POWERFACTORY

Indicative Capacity Analysis

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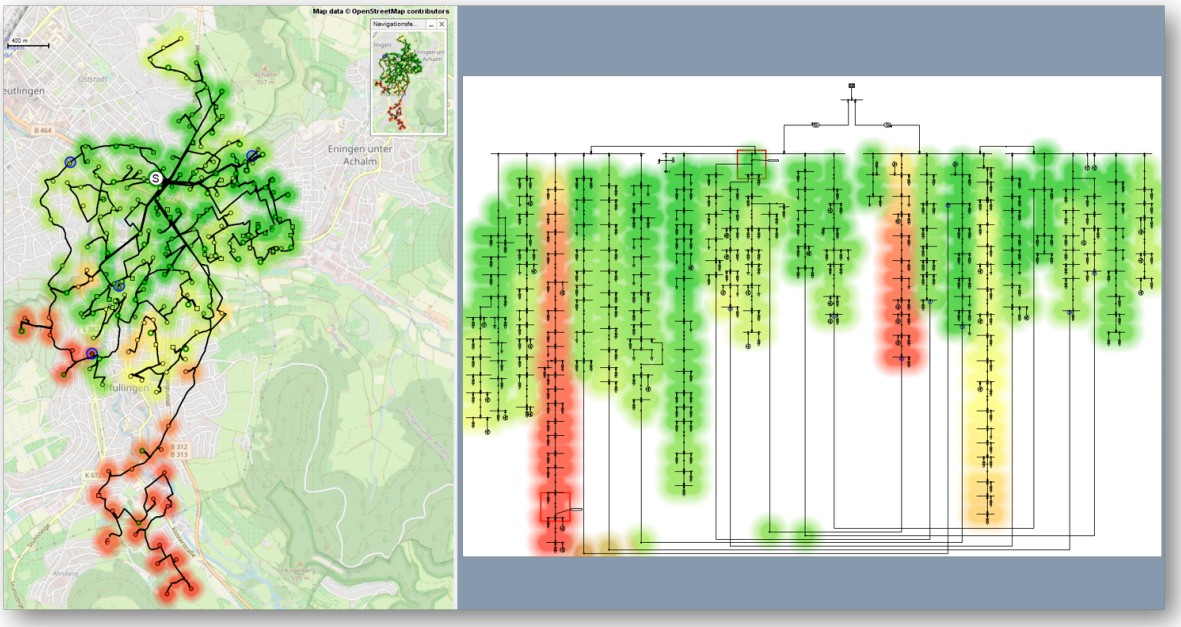
Automated Calculation of Hosting Capacity of Distribution Networks for Distributed Energy Resources and Additional Loads

Distribution System Operators are faced with an increasing number of connection requests for distributed energy resources such as **PV systems** or **wind turbines** and loads such as **charging points** for electric vehicles or **heat pumps**. Power flow is not only directed from central power plants to the consumers but can also flow from producers in low voltage grids towards higher voltage levels. In addition, private wallboxes have a higher connection power than that of a regular consumer connection.

DSOs need to know the **capacity of their grid** to rapidly answer **connection requests** and to plan the grid expansion accordingly. Planning engineers need an efficient automated process that yields results with minimal manual intervention. By means of the **ICA - Indicative Capacity Analysis**, *DIgSILENT* offers a solution to determine the capacity of distribution networks based on the well proven algorithms of *PowerFactory*. This white paper describes the capabilities and the architecture of tge solution.

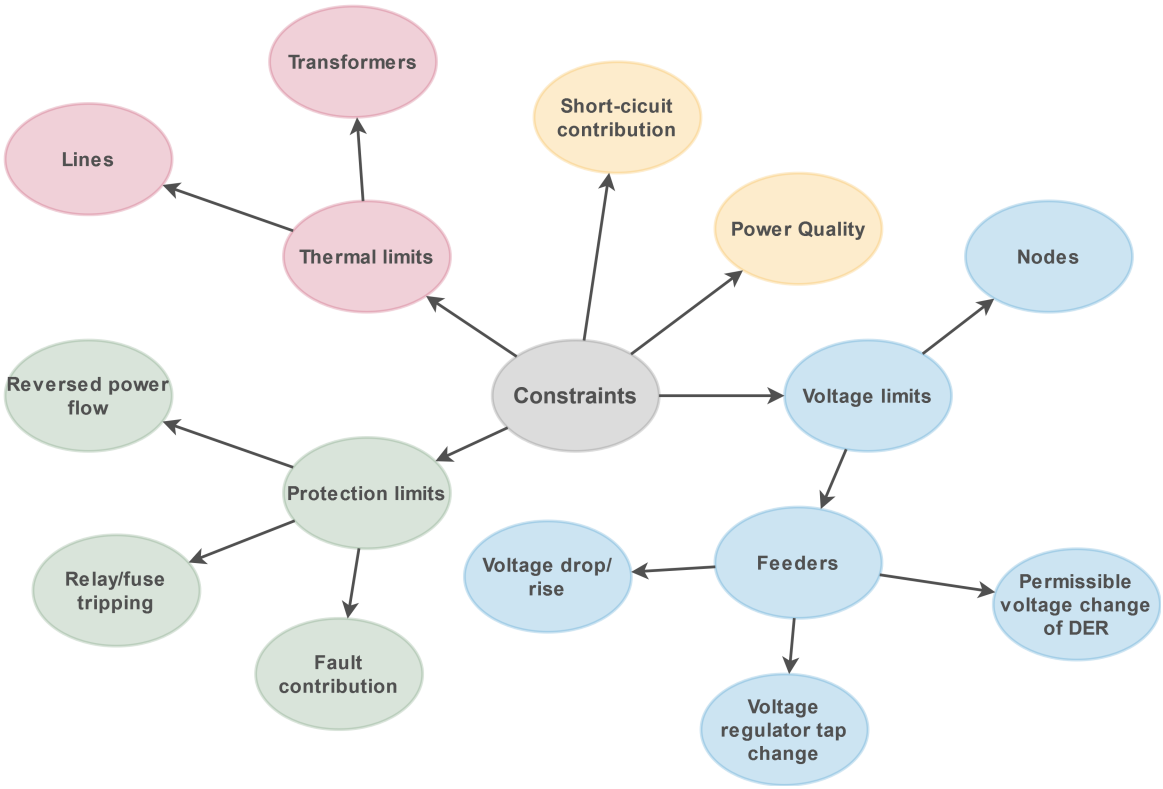


POWER SYSTEM SOLUTIONS
MADE IN GERMANY

1 Analysis of Hosting Capacity

Hosting Capacity is the capability of a grid, without any network expansion, to absorb **additional generation or load**. The capacity is provided for each node of the network model individually. With this calculation it is possible to retrieve the possible generation power of a PV plant at a certain node without lines being overloaded or voltage limits exceeded. By means of this information a connection request can be approved or rejected directly.

The basis of the solution is the standard function **Hosting Capacity Analysis** available in the *PowerFactory* module **Distribution Network Tools**. This function, which can be used for all voltage levels, provides fast evaluation of a network, combining load flow, protection and harmonic analysis. The ICA solution automates Hosting Capacity Analysis, so as to provide results with minimal intervention from the user, and enable multiple scenarios to be evaluated. Examples might include evaluation of **different switch states** or **seasonal conditions**.



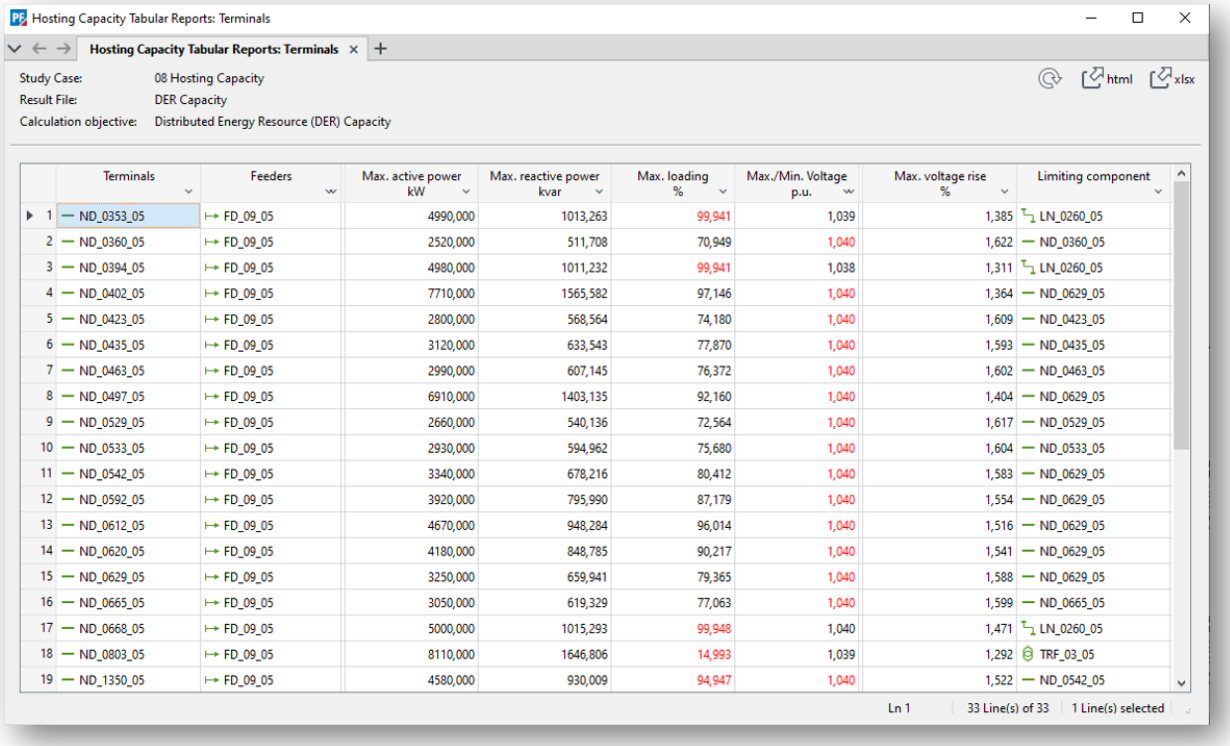
Supported constraints for the calculation of hosting capacity

Key Facts

- ✓ It is possible to select the constraints to be used and to define the values for the limits. Limits can be set globally or individually for each network element.
- ✓ For the validity range of the constraints the complete network, a specific network region such as a feeder or a custom set of elements can be used.
- ✓ The calculation is possible for both balanced or unbalanced networks. A standard load flow can be used, or the LV load flow, which takes into account the stochastic behaviour of loads.

- ✓ The capacity is provided with active and reactive power values. The reactive power depends on the power factor to be considered for the calculation.
- ✓ The calculation can be parallelised in order to reduce the execution time.

The results of the calculation are the maximum active and reactive power of additional generation or load is provided for nodes. In addition, the limiting component (node, line, transformer,...) is reported, as well as the violated constraint and other electrical quantities.



	Terminals	Feeders	Max. active power kW	Max. reactive power kvar	Max. loading %	Max./Min. Voltage p.u.	Max. voltage rise %	Limiting component
1	ND_0353_05	FD_09_05	4990,000	1013,263	99,941	1,039	1,385	LN_0260_05
2	ND_0360_05	FD_09_05	2520,000	511,708	70,949	1,040	1,622	ND_0360_05
3	ND_0394_05	FD_09_05	4980,000	1011,232	99,941	1,038	1,311	LN_0260_05
4	ND_0402_05	FD_09_05	7710,000	1565,582	97,146	1,040	1,364	ND_0629_05
5	ND_0423_05	FD_09_05	2800,000	568,564	74,180	1,040	1,609	ND_0423_05
6	ND_0435_05	FD_09_05	3120,000	633,543	77,870	1,040	1,593	ND_0435_05
7	ND_0463_05	FD_09_05	2990,000	607,145	76,372	1,040	1,602	ND_0463_05
8	ND_0497_05	FD_09_05	6910,000	1403,135	92,160	1,040	1,404	ND_0629_05
9	ND_0529_05	FD_09_05	2660,000	540,136	72,564	1,040	1,617	ND_0529_05
10	ND_0533_05	FD_09_05	2930,000	594,962	75,680	1,040	1,604	ND_0533_05
11	ND_0542_05	FD_09_05	3340,000	678,216	80,412	1,040	1,583	ND_0629_05
12	ND_0592_05	FD_09_05	3920,000	795,990	87,179	1,040	1,554	ND_0629_05
13	ND_0612_05	FD_09_05	4670,000	948,284	96,014	1,040	1,516	ND_0629_05
14	ND_0620_05	FD_09_05	4180,000	848,785	90,217	1,040	1,541	ND_0629_05
15	ND_0629_05	FD_09_05	3250,000	659,941	79,365	1,040	1,588	ND_0629_05
16	ND_0665_05	FD_09_05	3050,000	619,329	77,063	1,040	1,599	ND_0665_05
17	ND_0668_05	FD_09_05	5000,000	1015,293	99,948	1,040	1,471	LN_0260_05
18	ND_0803_05	FD_09_05	8110,000	1646,806	14,993	1,039	1,292	TRF_03_05
19	ND_1350_05	FD_09_05	4580,000	930,009	94,947	1,040	1,522	ND_0542_05

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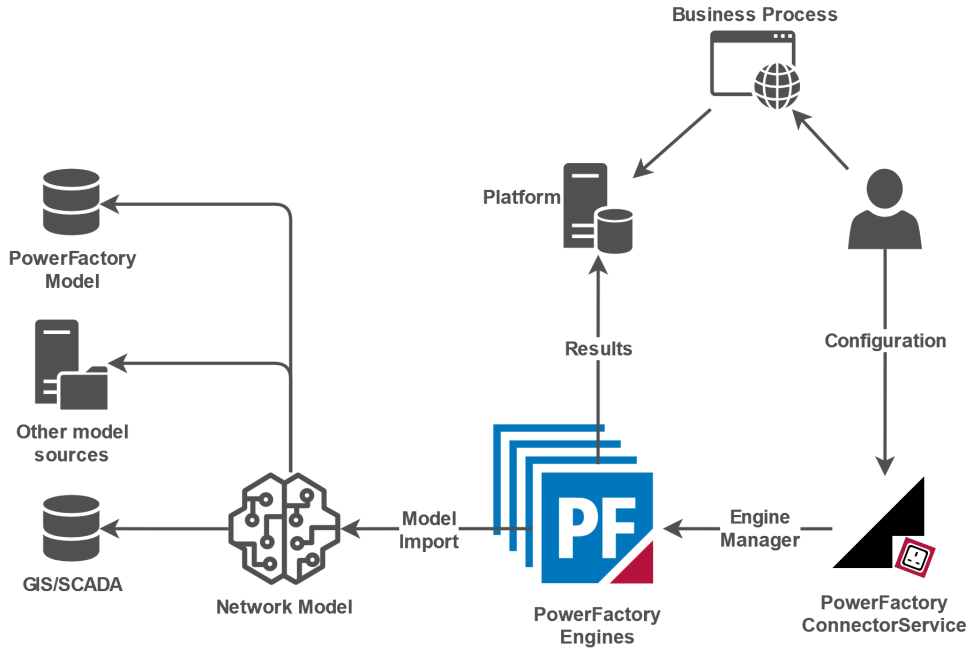
Capacity report

2 Solution Architecture

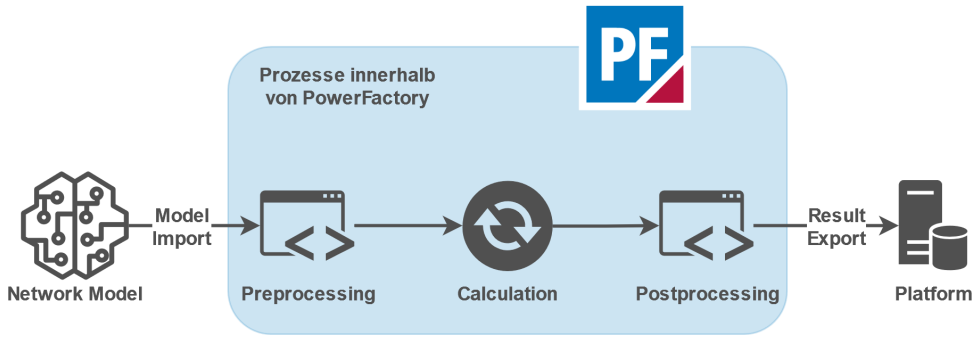
The ICA solution consists of *PowerFactory* engines running the calculations on servers without a graphical user interface. The number of engines depends on the size of network models and the frequency of the calculations. The calculations can be carried out on a regular basis or whenever the network model changes. The engines are controlled by the Connector Service. This is Windows service offered by *DIgSILENT*, to schedule and monitor tasks. The service uses the powerful API of *PowerFactory* to provide access between all elements, functions and external tools.

In this solution *PowerFactory* provides the calculation functions. The solution, itself can be part of a business process of the utility using the results to deal with connection requests or to regularly verify the capabilities of the grid. Alternatively, the results can be provided directly in a web browser by the *Connector Service*.

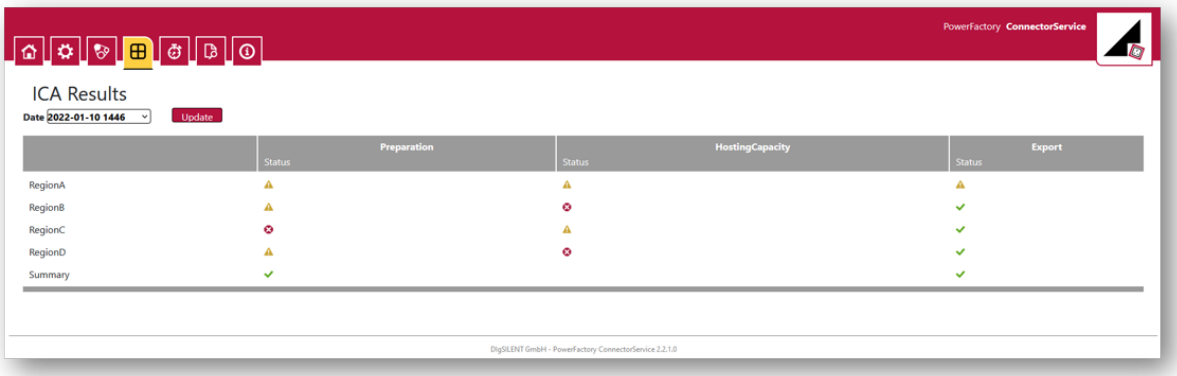


Overview of a possible system architecture

The process within the solution consists of three steps: *pre-processing* → *calculation* → *post-processing*. All steps allow individual configurations or extensions to meet customer requirements with minimal effort. As part of the post-processing, calculation results are provided for further business processes and integration into other systems. The network models and initial states can be versioned to rerun the automated calculations upon user request, for verification or regulation purposes.



Processes within *PowerFactory*



Engine monitoring with the Connector Service

Pre-processing: In the first part of the process, the network data is loaded into *PowerFactory*. Depending on the data quality and to fulfill the requirements of the solution, a validation based on rules may be necessary. For example the definition of feeders, the assignment of type specific limits or the import of scenario data are possible tasks.

Calculation: In this step, the hosting capacity analysis comes into play. The calculation is typically done based on feeders and the normal switching state. If necessary, further calculations can be executed to consider different switching or load scenarios.
In addition, other *PowerFactory* calculations available in *PowerFactory* can be carried out at this stage, to add more value. This can be a short-circuit calculation in example.

Post-processing: Finally the results are prepared for reporting or export to other systems and ongoing processes. This can include aggregation or determining the minimal capacity of a node from various calculated scenarios. Results can be exported into a database or file.

3 Data Provisioning

For the calculation, the network topology and associated scenario data are required. The network model can be provided in different ways:

- Interface to SCADA or GIS using CGMES or *PowerFactory*'s DGS format
- Models from an existing *PowerFactory* database
- Import from other power system analysis tools

Additional scenario data can be imported in the pre-processing step.

4 Executive Summary

By means of the **Indicative Capacity Analysis**, *DIgSILENT* offers utilities an ingenious and scalable solution to automatically and periodically determine the network capacity for additional load and generation. The solution provides a comprehensive overview of grid capacity and helps utilities to manage their assets.

5 Licence Configuration

For the implementation of the use case described, the licence modules shown in the box are required. If more calculation functions should be considered in the automated network analysis, further modules can be required.

- ✓ Scripting & Automation
- ✓ Distribution Network Tools
- ✓ Connector Service

For more information, visit
www.digsilent.de

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