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Source: https://www.azernews.az/media/pictures/renewable_energy.jpg

# Analysis of the energy efficiency of 110/6kV distribution network in an oil producing enterprise in Kazakhstan

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# AGENDA

- Energy sector of Kazakhstan;
- Required standards for the power quality;
- Motivation;
- Description of the object;
- Topology of the object;
- Methodology of the analysis;
- Results.

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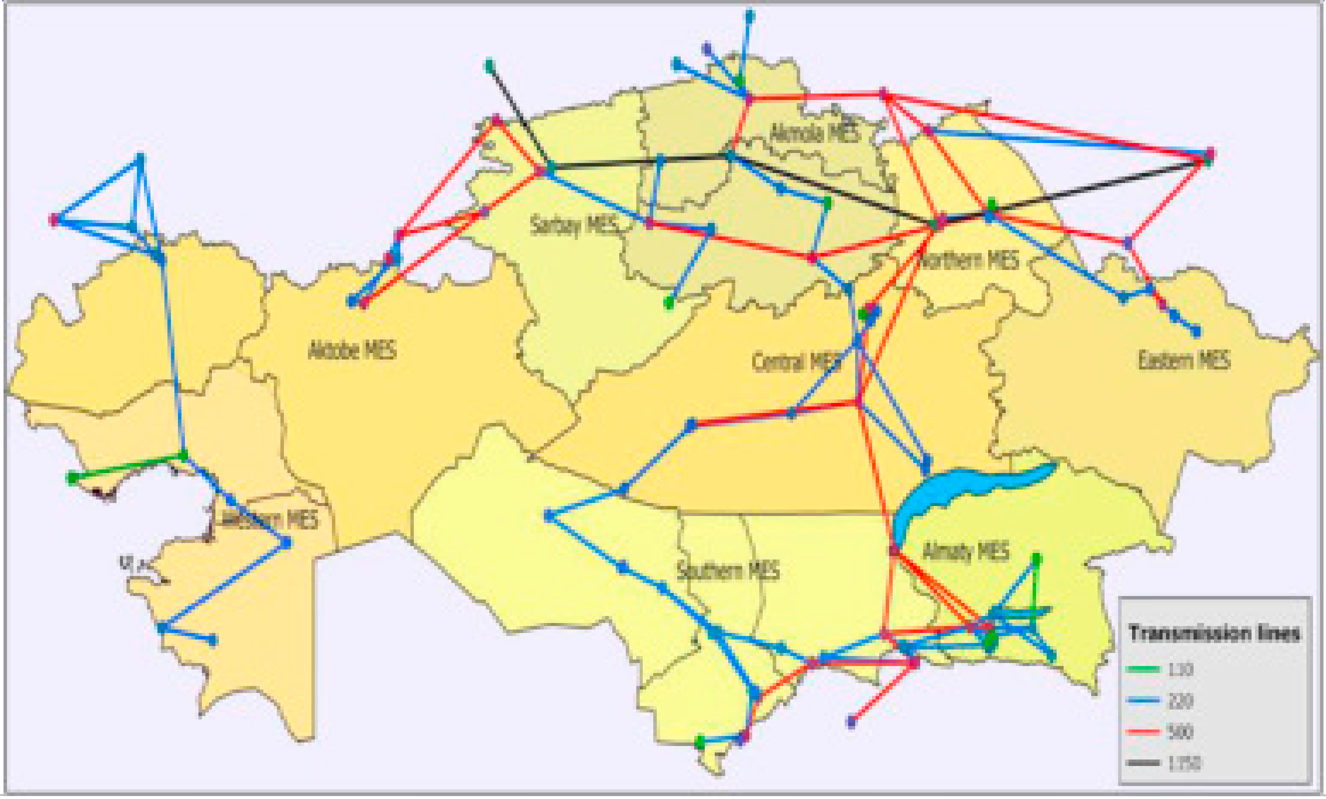
# ENERGY SECTOR OF KAZAKHSTAN

| Kazakhstan | |
|---|---|
| Area | 2.724.900 km$^2$ |
| Population | about 18 Million |
| Population density | 6,6 inhabitants per km$^2$ |

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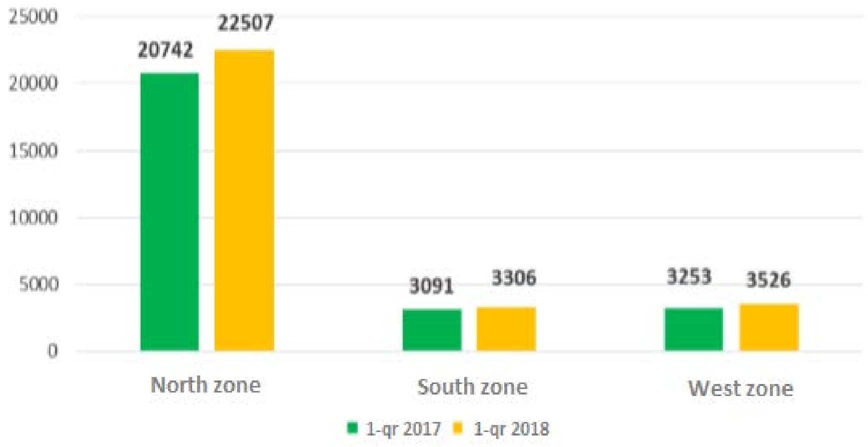
# ENERGY SECTOR OF KAZAKHSTAN

## Balance of generation and consumption of electricity in Kazakhstan



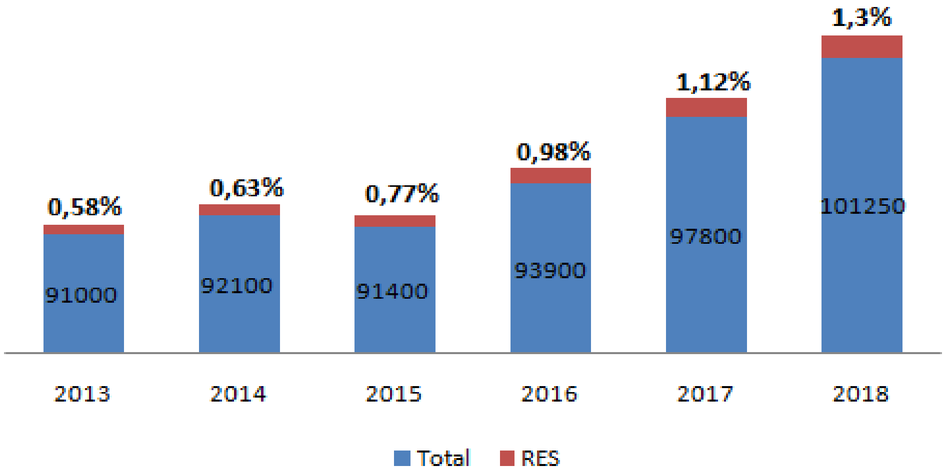


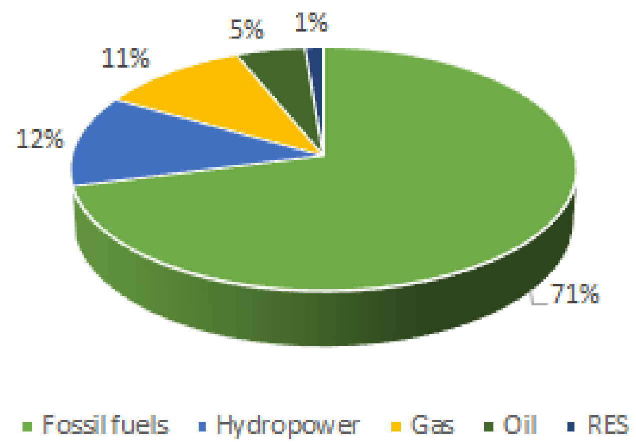
| | 1st qr. 2017 (mil.kWh) | 1st qr. 2018 (mil.kWh) | Difference | |
|---|---|---|---|---|
| | | | in mil.kWh | in % |
| Generation | 27 085,5 | 29 339,2 | 2 253,7 | 7,7 |
| Consumption | 26 259,7 | 27 763,3 | 1 503,6 | 5,4 |
| Electricity flow | -825,8 | -1 575,9 | -750,1 | 48 |
| Russia | -824,8 | -1 575,3 | -750,5 | |
| Central Asia | -1,0 | -0,6 | -0,4 | |

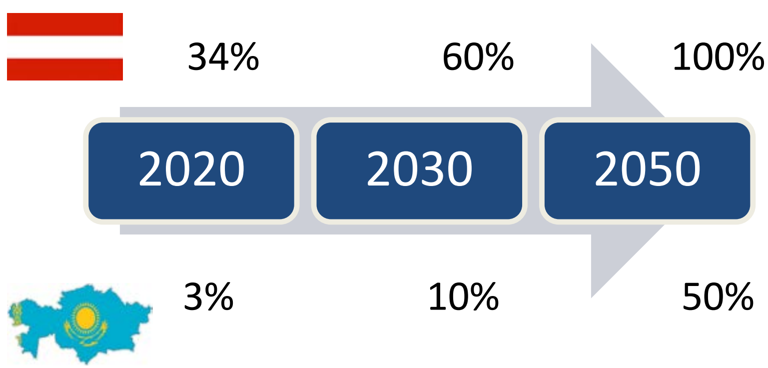
http://www.kea.kz/texts/sovet/2018_3.pdf

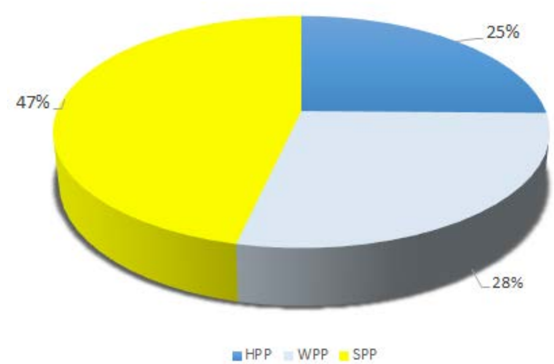
# ENERGY SECTOR OF KAZAKHSTAN

**The share of renewable energy in total electricity production (million kWh)**




http://energo.gov.kz

# REQUIRED STANDARDS FOR POWER QUALITY

***The main indicators of the quality of electrical energy according to GOST 13109-97***

| № | Electricity property | Power quality indicator | Standardized values of quality indicators |
|---|---|---|---|
| 1 | Voltage deviation | Steady voltage deviation δUy | ± 5% normal acceptable value<br>± 10% maximum permissible value |
| 2 | Voltage fluctuations | The magnitude of the voltage change δUt | Determined by<br>$\delta U_t = \frac{\lvert U_i - U_{i+1} \rvert}{U_{HOM}} \cdot 100$ |
| | | Dose of Flicker | Determined by<br>$P_t = \frac{1}{T_{ocp}} \int \sum g_i^2 \int \delta U_i^2 dt$ |
| 3 | Non-sinusoidal voltage | The distortion coefficient of the sinusoidal voltage curve $K_U$ | Determined by<br>$K_U = \frac{\sqrt{\sum_{n=2}^{N} U_{(n)}^2}}{U_{HOM}} \cdot 100\%$ |
| | | Coefficient of the n^th harmonic component of the voltage, $K_U$ (n). | Determined by<br>$K_{U(n)} = \frac{U_{(n)}}{U_{HOM}} \cdot 100\%$ |
| 4 | The asymmetry of the three-phase voltage system | Voltage unbalance factor by reverse sequence $K_{2U}$ | 2% - normally acceptable value;<br>4% - maximum permissible value |
| | | Voltage unbalance factor on zero sequence $K_{0U}$ | 2% - normally acceptable value;<br>4% - maximum permissible value |
| 5 | Frequency deviation | Frequency deviation Δf | ± 0.2 Hz - normally acceptable value;<br>± 0.4 Hz - maximum permissible value |
| 6 | Voltage failure | The duration of the voltage dip Δtp | Not standardized |
| 7 | Voltage impulse | Impulse voltage, U[illegible] | Not standardized |
| 8 | Short-term overvoltage | Time overvoltage coefficient, KovvU | Not standardized |

| Power factor | ≥ 0,89 for 110-220 kV |
|---|---|
| | ≥ 0,92 for 6-35 kV |
| | ≥ 0,93 for 0,4 kV |

***Order of the Minister for Investment and Development of the Republic of Kazakhstan dated 03.31.2015***

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# MOTIVATION

- Power quality ($\Delta U$, $\Delta W$, $\cos\phi$)

-Reactive power management

(no reqirements)

- Improving economical and ecological

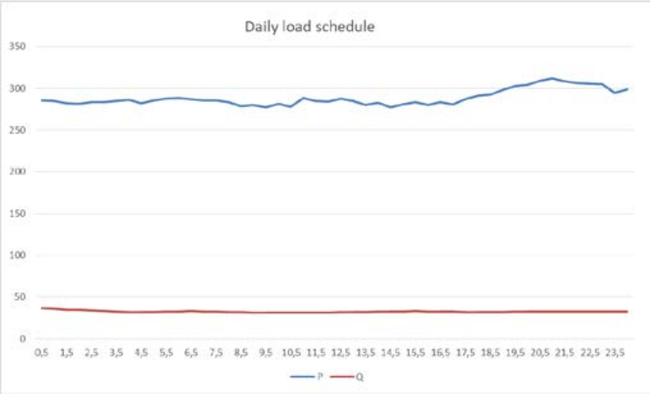
aspects

# DESCRIPTION OF THE OBJECT

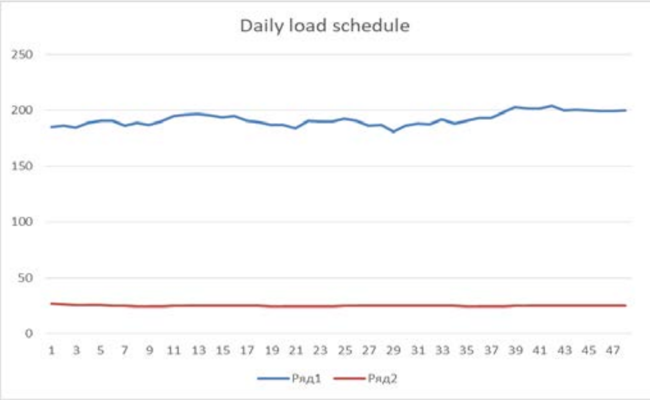
The enterprise has its **own** gas-turbine **power plant** with a capacity of **160 MW**, which supplies its facilities with electricity, and transfers part of the generated energy to the regional grid company.

There are 5 main substations (SS 110/6kV), which consist of 26 transformers and more than 100 package transformer substation (PTS 6/0,4kV).

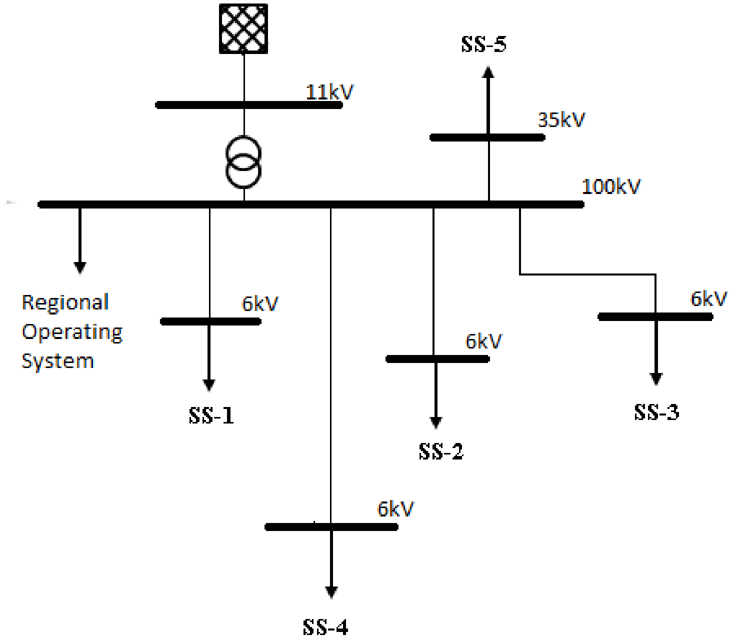
Electricity consumption **in Winter**




Electricity consumption **in Summer**



# TOPOLOGY OF THE OBJECT




| Name of the objects | Number of feeders | Number of PTS | Total power of PTS, кVA |
|---|---|---|---|
| 0.4 kV voltage measurements | | | |
| SS-1 | 7 | 35 | 3 826 |
| SS-2 | 5 | 28 | 993 |
| SS-3 | 5 | 31 | 1 617 |
| SS-4 | 2 | 15 | 549 |
| **Total** | **19** | **109** | **6 985** |

# METHODOLOGY OF THE ANALYSIS

A
- Initial network mode

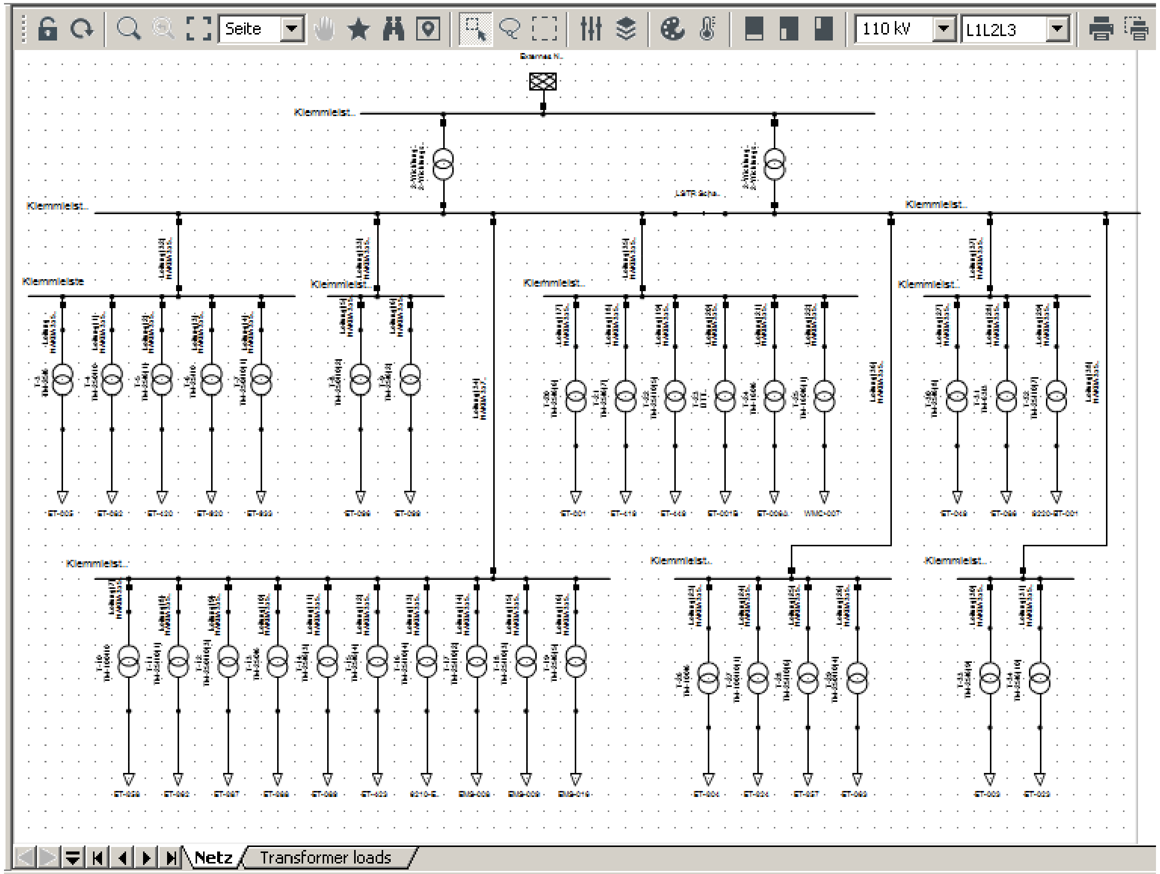
B
- Network operation mode when disconnecting an underloaded transformer

# METHODOLOGY OF THE ANALYSIS

The analysis was carried out using the software Power factory DigSilent.

Through this program, a 6/0,4kV distribution network was modeled. The following factors were taken into account in the simulation:

- Power supply source;
- Passport data of transformers and cables;
- Daily schedules of loads of the electric power consumers.



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# RESULTS

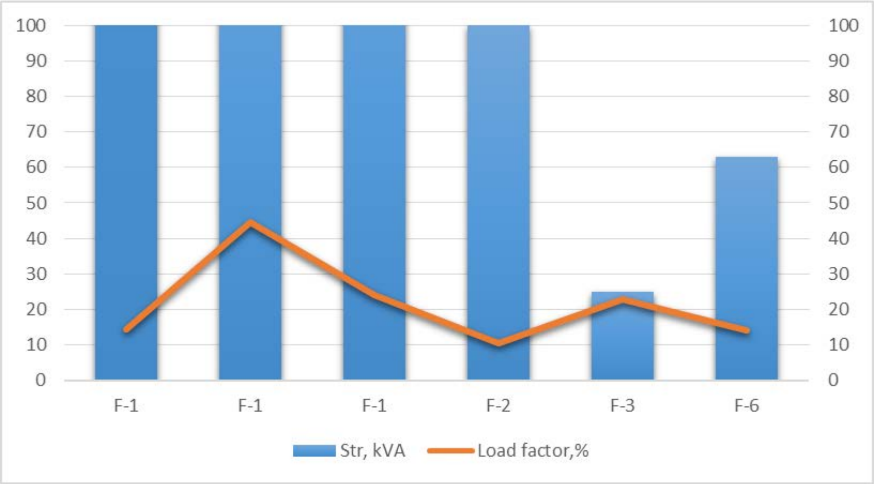
Due to the fact that in Kazakhstan there is no manual for energy-efficient analysis of electrical equipment, this analysis was conducted on the basis of a reference document on the best available methods for improving energy efficiency in the European Union.

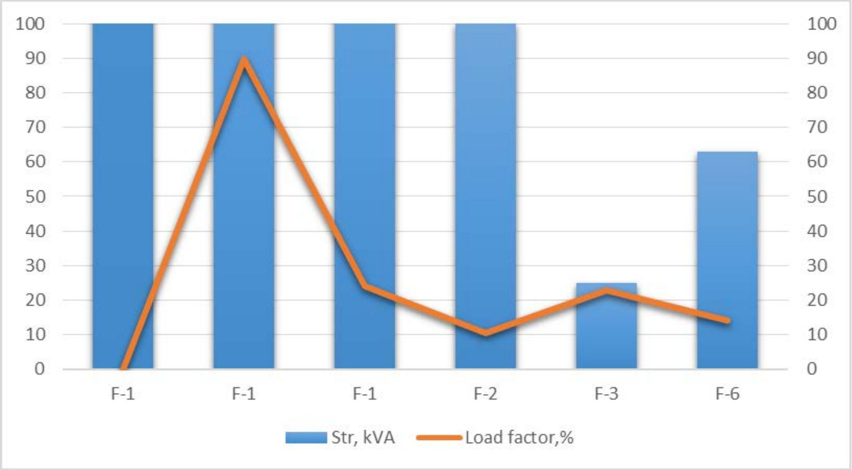
According to the results of the analysis carried out on option A, many underused transformers were identified. It would seem that under-utilization for transformers is a positive effect, which leads to an increase in the service life of equipment, however, as shown by field tests of the European Union, under-utilization of electrical equipment is negative in terms of energy efficiency. In this case, the European Union proposes to hold a series of events to improve the energy efficiency. One of them is considered in option B.

Reference document on best available techniques for Energy Efficiency, European commission, February 2009

| № | Feeder | Name of the PTS | Str, kVA | Pinst, kV | Pcons, kV | Load factor,% |
|---|---|---|---|---|---|---|
| SS-1 | | | | | | |
| 1 | F-1 | 1E-9200-ET-001A | 630 | 500 | 72,4 | 11,49206349 |
| 2 | F-1 | 1E-9200-ET-006A | 160 | 120 | 71,4 | 44,625 |
| 3 | F-1 | WMC-9210-ET-007 | 160 | 75 | 38,2 | 23,875 |
| 4 | F-2 | 10-9200-ET-004 | 100 | 101,9 | 10,3 | 10,3 |
| 5 | F-3 | 10-9200-ET-062 | 25 | 21,4 | 5,7 | 22,8 |
| 6 | F-6 | 10-9220-ET-001 | 63 | 12,5 | 8,9 | 14,12698413 |
| SS-2 | | | | | | |
| 7 | F-3 | 10-9200-ET-011 | 100 | 62,7 | 15,4 | 15,4 |
| 8 | F-4 | 20-9400-ET-002 | 25 | 5 | 1,8 | 7,2 |
| 9 | F-5 | 10-9200-ET-037 | 100 | 72 | 3,93 | 3,93 |
| 10 | F-11 | 30-9400-ET-002 | 25 | 6 | 4,37 | 17,48 |
| 11 | F-11 | 20-9400-ET-05 | 25 | 5 | 1,02 | 4,08 |
| SS-3 | | | | | | |
| 12 | F-2 | 10-9200-ET-012 | 100 | 36,1 | 14,88 | 14,88 |
| 13 | F-2 | 30-9400-ET-010 | 25 | 6 | 2,06 | 8,24 |
| 14 | F-3 | 10-9200-ET-006 | 100 | 86,7 | 36,81 | 36,81 |
| 15 | F-3 | 10-9200-ET-015 | 25 | 21,4 | 6,05 | 24,2 |
| 16 | F-3 | 10-9200-ET-034 | 25 | 14,7 | 3,28 | 13,12 |
| 17 | F-3 | 30-9400-ET-009 | 25 | 6 | 4,12 | 16,48 |
| 18 | F-8 | 30-9400-ET-004 | 25 | 6 | 2,14 | 8,56 |
| 19 | F-16 | 10-9200-ET-041 | 100 | 79,7 | 6,71 | 6,71 |
| 20 | F-18 | 10-9200-ET-007 | 100 | 78,7 | 23,5 | 23,5 |
| 21 | F-18 | 20-9400-ET-001 | 25 | 5 | 4,35 | 17,4 |
| SS-4 | | | | | | |
| 22 | F-20 | 10-9200-ET-042 | 100 | 120 | 24,2 | 24,2 |
| 23 | F-20 | 10-9200-ET-095 | 100 | 16,8 | 7,75 | 7,75 |
| 24 | F-20 | EMS-9200-ET-017 | 25 | 7,4 | 1,26 | 5,04 |
| 25 | F-21 | 10-9200-ET-031 | 25 | 35,2 | 10,8 | 43,2 |
| 26 | F-21 | 10-9200-ET-039 | 25 | 14,7 | 4,46 | 17,84 |
| 27 | F-21 | 10-9200-ET-048 | 25 | 15,9 | 7,1 | 28,4 |
| 28 | F-21 | EMS-9200-ET-006 | 10 | 7,4 | 0,34 | 3,4 |
| 29 | F-21 | 30-9400-ET-006 | 25 | 6 | 2,12 | 8,48 |

# RESULTS


100
90
80
70
60
50
40
30
20
10
0
F-1
F-1
F-1
F-2
F-3
F-6
Str, kVA
Load factor,%


100
90
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30
20
10
0
F-1
F-1
F-1
F-2
F-3
F-6
Str, kVA
Load factor,%

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# THANK YOU FOR ATTENTION!

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