IEE Solar Combi$^+$

WP3 – Virtual Case Studies

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2nd project meeting February 21-22, 2008
Bilbao, Spain

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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 possible system configurations and control strategies

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Subtasks of WP3

- **3.5** Simulation study (variation: load files, sizes and component characteristics)
- **3.6** Energy-related evaluation of case studies and comparison with reference systems
- **3.7** Economic-related evaluation of case studies and comparison with reference systems

3.2: Definition of applications and locations

- I. Office building
  cold distribution system: fan coils, supply air cooling (7°C/12°C)
- II. Residential building
  cold distribution system: fan coils (7°C/12/°C)
- III. Residential building
  cold distribution system: chilled ceilings, etc. (15°C/20°C)
- Building standard: according to climatic zones of Ecoheatcool?

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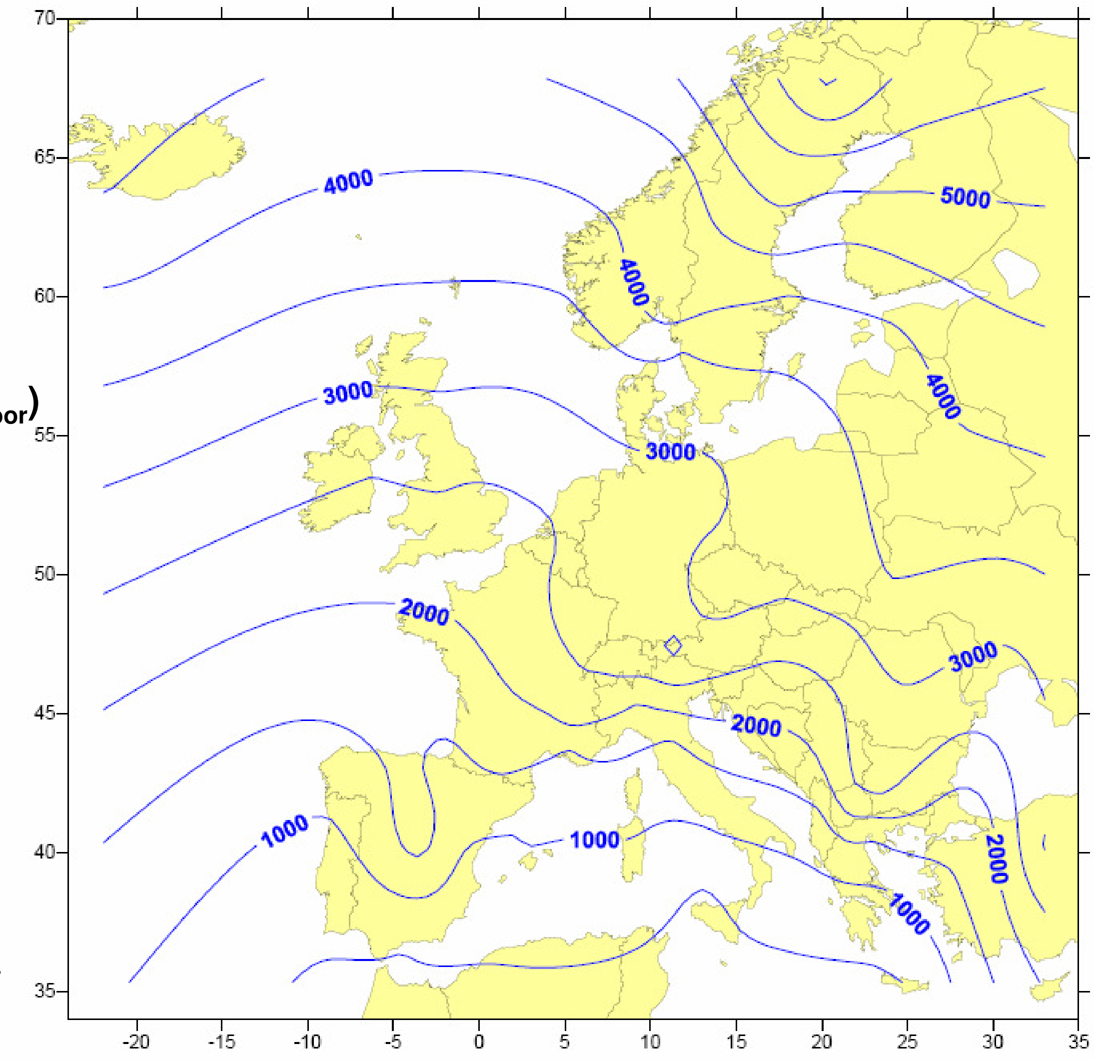
3.2: Definition of applications and locations

Ecoheatcool: Heating degree days

- Method:
  $T_{eff,indoor}$ = 17°C daily average
  $T_{outdoor}$ = daily average
  T_{limit} = 13°C

  if $T_{outdoor} < T_{limit}$:

  h_degree_days = ($T_{eff,indoor} - T_{outdoor}$)

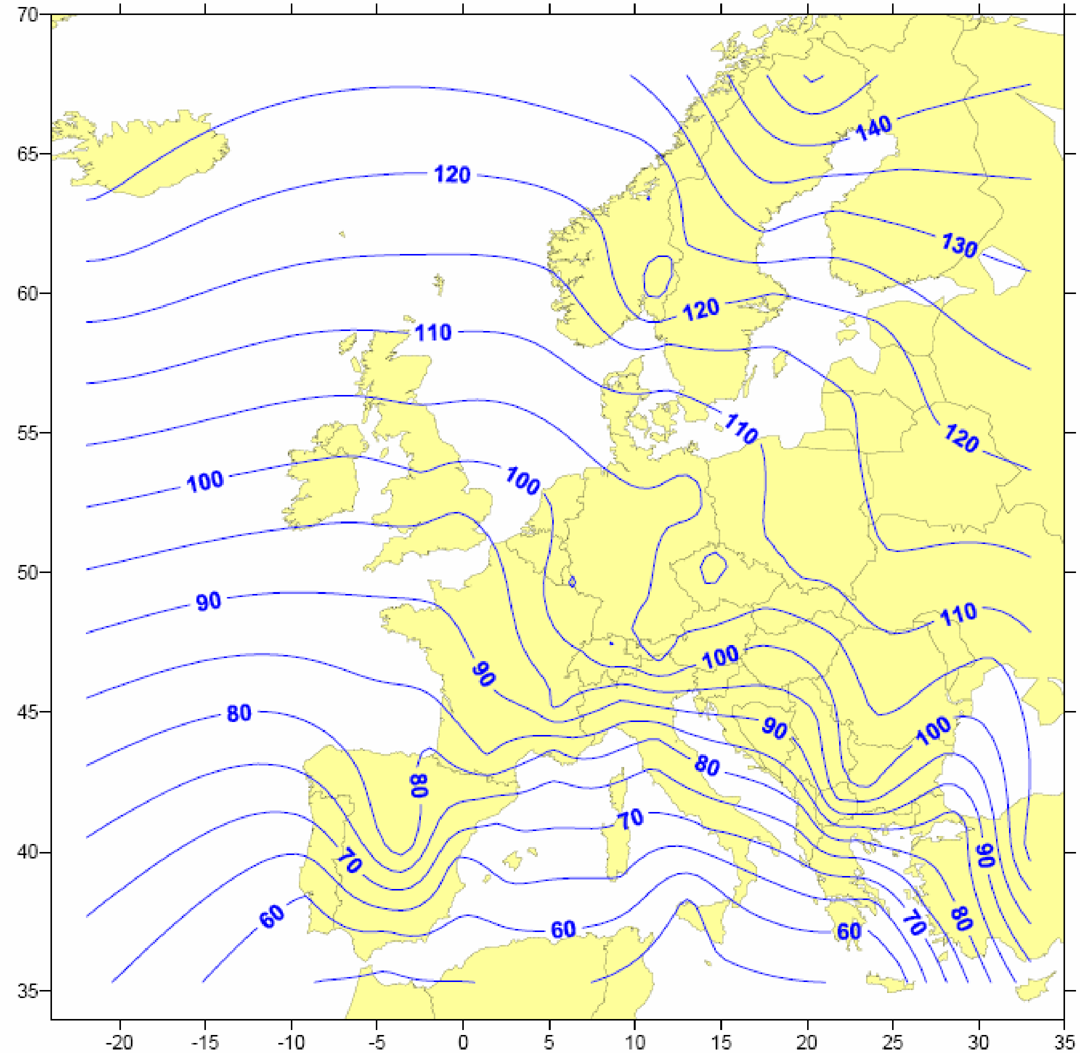


Source: Ecoheatcool / WP1: European heat market

Ecoheatcool: European heating index EHI

- Method:
  opt. Insulation thickness:
  ∝ (h_degree_days)½ ;
  heat use:
  ∝ (h_degree_days)½
  ⇒
  EHI: ∝ (h_degree_days)½ ,
  normalised at h_degree_day
  2600, e.g., Strasbourg
  (av. outdoor temp. approx. 10°C)

- Example:
  EHI Kiruna: 151
  EHI Palermo: 54
  heating demand ratio
  Kiruna / Palermo = 151/54 = 2.8



Source: Ecoheatcool / WP1: European heat market

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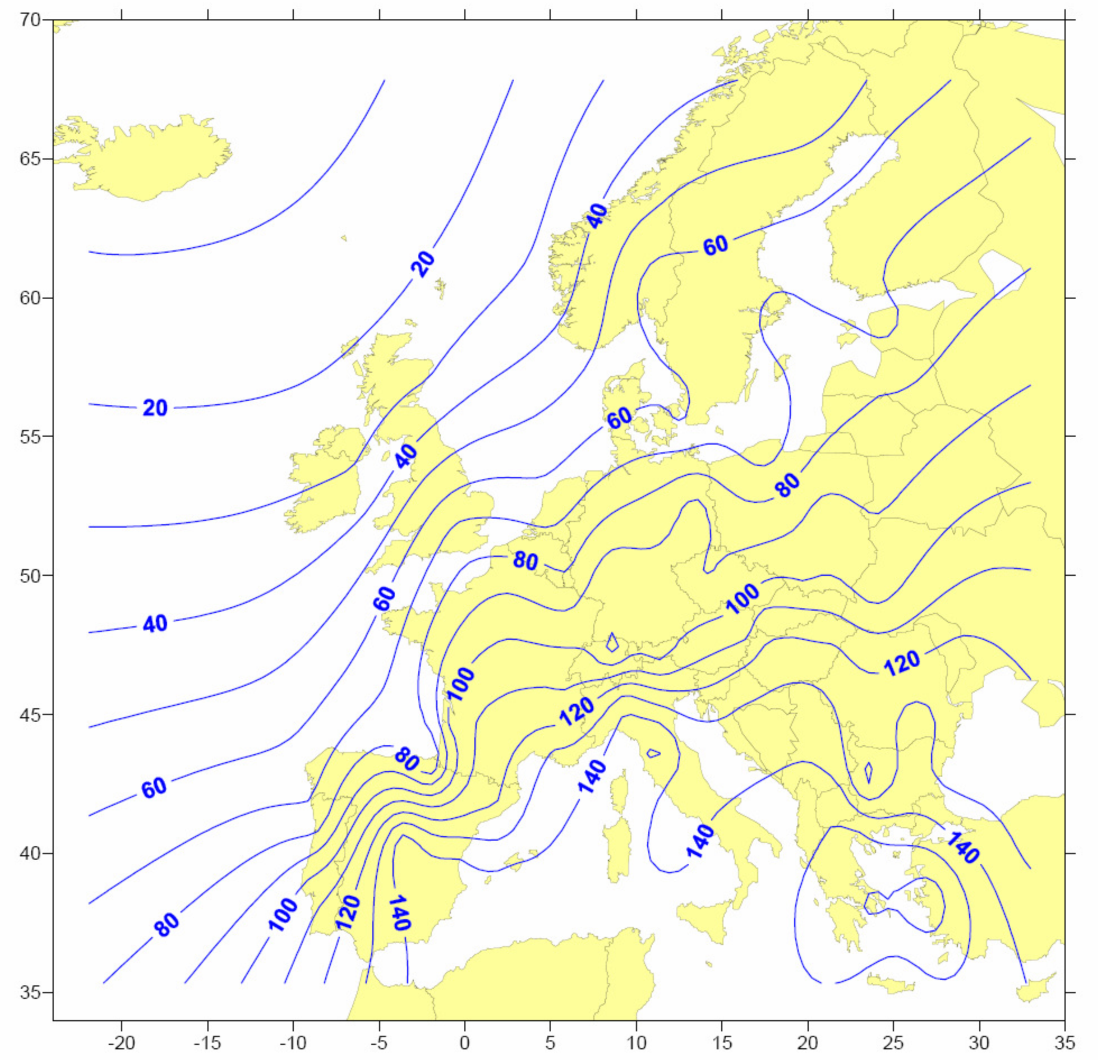
Ecoheatcool: European cooling index ECI

- Method:
  - Outdoor temperature predominates heating and cooling demand
  - heating demand predominates building insulation
  - Definition of cooling degree days:

  if $T_{outdoor} < 29°C$: $T_{indoor} = 22°C$
  else: ($T_{indoor} = T_{outdoor} - 7°C$)
  $\Rightarrow$
  EHI: $\propto$ (c_degree_days)^{½} , normalised to av. European cooling conditions (Strasbourg,..)
  (av. outdoor temp. approx. 10°C)

- Average space cooling demand proportional to ECI

- Humidity control <u>not</u> considered



Source: Ecoheatcool / WP2: European cold market

Climatic zones in Solar Combi+

- **3 climatic zones**
  Suggestion for EHI / ECI:
  100 / 100 (Strasbourg)
  90 / 120 (South of France, North of Italy)
  70 / 140 (South of Spain and Italy)

- Northern European ares:
  below economic reasonable operation time of cooling system?

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3.3: Determination of loads

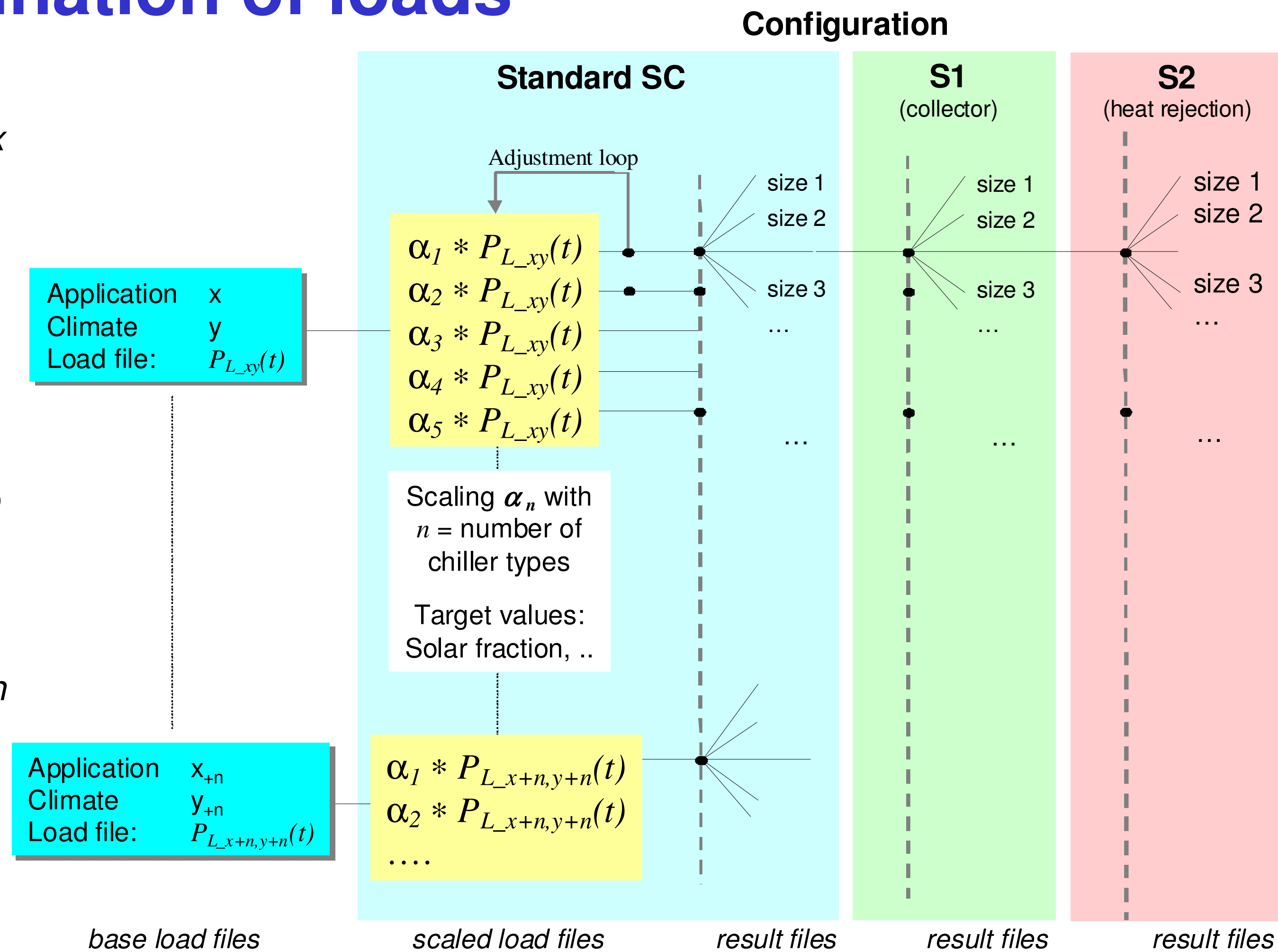
- **Base load files for heating / cooling / DHW**
  generated with *x* types of buildings (applications) for *y* climate zones
  (no. Of base laod files: $x*y$)

- **Problem: Building models with fixed geometry**
  With different chiller types (4.5 kW – 15 kW)
  different solar coverage of heating/cooling demand with base load files
  ⇒ difficult to interprete

- **Solution**
  ⇒ load file scaling procedure

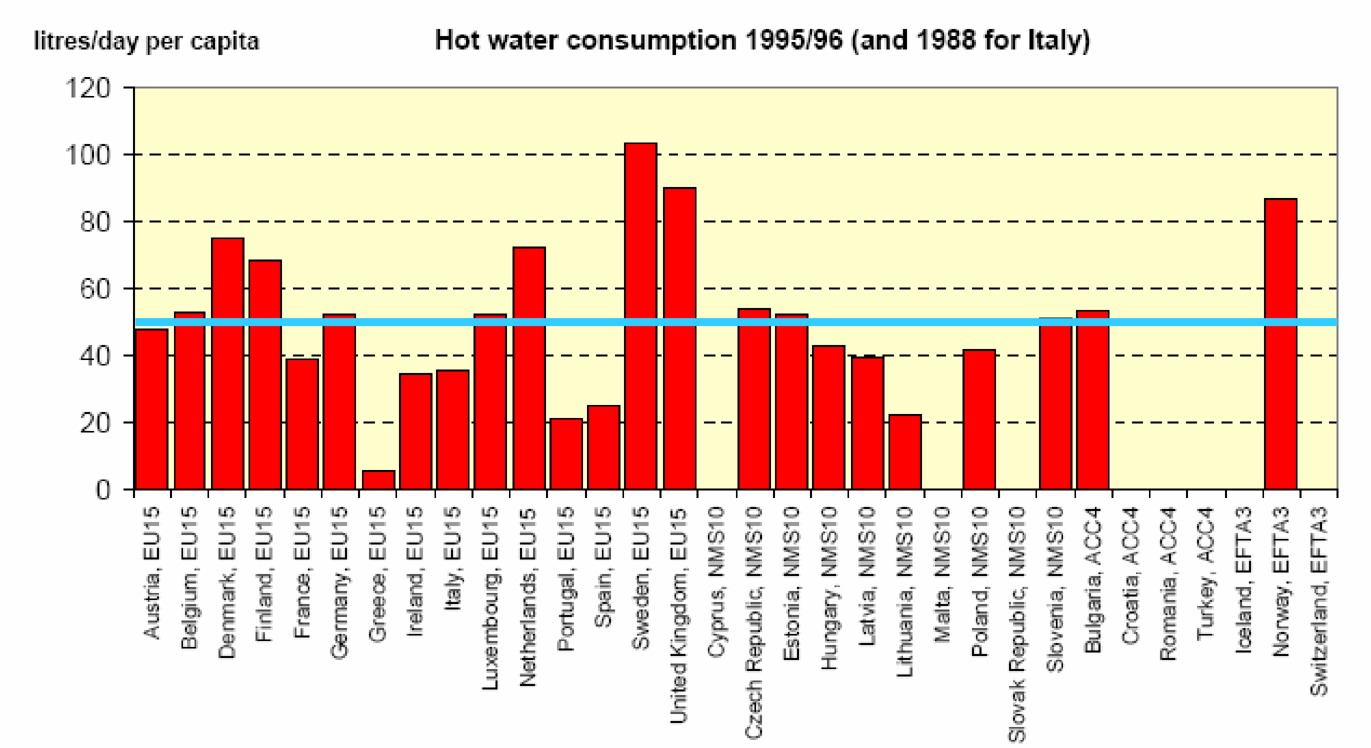
3.3: Determination of loads

- Generation of Base Load files for *x* applications, *y* climates
- Scaling procedure of Base Load files (interaction with System Standard Configuration)
  Scaling according to target values (PE-saving, ..)
- **Result:**
  Set of load files for *n* chillers, *x* applications and *y* climates for the system standard configuration



Ecoheatcool: domestic hot water consumption

- 50℃ temperature difference supply / source water
- Average: approx. 50 l/day per capity



Source: Ecoheatcool / WP1: European heat market

Structure of load files

- Example: 3 applications, 3 climate zones, 5 different chiller applications
  ⇒ 45 scaled load files
- Load file combines heating / cooling / DHW loads with meteorological data
- Time resolution of data: one hour; length: one year

Hour of the year	Month	Day	Hour	T_{amb}	rH_{amb}	$T_{room,set}$	$rH_{room,set}$	$P_{heating,sensible}$	$P_{heating,latent}$	..
hh	mm	dd	hh	°C	%	°C	%	kW	kW	..
1	1	1	1	..	..					
2	1	1	2	..						
3	..	..								

..	$P_{cooling,sensible}$	$P_{cooling,latent}$	T_{DHW}	V_{DHW}	$G_{horizontal}$	G_{diffus}
..	kW	kW	°C	m³/h	W/m²	W/m²
..	..	..				
..	..					

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3.4: system configurations

- **Small size chillers to be considered**

Chiller model	Manufacturer	Rated chilling capacity [kW]	Rated chilled water temperature* [°C]	heat rejection mode at rated conditions
Solar 7	Rotartica	**4.5**	7/12°C	Dry cooling
ACS 05	SorTech	**5.5** *	15/18°C	Wet cooling (dry cooling possible)
ClimateWell 10	ClimateWell	**10**	17/?°C	Wet cooling (dry cooling possible)
Suninverse	Sonnenklima	**10**	15/18°C	Wet cooling (dry cooling possible)
Wegracal SE 15	EAW	**15**	11/17°C	Wet cooling

* SorTech: replaced by new chiller with 7.5 kW capacity (spring 2008)

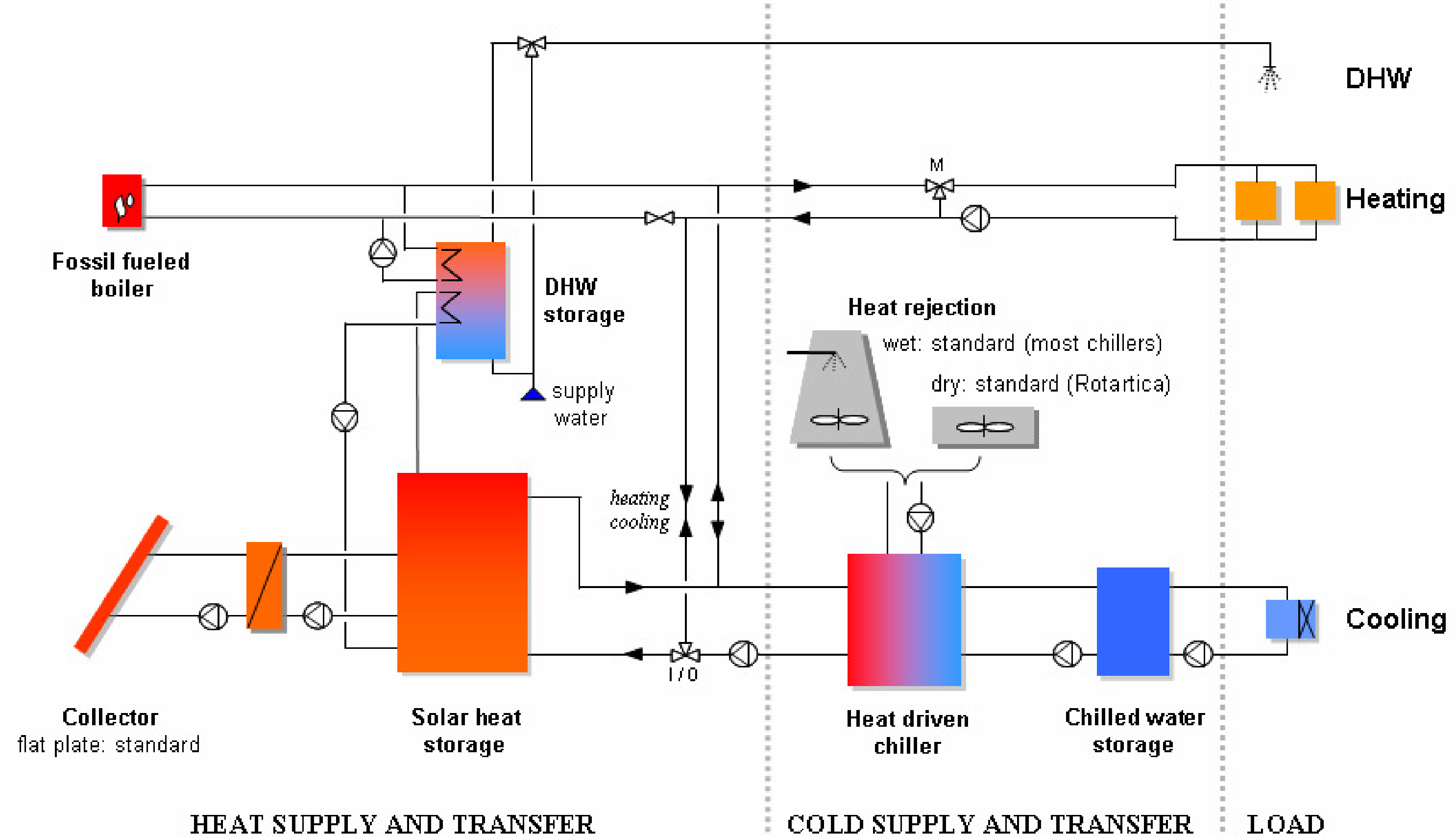
3.4: system configurations

Standard configuration

- No bypass of solar hot water storage (avoiding control problems, simplifying hydraulic)
- Either solar thermal operation <u>or</u> fossil fueled operation of chiller
- No return temperature lift of solar heat by fossil fueled boiler (avoiding fossil heating of solar storage and decrease of collector utilisation)
- Solar heat storage: with or without stratification charging unit? Will be considered in TRNSYS simulations, but the effect is probably small due to small temperature differences and high mass flow rates
- External solar heat exchanger: gives more flexibility in storage (normally larger than for pure solar combi systems
- Chilled water storage; size to be determined (hydraulic junction or real cold storage effect)
- Input from WP2

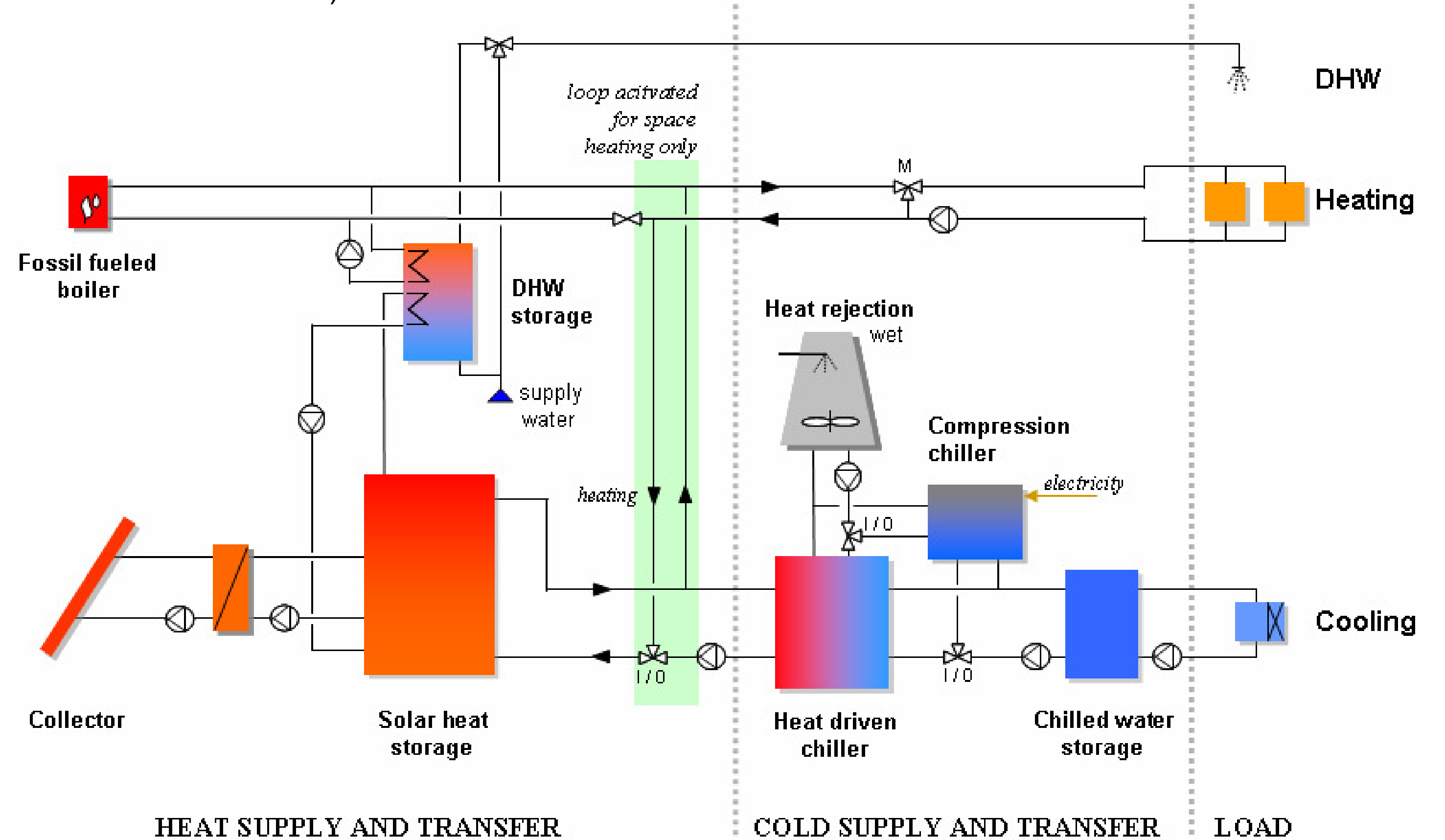
3.4: system configurations

- control strategy:
  different for each chiller type



3.4: system configurations

- Alternative configuration
  (e.g., for 15 kW EAW chiller)



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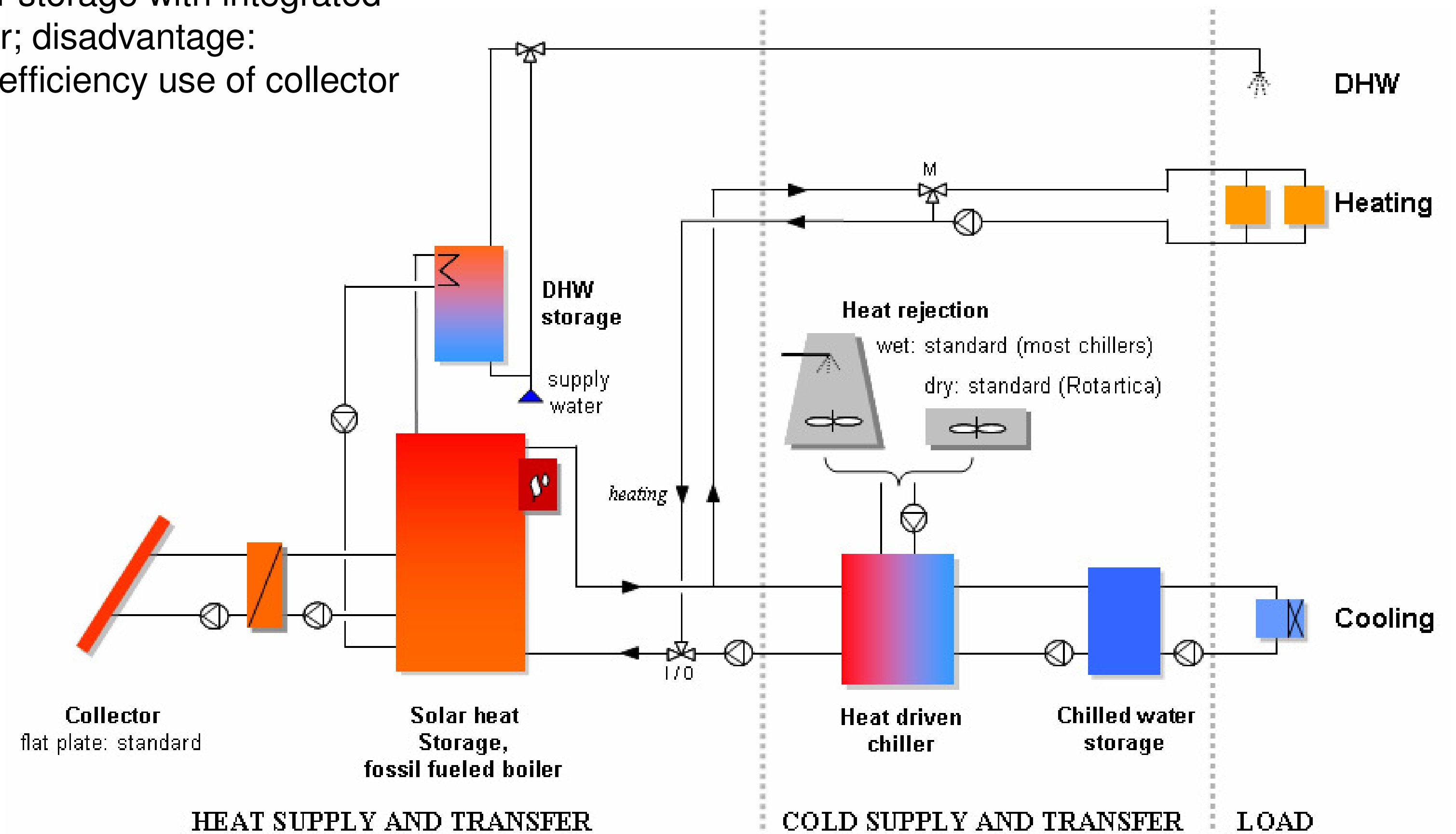
3.4: system configurations

- Alternative configuration
  Solar storage with integrated boiler; disadvantage:
  less efficiency use of collector



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3.4: system configurations

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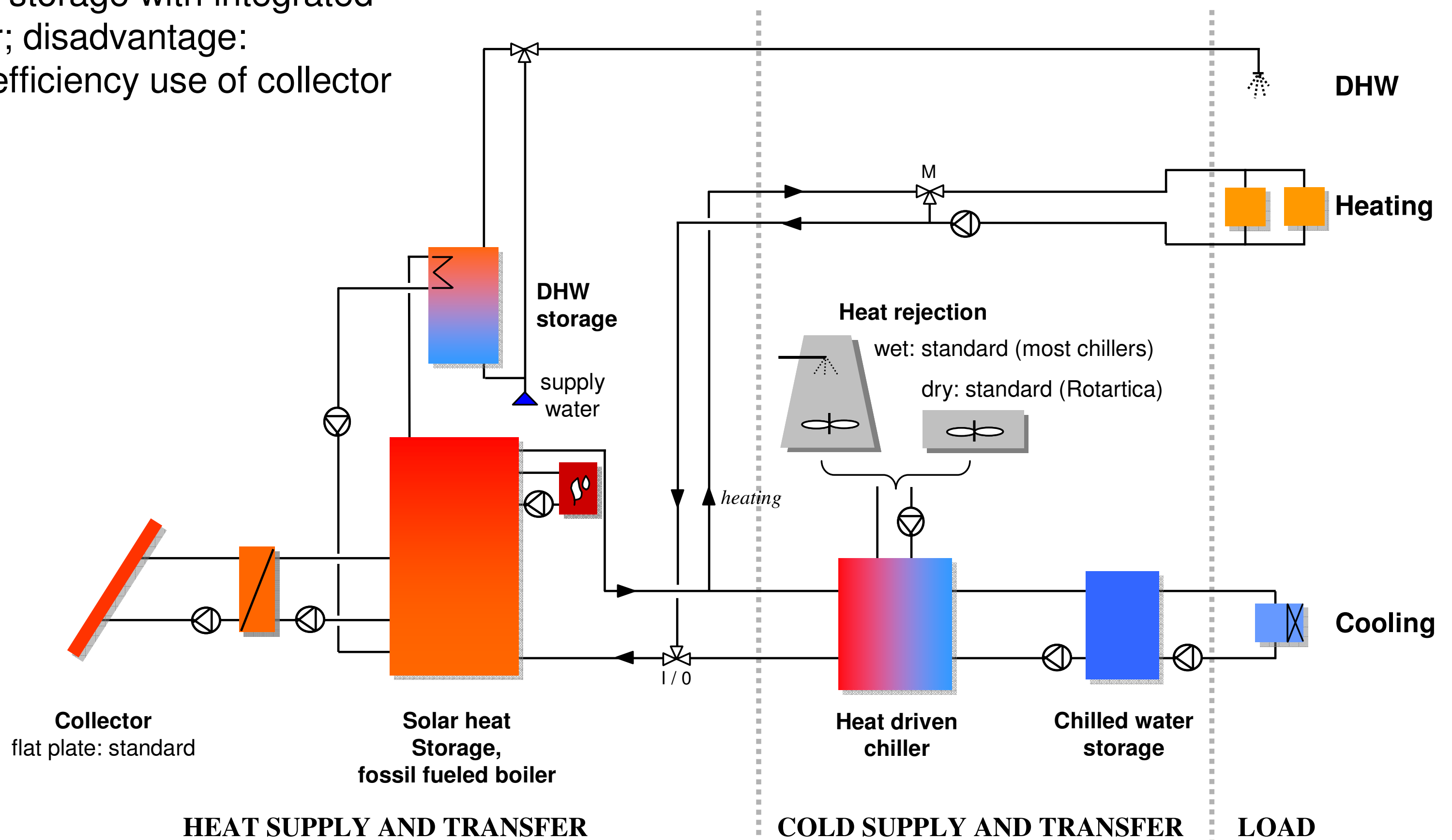


3.5: simulation study

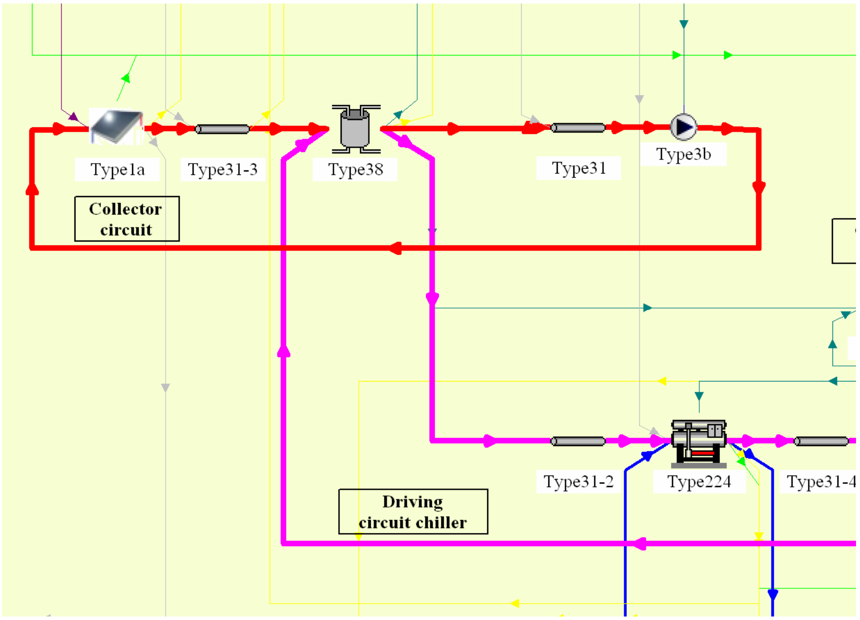
- Example: 3 applications, 3 climate zones, 5 different chiller applications
  ⇒ 45 scaled load files
- 2 collectors, 5 collector sizes, 2 storage sizes, 2 heat rejection systems
  ⇒ 1800 simulations (without reference calculations)
- Shared with partners

	Climate_1											
	Office				Residential_1				Residential_2			
config. S1	FPC		ETC		FPC		ETC		FPC		ETC	
config. S2	HR_{wet}	HR_{dry}	HR_{wet}	HR_{dry}	HR_{wet}	HR_{dry}	HR_{wet}	HR_{dry}	HR_{wet}	HR_{dry}	HR_{wet}	HR_{dry}
chiller_1	*dim*	*dim*										
chiller_2	*dim*	..										
chiller_3	..											
chiller_4												
chiller_5												
reference												
	Climate_2											
	Office				Residential_1				Residential_2			
…	…											

…

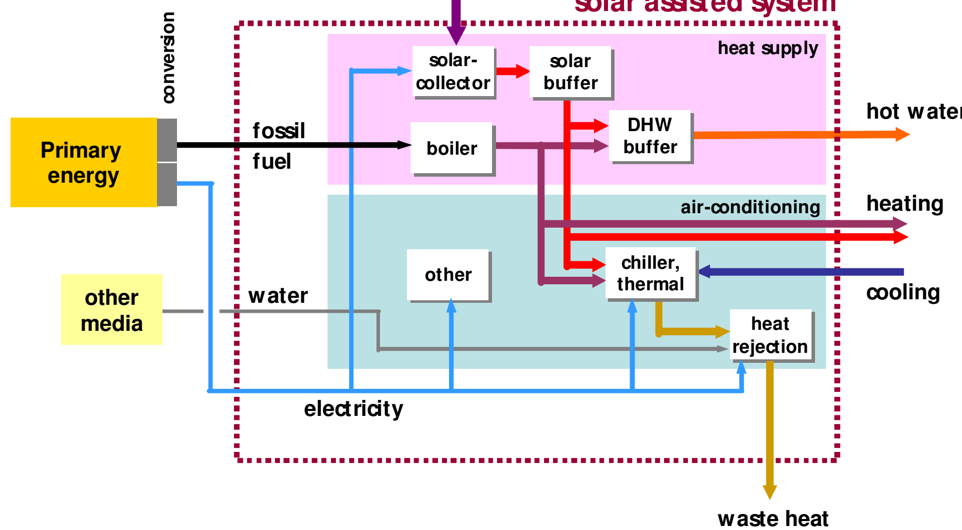
3.1: preparation of system implementation in simulation tools

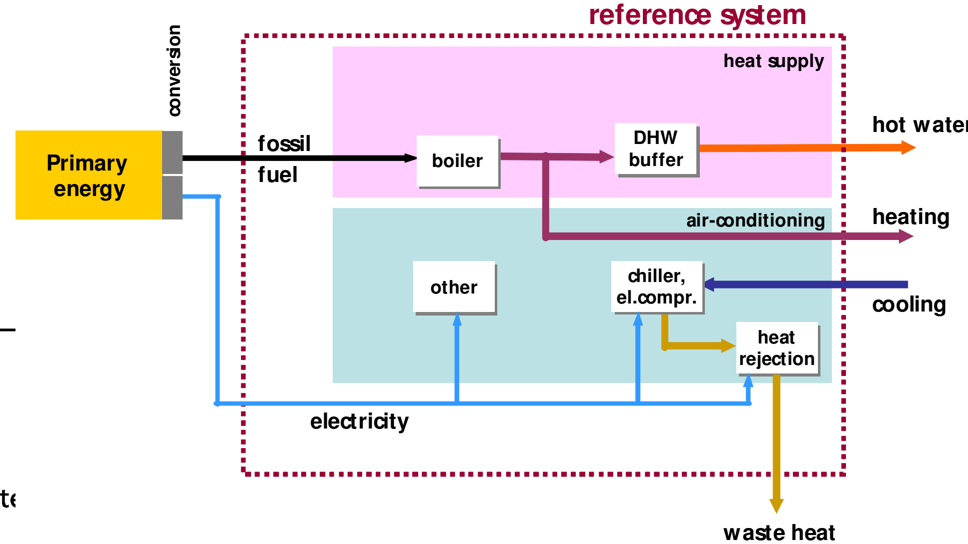
- No coupled building / system simulation
- Standard TRNSYS types as far as possible
- Chiller types:
  models or data files from manufacturer / distributor;
  received:
  - TRNSYS 16 type for ClimateWell chiller
  - TRNSYS 15 type for Sonnenklima (no source code, not transferable)
  - Data set of SorTech 5.5 kW chiller
- Further system implementation is connected with WP 3.4



3.6, 3.7: energetic and economic evaluation

- Comprehensive annual energy balance
- Comparison on base of reference system simulation results
- Collector efficiency, collector yield, Primary energy savings, ..
- On base of user input: cost figures
- Statistics: hours with additional auxiliary energy demand for cooling
- …





Next steps

- Applications:
  - building definition and modelling
- Selection of sites:
  - choice of climatic zones
- Calculation of base load files
- Agreement on system configurations
- Chiller models: support from supplier
- TRNSYS models of chillers and control; test of models

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Next steps

- Setup of TRNSYS decks:
  - standard types (collector, storages,..)
  - types or models for heat rejection
  - configurations (separate for each chiller model) and basic stability tests
  - programm output file structure definition
- Scaling of load files with standard configuration
- Definition of sizing range (collector, storage)
- Simulation runs
- Post-processing of results:
  - monthly / annual evaluation numbers
  - data table

Next steps

- **Applications:**
  building definition and modelling
  end of March 08
  Definition of applications
  support: EURAC, AEE-INTEC

  Building models (geometry, size, description,..)
  review: Task 32 (26)

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Next steps

- **Selection of sites**
  end 03/08
  according to ECOHEATCOOL or other approaches
  support: EURAC

- **Calculation of Base Load files**
  end of 04/08
  meteorological data

  Building simulation
  ISE

Next steps

- **Agreement on system configurations**
  defined: end 03/08

  selection of configurations
  ISE, TECSOL, commercial partners

  technical details (pumps, pipes, insulation, ..)
  ISE, commercial partners

  TRNSYS decks with system configurations
  ISE, support: Uni Bergamo

Next steps

- **Chiller models**

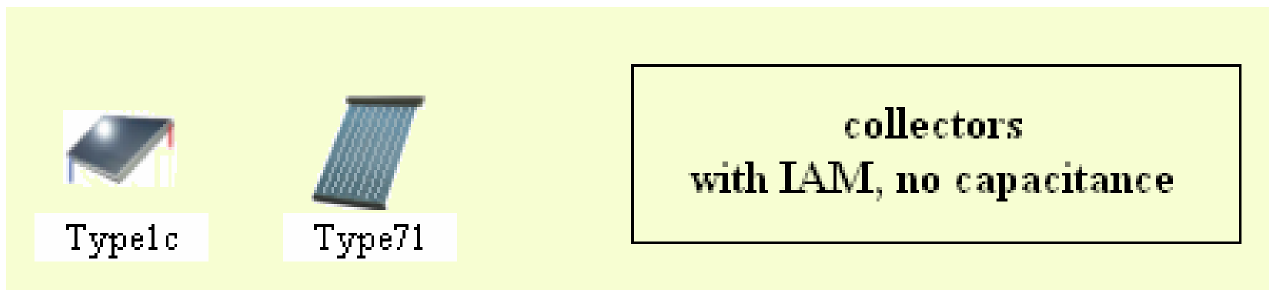
  data / models, control strategy
  ISE, commercial partners

  generic model (on base of EAW characteristics?)
  yes

- **TRNSYS models of chillers, tests**
  ISE

Next steps

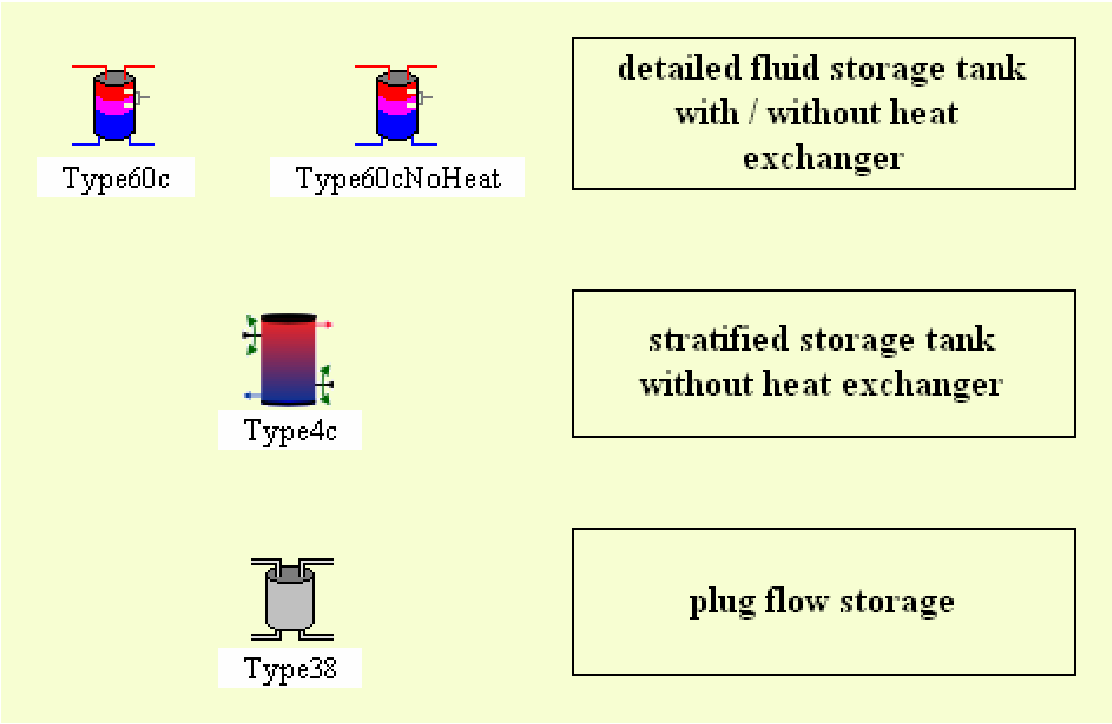
- **Setup of TRNSYS decks**
  - standard collector types
  - selection of collector parameters
  - possible: check of selected configuration with capacitance collector model (non-standard TRNSYS type)



ISE, support: Uni Bergamo

Next steps

- **Setup of TRNSYS decks**
  - selection of storage type (depending also from configuration)
  - no tank-in-tank storage model



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Next steps

- **Setup of TRNSYS decks**

configurations, stability tests

program output file structure

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Next steps

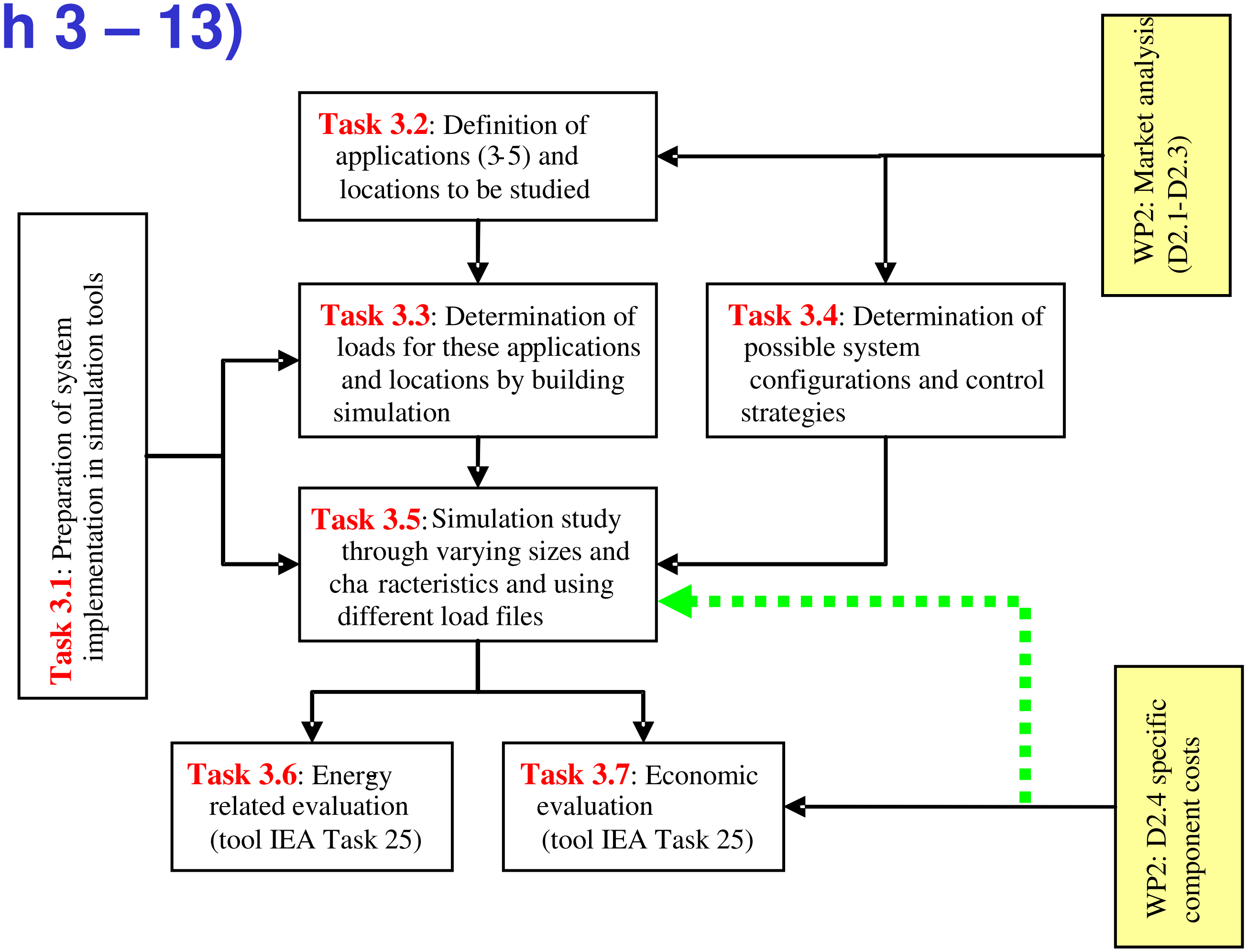
- **Scaling of load files (with standard configuration)**
- **Sizing range**
  to be determined from test runs
- **Simulation runs**

Subtask 3
Virtual case studies

Deliverables:

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

Solar Combi+, Work package 3 (month 3 – 13)



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Subtask 3.1
Preparation of system implementation in simulation tools

- Available model from IEA Task 25: a**b**sorption chiller model, developed by J. Albers, TU Berlin. Parameter sets available:
  - Yazaki WFC10 (with bubble pump),
  - EAW Wegracal SE 15 (15kW)
  - special .exe for Suninverse (10kW); no source code
  - parameters for other machines may be extracted from appropritate data sheets
- Available model from IEA Task 25: a**d**sorption chiller model, developed by Fraunhofer ISE. Parameters available:
  - Nishiyodo / Mayekawa chiller; > 50 kW
  - parameters for other machines may be extracted from appropriate data sheets
- Climatewell?

Subtask 3.3
Determination of loads / building simulation

NEXT STEPS:

- Building standards:
  - EURAC, CRES, ISE, AEE-INTEC, UNIBG, TECSOL?
- Definition of typical buildings shells, internal loads,…:
  - EURAC, CRES, ISE, AEE-INTEC, UNIBG, TECSOL?
- Calculation and Preparation of annually load files?
  - …?