IEE Solar Combi+

WP3 – Virtual Case Studies

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Fraunhofer Institute
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Bolzano, Italy

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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

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

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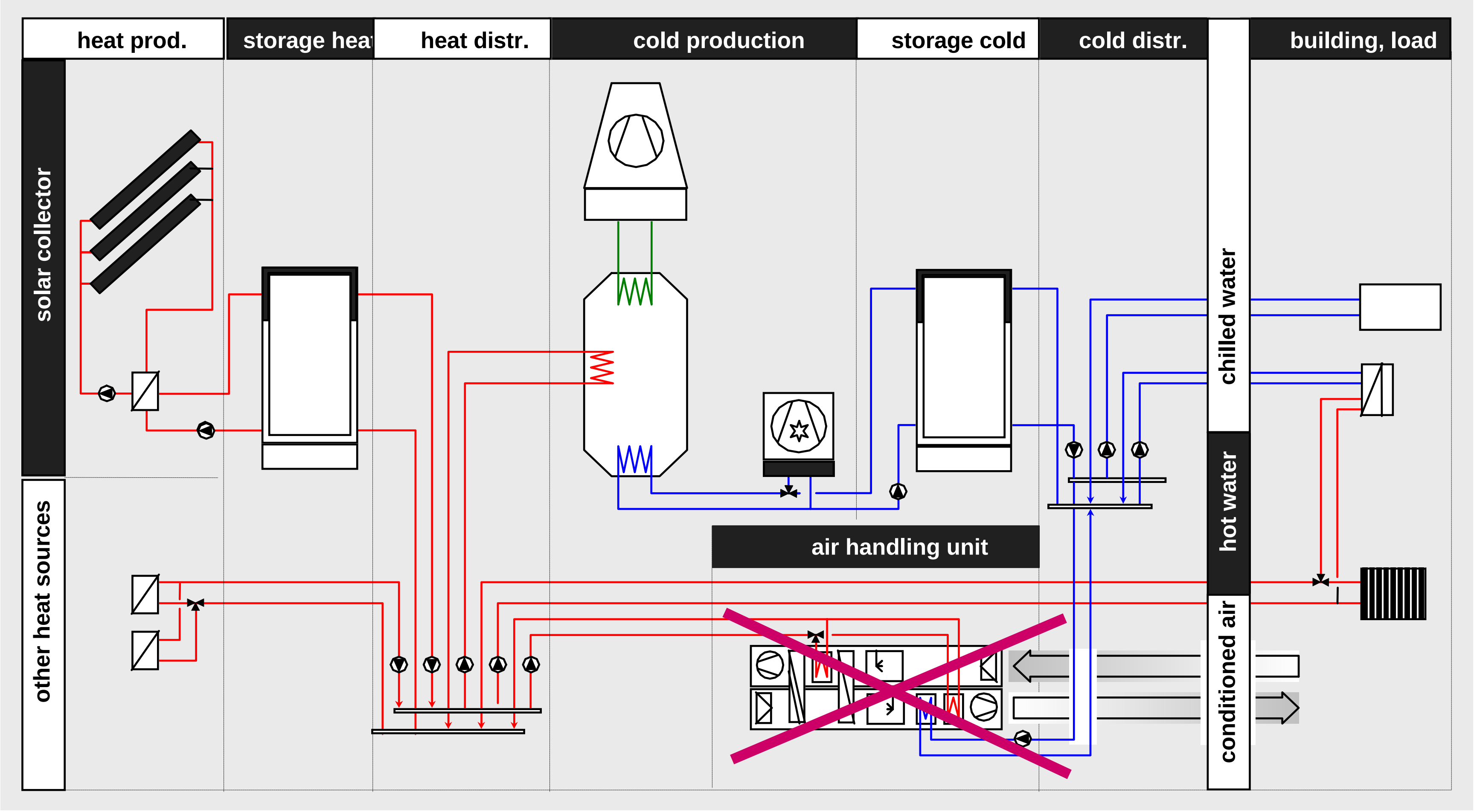
Systems in Solar Combi⁺



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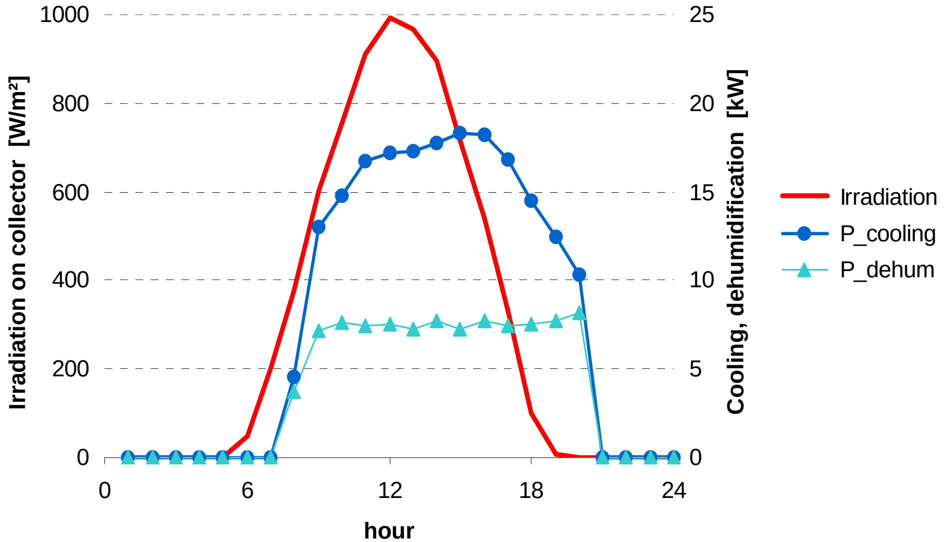
Example: Economic study in 'Solar Air-Conditioning in Europe (SACE)'

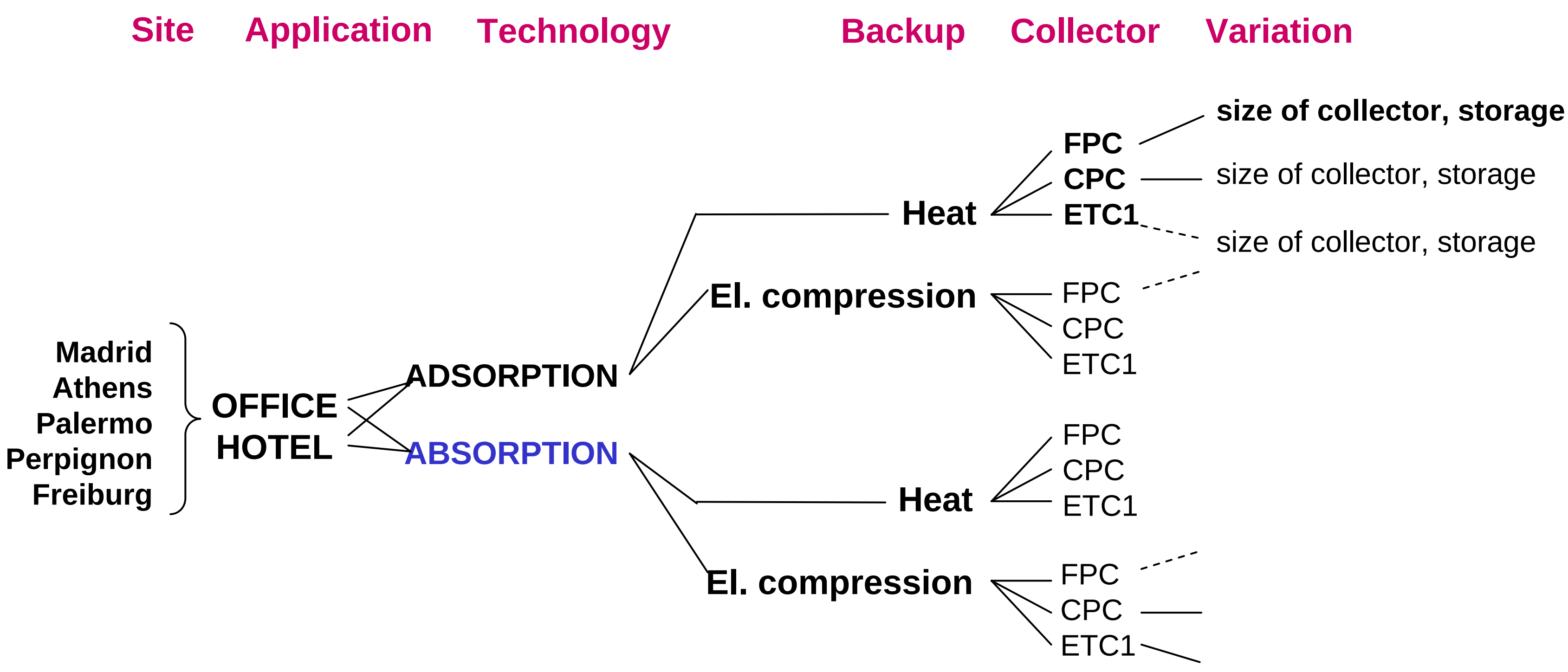
EU project, completed in 2003 www.cop.tudelft.nl/ev/res/sace.htm



Example: summer day load and radiation profile (lecture room, Palermo site)

- Model buildings, defined in IEA Task 25
  - Hotel
  - Office
  - Lecture Room
- Annual heating and cooling load profiles (time series with hourly data) for five European sites
  - Madrid
  - Athens
  - Palermo
  - Perpignan
  - Freiburg

SACE: approach (closed cycle systems)



+ Reference calculation of a conventional system for each site and application

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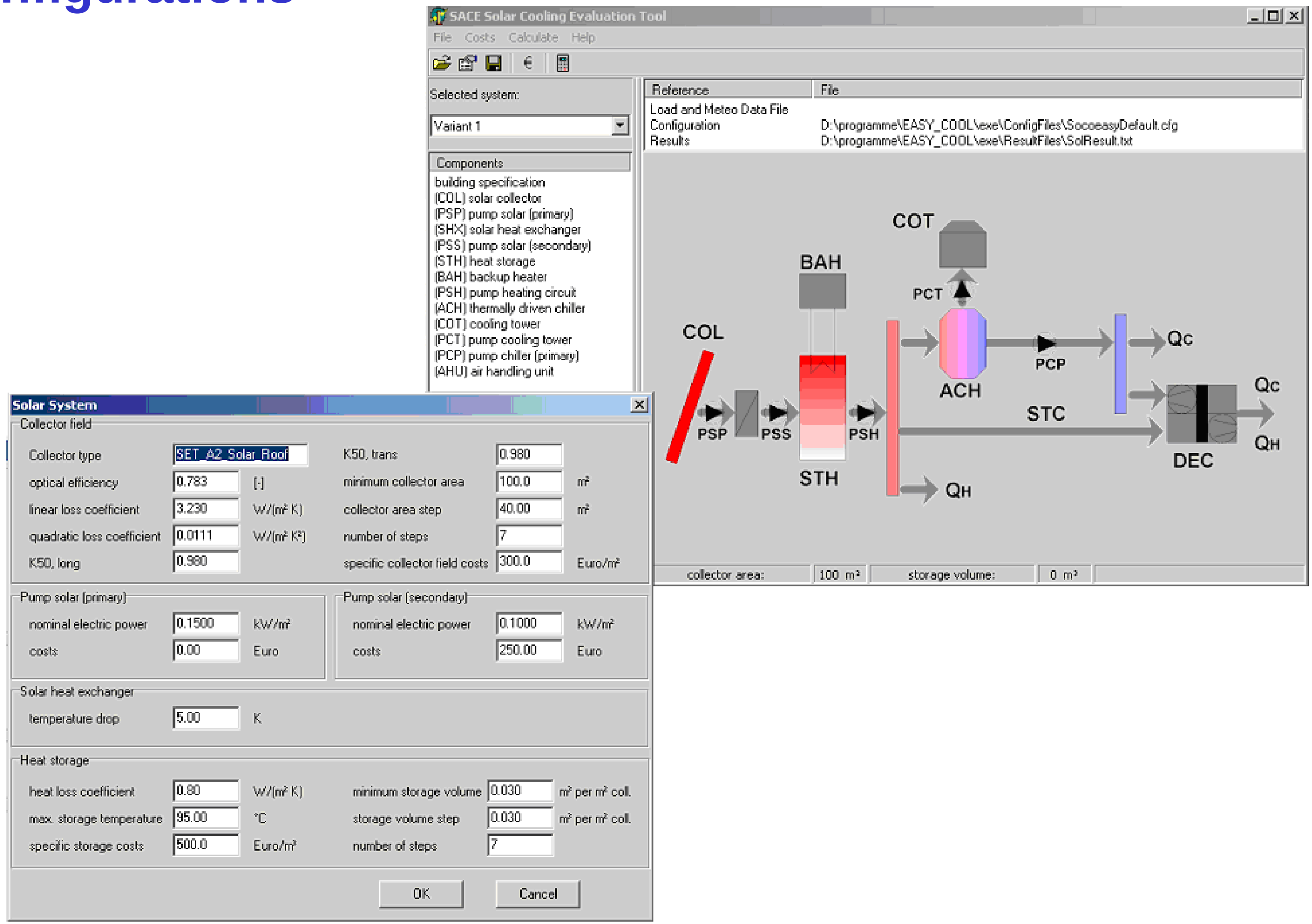
SACE: approach

- Identification of most promising system size and configuration with respect to comparative primary energy savings (compared to the reference system); considering of complete energy balance (including pumps, fans, etc.)

- Cost figures
  - initial cost: complete investment for the entire system including cost for planning
  - complete annual cost: capital cost (annuity method) + operation cost based on annual energy balance + maintenance cost
  - "cost of saved primary energy" by comparison with a reference system

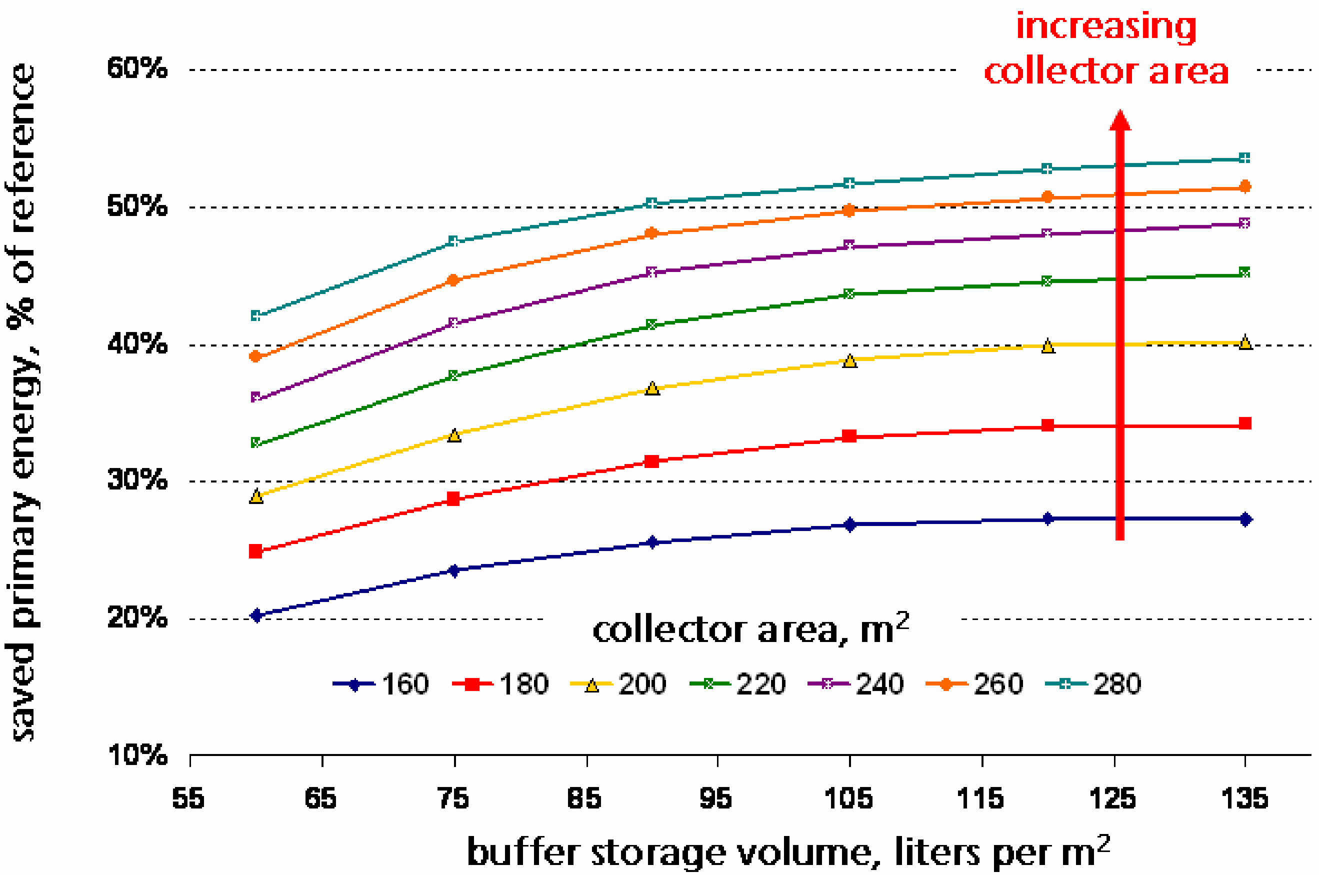
$$\textbf{cost of saved PE} = \frac{\text{extra annual cost of solar assisted system}}{\text{annual primary energy saving}} \left[€/kWh_{PE}\right]$$

SACE design tool with predefined configurations



SACE Pre-design tool; example

- Madrid
- office building
- flat plate collector
- back-up: boiler
- absorption chiller



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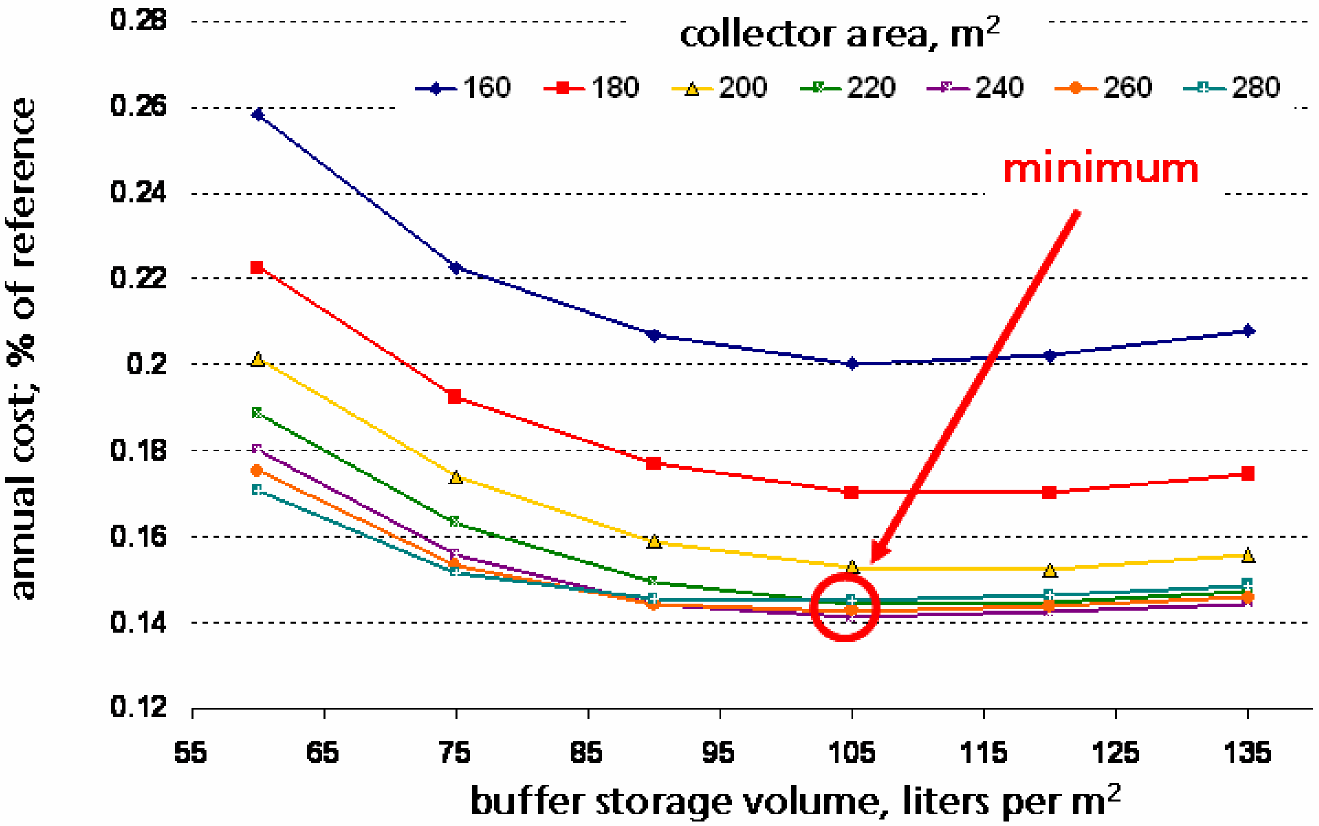

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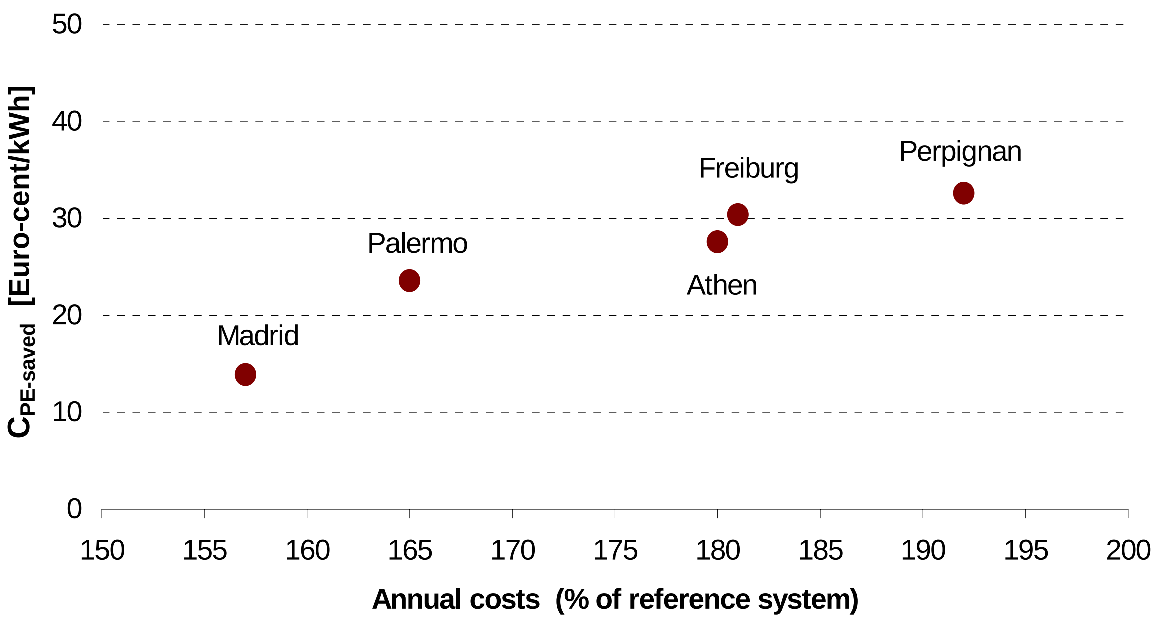
SACE study: results (office building)

- Conditions:

  primary energy saving > 25%; annual net collector effi-ciency > 20%

SITE	Collector type	Collector area per kW chiller	Heat storage size	Net collector efficiency	Chiller	Backup type	Annual cost of solar assisted cooling system	Primary energy saving	Cost of saved primary energy
Office at		m²/kW	hours	%			% of reference	%	Euro-cent per kWh
MADRID	CPC	3.3	4.2	21	ABS	heat	**157**	51	**13.9**
ATHENS	CPC	2.4	3.6	21	ABS	el. compr.	**180**	45	**27.6**
PALERMO	CPC	1.4	2.1	22	ABS	el. compr.	**165**	45	**23.6**
PERPIGNAN	ETC1	1.7	2.8	30	ABS	el. compr.	**192**	45	**32.6**
FREIBURG	ETC1	3.4	3.2	28	ABS	el. compr.	**181**	30	**30.4**



Experiences from design studies

- The specific combined energy-cost-performance parameter ‘cost per saved primary energy unit‘ supports the sizing and configuration of a solar assisted air-conditioning system
- Size and type of the collector and storage volume depends strongly on the site conditions, load structure and applied air-conditioning technology.
  A software tool is useful in the design of the system
- For thermal operated cooling processes with low COP and use of fossil fuels (heat back-up), a high percentage of solar thermal coverage is required in order to achieve savings in primary energy and CO_2 emmissions.
  Alternative: electrically driven compression chiller as cold side backup (‘fuel-saving‘ operation of solar thermal driven system) $\Rightarrow$ more adequate for large systems
- In most cases solar assisted cooling is today not economically viable without funding, but shows a large potential in primary energy saving

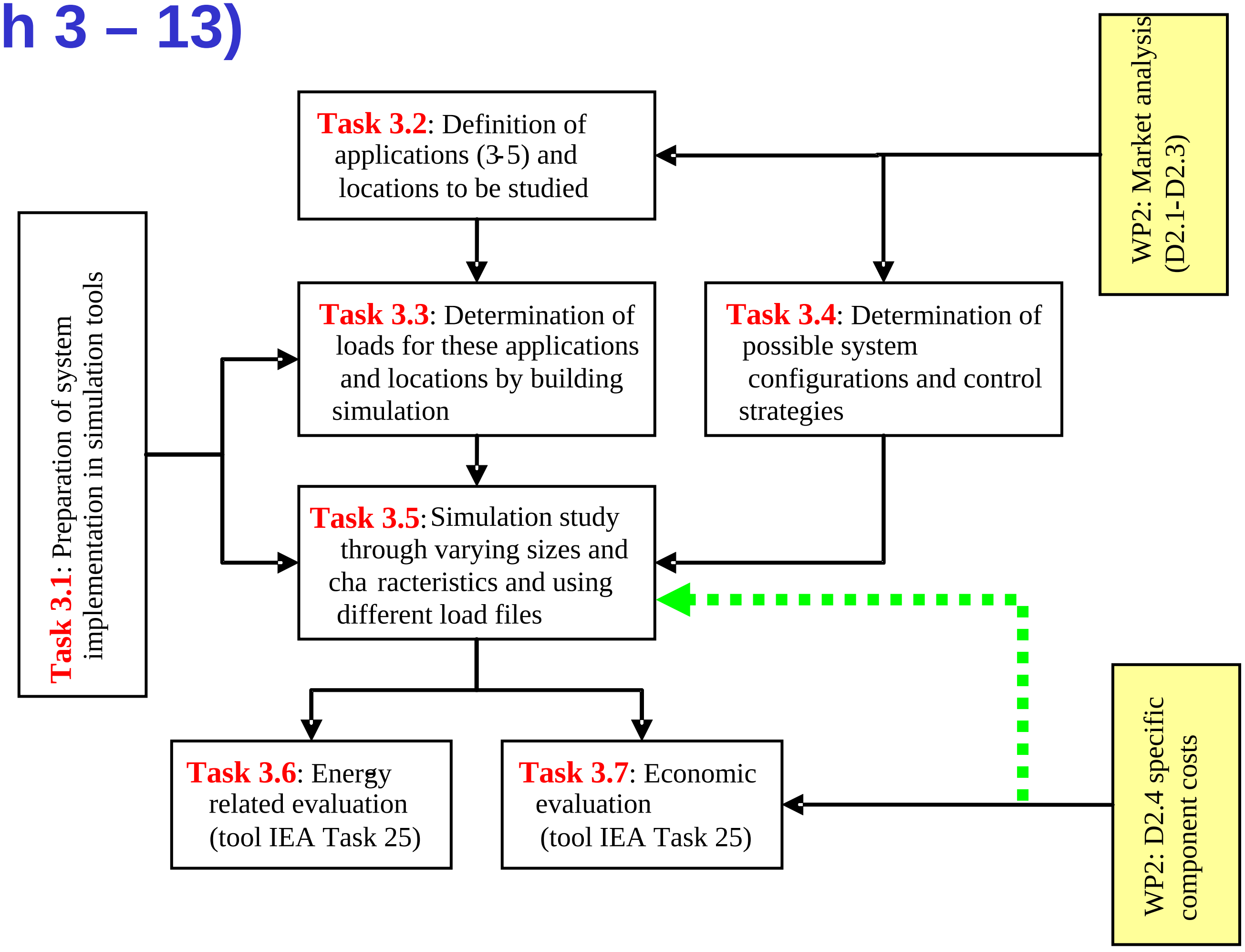
Experiences from design studies

- Most effective in primary energy saving are systems with solar autonomous cooling operation. But comfort room air-states may not be guaranteed for all hours in this application.
  $\Rightarrow$ favourable in buildings with dominating external loads and usage during day hours
- The exploitation of the solar thermal system should be maximised, using the system for space heating support and DHW as well (promising perspective for small scale applications)

In Solar Comi^{+}:

- more precision on modelling, configurations, control
- actual performance and cost figures
- applications based on market analysis

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



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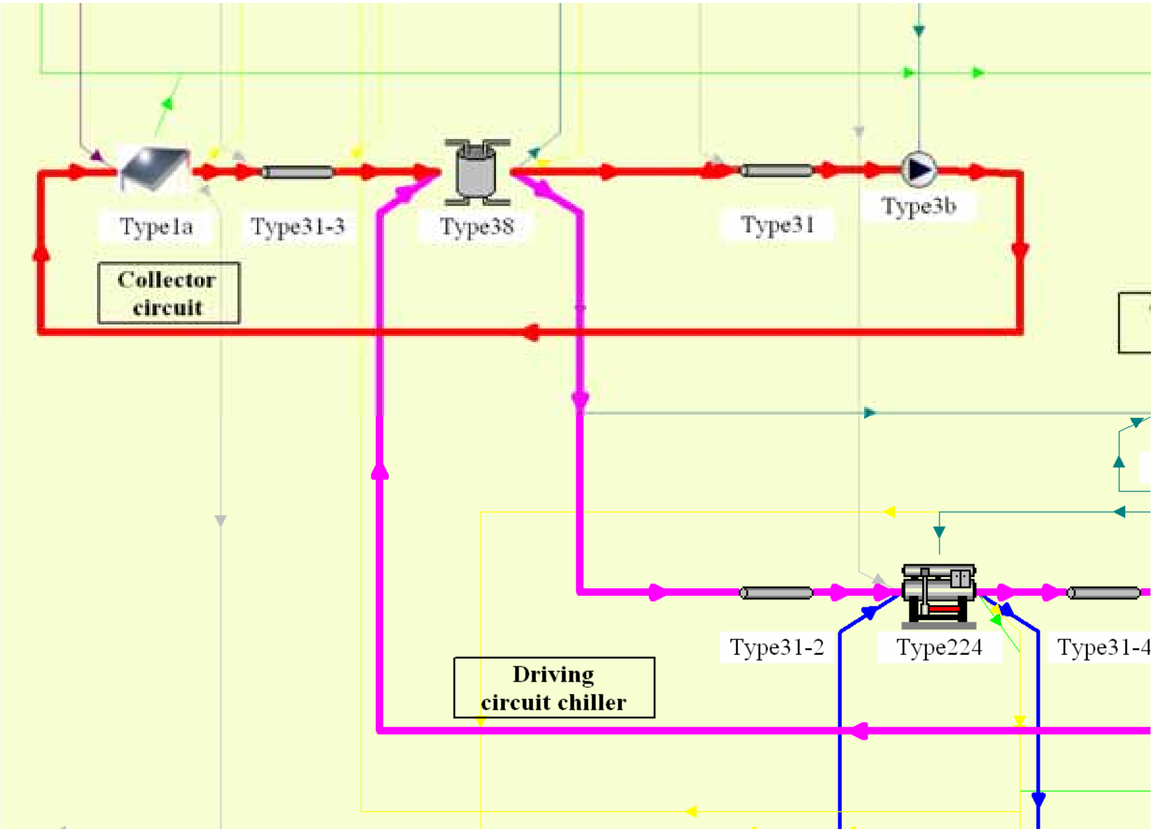
Subtask 3.1
Preparation of system implementation in simulation tools

- Software tool: TRNSYS
- Types:
  standard or non-standard for collectors, storages,..
- Chiller types:
  - capacities
  - 'generic' model (scaling) or specific models
  - on base of charac-teristics, NO research on component models



Subtask 3.2
Definition of applications and locations to be studied

- Applications:
  - residential
  - commercial (small offices)
  - small hotels
  - …

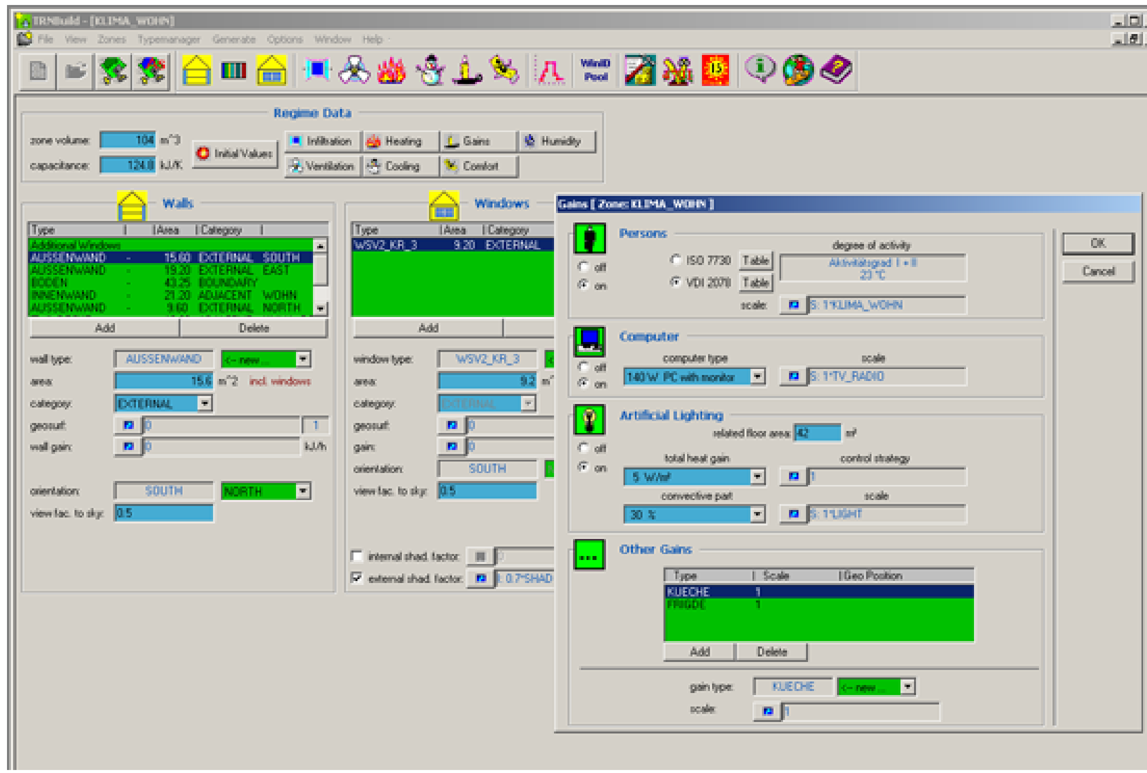
  $\Rightarrow$ input from WP2, SOLCO, ..

- Sites:
  - consortium partner countries ?
  - meteorological data source?

  $\Rightarrow$ Input from ECOHEATCOOL,..

Subtask 3.3
Determination of loads / building simulation

- Building standards
- Internal laods
- Heating / cooling / ventilation
- For each site and application: annual time series of sensible and latent heating / cooling loads



Subtask 3.4
Determination of system configurations

- Input from WP2 Market analysis
- Input from partners: configuration of marketed systems
- Advantages / disad-vantages from rea-lised systems
- Input to heating sup-port and domestic hot water preparation configurations:
  IEA Tasks (e.g., Task 26 Solar Combisystems)

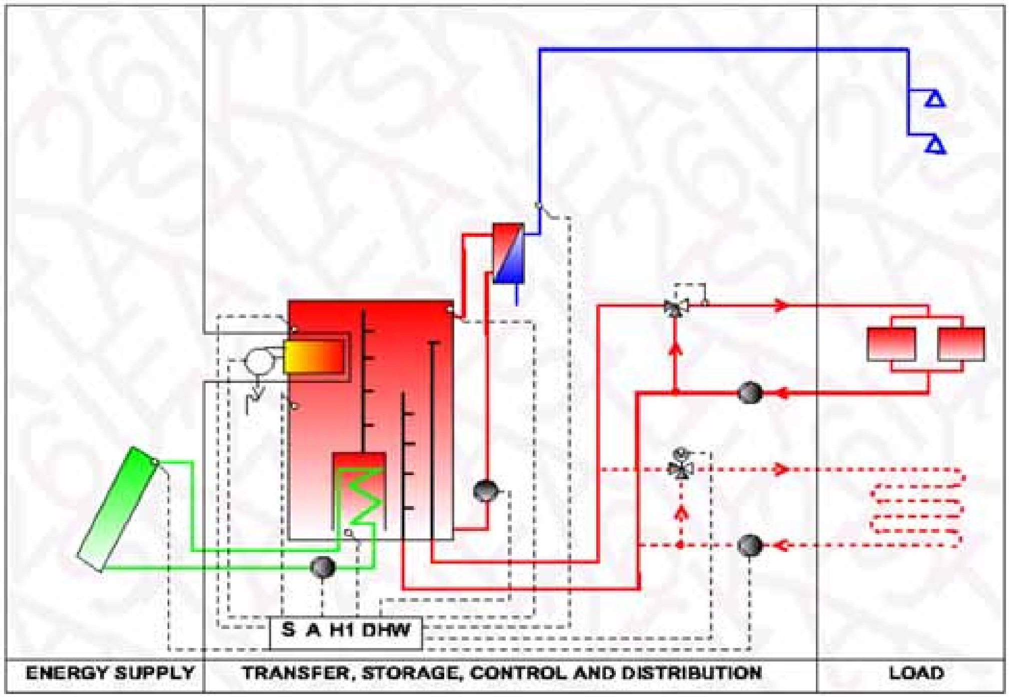


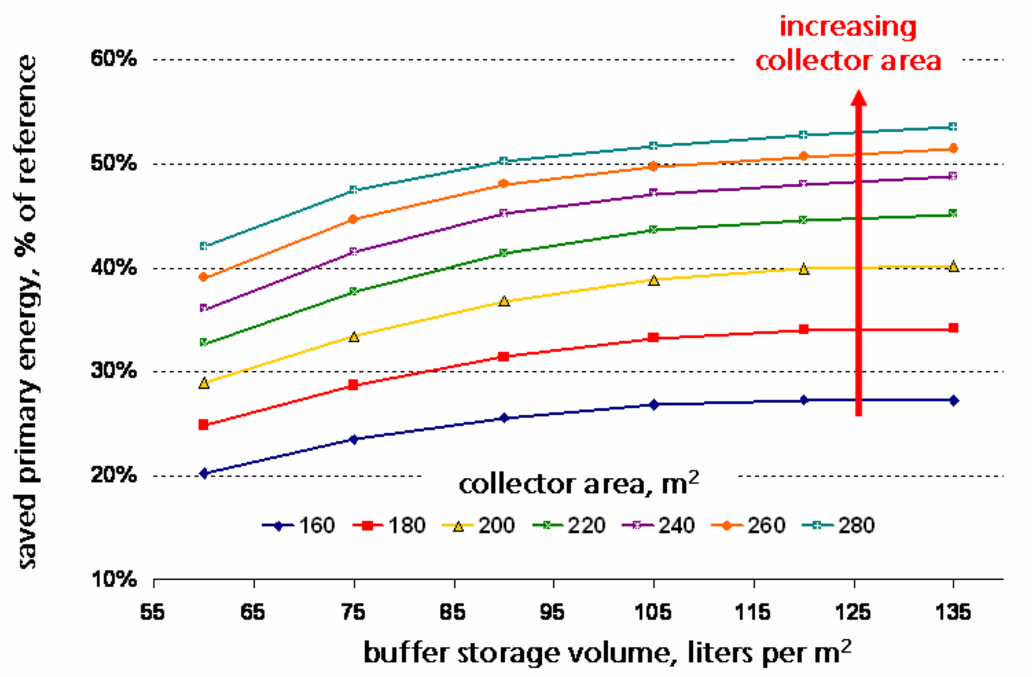
Figure from case study in Task 26

Subtask 3.5
Simulation study

- Large number of simulations according to:
  - sites
  - applications
  - configurations
  - components sizes
  - control strategies

- Annual simulations runs to cover heating/cooling period

- Data base containing useful results



Subtask 3.6, 3.7
Energy-related and economic evaluation of results

- Definition of appropriate energetic/economic evaluation numbers
- Reference calculations with non-renewable energy supply, e.g., electrically driven compression chillers for cooling
- Identification of most promising system configurations for each application/site
- ⇒ Input to online accessible data base

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

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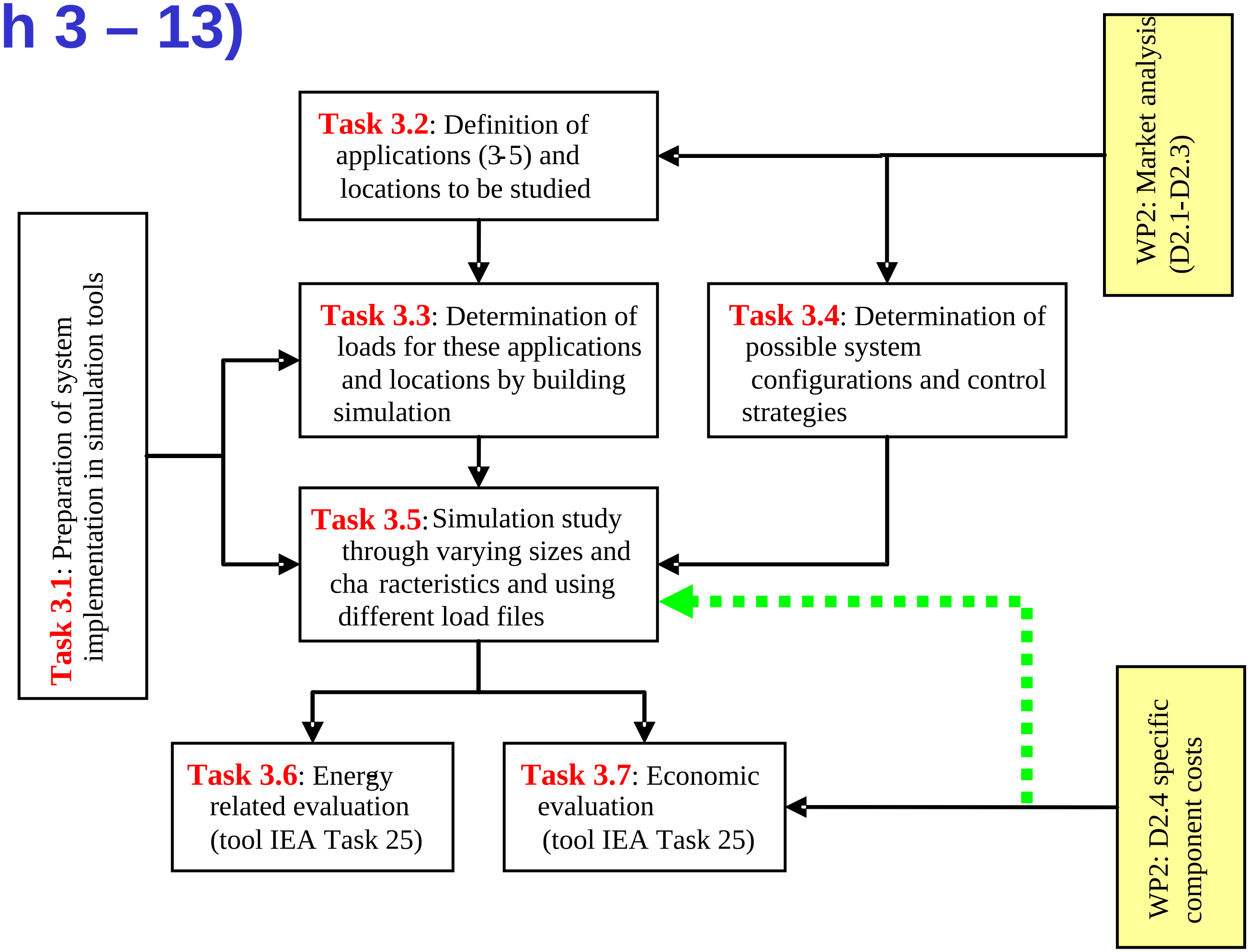
Solar Combi⁺, Work package 3 (month 3 – 13)



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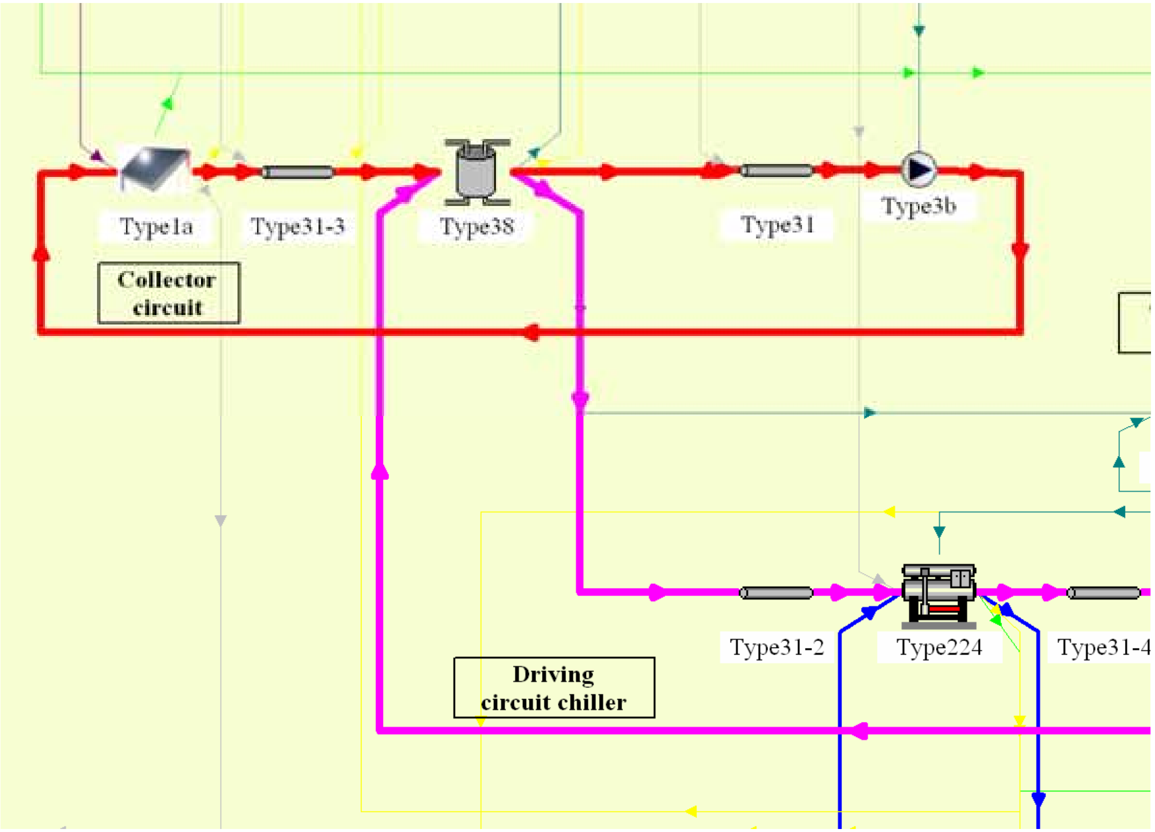
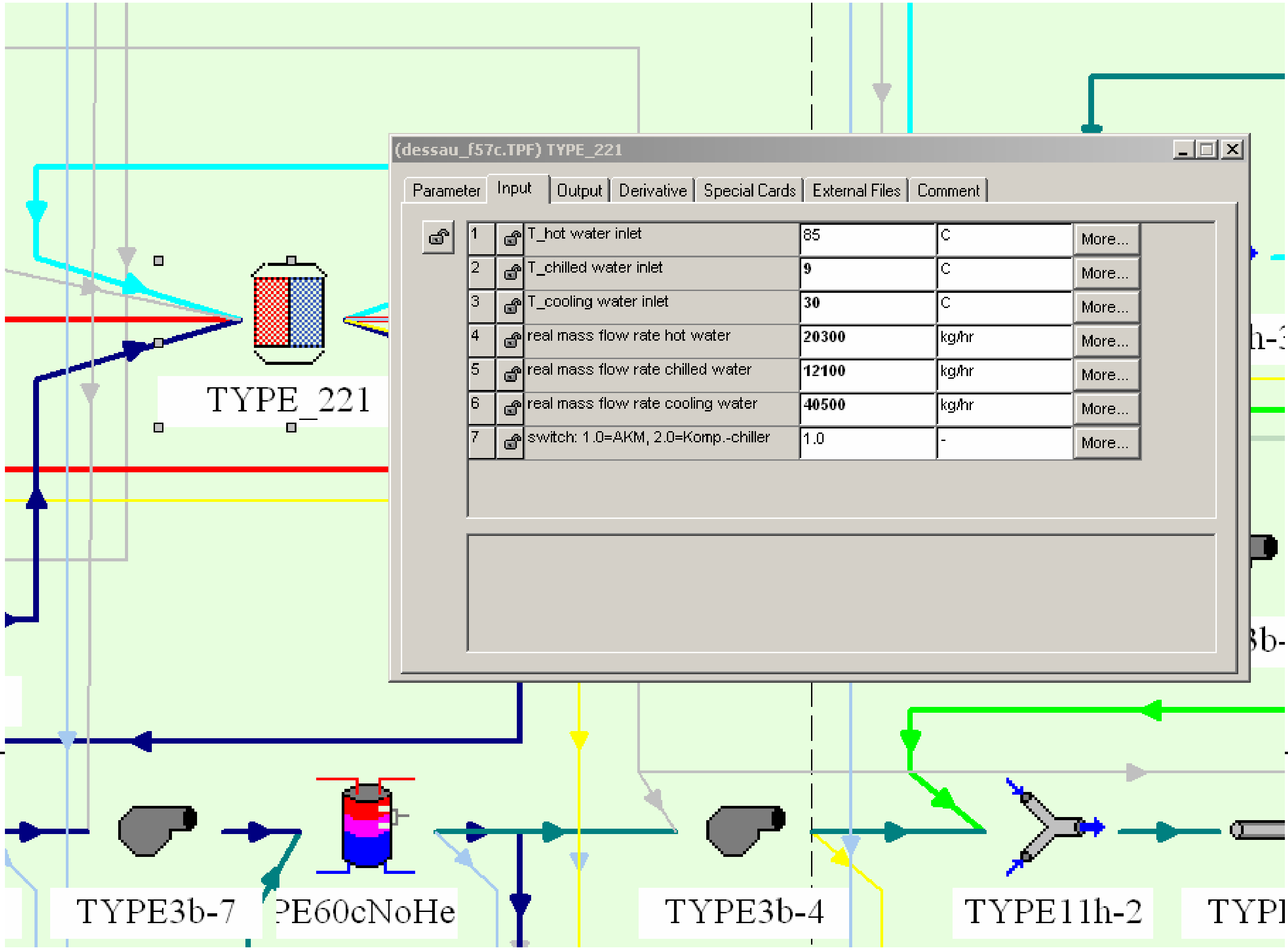


Subtask 3.1
Preparation of system implementation in simulation tools

- Types:
  standard or non-standard for collectors, storages,..
- Chiller:
  - which capacity?
  - representing chiller models of manufacturers in SolarCombi+ Consortium?
  - or: representing a ‘general‘ chiller type;
    variations on driving temperature, heat rejection temperature, chilled water temperature, nominal COP,…
  - model on base of steady state characteristics

Subtask 3.1
Preparation of system implementation in simulation tools

- To be defined: uniform input/output structure



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?

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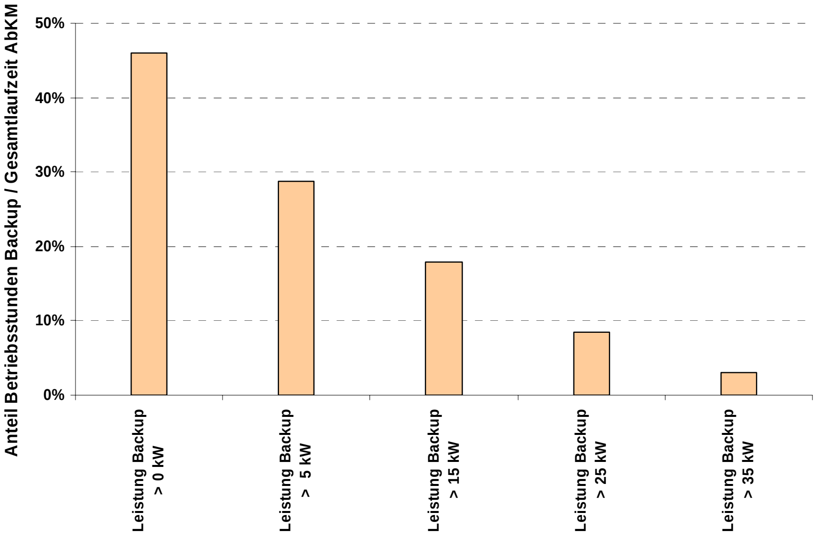
Subtask 3.1
Preparation of system implementation in simulation tools

- In general: coupled system / building simulation?
  (TRNSYS building model and system description in one simulation deck file)
  - \+ allows solar autonomous cooling operation
    (feedback to building type) ⇒ more flexibility
  - \- more stability problems with simulation, more complexity,
    remarkable inrease in running time

- compromise: separate load files and statistics of hours with auxiliary energy demand for cooling



Subtask 3.1
Preparation of system implementation in simulation tools

NEXT STEPS:

- Chiller models:
  characteristics, models (manufacturers)
  - ROTARTICA, CW, SorTech, SK, SOLution?

- Type of collectors, storages,.. Considered:
  - ISE, AEE INTEC, EURAC, CRES, TECSOL, UNIBG,..?

- General arrangements on TRNSYS decks:
  (solar autonomous or not, version, …)
  - ISE, AEE INTEC, EURAC, CRES, TECSOL, UNIBG,..?

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Subtask 3.2
Definition of applications and locations to be studied

- Maximum cooling loads?
- Applications:
  - residential
  - commercial (small offices)
  - small hotels
  - …

  ⇒ input from WP2, SOLCO, ..
- Sites:
  - consortium partner countries ?
  - meteorological data source?

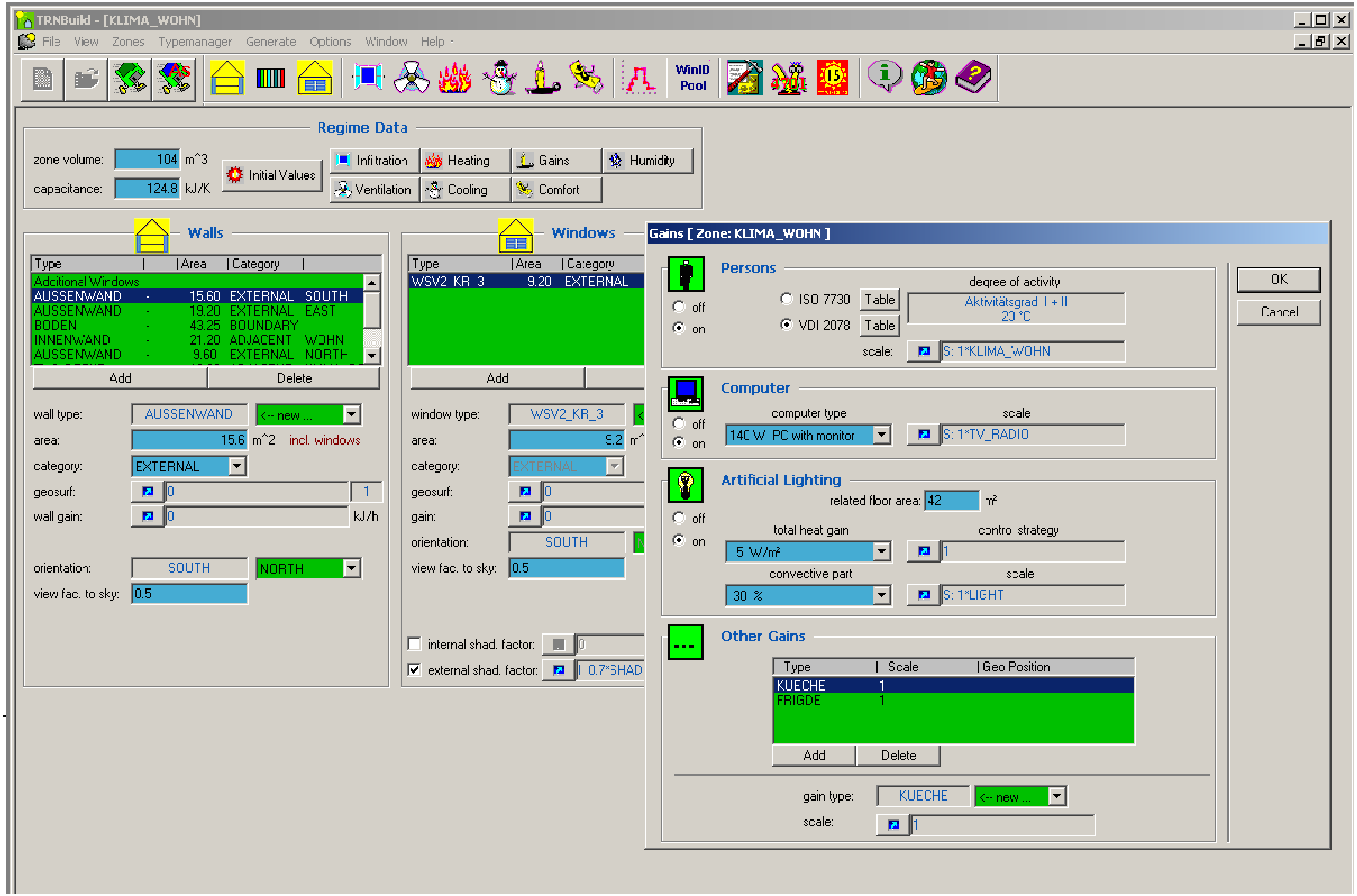
  ⇒ Input from ECOHEATCOOL,..

Subtask 3.2
Definition of applications and locations to be studied

NEXT STEPS:

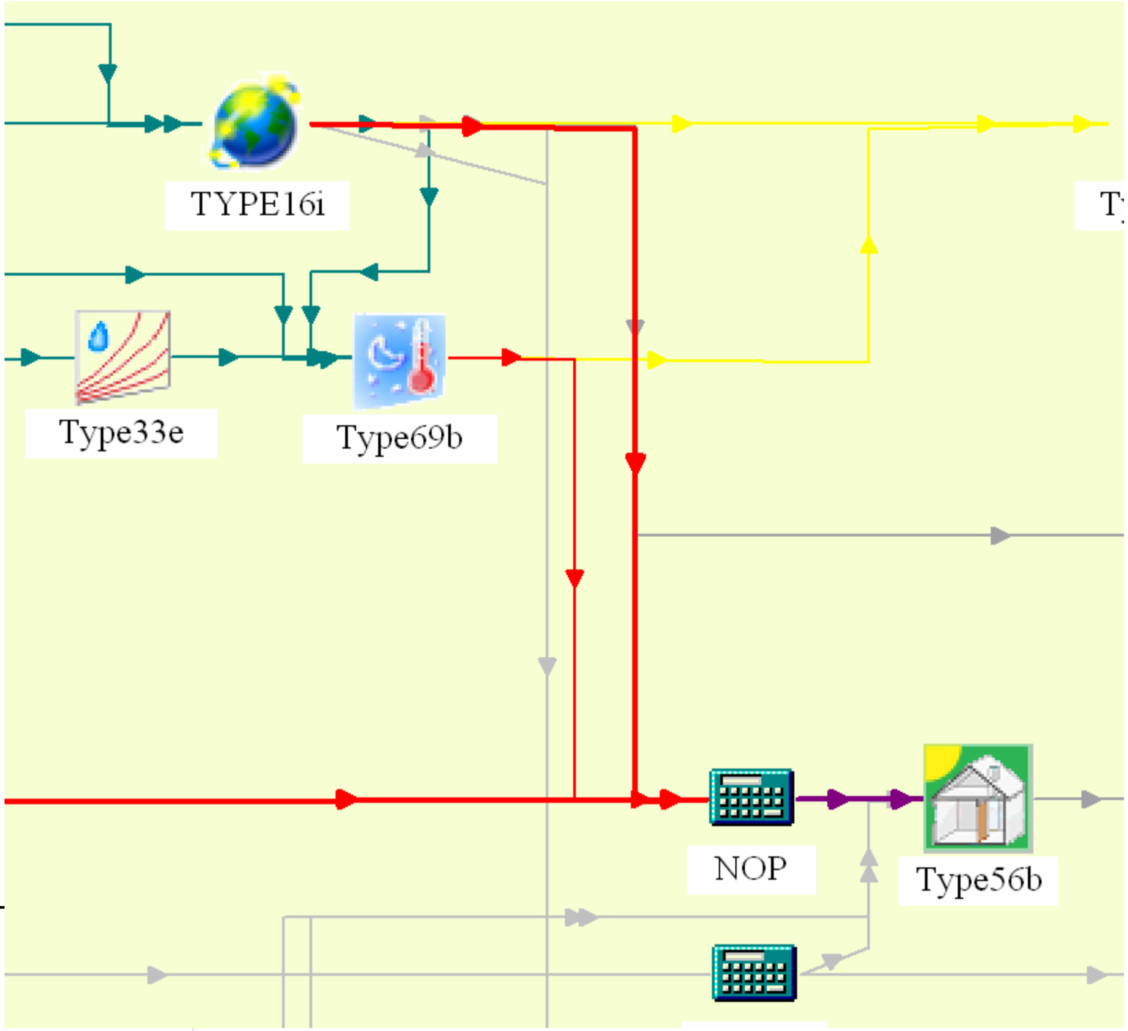
- Selection of applications:
  - …?
- Selection of sites, preparation of meteorological data files:
  - …?

Subtask 3.3
Determination of loads / building simulation



Subtask 3.3
Determination of loads / building simulation

- TRNSYS / PREBID?
  ⇒ depends on decison on coupled or seperate building / system simulation
- Generation of load data files



Subtask 3.3
Determination of loads / building simulation

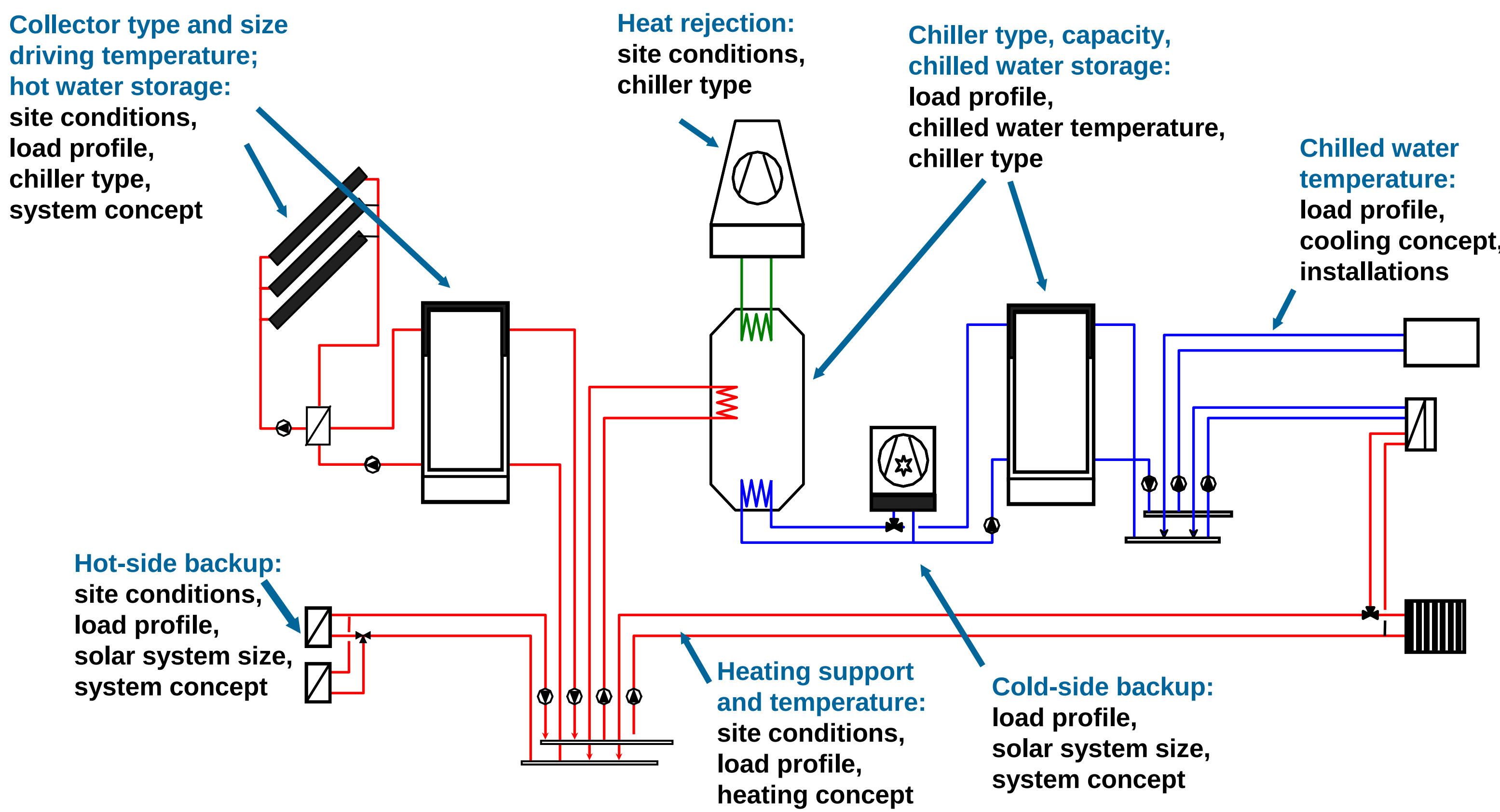
- Definition of building standards:
  - on base of present building standards
  - on base of national / European directives for new / refurbished buildings
- Definition of typical buildings for the defined applications (3.2)
- Definition of internal loads, equipment, ventilation,..

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?
  - …?

Subtask 3.4
Determination of system configurations



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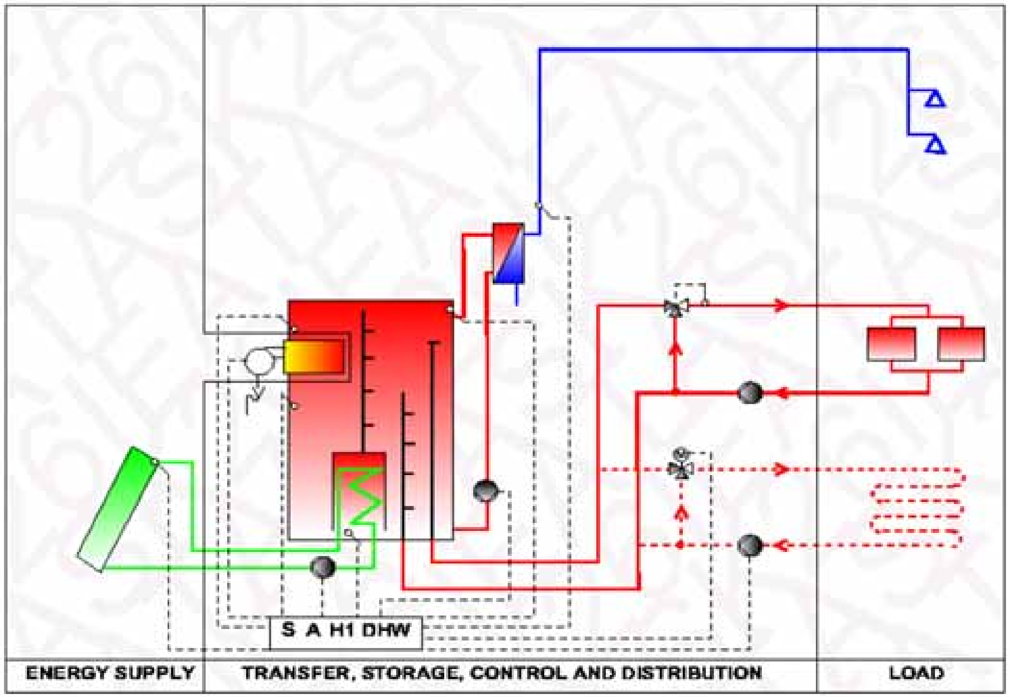

Figure from case study in Task 26

Subtask 3.4
Determination of system configurations

- **Collector:**
  - type of collector, fluid
  - heat exchanger (no/external/in storage)
  - pumps: controlled/fix speed

- **Storages:**
  - hot side / cold side / additional storages (DHW,..)
  - additional buffer for adsorption chillers

- **Heat rejection:** wet / closed / dry /ground

- **Auxiliary sources:** CHP / gas boiler / compression chiller

- ….

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Subtask 3.4
Determination of system configurations

- **Pre-selection of appropriate configurations:**
  - which configuration for which climate?
  - which chiller type for which application?
  - which collector for which chiller?
  - which heat rejection system for which configuration?

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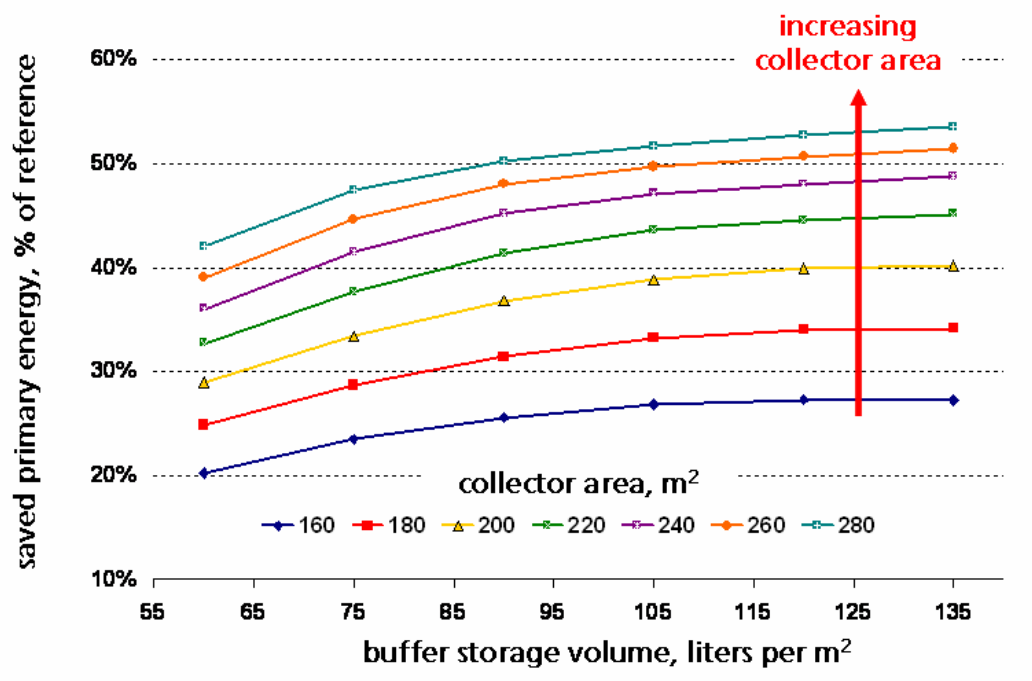

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