84.46 %
10.301 0.981 12.931
31.50 MW 19.94 Mvar 2.09 kA 95.87 %
40.50 MW 25.64 Mvar 2.69 kA 95.87 %
HPP5-GOLOV..HPP5-GOLOV..
PowerFactory 14.1.3
Project:
Graphic: GOLOVNOY
Date: 26/06/2013
Annex:

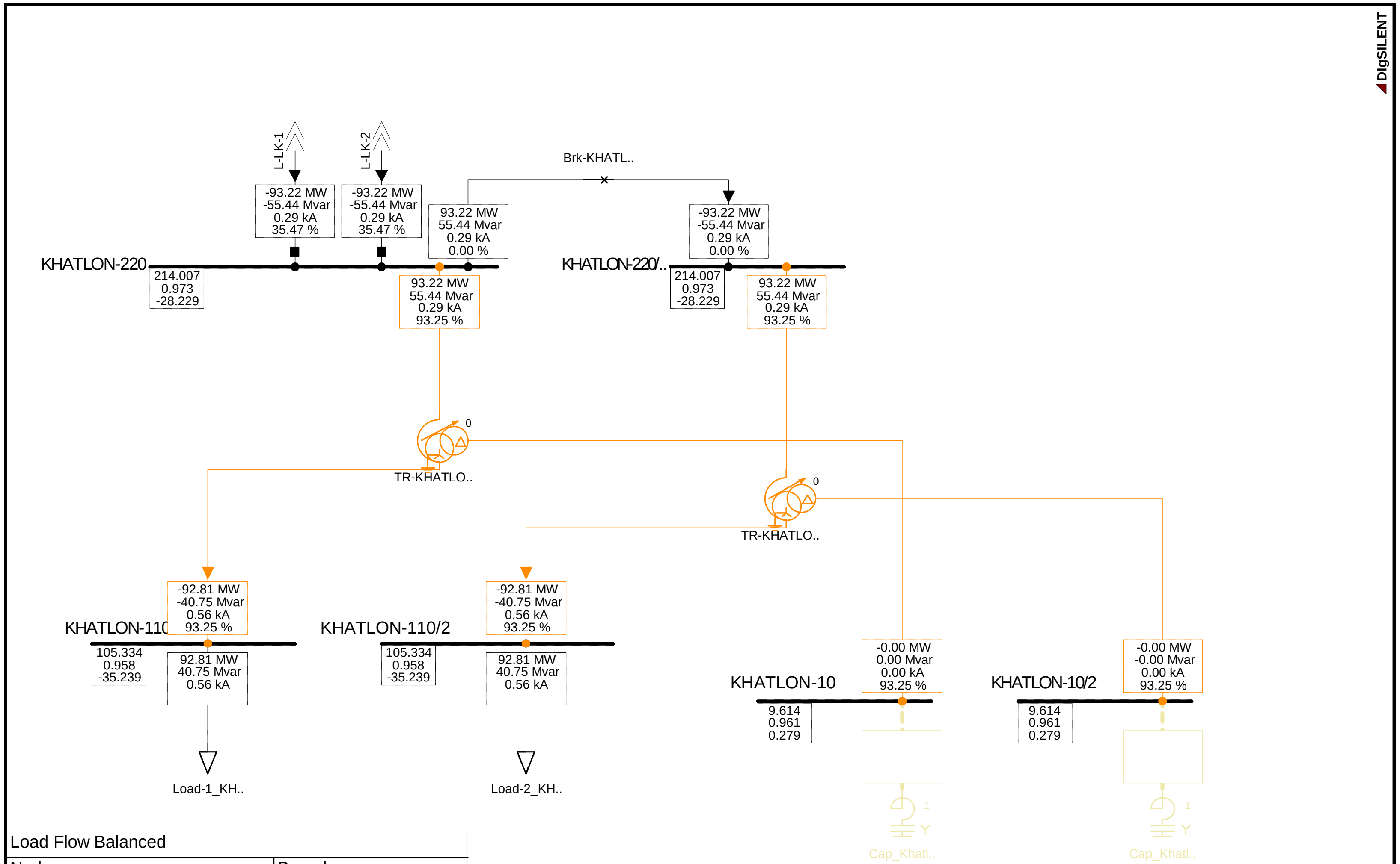



| Load Flow Balanced | |
|---|---|
| Nodes | Branches |
| Line-Line Voltage, Magnitude [kV] | Active Power [MW] |
| Voltage, Magnitude [p.u.] | Reactive Power [Mvar] |
| Voltage, Angle [deg] | Current, Magnitude [kA] |
| | Maximum Loading [%] |

| | | |
|---|---|---|
| | | Project: |
| | | Graphic: DJANGAL |
| | | Date: 26/06/2013 |
| PowerFactory 14.1.3 | | Annex: |

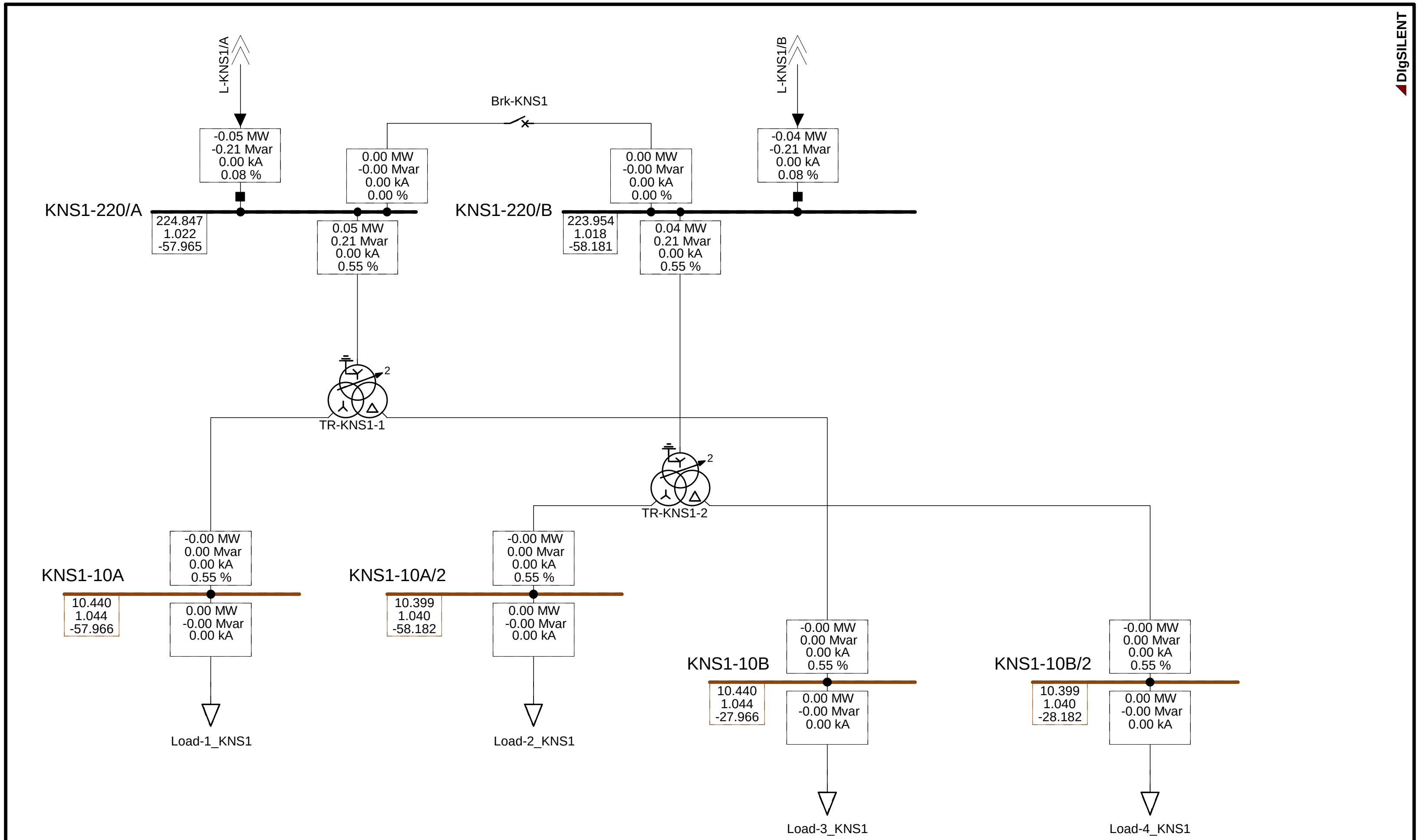

DIgSILENT
L-24-KB/2
-136.21 MW
-70.73 Mvar
0.42 kA
30.77 %
KANIBADAM-220/A
208.704
KANIBADAM-220/B
208.704
0.949
-63.381
0.00 MW
0.00 Mvar
0.00 kA
0.00 %
68.10 MW
35.36 Mvar
0.21 kA
67.65 %
68.10 MW
35.36 Mvar
0.21 kA
67.65 %
TR-KANIBADAM-1
TR-KANIBADAM-2
KANIBADAM-110
-67.91 MW
-23.39 Mvar
0.40 kA
67.65 %
103.087
0.937
-71.558
67.91 MW
23.39 Mvar
0.40 kA
KANIBADAM-110/2
-67.91 MW
-23.39 Mvar
0.40 kA
67.65 %
103.087
0.937
-71.558
67.91 MW
23.39 Mvar
0.40 kA
KANIBADAM-10
-0.00 MW
0.00 Mvar
0.00 kA
67.65 %
9.022
0.902
-40.963
KANIBADAM-10/2
-0.00 MW
0.00 Mvar
0.00 kA
67.65 %
9.022
0.902
-40.963
Load-1_KA..
Load-2_KA..
Cap_Kanib/1
Cap_Kanib/2
Load Flow Balanced
Nodes
Line-Line Voltage, Magnitude [kV]
Voltage, Magnitude [p.u.]
Voltage, Angle [deg]
Branches
Active Power [MW]
Reactive Power [Mvar]
Current, Magnitude [kA]
Loading [%]
PowerFactory 14.1.3
Project:
Graphic: KANIBADAM
Date: 26/06/2013
Annex:


DIgSILENT
L-K-A
KAYROKUM-220/A
215.280
0.979
-61.157
L-S-24/3
-56.79 MW
-30.79 Mvar
0.17 kA
25.11 %
48.45 MW
18.43 Mvar
0.14 kA
0.00 %
L-K-24
31.94 MW
3.09 Mvar
0.09 kA
12.63 %
-56.52 MW
-16.73 Mvar
0.16 kA
70.14 %
37.71 MW
12.71 Mvar
0.11 kA
0.00 %
-56.52 MW
-16.73 Mvar
0.16 kA
70.14 %
83.67 MW
33.09 Mvar
0.24 kA
0.00 %
137.89 MW
61.14 Mvar
0.40 kA
30.43 %
L-24-KB/1
KAYROKUM-220/B
215.280
0.979
-61.157
TR-KAYROKUM-1
TR-KAYROKUM-2
-0.00 MW
0.00 Mvar
0.00 kA
70.14 %
KAYROKUM-110
109.113
0.992
-58.966
-0.00 MW
0.00 Mvar
0.00 kA
70.14 %
KAYROKUM-110/b
109.113
0.992
-58.966
56.70 MW
24.73 Mvar
3.47 kA
70.14 %
KAYROKUM-10
10.290
0.980
-24.344
18.90 MW
8.24 Mvar
1.16 kA
88.37 %
56.70 MW
24.73 Mvar
3.47 kA
70.14 %
KAYROKUM-10/b
10.290
0.980
-24.344
18.90 MW
8.24 Mvar
1.16 kA
88.37 %
HPP24-KAYR-1
HPP24-KAYR-2
HPP24-KAYR-3
HPP24-KAYR-4
HPP24-KAYR-5
HPP24-KAYR-6



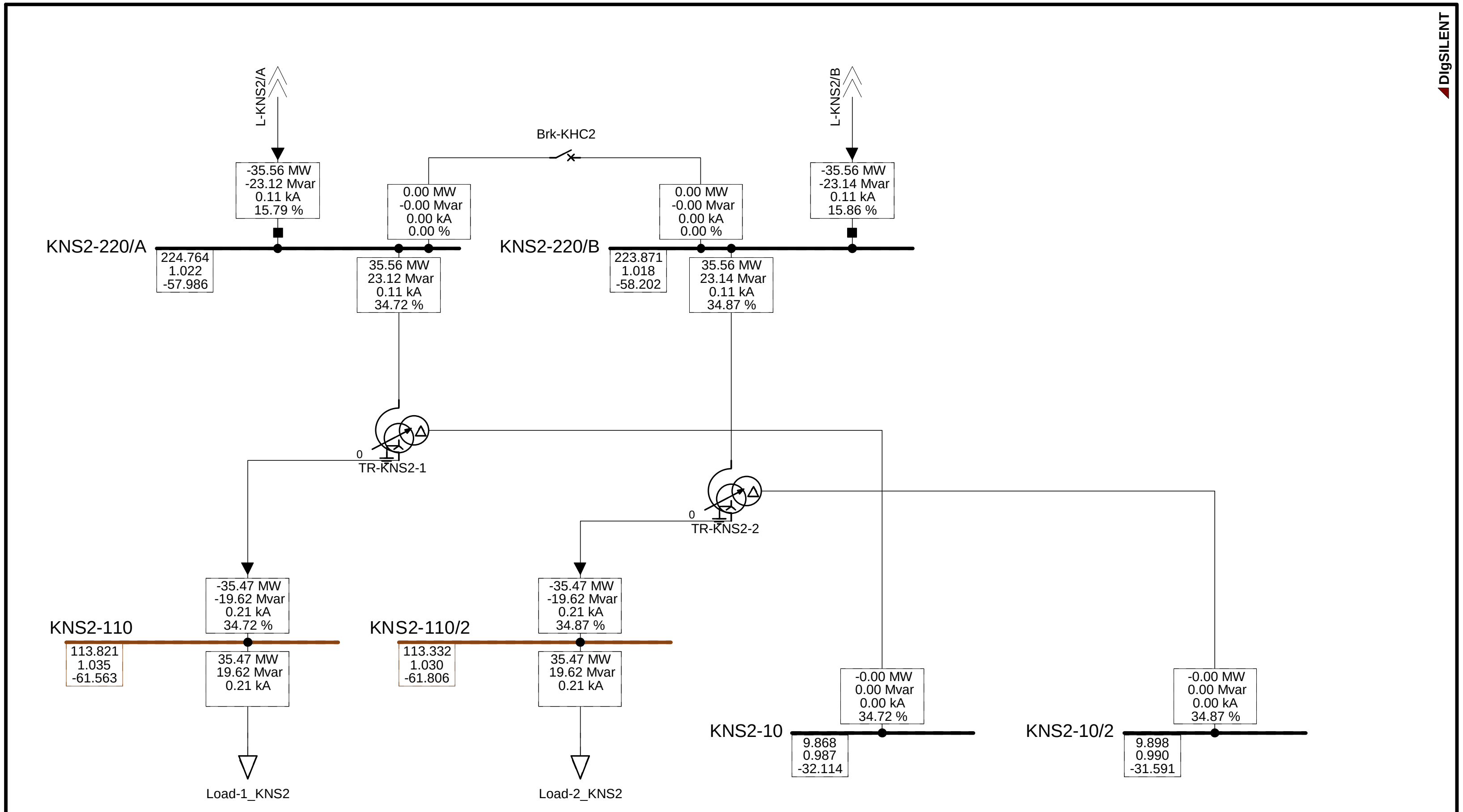

| Load Flow Balanced | |
|---|---|
| Nodes | Branches |
| Line-Line Voltage, Magnitude [kV] | Active Power [MW] |
| Voltage, Magnitude [p.u.] | Reactive Power [Mvar] |
| Voltage, Angle [deg] | Current, Magnitude [kA] |
| | Maximum Loading [%] |

| | | |
|---|---|---|
| | | Project: |
| | | Graphic: KHATLON |
| | | Date: 26/06/2013 |
| PowerFactory 14.1.3 | | Annex: |



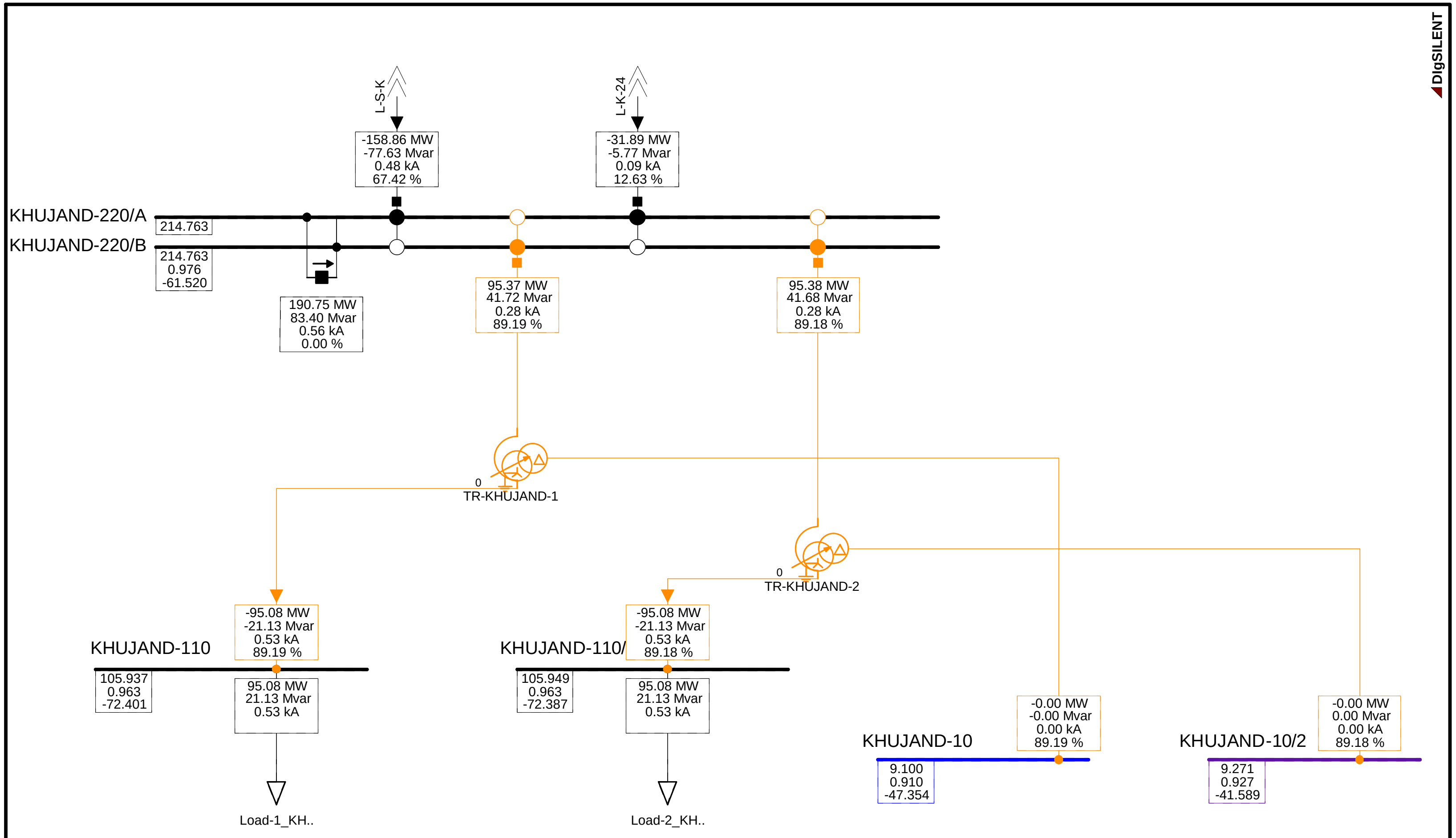

| Load Flow Balanced | |
|---|---|
| Nodes | Branches |
| Line-Line Voltage, Magnitude [kV] | Active Power [MW] |
| Voltage, Magnitude [p.u.] | Reactive Power [Mvar] |
| Voltage, Angle [deg] | Current, Magnitude [kA] |
| | Maximum Loading [%] |

| | | |
|---|---|---|
| | | Project: |
| | | Graphic: KNS1 |
| | | Date: 26/06/2013 |
| PowerFactory 14.1.3 | | Annex: |



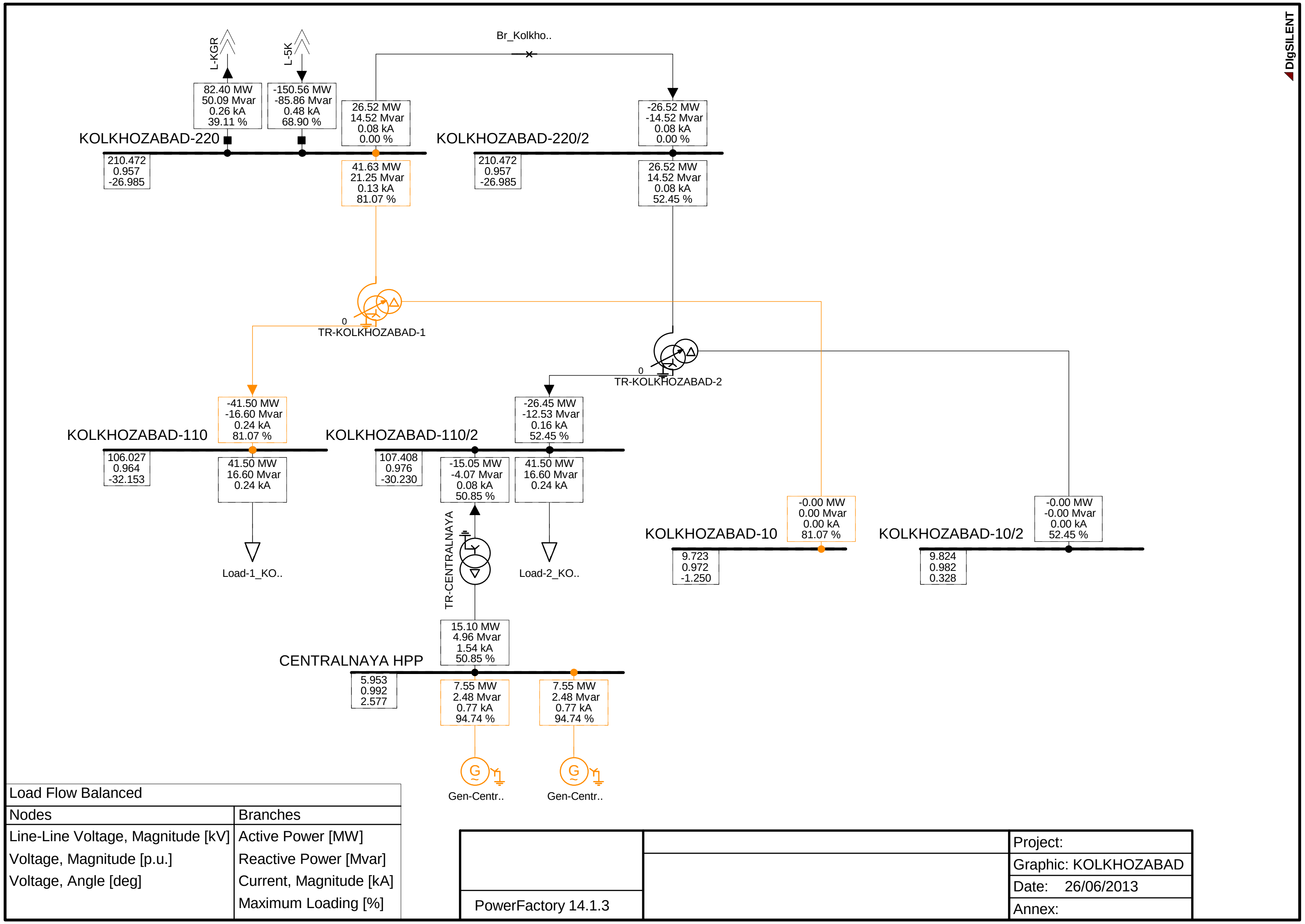

| Load Flow Balanced | |
|---|---|
| Nodes | Branches |
| Line-Line Voltage, Magnitude [kV] | Active Power [MW] |
| Voltage, Magnitude [p.u.] | Reactive Power [Mvar] |
| Voltage, Angle [deg] | Current, Magnitude [kA] |
| | Maximum Loading [%] |

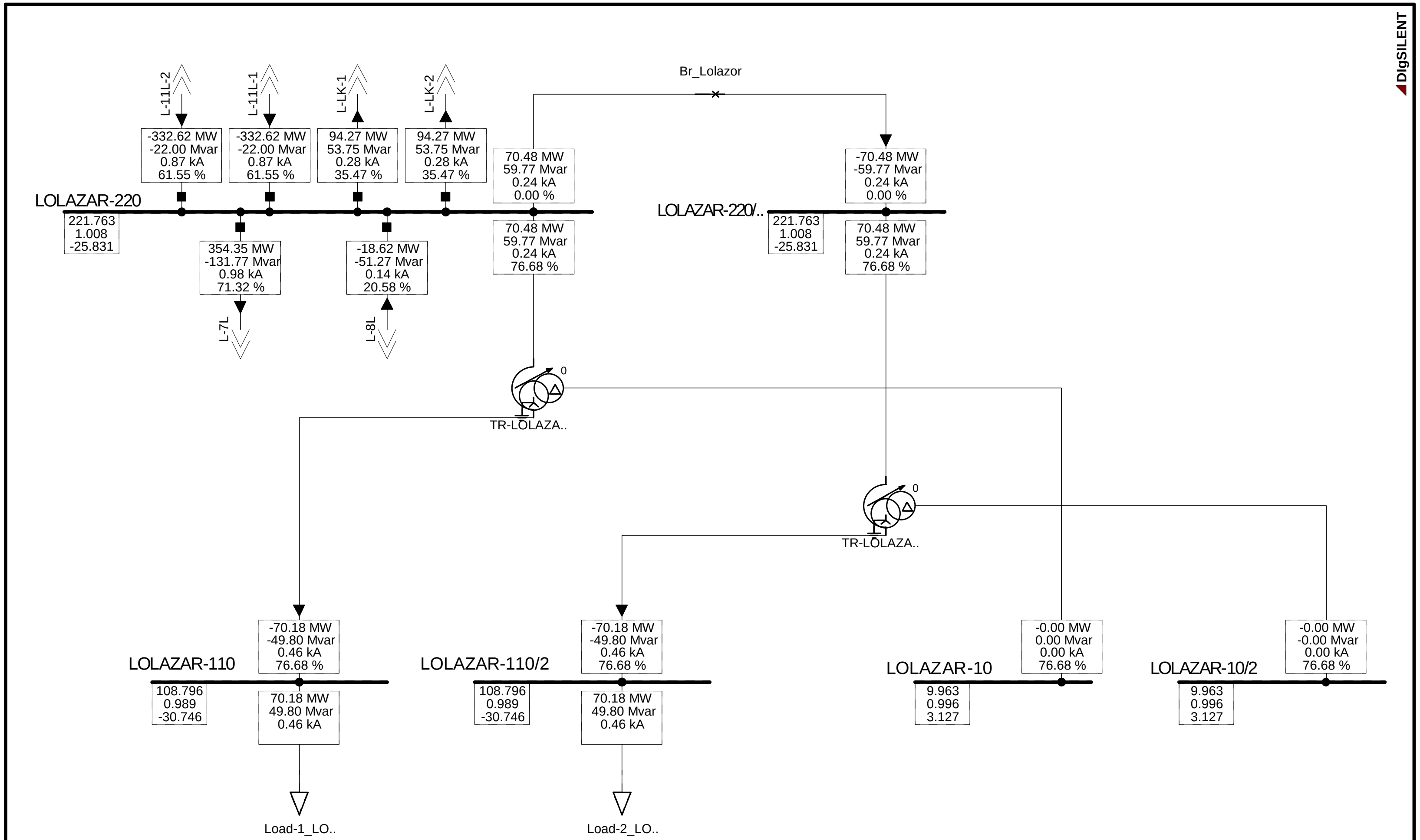
| | | |
|---|---|---|
| | | Project: |
| | | Graphic: KNS2 |
| | | Date: 26/06/2013 |
| PowerFactory 14.1.3 | | Annex: |




| Load Flow Balanced | |
|---|---|
| Nodes | Branches |
| Line-Line Voltage, Magnitude [kV] | Active Power [MW] |
| Voltage, Magnitude [p.u.] | Reactive Power [Mvar] |
| Voltage, Angle [deg] | Current, Magnitude [kA] |
| | Loading [%] |

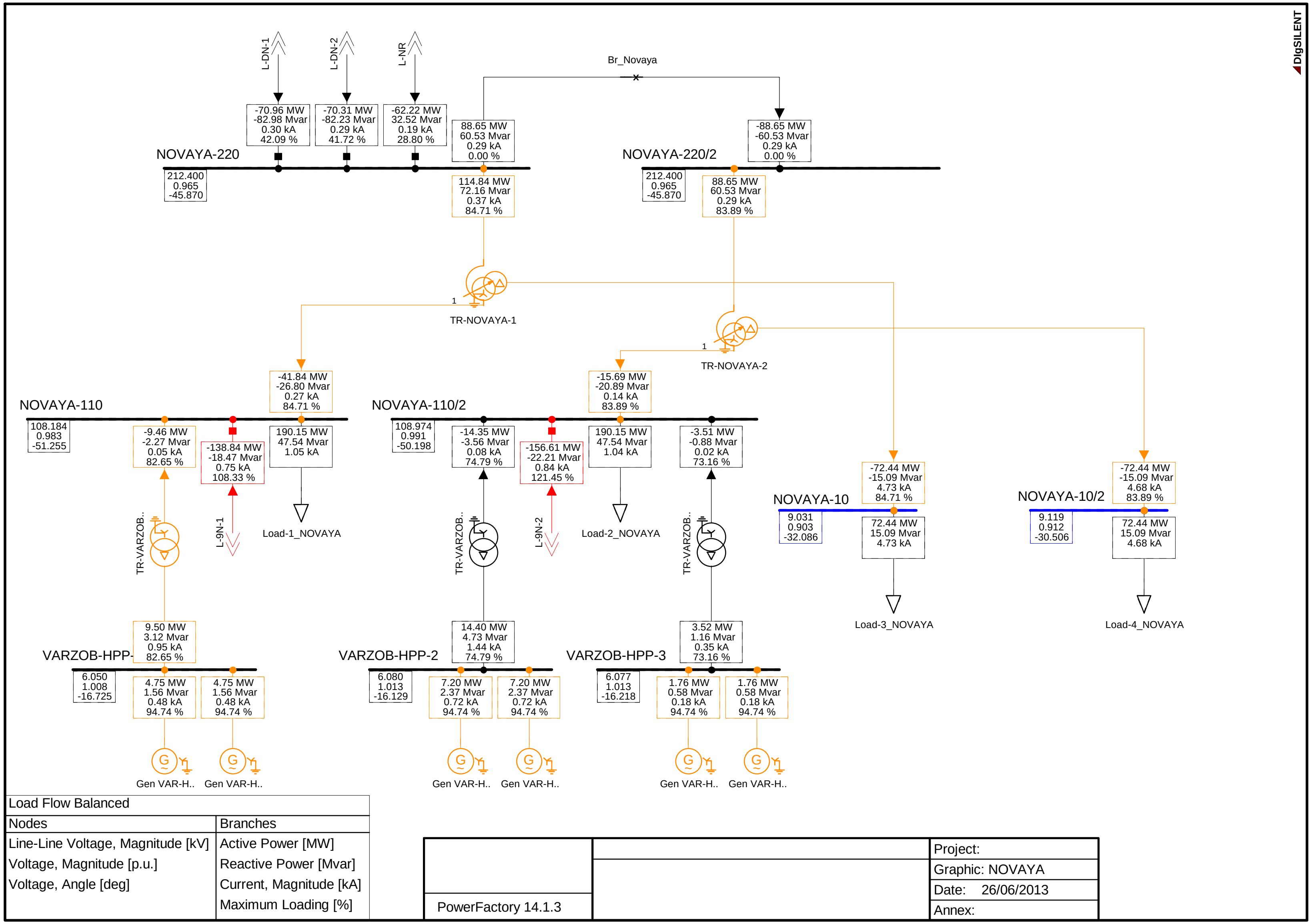
| | | |
|---|---|---|
| | | Project: |
| | | Graphic: KHUJAND |
| PowerFactory 14.1.3 | | Date: 26/06/2013 |
| | | Annex: |

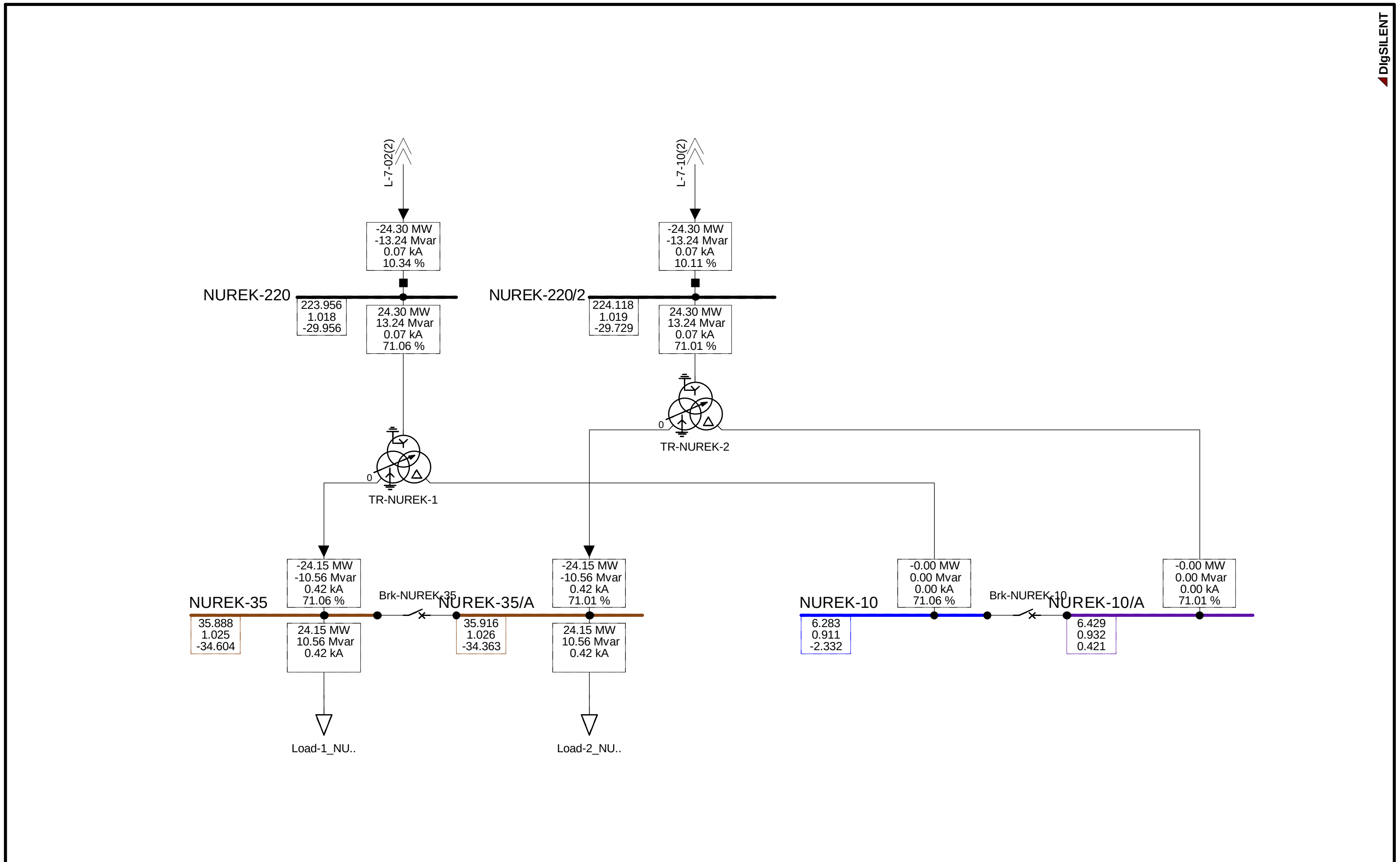

DIgSILENT
L-KGR
L-5K
Br_Kolkho..
82.40 MW
50.09 Mvar
0.26 kA
39.11 %
-150.56 MW
-85.86 Mvar
0.48 kA
68.90 %
26.52 MW
14.52 Mvar
0.08 kA
0.00 %
-26.52 MW
-14.52 Mvar
0.08 kA
0.00 %
KOLKHOZABAD-220
KOLKHOZABAD-220/2
210.472
0.957
-26.985
41.63 MW
21.25 Mvar
0.13 kA
81.07 %
210.472
0.957
-26.985
26.52 MW
14.52 Mvar
0.08 kA
52.45 %
TR-KOLKHOZABAD-1
TR-KOLKHOZABAD-2
-41.50 MW
-16.60 Mvar
0.24 kA
81.07 %
-26.45 MW
-12.53 Mvar
0.16 kA
52.45 %
KOLKHOZABAD-110
KOLKHOZABAD-110/2
106.027
0.964
-32.153
41.50 MW
16.60 Mvar
0.24 kA
107.408
0.976
-30.230
-15.05 MW
-4.07 Mvar
0.08 kA
50.85 %
41.50 MW
16.60 Mvar
0.24 kA
-0.00 MW
0.00 Mvar
0.00 kA
81.07 %
-0.00 MW
-0.00 Mvar
0.00 kA
52.45 %
KOLKHOZABAD-10
KOLKHOZABAD-10/2
9.723
0.972
-1.250
9.824
0.982
0.328
Load-1_KO..
Load-2_KO..
TR-CENTRALNAYA
15.10 MW
4.96 Mvar
1.54 kA
50.85 %
CENTRALNAYA HPP
5.953
0.992
2.577
7.55 MW
2.48 Mvar
0.77 kA
94.74 %
7.55 MW
2.48 Mvar
0.77 kA
94.74 %
Gen-Centr..
Gen-Centr..
Load Flow Balanced
Nodes
Branches
Line-Line Voltage, Magnitude [kV]
Voltage, Magnitude [p.u.]
Voltage, Angle [deg]
Active Power [MW]
Reactive Power [Mvar]
Current, Magnitude [kA]
Maximum Loading [%]
PowerFactory 14.1.3
Project:
Graphic: KOLKHOZABAD
Date: 26/06/2013
Annex:




| Load Flow Balanced | |
|---|---|
| Nodes | Branches |
| Line-Line Voltage, Magnitude [kV] | Active Power [MW] |
| Voltage, Magnitude [p.u.] | Reactive Power [Mvar] |
| Voltage, Angle [deg] | Current, Magnitude [kA] |
| | Maximum Loading [%] |

| | | |
|---|---|---|
| | | Project: |
| | | Graphic: LOLAZAR |
| | | Date: 26/06/2013 |
| PowerFactory 14.1.3 | | Annex: |

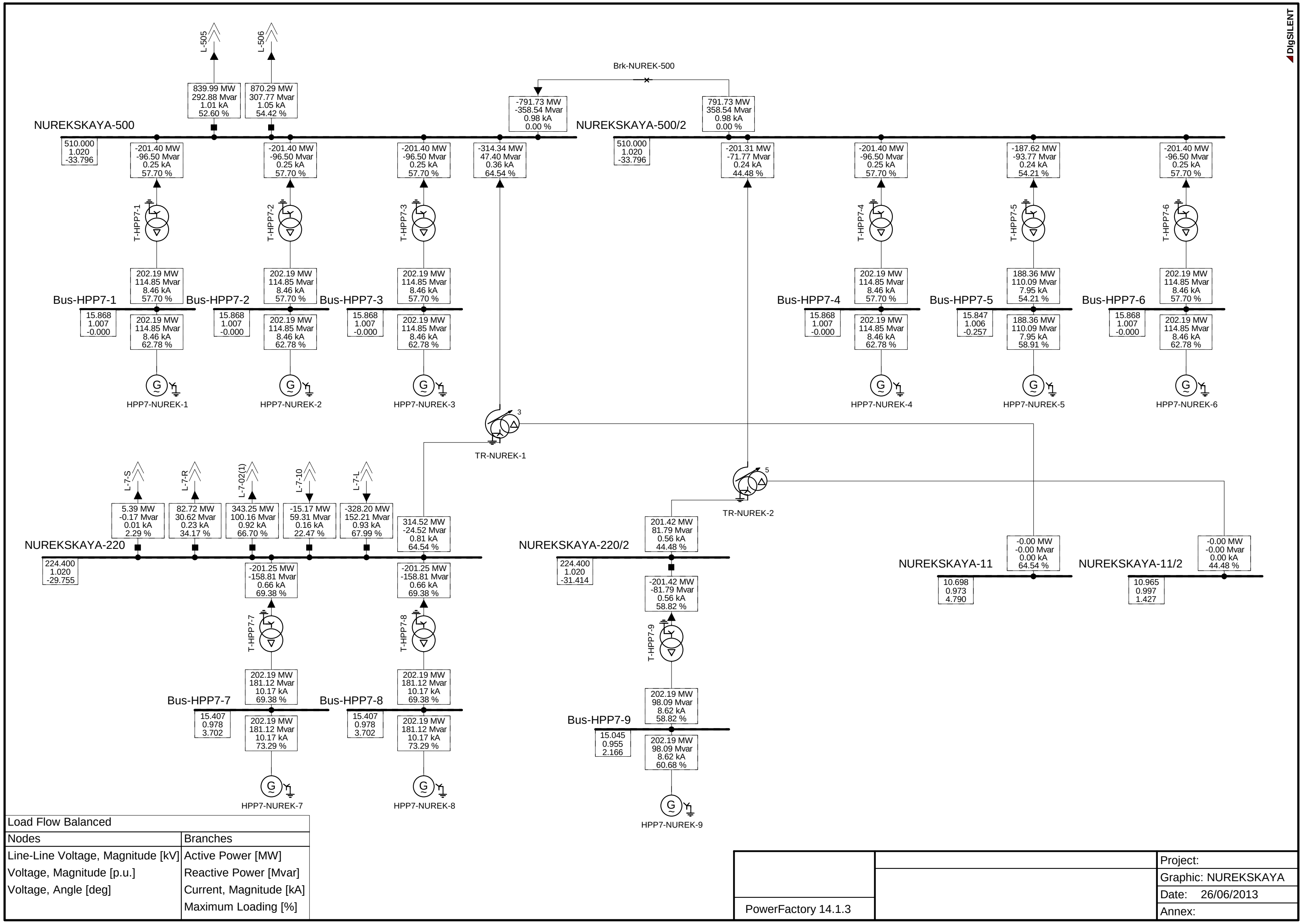

DIgSILENT
L-DN-1
L-DN-2
L-NR
Br_Novaya
-70.96 MW
-82.98 Mvar
0.30 kA
42.09 %
-70.31 MW
-82.23 Mvar
0.29 kA
41.72 %
-62.22 MW
32.52 Mvar
0.19 kA
28.80 %
88.65 MW
60.53 Mvar
0.29 kA
0.00 %
-88.65 MW
-60.53 Mvar
0.29 kA
0.00 %
NOVAYA-220
212.400
0.965
-45.870
NOVAYA-220/2
212.400
0.965
-45.870
114.84 MW
72.16 Mvar
0.37 kA
84.71 %
88.65 MW
60.53 Mvar
0.29 kA
83.89 %
TR-NOVAYA-1
TR-NOVAYA-2
-41.84 MW
-26.80 Mvar
0.27 kA
84.71 %
-15.69 MW
-20.89 Mvar
0.14 kA
83.89 %
NOVAYA-110
108.184
0.983
-51.255
NOVAYA-110/2
108.974
0.991
-50.198
-9.46 MW
-2.27 Mvar
0.05 kA
82.65 %
-138.84 MW
-18.47 Mvar
0.75 kA
108.33 %
190.15 MW
47.54 Mvar
1.05 kA
-14.35 MW
-3.56 Mvar
0.08 kA
74.79 %
-156.61 MW
-22.21 Mvar
0.84 kA
121.45 %
190.15 MW
47.54 Mvar
1.04 kA
-3.51 MW
-0.88 Mvar
0.02 kA
73.16 %
-72.44 MW
-15.09 Mvar
4.73 kA
84.71 %
-72.44 MW
-15.09 Mvar
4.68 kA
83.89 %
NOVAYA-10
9.031
0.903
-32.086
NOVAYA-10/2
9.119
0.912
-30.506
72.44 MW
15.09 Mvar
4.73 kA
72.44 MW
15.09 Mvar
4.68 kA
TR-VARZOB..
L-9N-1
Load-1_NOVAYA
TR-VARZOB..
L-9N-2
Load-2_NOVAYA
TR-VARZOB..
Load-3_NOVAYA
Load-4_NOVAYA
9.50 MW
3.12 Mvar
0.95 kA
82.65 %
14.40 MW
4.73 Mvar
1.44 kA
74.79 %
3.52 MW
1.16 Mvar
0.35 kA
73.16 %
VARZOB-HPP-
VARZOB-HPP-2
VARZOB-HPP-3
6.050
1.008
-16.725
4.75 MW
1.56 Mvar
0.48 kA
94.74 %
4.75 MW
1.56 Mvar
0.48 kA
94.74 %
6.080
1.013
-16.129
7.20 MW
2.37 Mvar
0.72 kA
94.74 %
7.20 MW
2.37 Mvar
0.72 kA
94.74 %
6.077
1.013
-16.218
1.76 MW
0.58 Mvar
0.18 kA
94.74 %
1.76 MW
0.58 Mvar
0.18 kA
94.74 %
Gen VAR-H..
Gen VAR-H..
Gen VAR-H..
Gen VAR-H..
Gen VAR-H..
Gen VAR-H..
Load Flow Balanced
Nodes
Branches
Line-Line Voltage, Magnitude [kV]
Voltage, Magnitude [p.u.]
Voltage, Angle [deg]
Active Power [MW]
Reactive Power [Mvar]
Current, Magnitude [kA]
Maximum Loading [%]
PowerFactory 14.1.3
Project:
Graphic: NOVAYA
Date: 26/06/2013
Annex:



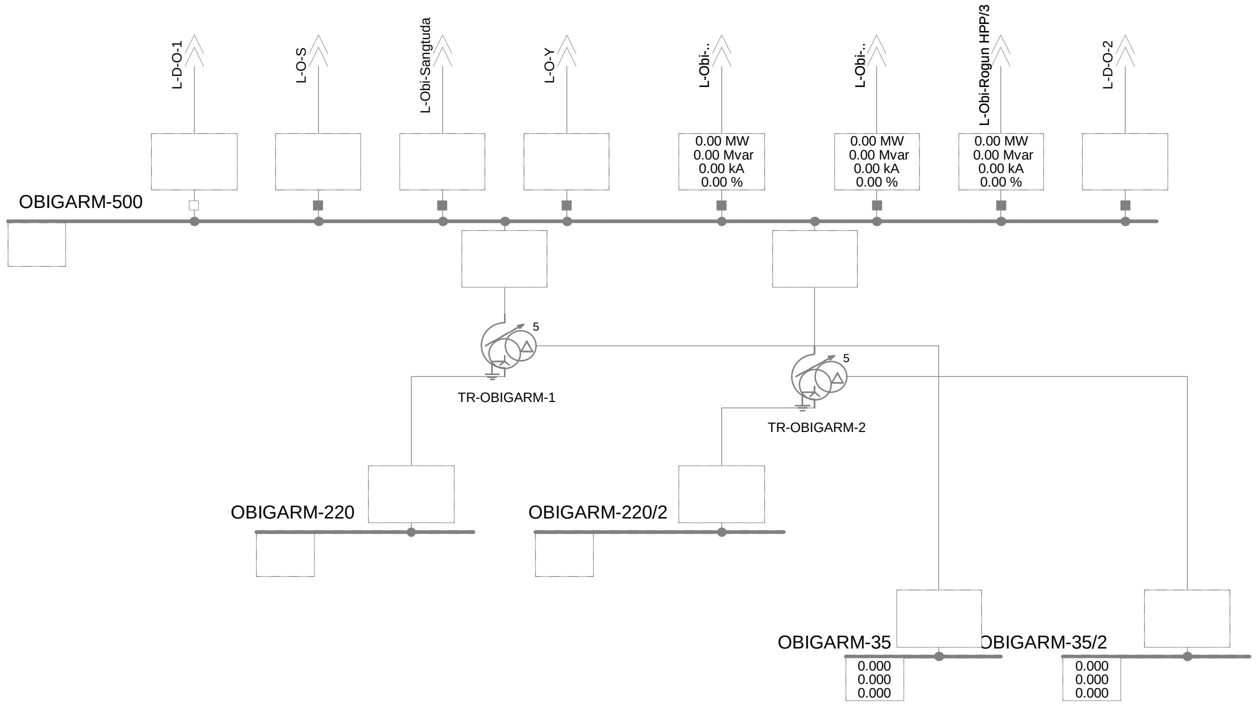

| Load Flow Balanced | |
|---|---|
| Nodes | Branches |
| Line-Line Voltage, Magnitude [kV] | Active Power [MW] |
| Voltage, Magnitude [p.u.] | Reactive Power [Mvar] |
| Voltage, Angle [deg] | Current, Magnitude [kA] |

PowerFactory 14.1.3

Project:
Graphic: NUREK
Date: 26/06/2013
Annex:

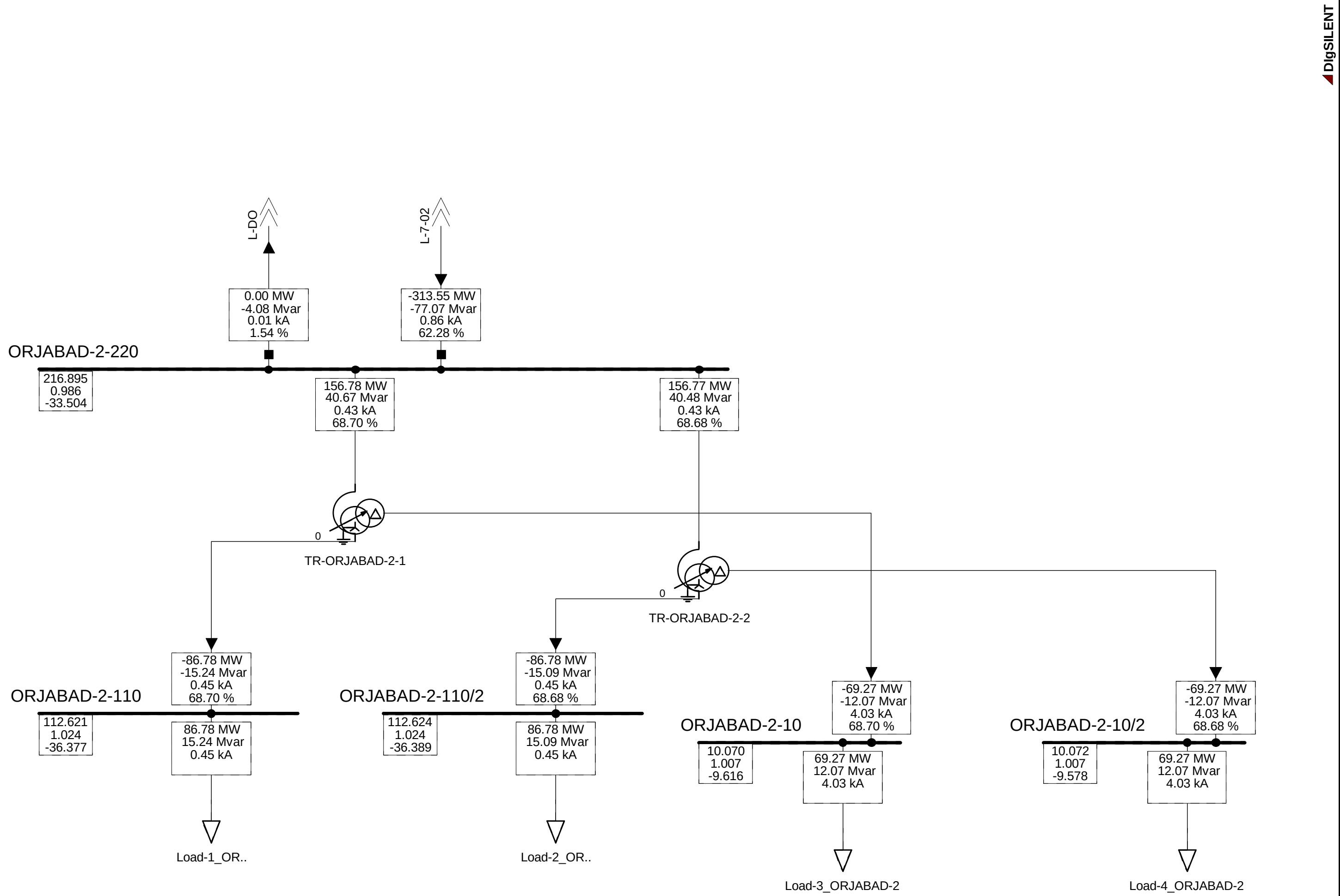

DIgSILENT
L-505
L-506
839.99 MW
292.88 Mvar
1.01 kA
52.60 %
870.29 MW
307.77 Mvar
1.05 kA
54.42 %
Brk-NUREK-500
-791.73 MW
-358.54 Mvar
0.98 kA
0.00 %
791.73 MW
358.54 Mvar
0.98 kA
0.00 %
NUREKSKAYA-500
510.000
1.020
-33.796
NUREKSKAYA-500/2
510.000
1.020
-33.796
-201.40 MW
-96.50 Mvar
0.25 kA
57.70 %
-314.34 MW
47.40 Mvar
0.36 kA
64.54 %
-201.31 MW
-71.77 Mvar
0.24 kA
44.48 %
-187.62 MW
-93.77 Mvar
0.24 kA
54.21 %
T-HPP7-1
T-HPP7-2
T-HPP7-3
T-HPP7-4
T-HPP7-5
T-HPP7-6
202.19 MW
114.85 Mvar
8.46 kA
57.70 %
188.36 MW
110.09 Mvar
7.95 kA
54.21 %
Bus-HPP7-1
Bus-HPP7-2
Bus-HPP7-3
Bus-HPP7-4
Bus-HPP7-5
Bus-HPP7-6
15.868
1.007
-0.000
15.847
1.006
-0.257
202.19 MW
114.85 Mvar
8.46 kA
62.78 %
188.36 MW
110.09 Mvar
7.95 kA
58.91 %
HPP7-NUREK-1
HPP7-NUREK-2
HPP7-NUREK-3
HPP7-NUREK-4
HPP7-NUREK-5
HPP7-NUREK-6
TR-NUREK-1
TR-NUREK-2
L-7-S
L-7-R
L-7-02(1)
L-7-10
L-7-L
5.39 MW
-0.17 Mvar
0.01 kA
2.29 %
82.72 MW
30.62 Mvar
0.23 kA
34.17 %
343.25 MW
100.16 Mvar
0.92 kA
66.70 %
-15.17 MW
59.31 Mvar
0.16 kA
22.47 %
-328.20 MW
152.21 Mvar
0.93 kA
67.99 %
314.52 MW
-24.52 Mvar
0.81 kA
64.54 %
NUREKSKAYA-220
224.400
1.020
-29.755
-201.25 MW
-158.81 Mvar
0.66 kA
69.38 %
NUREKSKAYA-220/2
224.400
1.020
-31.414
201.42 MW
81.79 Mvar
0.56 kA
44.48 %
-201.42 MW
-81.79 Mvar
0.56 kA
58.82 %
T-HPP7-7
T-HPP7-8
T-HPP7-9
202.19 MW
181.12 Mvar
10.17 kA
69.38 %
Bus-HPP7-7
Bus-HPP7-8
15.407
0.978
3.702
202.19 MW
181.12 Mvar
10.17 kA
73.29 %
HPP7-NUREK-7
HPP7-NUREK-8
202.19 MW
98.09 Mvar
8.62 kA
58.82 %
Bus-HPP7-9
15.045
0.955
2.166
202.19 MW
98.09 Mvar
8.62 kA
60.68 %
HPP7-NUREK-9
NUREKSKAYA-11
-0.00 MW
-0.00 Mvar
0.00 kA
64.54 %
10.698
0.973
4.790
NUREKSKAYA-11/2
-0.00 MW
-0.00 Mvar
0.00 kA
44.48 %
10.965
0.997
1.427
Load Flow Balanced
Nodes
Branches
Line-Line Voltage, Magnitude [kV]
Voltage, Magnitude [p.u.]
Voltage, Angle [deg]
Active Power [MW]
Reactive Power [Mvar]
Current, Magnitude [kA]
Maximum Loading [%]
PowerFactory 14.1.3
Project:
Graphic: NUREKSKAYA
Date: 26/06/2013
Annex:

DIgSILENT



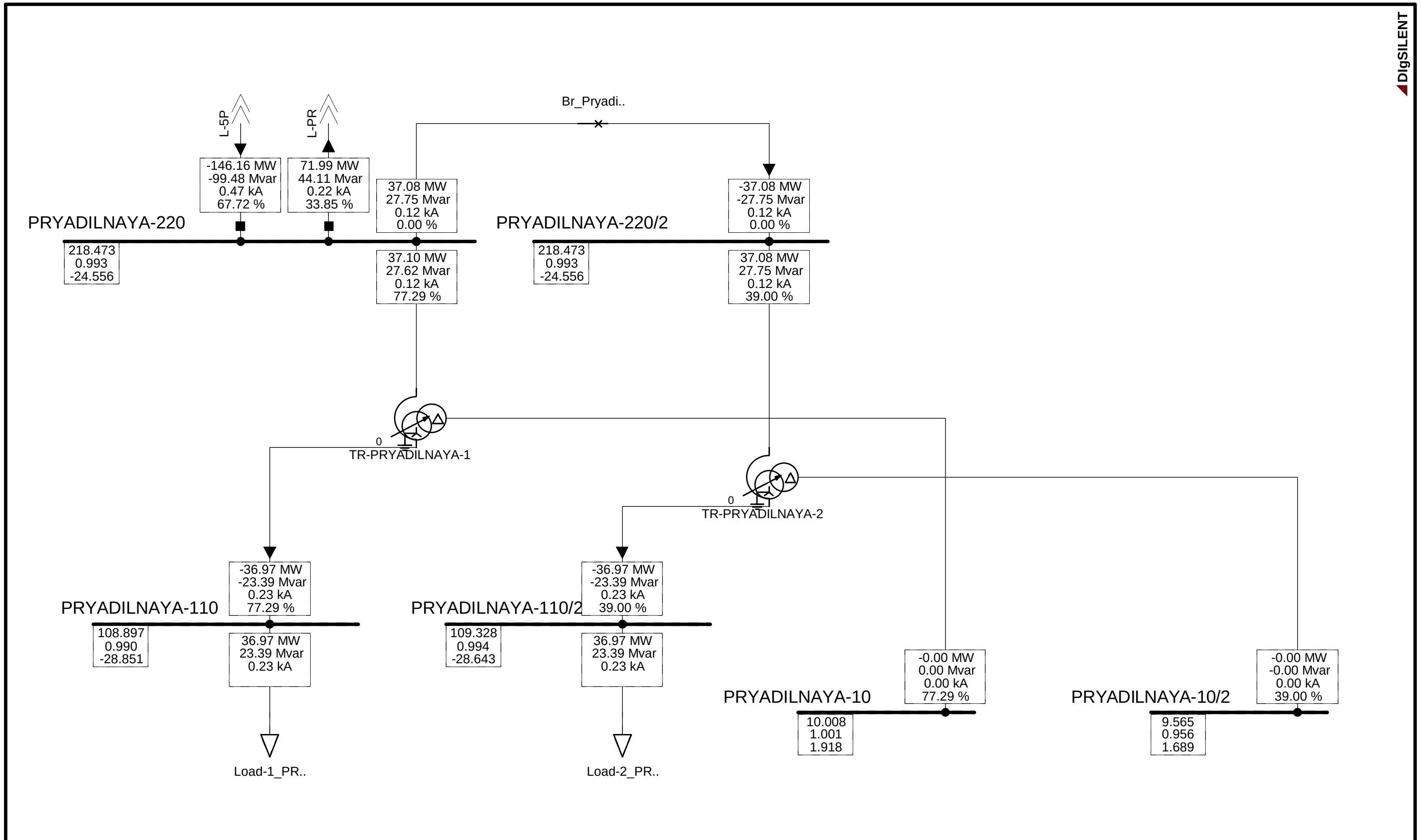

| Load Flow Balanced | |
|---|---|
| Nodes | Branches |
| Line-Line Voltage, Magnitude [kV] | Active Power [MW] |
| Voltage, Magnitude [p.u.] | Reactive Power [Mvar] |
| Voltage, Angle [deg] | Current, Magnitude [kA] |
| | Loading [%] |

| | | |
|---|---|---|
| | | Project: |
| | | Graphic: OBIGARM |
| | | Date: 26/06/2013 |
| PowerFactory 14.1.3 | | Annex: |



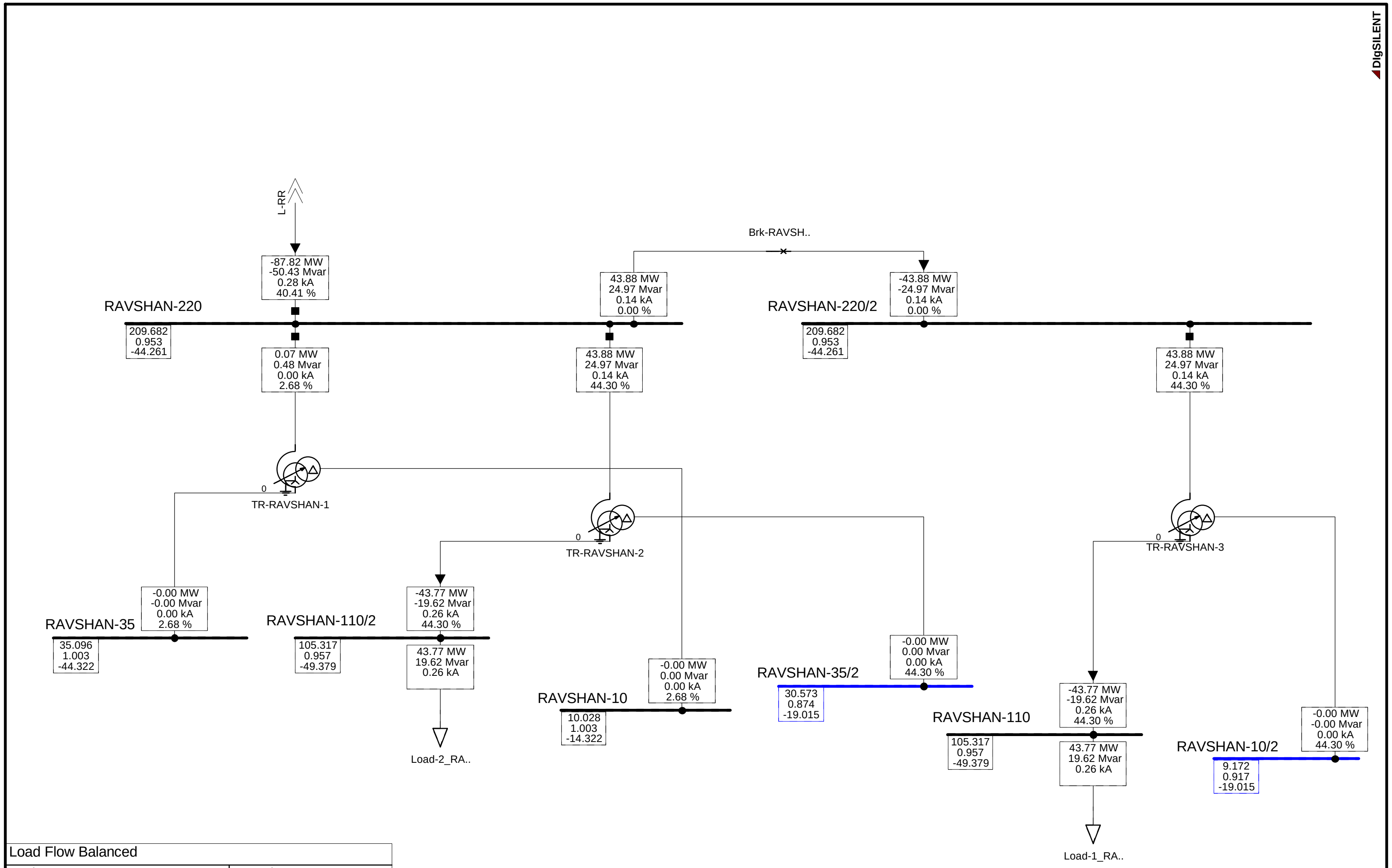

| Load Flow Balanced | |
|---|---|
| Nodes | Branches |
| Line-Line Voltage, Magnitude [kV] | Active Power [MW] |
| Voltage, Magnitude [p.u.] | Reactive Power [Mvar] |
| Voltage, Angle [deg] | Current, Magnitude [kA] |
| | Maximum Loading [%] |

| | | |
|---|---|---|
| | | Project: |
| | | Graphic: ORJABAD-2 |
| | | Date: 26/06/2013 |
| PowerFactory 14.1.3 | | Annex: |




| Load Flow Balanced | |
|---|---|
| Nodes | Branches |
| Line-Line Voltage, Magnitude [kV] | Active Power [MW] |
| Voltage, Magnitude [p.u.] | Reactive Power [Mvar] |
| Voltage, Angle [deg] | Current, Magnitude [kA] |
| | Maximum Loading [%] |

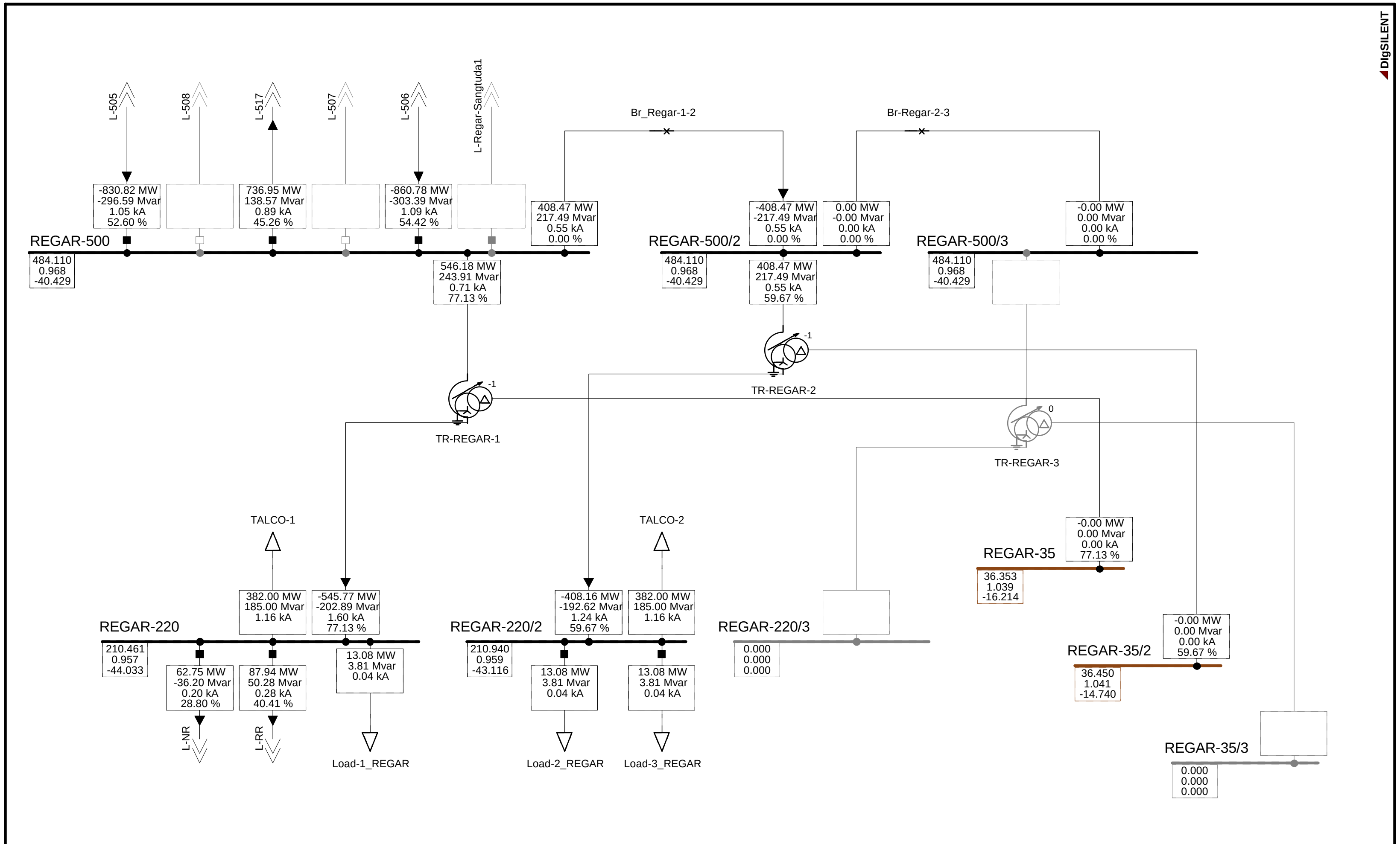
| | | |
|---|---|---|
| | | Project: |
| | | Graphic: PRYADILNAYA |
| | | Date: 26/06/2013 |
| PowerFactory 14.1.3 | | Annex: |




| Load Flow Balanced | |
|---|---|
| Nodes | Branches |
| Line-Line Voltage, Magnitude [kV] | Active Power [MW] |
| Voltage, Magnitude [p.u.] | Reactive Power [Mvar] |
| Voltage, Angle [deg] | Current, Magnitude [kA] |
| | Maximum Loading [%] |

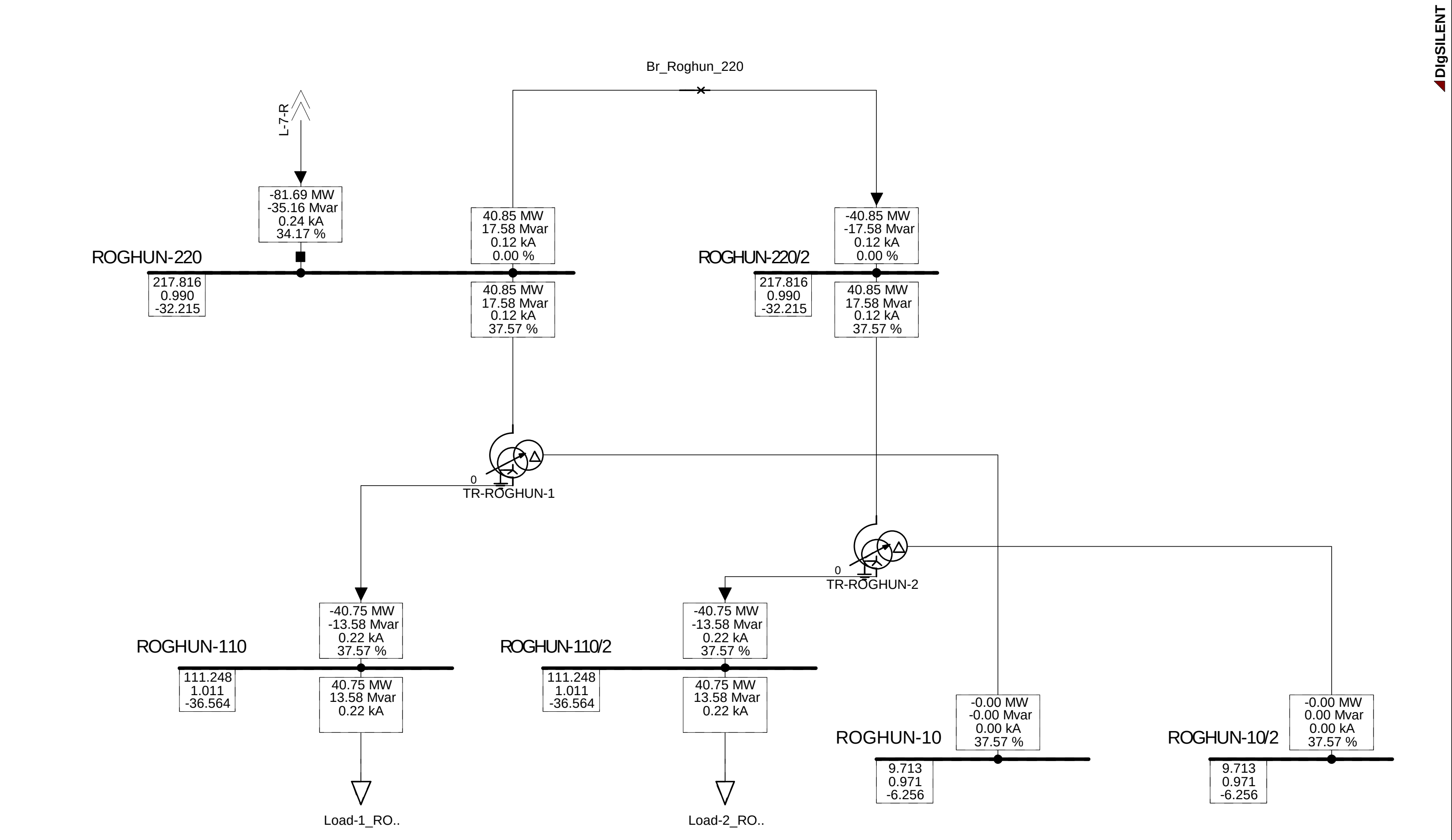
PowerFactory 14.1.3

Project:
Graphic: RAVSHAN
Date: 26/06/2013
Annex:



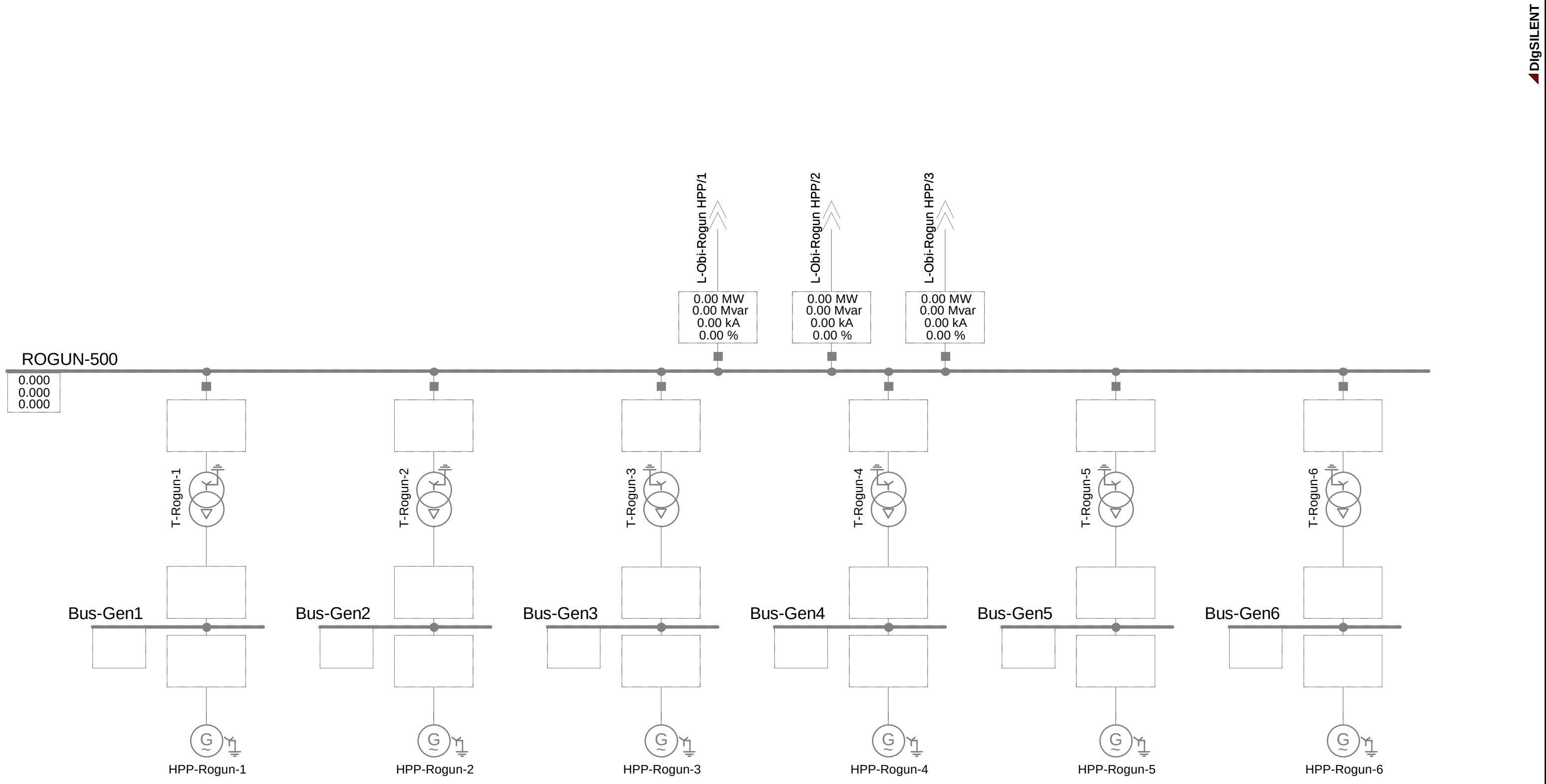

| Load Flow Balanced | |
|---|---|
| Nodes | Branches |
| Line-Line Voltage, Magnitude [kV] | Active Power [MW] |
| Voltage, Magnitude [p.u.] | Reactive Power [Mvar] |
| Voltage, Angle [deg] | Current, Magnitude [kA] |
| | Maximum Loading [%] |

| | | |
|---|---|---|
| | | Project: |
| | | Graphic: REGAR |
| | | Date: 26/06/2013 |
| PowerFactory 14.1.3 | | Annex: |



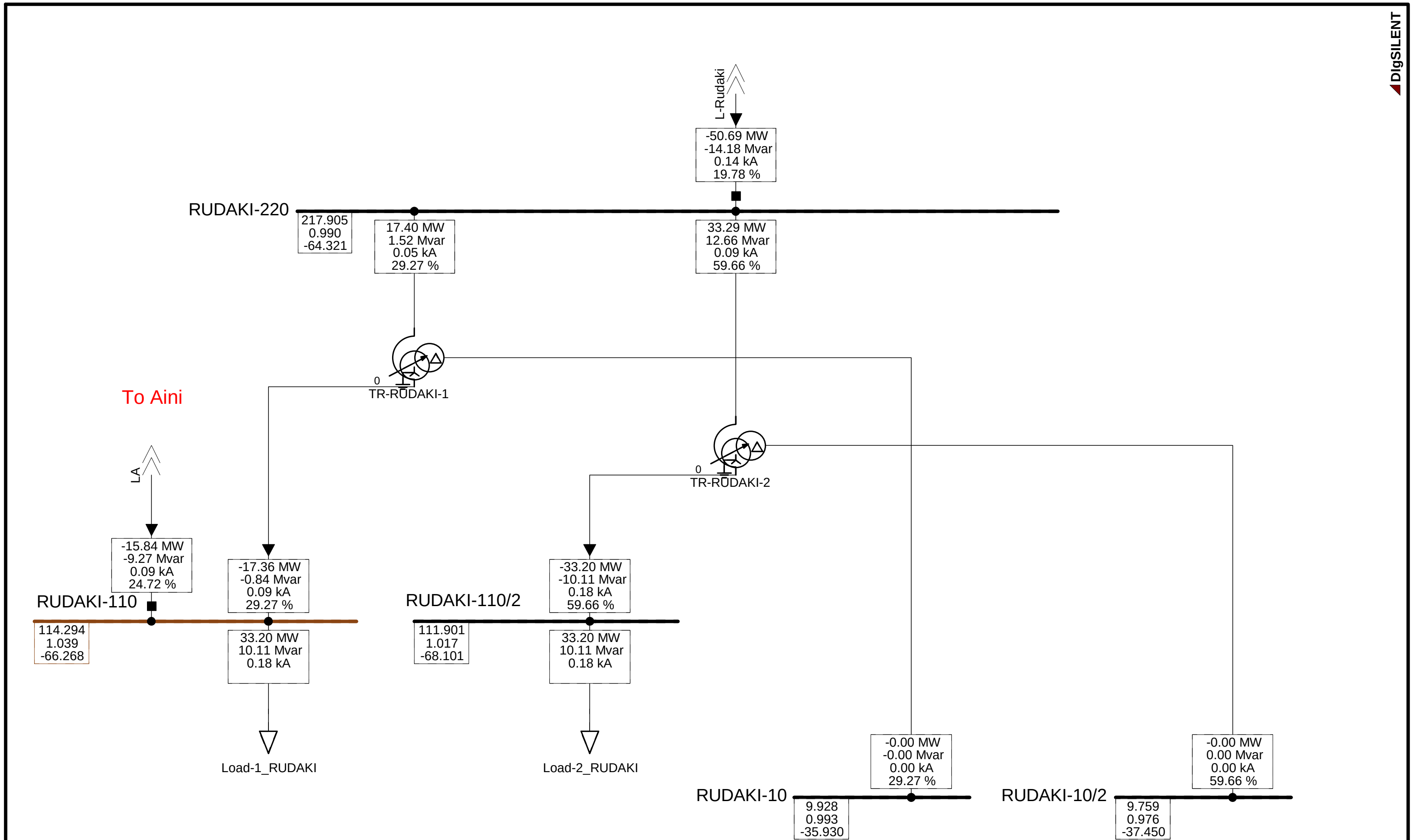

| Load Flow Balanced | |
|---|---|
| Nodes | Branches |
| Line-Line Voltage, Magnitude [kV] | Active Power [MW] |
| Voltage, Magnitude [p.u.] | Reactive Power [Mvar] |
| Voltage, Angle [deg] | Current, Magnitude [kA] |
| | Maximum Loading [%] |

| | | |
|---|---|---|
| | | Project: |
| | | Graphic: ROGHUN |
| | | Date: 26/06/2013 |
| PowerFactory 14.1.3 | | Annex: |



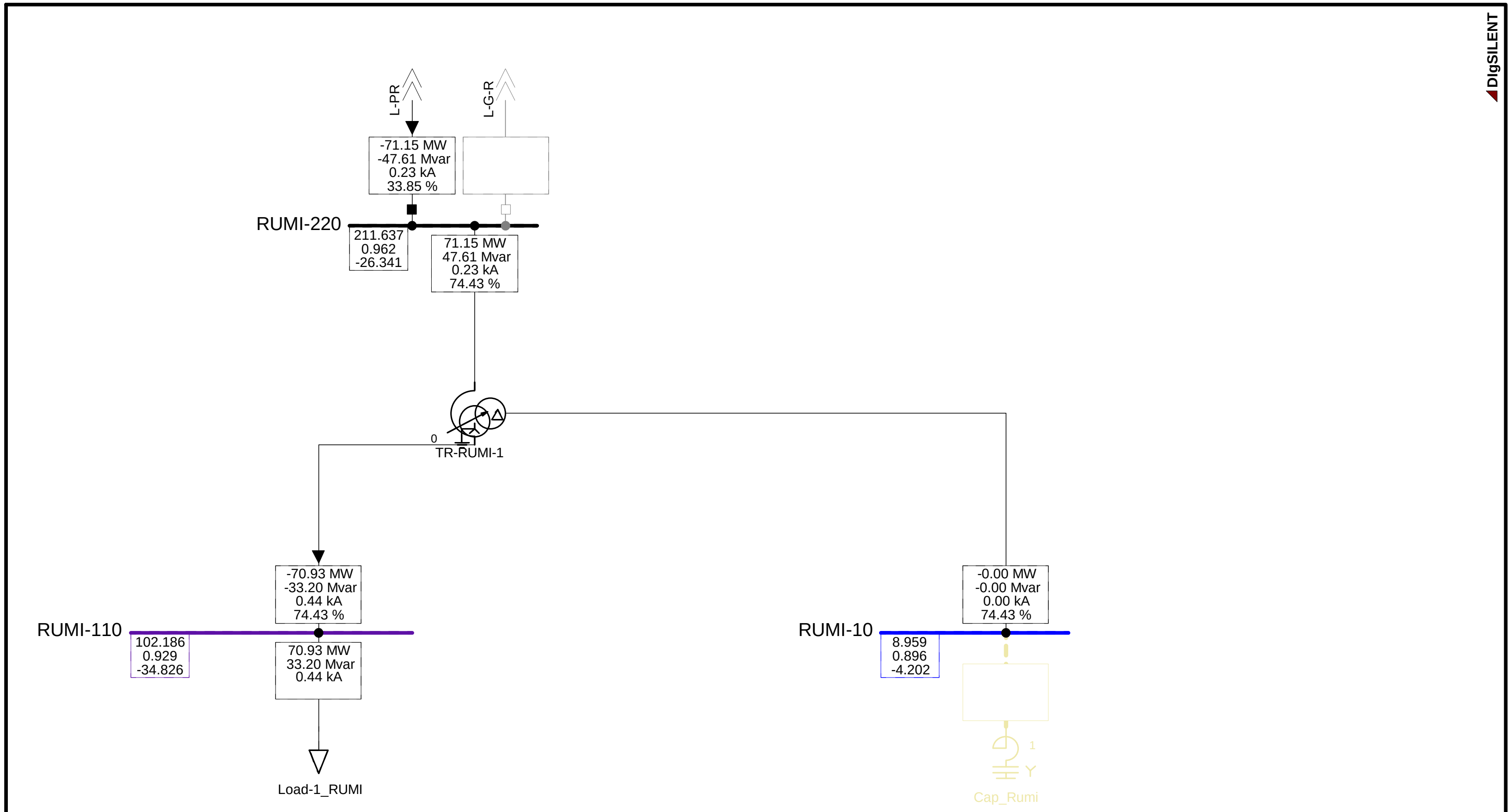

| Load Flow Balanced | |
|---|---|
| Nodes | Branches |
| Line-Line Voltage, Magnitude [kV] | Active Power [MW] |
| Voltage, Magnitude [p.u.] | Reactive Power [Mvar] |
| Voltage, Angle [deg] | Current, Magnitude [kA] |

| | | |
|---|---|---|
| | | Project: |
| | | Graphic: ROGUN HPP |
| | | Date: 26/06/2013 |
| PowerFactory 14.1.3 | | Annex: |



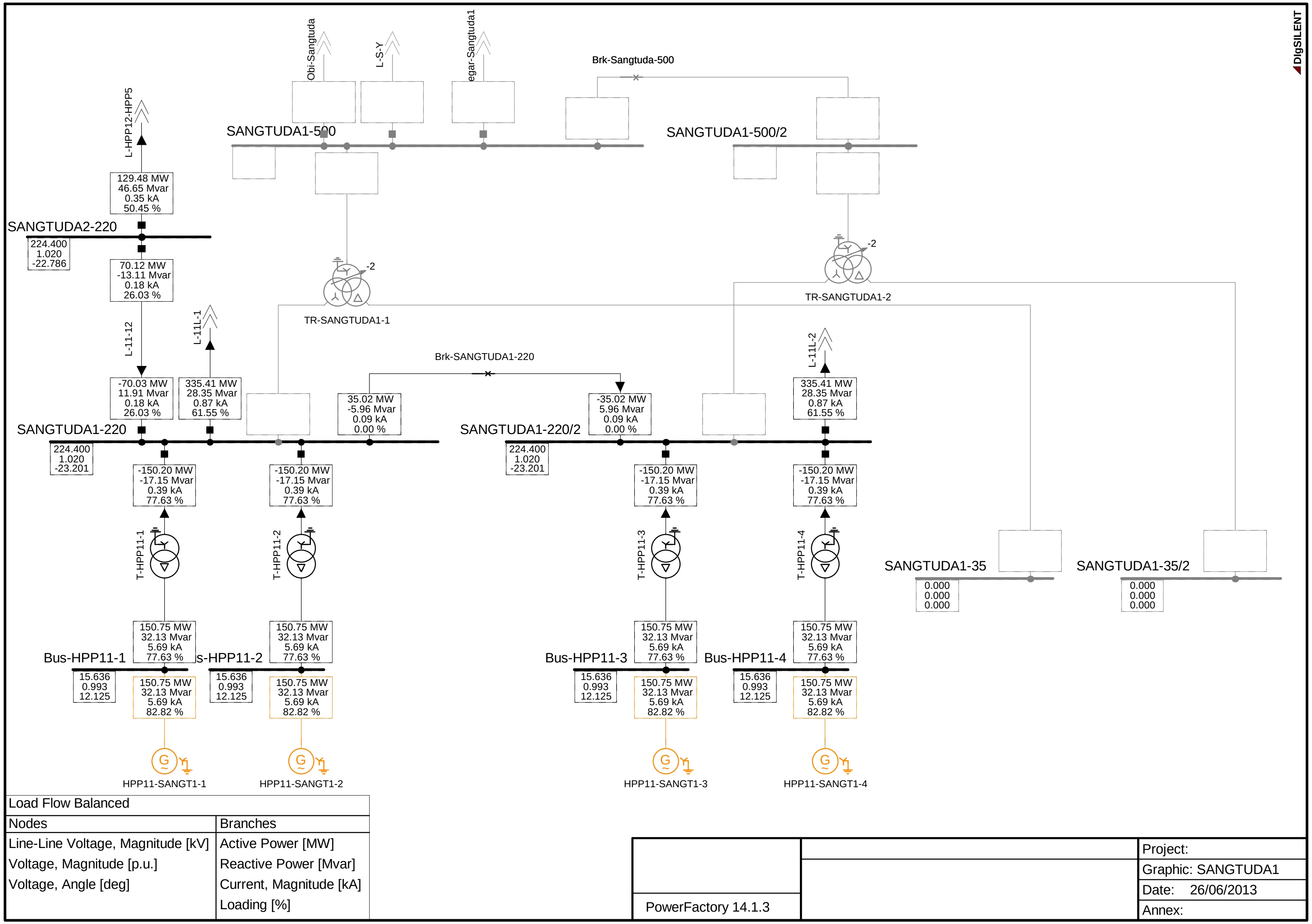

| Load Flow Balanced | |
|---|---|
| Nodes | Branches |
| Line-Line Voltage, Magnitude [kV] | Active Power [MW] |
| Voltage, Magnitude [p.u.] | Reactive Power [Mvar] |
| Voltage, Angle [deg] | Current, Magnitude [kA] |
| | Maximum Loading [%] |

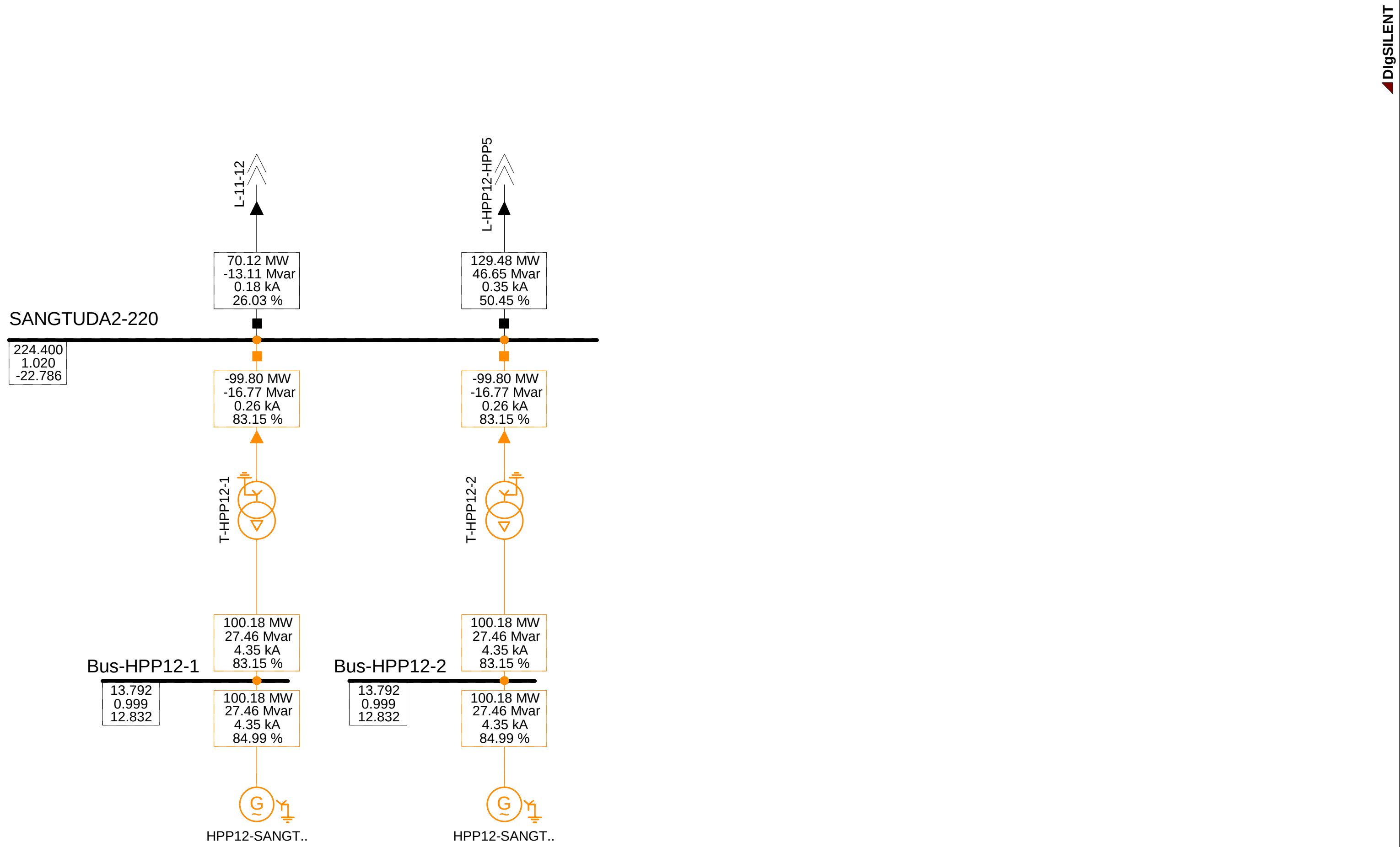
| | | |
|---|---|---|
| | | Project: |
| | | Graphic: RUDAKI |
| | | Date: 26/06/2013 |
| PowerFactory 14.1.3 | | Annex: |




| Load Flow Balanced | |
|---|---|
| Nodes | Branches |
| Line-Line Voltage, Magnitude [kV] | Active Power [MW] |
| Voltage, Magnitude [p.u.] | Reactive Power [Mvar] |
| Voltage, Angle [deg] | Current, Magnitude [kA] |
| | Maximum Loading [%] |

| | | |
|---|---|---|
| | | Project: |
| | | Graphic: RUMI |
| | | Date: 26/06/2013 |
| PowerFactory 14.1.3 | | Annex: |

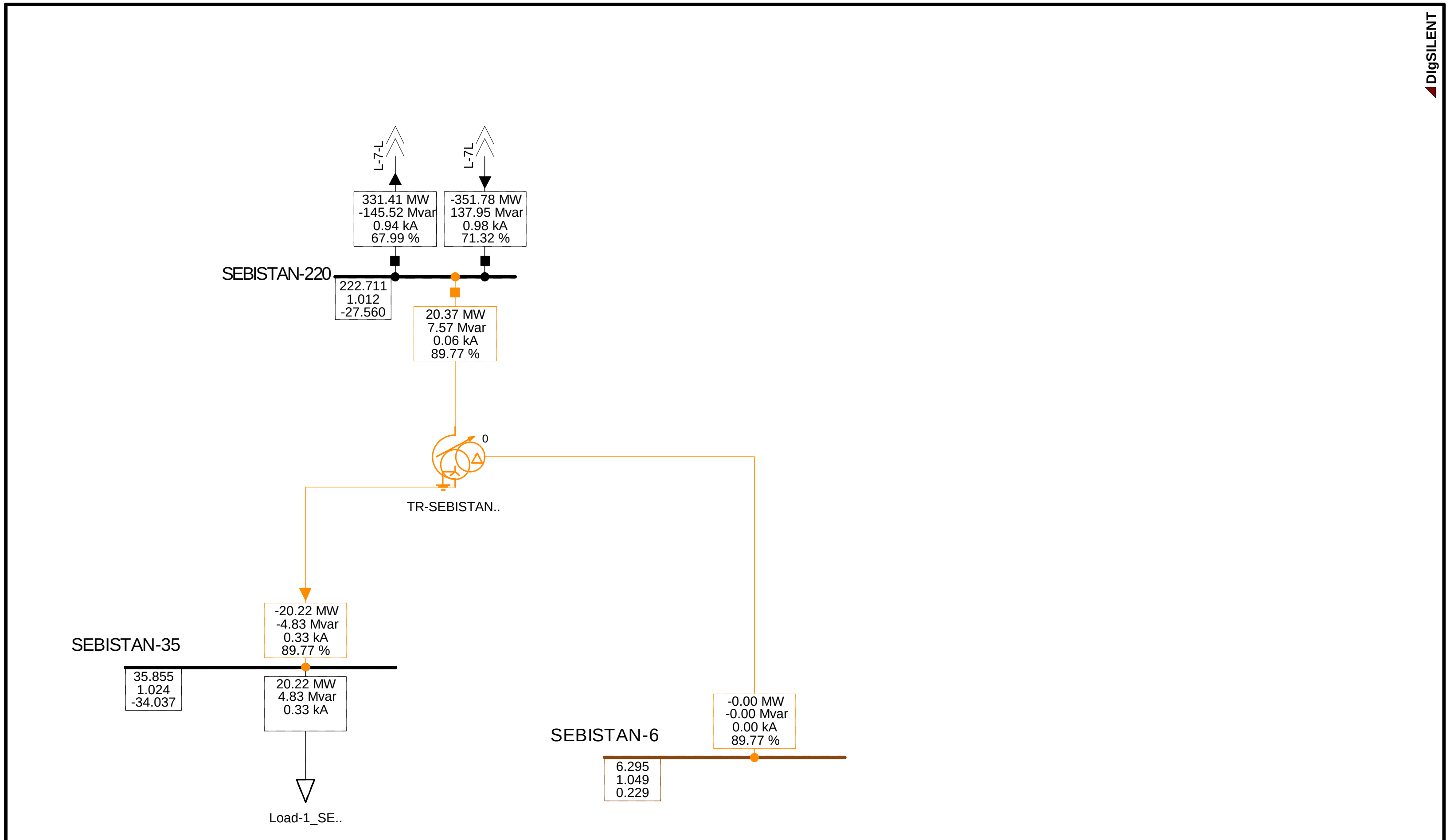

DIgSILENT
Obi-Sangtuda
L-S-Y
egar-Sangtuda1
Brk-Sangtuda-500
SANGTUDA1-500
SANGTUDA1-500/2
L-HPP12-HPP5
129.48 MW
46.65 Mvar
0.35 kA
50.45 %
SANGTUDA2-220
224.400
1.020
-22.786
70.12 MW
-13.11 Mvar
0.18 kA
26.03 %
TR-SANGTUDA1-1
TR-SANGTUDA1-2
L-11-12
L-11L-1
L-11L-2
Brk-SANGTUDA1-220
-70.03 MW
11.91 Mvar
0.18 kA
26.03 %
335.41 MW
28.35 Mvar
0.87 kA
61.55 %
35.02 MW
-5.96 Mvar
0.09 kA
0.00 %
-35.02 MW
5.96 Mvar
0.09 kA
0.00 %
SANGTUDA1-220
224.400
1.020
-23.201
SANGTUDA1-220/2
-150.20 MW
-17.15 Mvar
0.39 kA
77.63 %
T-HPP11-1
T-HPP11-2
T-HPP11-3
T-HPP11-4
SANGTUDA1-35
SANGTUDA1-35/2
0.000
0.000
0.000
150.75 MW
32.13 Mvar
5.69 kA
77.63 %
Bus-HPP11-1
s-HPP11-2
Bus-HPP11-3
Bus-HPP11-4
15.636
0.993
12.125
150.75 MW
32.13 Mvar
5.69 kA
82.82 %
HPP11-SANGT1-1
HPP11-SANGT1-2
HPP11-SANGT1-3
HPP11-SANGT1-4
Load Flow Balanced
Nodes
Line-Line Voltage, Magnitude [kV]
Voltage, Magnitude [p.u.]
Voltage, Angle [deg]
Branches
Active Power [MW]
Reactive Power [Mvar]
Current, Magnitude [kA]
Loading [%]
PowerFactory 14.1.3
Project:
Graphic: SANGTUDA1
Date: 26/06/2013
Annex:




| Load Flow Balanced | |
|---|---|
| Nodes | Branches |
| Line-Line Voltage, Magnitude [kV] | Active Power [MW] |
| Voltage, Magnitude [p.u.] | Reactive Power [Mvar] |
| Voltage, Angle [deg] | Current, Magnitude [kA] |
| | Loading [%] |

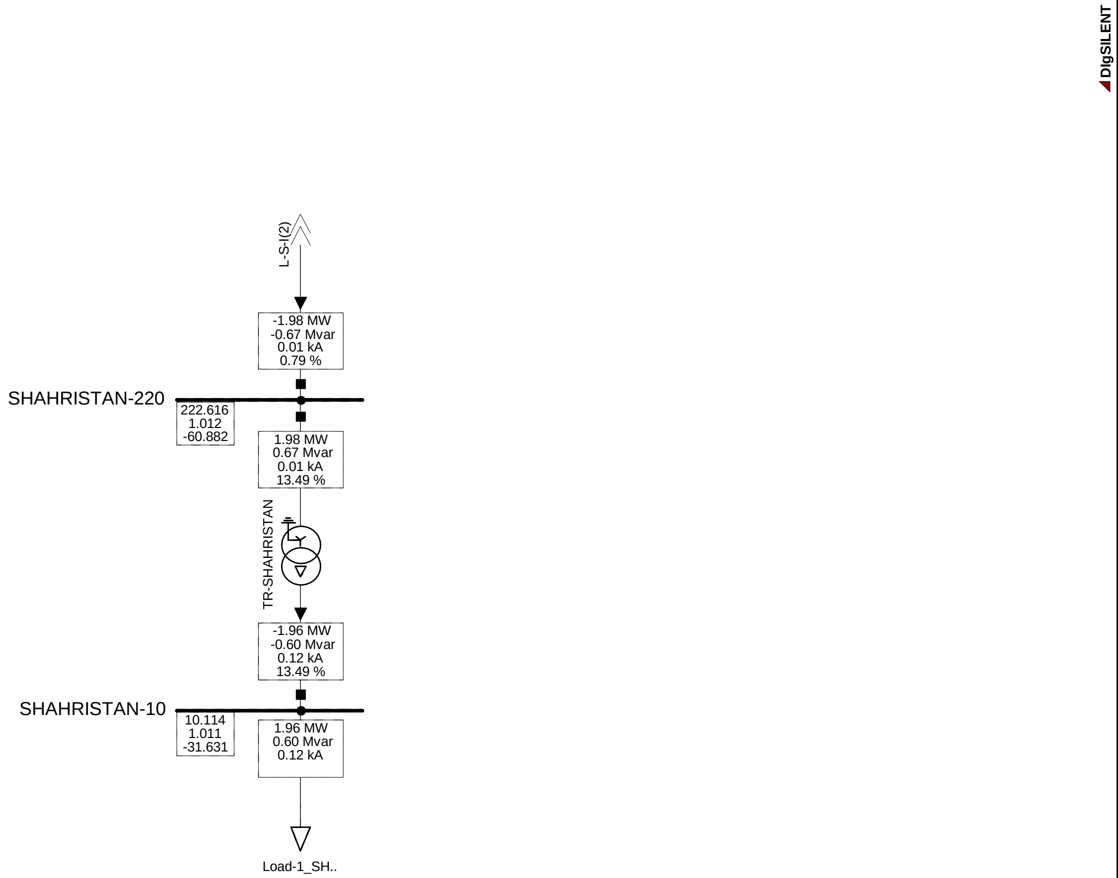
PowerFactory 14.1.3

Project:
Graphic: SANGTUDA2
Date: 26/06/2013
Annex:



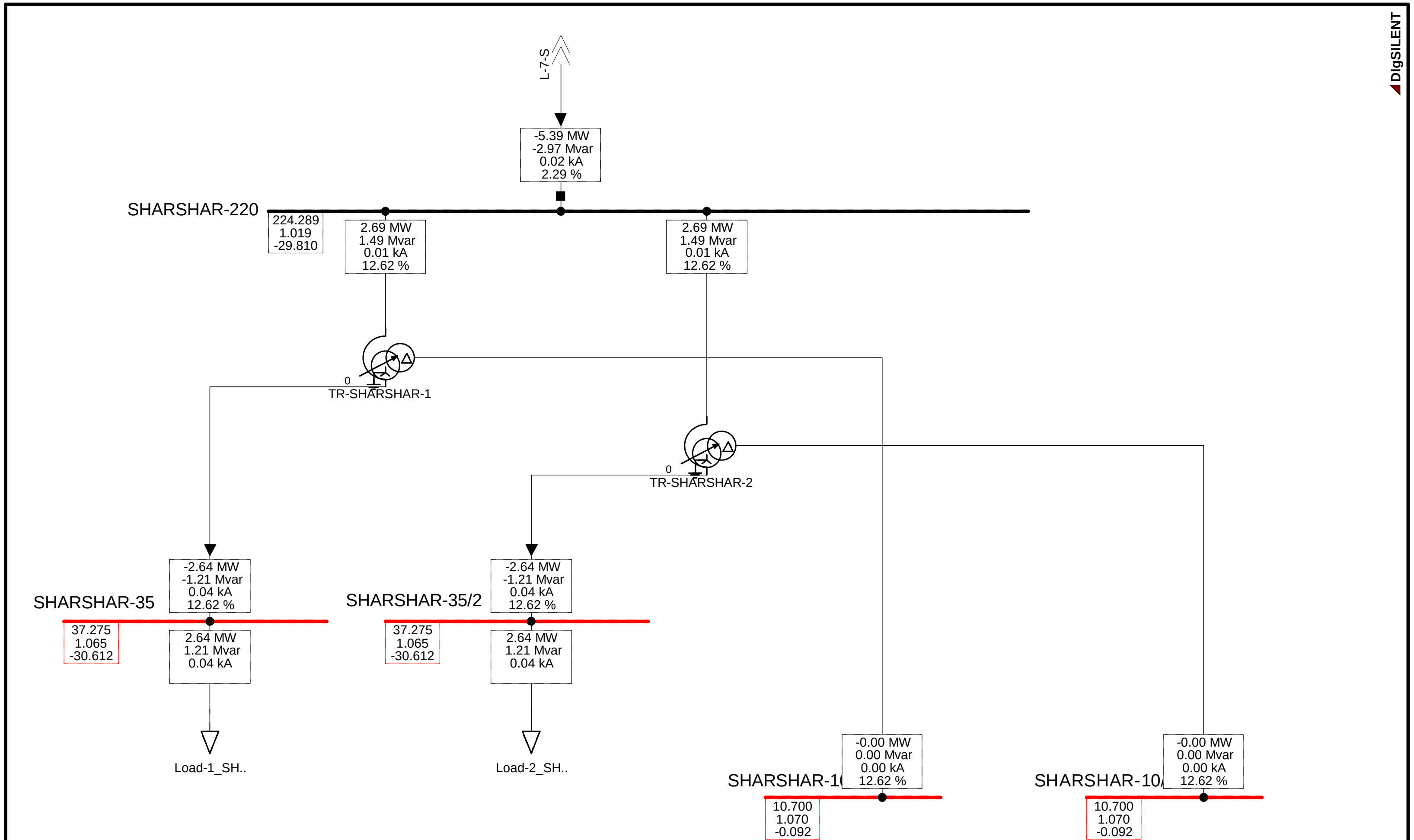

| Load Flow Balanced | |
|---|---|
| Nodes | Branches |
| Line-Line Voltage, Magnitude [kV] | Active Power [MW] |
| Voltage, Magnitude [p.u.] | Reactive Power [Mvar] |
| Voltage, Angle [deg] | Current, Magnitude [kA] |
| | Maximum Loading [%] |

| | | |
|---|---|---|
| | | Project: |
| | | Graphic: SEBISTAN |
| | | Date: 26/06/2013 |
| PowerFactory 14.1.3 | | Annex: |



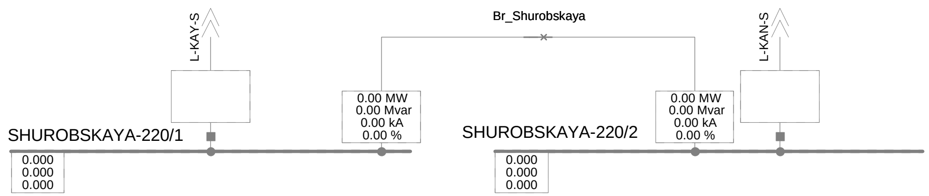

| Load Flow Balanced | |
|---|---|
| Nodes | Branches |
| Line-Line Voltage, Magnitude [kV] | Active Power [MW] |
| Voltage, Magnitude [p.u.] | Reactive Power [Mvar] |
| Voltage, Angle [deg] | Current, Magnitude [kA] |

| | |
|---|---|
| Project: | |
| Graphic: SHAHRISTAN | |
| Date: 26/06/2013 | |
| Annex: | |



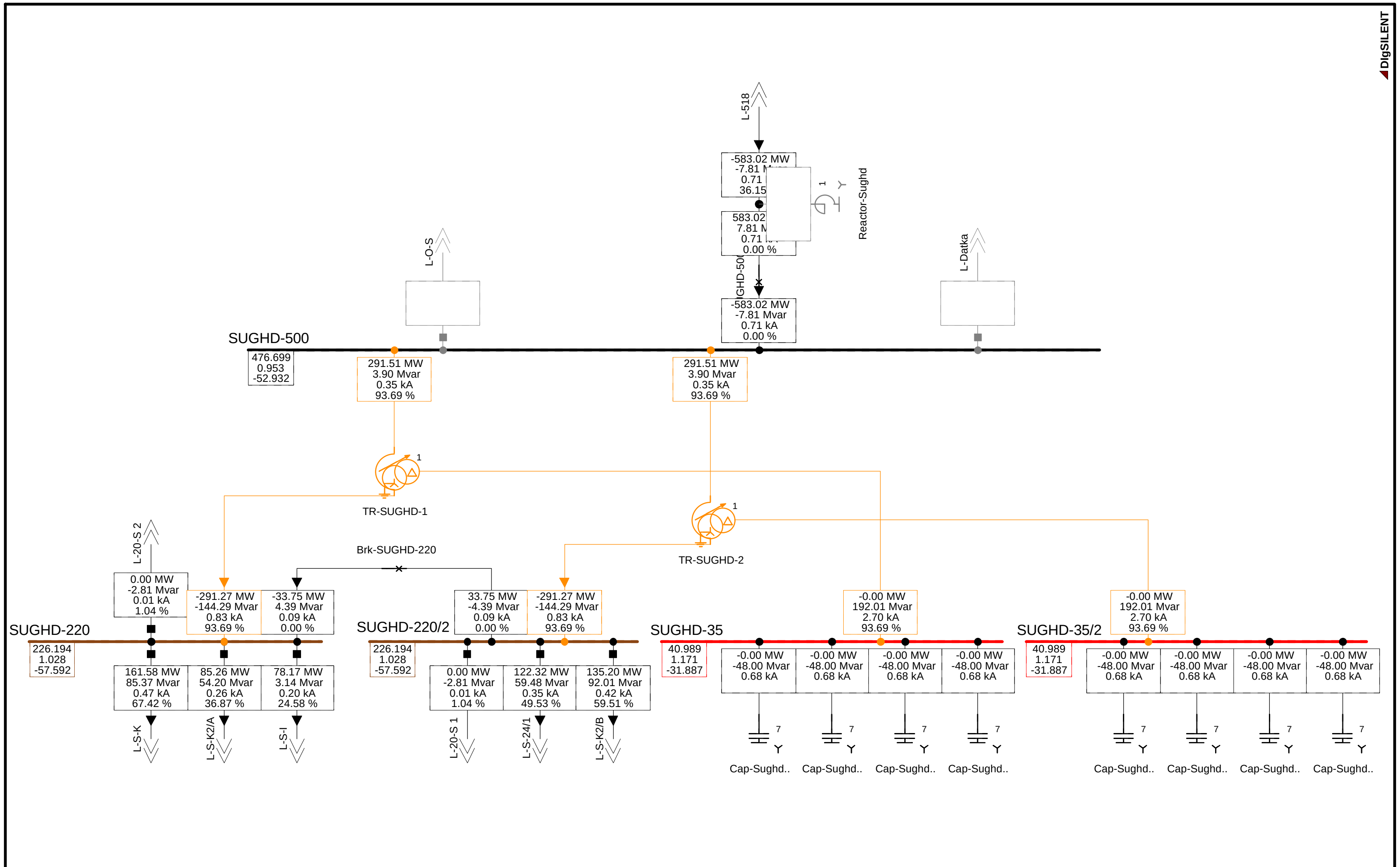

| Load Flow Balanced | |
|---|---|
| Nodes | Branches |
| Line-Line Voltage, Magnitude [kV] | Active Power [MW] |
| Voltage, Magnitude [p.u.] | Reactive Power [Mvar] |
| Voltage, Angle [deg] | Current, Magnitude [kA] |
| | Maximum Loading [%] |

| | | |
|---|---|---|
| | | Project: |
| | | Graphic: SHARSHAR |
| | | Date: 26/06/2013 |
| PowerFactory 14.1.3 | | Annex: |




| Load Flow Balanced | |
|---|---|
| Nodes | Branches |
| Line-Line Voltage, Magnitude [kV] | Active Power [MW] |
| Voltage, Magnitude [p.u.] | Reactive Power [Mvar] |
| Voltage, Angle [deg] | Current, Magnitude [kA] |
| | Loading [%] |

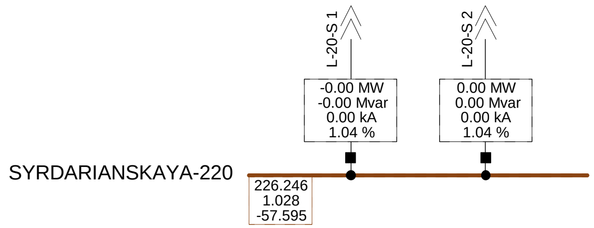
| | | |
|---|---|---|
| | | Project: |
| | | Graphic: SHUROBSKAYA |
| | | Date: 26/06/2013 |
| PowerFactory 14.1.3 | | Annex: |




| Load Flow Balanced | |
|---|---|
| Nodes | Branches |
| Line-Line Voltage, Magnitude [kV] | Active Power [MW] |
| Voltage, Magnitude [p.u.] | Reactive Power [Mvar] |
| Voltage, Angle [deg] | Current, Magnitude [kA] |

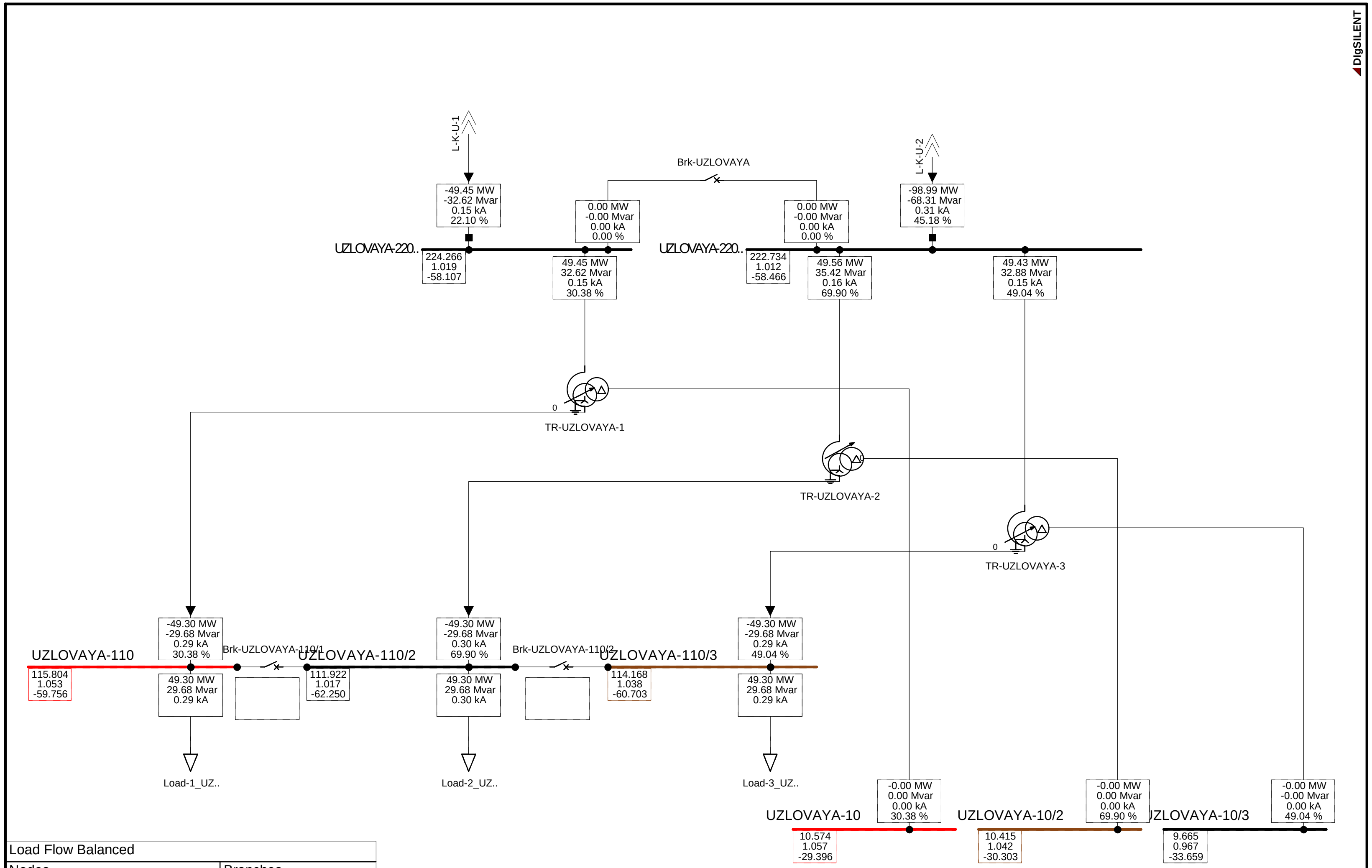
| | | |
|---|---|---|
| | | Project: |
| | | Graphic: SUGHD |
| | | Date: 26/06/2013 |
| PowerFactory 14.1.3 | | Annex: |

DIgSILENT



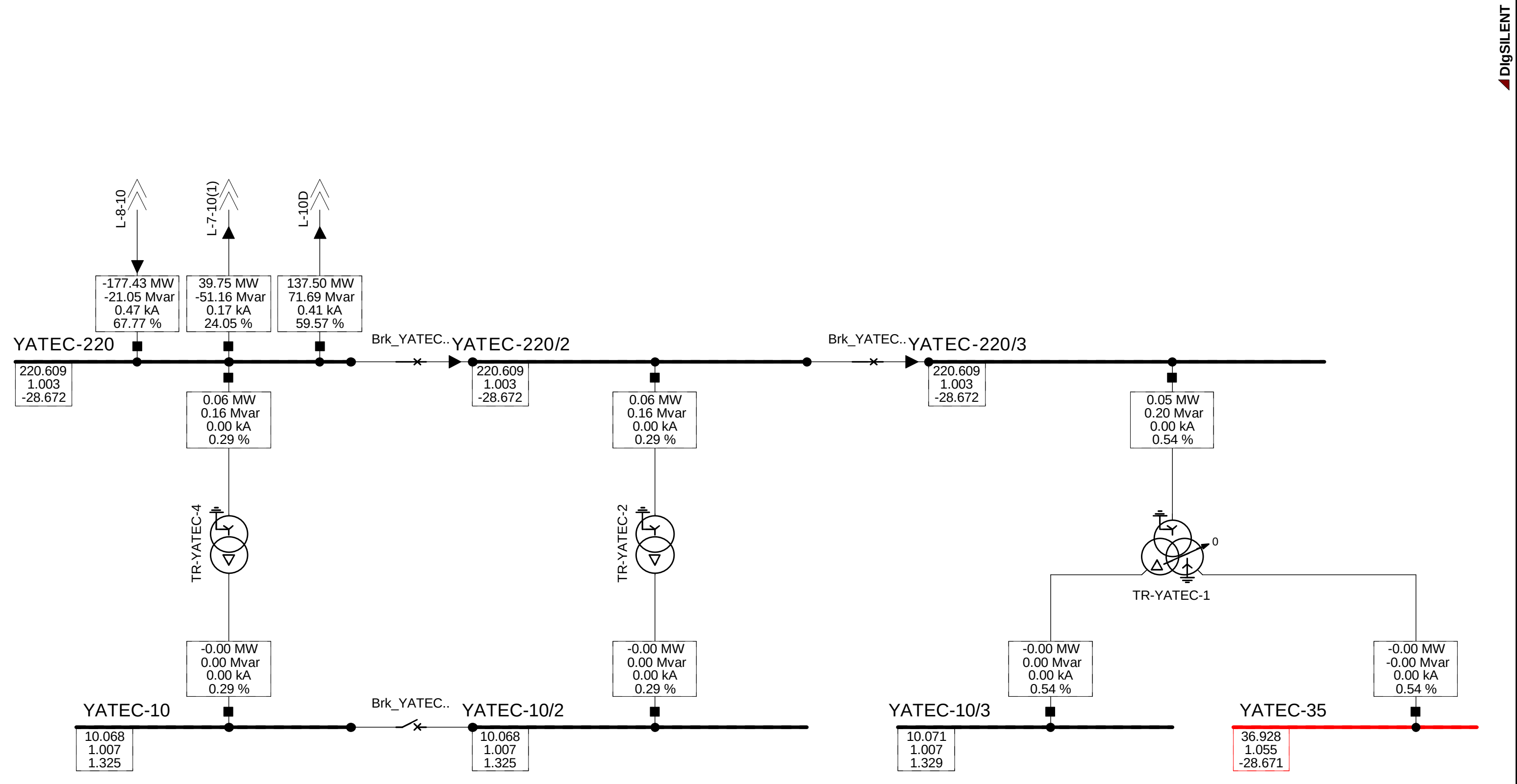

| Load Flow Balanced | |
|---|---|
| Nodes | Branches |
| Line-Line Voltage, Magnitude [kV] | Active Power [MW] |
| Voltage, Magnitude [p.u.] | Reactive Power [Mvar] |
| Voltage, Angle [deg] | Current, Magnitude [kA] |

| | | |
|---|---|---|
| | | Project: |
| | | Graphic: SYRDARINSKA |
| | | Date: 26/06/2013 |
| PowerFactory 14.1.3 | | Annex: |



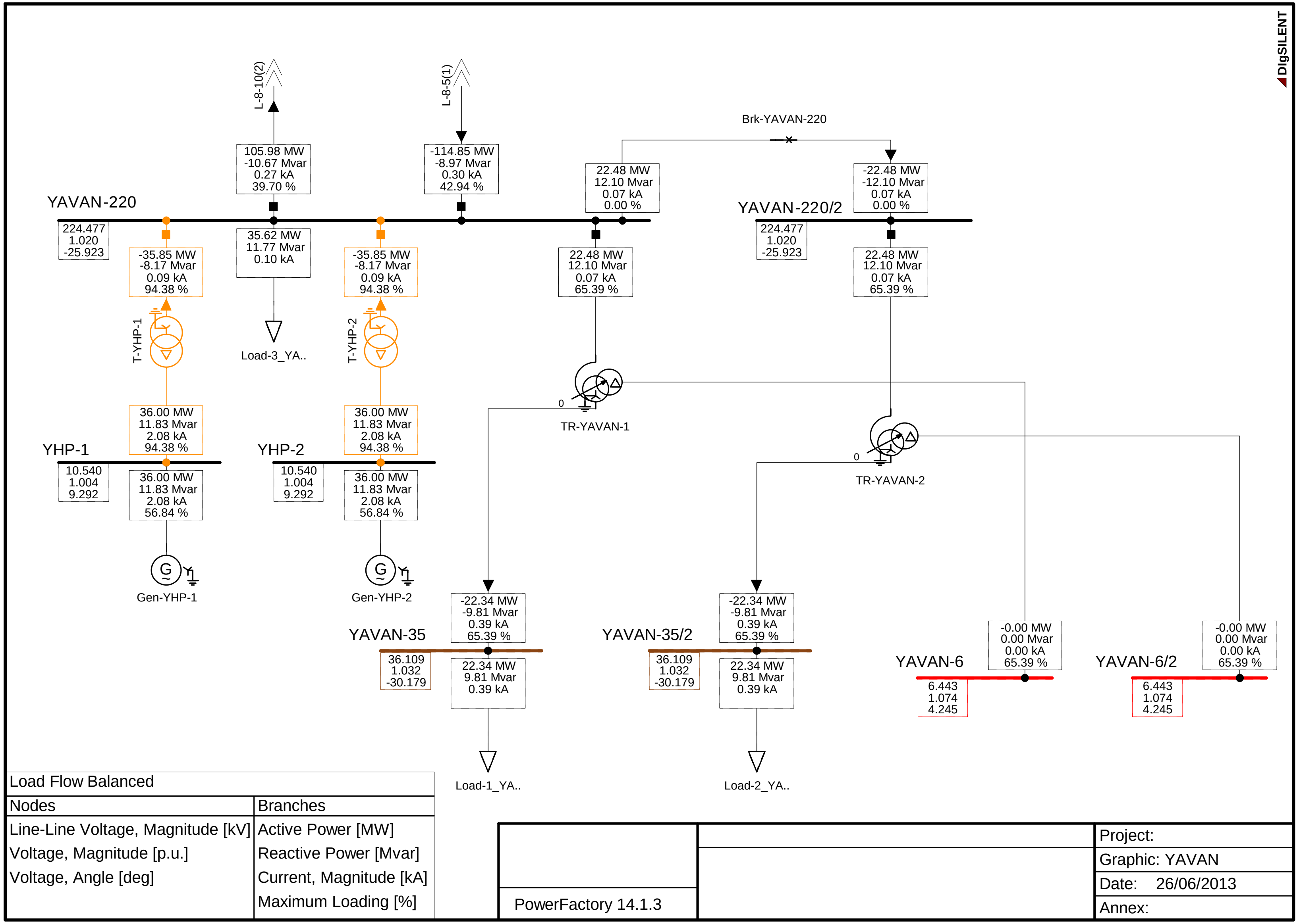

| Load Flow Balanced | |
|---|---|
| Nodes | Branches |
| Line-Line Voltage, Magnitude [kV] | Active Power [MW] |
| Voltage, Magnitude [p.u.] | Reactive Power [Mvar] |
| Voltage, Angle [deg] | Current, Magnitude [kA] |
| | Maximum Loading [%] |

| | | |
|---|---|---|
| | | Project: |
| | | Graphic: UZLOVAYA |
| | | Date: 26/06/2013 |
| PowerFactory 14.1.3 | | Annex: |

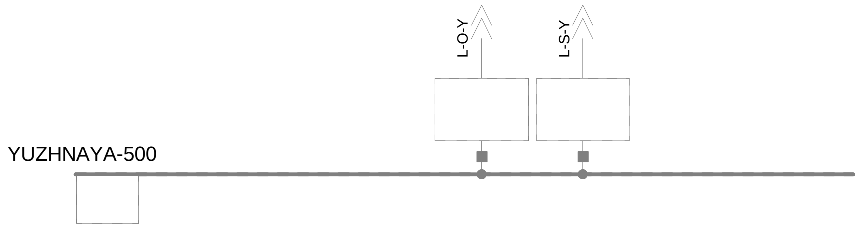



| Load Flow Balanced | |
|---|---|
| Nodes | Branches |
| Line-Line Voltage, Magnitude [kV] | Active Power [MW] |
| Voltage, Magnitude [p.u.] | Reactive Power [Mvar] |
| Voltage, Angle [deg] | Current, Magnitude [kA] |

| | | |
|---|---|---|
| | | Project: |
| | | Graphic: YATEC |
| | | Date: 26/06/2013 |
| PowerFactory 14.1.3 | | Annex: |


DIgSILENT
L-8-10(2)
L-8-5(1)
Brk-YAVAN-220
105.98 MW
-10.67 Mvar
0.27 kA
39.70 %
-114.85 MW
-8.97 Mvar
0.30 kA
42.94 %
22.48 MW
12.10 Mvar
0.07 kA
0.00 %
-22.48 MW
-12.10 Mvar
0.07 kA
0.00 %
YAVAN-220
224.477
1.020
-25.923
-35.85 MW
-8.17 Mvar
0.09 kA
94.38 %
35.62 MW
11.77 Mvar
0.10 kA
-35.85 MW
-8.17 Mvar
0.09 kA
94.38 %
22.48 MW
12.10 Mvar
0.07 kA
65.39 %
YAVAN-220/2
224.477
1.020
-25.923
22.48 MW
12.10 Mvar
0.07 kA
65.39 %
T-YHP-1
Load-3_YA..
T-YHP-2
TR-YAVAN-1
TR-YAVAN-2
36.00 MW
11.83 Mvar
2.08 kA
94.38 %
36.00 MW
11.83 Mvar
2.08 kA
94.38 %
YHP-1
10.540
1.004
9.292
36.00 MW
11.83 Mvar
2.08 kA
56.84 %
YHP-2
10.540
1.004
9.292
36.00 MW
11.83 Mvar
2.08 kA
56.84 %
Gen-YHP-1
Gen-YHP-2
-22.34 MW
-9.81 Mvar
0.39 kA
65.39 %
-22.34 MW
-9.81 Mvar
0.39 kA
65.39 %
-0.00 MW
0.00 Mvar
0.00 kA
65.39 %
-0.00 MW
0.00 Mvar
0.00 kA
65.39 %
YAVAN-35
36.109
1.032
-30.179
22.34 MW
9.81 Mvar
0.39 kA
YAVAN-35/2
36.109
1.032
-30.179
22.34 MW
9.81 Mvar
0.39 kA
YAVAN-6
6.443
1.074
4.245
YAVAN-6/2
6.443
1.074
4.245
Load-1_YA..
Load-2_YA..
Load Flow Balanced
Nodes
Line-Line Voltage, Magnitude [kV]
Voltage, Magnitude [p.u.]
Voltage, Angle [deg]
Branches
Active Power [MW]
Reactive Power [Mvar]
Current, Magnitude [kA]
Maximum Loading [%]
PowerFactory 14.1.3
Project:
Graphic: YAVAN
Date: 26/06/2013
Annex:

DIgSILENT




| Load Flow Balanced | |
|---|---|
| Nodes | Branches |

| | | |
|---|---|---|
| | | Project: |
| | | Graphic: YUZHNAYA |
| | | Date: 26/06/2013 |
| PowerFactory 14.1.3 | | Annex: |

## 8.2 The load-flow in year 2020

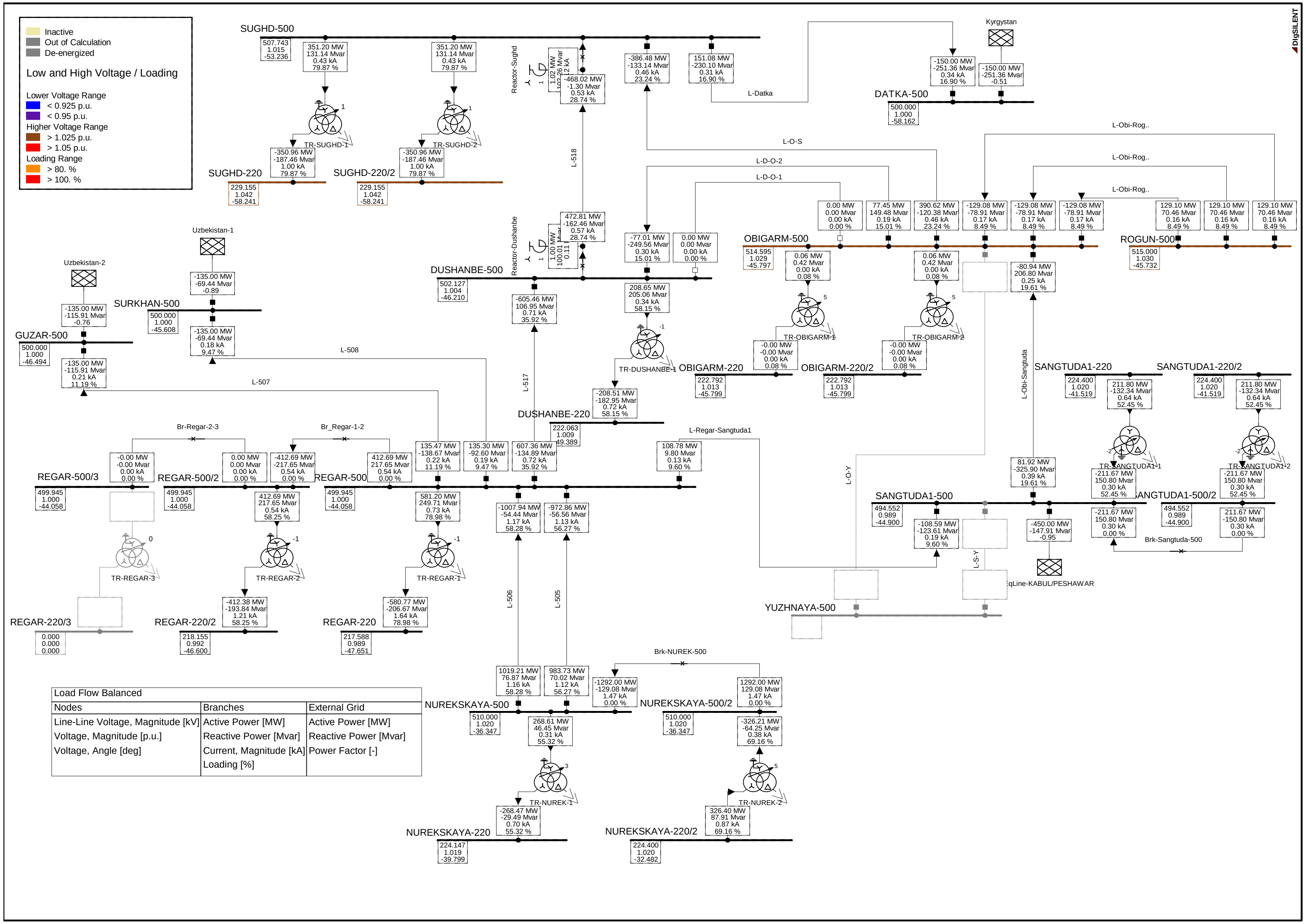



fig. 8.3: year 2020, maximum load, 500 kV system

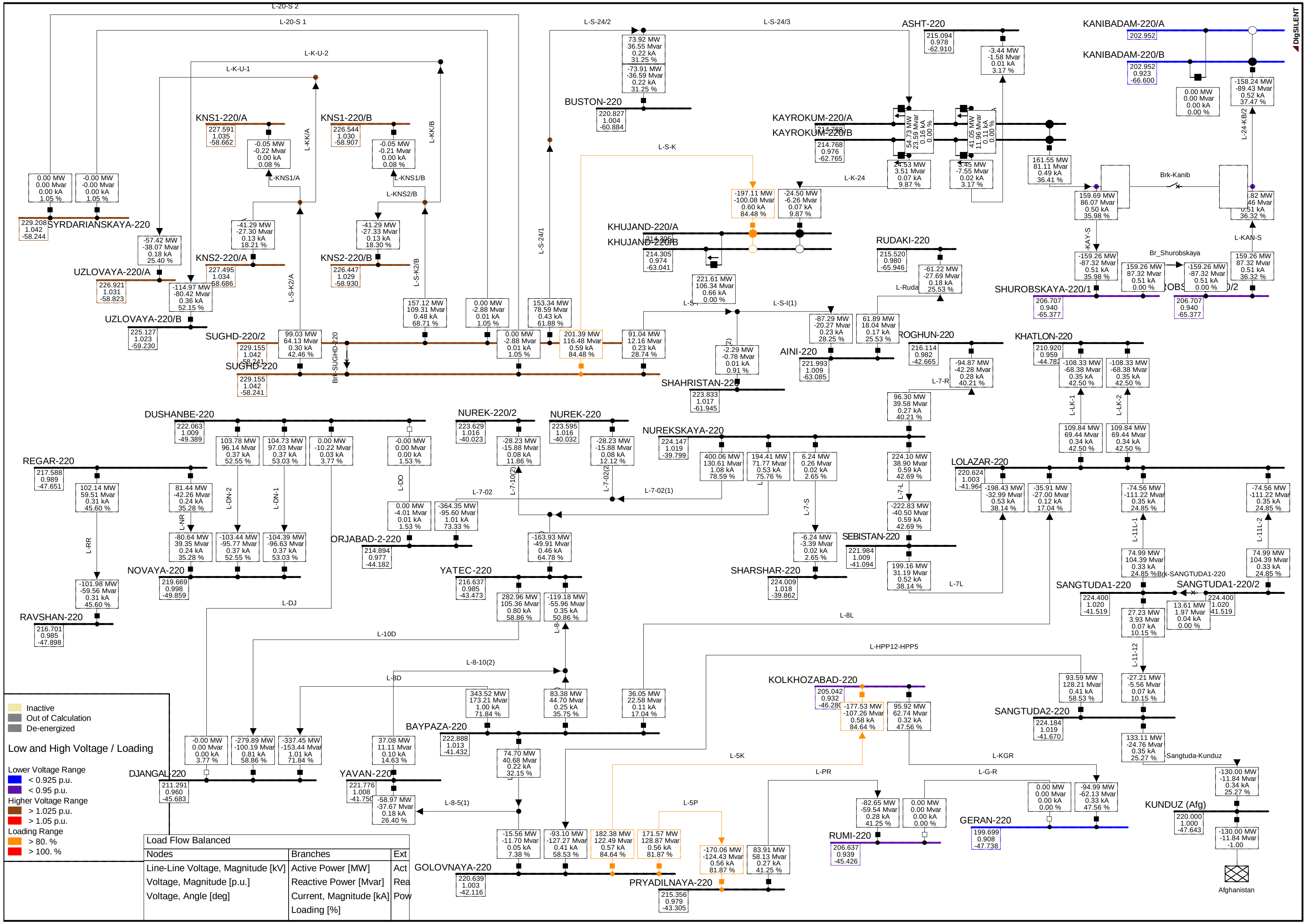



fig. 8.4: year 2020, maximum load, 220 kV system

## 8.3 The load-flow in year 2025

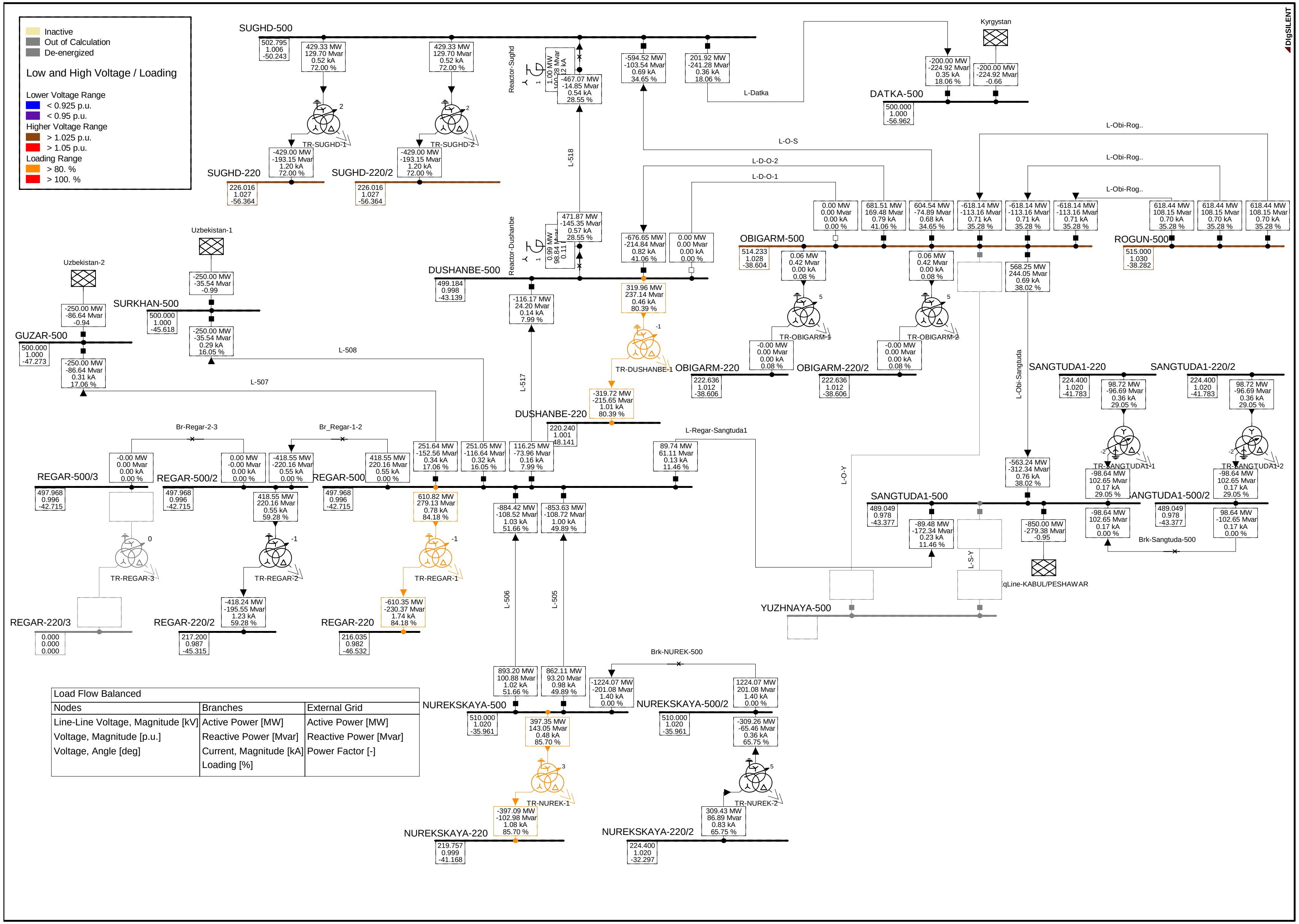



fig. 8.5:year 2025, maximum load, 500 kV system

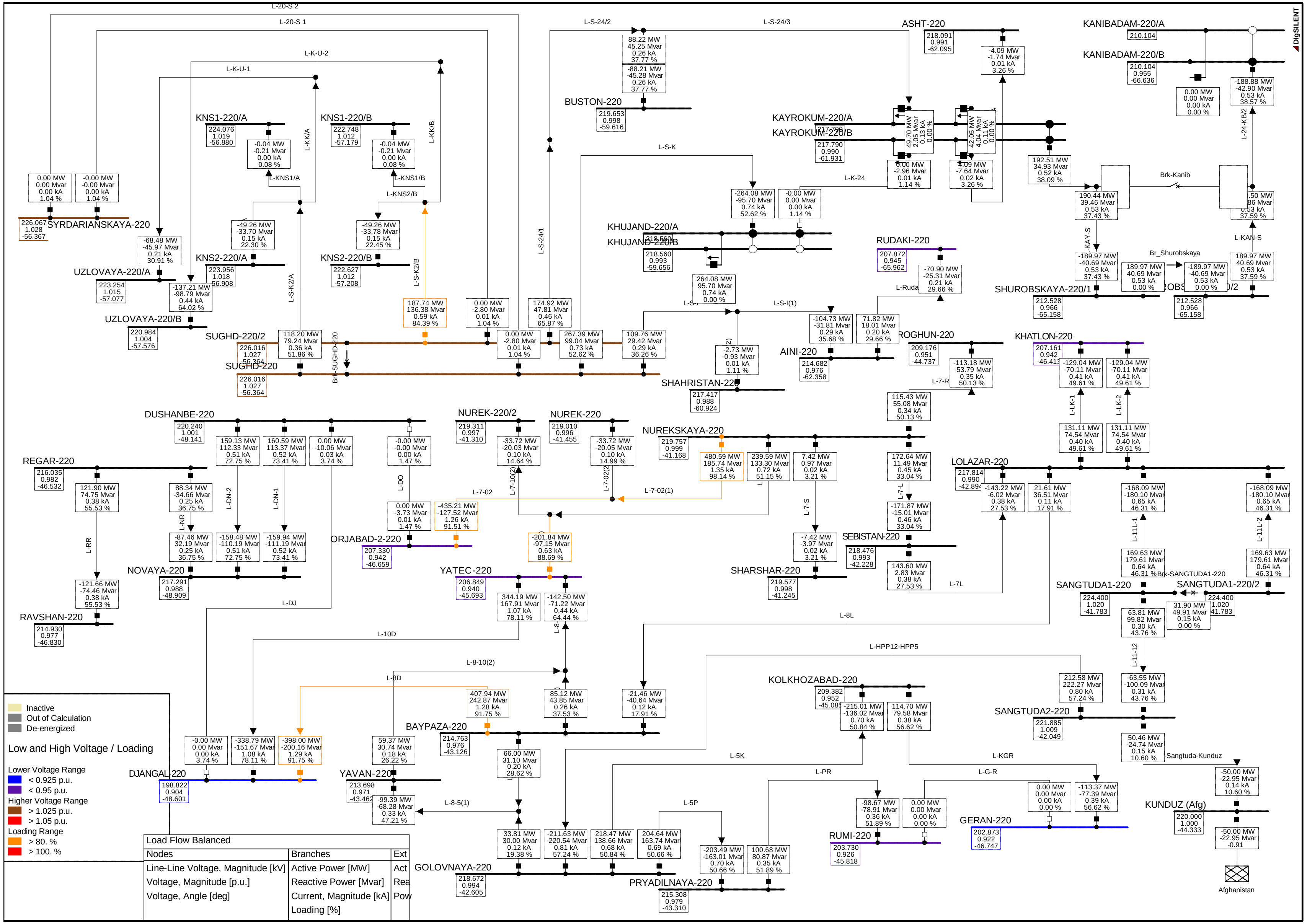



fig. 8.6: year 2025, maximum load,220 kV system

## 8.4 The load-flow in year 2027

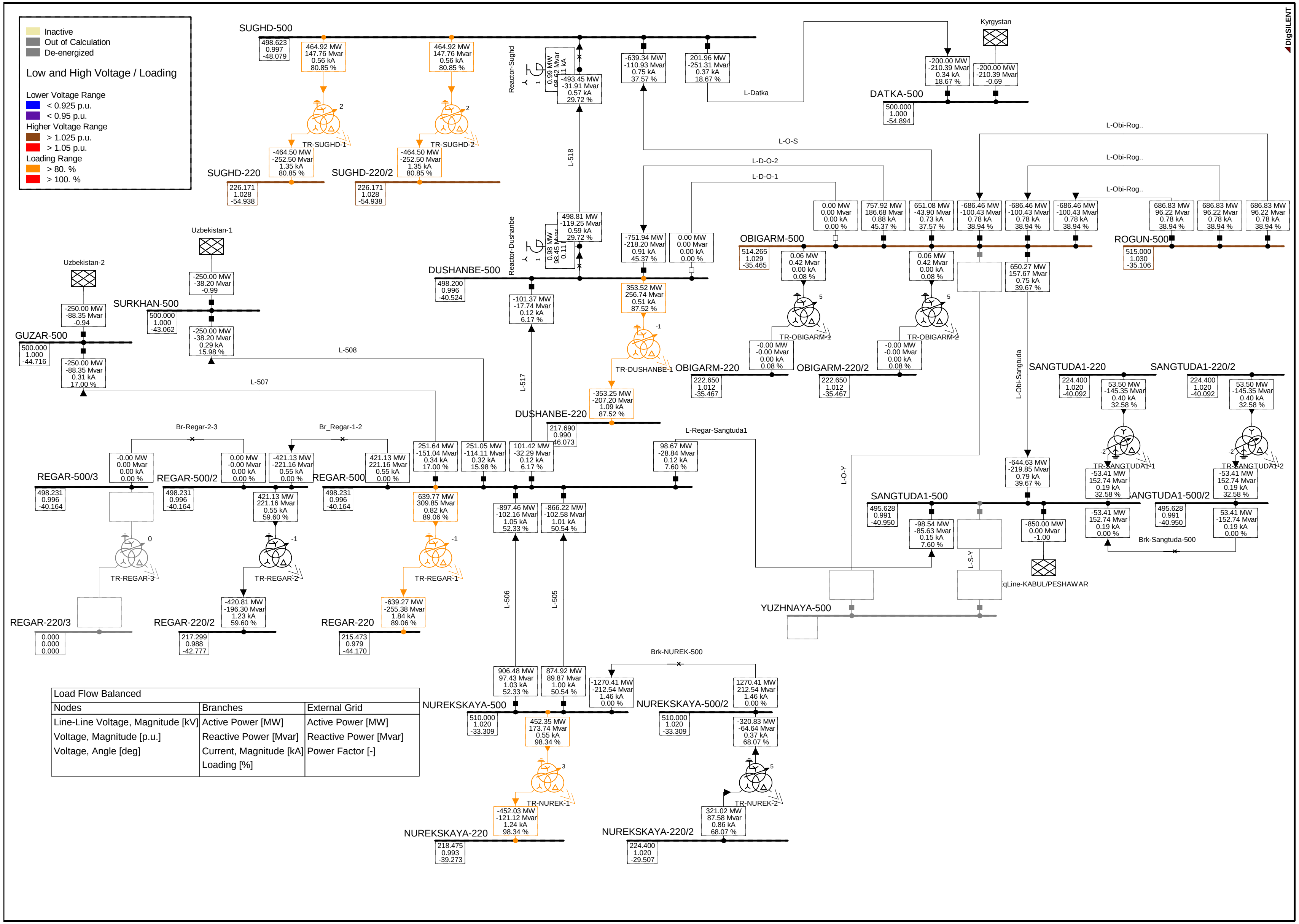


fig. 8.7: year 2027: maximum load, 500 kV system

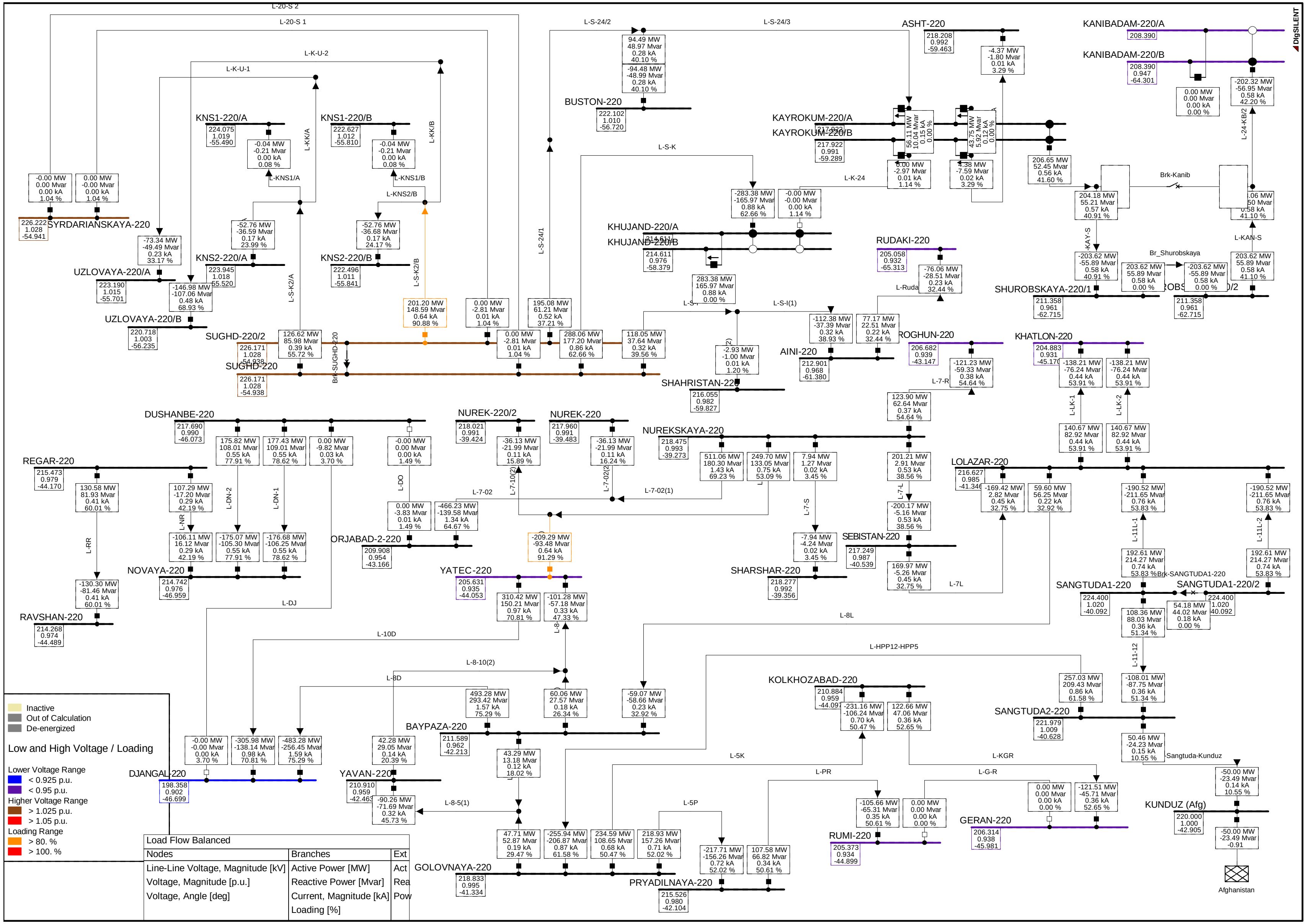



fig. 8.8: year 2027, maximum load, 220 kV system

## 8.5 The load-flow in year 2028

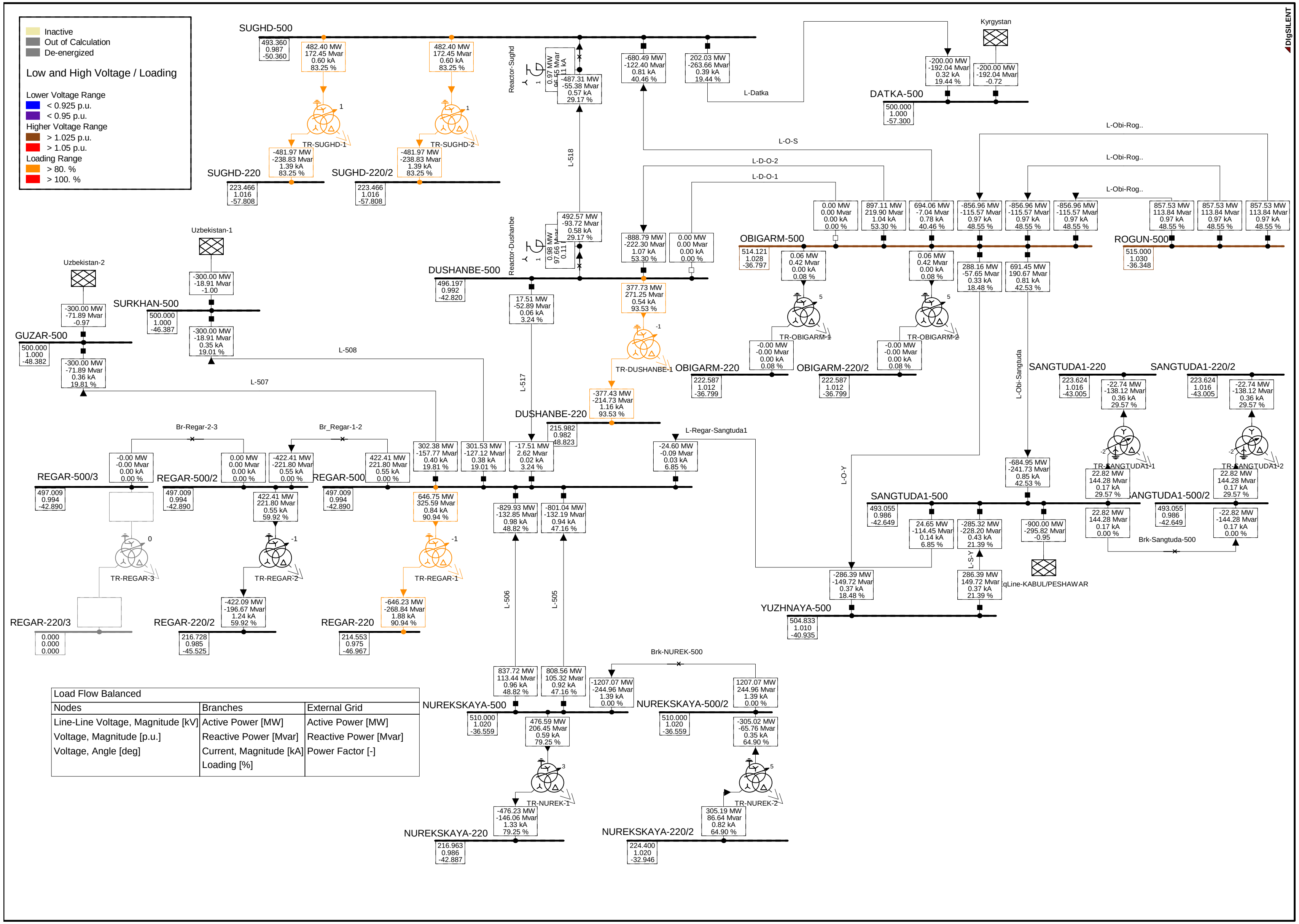



fig. 8.9: year 2028: maximum load, 500 kV system

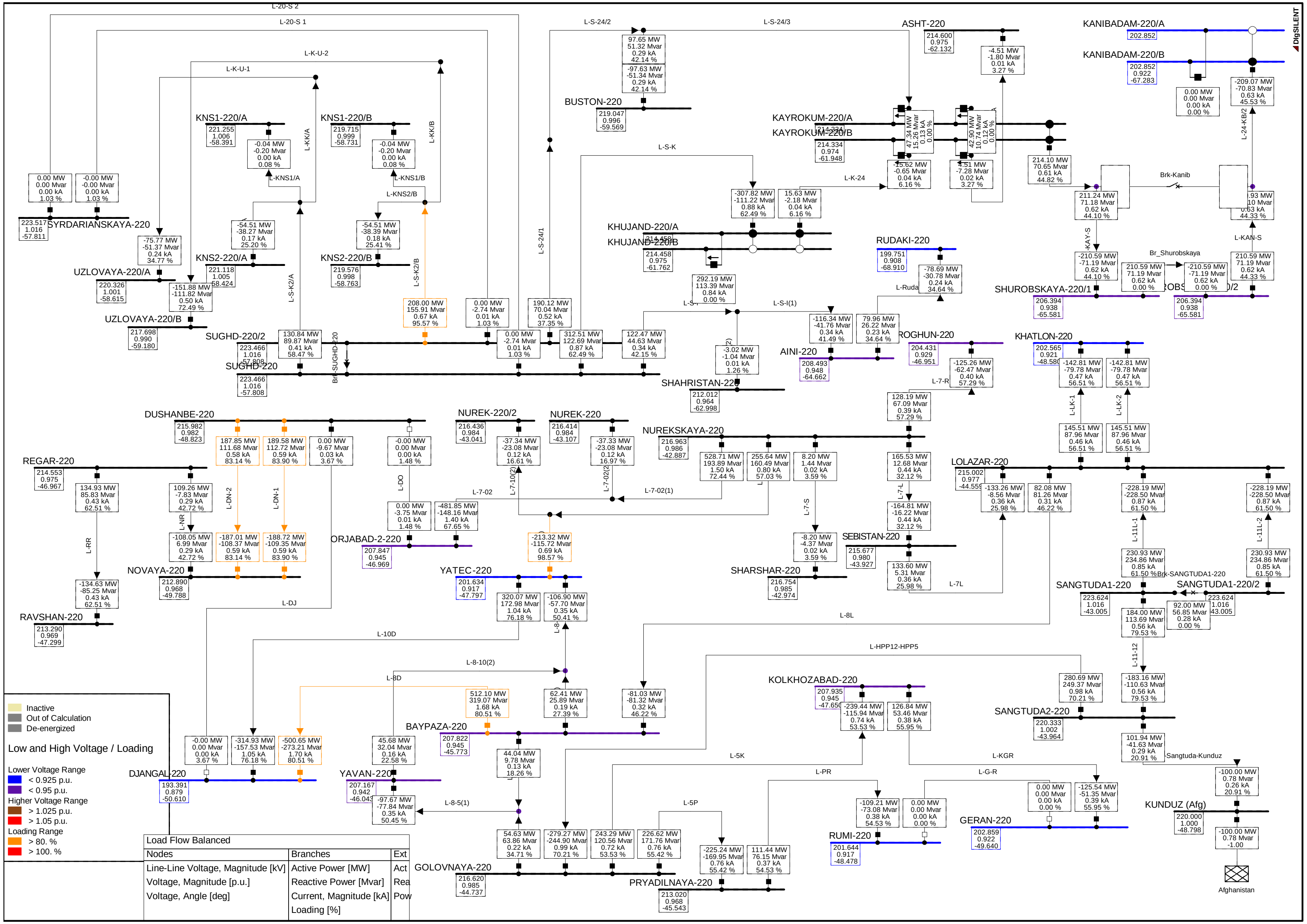



fig. 8.10: year 2028, maximum load, 220 kV system

## 8.6 The load-flow in year 2031 (Rogun maximum power 3600 MW)

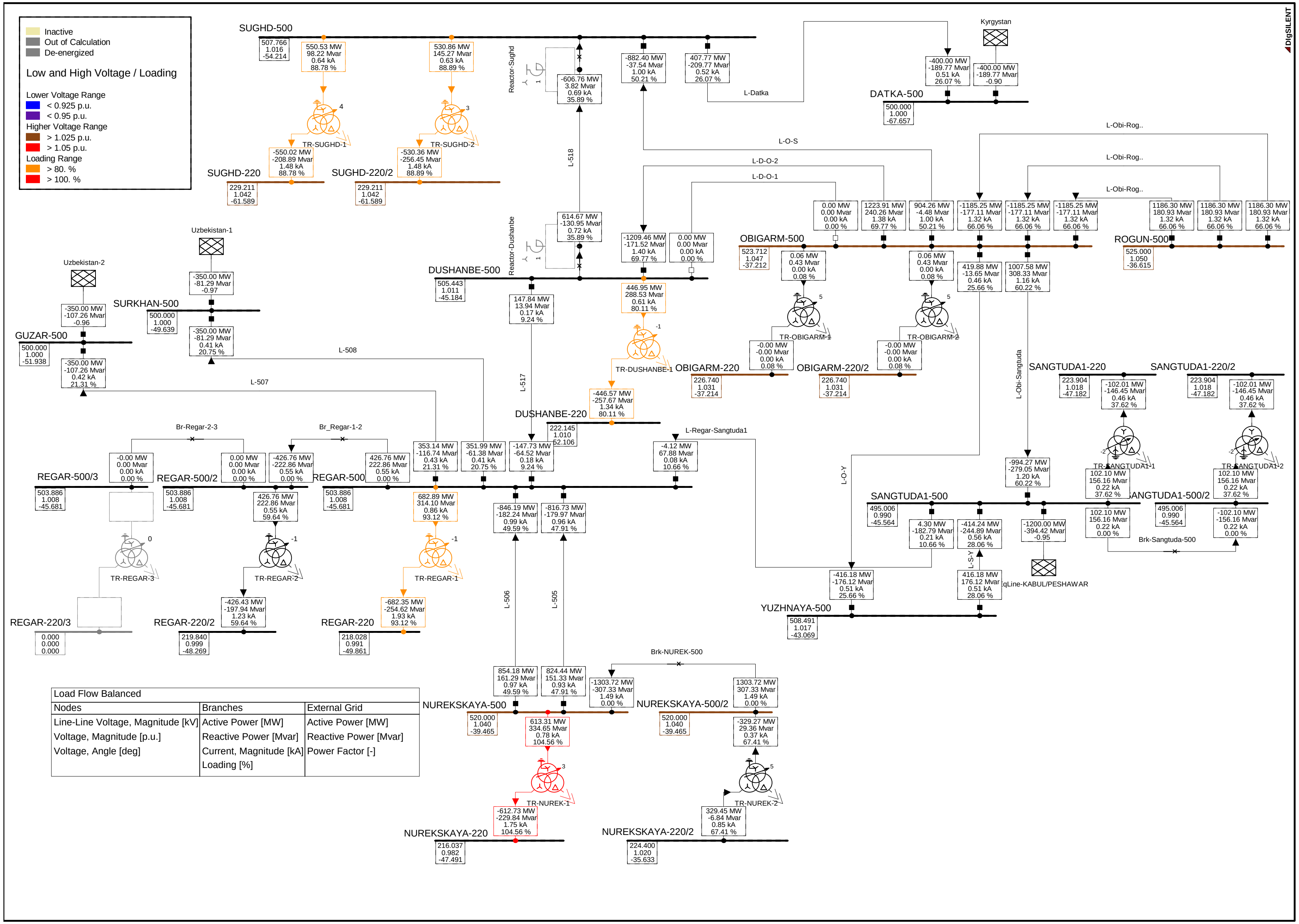



fig. 8.11: year 2031, maximum load, 500 kV system

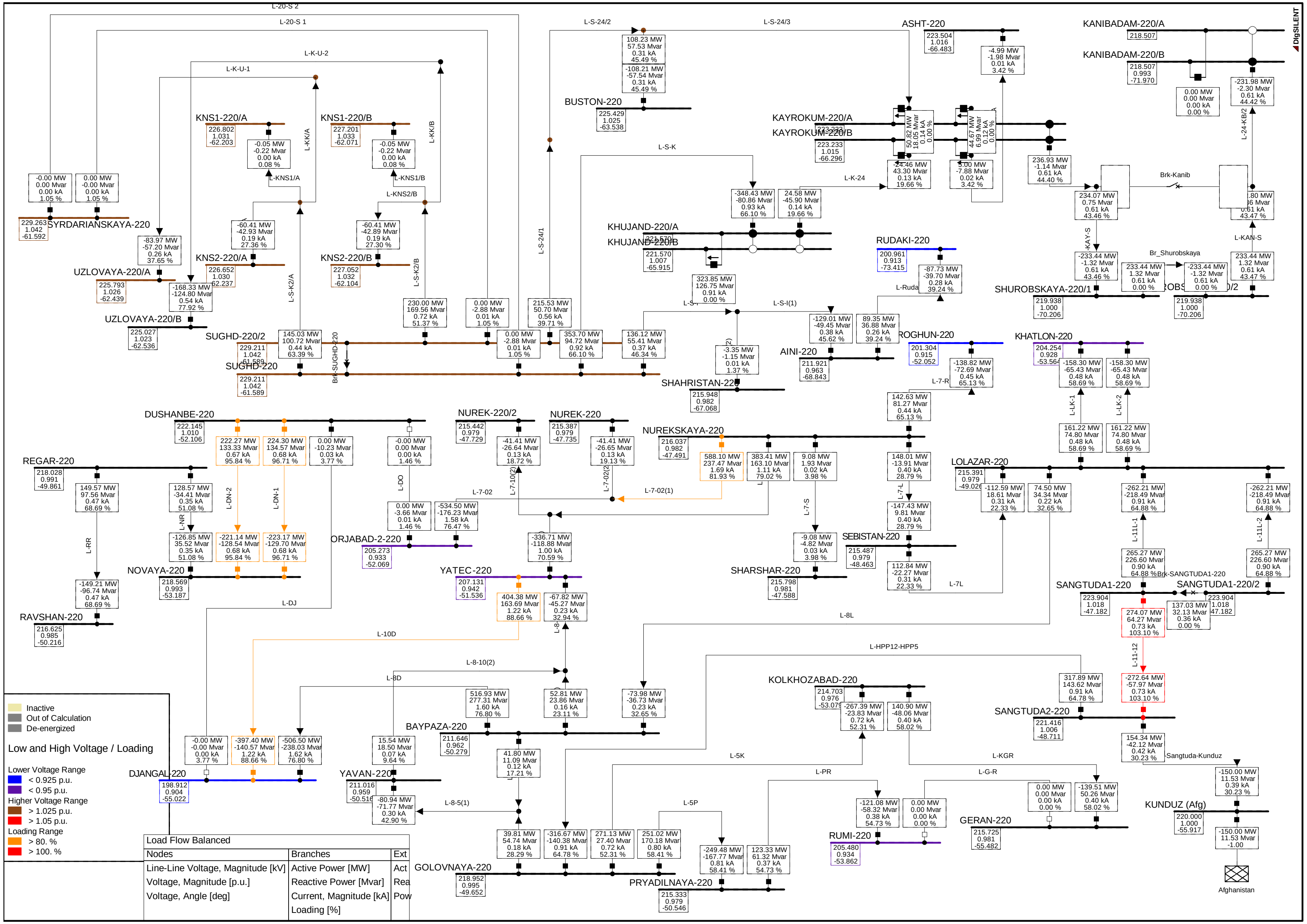



fig. 8.12: year 2031, maximum load, 220 kV system

# 9 SYSTEM DATA

## 9.1 Substations

| Name | Vn | Year |
|---|---|---|
| | kV | |
| AINI | 220 | |
| ASHT | 220 | |
| BAYPAZA | 220 | |
| BUSTON | 220 | |
| DJANGAL | 220 | |
| DUSHANBE | 500 | |
| GERAN | 220 | |
| GOLOVNAYA | 220 | |
| GUZAR | 500 | |
| KANIBADAM | 220 | |
| KAYROKUM | 220 | |
| KHATLON | 220 | |
| KHUJAND | 220 | |
| KNS1 | 220 | |
| KNS2 | 220 | |
| KOLKHOZABAD | 220 | |
| LOLAZAR | 220 | |
| NOVAYA | 220 | |
| NUREK | 220 | |
| NUREKSKAYA | 500 | |
| OBIGARM | 500 | 2016 |

| Name | Vn | Year |
|---|---|---|
| | kV | |
| ORJABAD-2 | 220 | |
| PRYADILNAYA | 220 | |
| RAVSHAN | 220 | |
| REGAR | 500 | |
| ROGHUN | 220 | |
| ROGUN HPP | 500 | 2016 |
| RUDAKI | 220 | |
| RUMI | 220 | |
| SANGTUDA-1 | 500 | 2016 |
| SANGTUDA-2 | 220 | |
| SEBISTAN | 220 | |
| SHAHRISTAN | 220 | |
| SHARSHAR | 220 | |
| SHUROBSKAYA | 500 | |
| SUGHD | 500 | |
| SURKHAN | 500 | |
| SYRDARINSKAYA-UZB | 220 | |
| UZLOVAYA | 220 | |
| YATEC | 220 | |
| YAVAN | 220 | |
| YUZHNAYA | 500 | 2028 |

## 9.2 Terminals

| Name | Station | Vn kV | Year |
|---|---|---|---|
| AINI-10 | AINI | 10 | |
| AINI-10/2 | AINI | 10 | |
| AINI-110 | AINI | 110 | |
| AINI-110/2 | AINI | 110 | |
| AINI-220 | AINI | 220 | |
| ASHT-110 | ASHT | 110 | |
| ASHT-110/2 | ASHT | 110 | |
| ASHT-220 | ASHT | 220 | |
| ASHT-6 | ASHT | 6 | |
| ASHT-6/2 | ASHT | 6 | |
| BAYPAZA-220 | BAYPAZA | 220 | |
| BUSTON-10 | BUSTON | 10 | |
| BUSTON-10/2 | BUSTON | 10 | |
| BUSTON-110 | BUSTON | 110 | |
| BUSTON-110/2 | BUSTON | 110 | |
| BUSTON-220 | BUSTON | 220 | |
| Bus-Gen1 | ROGUN HPP | 15.75 | 2016 |
| Bus-Gen2 | ROGUN HPP | 15.75 | 2016 |
| Bus-Gen3 | ROGUN HPP | 15.75 | 2025 |
| Bus-Gen4 | ROGUN HPP | 15.75 | 2025 |
| Bus-Gen5 | ROGUN HPP | 15.75 | 2025 |
| Bus-Gen6 | ROGUN HPP | 15.75 | 2025 |
| Bus-HPP11-1 | SANGTUDA-1 | 15.75 | |
| Bus-HPP11-2 | SANGTUDA-1 | 15.75 | |
| Bus-HPP11-3 | SANGTUDA-1 | 15.75 | |
| Bus-HPP11-4 | SANGTUDA-1 | 15.75 | |
| Bus-HPP12-1 | SANGTUDA-2 | 13.8 | |
| Bus-HPP12-2 | SANGTUDA-2 | 13.8 | |
| Bus-HPP5-3 | GOLOVNAYA | 10.5 | |

| Name | Station | Vn kV | Year |
|---|---|---|---|
| KAYROKUM-220/B | KAYROKUM | 220 | |
| KHATLON-10 | KHATLON | 10 | |
| KHATLON-10/2 | KHATLON | 10 | |
| KHATLON-110 | KHATLON | 110 | |
| KHATLON-110/2 | KHATLON | 110 | |
| KHATLON-220 | KHATLON | 220 | |
| KHATLON-220/2 | KHATLON | 220 | |
| KHUJAND-10 | KHUJAND | 10 | |
| KHUJAND-10/2 | KHUJAND | 10 | |
| KHUJAND-110 | KHUJAND | 110 | |
| KHUJAND-110/2 | KHUJAND | 110 | |
| KHUJAND-220/A | KHUJAND | 220 | |
| KHUJAND-220/B | KHUJAND | 220 | |
| KNS1-10A | KNS1 | 10 | |
| KNS1-10A/2 | KNS1 | 10 | |
| KNS1-10B | KNS1 | 10 | |
| KNS1-10B/2 | KNS1 | 10 | |
| KNS1-220/A | KNS1 | 220 | |
| KNS1-220/B | KNS1 | 220 | |
| KNS2-10 | KNS2 | 10 | |
| KNS2-10/2 | KNS2 | 10 | |
| KNS2-110 | KNS2 | 110 | |
| KNS2-110/2 | KNS2 | 110 | |
| KNS2-220/A | KNS2 | 220 | |
| KNS2-220/B | KNS2 | 220 | |
| KOLKHOZABAD-10 | KOLKHOZABAD | 10 | |
| KOLKHOZABAD-10/2 | KOLKHOZABAD | 10 | |
| KOLKHOZABAD-110 | KOLKHOZABAD | 110 | |
| KOLKHOZABAD-110/2 | KOLKHOZABAD | 110 | |

| Name | Station | Vn kV | Year |
|---|---|---|---|
| REGAR-220 | REGAR | 220 | |
| REGAR-220/2 | REGAR | 220 | |
| REGAR-220/3 | REGAR | 220 | |
| REGAR-35 | REGAR | 35 | |
| REGAR-35/2 | REGAR | 35 | |
| REGAR-35/3 | REGAR | 35 | |
| REGAR-500 | REGAR | 500 | |
| REGAR-500/2 | REGAR | 500 | |
| REGAR-500/3 | REGAR | 500 | |
| ROGHUN-10 | ROGHUN | 10 | |
| ROGHUN-10/2 | ROGHUN | 10 | |
| ROGHUN-110 | ROGHUN | 110 | |
| ROGHUN-110/2 | ROGHUN | 110 | |
| ROGHUN-220 | ROGHUN | 220 | |
| ROGHUN-220/2 | ROGHUN | 220 | |
| ROGUN-500 | ROGUN HPP | 500 | |
| RUDAKI-10 | RUDAKI | 10 | |
| RUDAKI-10/2 | RUDAKI | 10 | |
| RUDAKI-110 | RUDAKI | 110 | |
| RUDAKI-110/2 | RUDAKI | 110 | |
| RUDAKI-220 | RUDAKI | 220 | |
| RUMI-10 | RUMI | 10 | |
| RUMI-110 | RUMI | 110 | |
| RUMI-220 | RUMI | 220 | |
| SANGTUDA1-220 | SANGTUDA-1 | 220 | |
| SANGTUDA1-220/2 | SANGTUDA-1 | 220 | |
| SANGTUDA1-35 | SANGTUDA-1 | 35 | |
| SANGTUDA1-35/2 | SANGTUDA-1 | 35 | |
| SANGTUDA1-500 | SANGTUDA-1 | 500 | 2016 |

| Name | Station | Vn | Year |
|---|---|---|---|
| | | kV | |
| Bus-HPP7-1 | NUREKSKAYA | 15.75 | |
| Bus-HPP7-2 | NUREKSKAYA | 15.75 | |
| Bus-HPP7-3 | NUREKSKAYA | 15.75 | |
| Bus-HPP7-4 | NUREKSKAYA | 15.75 | |
| Bus-HPP7-5 | NUREKSKAYA | 15.75 | |
| Bus-HPP7-6 | NUREKSKAYA | 15.75 | |
| Bus-HPP7-7 | NUREKSKAYA | 15.75 | |
| Bus-HPP7-8 | NUREKSKAYA | 15.75 | |
| Bus-HPP7-9 | NUREKSKAYA | 15.75 | |
| Bus-HPP8-1 | BAYPAZA | 15.75 | |
| Bus-HPP8-2 | BAYPAZA | 15.75 | |
| Bus-HPP8-3 | BAYPAZA | 15.75 | |
| Bus-HPP8-4 | BAYPAZA | 15.75 | |
| CENTRALNAYA HPP | KOLKHOZABAD | 6 | |
| DATKA-500 | KIRGYZTAN | 500 | |
| DJANGAL-10 | DJANGAL | 10 | |
| DJANGAL-10/2 | DJANGAL | 10 | |
| DJANGAL-110 | DJANGAL | 110 | |
| DJANGAL-110/2 | DJANGAL | 110 | |
| DJANGAL-220 | DJANGAL | 220 | |
| DJANGAL-220/2 | DJANGAL | 220 | |
| DUSHANBE-110 | DUSHANBE | 110 | |
| DUSHANBE-220 | DUSHANBE | 220 | |
| DUSHANBE-35 | DUSHANBE | 35 | |
| DUSHANBE-500 | DUSHANBE | 500 | |
| GERAN-10 | GERAN | 10 | |
| GERAN-10/2 | GERAN | 10 | |
| GERAN-110 | GERAN | 110 | |
| GERAN-110/2 | GERAN | 110 | |
| GERAN-220 | GERAN | 220 | |
| GOLOVNAYA-10 | GOLOVNAYA | 10.5 | |

| Name | Station | Vn | Year |
|---|---|---|---|
| | | kV | |
| KOLKHOZABAD-220 | KOLKHOZABAD | 220 | |
| KOLKHOZABAD-220/2 | KOLKHOZABAD | 220 | |
| KUNDUZ (Afg) | AFGHANISTAN | 220 | |
| LOLAZAR-10 | LOLAZAR | 10 | |
| LOLAZAR-10/2 | LOLAZAR | 10 | |
| LOLAZAR-110 | LOLAZAR | 110 | |
| LOLAZAR-110/2 | LOLAZAR | 110 | |
| LOLAZAR-220 | LOLAZAR | 220 | |
| LOLAZAR-220/2 | LOLAZAR | 220 | |
| NOVAYA-10 | NOVAYA | 10 | |
| NOVAYA-10/2 | NOVAYA | 10 | |
| NOVAYA-110 | NOVAYA | 110 | |
| NOVAYA-110/2 | NOVAYA | 110 | |
| NOVAYA-220 | NOVAYA | 220 | |
| NOVAYA-220/2 | NOVAYA | 220 | |
| NUREK-10 | NUREK | 6.9 | |
| NUREK-10/A | NUREK | 6.9 | |
| NUREK-220 | NUREK | 220 | |
| NUREK-220/2 | NUREK | 220 | |
| NUREK-35 | NUREK | 35 | |
| NUREK-35/A | NUREK | 35 | |
| NUREKSKAYA-11 | NUREKSKAYA | 11 | |
| NUREKSKAYA-11/2 | NUREKSKAYA | 11 | |
| NUREKSKAYA-220 | NUREKSKAYA | 220 | |
| NUREKSKAYA-220/2 | NUREKSKAYA | 220 | |
| NUREKSKAYA-500 | NUREKSKAYA | 500 | |
| NUREKSKAYA-500/2 | NUREKSKAYA | 500 | |
| OBIGARM-220 | OBIGARM | 220 | 2016 |
| OBIGARM-220/2 | OBIGARM | 220 | 2016 |
| OBIGARM-35 | OBIGARM | 35 | |
| OBIGARM-35/2 | OBIGARM | 35 | |

| Name | Station | Vn | Year |
|---|---|---|---|
| | | kV | |
| SANGTUDA1-500/2 | SANGTUDA-1 | 500 | 2016 |
| SANGTUDA2-220 | SANGTUDA-2 | 220 | |
| SEBISTAN-220 | SEBISTAN | 220 | |
| SEBISTAN-35 | SEBISTAN | 35 | |
| SEBISTAN-6 | SEBISTAN | 6 | |
| SHAHRISTAN-10 | SHAHRISTAN | 10 | |
| SHAHRISTAN-220 | SHAHRISTAN | 220 | |
| SHARSHAR-10 | SHARSHAR | 10 | |
| SHARSHAR-10/2 | SHARSHAR | 10 | |
| SHARSHAR-220 | SHARSHAR | 220 | |
| SHARSHAR-35 | SHARSHAR | 35 | |
| SHARSHAR-35/2 | SHARSHAR | 35 | |
| SHUROBSKAYA-220/1 | SHUROBSKAYA | 220 | |
| SHUROBSKAYA-220/2 | SHUROBSKAYA | 220 | |
| SUGHD-220 | SUGHD | 220 | |
| SUGHD-220/2 | SUGHD | 220 | |
| SUGHD-35 | SUGHD | 35 | |
| SUGHD-35/2 | SUGHD | 35 | |
| SUGHD-500 | SUGHD | 500 | |
| SURKHAN-500 | SURKHAN | 500 | |
| SYRDARIANSKAYA-220 | SYRDARINSKAYA-UZB | 220 | |
| UZLOVAYA-10 | UZLOVAYA | 10 | |
| UZLOVAYA-10/2 | UZLOVAYA | 10 | |
| UZLOVAYA-10/3 | UZLOVAYA | 10 | |
| UZLOVAYA-110 | UZLOVAYA | 110 | |
| UZLOVAYA-110/2 | UZLOVAYA | 110 | |
| UZLOVAYA-110/3 | UZLOVAYA | 110 | |
| UZLOVAYA-220/A | UZLOVAYA | 220 | |
| UZLOVAYA-220/B | UZLOVAYA | 220 | |
| VARZOB-HPP-1 | NOVAYA | 6 | |
| VARZOB-HPP-2 | NOVAYA | 6 | |

| Name | Station | Vn | Year |
|---|---|---|---|
| | | kV | |
| GOLOVNAYA-10/2 | GOLOVNAYA | 10.5 | |
| GOLOVNAYA-110 | GOLOVNAYA | 110 | |
| GOLOVNAYA-110/2 | GOLOVNAYA | 110 | |
| GOLOVNAYA-220 | GOLOVNAYA | 220 | |
| GUZAR-500 | GUZAR | 500 | |
| TPP-DUSH | DUSHANBE | 10 | |
| TPP4 | DUSHANBE | 6 | |
| TPP5 | DUSHANBE | 6 | |
| TPP6 | DUSHANBE | 10 | |
| TPP7 | DUSHANBE | 10 | |
| KANIBADAM-10 | KANIBADAM | 10 | |
| KANIBADAM-10/2 | KANIBADAM | 10 | |
| KANIBADAM-110 | KANIBADAM | 110 | |
| KANIBADAM-110/2 | KANIBADAM | 110 | |
| KANIBADAM-220/A | KANIBADAM | 220 | |
| KANIBADAM-220/B | KANIBADAM | 220 | |
| KAYROKUM-10 | KAYROKUM | 10.5 | |
| KAYROKUM-10/b | KAYROKUM | 10.5 | |
| KAYROKUM-110 | KAYROKUM | 110 | |
| KAYROKUM-110/b | KAYROKUM | 110 | |
| KAYROKUM-220/A | KAYROKUM | 220 | |

| Name | Station | Vn | Year |
|---|---|---|---|
| | | kV | |
| OBIGARM-500 | OBIGARM | 500 | 2016 |
| ORJABAD-2-10 | ORJABAD-2 | 10 | |
| ORJABAD-2-10/2 | ORJABAD-2 | 10 | |
| ORJABAD-2-110 | ORJABAD-2 | 110 | |
| ORJABAD-2-110/2 | ORJABAD-2 | 110 | |
| ORJABAD-2-220 | ORJABAD-2 | 220 | |
| PEREPADNAYA | GOLOVNAYA | 6 | |
| PRYADILNAYA-10 | PRYADILNAYA | 10 | |
| PRYADILNAYA-10/2 | PRYADILNAYA | 10 | |
| PRYADILNAYA-110 | PRYADILNAYA | 110 | |
| PRYADILNAYA-110/2 | PRYADILNAYA | 110 | |
| PRYADILNAYA-220 | PRYADILNAYA | 220 | |
| PRYADILNAYA-220/2 | PRYADILNAYA | 220 | |
| RAVSHAN-10 | RAVSHAN | 10 | |
| RAVSHAN-10/2 | RAVSHAN | 10 | |
| RAVSHAN-110 | RAVSHAN | 110 | |
| RAVSHAN-110/2 | RAVSHAN | 110 | |
| RAVSHAN-220 | RAVSHAN | 220 | |
| RAVSHAN-220/2 | RAVSHAN | 220 | |
| RAVSHAN-35 | RAVSHAN | 35 | |
| RAVSHAN-35/2 | RAVSHAN | 35 | |

| Name | Station | Vn | Year |
|---|---|---|---|
| | | kV | |
| VARZOB-HPP-3 | NOVAYA | 6 | |
| YATEC-10 | YATEC | 10 | |
| YATEC-10/2 | YATEC | 10 | |
| YATEC-10/3 | YATEC | 10 | |
| YATEC-220 | YATEC | 220 | |
| YATEC-220/2 | YATEC | 220 | |
| YATEC-220/3 | YATEC | 220 | |
| YATEC-35 | YATEC | 35 | |
| YAVAN-220 | YAVAN | 220 | |
| YAVAN-220/2 | YAVAN | 220 | |
| YAVAN-35 | YAVAN | 35 | |
| YAVAN-35/2 | YAVAN | 35 | |
| YAVAN-6 | YAVAN | 6 | |
| YAVAN-6/2 | YAVAN | 6 | |
| YHP-1 | YAVAN | 10.5 | |
| YHP-2 | YAVAN | 10.5 | |
| YUZHNAYA-500 | YUZHNAYA | 500 | 2028 |

## 9.3 Loads

Absorbed P and Q are referred to demand forecast peak demand and assigned to each local load / substation with the proportion of winter load 2011 (doc [26]).

| Name | Station | P abs | Q abs | S abs |
|---|---|---|---|---|
| | | MW | Mvar | MVA |
| Load-1_AINI | AINI | 3.773 | 1.358 | 4.010 |
| Load-2_AINI | AINI | 3.773 | 1.358 | 4.010 |
| Load-1_ASHT | ASHT | 1.434 | 0.302 | 1.465 |
| Load-2_ASHT | ASHT | 1.434 | 0.302 | 1.465 |
| Load-1_BUSTON | BUSTON | 31.692 | 12.828 | 34.190 |
| Load-2_BUSTON | BUSTON | 31.692 | 12.828 | 34.190 |
| Load-3_DJANGAL | DJANGAL | 75.834 | 16.600 | 77.630 |
| Load-4_DJANGAL | DJANGAL | 73.948 | 15.091 | 75.472 |
| Load-1_DJANGAL | DJANGAL | 190.151 | 47.538 | 196.003 |
| Load-2_DJANGAL | DJANGAL | 190.151 | 47.538 | 196.003 |
| Load-1_GERAN | GERAN | 40.747 | 20.373 | 45.556 |
| Load-2_GERAN | GERAN | 40.747 | 20.373 | 45.556 |
| Load-1_KANIBADAM | KANIBADAM | 67.911 | 23.392 | 71.827 |
| Load-2_KANIBADAM | KANIBADAM | 67.911 | 23.392 | 71.827 |
| Load-1_KHATLON | KHATLON | 92.812 | 40.747 | 101.363 |
| Load-2_KHATLON | KHATLON | 92.812 | 40.747 | 101.363 |
| Load-1_KHUJAND | KHUJAND | 95.076 | 21.128 | 97.395 |
| Load-2_KHUJAND | KHUJAND | 95.076 | 21.128 | 97.395 |
| Load-1_KNS1 | KNS1 | 0.000 | 0.000 | 0.000 |
| Load-2_KNS1 | KNS1 | 0.000 | 0.000 | 0.000 |
| Load-3_KNS1 | KNS1 | 0.000 | 0.000 | 0.000 |
| Load-4_KNS1 | KNS1 | 0.000 | 0.000 | 0.000 |
| Load-1_KNS2 | KNS2 | 35.465 | 19.619 | 40.530 |
| Load-2_KNS2 | KNS2 | 35.465 | 19.619 | 40.530 |
| Load-1_KOLKHOZABAD | KOLKHOZABAD | 41.501 | 16.600 | 44.698 |
| Load-2_KOLKHOZABAD | KOLKHOZABAD | 41.501 | 16.600 | 44.698 |
| Load-1_LOLAZAR | LOLAZAR | 70.175 | 49.801 | 86.050 |
| Load-2_LOLAZAR | LOLAZAR | 70.175 | 49.801 | 86.050 |
| Load-3_NOVAYA | NOVAYA | 72.439 | 15.091 | 73.994 |
| Load-4_NOVAYA | NOVAYA | 72.439 | 15.091 | 73.994 |
| Load-1_NOVAYA | NOVAYA | 190.151 | 47.538 | 196.003 |

| Name | Station | P abs | Q abs | S abs |
|---|---|---|---|---|
| | | MW | Mvar | MVA |
| Load-2_NOVAYA | NOVAYA | 190.151 | 47.538 | 196.003 |
| Load-1_NUREK | NUREK | 24.146 | 10.564 | 26.356 |
| Load-2_NUREK | NUREK | 24.146 | 10.564 | 26.356 |
| Load-3_ORJABAD-2 | ORJABAD-2 | 69.269 | 12.073 | 70.313 |
| Load-4_ORJABAD-2 | ORJABAD-2 | 69.269 | 12.073 | 70.313 |
| Load-1_ORJABAD-2 | ORJABAD-2 | 86.775 | 15.242 | 88.103 |
| Load-2_ORJABAD-2 | ORJABAD-2 | 86.775 | 15.091 | 88.077 |
| Load-1_PRYADILNAYA | PRYADILNAYA | 36.974 | 23.392 | 43.752 |
| Load-2_PRYADILNAYA | PRYADILNAYA | 36.974 | 23.392 | 43.752 |
| Load-1_RAVSHAN | RAVSHAN | 43.765 | 19.619 | 47.961 |
| Load-2_RAVSHAN | RAVSHAN | 43.765 | 19.619 | 47.961 |
| Load-1_REGAR | REGAR | 13.079 | 3.808 | 13.622 |
| TALCO-1 | REGAR | 382.000 | 185.000 | 424.440 |
| Load-2_REGAR | REGAR | 13.079 | 3.808 | 13.622 |
| Load-3_REGAR | REGAR | 13.079 | 3.808 | 13.622 |
| TALCO-2 | REGAR | 382.000 | 185.000 | 424.440 |
| Load-1_ROGHUN | ROGHUN | 40.747 | 13.582 | 42.951 |
| Load-2_ROGHUN | ROGHUN | 40.747 | 13.582 | 42.951 |
| Load-1_RUDAKI | RUDAKI | 33.201 | 10.111 | 34.706 |
| Load-2_RUDAKI | RUDAKI | 33.201 | 10.111 | 34.706 |
| Load-1_RUMI | RUMI | 70.929 | 33.201 | 78.315 |
| Load-1_SEBISTAN | SEBISTAN | 20.222 | 4.829 | 20.791 |
| Load-1_SHAHRISTAN | SHAHRISTAN | 1.962 | 0.604 | 2.053 |
| Load-1_SHARSHAR | SHARSHAR | 2.641 | 1.207 | 2.904 |
| Load-2_SHARSHAR | SHARSHAR | 2.641 | 1.207 | 2.904 |
| Load-1_UZLOVAYA | UZLOVAYA | 49.298 | 29.680 | 57.543 |
| Load-2_UZLOVAYA | UZLOVAYA | 49.298 | 29.680 | 57.543 |
| Load-3_UZLOVAYA | UZLOVAYA | 49.298 | 29.680 | 57.543 |
| Load-3_YAVAN | YAVAN | 35.616 | 11.771 | 37.511 |
| Load-1_YAVAN | YAVAN | 22.335 | 9.809 | 24.394 |
| Load-2_YAVAN | YAVAN | 22.335 | 9.809 | 24.394 |

## 9.4 Lines

| Name | Type | Station 1 | Terminal 1 | Station 2 | Terminal 2 | Vn | Length | Irated | R' (20℃) | X' | C' | Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | kV | km | kA | Ohm/km | Ohm/km | uF/km | |
| L-505 | Line_500 kV 3xAC-400 | REGAR | REGAR-500 | NUREKSKAYA | NUREKSKAYA-500 | 500 | 114.9 | 2 | 0.025 | 0.306 | 0.013 | |
| L-506 | Line_500 kV 3xAC-400 | REGAR | REGAR-500 | NUREKSKAYA | NUREKSKAYA-500 | 500 | 110.9 | 2 | 0.025 | 0.306 | 0.013 | |
| L-507 | Line_500 kV 3xAC-400 | REGAR | REGAR-500 | GUZAR | GUZAR-500 | 500 | 255 | 2 | 0.025 | 0.306 | 0.013 | |
| L-508 | Line_500 kV 3xAC-400 | REGAR | REGAR-500 | SURKHAN | SURKHAN-500 | 500 | 162.3 | 2 | 0.025 | 0.306 | 0.013 | |
| L-517 | Line_500 kV 3xAC-400 | REGAR | REGAR-500 | DUSHANBE | DUSHANBE-500 | 500 | 49.98 | 2 | 0.025 | 0.306 | 0.013 | |
| L-518 | Line_500 kV 3xAC-400 | DUSHANBE | DUSHANBE-500 | SUGHD | SUGHD-500 | 500 | 213.6 | 2 | 0.025 | 0.306 | 0.013 | |
| L-D-O-1 | Line_500 kV 3xAC-400 | DUSHANBE | DUSHANBE-500 | OBIGARM | OBIGARM-500 | 500 | 100 | 2 | 0.025 | 0.306 | 0.013 | 2014 |
| L-D-O-2 | Line_500 kV 3xAC-400 | DUSHANBE | DUSHANBE-500 | OBIGARM | OBIGARM-500 | 500 | 100 | 2 | 0.025 | 0.306 | 0.013 | 2014 |
| L-Datka | Line_500 kV 3xAC-400 | SUGHD | SUGHD-500 | | DATKA-500 | 500 | 477 | 2 | 0.025 | 0.306 | 0.013 | 2016 |
| L-O-S | Line_500 kV 3xAC-400 | OBIGARM | OBIGARM-500 | SUGHD | SUGHD-500 | 500 | 285 | 2 | 0.025 | 0.306 | 0.013 | 2020 |
| L-O-Y | Line_500 kV 3xAC-400 | OBIGARM | OBIGARM-500 | YUZHNAYA | YUZHNAYA-500 | 500 | 216 | 2 | 0.025 | 0.306 | 0.013 | 2028 |
| L-Obi-Rogun HPP/1 | Line_500 kV 3xAC-400 | OBIGARM | OBIGARM-500 | ROGUN HPP | ROGUN-500 | 500 | 8 | 2 | 0.025 | 0.306 | 0.013 | 2016 |
| L-Obi-Rogun HPP/2 | Line_500 kV 3xAC-400 | OBIGARM | OBIGARM-500 | ROGUN HPP | ROGUN-500 | 500 | 8 | 2 | 0.025 | 0.306 | 0.013 | 2016 |
| L-Obi-Rogun HPP/3 | Line_500 kV 3xAC-400 | OBIGARM | OBIGARM-500 | ROGUN HPP | ROGUN-500 | 500 | 8 | 2 | 0.025 | 0.306 | 0.013 | 2016 |
| L-Obi-Sangtuda | Line_500 kV 3xAC-400 | OBIGARM | OBIGARM-500 | SANGTUDA-1 | SANGTUDA1-500 | 500 | 126 | 2 | 0.025 | 0.306 | 0.013 | 2020 |
| L-Regar-Sangtuda1 | Line_500 kV 3xAC-400 | REGAR | REGAR-500 | SANGTUDA-1 | SANGTUDA1-500 | 500 | 115 | 2 | 0.025 | 0.306 | 0.013 | 2016 |
| L-S-Y | Line_500 kV 3xAC-400 | SANGTUDA-1 | SANGTUDA1-500 | YUZHNAYA | YUZHNAYA-500 | 500 | 90 | 2 | 0.025 | 0.306 | 0.013 | 2028 |
| L-10D | Line_220 kV AC-300 | YATEC | YATEC-220 | DJANGAL | DJANGAL-220 | 220 | 31.9 | 0.69 | 0.098 | 0.429 | 0.009 | |
| L-11-12 | Line_220 kV AC-400 | SANGTUDA-1 | SANGTUDA1-220 | SANGTUDA-2 | SANGTUDA2-220 | 220 | 12 | 0.705 | 0.075 | 0.42 | 0.009 | |
| L-11L-1 | Line_220 kV AC-400 | LOLAZAR | LOLAZAR-220 | SANGTUDA-1 | SANGTUDA1-220 | 220 | 33 | 1.41 | 0.075 | 0.42 | 0.009 | |
| L-11L-2 | Line_220 kV AC-400 | LOLAZAR | LOLAZAR-220 | SANGTUDA-1 | SANGTUDA1-220/2 | 220 | 33 | 1.41 | 0.075 | 0.42 | 0.009 | |
| L-20-S 1 | Line_220 kV AC-300 | SUGHD | SUGHD-220/2 | SYRDARINSKAYA-UZB | SYRDARIANSKAYA-220 | 220 | 19.4 | 0.69 | 0.098 | 0.429 | 0.009 | |
| L-20-S 2 | Line_220 kV AC-300 | SUGHD | SUGHD-220 | SYRDARINSKAYA-UZB | SYRDARIANSKAYA-220 | 220 | 19.4 | 0.69 | 0.098 | 0.429 | 0.009 | |
| L-24-KB/1 | Line_220 kV AC-300 | KAYROKUM | KAYROKUM-220/B | | T-Shurob-1 | 220 | 51.7 | 1.38 | 0.098 | 0.429 | 0.009 | |
| L-24-KB/2 | Line_220 kV AC-300 | | T-Shurob-2 | KANIBADAM | KANIBADAM-220/B | 220 | 15 | 1.38 | 0.098 | 0.429 | 0.009 | |
| L-5K | Line_220 kV ACO-300b | GOLOVNAYA | GOLOVNAYA-220 | KOLKHOZABAD | KOLKHOZABAD-220 | 220 | 49.03 | 0.69 | 0.098 | 0.435 | 0.009 | |
| L-5P | Line_220 kV AC-300 | GOLOVNAYA | GOLOVNAYA-220 | PRYADILNAYA | PRYADILNAYA-220 | 220 | 16.2 | 0.69 | 0.098 | 0.429 | 0.009 | |
| L-7-02 | Line_220 kV AC-300 | ORJABAD-2 | ORJABAD-2-220 | | T_NUREK | 220 | 47.2 | 1.38 | 0.098 | 0.429 | 0.009 | |
| L-7-02(1) | Line_220 kV AC-300 | | T_NUREK | NUREKSKAYA | NUREKSKAYA-220 | 220 | 2.5 | 1.38 | 0.098 | 0.429 | 0.009 | |

| Name | Type | Station 1 | Terminal 1 | Station 2 | Terminal 2 | Vn | Length | Irated | R' (20℃) | X' | C' | Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | kV | km | kA | Ohm/km | Ohm/km | uF/km | |
| L-7-02(2) | Line_220 kV AC-300 | | T_NUREK | NUREK | NUREK-220 | 220 | 0.5 | 0.69 | 0.098 | 0.429 | 0.009 | |
| L-7-10 | Line_220 kV AC-400 | NUREKSKAYA | NUREKSKAYA-220 | | T_NUREK_2 | 220 | 2.5 | 0.705 | 0.075 | 0.42 | 0.009 | |
| L-7-10(1) | Line_220 kV AC-400 | | T_NUREK_2 | YATEC | YATEC-220 | 220 | 44.7 | 0.705 | 0.075 | 0.42 | 0.009 | |
| L-7-10(2) | Line_220 kV AC-400 | | T_NUREK_2 | NUREK | NUREK-220/2 | 220 | 0.5 | 0.705 | 0.075 | 0.42 | 0.009 | |
| L-7-L | Line_220 kV ACO-300 | NUREKSKAYA | NUREKSKAYA-220 | SEBISTAN | SEBISTAN-220 | 220 | 25 | 1.38 | 0.098 | 0.42 | 0.009 | |
| L-7-R | Line_220 kV AC-300 | NUREKSKAYA | NUREKSKAYA-220 | ROGHUN | ROGHUN-220 | 220 | 65.5 | 0.69 | 0.098 | 0.429 | 0.009 | |
| L-7-S | Line_220 kV AC-300 | NUREKSKAYA | NUREKSKAYA-220 | SHARSHAR | SHARSHAR-220 | 220 | 22.1 | 0.69 | 0.098 | 0.429 | 0.009 | |
| L-7L | Line_220 kV AC-300 | SEBISTAN | SEBISTAN-220 | LOLAZAR | LOLAZAR-220 | 220 | 18.1 | 1.38 | 0.098 | 0.429 | 0.009 | |
| L-8-10 | Line_220 kV AC-300 | YATEC | YATEC-220 | | T_YAVAN | 220 | 31 | 0.69 | 0.098 | 0.429 | 0.009 | |
| L-8-10(1) | Line_220 kV AC-300 | | T_YAVAN | BAYPAZA | BAYPAZA-220 | 220 | 9.5 | 0.69 | 0.098 | 0.429 | 0.009 | |
| L-8-10(2) | Line_220 kV AC-300 | | T_YAVAN | YAVAN | YAVAN-220 | 220 | 1.6 | 0.69 | 0.098 | 0.429 | 0.009 | |
| L-8-5 | Line_220 kV AC-300 | BAYPAZA | BAYPAZA-220 | | T_YAVAN2 | 220 | 8.7 | 0.69 | 0.098 | 0.429 | 0.009 | |
| L-8-5(1) | Line_220 kV AC-300 | | T_YAVAN2 | YAVAN | YAVAN-220 | 220 | 1.4 | 0.69 | 0.098 | 0.429 | 0.009 | |
| L-85 | Line_220 kV AC-300 | | T_YAVAN2 | GOLOVNAYA | GOLOVNAYA-220 | 220 | 58 | 0.69 | 0.098 | 0.429 | 0.009 | |
| L-8D | Line_220 kV AC-400 | DJANGAL | DJANGAL-220 | BAYPAZA | BAYPAZA-220 | 220 | 53.4 | 1.41 | 0.075 | 0.42 | 0.009 | |
| L-8L | Line_220 kV ACO-300 | BAYPAZA | BAYPAZA-220 | LOLAZAR | LOLAZAR-220 | 220 | 36 | 0.69 | 0.098 | 0.42 | 0.009 | |
| L-Buston | Line_220 kV AC-300 | | T_Buston | BUSTON | BUSTON-220 | 220 | 0.6 | 0.69 | 0.098 | 0.429 | 0.009 | |
| L-DJ | Line_220 kV AC-400 | DUSHANBE | DUSHANBE-220 | DJANGAL | DJANGAL-220 | 220 | 73.2 | 0.705 | 0.075 | 0.42 | 0.009 | |
| L-DN-1 | Line_220 kV AC-400 | DUSHANBE | DUSHANBE-220 | NOVAYA | NOVAYA-220 | 220 | 10.9 | 0.705 | 0.075 | 0.42 | 0.009 | |
| L-DN-2 | Line_220 kV AC-400 | DUSHANBE | DUSHANBE-220 | NOVAYA | NOVAYA-220 | 220 | 11 | 0.705 | 0.075 | 0.42 | 0.009 | |
| L-DO | Line_220 kV AC-400 | DUSHANBE | DUSHANBE-220 | ORJABAD-2 | ORJABAD-2-220 | 220 | 30.7 | 0.705 | 0.075 | 0.42 | 0.009 | |
| L-G-R | Line_220 kV AC-400 | GERAN | GERAN-220 | RUMI | RUMI-220 | 220 | 75 | 0.705 | 0.075 | 0.42 | 0.009 | 2014 |
| L-HPP12-HPP5 | Line_220 kV AC-400 | SANGTUDA-2 | SANGTUDA2-220 | GOLOVNAYA | GOLOVNAYA-220 | 220 | 13 | 0.705 | 0.075 | 0.42 | 0.009 | |
| L-K-24 | Line_220 kV AC-300 | KHUJAND | KHUJAND-220/A | KAYROKUM | KAYROKUM-220/B | 220 | 22.1 | 0.69 | 0.098 | 0.429 | 0.009 | |
| L-K-A | Line_220 kV AC-400 | ASHT | ASHT-220 | KAYROKUM | KAYROKUM-220/B | 220 | 70 | 0.705 | 0.075 | 0.42 | 0.009 | 2014 |
| L-K-U-1 | Line_220 kV ACO-300 | | T_UZLOVAYA-1 | UZLOVAYA | UZLOVAYA-220/A | 220 | 0.3 | 0.69 | 0.098 | 0.42 | 0.009 | |
| L-K-U-2 | Line_220 kV ACO-300 | | T_UZLOVAYA-2 | UZLOVAYA | UZLOVAYA-220/B | 220 | 0.3 | 0.69 | 0.098 | 0.42 | 0.009 | |
| L-KAN-S | Line_220 kV AC-400 | | T-Shurob-2 | SHUROBSKAYA | SHUROBSKAYA-220/2 | 220 | 15 | 0.705 | 0.075 | 0.42 | 0.009 | 2016 |
| L-KAY-S | Line_220 kV AC-400 | | T-Shurob-1 | SHUROBSKAYA | SHUROBSKAYA-220/1 | 220 | 15 | 0.705 | 0.075 | 0.42 | 0.009 | 2016 |
| L-KGR | Line_220 kV AC-300 | KOLKHOZABAD | KOLKHOZABAD-220 | GERAN | GERAN-220 | 220 | 29.9 | 0.69 | 0.098 | 0.429 | 0.009 | |
| L-KK/A | Line_220 kV ACO-300 | | T_KNS-1 | | T_UZLOVAYA-1 | 220 | 6.8 | 0.69 | 0.098 | 0.42 | 0.009 | |

| Name | Type | Station 1 | Terminal 1 | Station 2 | Terminal 2 | Vn | Length | Irated | R' (20℃) | X' | C' | Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | kV | km | kA | Ohm/km | Ohm/km | uF/km | |
| L-KK/B | Line_220 kV ACO-300 | | T_KNS-2 | | T_UZLOVAYA-2 | 220 | 6.8 | 0.69 | 0.098 | 0.42 | 0.009 | |
| L-KNS1/A | Line_220 kV AC-300 | | T_KNS-1 | KNS1 | KNS1-220/A | 220 | 1.2 | 0.69 | 0.098 | 0.429 | 0.009 | |
| L-KNS1/B | Line_220 kV AC-300 | | T_KNS-2 | KNS1 | KNS1-220/B | 220 | 1.2 | 0.69 | 0.098 | 0.429 | 0.009 | |
| L-KNS2/A | Line_220 kV AC-300 | | T_KNS-1 | KNS2 | KNS2-220/A | 220 | 1.4 | 0.69 | 0.098 | 0.429 | 0.009 | |
| L-KNS2/B | Line_220 kV AC-300 | | T_KNS-2 | KNS2 | KNS2-220/B | 220 | 1.4 | 0.69 | 0.098 | 0.429 | 0.009 | |
| L-LK-1 | Line_220 kV AC-400 bis | LOLAZAR | LOLAZAR-220 | KHATLON | KHATLON-220 | 220 | 56.3 | 0.825 | 0.075 | 0.42 | 0.009 | |
| L-LK-2 | Line_220 kV AC-400 bis | LOLAZAR | LOLAZAR-220 | KHATLON | KHATLON-220 | 220 | 56.3 | 0.825 | 0.075 | 0.42 | 0.009 | |
| L-NR | Line_220 kV AC-300 | NOVAYA | NOVAYA-220 | REGAR | REGAR-220 | 220 | 47.5 | 0.69 | 0.098 | 0.429 | 0.009 | |
| L-PR | Line_220 kV AC-300 | PRYADILNAYA | PRYADILNAYA-220 | RUMI | RUMI-220 | 220 | 54.98 | 0.69 | 0.098 | 0.429 | 0.009 | |
| L-RR | Line_220 kV ACO-300 | REGAR | REGAR-220 | RAVSHAN | RAVSHAN-220 | 220 | 5.5 | 0.69 | 0.098 | 0.42 | 0.009 | |
| L-Rudaki | Line_220 kV AC-400 | AINI | AINI-220 | RUDAKI | RUDAKI-220 | 220 | 99 | 0.705 | 0.075 | 0.42 | 0.009 | |
| L-S-24/1 | Line_220 kV AC-400 | SUGHD | SUGHD-220/2 | | T_Sughd | 220 | 12.5 | 0.705 | 0.075 | 0.42 | 0.009 | |
| L-S-24/2 | Line_220 kV AC-300 | | T_Sughd | | T_Buston | 220 | 27.5 | 0.69 | 0.098 | 0.429 | 0.009 | |
| L-S-24/3 | Line_220 kV AC-300 | | T_Buston | KAYROKUM | KAYROKUM-220/A | 220 | 54.1 | 0.69 | 0.098 | 0.429 | 0.009 | |
| L-S-I | Line_220 kV AC-400 bis | SUGHD | SUGHD-220 | | T_Shahristan | 220 | 90 | 0.825 | 0.075 | 0.42 | 0.009 | 2011 |
| L-S-I(1) | Line_220 kV AC-400 bis | | T_Shahristan | AINI | AINI-220 | 220 | 28 | 0.825 | 0.075 | 0.42 | 0.009 | 2011 |
| L-S-I(2) | Line_220 kV AC-300 | | T_Shahristan | SHAHRISTAN | SHAHRISTAN-220 | 220 | 0.1 | 0.69 | 0.098 | 0.429 | 0.009 | |
| L-S-K | Line_220 kV AC-400 | SUGHD | SUGHD-220 | KHUJAND | KHUJAND-220/A | 220 | 54.4 | 0.705 | 0.075 | 0.42 | 0.009 | |
| L-S-K2/A | Line_220 kV AC-400b | SUGHD | SUGHD-220 | | T_KNS-1 | 220 | 10.2 | 0.705 | 0.075 | 0.429 | 0.009 | |
| L-S-K2/B | Line_220 kV AC-400b | SUGHD | SUGHD-220/2 | | T_KNS-2 | 220 | 10.2 | 0.705 | 0.075 | 0.429 | 0.009 | |
| L-Sangtuda-Kunduz | Line_220 kV AC-300 | SANGTUDA-2 | SANGTUDA2-220 | | KUNDUZ (Afg) | 220 | 180 | 1.38 | 0.098 | 0.429 | 0.009 | |
| L-9N-1 | Line_110 kV ACO-300 | DUSHANBE | DUSHANBE-110 | NOVAYA | NOVAYA-110 | 110 | 6.1 | 0.69 | 0.098 | 0.42 | 0.009 | |
| L-9N-2 | Line_110 kV ACO-300 | DUSHANBE | DUSHANBE-110 | NOVAYA | NOVAYA-110/2 | 110 | 2 | 0.69 | 0.098 | 0.42 | 0.009 | |
| LA | Line_110 kV AC-120 | AINI | AINI-110/2 | RUDAKI | RUDAKI-110 | 110 | 100 | 0.375 | 0.2376 | 0.429 | 0.009 | |

## 9.5 2-winding transformers

| Name | Station | Bus HV side | Bus LV side | Sn | Vn HV | Vn LV | Vector Group | Vcc | Pcu | I0 | Pfe | Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | MVA | kV | kV | | % | kW | % | kW | |
| T-HPP11-1 | SANGTUDA-1 | SANGTUDA1-220 | Bus-HPP11-1 | 200 | 230 | 15.75 | YNd11 | 12 | 600 | 0.3 | 200 | |
| T-HPP11-2 | SANGTUDA-1 | SANGTUDA1-220 | Bus-HPP11-2 | 200 | 230 | 15.75 | YNd11 | 12 | 600 | 0.3 | 200 | |
| T-HPP11-3 | SANGTUDA-1 | SANGTUDA1-220/2 | Bus-HPP11-3 | 200 | 230 | 15.75 | YNd11 | 12 | 600 | 0.3 | 200 | |
| T-HPP11-4 | SANGTUDA-1 | SANGTUDA1-220/2 | Bus-HPP11-4 | 200 | 230 | 15.75 | YNd11 | 12 | 600 | 0.3 | 200 | |
| T-HPP12-1 | SANGTUDA-2 | SANGTUDA2-220 | Bus-HPP12-1 | 125 | 230 | 13.8 | YNd11 | 12 | 375 | 0.3 | 125 | |
| T-HPP12-2 | SANGTUDA-2 | SANGTUDA2-220 | Bus-HPP12-2 | 125 | 230 | 13.8 | YNd11 | 12 | 375 | 0.3 | 125 | |
| T-HPP5-3 | GOLOVNAYA | GOLOVNAYA-110 | Bus-HPP5-3 | 125 | 121 | 10.5 | YNd11 | 11.7 | 375 | 0.3 | 125 | |
| T-HPP7-1 | NUREKSKAYA | NUREKSKAYA-500 | Bus-HPP7-1 | 400 | 525 | 15.75 | YNd11 | 13 | 1200 | 0.3 | 400 | |
| T-HPP7-2 | NUREKSKAYA | NUREKSKAYA-500 | Bus-HPP7-2 | 400 | 525 | 15.75 | YNd11 | 13 | 1200 | 0.3 | 400 | |
| T-HPP7-3 | NUREKSKAYA | NUREKSKAYA-500 | Bus-HPP7-3 | 400 | 525 | 15.75 | YNd11 | 13 | 1200 | 0.3 | 400 | |
| T-HPP7-4 | NUREKSKAYA | NUREKSKAYA-500/2 | Bus-HPP7-4 | 400 | 525 | 15.75 | YNd11 | 13 | 1200 | 0.3 | 400 | |
| T-HPP7-5 | NUREKSKAYA | NUREKSKAYA-500/2 | Bus-HPP7-5 | 400 | 525 | 15.75 | YNd11 | 13 | 1200 | 0.3 | 400 | |
| T-HPP7-6 | NUREKSKAYA | NUREKSKAYA-500/2 | Bus-HPP7-6 | 400 | 525 | 15.75 | YNd11 | 13 | 1200 | 0.3 | 400 | |
| T-HPP7-7 | NUREKSKAYA | NUREKSKAYA-220 | Bus-HPP7-7 | 400 | 242 | 15.75 | YNd11 | 11.1 | 1200 | 0.3 | 400 | |
| T-HPP7-8 | NUREKSKAYA | NUREKSKAYA-220 | Bus-HPP7-8 | 400 | 242 | 15.75 | YNd11 | 11.1 | 1200 | 0.3 | 400 | |
| T-HPP7-9 | NUREKSKAYA | NUREKSKAYA-220/2 | Bus-HPP7-9 | 400 | 242 | 15.75 | YNd11 | 11.1 | 1200 | 0.3 | 400 | |
| T-HPP8-1 | BAYPAZA | BAYPAZA-220 | Bus-HPP8-1 | 200 | 242 | 15.75 | YNd11 | 10.8 | 600 | 0.3 | 200 | |
| T-HPP8-2 | BAYPAZA | BAYPAZA-220 | Bus-HPP8-2 | 200 | 242 | 15.75 | YNd11 | 10.8 | 600 | 0.3 | 200 | |
| T-HPP8-3 | BAYPAZA | BAYPAZA-220 | Bus-HPP8-3 | 200 | 242 | 15.75 | YNd11 | 10.8 | 600 | 0.3 | 200 | |
| T-HPP8-4 | BAYPAZA | BAYPAZA-220 | Bus-HPP8-4 | 200 | 242 | 15.75 | YNd11 | 10.8 | 600 | 0.3 | 200 | |
| T-TPP-DUSHANBE-2 | DUSHANBE | DUSHANBE-110 | TPP-DUSH | 125 | 120 | 10 | YNd11 | 10 | 360 | 0.3 | 120 | |
| T-TPP4 | DUSHANBE | DUSHANBE-110 | TPP4 | 40 | 120 | 6 | YNd11 | 10 | 120 | 0.3 | 40 | |
| T-TPP5 | DUSHANBE | DUSHANBE-110 | TPP5 | 40 | 120 | 6 | YNd11 | 10 | 120 | 0.3 | 40 | |
| T-TPP6 | DUSHANBE | DUSHANBE-110 | TPP6 | 80 | 120 | 10 | YNd11 | 10 | 240 | 0.3 | 80 | |
| T-TPP7 | DUSHANBE | DUSHANBE-110 | TPP7 | 125 | 120 | 10 | YNd11 | 10 | 360 | 0.3 | 120 | |
| T-Rogun-1 | ROGUN HPP | ROGUN-500 | Bus-Gen1 | 700 | 525 | 15.75 | YNd11 | 14 | 2000 | 0.3 | 700 | 2016 |
| T-Rogun-2 | ROGUN HPP | ROGUN-500 | Bus-Gen2 | 700 | 525 | 15.75 | YNd11 | 14 | 2000 | 0.3 | 700 | 2016 |
| T-Rogun-3 | ROGUN HPP | ROGUN-500 | Bus-Gen3 | 700 | 525 | 15.75 | YNd11 | 14 | 2000 | 0.3 | 700 | 2025 |
| T-Rogun-4 | ROGUN HPP | ROGUN-500 | Bus-Gen4 | 700 | 525 | 15.75 | YNd11 | 14 | 2000 | 0.3 | 700 | 2025 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| T-Rogun-5 | ROGUN HPP | ROGUN-500 | Bus-Gen5 | 700 | 525 | 15.75 | YNd11 | 14 | 2000 | 0.3 | 700 | 2025 |
| T-Rogun-6 | ROGUN HPP | ROGUN-500 | Bus-Gen6 | 700 | 525 | 15.75 | YNd11 | 14 | 2000 | 0.3 | 700 | 2025 |
| T-YHP-1 | YAVAN | YAVAN-220 | YHP-1 | 40 | 230 | 10.5 | YNd11 | 10 | 120 | 0.3 | 40 | |
| T-YHP-2 | YAVAN | YAVAN-220 | YHP-2 | 40 | 230 | 10.5 | YNd11 | 10 | 120 | 0.3 | 40 | |
| TR-CENTRALNAYA | KOLKHOZABAD | KOLKHOZABAD-110/2 | CENTRALNAYA HPP | 31.5 | 110 | 6 | YNd11 | 10 | 90 | 0.3 | 31.5 | |
| TR-PEREPADNAYA | GOLOVNAYA | GOLOVNAYA-220 | PEREPADNAYA | 75 | 220 | 6 | YNd11 | 10 | 225 | 0.3 | 75 | |
| TR-SHAHRISTAN | SHAHRISTAN | SHAHRISTAN-220 | SHAHRISTAN-10 | 16 | 230 | 10.5 | YNd11 | 10 | 48 | 0.3 | 16 | |
| TR-VARZOB-1 | NOVAYA | NOVAYA-110 | VARZOB-HPP-1 | 12 | 110 | 6 | YNd11 | 10 | 36 | 0.3 | 12 | |
| TR-VARZOB-2 | NOVAYA | NOVAYA-110/2 | VARZOB-HPP-2 | 20 | 110 | 6 | YNd11 | 10 | 60 | 0.3 | 20 | |
| TR-VARZOB-3 | NOVAYA | NOVAYA-110/2 | VARZOB-HPP-3 | 5 | 110 | 6 | YNd11 | 10 | 15 | 0.3 | 5 | |
| TR-YATEC-2 | YATEC | YATEC-220/2 | YATEC-10/2 | 63 | 230 | 10.5 | YNd11 | 10 | 190 | 0.3 | 63 | |
| TR-YATEC-4 | YATEC | YATEC-220 | YATEC-10 | 63 | 230 | 10.5 | YNd11 | 10 | 190 | 0.3 | 63 | |

## 9.6 3-winding transformers

| Name | Station | Sn_1 | Sn_2 | Sn_3 | Vn_1 | Vn_2 | Vn_3 | Vector Group | Vcc 1-2 | Vcc 2-3 | Vcc 3-1 | P_Cu 1-2 | P_Cu 2-3 | P_Cu 3-1 | Io | P_Fe | Tap Side | DV step | Tap min | Tap max | Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | MVA | MVA | MVA | kV | kV | kV | | % | % | % | kW | kW | kW | % | kW | | % | | | |
| TR-AINI-1 | AINI | 63 | 63 | 32 | 230 | 121 | 10.5 | YN0yn0d11 | 11.0 | 11.3 | 21.0 | 154.1 | 192.4 | 160.3 | 0.15 | 33.9 | 1 | 1.25 | -8 | 8 | |
| TR-AINI-2 | AINI | 63 | 63 | 32 | 230 | 121 | 10.5 | YN0yn0d11 | 11.0 | 11.3 | 21.0 | 154.1 | 192.4 | 160.3 | 0.15 | 33.9 | 1 | 1.25 | -8 | 8 | |
| TR-ASHT-1 | ASHT | 125 | 125 | 63 | 230 | 121 | 6.6 | YN0yn0d11 | 20.3 | 21.5 | 28.4 | 315.0 | 280.0 | 277.0 | 0.4 | 65 | 1 | 2 | -6 | 6 | |
| TR-ASHT-2 | ASHT | 125 | 125 | 63 | 230 | 121 | 6.6 | YN0yn0d11 | 11.0 | 22.1 | 28.4 | 315.0 | 280.0 | 277.0 | 0.4 | 65 | 1 | 2 | -6 | 6 | |
| TR-BUSTON-1 | BUSTON | 63 | 63 | 32 | 230 | 121 | 10.54 | YN0yn0d11 | 11.0 | 11.3 | 21.0 | 154.1 | 192.4 | 160.3 | 0.15 | 33.9 | 2 | 1.5 | -8 | 8 | |
| TR-BUSTON-2 | BUSTON | 32 | 32 | 16 | 230 | 121 | 11 | YN0yn0d11 | 11.0 | 17.0 | 21.0 | 163.0 | 145.0 | 128.0 | 0.6 | 32 | 2 | 2 | -6 | 6 | |
| TR-DJANGAL-1 | DJANGAL | 200 | 200 | 80 | 230 | 121 | 11 | YN0yn0d11 | 11.0 | 12.8 | 20.0 | 430.0 | 360.0 | 320.0 | 0.5 | 125 | 1 | 2 | -6 | 6 | |
| TR-DJANGAL-2 | DJANGAL | 200 | 200 | 80 | 230 | 121 | 11 | YN0yn0d11 | 11.0 | 12.8 | 20.0 | 430.0 | 360.0 | 320.0 | 0.5 | 125 | 1 | 2 | -6 | 6 | |
| TR-DUSHANBE-1 | DUSHANBE | 501 | 501 | 180 | 500 | 230 | 36 | YN0yn0d11 | 12.5 | 15.7 | 28.8 | 285.7 | 97.4 | 99.9 | 0.09 | 61.6 | 1 | 1.25 | -8 | 8 | |
| TR-GERAN-1 | GERAN | 63 | 63 | 32 | 230 | 121 | 11 | YN0yn0d11 | 11.1 | 17.7 | 21.3 | 157.1 | 192.4 | 160.3 | 0.15 | 33.9 | 2 | 1.5 | -8 | 8 | |
| TR-GERAN-2 | GERAN | 63 | 63 | 32 | 230 | 121 | 11 | YN0yn0d11 | 11.1 | 17.7 | 21.3 | 157.1 | 192.4 | 160.3 | 0.15 | 33.9 | 2 | 1.5 | -8 | 8 | |
| TR-GOLOVNAYA-1 | GOLOVNAYA | 80 | 80 | 80 | 242 | 121 | 10.5 | YN0yn0d11 | 13.0 | 34.7 | 22.5 | 99.0 | 99.0 | 99.0 | 0 | 0 | | | | | |
| TR-GOLOVNAYA-2 | GOLOVNAYA | 80 | 80 | 80 | 242 | 121 | 10.5 | YN0yn0d11 | 13.0 | 34.7 | 22.5 | 99.0 | 99.0 | 99.0 | 0 | 0 | | | | | |
| TR-KANIBADAM-1 | KANIBADAM | 125 | 125 | 63 | 230 | 121 | 10.54 | YN0yn0d11 | 20.3 | 21.5 | 30.3 | 315.0 | 280.0 | 277.0 | 0.4 | 65 | 3 | 2 | -6 | 6 | |

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TR-KANIBADAM-2 | KANIBADAM | 125 | 125 | 63 | 230 | 121 | 10.54 | YN0yn0d11 | 20.3 | 21.5 | 30.3 | 315.0 | 280.0 | 277.0 | 0.4 | 65 | 3 | 2 | -6 | 6 | |
| TR-KAYROKUM-1 | KAYROKUM | 90 | 90 | 90 | 230 | 115 | 10.5 | YN0yn0d11 | 11.0 | 17.5 | 17.4 | 322.0 | 286.0 | 254.0 | 0.4 | 65 | 1 | 1.5 | -6 | 6 | |
| TR-KAYROKUM-2 | KAYROKUM | 90 | 90 | 90 | 230 | 115 | 10.5 | YN0yn0d11 | 11.0 | 17.5 | 17.4 | 322.0 | 286.0 | 254.0 | 0.4 | 65 | 1 | 1.5 | -6 | 6 | |
| TR-KHATLON-1 | KHATLON | 125 | 125 | 62.5 | 230 | 121 | 10.5 | YN0yn0d11 | 13.5 | 12.1 | 8.4 | 386.0 | 133.4 | 94.2 | 0.12 | 88 | 1 | 1.25 | -8 | 8 | |
| TR-KHATLON-2 | KHATLON | 125 | 125 | 62.5 | 230 | 121 | 10.5 | YN0yn0d11 | 13.5 | 12.1 | 8.4 | 386.0 | 133.4 | 94.2 | 0.12 | 88 | 1 | 1.25 | -8 | 8 | |
| TR-KHUJAND-1 | KHUJAND | 125 | 125 | 63 | 230 | 121 | 10.54 | YN0yn0d11 | 20.3 | 11.5 | 30.3 | 315.0 | 280.0 | 277.0 | 0.4 | 65 | 2 | 2 | -6 | 6 | |
| TR-KHUJAND-2 | KHUJAND | 125 | 125 | 63 | 230 | 121 | 10.54 | YN0yn0d11 | 20.3 | 21.5 | 30.3 | 315.0 | 280.0 | 277.0 | 0.4 | 65 | 2 | 2 | -6 | 6 | |
| TR-KNS1-1 | KNS1 | 40 | 40 | 20 | 230 | 11 | 11 | YN0yn0d11 | 5.9 | 21.2 | 21.2 | 170.0 | 170.0 | 170.0 | 0.6 | 50 | 1 | 1.5 | -8 | 8 | |
| TR-KNS1-2 | KNS1 | 40 | 40 | 20 | 230 | 11 | 11 | YN0yn0d11 | 5.9 | 21.2 | 21.2 | 170.0 | 170.0 | 170.0 | 0.6 | 50 | 1 | 1.5 | -8 | 8 | |
| TR-KNS2-1 | KNS2 | 125 | 125 | 63 | 230 | 121 | 10.54 | YN0yn0d11 | 20.3 | 17.1 | 30.3 | 315.0 | 280.0 | 277.0 | 0.4 | 65 | 2 | 2 | -6 | 6 | |
| TR-KNS2-2 | KNS2 | 125 | 125 | 63 | 230 | 121 | 10.54 | YN0yn0d11 | 20.3 | 21.3 | 30.3 | 315.0 | 280.0 | 277.0 | 0.4 | 65 | 2 | 2 | -6 | 6 | |
| TR-KOLKHOZABAD-1 | KOLKHOZABAD | 63 | 63 | 32 | 230 | 121 | 11 | YN0yn0d11 | 11.1 | 17.7 | 21.3 | 157.0 | 192.4 | 160.3 | 0.15 | 33.9 | 2 | 1.5 | -8 | 8 | |
| TR-KOLKHOZABAD-2 | KOLKHOZABAD | 63 | 63 | 32 | 230 | 121 | 11 | YN0yn0d11 | 11.1 | 17.7 | 21.3 | 157.0 | 192.4 | 160.3 | 0.15 | 33.9 | 2 | 1.5 | -8 | 8 | |
| TR-LOLAZAR-1 | LOLAZAR | 125 | 125 | 62.5 | 230 | 121 | 10.5 | YN0yn0d11 | 13.5 | 12.1 | 8.4 | 386.0 | 133.4 | 94.2 | 0.12 | 88 | 1 | 1.25 | -8 | 8 | |
| TR-LOLAZAR-2 | LOLAZAR | 125 | 125 | 62.5 | 230 | 121 | 10.5 | YN0yn0d11 | 13.5 | 12.1 | 8.4 | 386.0 | 133.4 | 94.2 | 0.12 | 88 | 1 | 1.25 | -8 | 8 | |
| TR-NOVAYA-1 | NOVAYA | 200 | 200 | 80 | 230 | 121 | 11 | YN0yn0d11 | 11.0 | 12.8 | 20.0 | 430.0 | 360.0 | 320.0 | 0.5 | 125 | 2 | 2 | -6 | 6 | |
| TR-NOVAYA-2 | NOVAYA | 200 | 200 | 80 | 230 | 121 | 11 | YN0yn0d11 | 11.0 | 12.8 | 20.0 | 430.0 | 360.0 | 320.0 | 0.5 | 125 | 2 | 2 | -6 | 6 | |
| TR-NUREK-1 | NUREK | 40 | 40 | 40 | 230 | 38.5 | 6.6 | YN0yn0d11 | 12.4 | 10.1 | 10.5 | 201.5 | 237.1 | 177.0 | 0.54 | 62.1 | 2 | 1 | -12 | 12 | |
| TR-NUREK-2 | NUREK | 40 | 40 | 40 | 230 | 38.5 | 6.6 | YN0yn0d11 | 12.4 | 22.7 | 9.8 | 202.3 | 202.3 | 173.9 | 0.56 | 58.5 | 2 | 1 | -12 | 12 | |
| TR-NUREK-1 | NUREKSKAYA | 501 | 501 | 180 | 500 | 230 | 11 | YN0yn0d11 | 12.5 | 15.7 | 28.8 | 285.7 | 97.4 | 99.9 | 0.09 | 61.6 | 1 | 1.25 | -8 | 8 | |
| TR-NUREK-2 | NUREKSKAYA | 501 | 501 | 180 | 500 | 230 | 11 | YN0yn0d11 | 12.5 | 15.7 | 28.8 | 285.7 | 97.4 | 99.9 | 0.09 | 61.6 | 1 | 1.25 | -8 | 8 | |
| TR-OBIGARM-1 | OBIGARM | 501 | 501 | 180 | 500 | 230 | 36 | YN0yn0d11 | 12.5 | 15.7 | 28.8 | 285.7 | 97.4 | 99.9 | 0.09 | 61.6 | 1 | 1.25 | -8 | 8 | 2016 |
| TR-OBIGARM-2 | OBIGARM | 501 | 501 | 180 | 500 | 230 | 36 | YN0yn0d11 | 12.5 | 15.7 | 28.8 | 285.7 | 97.4 | 99.9 | 0.09 | 61.6 | 1 | 1.25 | -8 | 8 | 2016 |
| TR-ORJABAD-2-1 | ORJABAD-2 | 125 | 79 | 63 | 230 | 121 | 11 | YN0yn0d11 | 10.0 | 30.7 | 19.1 | 315.0 | 280.0 | 277.0 | 0.4 | 65 | 2 | 2 | -6 | 6 | |
| TR-ORJABAD-2-2 | ORJABAD-2 | 125 | 79 | 63 | 230 | 121 | 11 | YN0yn0d11 | 9.9 | 30.3 | 18.9 | 315.0 | 280.0 | 277.0 | 0.4 | 65 | 2 | 2 | -6 | 6 | |
| TR-PRYADILNAYA-1 | PRYADILNAYA | 63 | 63 | 32 | 230 | 121 | 11 | YN0yn0d11 | 11.1 | 17.7 | 21.3 | 157.1 | 192.4 | 160.3 | 0.15 | 33.9 | 2 | 1.5 | -8 | 8 | |
| TR-PRYADILNAYA-2 | PRYADILNAYA | 125 | 125 | 63 | 230 | 121 | 10.54 | YN0yn0d11 | 20.8 | 21.5 | 30.3 | 315.0 | 280.0 | 277.0 | 0.4 | 65 | 2 | 2 | -6 | 6 | |
| TR-RAVSHAN-1 | RAVSHAN | 20 | 20 | 20 | 230 | 38.5 | 11 | YN0yn0d11 | 12.6 | 18.9 | 63.0 | 135.3 | 148.8 | 106.4 | 2.92 | 79 | 2 | 1.2 | -10 | 10 | |
| TR-RAVSHAN-2 | RAVSHAN | 125 | 125 | 63 | 230 | 121 | 35 | YN0yn0d11 | 20.3 | 21.5 | 30.3 | 315.0 | 280.0 | 277.0 | 0.4 | 65 | 2 | 2 | -6 | 6 | |
| TR-RAVSHAN-3 | RAVSHAN | 125 | 125 | 63 | 230 | 121 | 10.5 | YN0yn0d11 | 20.3 | 21.5 | 30.3 | 315.0 | 280.0 | 277.0 | 0.4 | 65 | 2 | 2 | -6 | 6 | |
| TR-REGAR-1 | REGAR | 801 | 801 | 288 | 500 | 220 | 38.5 | YN0yn0d11 | 8.3 | 5.8 | 12.4 | 438.0 | 76.5 | 63.0 | 0.11 | 175 | 1 | 1.4 | -8 | 8 | |
| TR-REGAR-2 | REGAR | 801 | 801 | 288 | 500 | 220 | 38.5 | YN0yn0d11 | 8.3 | 5.8 | 12.4 | 438.0 | 76.5 | 63.0 | 0.11 | 175 | 1 | 1.4 | -8 | 8 | |

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TR-REGAR-3 | REGAR | 801 | 801 | 288 | 500 | 220 | 38.5 | YN0yn0d11 | 11.3 | 9.1 | 23.0 | 470.0 | 86.6 | 78.3 | 0.11 | 292.7 | 1 | 1.4 | -8 | 8 | |
| TR-ROGHUN-1 | ROGHUN | 125 | 125 | 63 | 230 | 121 | 10.54 | YN0yn0d11 | 20.3 | 21.5 | 30.3 | 315.0 | 280.0 | 277.0 | 0.4 | 65 | 2 | 2 | -6 | 6 | |
| TR-ROGHUN-2 | ROGHUN | 125 | 125 | 63 | 230 | 121 | 10.54 | YN0yn0d11 | 20.3 | 21.5 | 30.3 | 315.0 | 280.0 | 277.0 | 0.4 | 65 | 2 | 2 | -6 | 6 | |
| TR-RUDAKI-1 | RUDAKI | 63 | 63 | 32 | 230 | 121 | 10.5 | YN0yn0d11 | 11.0 | 17.3 | 21.0 | 157.1 | 192.4 | 160.3 | 0.15 | 33.9 | 2 | 1.5 | -8 | 8 | |
| TR-RUDAKI-2 | RUDAKI | 63 | 63 | 32 | 230 | 121 | 10.5 | YN0yn0d11 | 11.0 | 17.3 | 21.0 | 157.1 | 192.4 | 160.3 | 0.15 | 33.9 | 2 | 1.5 | -8 | 8 | |
| TR-RUMI-1 | RUMI | 125 | 125 | 63 | 230 | 121 | 10.54 | YN0yn0d11 | 20.3 | 21.5 | 30.3 | 315.0 | 280.0 | 277.0 | 0.4 | 65 | 2 | 2 | -6 | 6 | |
| TR-SANGTUDA1-1 | SANGTUDA-1 | 501 | 501 | 180 | 500 | 230 | 36 | YN0yn0d11 | 12.5 | 15.7 | 28.8 | 285.7 | 97.4 | 99.9 | 0.09 | 61.6 | 1 | 1.25 | -8 | 8 | 2016 |
| TR-SANGTUDA1-2 | SANGTUDA-1 | 501 | 501 | 180 | 500 | 230 | 36 | YN0yn0d11 | 12.5 | 15.7 | 28.8 | 285.7 | 97.4 | 99.9 | 0.09 | 61.6 | 1 | 1.25 | -8 | 8 | 2016 |
| TR-SEBISTAN-1 | SEBISTAN | 25 | 25 | 25 | 230 | 38.5 | 6.6 | YN0yn0d11 | 12.7 | 10.1 | 6.3 | 130.0 | 135.0 | 105.0 | 0.9 | 50 | 1 | 1 | -12 | 12 | |
| TR-SHARSHAR-1 | SHARSHAR | 25 | 25 | 25 | 230 | 38.5 | 11 | YN0yn0d11 | 12.7 | 10.1 | 6.3 | 130.0 | 135.0 | 105.0 | 1 | 53 | 2 | 1 | -12 | 12 | |
| TR-SHARSHAR-2 | SHARSHAR | 25 | 25 | 25 | 230 | 38.5 | 11 | YN0yn0d11 | 12.7 | 10.1 | 6.3 | 130.0 | 135.0 | 105.0 | 1 | 53 | 2 | 1 | -12 | 12 | |
| TR-SUGHD-1 | SUGHD | 500 | 500 | 180 | 500 | 230 | 36 | YN0yn0d11 | 12.5 | 15.7 | 28.8 | 285.7 | 97.4 | 99.9 | 0.09 | 61.6 | 1 | 1.25 | -8 | 8 | |
| TR-SUGHD-2 | SUGHD | 500 | 500 | 180 | 500 | 230 | 36 | YN0yn0d11 | 12.5 | 15.7 | 28.8 | 285.7 | 97.4 | 99.9 | 0.09 | 61.6 | 1 | 1.25 | -8 | 8 | |
| TR-UZLOVAYA-1 | UZLOVAYA | 200 | 200 | 80 | 230 | 121 | 11 | YN0yn0d11 | 11.0 | 17.6 | 20.0 | 430.0 | 360.0 | 320.0 | 0.5 | 125 | 2 | 2 | -6 | 6 | |
| TR-UZLOVAYA-2 | UZLOVAYA | 90 | 90 | 47 | 230 | 121 | 11 | YN0yn0d11 | 11.0 | 17.5 | 17.4 | 322.0 | 286.0 | 254.0 | 1.2 | 122 | 1 | 2.5 | -2 | 2 | |
| TR-UZLOVAYA-3 | UZLOVAYA | 125 | 125 | 63 | 230 | 121 | 10.54 | YN0yn0d11 | 9.2 | 14.4 | 30.3 | 315.0 | 280.0 | 277.0 | 0.4 | 65 | 2 | 2 | -6 | 6 | |
| TR-YATEC-1 | YATEC | 40 | 40 | 40 | 230 | 38.5 | 10.5 | YN0yn0d11 | 12.4 | 22.7 | 9.8 | 202.3 | 202.3 | 173.9 | 0.56 | 58.5 | 2 | 1 | -12 | 12 | |
| TR-YAVAN-1 | YAVAN | 40 | 40 | 40 | 230 | 38.5 | 6.6 | YN0yn0d11 | 12.4 | 22.7 | 9.5 | 201.5 | 237.1 | 177.0 | 0.54 | 62.1 | 2 | 1 | -12 | 12 | |
| TR-YAVAN-2 | YAVAN | 40 | 40 | 40 | 230 | 38.5 | 6.6 | YN0yn0d11 | 12.4 | 22.7 | 9.5 | 201.5 | 237.1 | 177.0 | 0.54 | 62.1 | 2 | 1 | -12 | 12 | |

## 9.7 Shunts

| Name | Station | Bus | Vn | Type | Qmax | Num step max |
|---|---|---|---|---|---|---|
| | | | kV | | Mvar | |
| Cap-Dushanbe 35 | DUSHANBE | DUSHANBE-35 | 35 | C | 40 | 8 |
| Cap-Sughd35-1 | SUGHD | SUGHD-35 | 35 | C | 40 | 8 |
| Cap-Sughd35-2 | SUGHD | SUGHD-35 | 35 | C | 40 | 8 |
| Cap-Sughd35-3 | SUGHD | SUGHD-35 | 35 | C | 40 | 8 |
| Cap-Sughd35-4 | SUGHD | SUGHD-35 | 35 | C | 40 | 8 |
| Cap-Sughd35-5 | SUGHD | SUGHD-35/2 | 35 | C | 40 | 8 |
| Cap-Sughd35-6 | SUGHD | SUGHD-35/2 | 35 | C | 40 | 8 |
| Cap-Sughd35-7 | SUGHD | SUGHD-35/2 | 35 | C | 40 | 8 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Cap-Sughd35-8 | SUGHD | SUGHD-35/2 | 35 | C | 40 | 8 |
| Reactor-Dushanbe | DUSHANBE | DUSHANBE-500 | 550 | R-L | 120 | 1 |
| Reactor-Sughd | SUGHD | SUGHD-500 | 550 | R-L | 120 | 1 |

## 9.8 Generators

| Name | Station | Busbar | Vn | Pn | Sn | Pow.Fact. | xd | xq | xd" | Year |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | kV | MW | MVA | | p.u. | p.u. | p.u. | |
| Gen VAR-HPP1-1 | NOVAYA | VARZOB-HPP-1 | 6 | 4.75 | 5.28 | 0.9 | 2 | 2 | 0.225 | |
| Gen VAR-HPP1-2 | NOVAYA | VARZOB-HPP-1 | 6 | 4.75 | 5.28 | 0.9 | 2 | 2 | 0.225 | |
| Gen VAR-HPP2-1 | NOVAYA | VARZOB-HPP-2 | 6 | 7.20 | 8.00 | 0.9 | 2 | 2 | 0.225 | |
| Gen VAR-HPP2-2 | NOVAYA | VARZOB-HPP-2 | 6 | 7.20 | 8.00 | 0.9 | 2 | 2 | 0.225 | |
| Gen VAR-HPP3-1 | NOVAYA | VARZOB-HPP-3 | 6 | 1.76 | 1.96 | 0.9 | 2 | 2 | 0.225 | |
| Gen VAR-HPP3-2 | NOVAYA | VARZOB-HPP-3 | 6 | 1.76 | 1.96 | 0.9 | 2 | 2 | 0.225 | |
| Gen-Centralnaya-HPP1 | KOLKHOZABAD | CENTRALNAYA HPP | 6 | 7.55 | 8.39 | 0.9 | 2 | 2 | 0.225 | |
| Gen-Centralnaya-HPP2 | KOLKHOZABAD | CENTRALNAYA HPP | 6 | 7.55 | 8.39 | 0.9 | 2 | 2 | 0.225 | |
| Gen-Perepadnaya-HPP1 | GOLOVNAYA | PEREPADNAYA | 6 | 10.80 | 12.00 | 0.9 | 2 | 2 | 0.225 | |
| Gen-Perepadnaya-HPP2 | GOLOVNAYA | PEREPADNAYA | 6 | 10.80 | 12.00 | 0.9 | 2 | 2 | 0.225 | |
| Gen-Perepadnaya-HPP3 | GOLOVNAYA | PEREPADNAYA | 6 | 8.35 | 9.28 | 0.9 | 2 | 2 | 0.225 | |
| Gen-YHP-1 | YAVAN | YHP-1 | 10.5 | 60.00 | 66.67 | 0.9 | 2 | 2 | 0.225 | |
| Gen-YHP-2 | YAVAN | YHP-2 | 10.5 | 60.00 | 66.67 | 0.9 | 2 | 2 | 0.225 | |
| HPP-Rogun-1 | ROGUN HPP | Bus-Gen1 | 15.75 | 600.00 | 666.67 | 0.9 | 2 | 2 | 0.18 | 2016 |
| HPP-Rogun-2 | ROGUN HPP | Bus-Gen2 | 15.75 | 600.00 | 666.67 | 0.9 | 2 | 2 | 0.18 | 2016 |
| HPP-Rogun-3 | ROGUN HPP | Bus-Gen3 | 15.75 | 600.00 | 666.67 | 0.9 | 2 | 2 | 0.18 | 2025 |
| HPP-Rogun-4 | ROGUN HPP | Bus-Gen4 | 15.75 | 600.00 | 666.67 | 0.9 | 2 | 2 | 0.18 | 2025 |
| HPP-Rogun-5 | ROGUN HPP | Bus-Gen5 | 15.75 | 600.00 | 666.67 | 0.9 | 2 | 2 | 0.18 | 2025 |
| HPP-Rogun-6 | ROGUN HPP | Bus-Gen6 | 15.75 | 600.00 | 666.67 | 0.9 | 2 | 2 | 0.18 | 2025 |
| HPP11-SANGT1-1 | SANGTUDA-1 | Bus-HPP11-1 | 15.75 | 167.50 | 186.11 | 0.9 | 2 | 2 | 0.235 | |
| HPP11-SANGT1-2 | SANGTUDA-1 | Bus-HPP11-2 | 15.75 | 167.50 | 186.11 | 0.9 | 2 | 2 | 0.235 | |
| HPP11-SANGT1-3 | SANGTUDA-1 | Bus-HPP11-3 | 15.75 | 167.50 | 186.11 | 0.9 | 2 | 2 | 0.235 | |
| HPP11-SANGT1-4 | SANGTUDA-1 | Bus-HPP11-4 | 15.75 | 167.50 | 186.11 | 0.9 | 2 | 2 | 0.235 | |
| HPP12-SANGT2-1 | SANGTUDA-2 | Bus-HPP12-1 | 13.8 | 110.00 | 122.22 | 0.9 | 2 | 2 | 0.204 | 2013 |
| HPP12-SANGT2-2 | SANGTUDA-2 | Bus-HPP12-2 | 13.8 | 110.00 | 122.22 | 0.9 | 2 | 2 | 0.204 | 2013 |

| Name | Station | Busbar | Vn | Pn | Sn | Pow.Fact. | xd | xq | xd'' | Year |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | kV | MW | MVA | | p.u. | p.u. | p.u. | |
| HPP24-KAYR-1 | KAYROKUM | KAYROKUM-10 | 10.5 | 21.00 | 23.33 | 0.9 | 2 | 2 | 0.225 | |
| HPP24-KAYR-2 | KAYROKUM | KAYROKUM-10 | 10.5 | 21.00 | 23.33 | 0.9 | 2 | 2 | 0.225 | |
| HPP24-KAYR-3 | KAYROKUM | KAYROKUM-10 | 10.5 | 21.00 | 23.33 | 0.9 | 2 | 2 | 0.225 | |
| HPP24-KAYR-4 | KAYROKUM | KAYROKUM-10/b | 10.5 | 21.00 | 23.33 | 0.9 | 2 | 2 | 0.225 | |
| HPP24-KAYR-5 | KAYROKUM | KAYROKUM-10/b | 10.5 | 21.00 | 23.33 | 0.9 | 2 | 2 | 0.225 | |
| HPP24-KAYR-6 | KAYROKUM | KAYROKUM-10/b | 10.5 | 21.00 | 23.33 | 0.9 | 2 | 2 | 0.225 | |
| HPP5-GOLOV-1 | GOLOVNAYA | GOLOVNAYA-10 | 10.5 | 35.00 | 38.89 | 0.9 | 2 | 2 | 0.2 | |
| HPP5-GOLOV-2 | GOLOVNAYA | GOLOVNAYA-10/2 | 10.5 | 35.00 | 38.89 | 0.9 | 2 | 2 | 0.2 | |
| HPP5-GOLOV-3 | GOLOVNAYA | GOLOVNAYA-10 | 10.5 | 35.00 | 38.89 | 0.9 | 2 | 2 | 0.2 | |
| HPP5-GOLOV-4 | GOLOVNAYA | GOLOVNAYA-10/2 | 10.5 | 45.00 | 50.00 | 0.9 | 2 | 2 | 0.2 | |
| HPP5-GOLOV-5 | GOLOVNAYA | Bus-HPP5-3 | 10.5 | 45.00 | 50.00 | 0.9 | 2 | 2 | 0.2 | |
| HPP5-GOLOV-6 | GOLOVNAYA | Bus-HPP5-3 | 10.5 | 45.00 | 50.00 | 0.9 | 2 | 2 | 0.2 | |
| HPP7-NUREK-1 | NUREKSKAYA | Bus-HPP7-1 | 15.75 | 333.33 | 370.37 | 0.9 | 2 | 2 | 0.237 | |
| HPP7-NUREK-2 | NUREKSKAYA | Bus-HPP7-2 | 15.75 | 333.33 | 370.37 | 0.9 | 2 | 2 | 0.237 | |
| HPP7-NUREK-3 | NUREKSKAYA | Bus-HPP7-3 | 15.75 | 333.33 | 370.37 | 0.9 | 2 | 2 | 0.237 | |
| HPP7-NUREK-4 | NUREKSKAYA | Bus-HPP7-4 | 15.75 | 333.33 | 370.37 | 0.9 | 2 | 2 | 0.237 | |
| HPP7-NUREK-5 | NUREKSKAYA | Bus-HPP7-5 | 15.75 | 333.33 | 370.37 | 0.9 | 2 | 2 | 0.237 | |
| HPP7-NUREK-6 | NUREKSKAYA | Bus-HPP7-6 | 15.75 | 333.33 | 370.37 | 0.9 | 2 | 2 | 0.237 | |
| HPP7-NUREK-7 | NUREKSKAYA | Bus-HPP7-7 | 15.75 | 333.33 | 370.37 | 0.9 | 2 | 2 | 0.237 | |
| HPP7-NUREK-8 | NUREKSKAYA | Bus-HPP7-8 | 15.75 | 333.33 | 370.37 | 0.9 | 2 | 2 | 0.237 | |
| HPP7-NUREK-9 | NUREKSKAYA | Bus-HPP7-9 | 15.75 | 333.33 | 370.37 | 0.9 | 2 | 2 | 0.237 | |
| HPP8-BAYPAZA-1 | BAYPAZA | Bus-HPP8-1 | 15.75 | 150.00 | 166.67 | 0.9 | 2 | 2 | 0.235 | |
| HPP8-BAYPAZA-2 | BAYPAZA | Bus-HPP8-2 | 15.75 | 150.00 | 166.67 | 0.9 | 2 | 2 | 0.235 | |
| HPP8-BAYPAZA-3 | BAYPAZA | Bus-HPP8-3 | 15.75 | 150.00 | 166.67 | 0.9 | 2 | 2 | 0.235 | |
| HPP8-BAYPAZA-4 | BAYPAZA | Bus-HPP8-4 | 15.75 | 150.00 | 166.67 | 0.9 | 2 | 2 | 0.235 | |
| TPP-DUSHANBE-2 | DUSHANBE | TPP-DUSH | 10 | 100.00 | 111.11 | 0.9 | 2 | 2 | 0.18 | 2013 |
| TPP4-DUSHANBE-1 | DUSHANBE | TPP4 | 6 | 35.00 | 38.89 | 0.9 | 2 | 2 | 0.143 | |
| TPP5-DUSHANBE-2 | DUSHANBE | TPP5 | 6 | 35.00 | 38.89 | 0.9 | 2 | 2 | 0.143 | |
| TPP6-DUSHANBE-3 | DUSHANBE | TPP6 | 10 | 42.00 | 46.67 | 0.9 | 2 | 2 | 0.2 | |
| TPP7-DUSHANBE-4 | DUSHANBE | TPP7 | 10 | 86.00 | 101.18 | 0.85 | 2 | 2 | 0.18 | |