

HVDC and SUPERGRIDS Brochure

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HVDC and SUPERGRIDS | Sales Brochure

Expertise on HVDC: studies, modelling and simulation, training, and R&D

Tractebel Engineering is a global engineering consultancy company with more than 100 years of expertise in energy and infrastructure projects. Its Power System Consulting department is one of the leading groups in power system analysis, and has built up considerable experience in HVDC and Supergrids through its participation as consultant in various international projects, covering energy system planning & economics, power system operation & control, and smart systems.

Tractebel Engineering builds on the know-how acquired through the continued development of its power system computation platforms, *EUROSTAG*® and *SMART FLOW*, to offer consulting services on HVDC and Supergrids. Our power system computation platforms boast an extensive and fully customizable HVDC library, consisting of numerous models for Current Source Converter (CSC) and Voltage Source Converter (VSC) HVDC systems. Thanks to advanced algorithms, the software is capable of solving very large AC/DC networks, with high speed and accuracy.

Our experts are available to train your staff on all aspects of HVDC and Supergrids, going from converter theory, to hands-on experience on the EGIDE-based HVDC simulator. We also participate in groundbreaking R&D projects in the field of HVDC.

Tractebel Engineering can be a key partner in your HVDC project

CONSULTING SERVICES

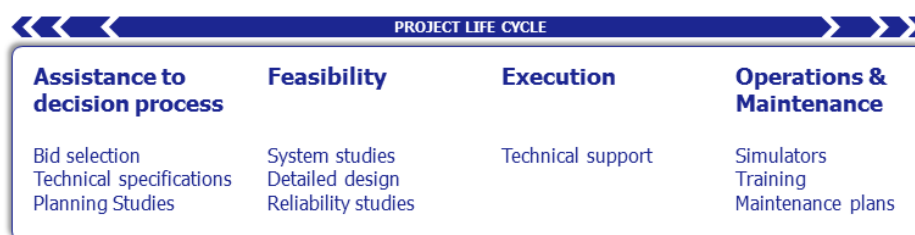
Tractebel Engineering's Power System Consulting department provides consulting services worldwide on various aspects of electric power systems. One of the department's areas of expertise is HVDC. Tractebel Engineering is active in the field of HVDC for more than 10 years, and has built up considerable experience in the field.

1. A Wide Range of Consulting Services

Due to its expertise and experience in the field, Tractebel Engineering can provide a wide range of consulting services in HVDC, ranging from **energy system planning & economics**, over **power system operation & control**, to **smart systems**.

2. A Proven Track Record in HVDC Studies

Tractebel Engineering has more than 25 international references in HVDC. We have covered the whole life cycle of HVDC systems, from the decision process through to operations & maintenance.



Energy System Planning & Economics

- **MEDGRID:** Technical feasibility and economic viability analysis of future trans-Mediterranean interconnections.
- **Eleclink:** Feasibility study of a HVDC link in the Channel Tunnel (50 km). Budget estimation and technical specifications for tender documents for the 400kV stations and underground cables in the countries, HVDC stations at Eurotunnel switchyards, and HVDC cables in the tunnel (supply & installation).
- ...

Power System Operation & Control

- **Saudi Arabia HVDC interconnector:** Technical specifications, protection architecture, and technical support for a new 800 km, 3000 MW HVDC system between Riyadh and Jeddah.
- **Baltic Ring:** Modelling of the Baltic Ring multi-terminal HVDC system with NIPT (Saint Petersburg HVDC research centre).
- ...

MODELLING AND SIMULATION

HVDC models for *EUROSTAG*® and *SMART FLOW*

EUROSTAG® is a software package developed by Tractebel Engineering GDF SUEZ and RTE for accurate and reliable simulations of power systems dynamics.

EUROSTAG® is used worldwide for studies, research, design and operational optimization by Transmission System Operators and Generation Companies, but also by consulting companies.

The advanced dynamic functions of *EUROSTAG*® allow for the full range of transient, mid and long-term stability to be covered thanks to a robust algorithm using an auto-adaptative integration stepsize.

All HVDC models are fully compatible with the *EUROSTAG*® add-ons, such as Dynamic Security Assessment (*SYSCAN*), Dynamic Response Optimization (*STAG-O!*), and the Small Signal Analysis package (*HERCULES*).

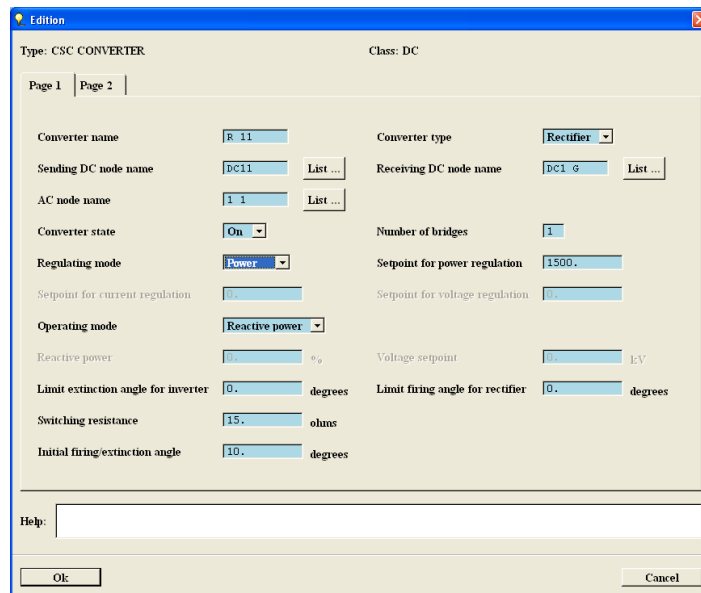


The *SMART FLOW* software package is a complete power system calculation tool. It benefits from the renowned dynamic functions of *EUROSTAG*®, but also embeds a large set of static functions, from basic power flow computation to very advanced Optimal Power Flow.

1. Static Modelling and Simulation

Power flow and related calculations

The static modelling capabilities of *SMART FLOW* include DC zones, DC nodes, DC lines, and CSC and VSC HVDC converters. The models are very flexible and detailed. Numerous control modes can be selected; operating limits and converter losses are taken into account. The models allow simulating HVDC Supergrids with complex topologies, comprised of multiple converters, lines of different polarity, series and parallel connection of converters, ...



Reliable and robust calculation methods

The power flow calculation method used in *EUROSTAG*® and *SMART FLOW*, is based on a powerful Newton-Raphson method. DC state variables are treated in the same way as AC variables. The whole combined AC-DC system is solved at once, without separate AC and DC iterations, to assure a reliable and robust power flow computation.

The optimal power flow tool, IPSO, utilizes the KNITRO solver, developed by Ziena Optimization, Inc. in its optimization core. The AC and the DC network can be simultaneously optimized.

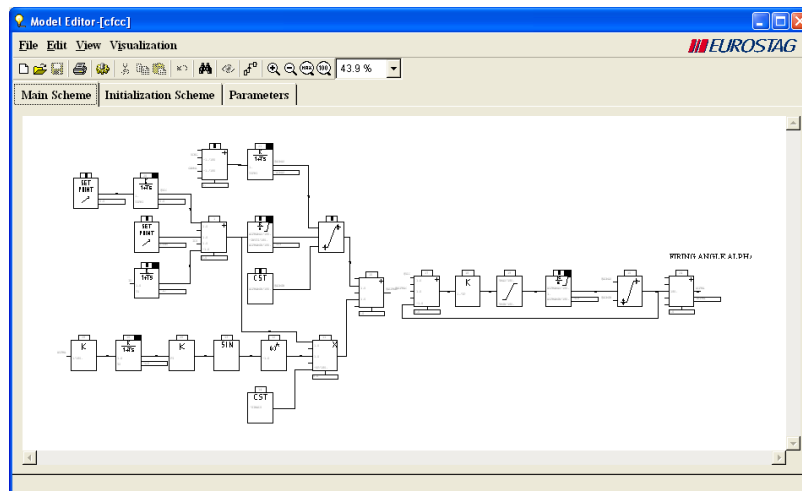
2. Dynamic Modelling and Simulation

Our HVDC modelling philosophy: flexibility, modularity, accuracy

Flexible and simple

The *EUROSTAG*® Model Editor enables the user to graphically and interactively create his own models, avoiding heavy coding and debug procedures to design user defined controllers, protection schemes,... This modeling framework offers flexibility, security and simplicity.

EUROSTAG® offers a vast library of HVDC models and controllers. These can be used directly or modified. All library models are completely visible to the user; they can be changed to the smallest details, to fit your modelling needs.



Modular

The converter and regulator models can be combined in several ways. Highly complex multi-terminal systems, mono- and bipolar, parallel and series connection of converters can be modelled.

EUROSTAG®'s CSC HVDC model library consists of a large number of controllers such as

- Current controller;
- Extinction angle controller;
- Voltage dependent current order limiter;
- Master controller.
- ...

For the CSC, and for the VSC models:

- Current controller
- Active power controllers
- DC voltage controllers
- ...

State-of-the-art models and high Accuracy

Thanks to a unique and robust algorithm using an **auto-adaptive integration stepsize**, you do not have to think about the time step value, you just have to specify the required accuracy. Thanks to the powerful algorithm, implemented in EUROSTAG®, fast phenomena are simulated according to user defined accuracy. Thanks to this efficient algorithm, the HVDC converters and controllers can be represented in great detail, while still achieving great simulation speed and accuracy.

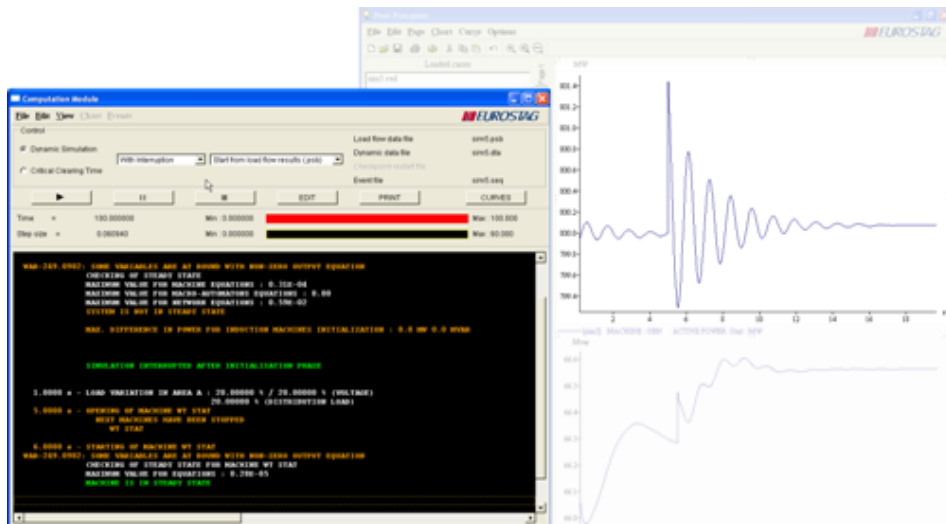
The CSC dynamic converter models and their associated control systems are an implementation of the CIGRE standard model presented in "A Digital Model of an HVDC System for System Planning Studies", prepared by CIGRE TF 38-05-05. The models allow faithful simulations with EUROSTAG® of combined AC/DC systems.

The EUROSTAG® VSC HVDC models are based on the latest research in HVDC modelling. They boast an impressive list of features, such as:

- DC voltage droop control;

- Transient detector;
- Voltage control;
- Power factor control;
- Passive grid operation;
- Converter blocking;
- And more.

We recognize that the advanced features of the models are not needed in all studies. Therefore, the *EUROSTAG*® HVDC library also contains a set of simplified models for both CSC and VSC systems. The simplified models provide enhanced robustness against severe disturbances, reduce considerably the number of state variables, and have higher time constants. This allows larger time steps, making the calculations even faster.



TRAINING

The Tractebel Engineering HVDC and Supergrids Training is ideally suited for HVDC installation engineers or operators, for future HVDC project managers, Transmission System Operators, or other energy professionals wanting to acquire competencies in HVDC or deepen their knowledge of HVDC systems and Supergrids.

The training consists of theoretical and practical elements.

1. Acquire a Deep Understanding of HVDC Technology and Operating Principles

We start with reviewing the HVDC fundamentals. We cover HVDC components, comparison with AC systems, application of HVDC systems, converter theory, HVDC control systems, extension to multi-terminal systems and Supergrids. The trainees will learn to:

- Identify the advantages and drawbacks of HVDC systems with respect to AC transmission systems;
- Identify the main applications of HVDC;
- Analyse in detail the operation of HVDC converters, both CSCs (Current Source Converter) and VSCs (Voltage Source Converter);
- Analyse in detail the control schemes of HVDC systems;
- ...

2. HVDC and Supergrid Modelling and Simulation

After this training you will understand the principles and details of HVDC system modelling in power flow calculations and time-domain simulation. This part of the training addresses not only two-terminal systems, but also multi-terminal configurations and Supergrids.

Power flow models

- Principles of HVDC power flow modelling: unified and sequential methods;
- Detailed CSC HVDC modelling using the unified method;
- Detailed VSC HVDC modelling using the sequential method;

Dynamic HVDC models for time-domain simulation

- Explanation of the dynamic CIGRE model for CSC HVDC systems;
- Software implementation of the CIGRE model;
- Dynamic VSC HVDC modelling.

The power system analysis software *EUROSTAG*® is used to model and simulate a sample HVDC system. No prior knowledge of *EUROSTAG*® is required.

3. Hands-on Experience with the EGIDE-Based HVDC Simulator

EGIDE – Educational Graphical Interface DEvelopment software is a dedicated, dynamic teaching tool based on the simulation of power system performance. Designed by experts to train non-experts and newcomers to the electrotechnical field who need to acquire practical, yet high-level knowledge of power systems, EGIDE makes the theory of power system analysis easier to understand through interactive exercises and clear, animated graphics.

Two HVDC exercises have been included in EGIDE, extending its use to an HVDC simulator.

The first exercise is a two-terminal CSC HVDC system. A detailed CSC HVDC system model is used, including current controllers, voltage dependent current order limiter, tap changer controllers,... The HVDC simulator allows grasping the following concepts in an interactive way:

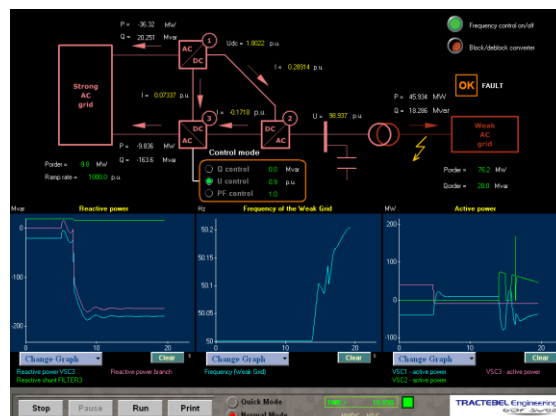
- Basic principles: ignition, extinction, and overlap angles;
- Power and voltage control;
- Tap changer controller;
- Voltage dependent current order limiter;
- Inverter short-circuits;
- Reactive power management;
- And more...



The second exercise is a three-terminal VSC HVDC Supergrid. A detailed model is used including current controllers, converter blocking, frequency control, power factor control,...

The VSC HVDC simulator allows mastering diverse concepts such as:

- Basic principles of active power and DC voltage control;
- Reactive power, voltage and power factor control;
- Frequency control;
- Short-circuits;
- Converter blocking;
- Multi-terminal operation
- And more...



4. References

Tractebel Engineering has provided numerous trainings on HVDC.

- TE was in charge of the EDF-Clamart staff training on HVDC modelling with EUROSTAG of the three-terminal SACOI (Sardinia-Corsica-Italy) interconnection.
- HVDC course for the partners of the European FP7 project ICOEUR
- ...

The training can be customized to your needs and can be organized at your premises or at Tractebel Engineering offices in Brussels.

R&D

Tractebel Engineering's Power System Consulting department has contributed to FP7 European research projects, where its expertise in HVDC was successfully leveraged:

- in the **ICOEUR** project, an HVDC interconnection between the European and Russian power systems was studied;
- in the **PEGASE** project, HVDC models and simulation tools were developed capable of simulating the whole Pan-European electricity system.

Our experts participate in international working groups, and conferences, and have published extensively on HVDC in peer-reviewed, international journals.



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