Solar Space Heating

The Student Design and Build Project Kindergarten Brak en Jan in Raithby

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Dipl.-Ing. Civil Engineering
MSc Environmental Design and Engineering

Before 2005: Consultant in the field of Building Physics and Building Simulation

Since 2005: Lecturer and researcher at the University of Technology Munich, Department of Civil Engineering, Chair for Timber Engineering and Building Construction

Focus

- Window and Façade Technology
- Modelling of Dynamic Systems – Buildings and Renewables

SUSTAINABILITY

SUSTAINABILITY

Sustainability is a societal dictum

generally related to the aim, to conserve nature and our livelihood, the capacity to endure

Energy aspect of sustainability

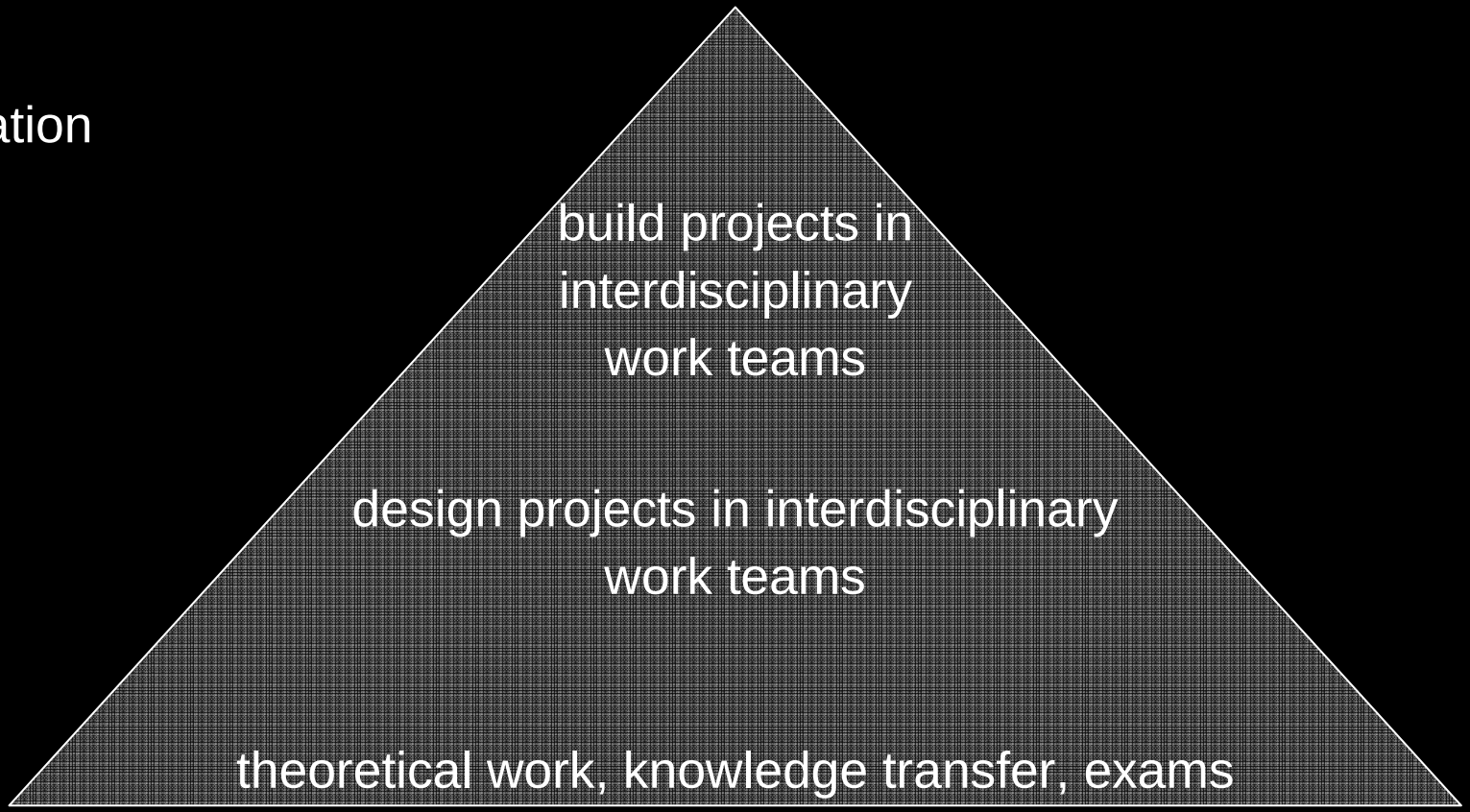
energy consumption, concepts like “embodied energy” for the materials

Occupant aspect of sustainability

design of the space, comfort requirements

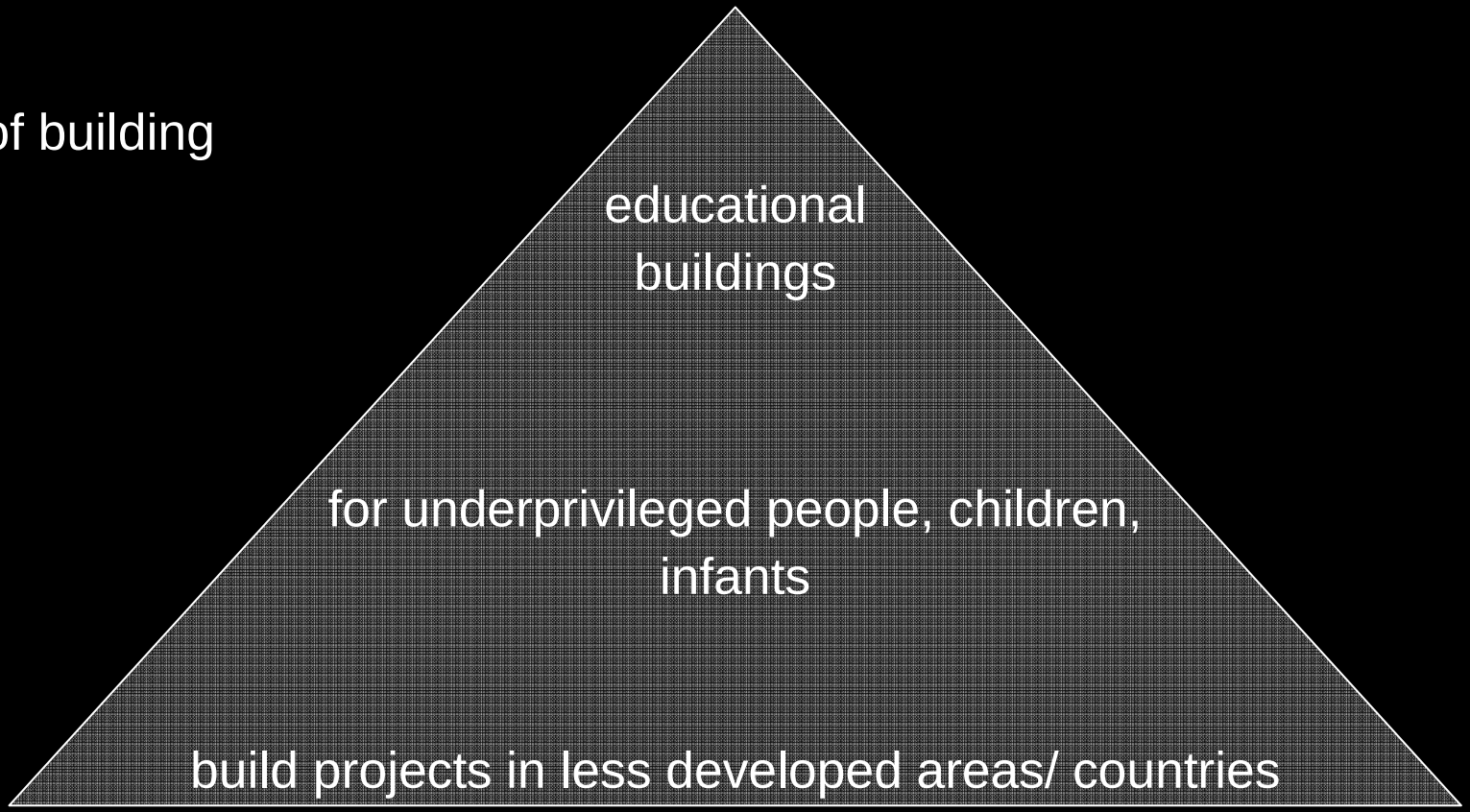
SUSTAINABILITY

Education



SUSTAINABILITY

Kind of building



DESIGN CONDITIONS

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Former Kindergarten

Old kindergarten building, located on a wine farm,
was about to be torn down

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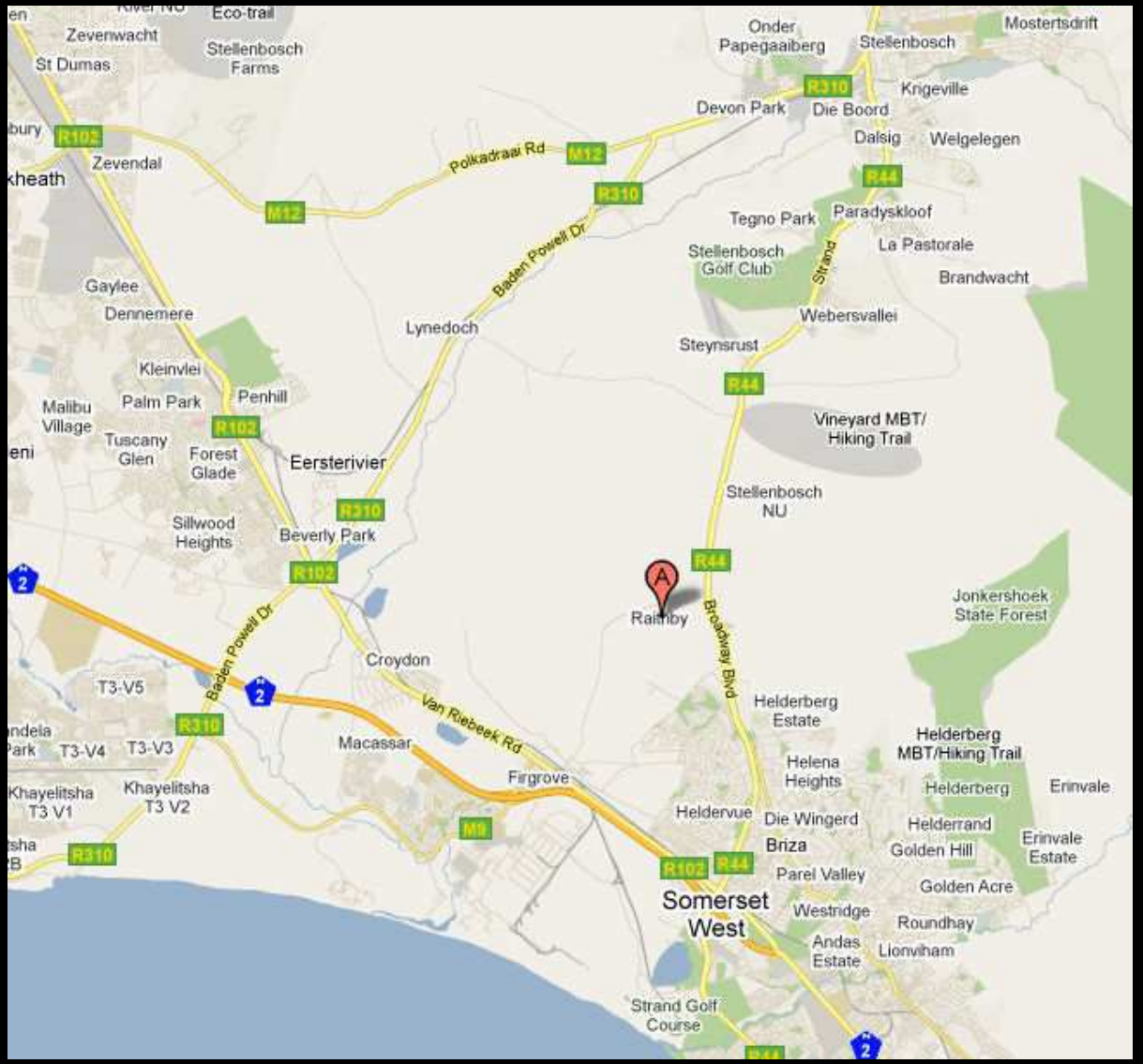
DESIGN CONDITIONS

Location



DESIGN CONDITIONS

Location

DESIGN CONDITIONS

Social Situation

Parents are poor farm workers
Raithby: Satisfactory infrastructure

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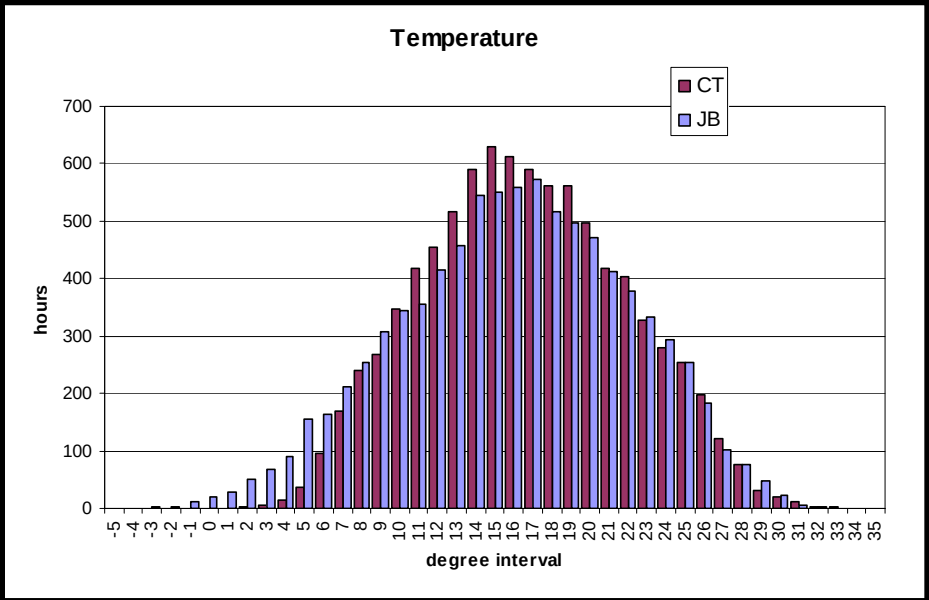
DESIGN CONDITIONS

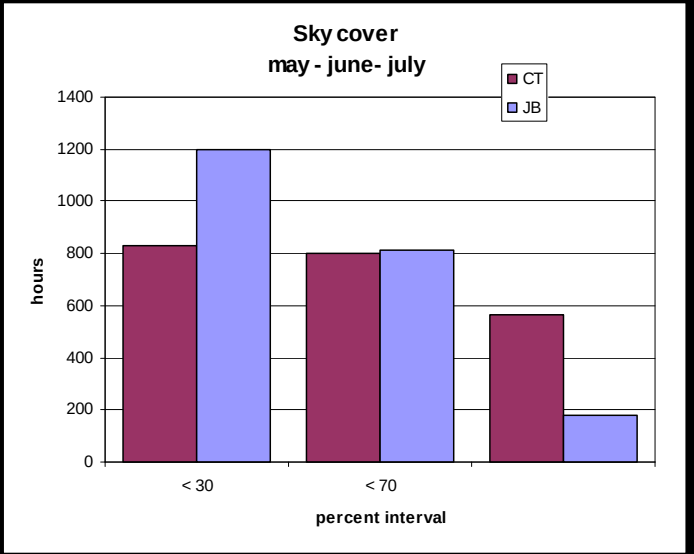
Climate

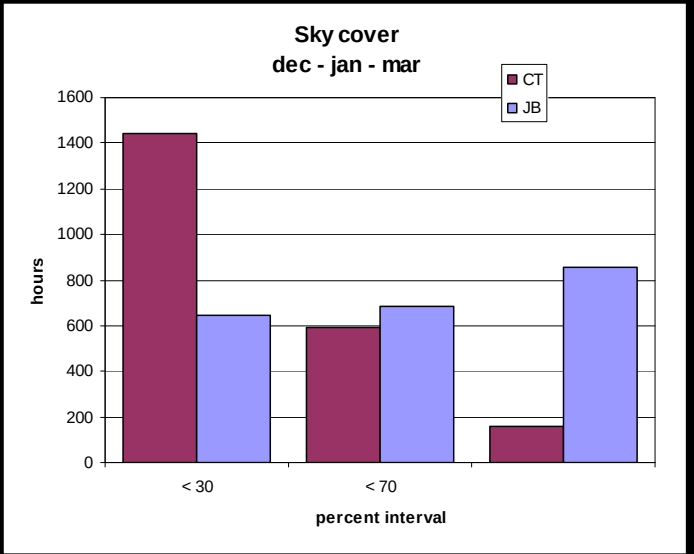
Longitude: 18° E

Latitude: 34° S

Height above SL: 100m







DESIGN CONDITIONS

General Requirements

Space for playing, resting, sleeping for different age groups, sound protection
protection against summer heat and winter cold

Enough daylight

Shaded external areas, protection against rain

Kitchen, storeroom, office, sanitary rooms

Simple construction: built by untrained students/ easy to copy

DESIGN CONDITIONS

Design and Building Process

Student design contest at the department of architecture and the department of civil engineering

Designed during the winter semester 2008/2009 by interdisciplinary teams of students of architecture and civil engineering

Erected in spring 2009

9 weeks construction time

Two groups of 15 to 20 students each

15 local, paid workers

SOLUTION

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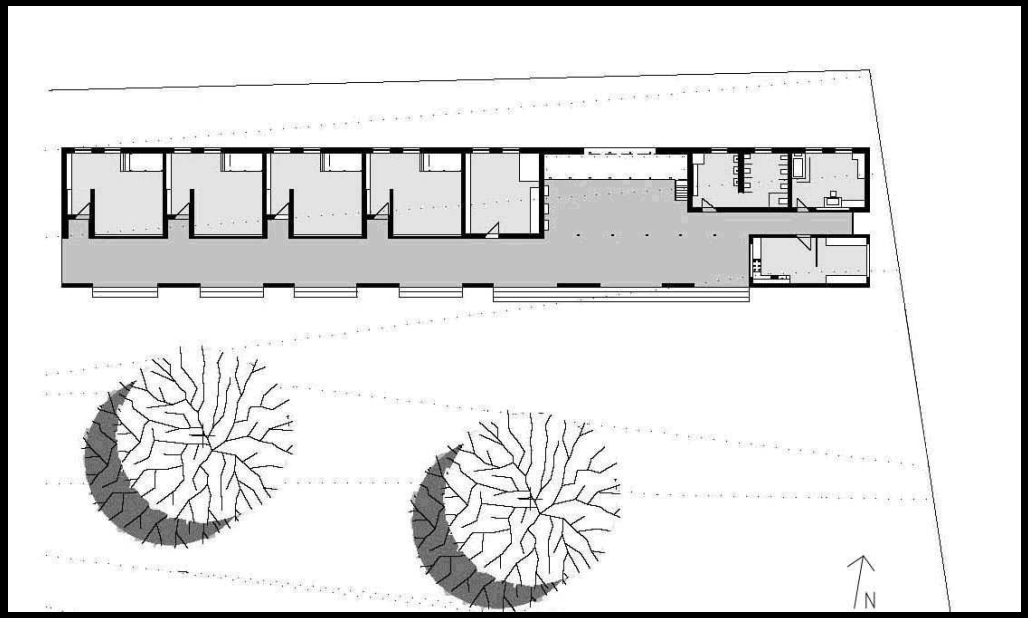
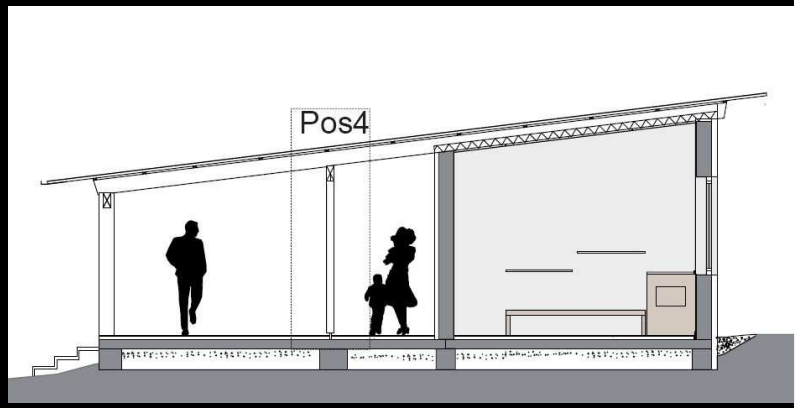
SOLUTION

Layout



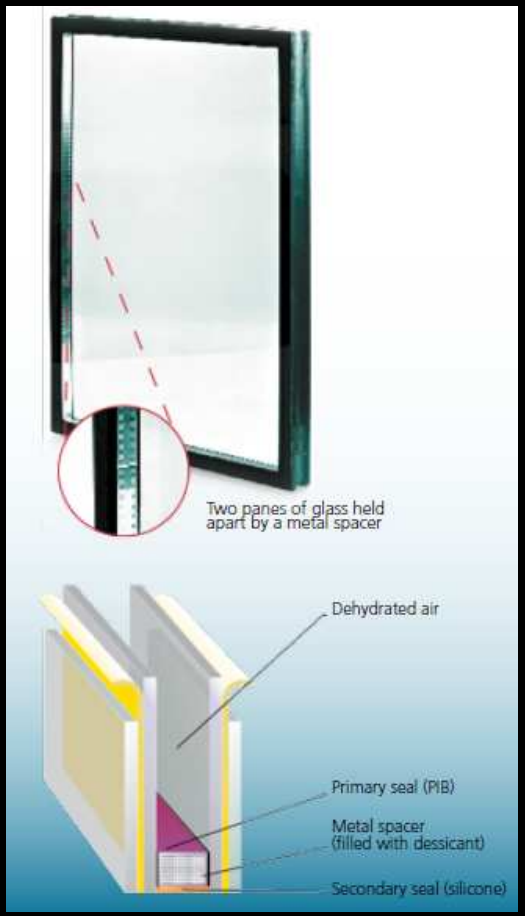


SOLUTION

Summer Heat Protection

Shading + glazing

No roof overhang on the north facade
but
Double glazed units with coating, Transmission 0,34



SOLUTION

Summer Heat Protection

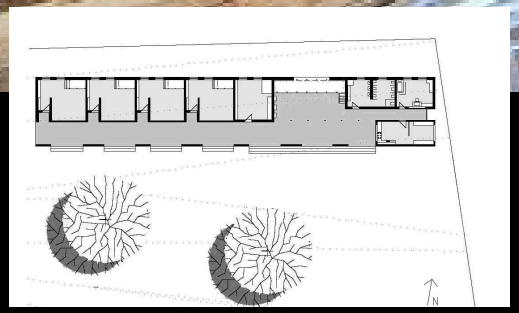
Shading + glazing

PRODUCT	VISIBLE LIGHT		SOLAR ENERGY					SHADING COEFFICIENT	U VALUE	UV	NOISE CONTROL	SAFETY	SECURITY	INSULVUE™ (Serene Green Low E & Intruderprufe Low E)
INSULVUE™ E Range & Intruderprufe Low E *E Range +12mm air gap + Intruderprufe Low E*	transmission	reflection	total elimination	reflectance	absorption	direct transmission	total transmission	ratio	(W/m²).K	elimination %	ISO rating / STC value	rating (see below)	rating (see below)	
Serene Green Low E	54	14	66	9	69	22	34	0.39	1.8	99	34	0	1	

SOLUTION

Summer Heat Protection

Thermal mass in combination with night ventilation



SOLUTION

Winter Temperatures

Maintaining comfortable conditions

Passive and active means
Well insulated roof and south wall

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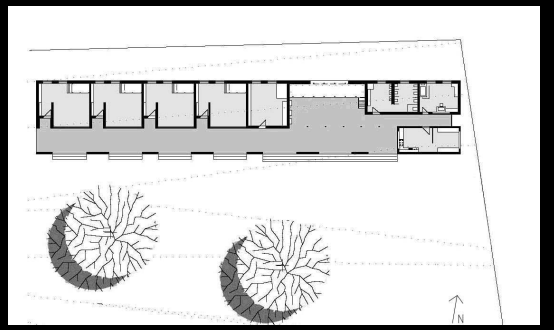
SOLUTION

Winter Temperatures

Maintaining comfortable conditions

Solar space heating



SOLUTION

Beyond Building Physics

Availability of materials and example building: All materials are available in the western cape region, only few products are imported: collectors, pumps, thermostats and system controller

Local products: timber, adobe bricks, double glazed units, window frames (from demolition sites, refurbished)

Adobe bricks, produced on the neighbour farm

Low production energy, low transport energy, strengthening of local production, strengthening of alternative technology

THE BUILDING PROCESS

Solar Space Heating

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THE BUILDING PROCESS

Students

THE BUILDING PROCESS

Local Workers and Local Knowledge

Employing local labourer, bi-directional knowledge-transfer

THE BUILDING PROCESS

Building Process 1












THE BUILDING PROCESS

Building Process 2










SOLAR SPACE HEATING IN DETAIL

SOLAR SPACE HEATING IN DETAIL

Heating and carbon dioxide

Space heating can be provided by:

electricity
oil/coal (fossil fuels)
renewable sources (basically solar energy)

Where does electricity come from?

nuclear power station
coal fired power station

Coal fired power station → 30…40% → electricity
Coal fired power station → 60…70 → heat, released

to have 1kWh heat in the room provided by electricity, you need 2.5 to 3 kWh coal fired

→ 2.5 to 3 times more use of carbon dioxide compared to an oil-heated room!

if supply is mixed (nuclear, coal fired) the factor might be about 2!

SOLAR SPACE HEATING IN DETAIL

Comparison Munich/ Cape Region/ Raithby

Munich:	Cape Region:	Brak en Jan:
transmission losses		
u-value walls/roof… : 0.25 W/m²/K u-value windows: 1.5 W/m²/K	u-value walls/roof… : 1.25 W/m²/K u-value windows: 6 W/m²/K	u-value walls/roof… : 0.6 W/m²/K u-value windows: 1.8 W/m²/K
winter temperature diff: 30K	winter temperature diff: 15K	winter temperature diff: 15K
→ walls: 7.5 W/m² → windows: 45 W/m²	→ walls: 18.75 W/m² → windows: 90 W/m²	→ walls: 9 W/m² → windows: 27 W/m²

(unwanted) ventilation losses

solar gains through walls and windows not included, therefore roughly the same energy demand per m² building envelope

→ twice as much carbon dioxide use without insulation and with electrical heating!

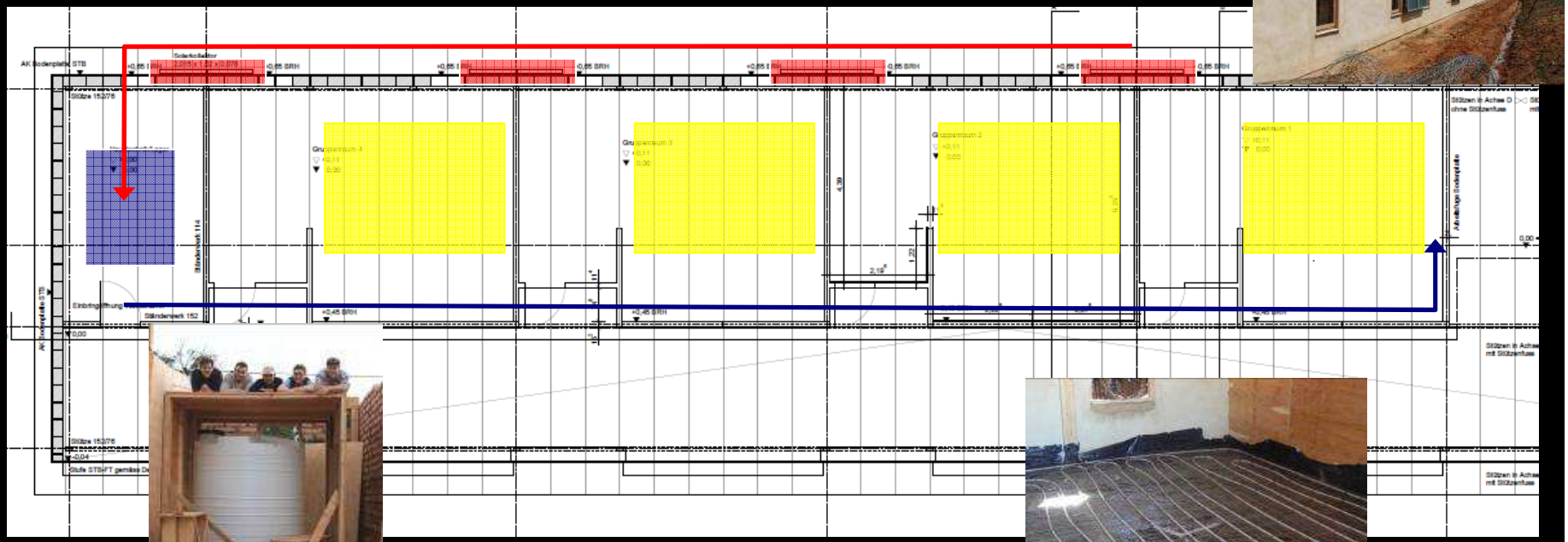
SOLAR SPACE HEATING IN DETAIL

Solar Heating Principle

flat plate collector

storage tank

floor heating system



SOLAR SPACE HEATING IN DETAIL

Design Tool

TRaNsient SYstem Simulation program → TRNSYS

Modelling of all energy processes that take place

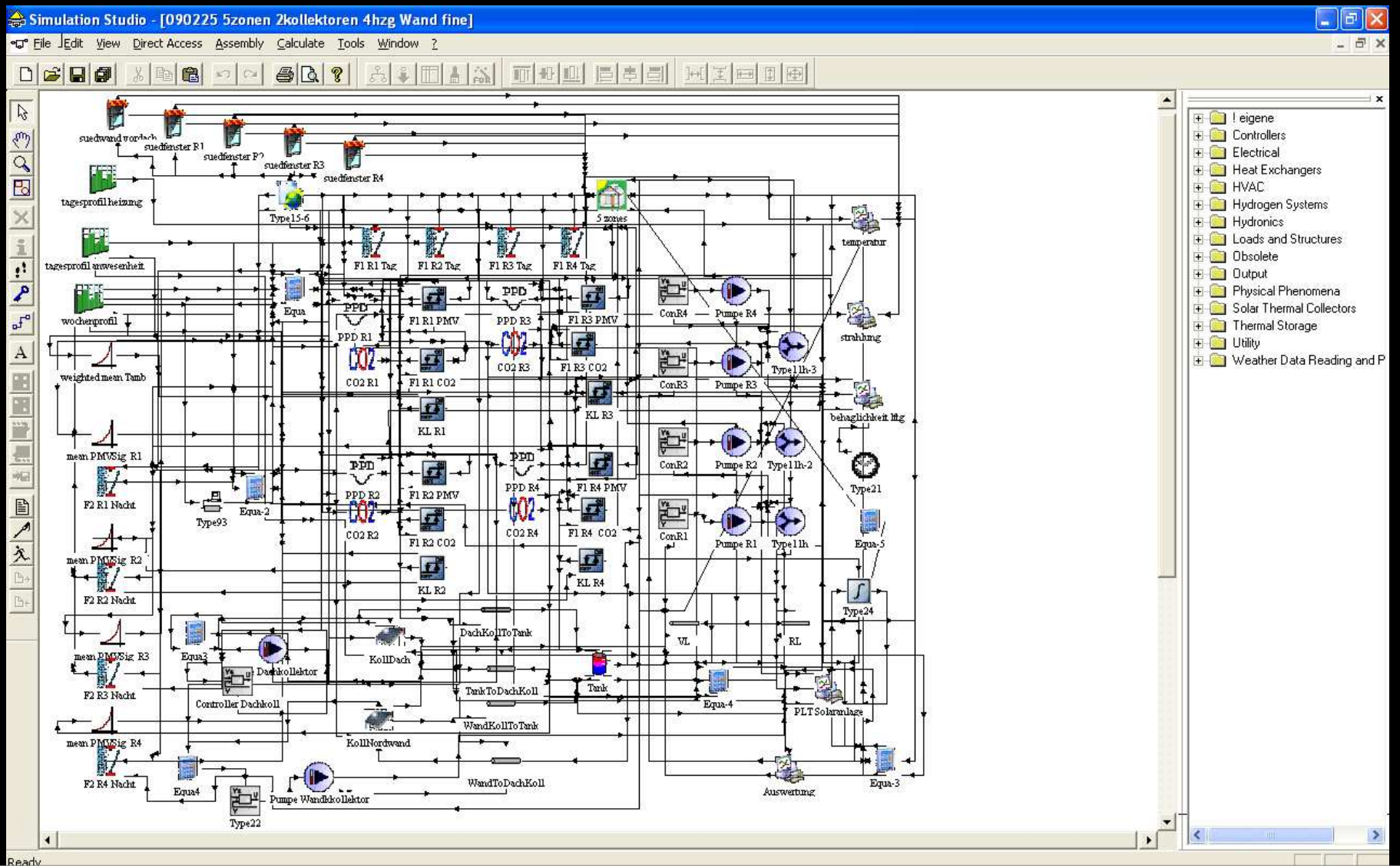
Simulation of a full year (8760h), time steps arbitrary

Results:
Temperatures for rooms, surfaces
Energy flux

Basis:
Statistical weather data of location (cold, mean, warm)

SOLAR SPACE HEATING IN DETAIL

Design Tool



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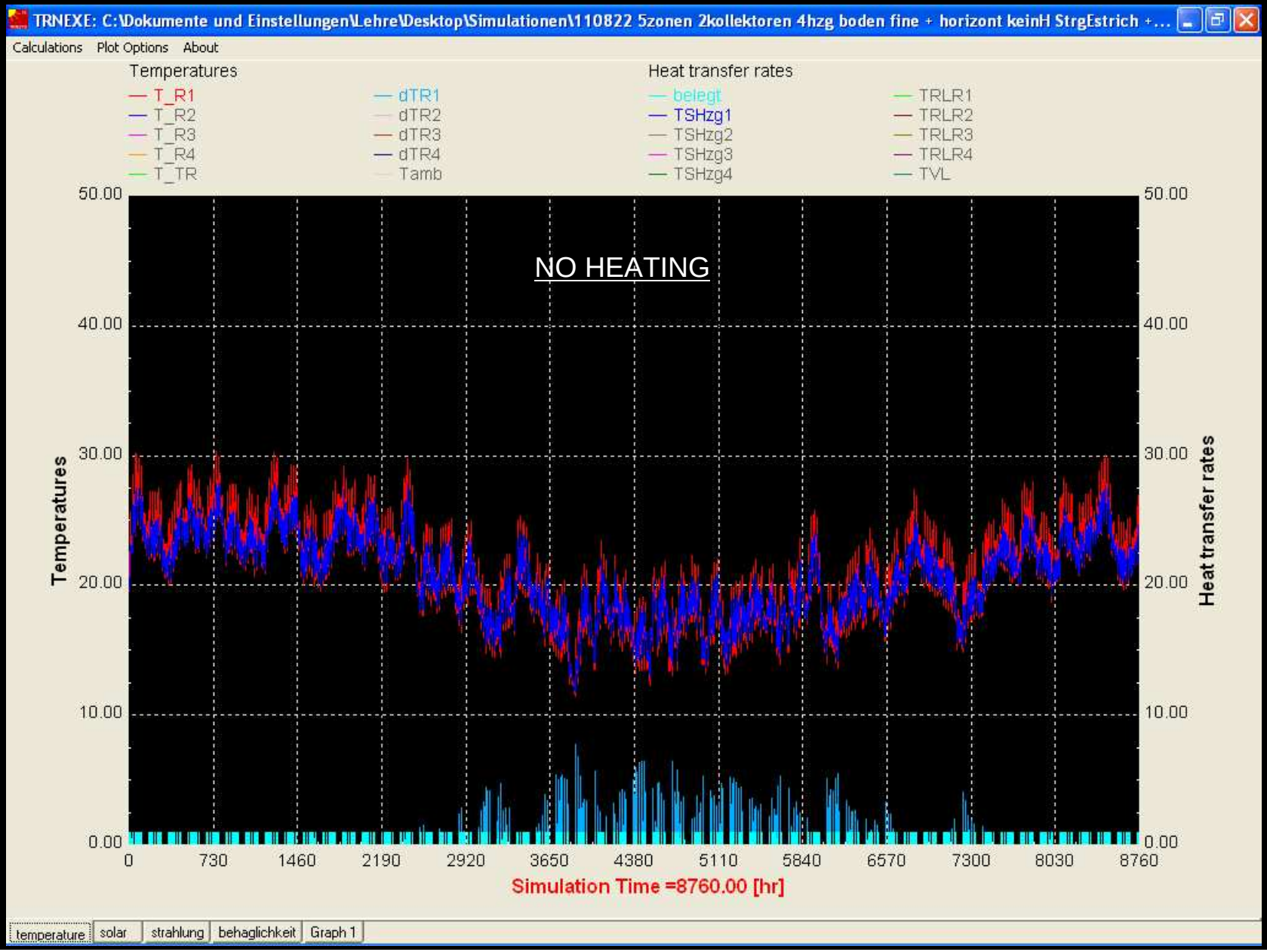

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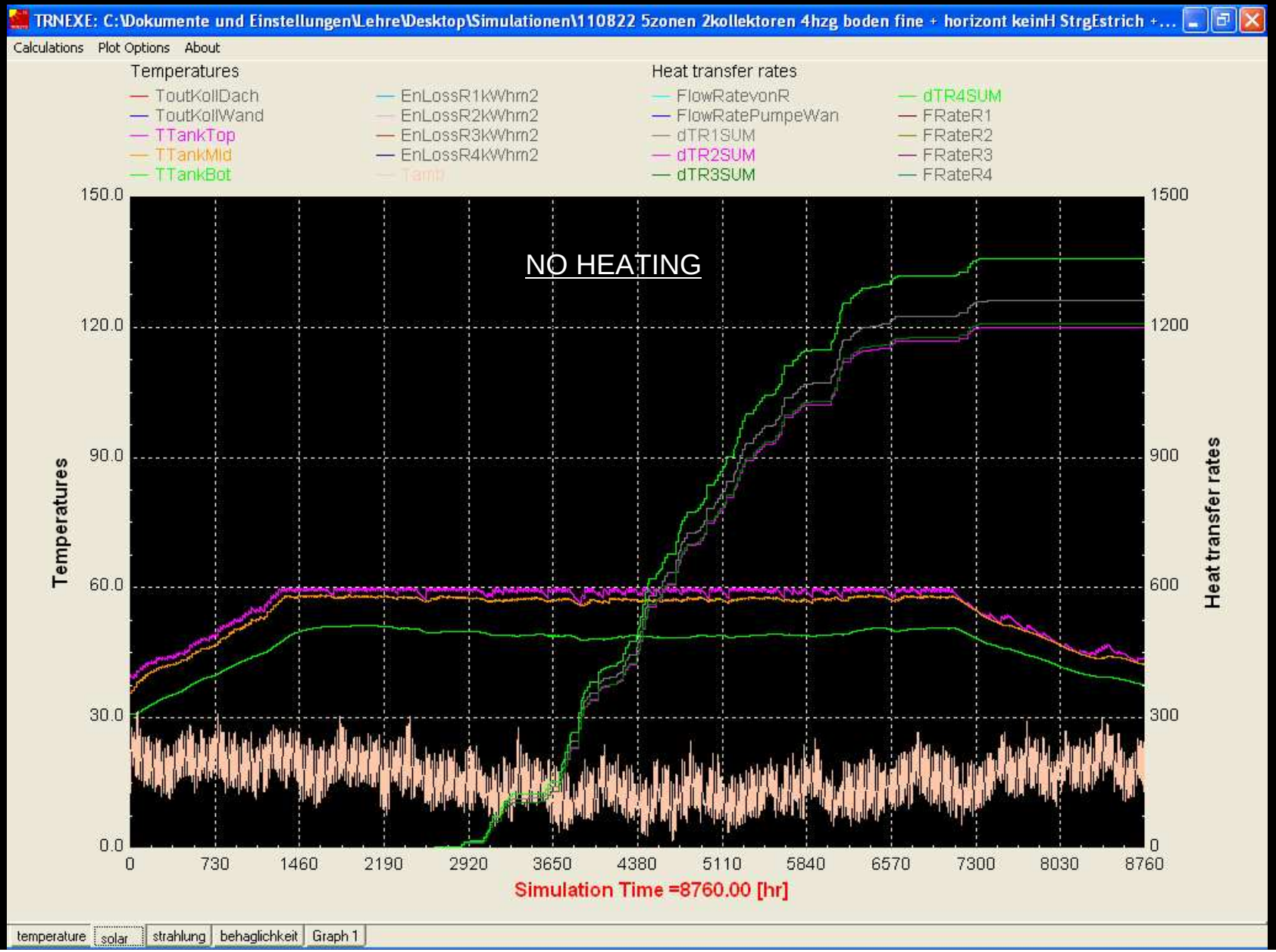

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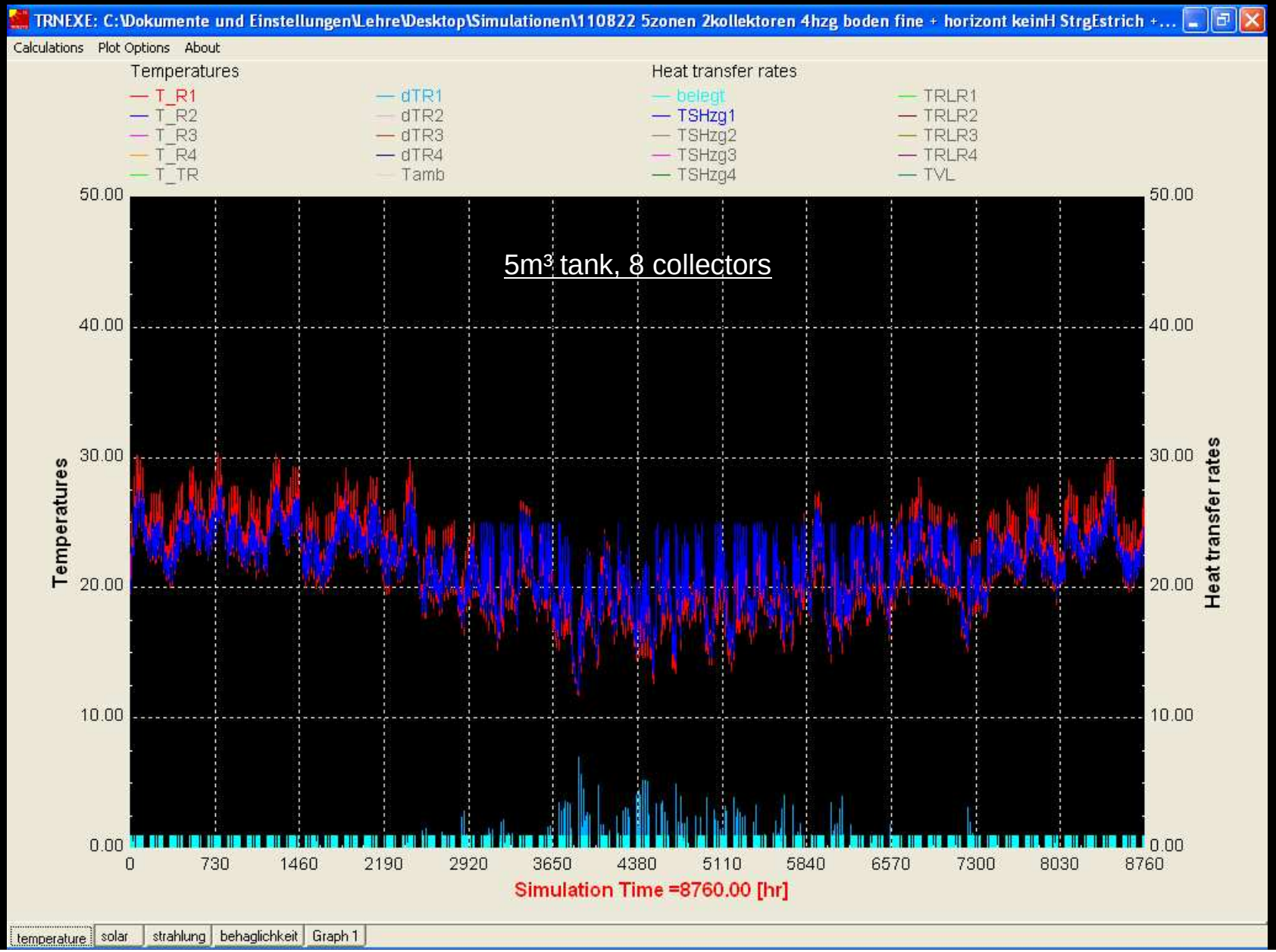

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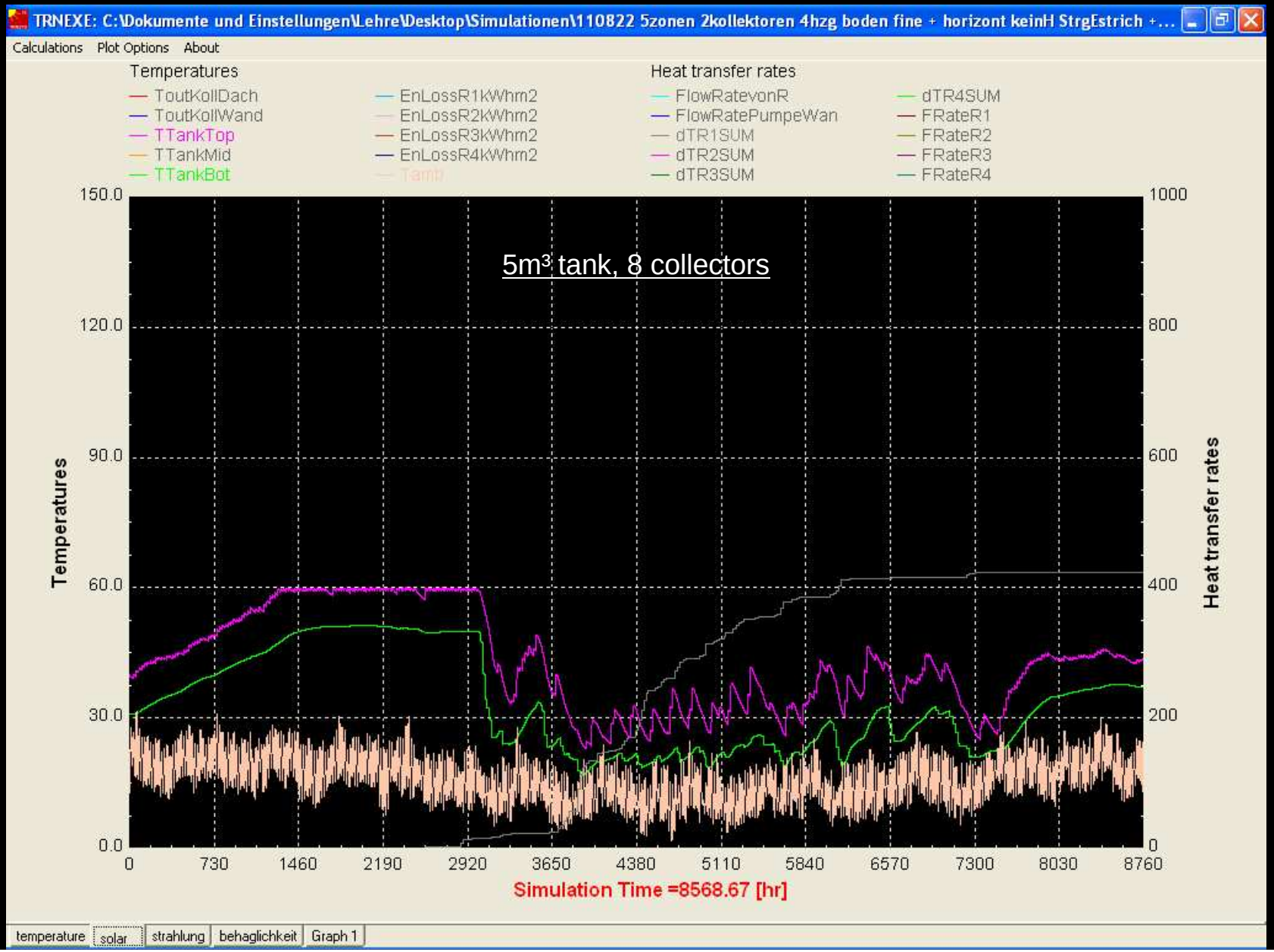

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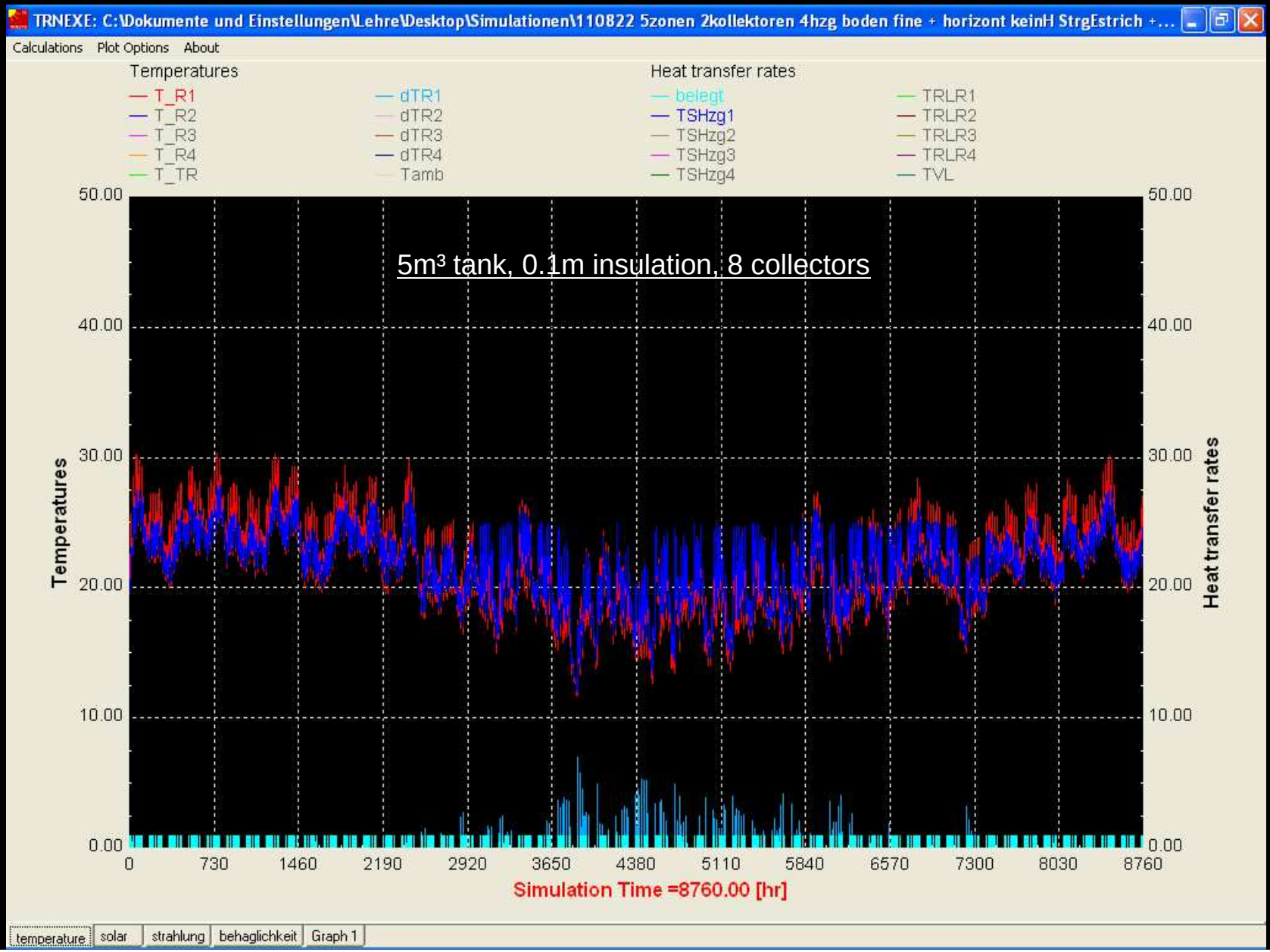

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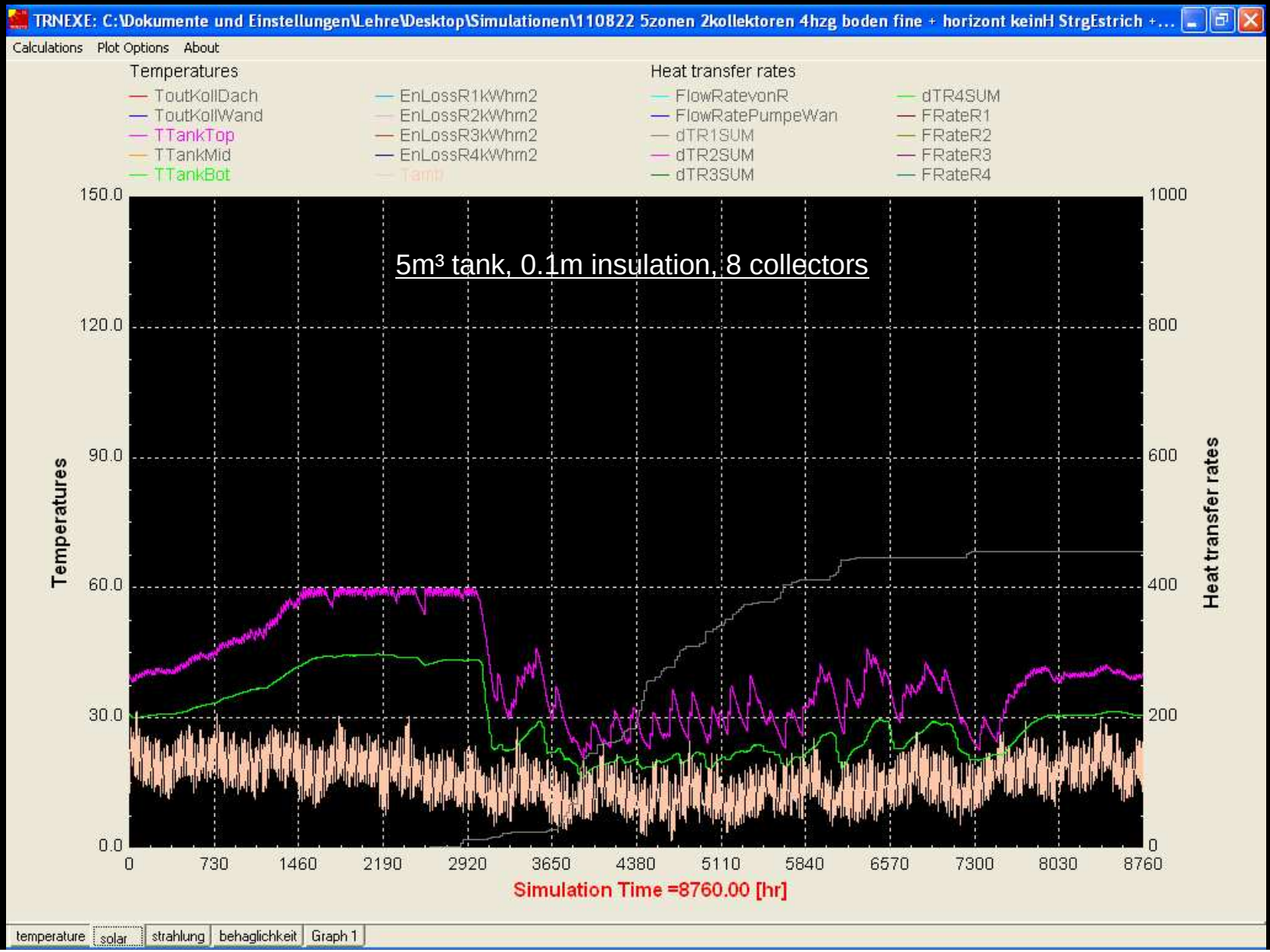

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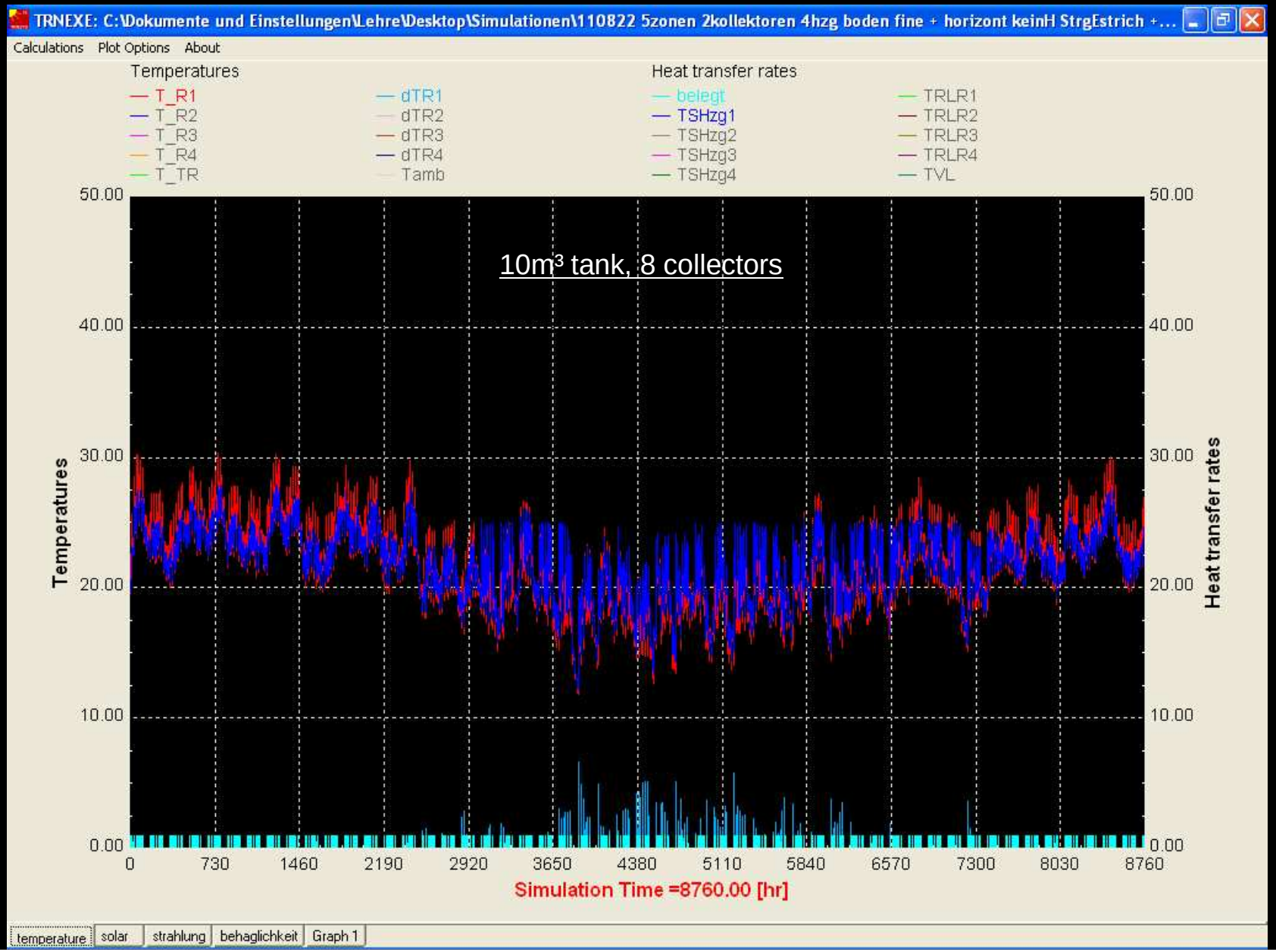

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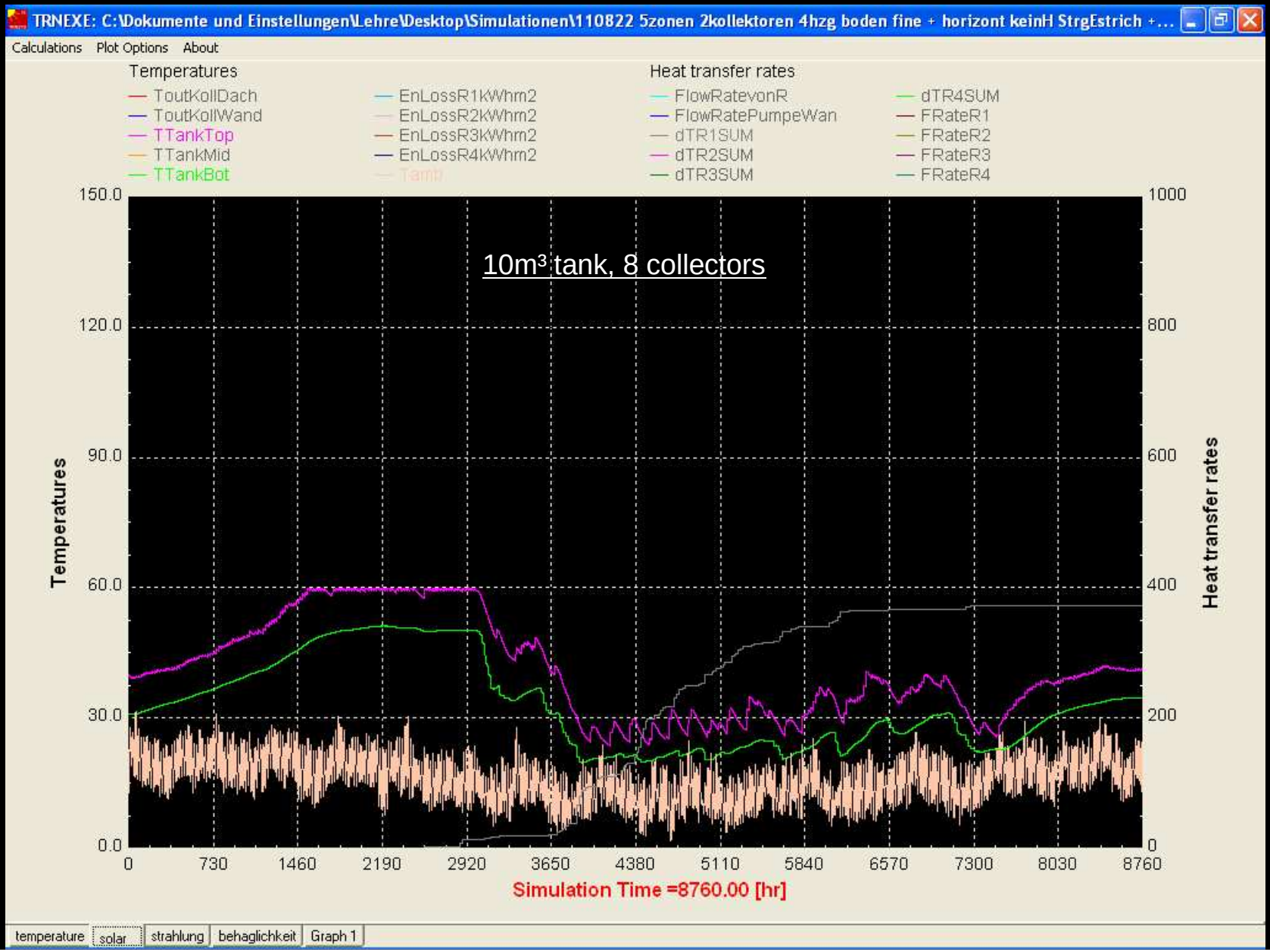

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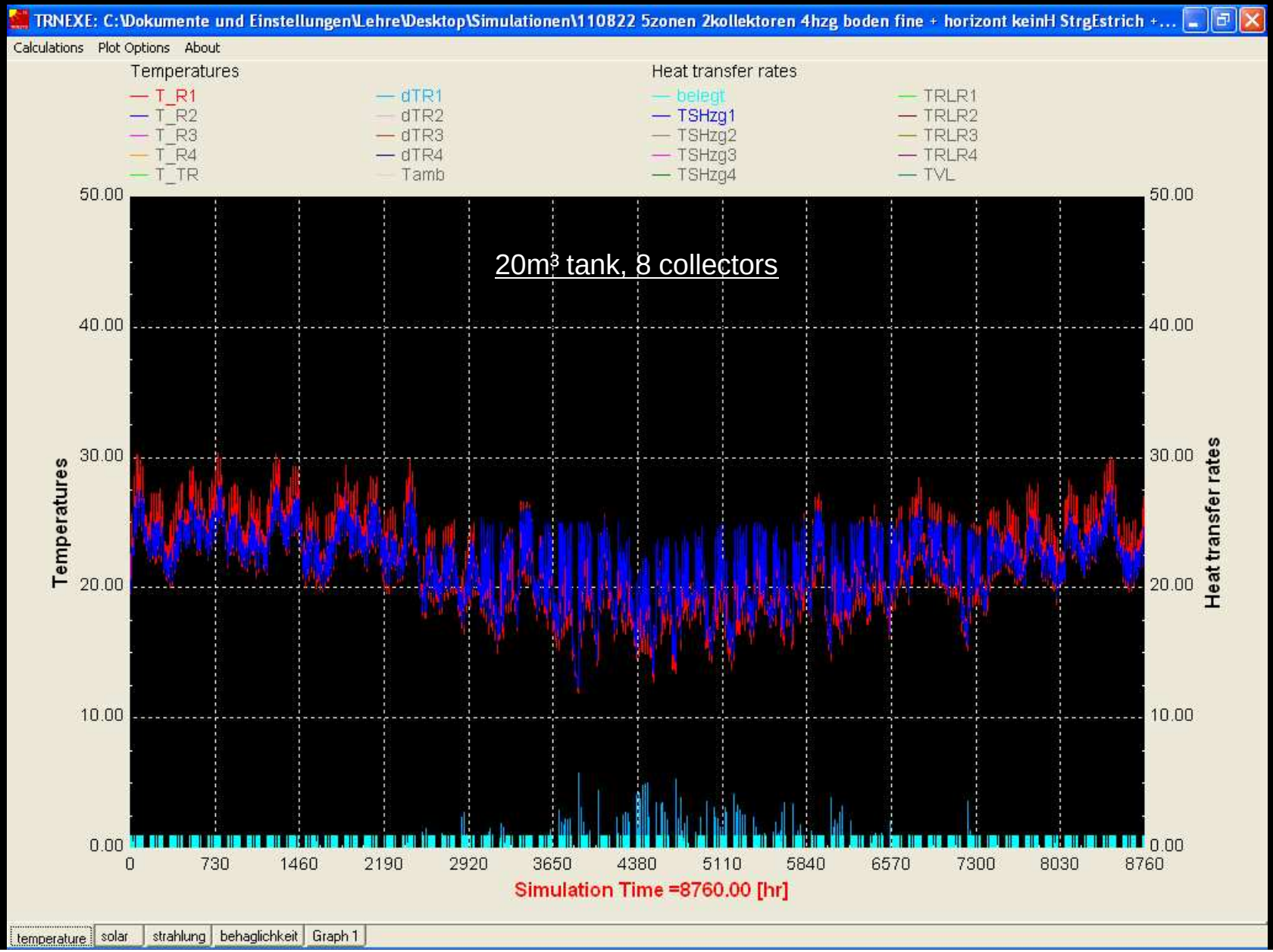

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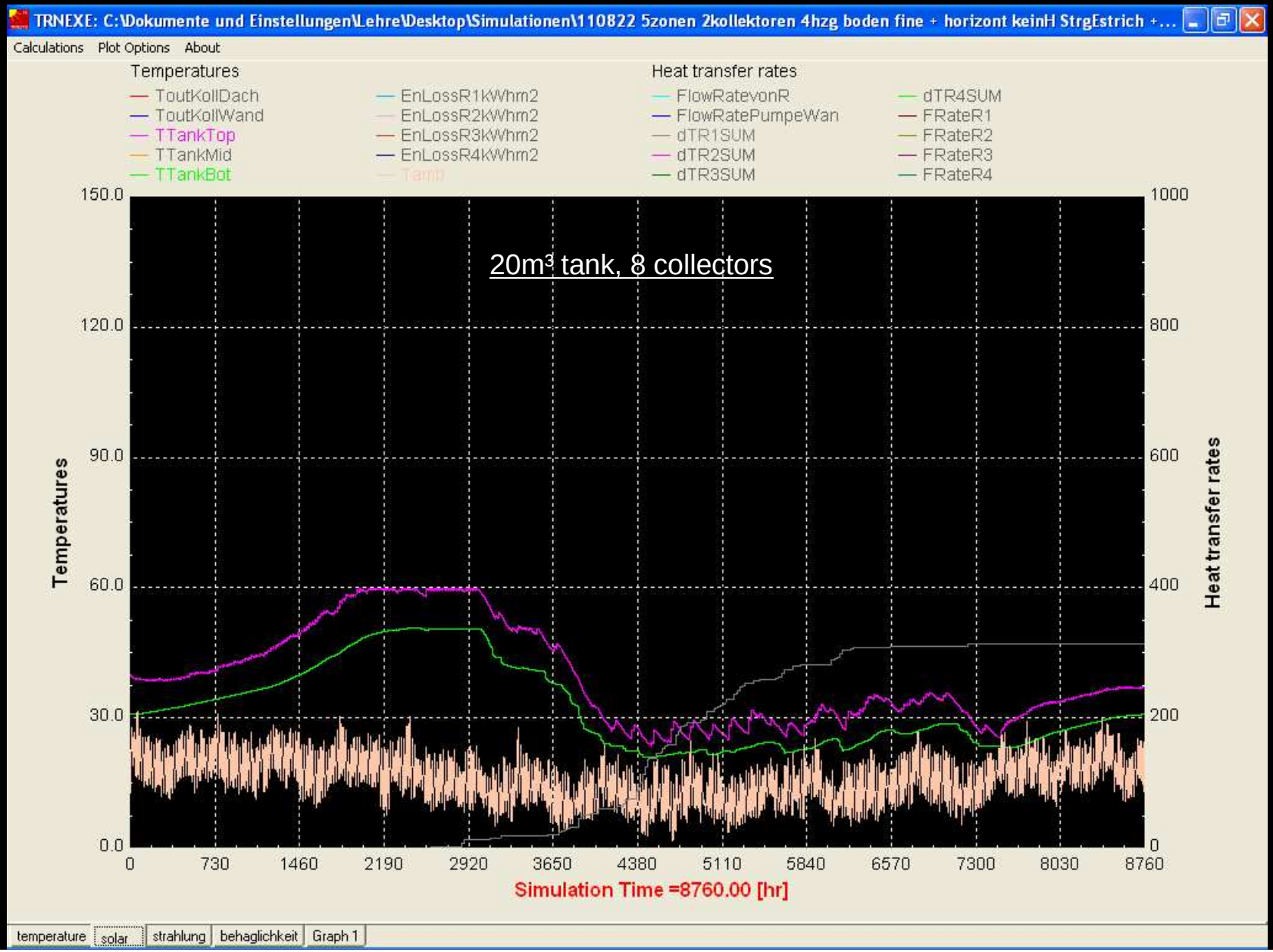

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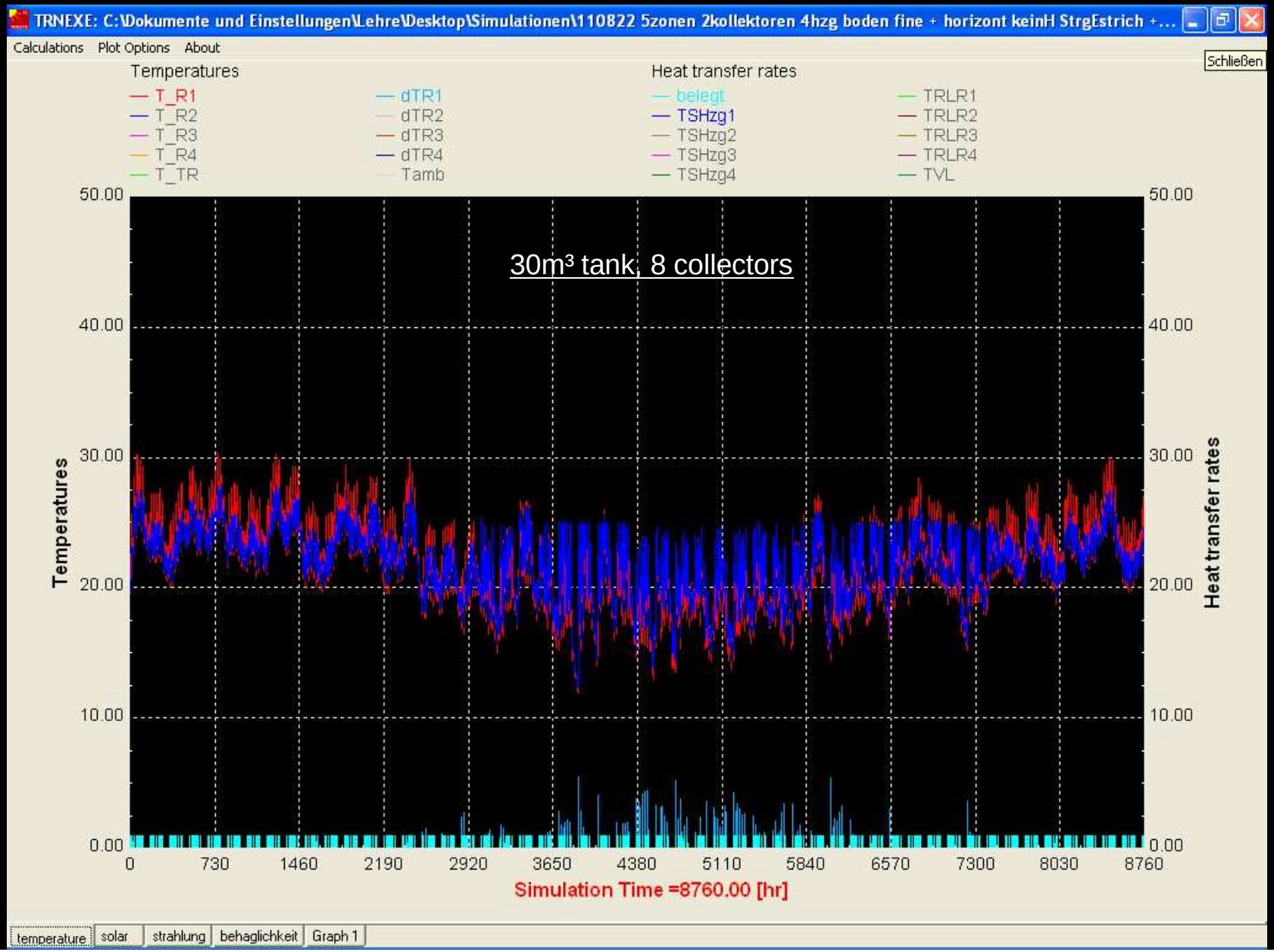

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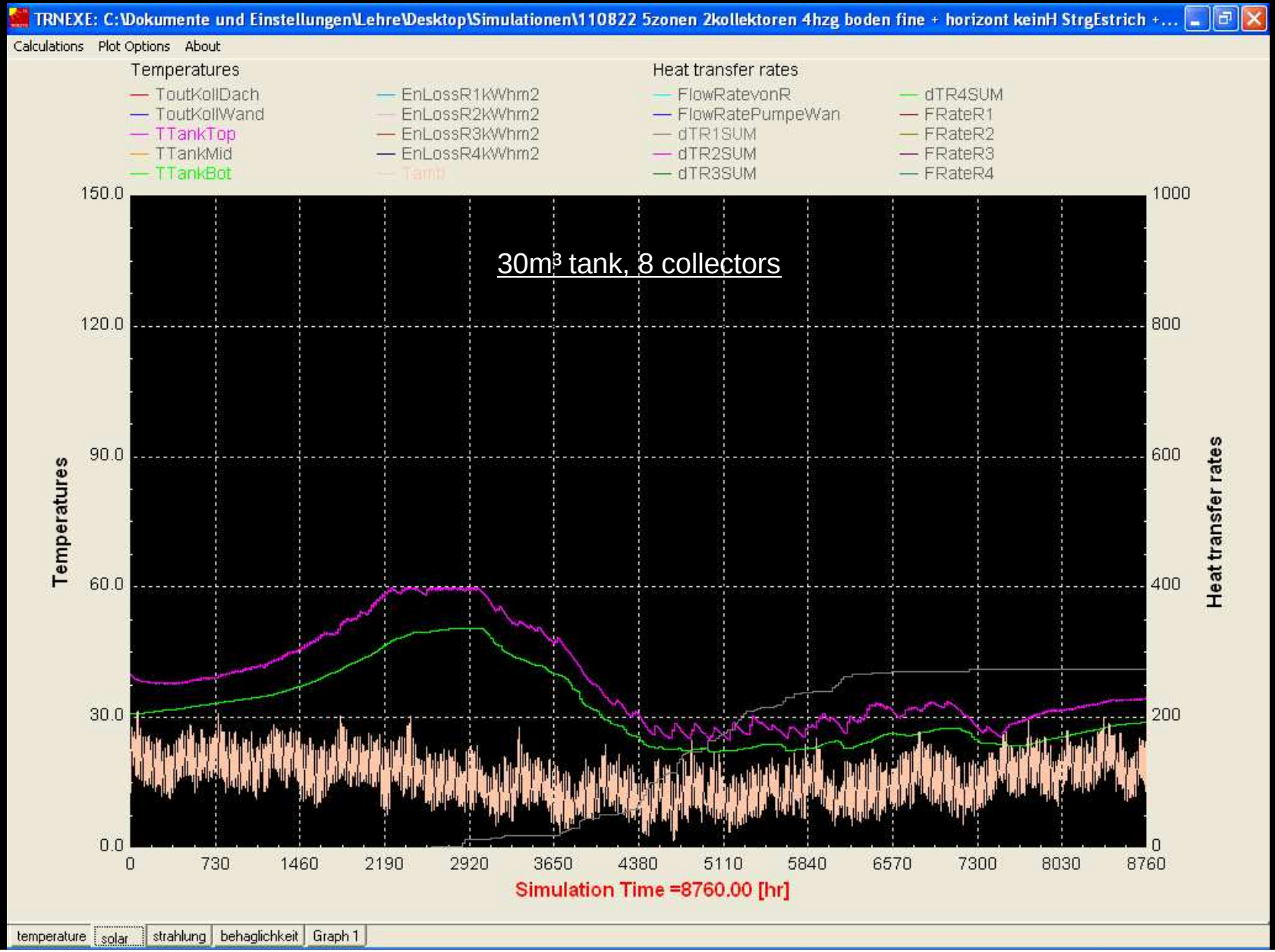
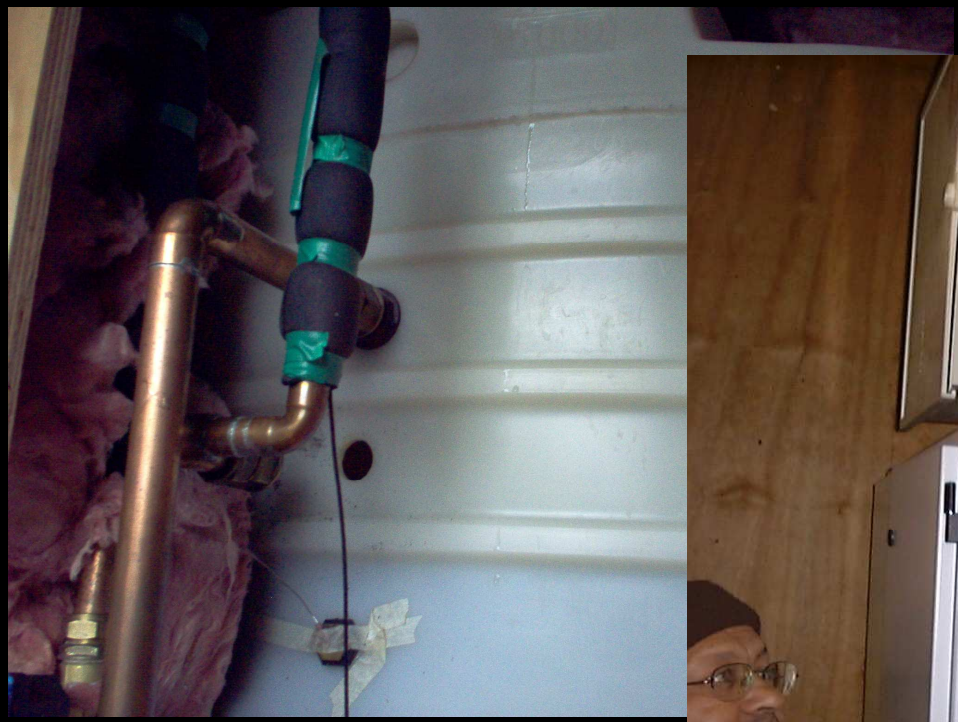


Learned Lessons



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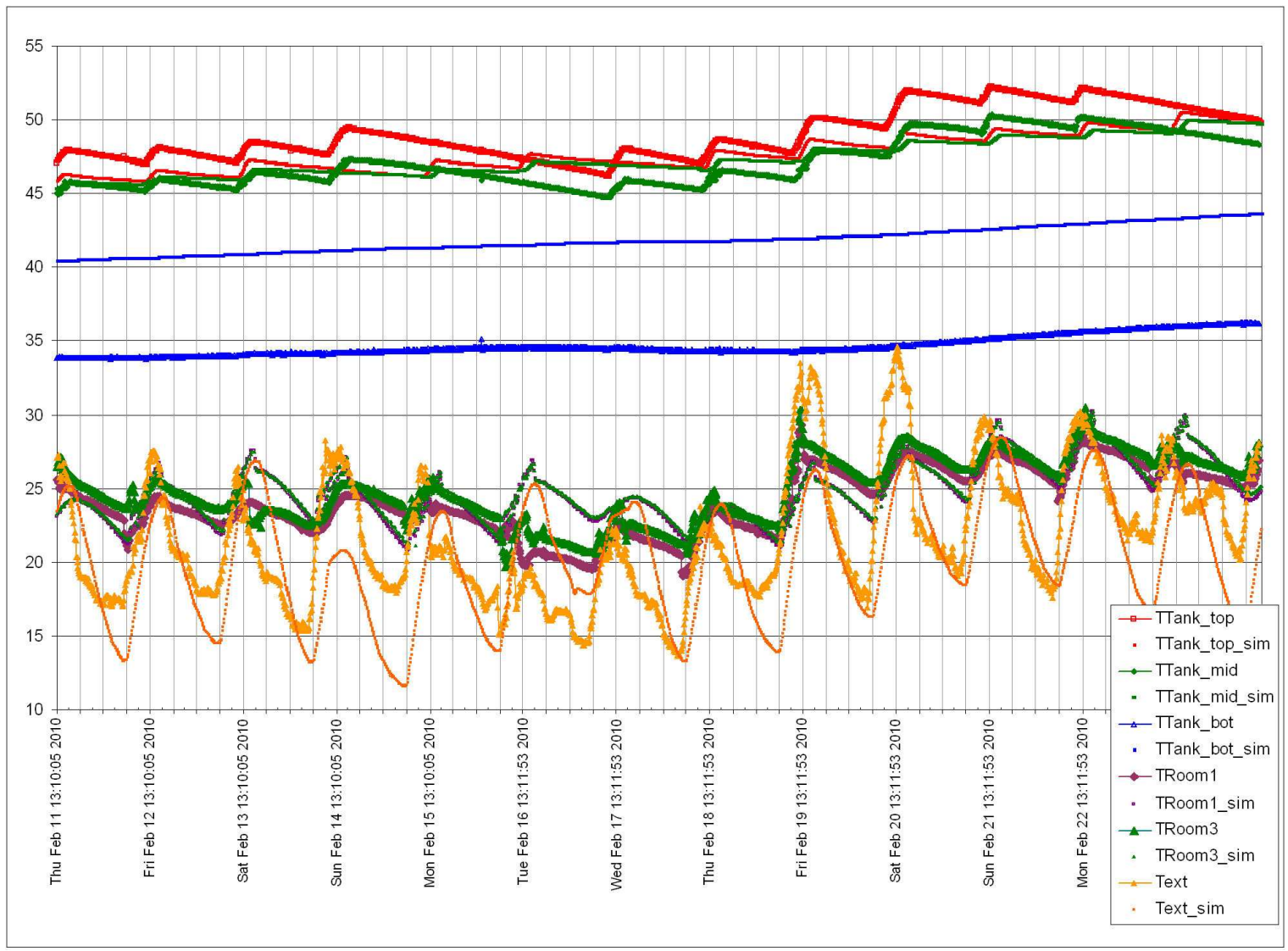

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