FEFLOW

Modelling geothermal energy for feasibility, planning and operation projects

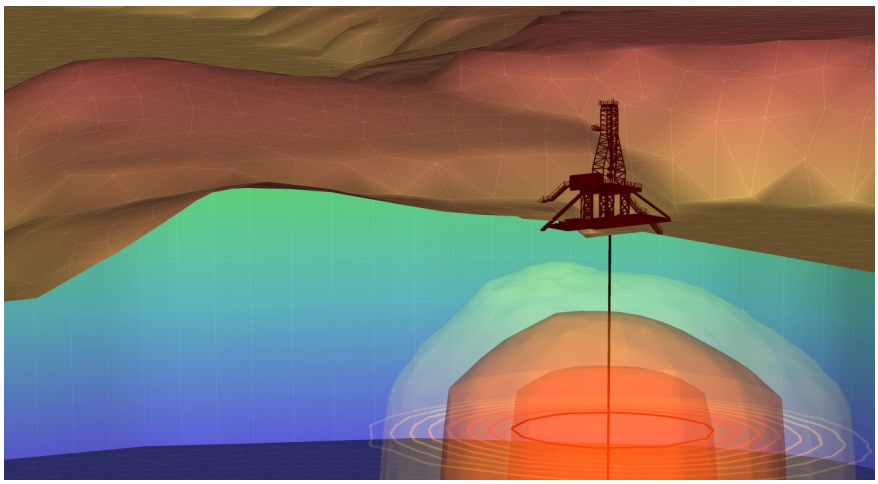
With the rapid growth of the geothermal energy market, simulation models for heat transport have evolved from an exotic exercise to a standard application during the last decade. FEFLOW's ability to model all relevant components of heat transport processes combined with its flexible meshing strategies have made FEFLOW an industry standard for geothermal modelling.

APPLICATIONS

- Feasibility assessment of feature geothermal installations
- Design and planning of near-surface and medium-deep geothermal systems
- System optimization (amount and location of boreholes, flow rates, etc.)
- Evaluation of possible interaction with existing installations (heating/cooling)

TYPICAL INSTALLATIONS

- Near-surface and medium-deep geothermal installations
- Open and closed loop systems: Direct use of geothermal resources.
- Borehole heat exchangers (BHE) w/o arrays
- Aquifer thermal energy storage (ATES) and Borehole Thermal Storage (BTES)



Visualisation of a heat plume in 3D.

BENEFITS

- Efficient and precise simulation of geothermal installations
- Support for open-loop and closed-loop systems
- Calculation of the influence of groundwater flow
- Interaction of neighbouring installations
- Possibility of including complex geology
- Decision support for resource management

FEATURES

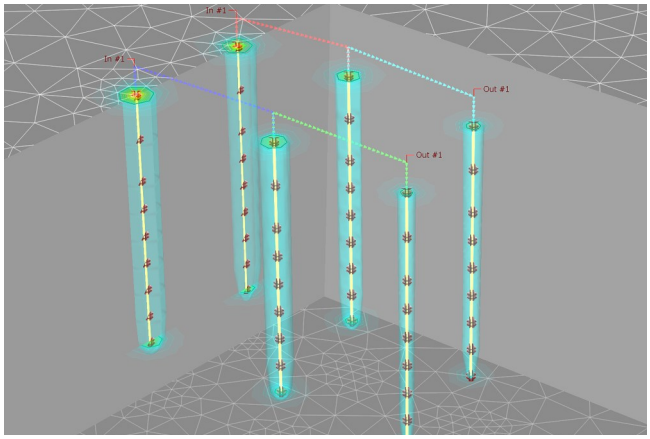
- Advection-conduction/dispersion heat transport
- Free, forced and mixed convection
- Fracture flow and fracture heat transport
- Fracture media modelled either as equivalent porous media, discrete network or both.
- Thermohaline convection
- Coupled density dependent simulation for varying temperature and/or brine concentrations
- Linear or nonlinear temperature-density relationship
- Predefined or user defined temperature-viscosity relationship
- Variable density flow in both porous and fracture media
- Saturated and unsaturated porous media
- Borehole heat exchangers (BHE)
- Heat exchanger arrays
- Open loop systems
- Interoperability with 3D geological software
- Access to Open Programming Interface for results customization (e.g. dashboards) and workflow automation.

PHYSICAL PROCESSES

To model geothermal energy systems, multiple interlinked physical processes in the subsurface need to be accounted for simultaneously. FEFLOW considers all relevant processes from advective, conductive and dispersive heat transport to temperature-related fluid density and viscosity in deep aquifers as well as under variably saturated conditions in the vadose zone.

NEAR SURFACE GEOTHERMAL ENERGY

The thermal storage capacity of shallow aquifers and aquitards is a valuable resource for the heating and cooling of buildings and facilities. FEFLOW simulations covering both the unsaturated zone and underlying aquifer(s) can provide essential information for evaluating system feasibility, for deciding on the system design and for assessing environmental impacts.



Borehole heat exchanger arrays.

DEEP GEOTHERMAL ENERGY

Driven by the growing use of geothermal energy from deep geological structures for power plants and district heating, there is increasing demand for detailed simulations to estimate energy yield, lifetime and potential impacts on the environment and on adjoining installations, with the overall goal to maximize profitability. FEFLOW provides the tools to model all relevant aspects of deep geothermal systems.

OPEN LOOP SYSTEMS

Open loop systems, consisting of at least one pair of extraction/injection wells, are commonly used for cooling or heating of large apartment buildings, industrial facilities and for electrical power generation. Providing input for design and optimisation of such well systems is a standard FEFLOW application.

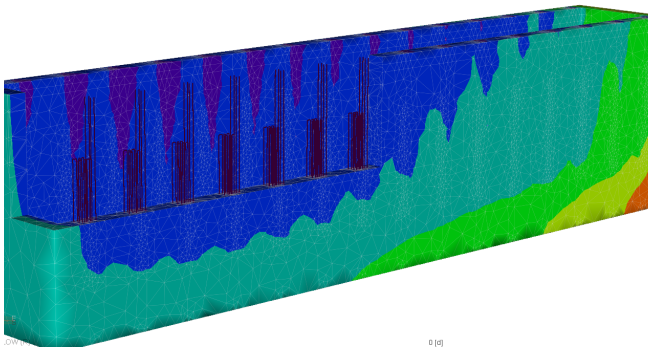
CLOSED LOOP SYSTEMS

Closed loop systems such as borehole heat exchangers can be modelled on different levels of detail from large scale regional systems to design studies for new types of BHE. Our software solution combines a very precise representation of the BHE with a high level of numerical efficiency.

BHEs can also be combined into arrays, prescribing refrigerant and heat flow only at the array inlet and outlet.

COMPLEX GEOMETRICAL CONFIGURATIONS

FEFLOW's 3D meshes support several geometrical configurations of geothermal systems from vertical boreholes (piles), deviated boreholes, basket geothermal heat exchangers (cylindrical/helicoidal), energy diaphragm walls, etc.

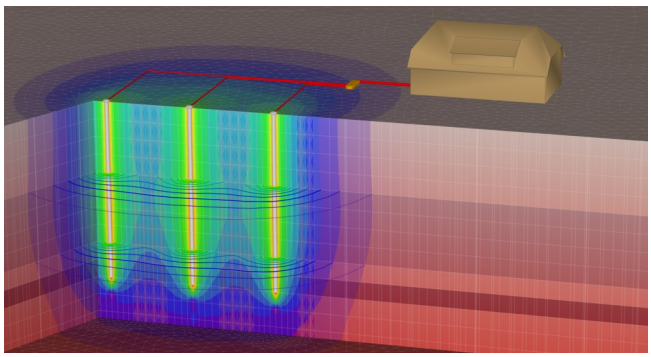


Energy diaphragm walls (EDW) using 3D unstructured meshes.

UP-TO-DATE VISUALISATION TOOLS

FEFLOW's generally cutting edge visualisation encompasses the following tools specifically for geothermal simulations:

- Chart windows to monitor the temperature development of individual BHE elements
- Array connections in 2D/3D view windows
- Temperature distributions in 2D/3D windows



Borehole heat exchangers in parallel connection.

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