Simulation, analysis and planning of energy networks

In the future, thousands of kilometers of new grids will be built in Germany to make greater use of electricity from renewable energies. These new "intelligent networks" (smart grids) increase complexity, costs, and vulnerability. Fraunhofer SCAI has developed a software tool to analyze and optimize transport networks for gas, electricity, water, and heat and integrate these energy sectors using numerical simulations as early as the planning stage. This makes conversion and expansion more flexible for network operators, saves energy and expenses, and increases the security of the energy supply.

Efficient transport networks are essential. One example: studies show that around three percent of the total electrical energy consumed is used for water supply – primarily for pumps. Optimized control has great economic potential: even small percentage savings significantly contribute to the environment and help save costs.

Improved network planning, optimized use of stored energy and cost savings

Another example is the massive expansion and restructuring of the power grids in Germany that is needed to cope with the switch to renewable energies. The software is also interesting regarding smart grids, the expansion of which is being promoted by the German government. After all,

the intelligent networking and control of power generators, storage facilities, consumers, and grid resources are major economic and environmental challenges. Local solutions can also make essential contributions: improved timing and savings, especially for energy-intensive companies, can reduce peak consumption and match electricity and gas consumption with supply.

Flexible planning of energy networks

The simulation software MYNTS (Multiphysical Network Simulator), which Fraunhofer SCAI developed, helps operate and plan complex networks. The program models the networks as a system of algebraic differential equations so users can flexibly analyze and better draft them by numerical simulation. Above all, the simulation immediately shows the effects of changes in various factors. For example, MYNTS can be used to calculate how temperature fluctuations change flow rates and how the failure of subnetworks affects the remaining network components.

MYNTS takes advantage of the fact that simulations of transportation networks for gas, electricity, heat, and water are always based on the same numerical core. Nevertheless, each application field has its particularities. The software is therefore available in dedicated versions for different areas of application.

Combinations are also possible, for example, for investigations of power-to-gas scenarios. When simulating gas networks, users can use MYNTS to create and control subnetworks, for example, compressor stations or mixing chambers. Fraunhofer SCAI continuously develops MYNTS in close cooperation with industrial users (e.g., Open Grid Europe). Combined with the software tools "net'O'graph" and MYNTS-T, which were also developed by SCAI, graph analysis and comparison tasks, statistical analyses, and parametric optimization tasks can be handled.

New developments in MYNTS:

- transient gas model
- extension to liquid phases (e.g., for CO_2-transport)
- templates (programmable assemblies) for reusable subnetworks
- more flexible modeling
- sector coupling (gas-electricity-heat)
- network viewer (Open Street Map)
- hydrogen share up to 100 percent (modeling according to GERG-2008)
- free MYNTS reader for viewing and searching energy grids and scenarios
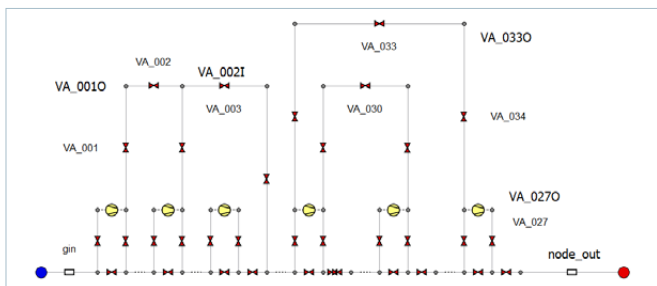
Subnet example: A compressor station with six compressors
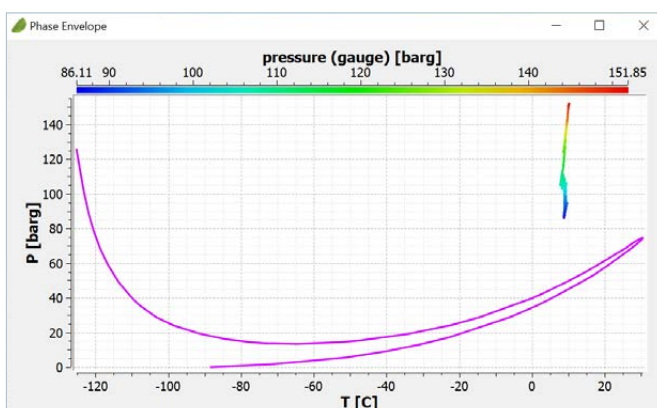
Phase diagram of CO_2 during transition in the liquid phase

Software: MYNTS

- **Tasks:** Simulation, analysis, optimization, and planning of transport networks for gas, electricity, heat, and water
- **Special features:** programmable subnetworks and elements, open modeling, steady-state, and time-dependent calculations; efficient numerical kernels, suitable for multi-processor computers; visualization
- **Versions:**
  - MYNTS-Gas: Windows, Linux
  - MYNTS-CO_2 (gas and liquid phase)
  - MYNTS-Water: for research purposes
  - MYNTS-Heat: for research purposes
  - MYNTS-Electricity: for research purposes
  - MYNTS-Sector coupling: under development

Software: MYNTS-T

- **Tasks:** Formulating transport network problems using a linguistic approach to translate between two domain-specific languages (DSL)
- **Special features:** a rapid algorithm to translate between two DSL, allowing elementwise separation, to be massively parallelized
- **Available for** Windows, Linux

More information: **www.scai.fraunhofer.de/mynts-t**

Software: net'O'graph

- **Tasks:** Network and graph analysis, matching, layout
- **Special features:** extensive C++ library for analysis and optimization, drivers for various formats, efficient routines even for large networks
- **Available for** Windows, other operating systems on request

More information: **www.scai.fraunhofer.de/netograph**

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