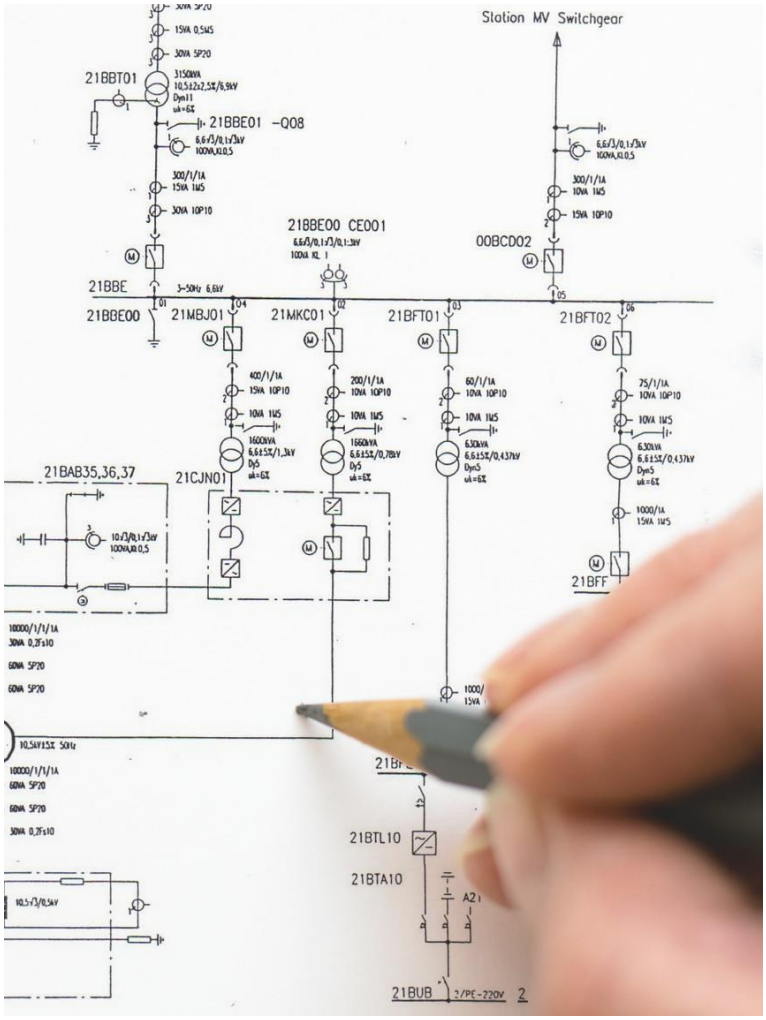
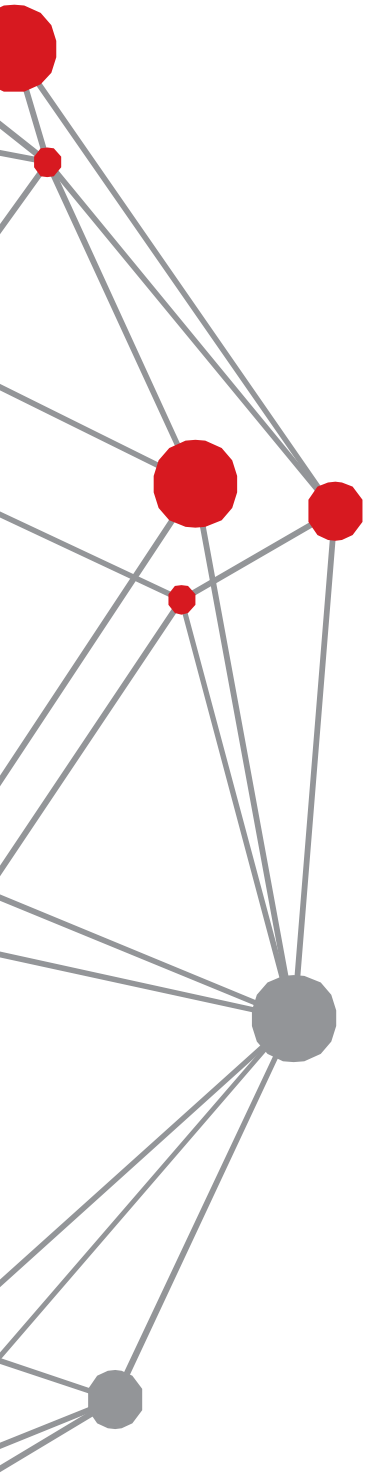
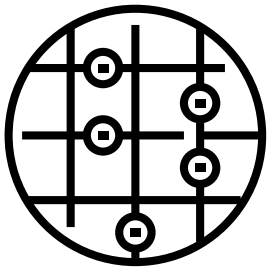


NetVision EMS (Energy management system)



Computational network model



The network model is created according to the CIM (Common Information Model) standard. The computational model of the network is formed on the basis of the parameters of the objects in the network model, network topology and network metrics coverage. Depending on the network metrics coverage, one or more observable networks are formed and the estimates are activated for the largest one

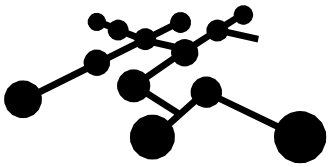
- estimation
- flows
- N-1 analysis
- short circuit

in real-time (on-line) or off-line mode on either the last or the archived network state.

The estimation result tracking interface displays a computational model with edges, nodes, and objects that are included in the estimation. All parameters of the network model can be seen on the interface. The model data can be saved in the excel file, which further facilitates the analysis.

Estimations fall within the real-time extended domain, popularly known as RTX, meaning that they are performed in the minute scope, and based on the collected remote metering and signals gained by the SCADA system.

Topological analysis



Topological analysis requires and groups the connection of network objects (lines and network transformers) to find subnets and generates a computational model from the largest network.

The results of the analysis can be monitored by coloring the subnetworks on the interface.

Static and working topology

Static topological connectivity is defined through:

- substation topology (connection of objects within a substation)
- grid topology (connection of substations to lines and transformers).

The topology of each substation is defined by a special graph. Grid topology is defined by a network-level graph.

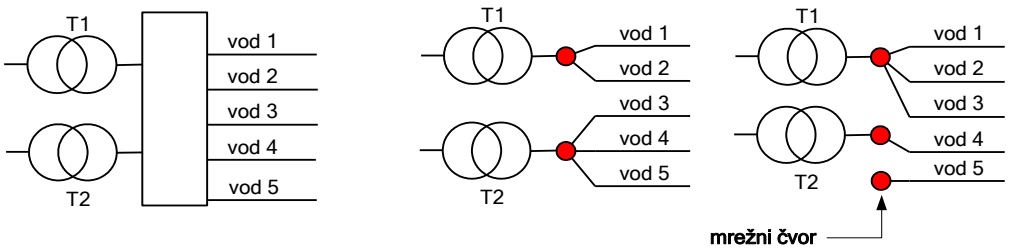
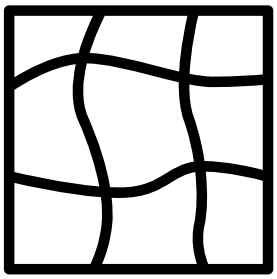


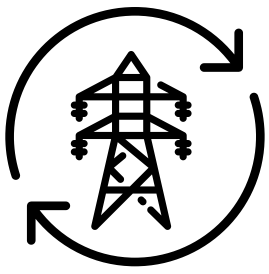
Figure 3. Nodes of the network - two situations

The substation working topology depends on the switching state of switches and disconnectors in a substation and affects network working topology - the number of nodes in the network changes depending on the substation working topology. The substation and grid working topology is determined in real time spontaneously on each change in the switching state of the substation subdivision.



State estimation

The task of estimating the state is to take the metrics of the real system and calculated topology, and determine the **vector state** (node voltages by amount and angle). Given that the collected data "hides" in itself the errors generated in the measurement process, the task of the state estimation program is to find all these "wrong" measurements. Insufficient reliability of information from the real system is overcome by redundancy and by the excess of measurement in relation to the number of unknowns. This enables the estimation program to eliminate the wrong measurements and replace them with estimated values.



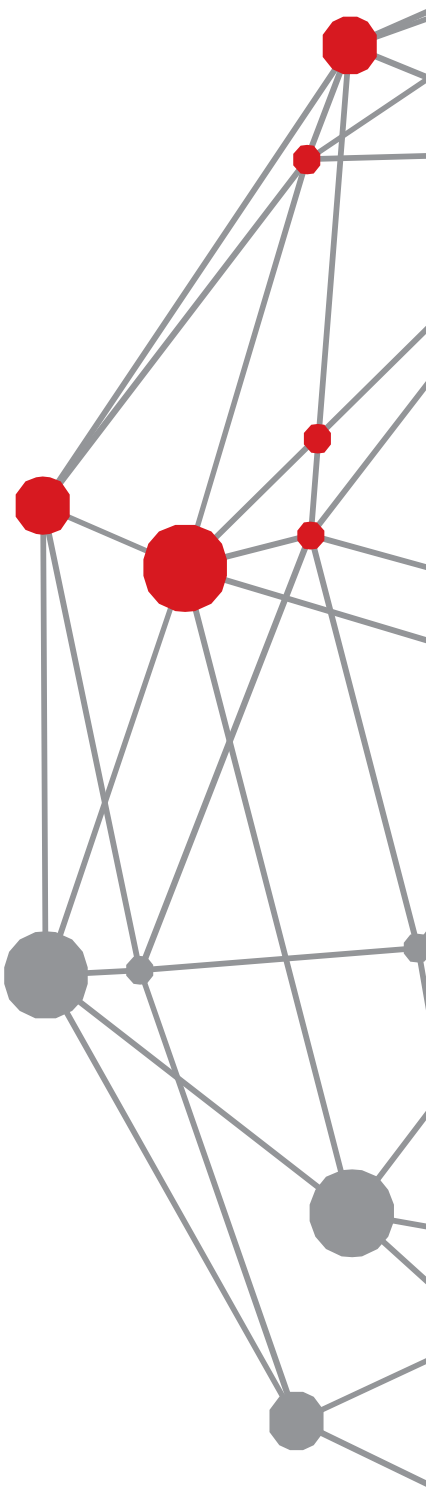
Flows

The Power Flow Estimation Program is the underlying program for driving, analyzing and planning the electrical power system operation. The input data of the program is the **vector state** that is prepared by the state estimation program (either online, or in the off-line mode).

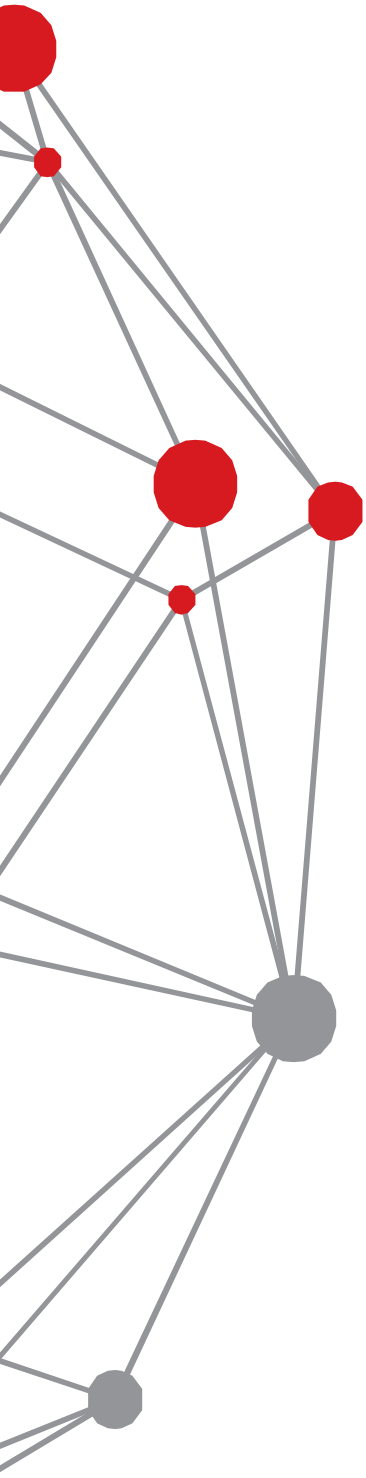
Execution of the Extended Real-Time Estimation (on-line) serves as a preparatory program for security analysis (N-1). With calculations on archived data, the graphical interface can be used to change switching states, production and consumption, types of nodes in the EE grid, several times during the analysis. In this way, it is possible to analyze and predict the critical situations in the EES facility.

After the calculation, the notification list displays:

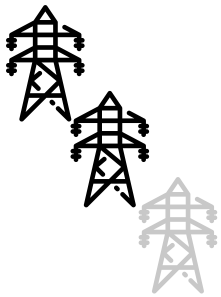
- power lines and transformers that are overloaded



- bus voltages that are out of bounds
- regulating power plants if production is outside of the permitted limits.



N-1 analysis

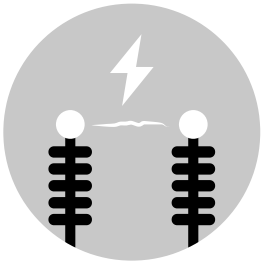


The N-1 (contingency analysis) program simulates the exclusion of transmission objects (power lines and transformers) and production generators, enabling prediction of critical switching and operating states of the EES. The estimation can be run on real-time data (on-line security analysis) or archived data (off-line). Transmission objects and production generators whose exclusion is analyzed may be arbitrarily determined:

- according to the load threshold
- according to a pre-defined list.

From the results of the conducted security analysis reports are made about potential overload of power lines and transformers, voltage limitations on nodes, and possible separation of the grid into two parts (shown in the alarm list). All this information is a help to drive dispatchers as well as planners in determining planned switching and operating conditions.

Short circuit



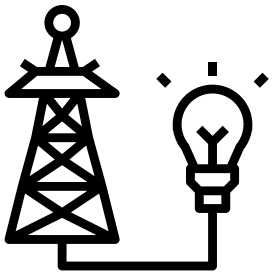
The short-circuit current calculation program is used to check circuit breaker disconnection capability. Namely, when changing the switching and drive status of the transmission grid, the short-circuit current sizes are also changed, and the short-circuit calculation and the drive management process need to be performed.

In order to complete the short circuit calculation, besides direct system impedance data, it is also necessary to have data on the impedances of the inverse and zero system in order to carry out a three-pole short circuit and calculate a one-pole short circuit.

Extended Real Time Short Circuit Calculation uses true switching status of networks and voltages on nodes.

This analysis makes an alarm if some of the switches do not have enough power off. When analyzing archived data, it is also possible to check the short circuit current according to the IEC regulations, i.e. for a fully closed grid with a voltage increased by 10%.

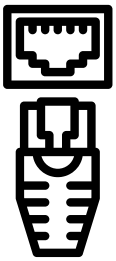
The short-circuit analysis results form a list of overloaded switch gear (i.e. whole bays) and busbars.



Losses

Calculation of Losses is performed after the calculation of Estimation and Power Flows. The output result of the estimate is the vector state of the grid (voltages by amount and angles). Losses are determined by node voltages and the amount of network elements admittances.

Losses are calculated for all objects in the computing model and sums are determined according to the "owner".



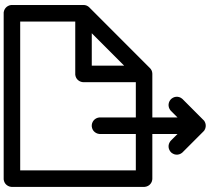
Online / offline mode

Online and offline clients can use the same or a different network model.

The online client displays the last received process data and refreshes views in real time.

The calculation startup service creates a computational model and invokes estimates, N-1 analysis, flows, three-pole and single-pole short circuit, loss calculation in set intervals of time.

Offline analysis is triggered on the saved state image, i.e., a set of process data stored at some point.



Export network model

The status and model of the network can be exported in standard formats (UCTE CGMES) or in the format of the customized PSS package for network calculations.