Modeling Hybrid CST Systems for Industrial Heat: Enhancements in the greenius Simulation Tool

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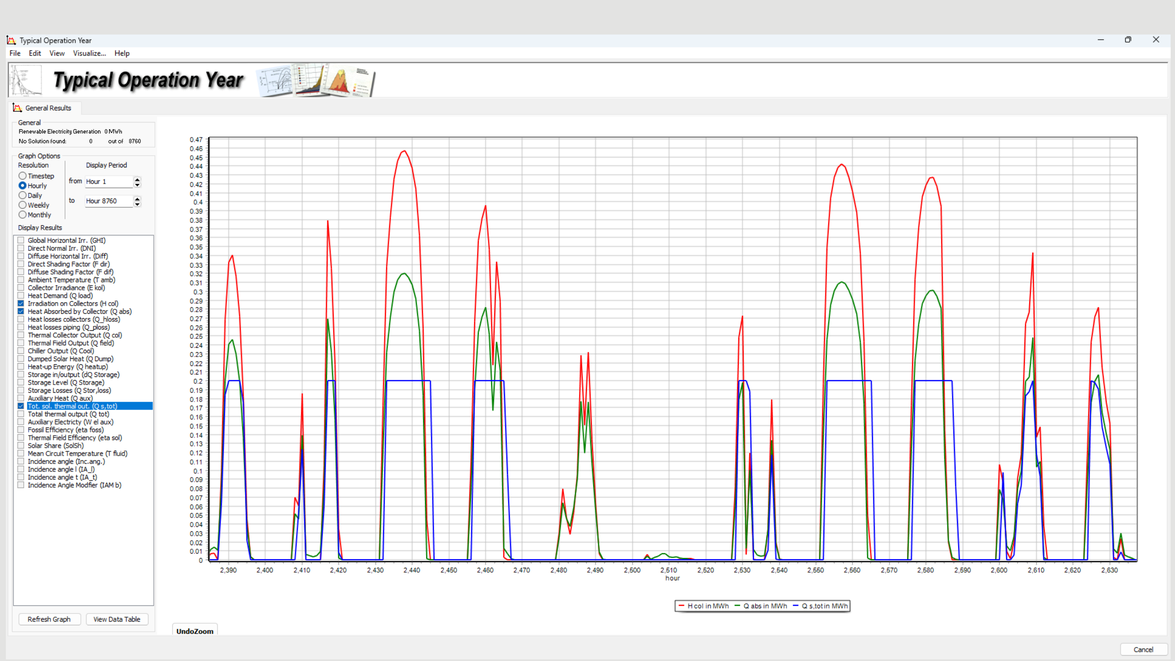
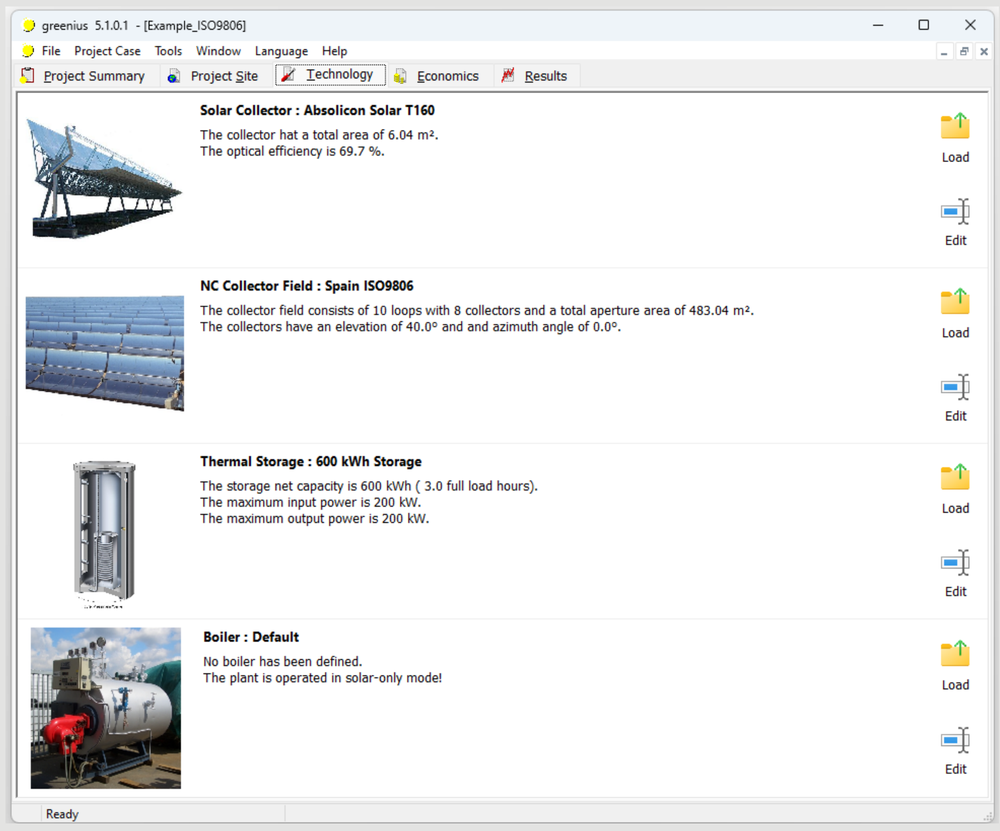
greenius at a glance

- greenius is a simulation tool for renewable energy systems, modelling a complete plant from weather data and component parameters.
- Originally developed for concentrating solar power, now extended towards heat supply and hybrid systems.
- Free of charge, developed and maintained by DLR [1].
- Hourly yield simulation of a typical meteorological year, minimum time step 10 minutes.
- Detailed technical performance modelling combined with economic evaluation.
- Made for pre-feasibility and technology comparisons.

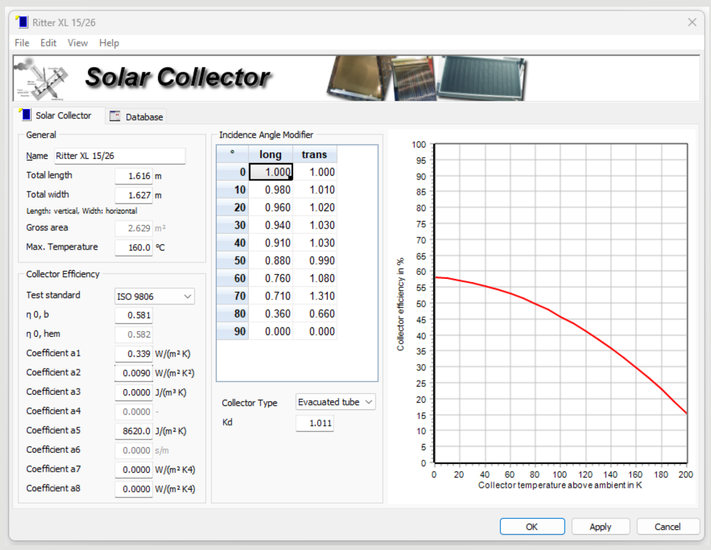




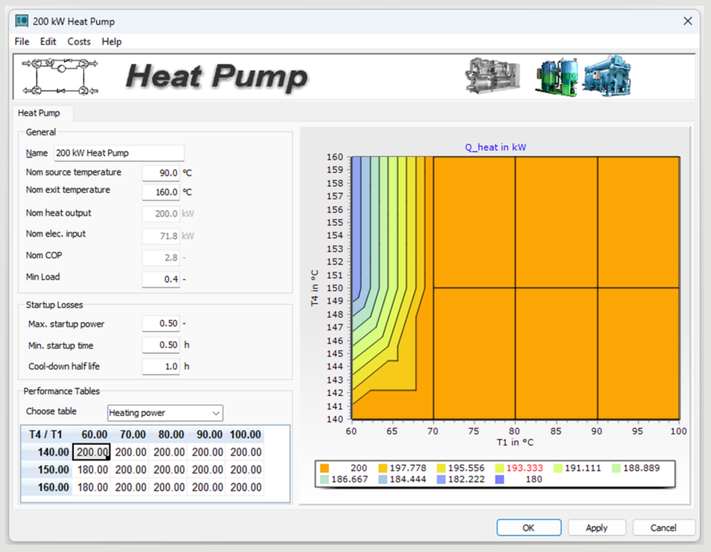
greenius user interface (right): a project case is defined component by component in dedicated parameter windows. Result view (left): selected variables over a chosen period, one of several visualisation options.

Recent developments

- Solar field yield calculation according to **ISO 9806** for concentrating and non-concentrating collectors.
- Integration of the **Solar Keymark** database: certified collector data available directly inside greenius.
- **Stratified thermal storage** and **seasonal storage** models.
- High-temperature **heat pump** model based on manufacturer performance tables.
- **Validation** of greenius against a parabolic trough plant in Limassol, Cyprus.



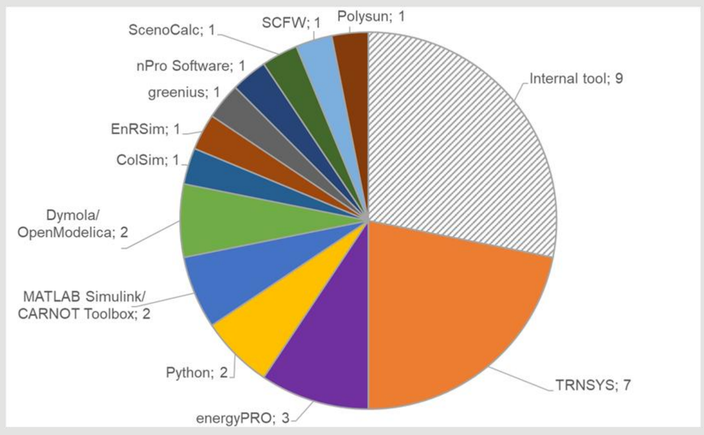
Collector window with ISO 9806 parameters, tabulated incidence angle modifier and access to the Solar Keymark database.



Heat pump window: performance tables and resulting heat output map over source and sink temperature.

The project Plants by Tools

- CST can supply industrial **process heat up to 400 °C**, yet it is still rarely considered in industrial energy concepts.
- Existing planning tools lack at least one of: realistic annual CST modelling, integration of hybrid plants, comparability with alternative concepts such as Power-to-Heat, and professional support.
- The small market volume prevents commercial vendors from closing this gap.
- To close this gap, greenius is being extended within Plants by Tools so that energy planners have a reliable tool at hand in the short term.
- **Two-track approach**: provide CST modelling knowhow to commercial tool vendors, and extend greenius for direct use by industry.
- Funded by the BMWE, coordinated by DLR, 01/2026 – 12/2028, with industry partners and associations.
- To be implemented: integrated simulation of hybrid systems, dynamic electricity prices, automated parameter variation, CO_2 mitigation potential, an interface module for other tools and improved usability, among others.



Tools used by experts for solar district heating — 32 responses, nine of them internal tools. Data: Tamm et al., IEA SHC Task 68 / Subtask A (2025) [2].

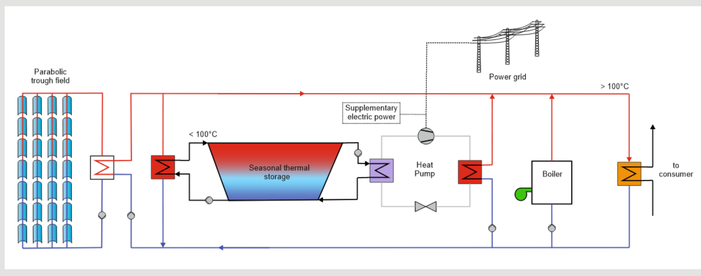
Releases
New versions are published continuously on the DLR website.
2027 — first hybrid process heat systems
2028 — all hybrid configurations, extended tool interface

Hybrid systems for industrial heat

- Decarbonizing industrial **process heat** requires more than one technology. Solar heat, electrification and backup firing complement each other, and thermal storage bridges the **mismatch between supply and demand.**
- The contribution of each technology only becomes visible in an annual, hourly simulation of the whole system. greenius models these configurations within one integrated simulation, including **grid electricity at dynamic prices.**

Configurations implemented or under implementation

- CST field + storage + backup boiler
- CST field + short-term/seasonal storage + power-to-heat
- CST field + storage + PV plant + power-to-heat
- PV + electric heater or heat pump (power-to-heat) + storage
- PV + storage + power-to-heat + boiler
- Scenarios with 100 % renewable supply



greenius simulation model of a hybrid heating system, featuring a parabolic trough solar field, seasonal thermal energy storage, and a heat pump to supply year-round process heat.

Download greenius and try it: freegreenius.dlr.de

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References:
[1] German Aerospace Center (DLR): greenius. http://freegreenius.dlr.de).
[2] Tamm, Berberich, Pauletta et al. (2025): Simulation and calculation tools for Solar District Heating — an overview of the tools used by experts. IEA SHC Task 68, Subtask A.