IEE Solar Combi+

WP3 – Virtual Case Studies

Edo Wiemken, Björn Nienborg

Fraunhofer Institute
for Solar Energy Systems ISE

Kick-off meeting September 27-28, 2007
Bolzano, Italy

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 possible system configurations and control strategies

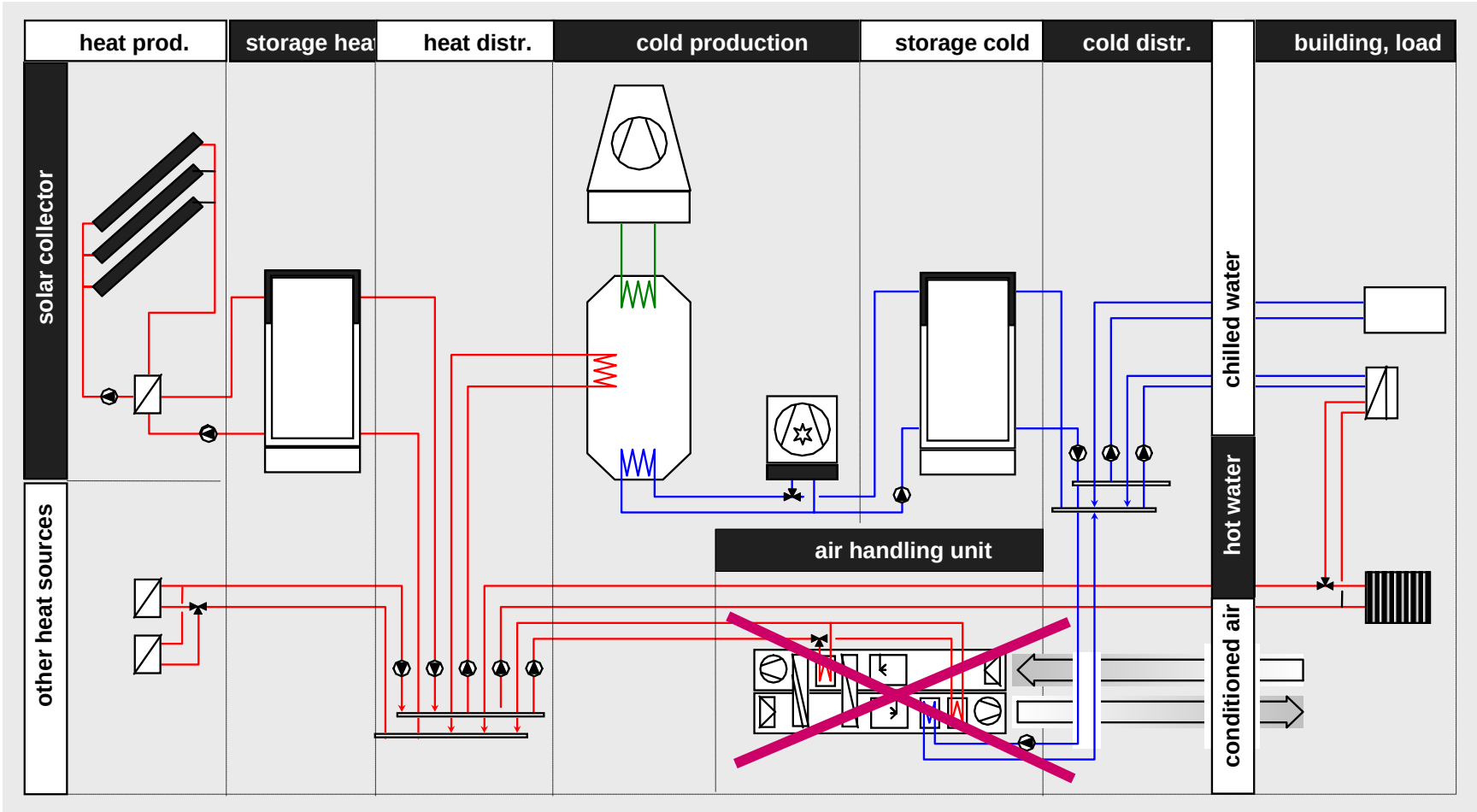
Fraunhofer ISE Institut Solare Energiesysteme

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

Fraunhofer Institut Solare Energiesysteme

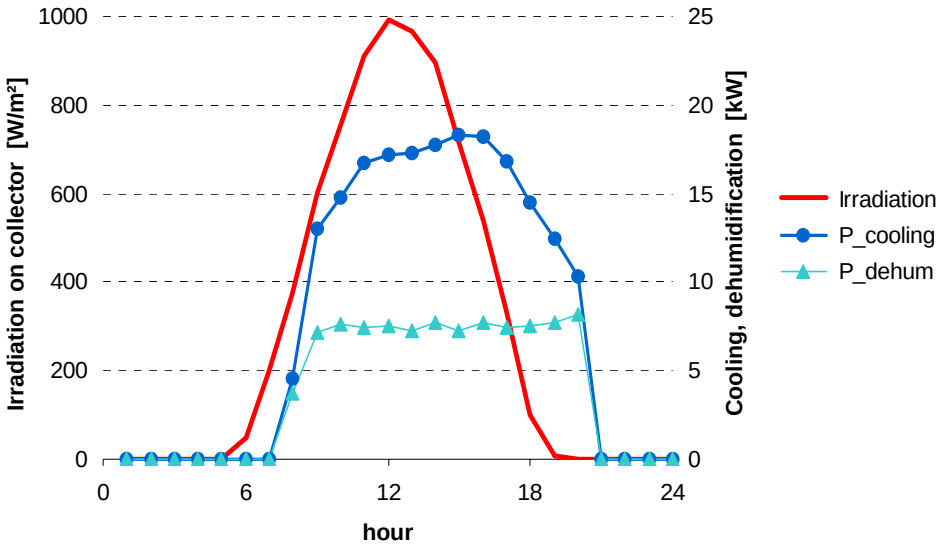
Systems in Solar Combi+



Fraunhofer ISE Institut Solare Energiesysteme

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

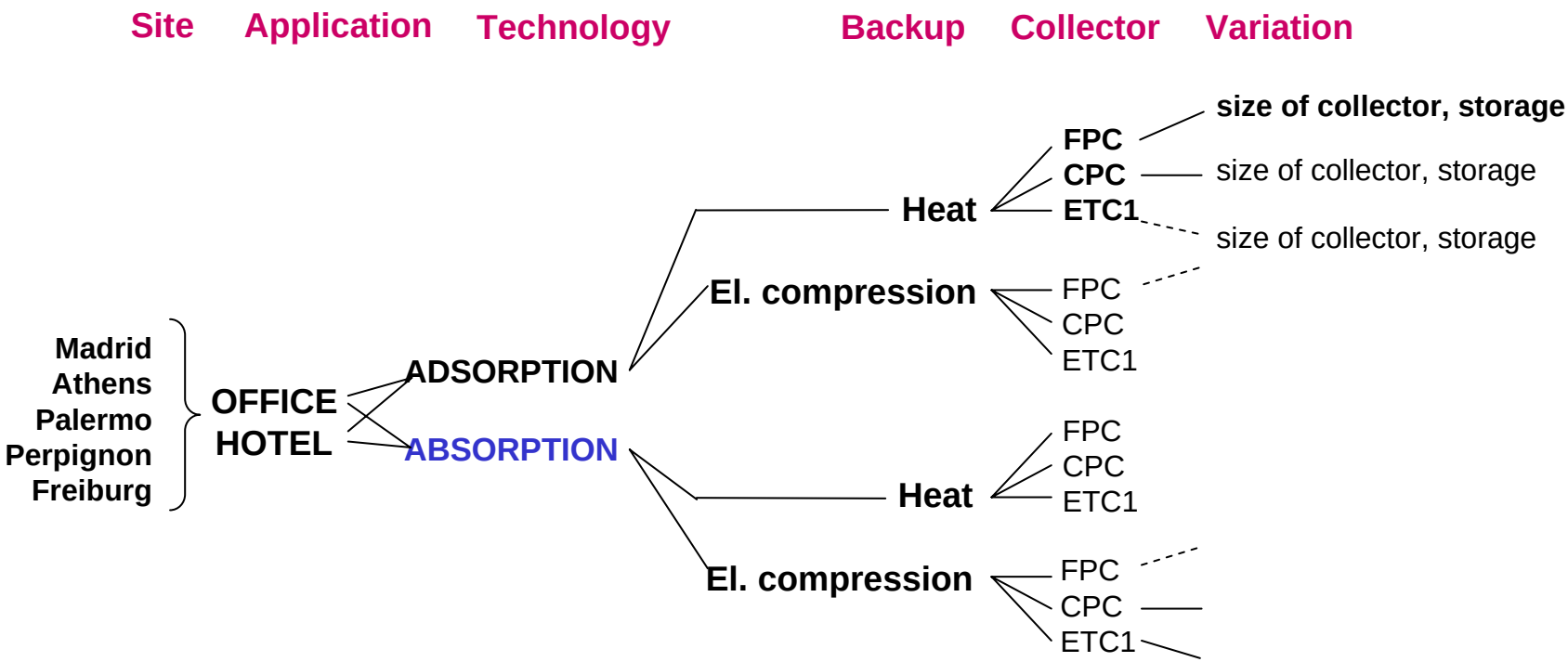
EU project, completed in 2003 www.cop.tudelft.nl/ev/res/sace.htm



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

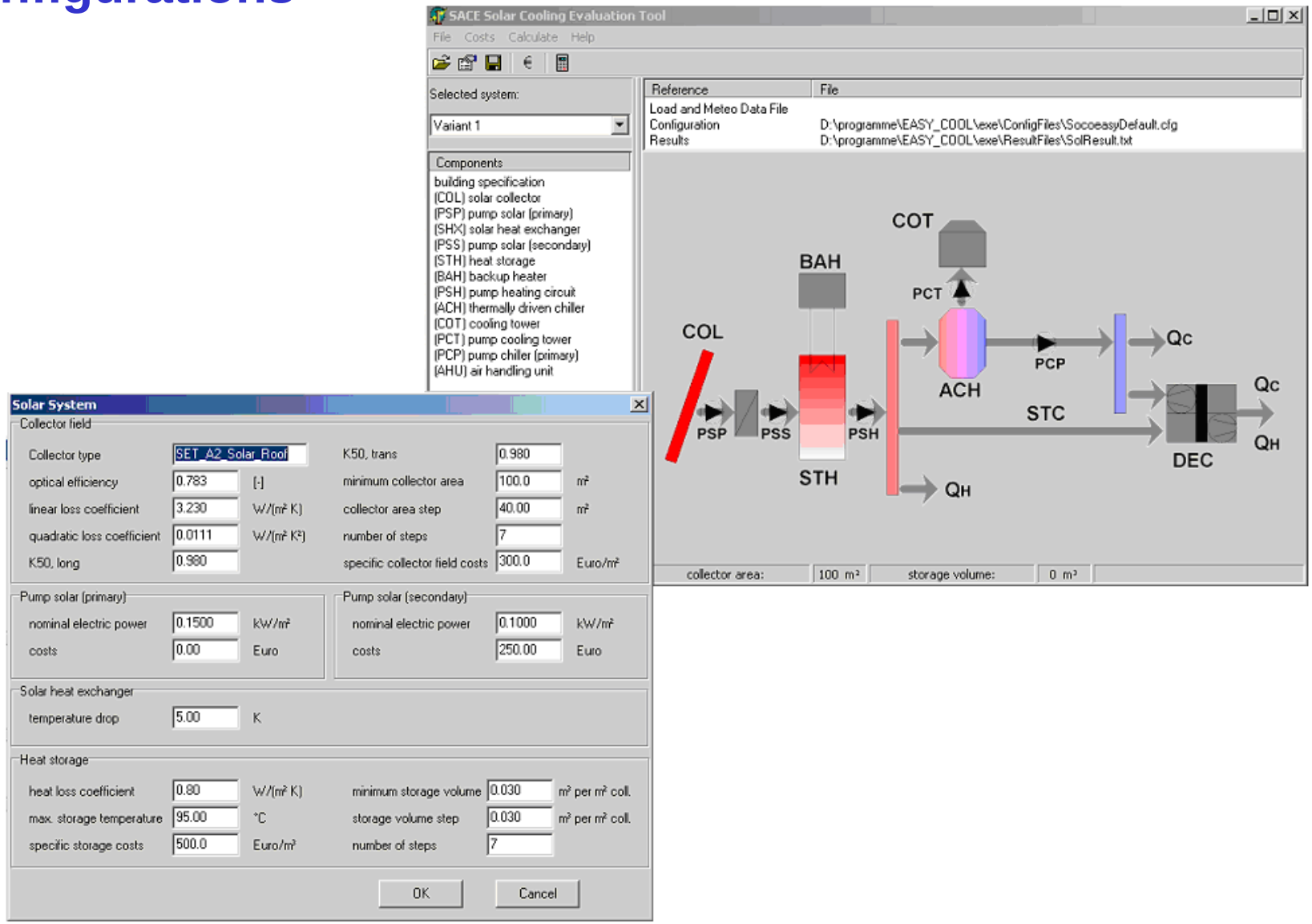
SACE: approach

- 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

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

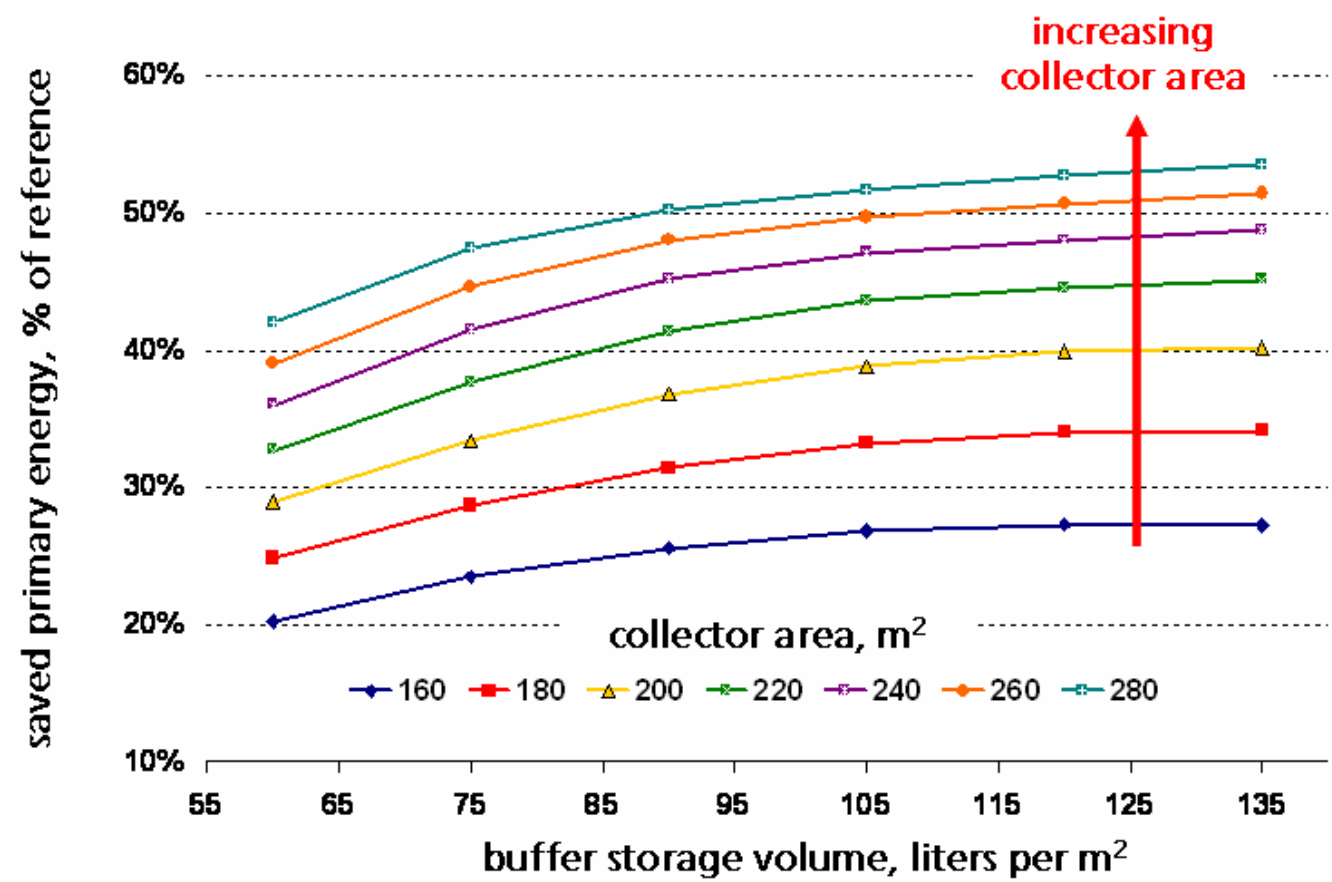
Fraunhofer ISE Institut Solare Energiesysteme

SACE design tool with predefined configurations



SACE Pre-design tool; example

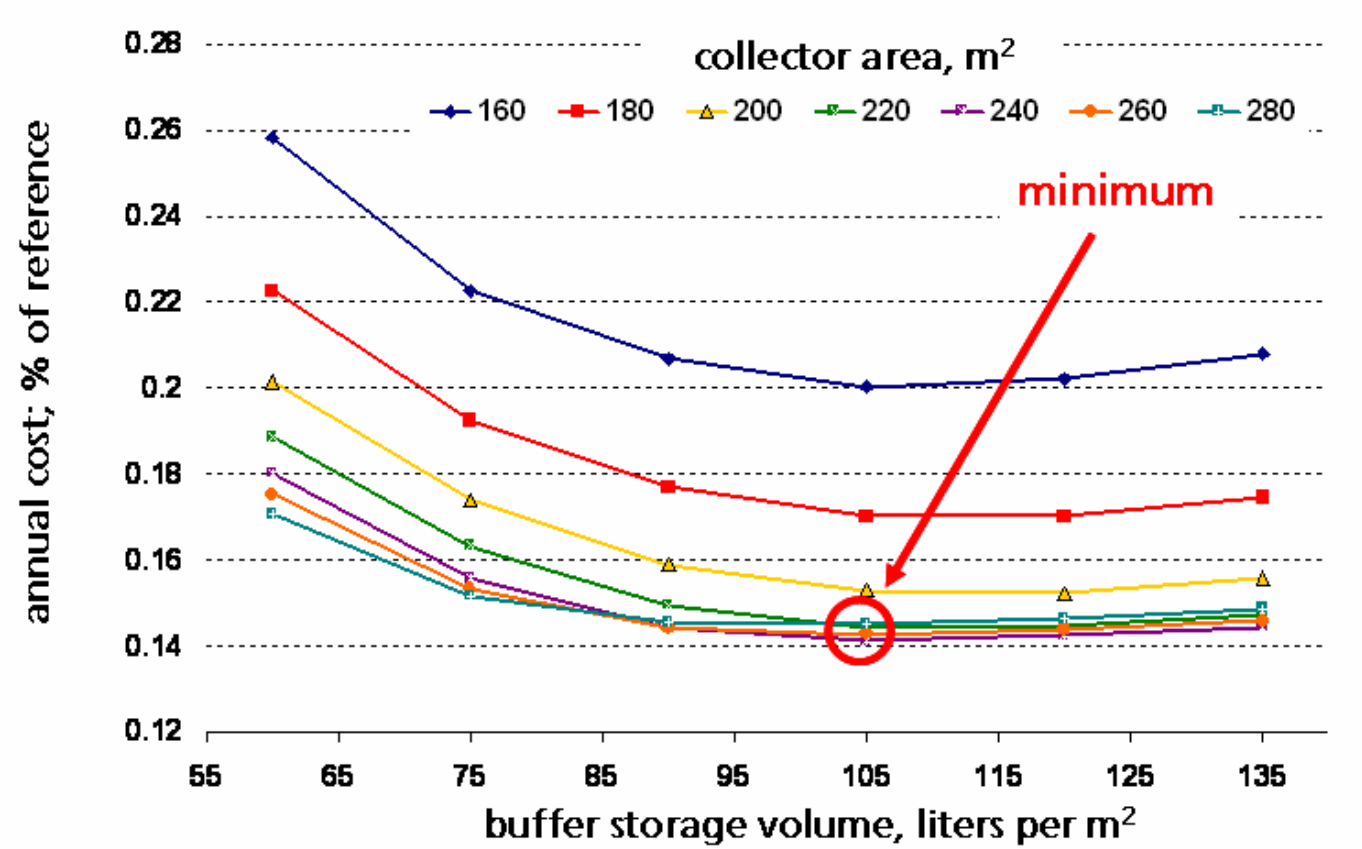
- Madrid
- office building
- flat plate collector
- back-up: boiler
- absorption chiller



Fraunhofer Institut Solare Energiesysteme

SACE Pre-design tool; example

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



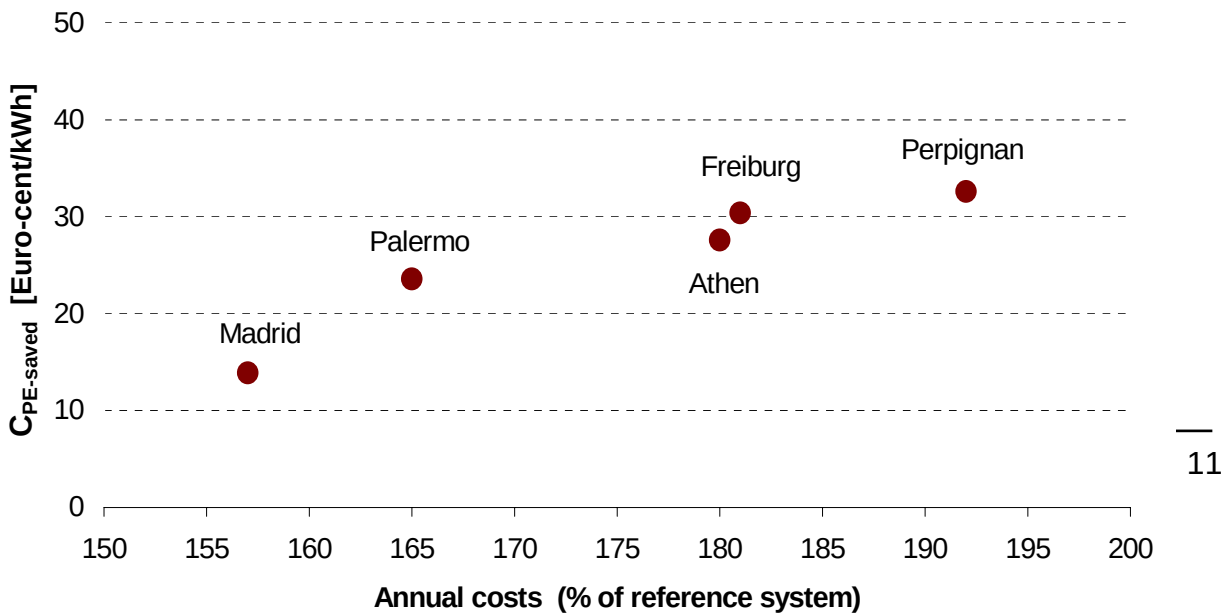
Fraunhofer ISE Institut Solare Energiesysteme

SACE study: results (office building)

- Conditions:

  primary energy saving > 25%; annual net collector efficiency > 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

Fraunhofer Institut Solare Energiesysteme

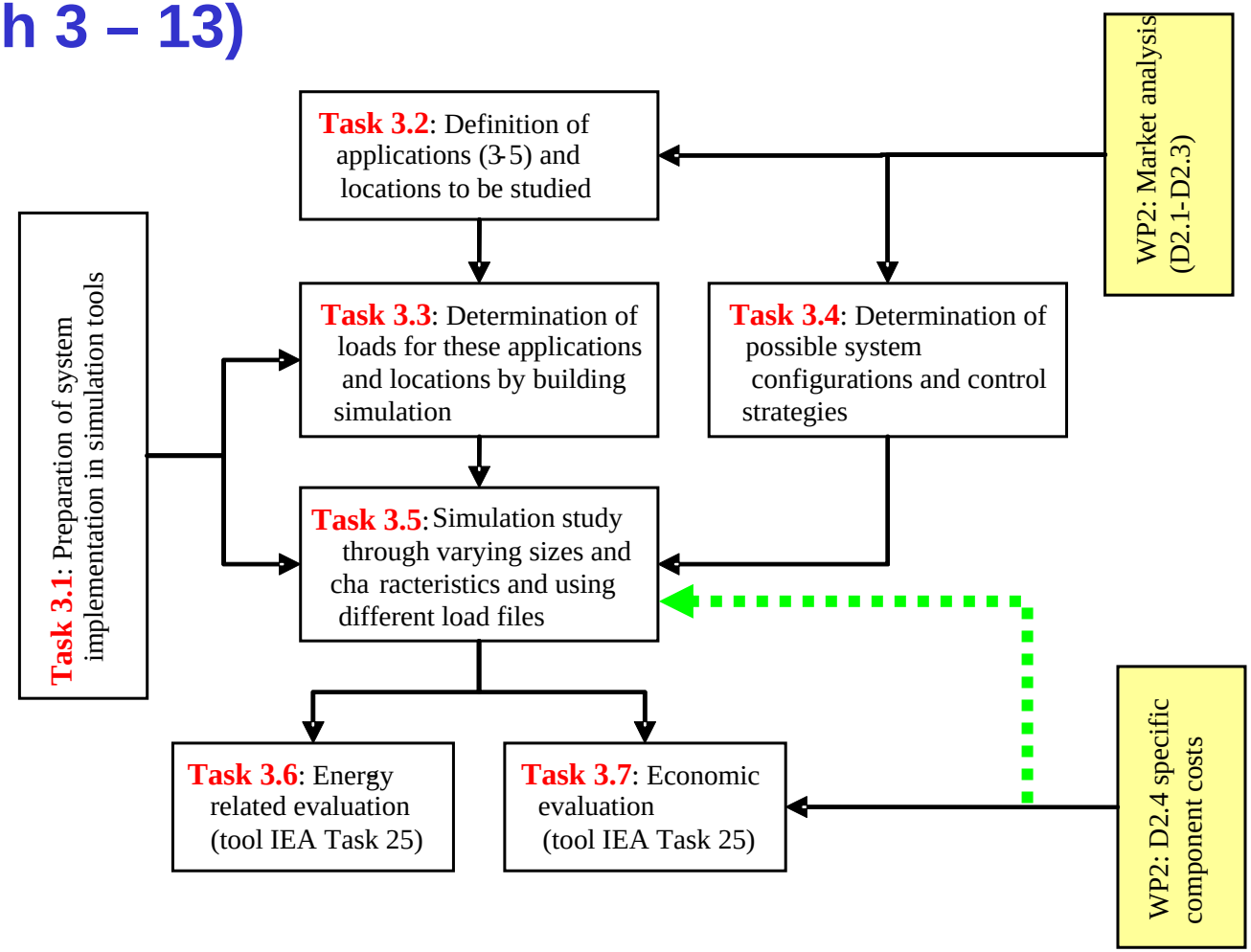
Experiences from design studies

- 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.
  ⇒ 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+:

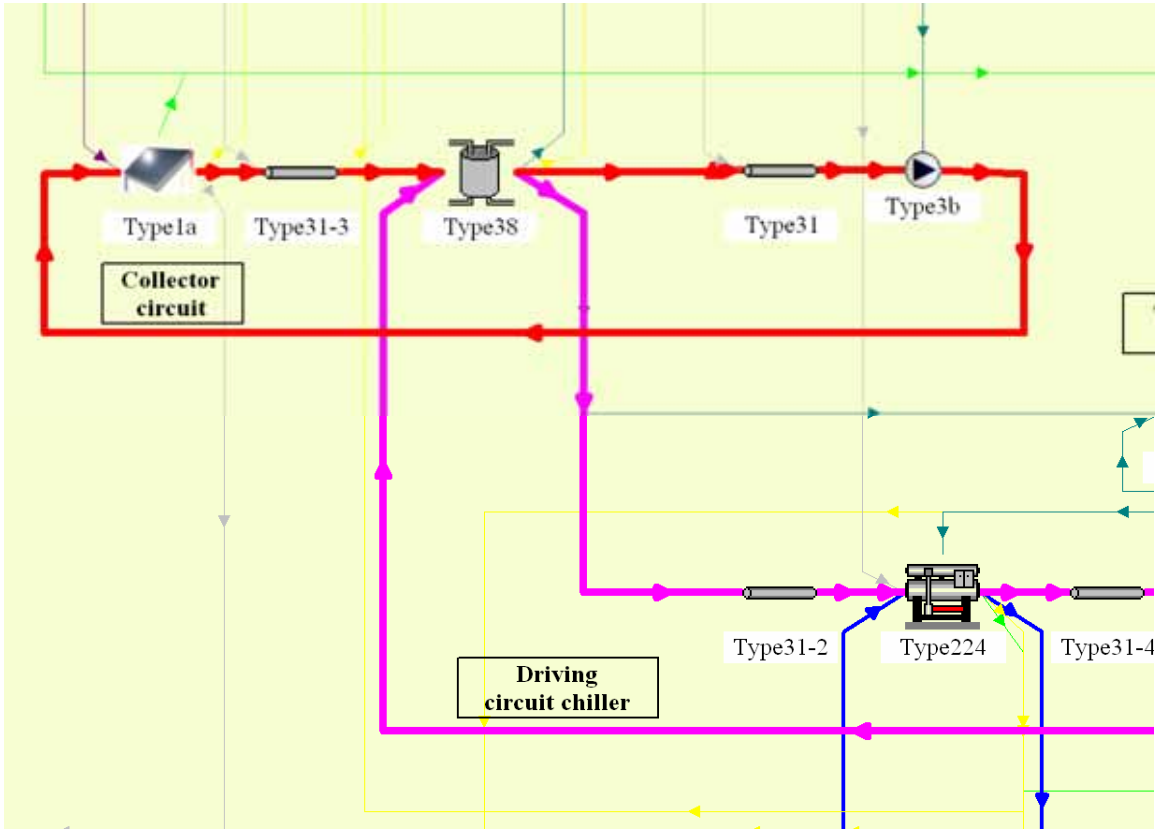
- more precision on modelling, configurations, control
- actual performance and cost figures
- applications based on market analysis

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



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



Fraunhofer Institut Solare Energiesysteme

Subtask 3.2
Definition of applications and locations to be studied

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

  ⇒ input from WP2, SOLCO, ..

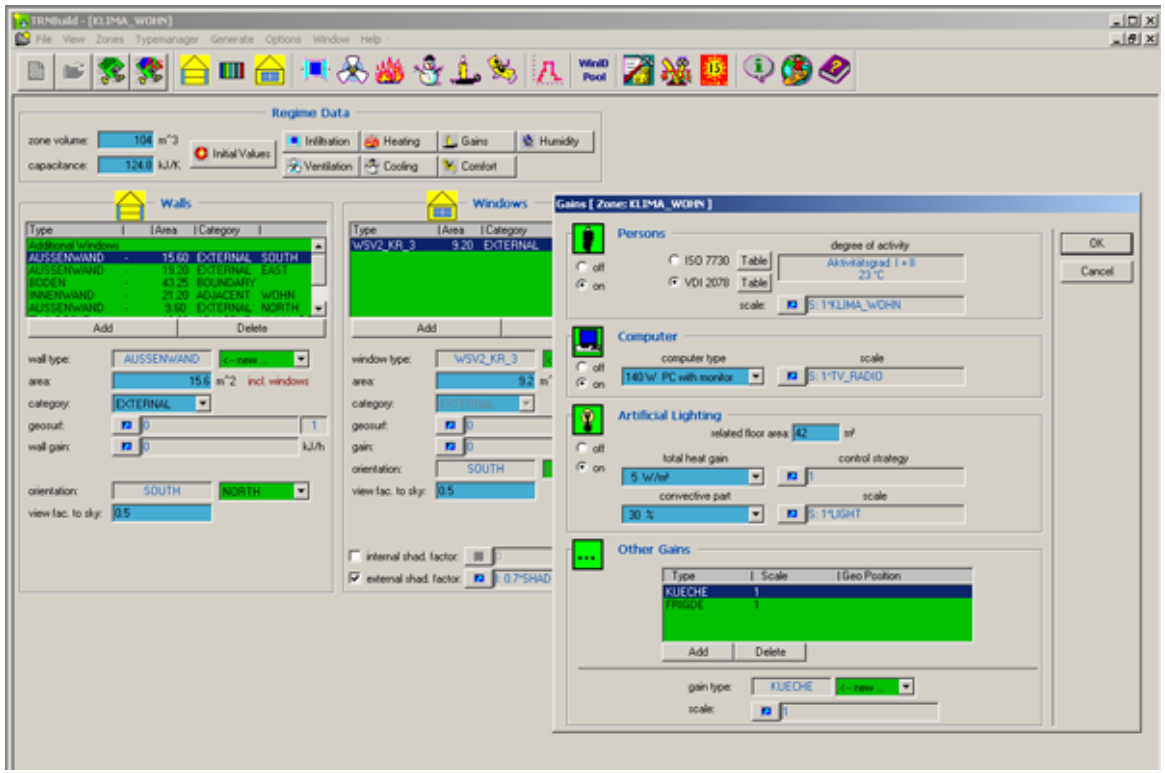
- Sites:
  - consortium partner countries ?
  - meteorological data source?

  ⇒ Input from ECOHEATCOOL,..

Fraunhofer ISE Institut Solare Energiesysteme

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



Fraunhofer ISE Institut Solare Energiesysteme

Subtask 3.4
Determination of system configurations

- Input from WP2 Market analysis
- Input from partners: configuration of marketed systems
- Advantages / disadvantages from realised systems
- Input to heating support and domestic hot water preparation configurations:
  IEA Tasks (e.g., Task 26 Solar Combisystems)

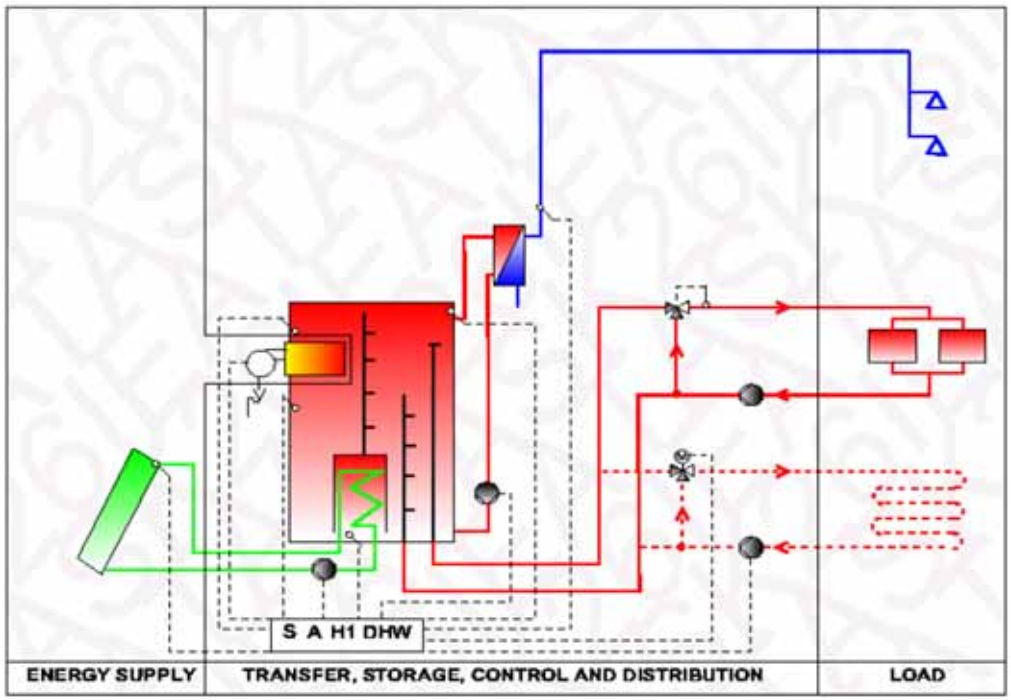
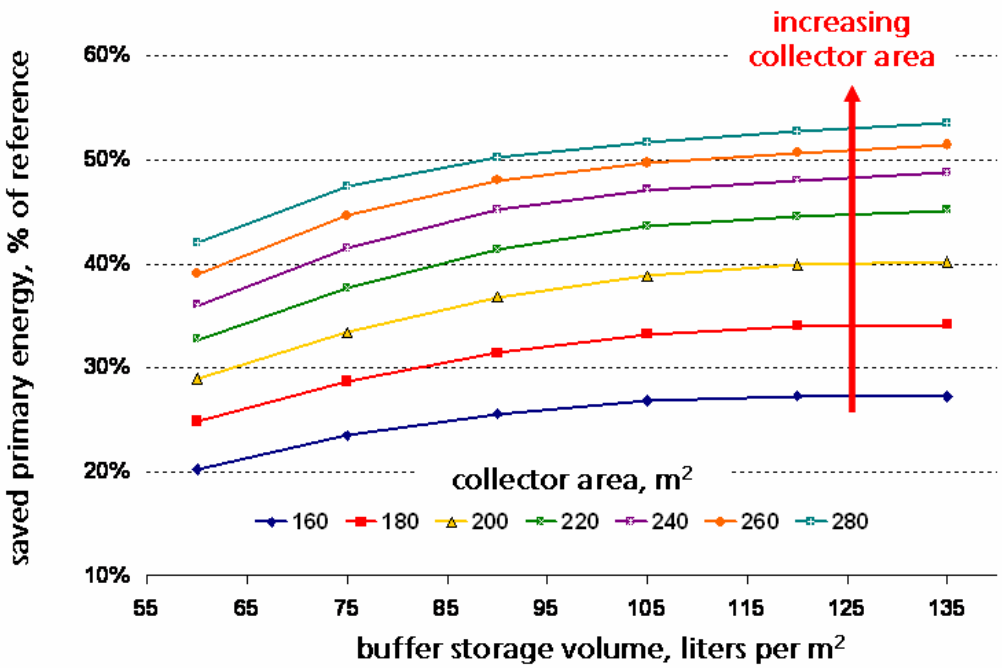


Figure from case study in Task 26

Fraunhofer Institut Solare Energiesysteme

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



Fraunhofer Institut Solare Energiesysteme

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

Fraunhofer ISE Institut Solare Energiesysteme