IEE Solar Combi+

WP3 – Virtual Case Studies

Actual project stage

Björn Nienborg, Lotta Koch,
Edo Wiemken

Fraunhofer Institute
for Solar Energy Systems ISE

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Fraunhofer Institut
Solare Energiesysteme

Subtasks of WP3

- **3.1** Preparation of system implementation in simulation tools
- **3.2** Definition of applications (3-5) and locations to be studied
- **3.3** Determination of loads for the applications and locations
- **3.4** Determination of basic system configurations and control strategies
- **3.5** Simulation study (variation of locations, buildings, components and parameters)
- **3.6** Energy-related evaluation of case studies
- **3.7** Economic-related evaluation of case studies

3.2: Definition of applications and locations

- Locations
- I. Office building
  cold distribution system: fan coils, supply air cooling
  (10°C/15°C)
- II. Residential building
  cold distribution system: fan coils (10°C/15°C)
- III. Residential building
  cold distribution system: chilled ceilings, etc. (15°C/18°C)

Ecoheatcool: European heating index EHI

- **3 climatic zones**

  Selected by EHI / ECI:

  ○ 100 / 100 – Strasbourg, Franc

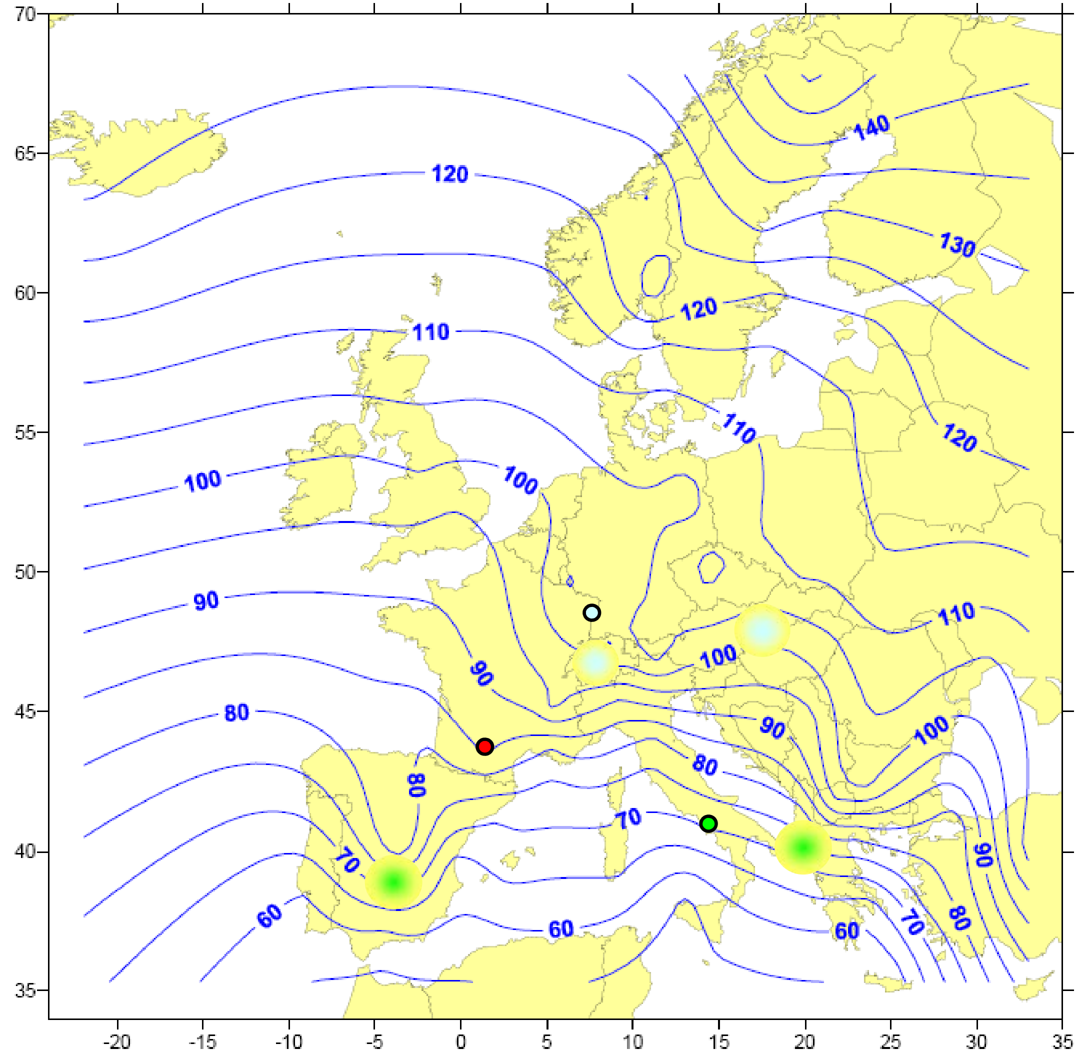
  ● 85 / 115 – Toulouse, France

  ● 70 / 140 – Naples, Italy

  Areas with similar EHI / ECI index (latent loads not considered):

  100 / 100

  70 / 140



Source: Ecoheatcool / WP1: European heat market

Ecoheatcool: European cooling index ECI

- **3 climatic zones**

  Selected by EHI / ECI:

  ○ 100 / 100 – Strasbourg, France

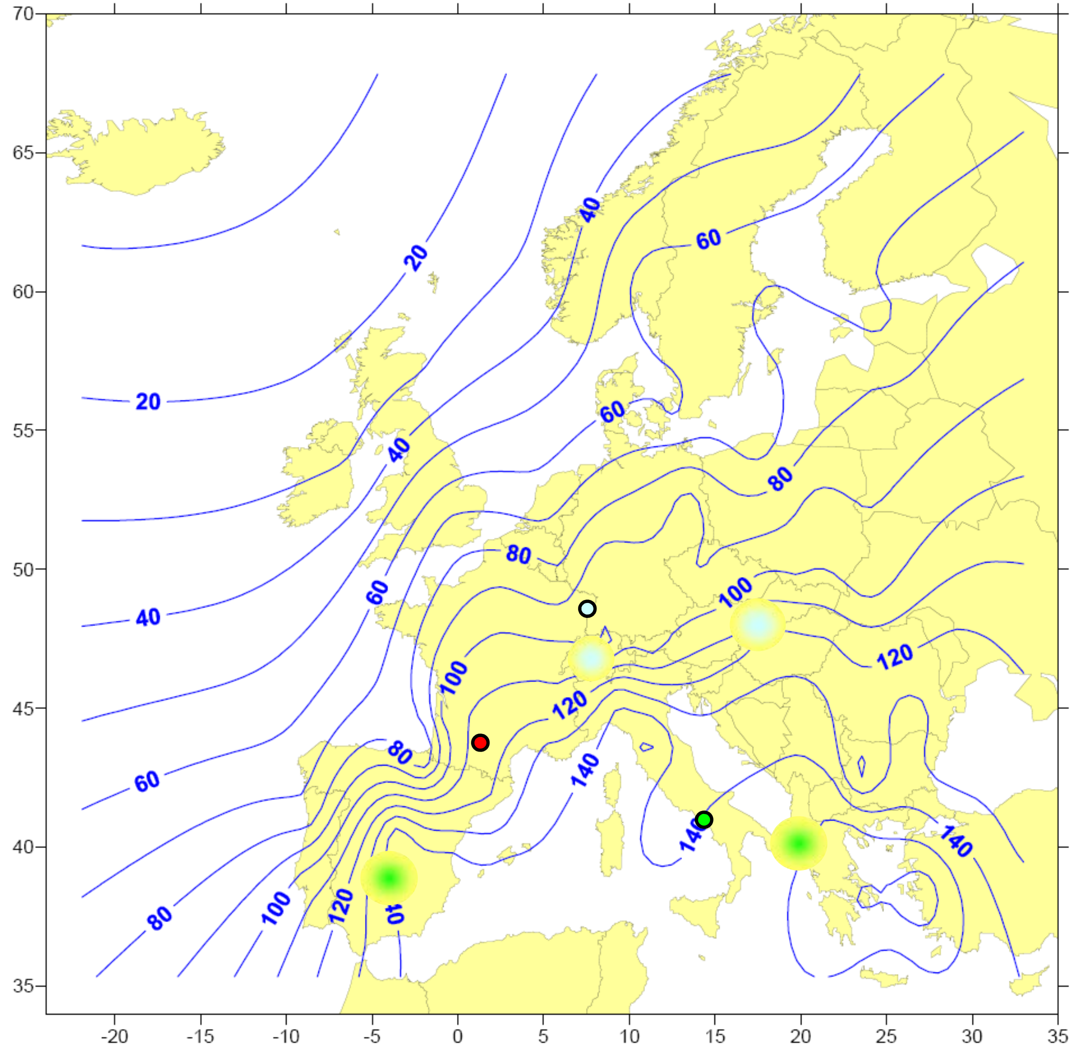
  ● 85 / 115 – Toulouse, France

  ● 70 / 140 – Naples, Italy

  Areas (latent loads not considered) with respective index EHI / ECI index:

  100 / 100

  70 / 140



Source: Ecoheatcool / WP2: European cold market

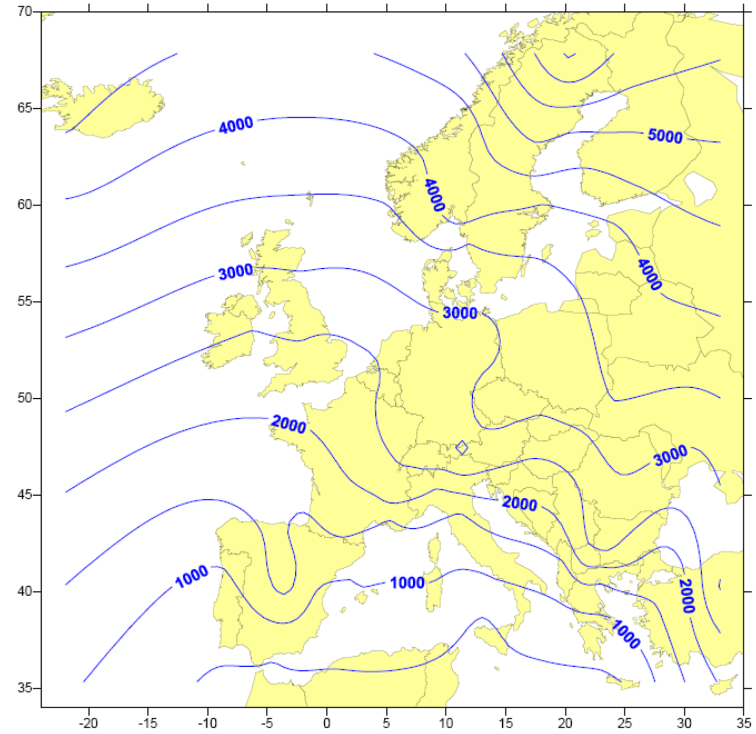
3.2: Definition of applications and locations

- Building standard:

→ not according to assumption in ECOHEATCOOL:

insulation ~ [heat-degree-days]$^{1/2}$

→ Unchanged (according to available reference building models)



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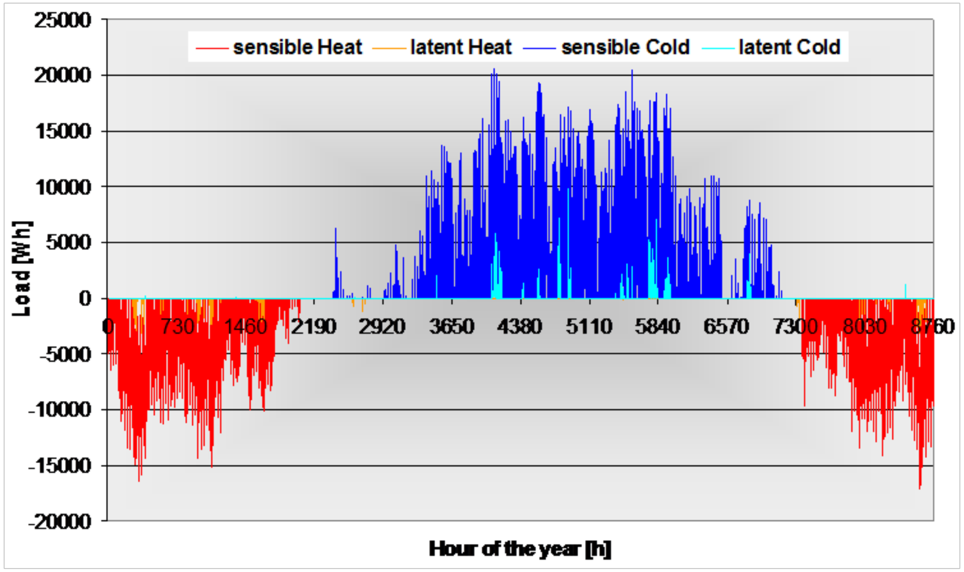
3.2: Definition of applications and locations

- I. Office building
  cold distribution system: fan coils, supply air cooling
  (10°C/15°C)

→ One-storied office building

→ Ca. 310m² cooled floor area

→ Based on Task 38 reference building



Load profile of office building for Toulouse

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3.2: Definition of applications and locations

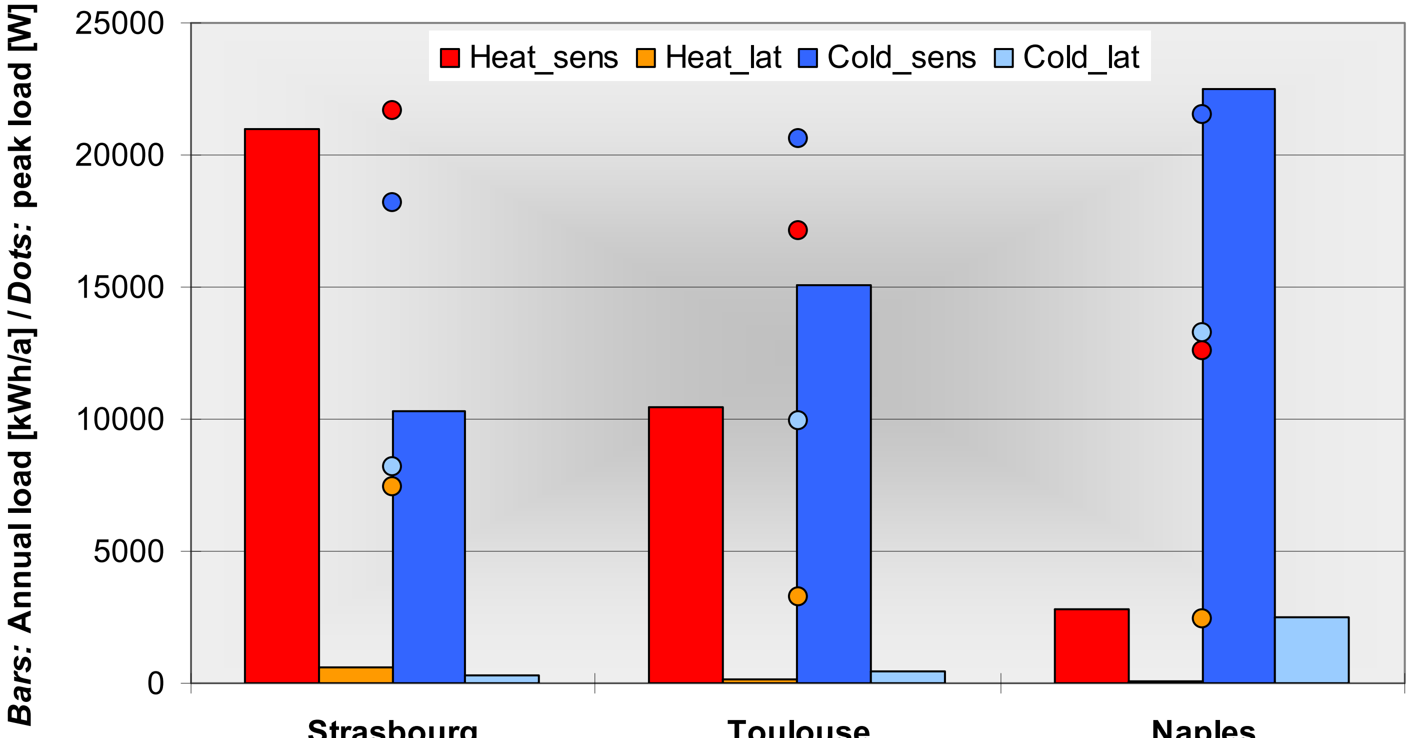
- I. Office building
  cold distribution system: fan coils, supply air cooling
  (10°C/15°C)

OFFICE (310 m² conditioned area)										
	Heating				Cooling				DHW	
	sensible	latent	sensible	latent	sensible	latent	sensible	latent	-	-
	kWh/a	kWh/a	kWh/ m²*a	kWh/ m²*a	kWh/a	kWh/a	kWh/ m²*a	kWh/ m²*a	kWh/a	kWh/ m²*a
Strasbourg	20999	621	67.74	2.00	10303	295	33.24	0.95	0	0
Toulouse	10437	143	33.67	0.46	15102	484	48.72	1.56	0	0
Naples	2796	62	9.02	0.20	22537	2496	72.70	8.05	0	0

→ Heating load: sensible load
→ Cooling load: sensible + latent load

3.2: Definition of applications and locations

- I. Office building



3.2: Definition of applications and locations

- II / III. Residential buildings
  II. cold distribution system: fan coils (10°C/15°C)
  III. cold distribution system: chilled ceiling (15°C/18°C)

→ Two-storied building

→ 140 m² cooled floor area

→ Based on Task 32 reference buildings

→ 2 building standards (60kWh/m² and 100kWh/m² in Zurich, Switzerland)

→ Only 2 locations (Toulouse and Naples)

3.2: Definition of applications and locations

- II / III. Residential buildings
  II. cold distribution system: fan coils (10°C/15°C)
  III. cold distribution system: chilled ceiling (15°C/18°C)

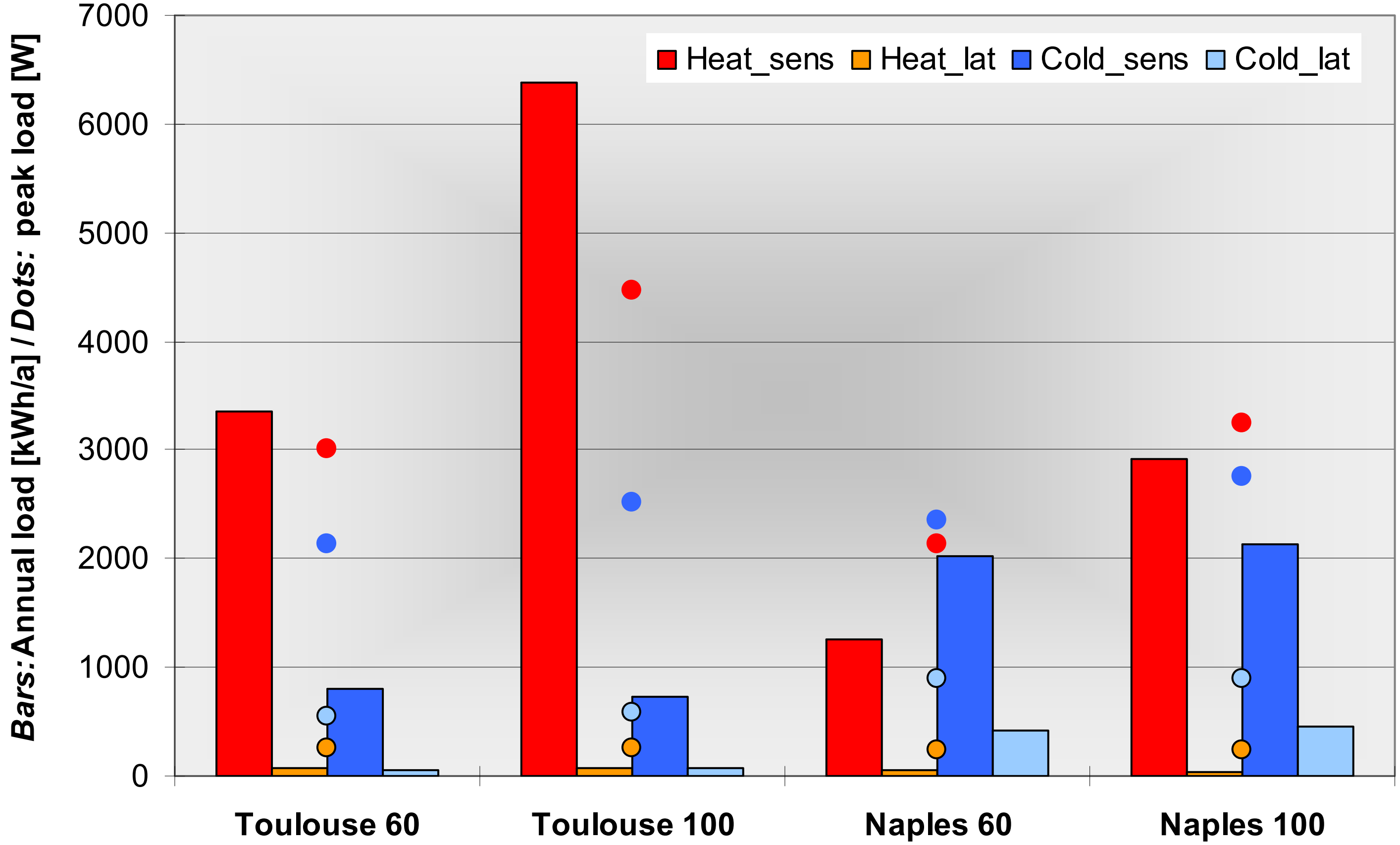
Residential (140 m² conditioned area)										
	Heating				Cooling				DHW	
	sensible	latent	sensible	latent	sensible	latent	sensible	latent	-	-
	kWh/a	kWh/a	kWh/ m²*a	kWh/ m²*a	kWh/a	kWh/a	kWh/ m²*a	kWh/ m²*a	kWh/a	kWh/ m²*a
Strasbourg *	-	-	-	-	-	-	-	-	-	-
Toulouse 60	3361	82	24.00	0.58	800	58	5.71	0.41	1772	12.66
Toulouse 100	6376	71	45.54	0.51	726	71	5.18	0.51	1772	12.66
Naples 60	1265	46	9.04	0.33	2032	412	14.51	2.94	1600	11.43
Naples 100	2917	39	20.83	0.28	2135	449	15.25	3.20	1600	11.43

Fan coils
→ Heating load: sensible load
→ Cooling load: sensible + latent load

Chilled ceiling:
→ Heating load: sensible load
→ Cooling load: sensible load

3.2: Definition of applications and locations

- II / III. Residential buildings



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3.3: Determination of loads

- **Problem: Building models with fixed geometry**
  chillers with 4.5 kW – 15 kW nominal chilling capacity + fixed load files → difficult to compare

- **Approach**
  → scaling of load file

$$f_{scale} = \frac{Q_{chill,ref}}{Q_{coolingload,\max}}$$

$Q_{chill,ref}$: Chilling power at reference temperatures

$Q_{coolingload,max}$: Maximum cooling load of load file

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3.3: Determination of loads

- **Chilling power at reference inlet temperatures**

- hot water circuit:	80°C for flat plate collector
	85°C for evacuated tube collector
- cooling water circuit:	27°C for wet cooling tower
	35°C for dry cooling tower
- chilled water circuit:	18°C for chilled ceiling
	15°C for fan coil

- **Maximum cooling load of load file**

  - maximum sensible + latent cooling load for fan coil
  - maximum sensible cooling load for chilled ceiling

3.4: Basic system configurations

- 2 standard configurations have been defined
- 1 configuration does NOT meet "Spanish requirement"
- Each chiller will be simulated with one configuration
- Variation of components

  - collector (flat plate or vacuum tube)

  - cooling tower (wet or dry)

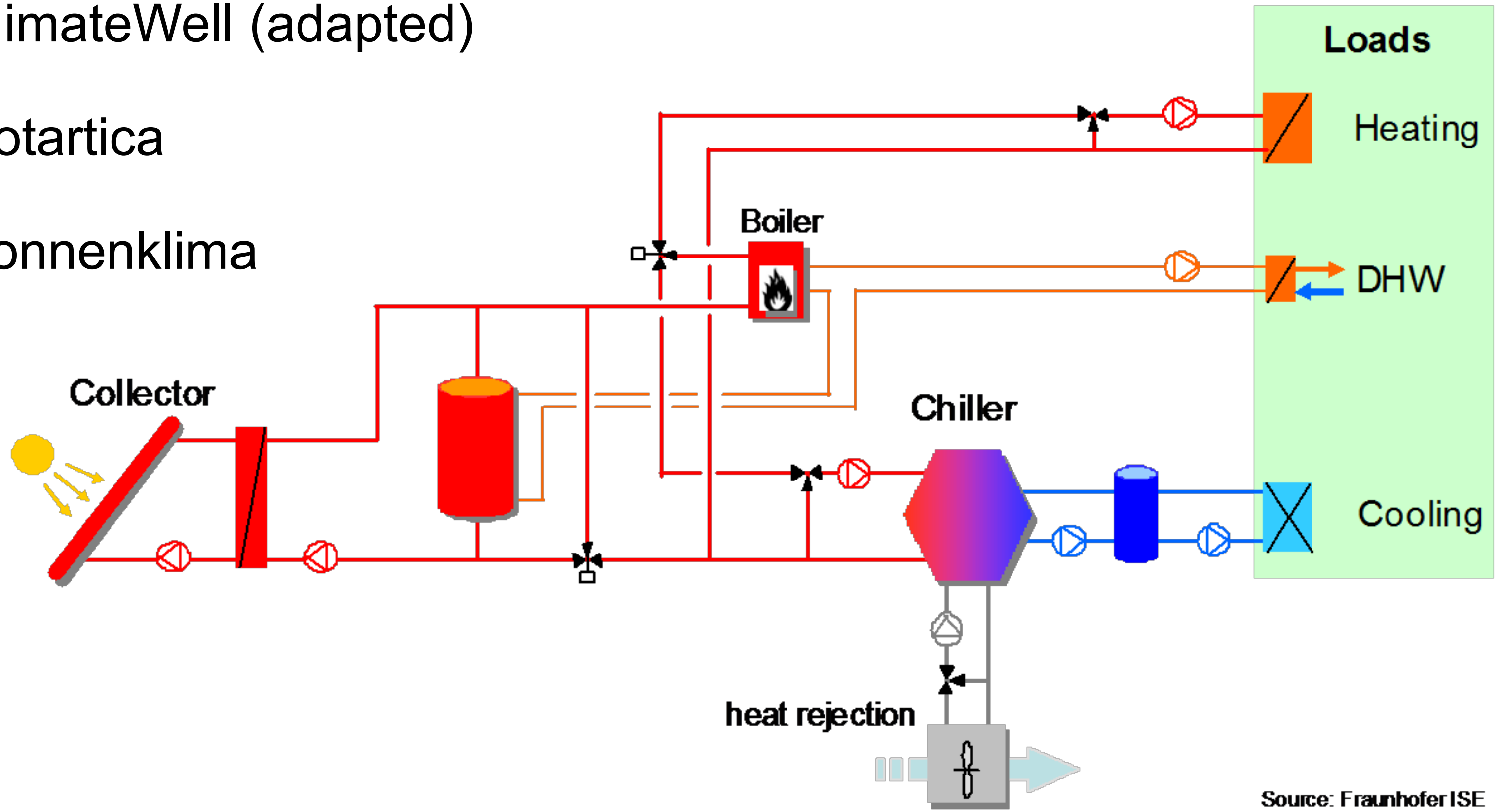
  - cold distribution system (fan coil or chilled ceiling)

  - load file (building and location)

3.4: System configuration C1

Simulated for:

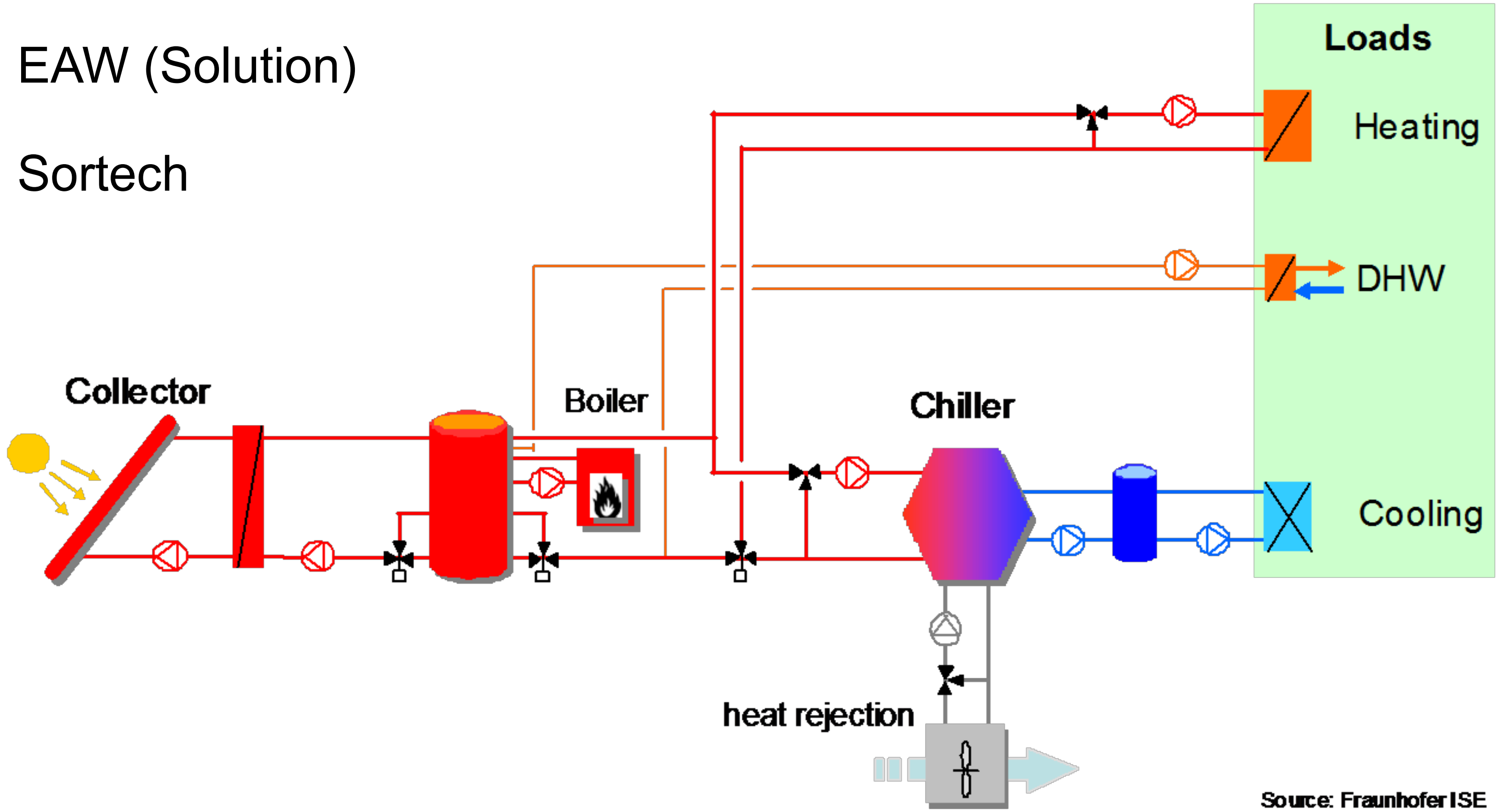
- ClimateWell (adapted)
- Rotartica
- Sonnenklima



3.4: System configuration E1

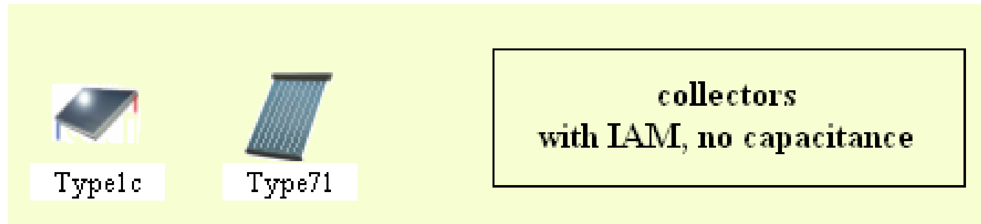
Simulated for:

- EAW (Solution)
- Sortech



3.4: Collectors

- Standard Trnsys components



Collector	Type	Tested flow rate (kg/hrm²)	η_0	a_1 (W/ Km²)	a_2 (W/ K²m²)
SolTop Cobra X	Flat plate	120	0.823	3.02	0.0125
Phönix CPC 14/21	Evacuated tube	30	0.601	0.767	0.0038

Data referring to aperture area

3.4: Variation of collector area and storage volume

- Collector (aperture area):

  - 5 steps

  - 2 … 5 m²/kW reference chilling capacity

- Hot water storage (volume):

  - 3 steps

  - 25 - 50 - 75 l/m² aperture area

3.4: Chiller models

- ClimateWell: physical model provided by ClimateWell; 2*Type 215 (barrels) + Type 216 (Controller)
- EAW: Type 307 (adapted Type 107) by Eurac
- Rotartica: characteristic model by ISE; Type 231
- Sonnenklima: because of problems with Type 177 characteristic model by ISE; Type 233
- Sortech: model provided by Sortech, implemented in Fortran by ISE; Type 290

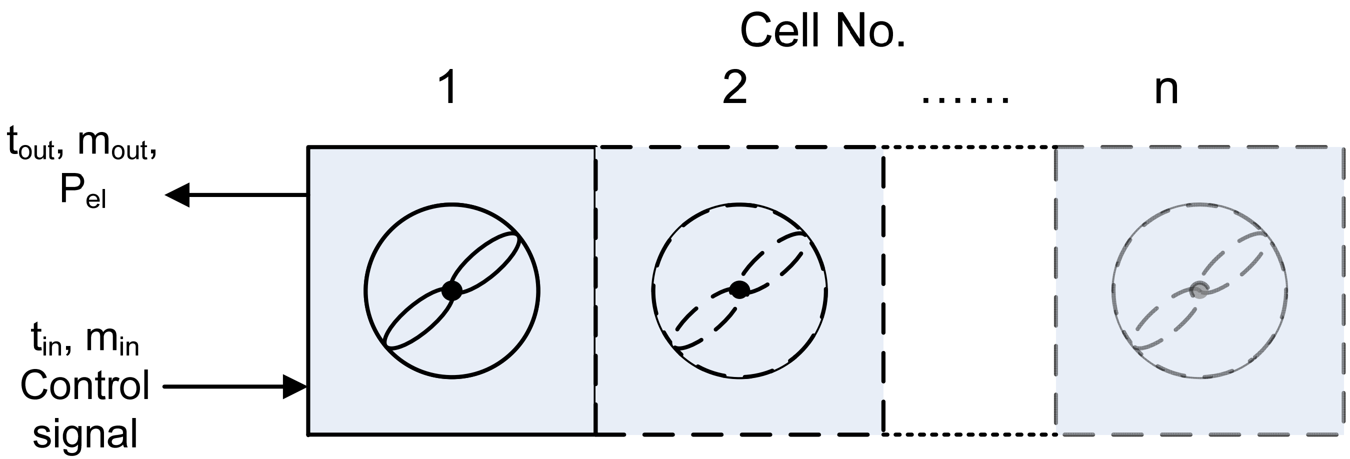
3.4: Heat rejection

- Dry cooler

  - model developed by Francesco Besana (Eurac)

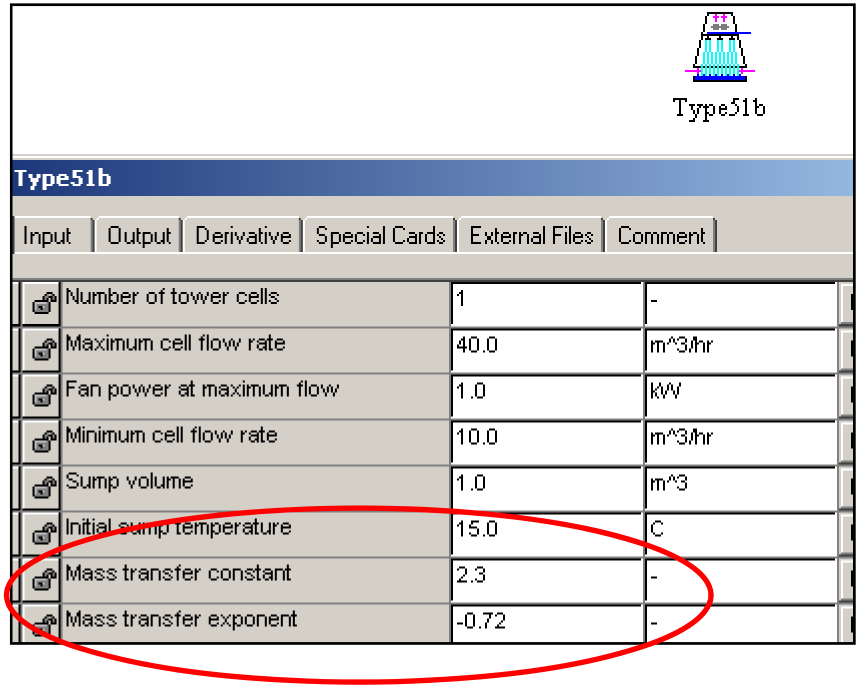
  - definition of a *standard cell* with one fan

  - number of cells can be selected by user (adaption to chiller)



3.4: Heat rejection

- Wet cooling tower
  - Trnsys standard Type 51
  - parameters ???
  - Sonnenklima
  - Axima
  - Type 551 by TU Berlin ??



Number of tower cells	1	-
Maximum cell flow rate	40.0	m^3/hr
Fan power at maximum flow	1.0	kW
Minimum cell flow rate	10.0	m^3/hr
Sump volume	1.0	m^3
Initial sump temperature	15.0	C
Mass transfer constant	2.3	-
Mass transfer exponent	-0.72	-

3.4: Control strategy

- Collector circuit

  - ΔT-controlled

  - Flow rate dependent on irradiation :

  150 W/m² … 800 W/m² corresponds to 20% … 100 %

- Boiler

  - System C1: if solar heat insufficient then 80°C for chiller;
    40°C for heating; 60°C for DHW

  - System E1:

  winter: storage top 200 l maintained at 60°C

  summer: storage top 200l maintained at 75°C (day) / 70°C (night)

3.4: Control strategy

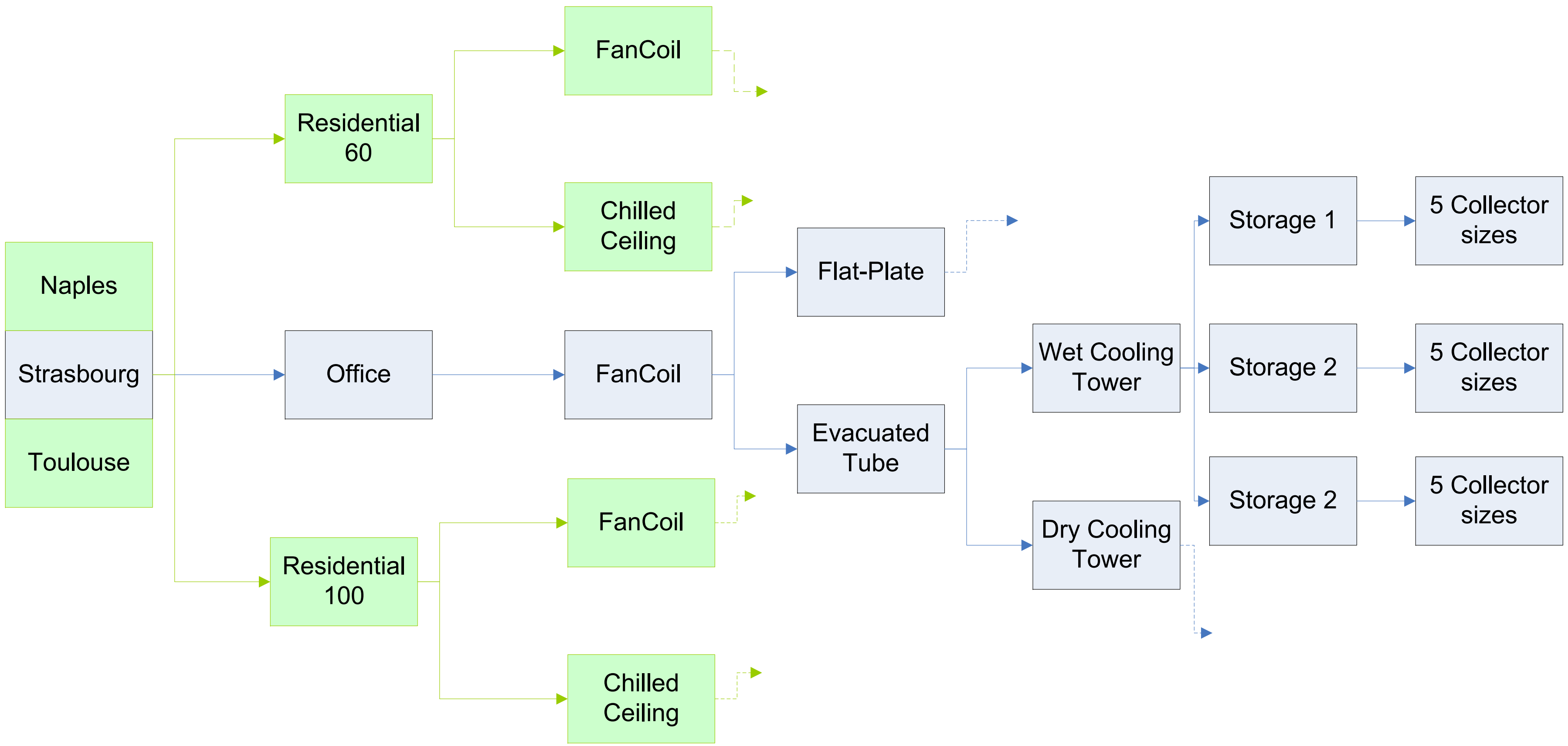
- Chiller
  - runs if cooling demand
  - 1 kWh storage implemented (integrator)
    → to prevent clocking at low cooling loads
    → to reproduce inertia of building
- Control of chilling capacity
  - by fan of heat rejection unit (Sonnenklima)
  - internally by duration of cycles (Sortech)
  - by hot water temperature (Rotartica)
  - none → cold water storage (EAW)
  - ClimateWell ??

3.5: Simulation study

- Division of simulation work:

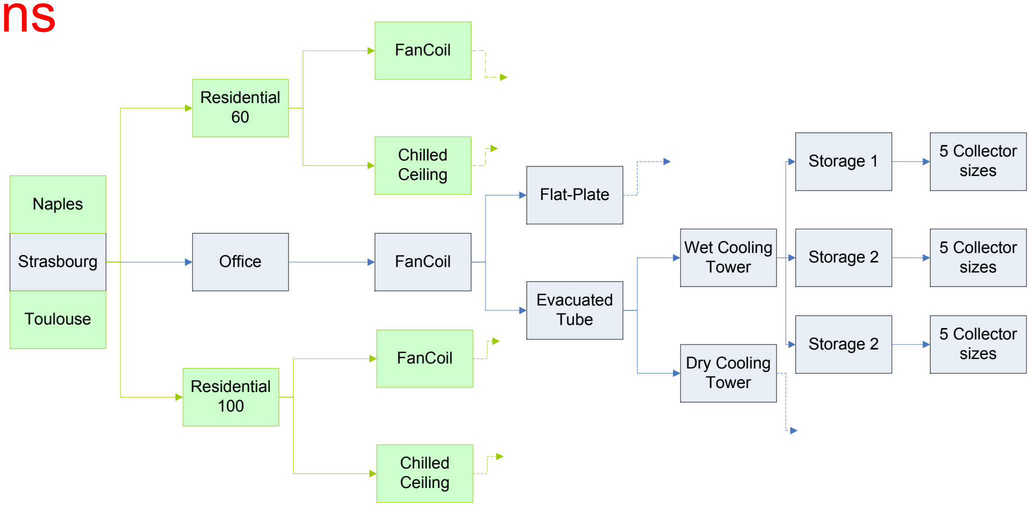
Chiller \ System	C1	E1
ClimateWell	EURAC	
EAW		AEE Intec
Rotartica	UNIBG	
Sonnenklima	CRES	
Sortech		ISE

3.5: Simulation study



3.5: Simulation study

- Strasbourg: 1*2*2*3*5 = 60 variations
- Toulouse: 5*2*2*3*5 = 300 variations
- Naples: 5*2*2*3*5 = 300 variations
- Sub-total: 660 variations per chiller
- TOTAL: 3300 variations



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3.1: Simulation outputs – annual values *

- Thermal energies:

  - sources: collector, boiler

  - consumers: DHW, heating, cooling

  - chiller: all 3 circuits

- Electric energies:

  - heat sources: collector, boiler

  - chiller: all 3 circuits; heat rejection

- Reference system

  - compression chiller

  - boiler

- Rest: water consumption, …

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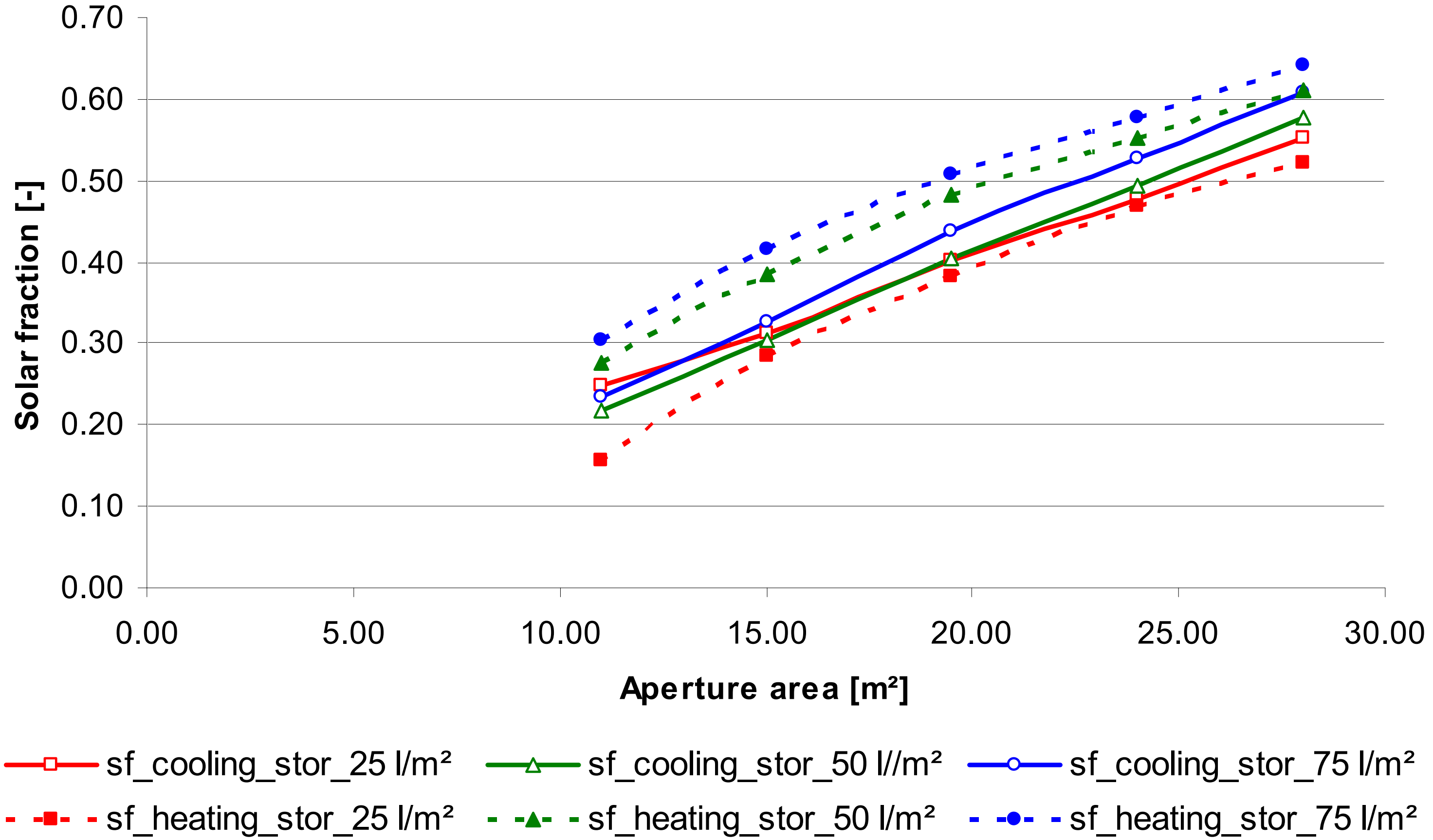
3.1: Simulation output data

Toulouse, office, dry cooling, flat plate collector, Sortech



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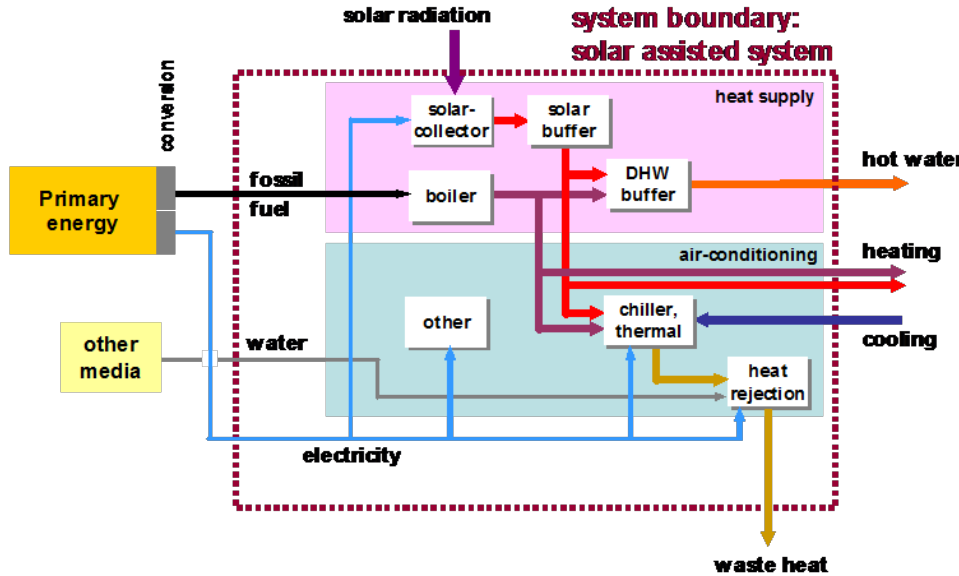
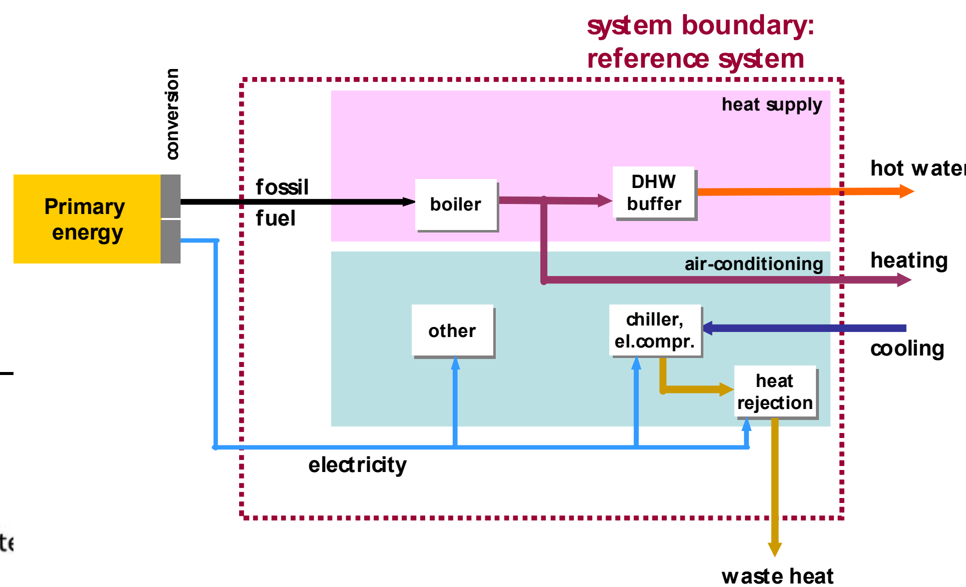
3.6, 3.7: energetic and economic evaluation

- **Performance figures of the system:** Collector efficiency, collector yield, solar fractions, COP, …
- **Environmental performance figures:** PE-savings, PE-COP, CO2-savings, PER, …
- **Economical figures:** Investment costs, annual costs, costs per saved kWh PE, ...





Next steps

- Definition of performance figures
- Completion of dry cooling tower
- Decision on wet cooling tower
- Testing of stability of Trnsys decks
- Carrying out simulations
- Verification of results
- Comparison of system C1 and E1
- …

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Deliverables

- D3.1
  Database with case studies: description and results
  month 13 → month 17
- D3.2
  Report with description of methodology
  month 13 → month 17
- D3.3
  Report on results
  month 13 → month 17

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