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DEVELOPMENT OF A SOLAR DISTRICT HEATING ONLINE CALCULATION TOOL

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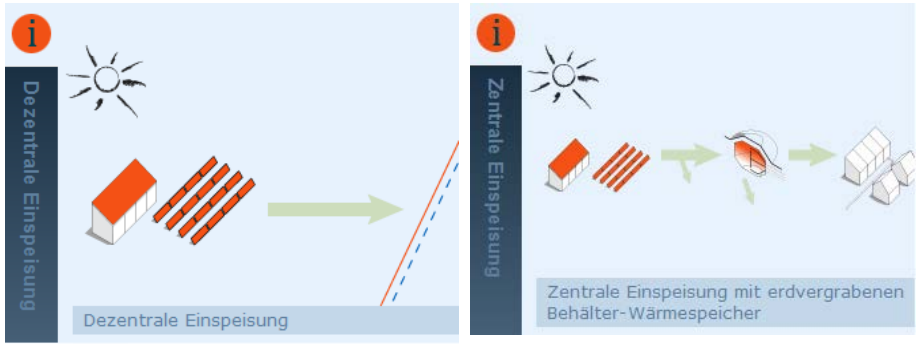
Development of the tool | Introduction

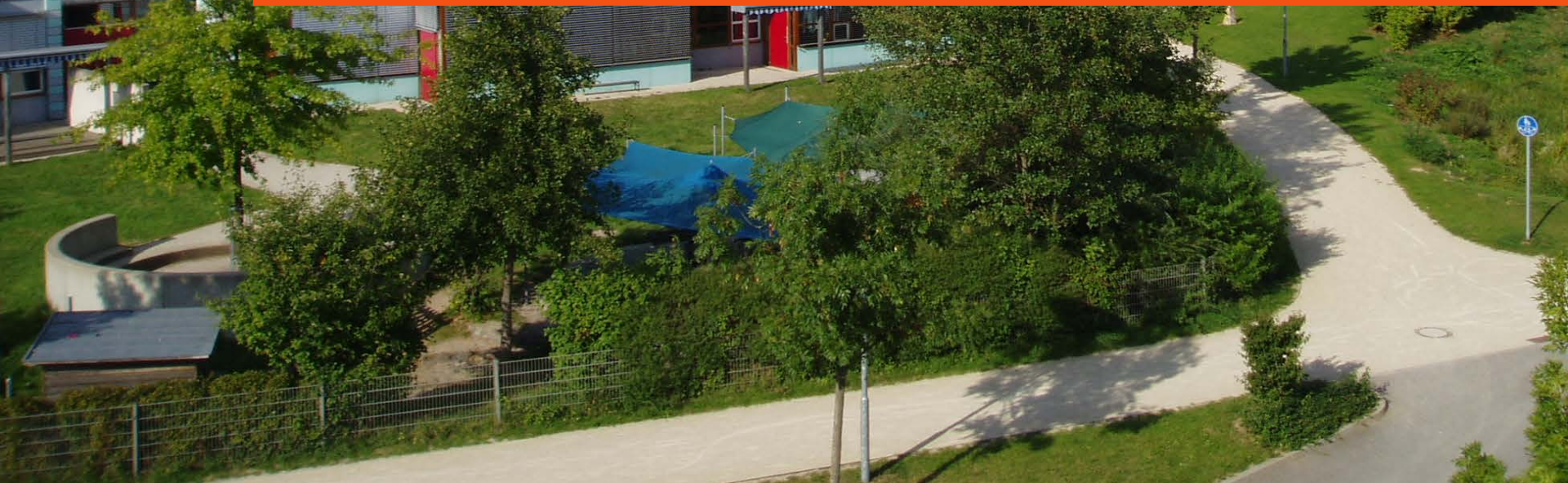
- Conception phase
- Online tool, user-friendly
- Based on TRNSYS simulations
- Two different configurations available: central and distributed



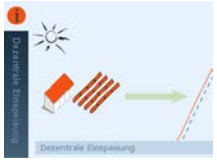
Contents

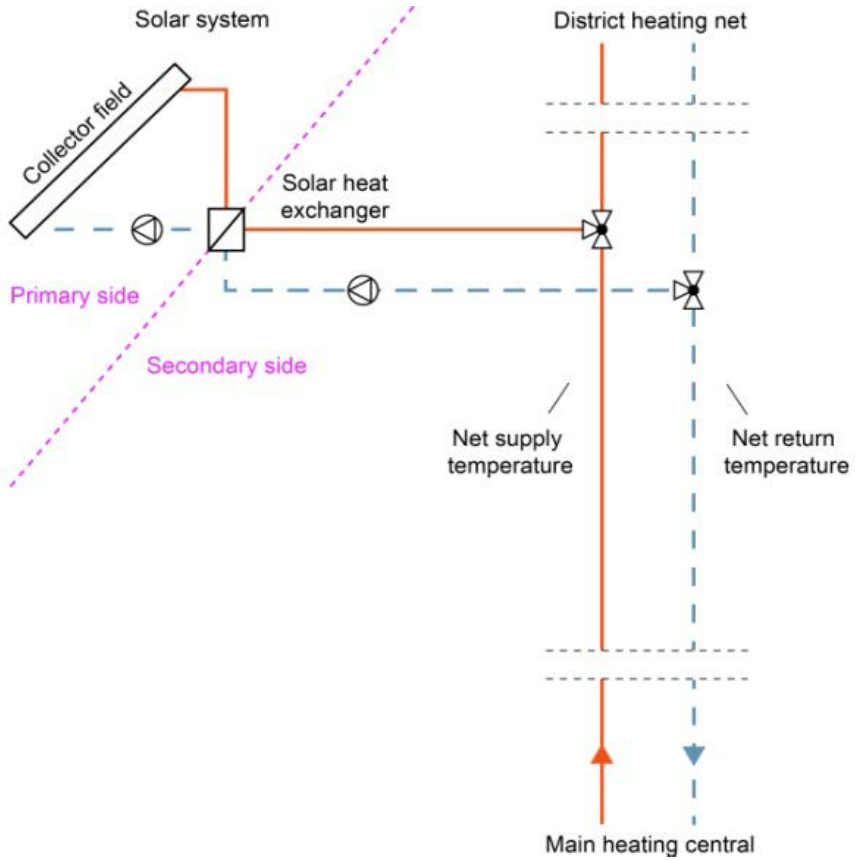
- Development of the tool
  - Distributed system
  - Central system

- Economics and environmental performance



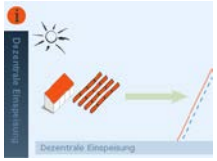
The distributed system | Definition





- The solar heating plant feeds into the supply pipe
- The net is theoretically infinite
- All the heat produced at set temperature is fed into the net

The distributed system | Parameters



- **Collector type**: flat-plate, high temperature flat-plate, evacuated tube, evacuated tube with compound parabolic concentrator (CPC).

- **Climate**: Würzburg, Frankfurt and Hamburg for Germany; Stockholm (SE), Milan (IT) and Barcelona (ES)

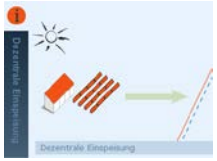
- **Operation temperatures**: nine combinations of winter/summer supply temperature and winter/summer return temperature from 70/70/30/40 to 110/90/60/70

- **Collector area, azimuth and slope**

Distributed		
Parameter	Steps	Unit
Collector area	100-200-500-1000-2000-5000-10000-20000-50000	m²
Collector azimuth	(-45) - (-30) - (-15) - 0 - 15 - 30 - 45	°
Collector slope	15 - 30 - 45 - 60	°

→ 72 576 TRNSYS simulations

The distributed system | Parameters



SDH ONLINE-RECHNER

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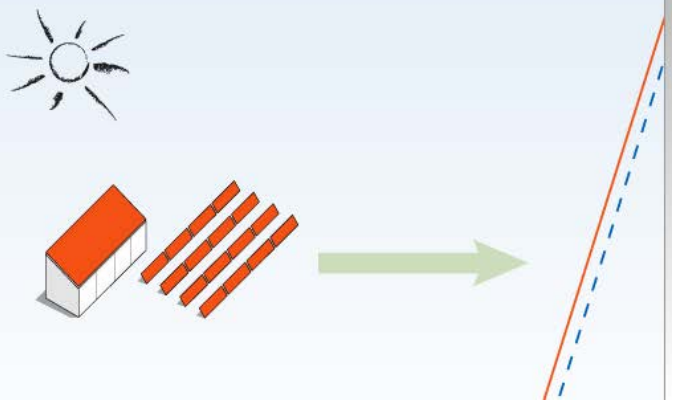
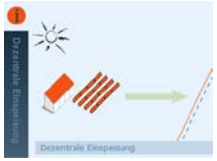
Dezentrale Einspeisung | Eingabe

Standort	Frankfurt
Kollektortyp	CPC Kollektor
Kollektorfläche in m²	300
Kollektorausrichtung in Grad	15
Kollektorneigung in Grad	20
Betriebstemperaturen im Wärmenetz in °C	VL(100/80); RL(30/40)

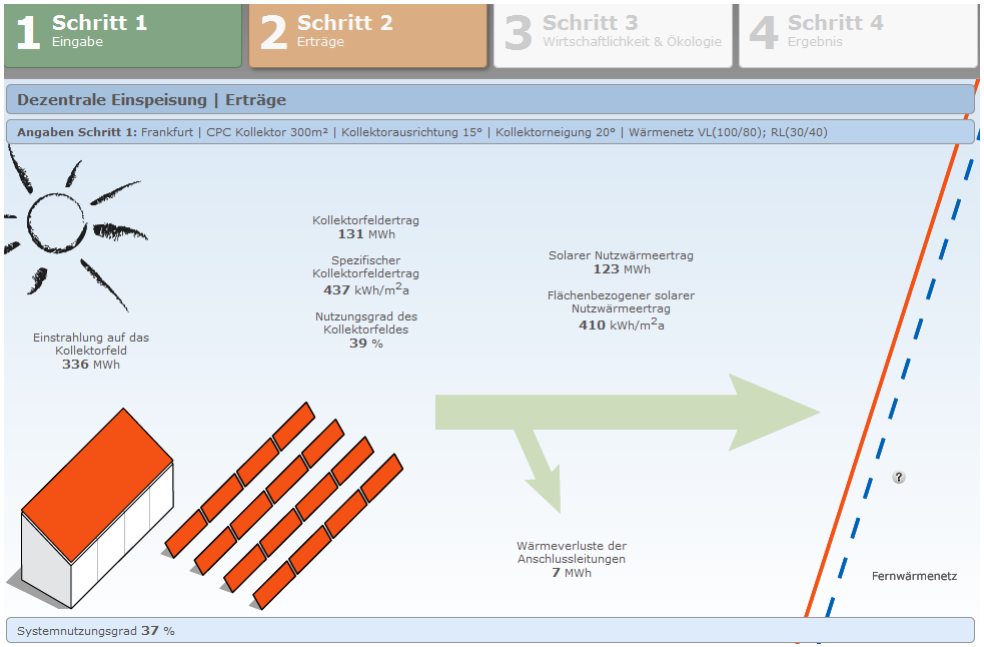


The distributed system | Results

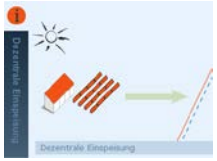


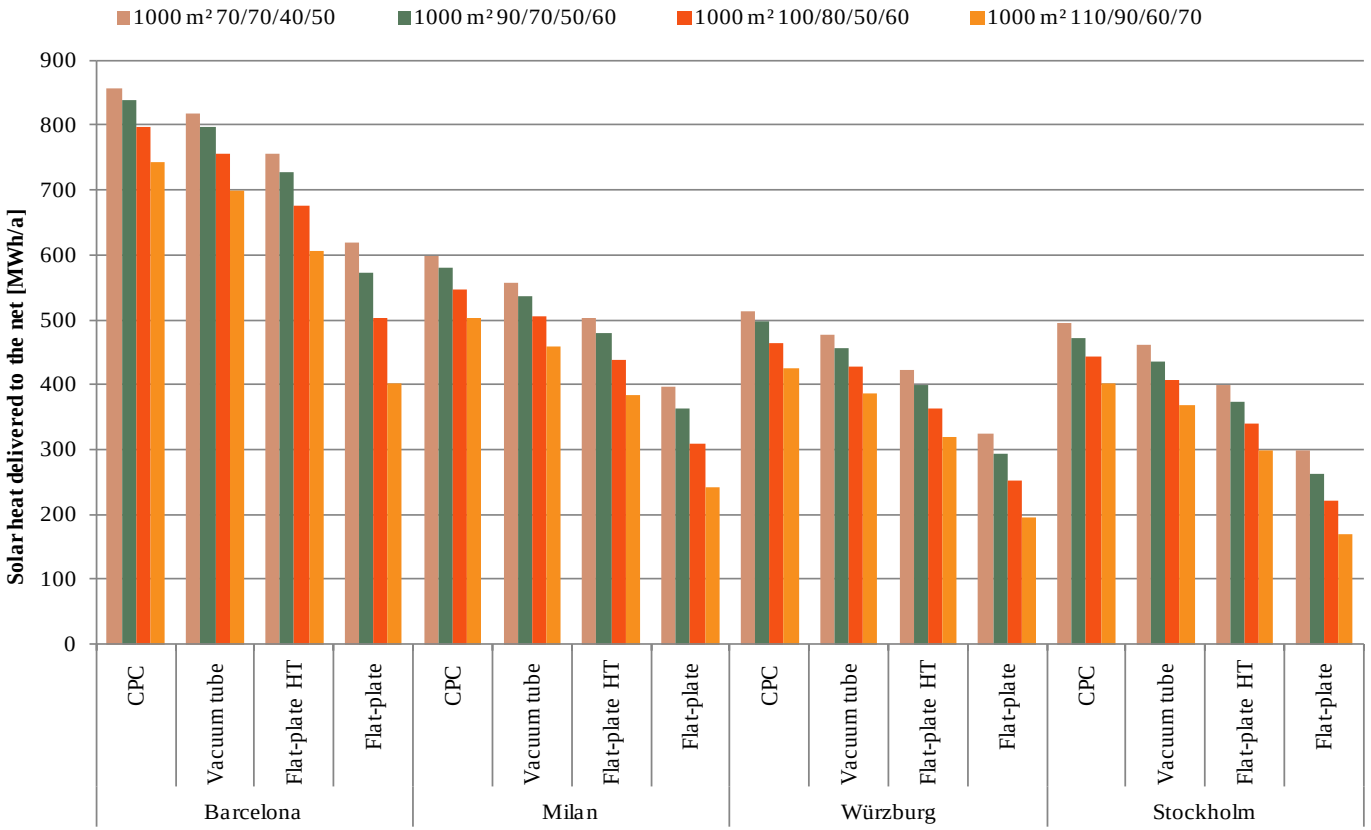
- Multi-linear interpolation

- Radiation on the collector plane
- Collector plant yield
- Efficiency of the collector plant
- Solar energy delivered to the net
- Heat losses through the connection pipes
- System efficiency



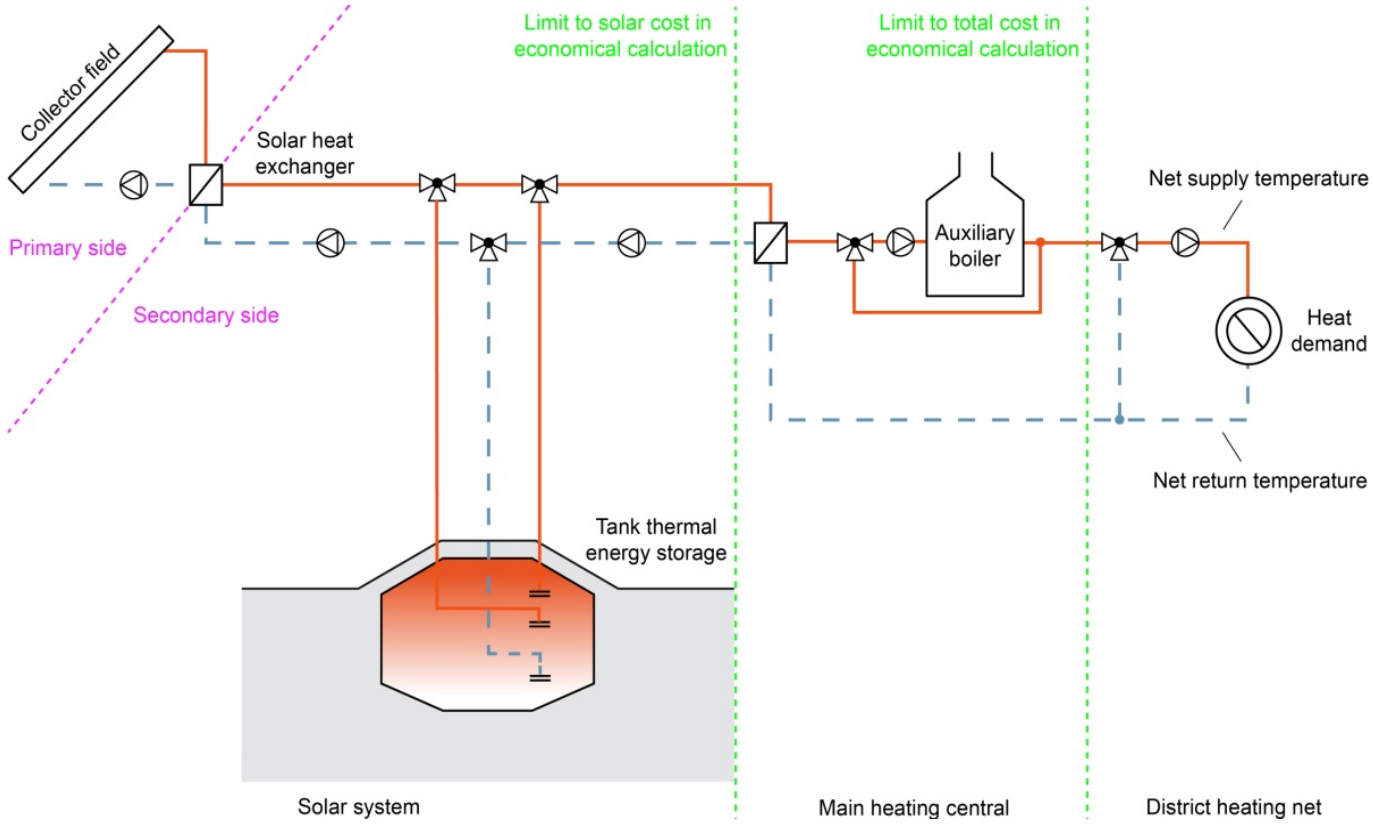
The distributed system | Results





Solar heat delivered to the net by the distributed system for 1000 m² collector area and different combinations of operation temperatures ($T_{supply,\ winter}/T_{supply,\ summer}/T_{return,\ winter}/T_{return,\ summer}$), for each location and collector type.

The central system | Definition



The central system | Parameters

- **Collector type**: flat-plate, high temperature flat-plate, evacuated tube, evacuated tube with compound parabolic concentrator (CPC).

- **Climate**: Würzburg, Frankfurt and Hamburg for Germany; Stockholm (SE), Milan (IT) and Barcelona (ES)

- **Operation temperatures**: supply/return temperatures 60/30, 70/40, 80/50, 90/60

The central system | Parameters

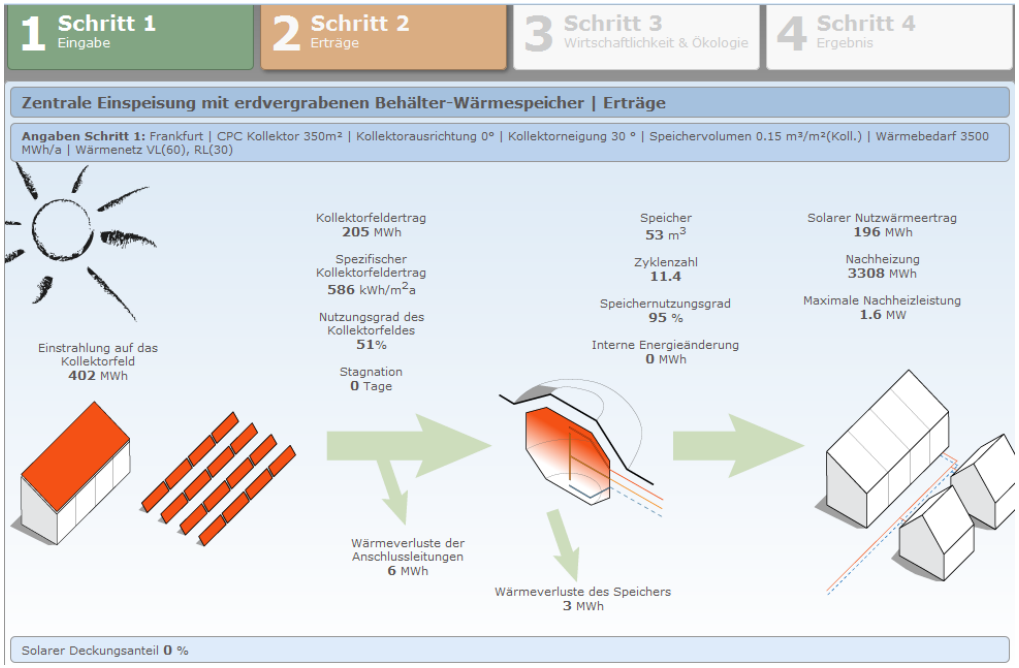
- **Collector area, azimuth and slope**
- **Specific storage volume**
- **Specific yearly heat demand**

Central		
Parameter	Steps	Unit
Collector area	100-350-1200-4300-15000-50000	m^2
Collector azimuth	(-45) - (-30) - (-15) - 0 - 15 - 30 - 45	°
Collector slope	15 - 30 - 45	°
Specific storage volume	0.05 - 0.15 - 0.4 - 1.1 - 3	m^3/m^2
Specific load	200 - 500 - 1500 - 4000 - 10000	KWh/m^2

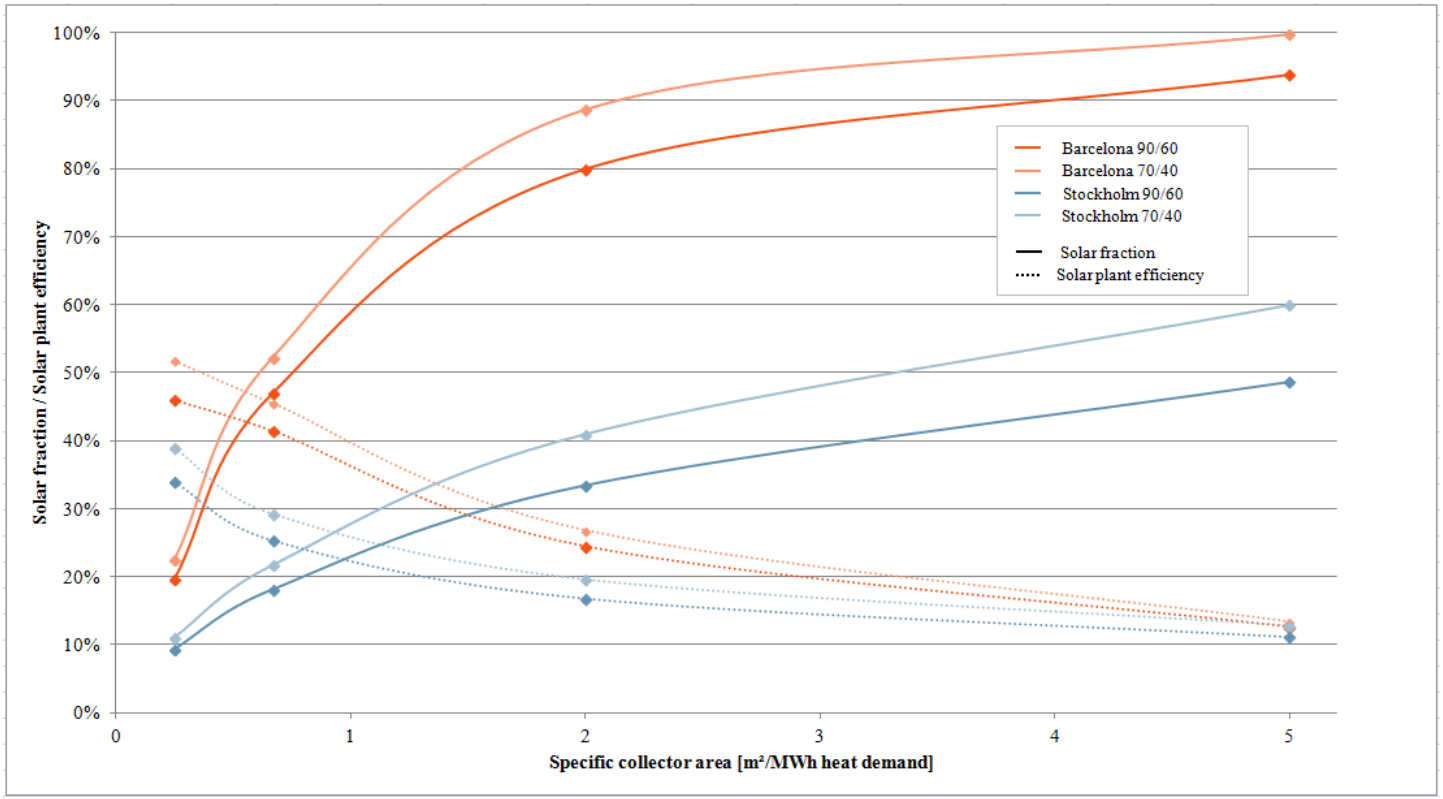
→ 145 152 simulations

The central system | Results

- Radiation on the collector plane
- Collector plant yield
- Efficiency of the collector plant
- Number of stagnation days
- Heat losses through the connection pipes
- Heat losses through the storage
- Number of cycles of the storage
- Efficiency of the storage
- Solar energy delivered to the net
- Auxiliary heat delivered to the net
- Maximal auxiliary boiler power
- System efficiency



The central system | Results



Evolution of the solar fraction and the solar plant efficiency related to increasing collector area per MWh yearly heat demand for the central system in two different locations and net operation temperatures (T_{supply}/T_{return}) for 1 200 m².

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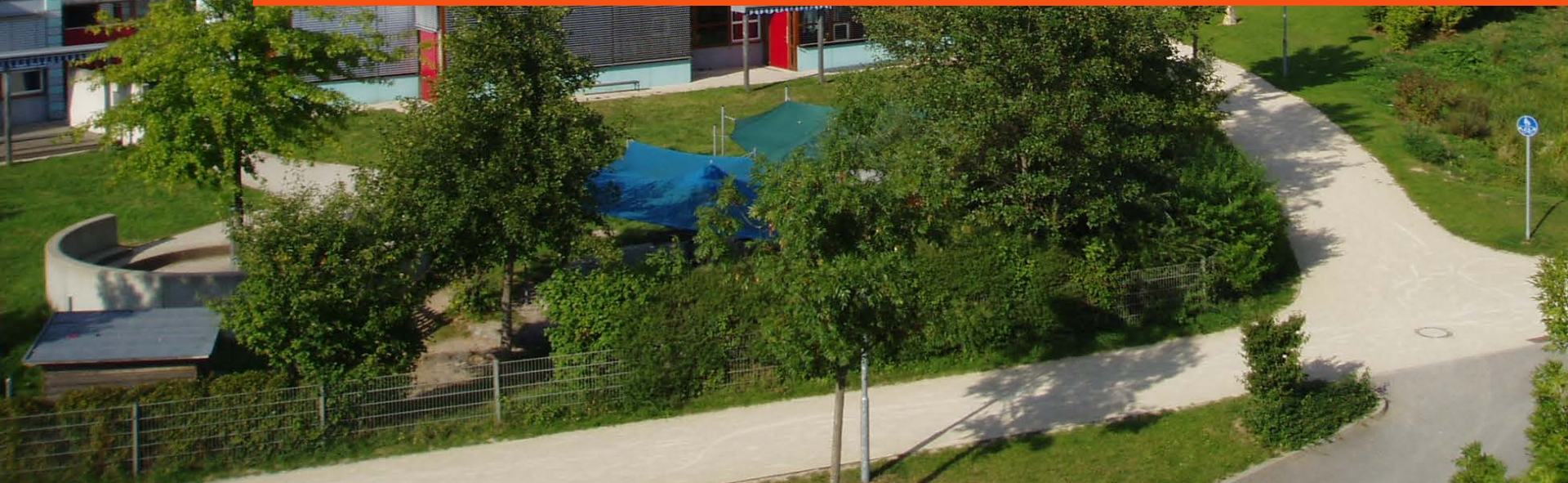

Environmental performances

- Primary energy saving rate

- CO_2 equivalent emissions avoided in kg

- Calculation in comparison to a system in which the solar heat would be produced by another energy, called energy of reference (gas, biomass, coal, oil or electricity)

Economics

- Calculations according to VDI 2067
- Default values available for components costs

System	Distributed
Collector area	10 000 m²
Location	Stockholm, SE
Collector type	HT Flat-plate
$T_{ws}/T_{ss}/T_{wr}/T_{sr}$	70/70/30/40
Specific collector cost	180 €/m²
Interest rate	3 %
Additional charge building/terrain	5 % of the collector investment cost
Additional charge control system	5 % of the collector investment cost
Additional charge system installations	10 % of the collector investment cost
Design	7 % of the total investment cost without design

→ Heat cost: 45 €/MWh

Economics

System	Distributed
Collector area	10 000 m²
Location	Würzburg, DE
Collector type	HT Flat-plate
$T_{ws}/T_{ss}/T_{wr}/T_{sr}$	70/70/30/40
Specific collector cost	246 €/MWh
Interest rate	6%
Additional charge building/terrain	5 % of the collector investment cost
Additional charge control system	5 % of the collector investment cost
Additional charge system installations	10 % of the collector investment cost
Design	7 % of the total investment cost without design
Incentive	40 % on collector cost

→ Heat cost: 74 €/MWh

→ Heat cost: 44 €/MWh

Barcelona without incentives: 42 €/MWh and 53 €/MWh for the highest operation temperatures

Economics

System	**Central**
Collector area	10 000 m²
Location	Würzburg, DE
Collector type	HT Flat-plate
Specific storage volume	2 $m^3/m^2_{collector\ area}$
Total heat demand	5000 MWh
T_s/T_r	70/40 °C
Specific collector cost	246 €/m²
Specific storage cost	93 €/m³
Specific cost of additional boiler	58 €/kW
Specific connecting pipes cost	300 €/m²
Interest rate	6 %
Additional charge building/system installations	12 % of the components investment cost
Additional charge control system	8 % of the components investment cost
Design	10 % of the total investment cost without design
Financial support	40 % of the collector cost and complete storage cost (maximum possible 250 €/MWh)

→ Solar heat cost: 75 €/MWh

→ Solar fraction: 49 %

→ Compared to a 100% gas powered system with a boiler efficiency of 0.9:

- 49 % primary energy savings
- 508 tons of CO_2 equivalent emissions avoided

Conclusion

- Different level of usage
- Extension possibility
- No replacement of detailed simulations
- Beta version available soon on www.sdh-online.solites.de
- German and English versions
- Feedback welcome