SolarCoolingOpt
Austrian R&D project
2010 - 2013

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Funding authority and partners

Funding Authority:

Klima- und Energiefonds

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Partner:

AEE - Institute for Sustainable Technologies (projekt coordination)

AIT - Austrian Institute of Technology

ITW TU Graz - Institute of Thermal Engineering, Graz University of Technology

ASiC - Austria Solar Innovation Center

Podesser Consulting

Joanneum Research Forschungsgesellschaft mbH

Institute of Computer Technology Wien

Pink Energie- und Speichertechnik GmbH

SOLID GmbH

Enertec Naftz & Partner OG

Feistritzwerke – STEWEAG GmbH

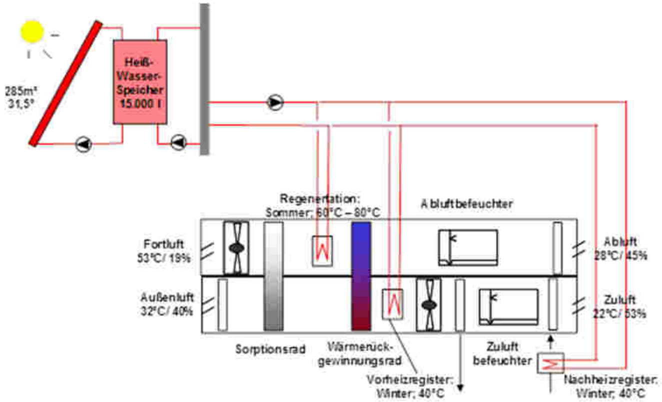
Greiner Renewable Energy GmbH

WILO Pumpen Österreich GmbH

University oft Innsbruck,
Institute for Structural Engineering and Material Sciences, Energy Efficient Buildings

Starting Point

Solar Cooling Monitor (2009 – 2012)

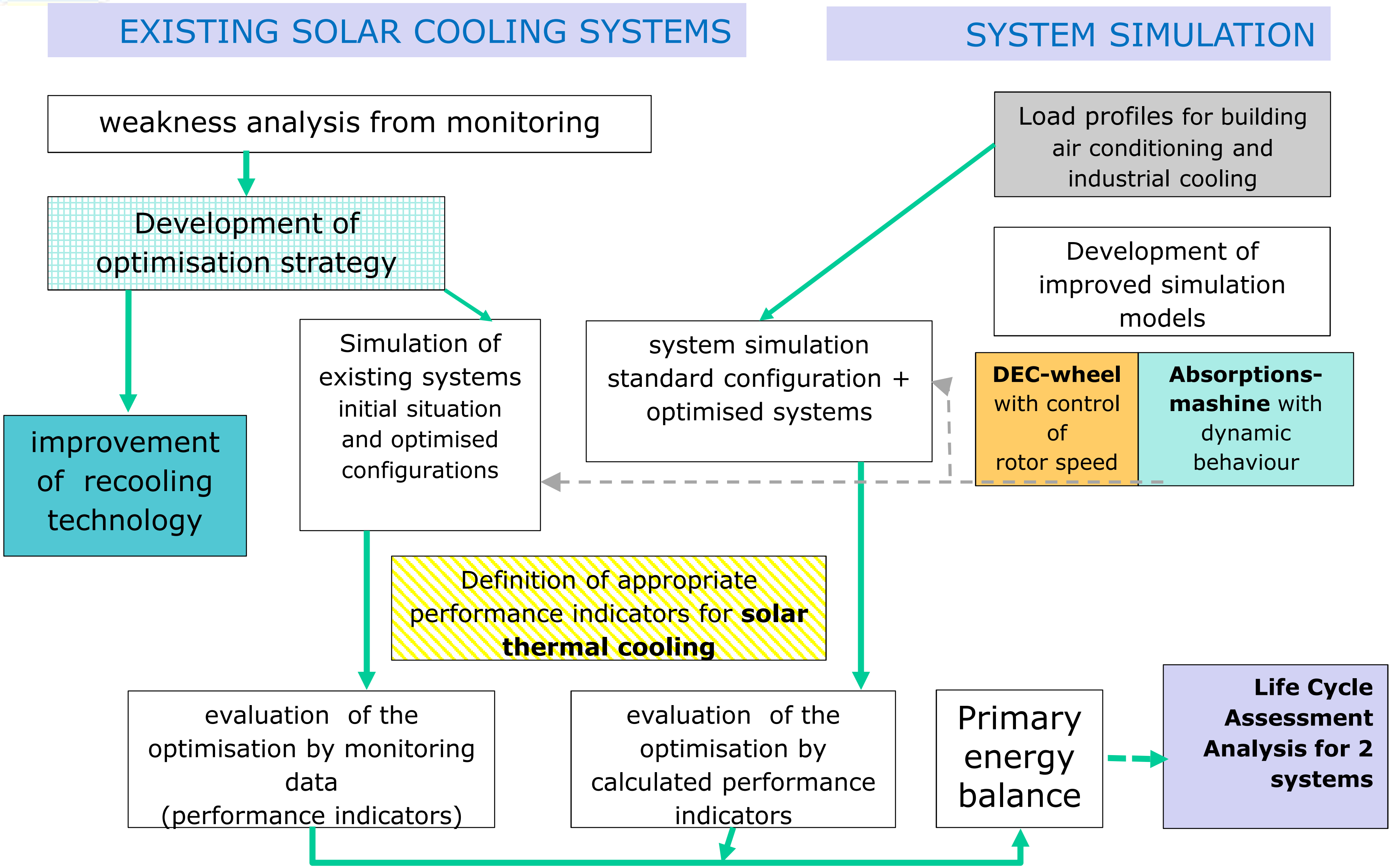


A lot of „well intentioned" plants, but low efficiency noted

Idea of the project:

Optimisation of primary energy consumption of solar cooling plants by means of efficient technology and innovative control strategies – ***SolarCoolingOpt***

Targets of the project and method



New simulation models for SHC-components

- **DEC-Rotor**

Speed dependant desiccant wheel

Development of a new TRNSYS type considering the rotor speed for dehumidification effectiveness

The mathematical model is based on effectiveness parameters of the desiccant wheel

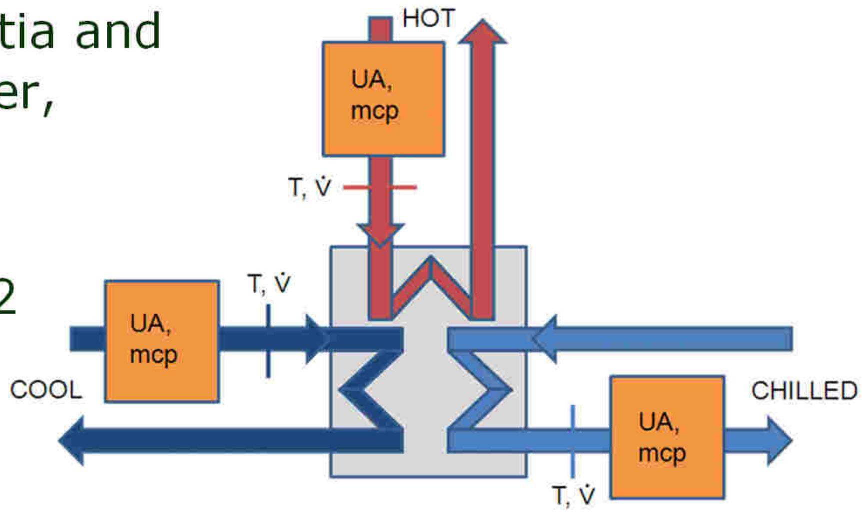
$\varepsilon_d = f(n)$

New simulation models for SHC-components

Absorption machine NH_3-H_2O 19 kW (Pink) was exactly measured, including the OnOff-behaviour and the internal states (TU Graz)

Simulation model based on characteristic curves:

- ⇨ matrix with ca. 9000 states of operating conditions (temperatures and mass flow rates)
- ⇨ Considering thermal inertia and internal state of the chiller, modelling a dynamic power control is possible
- ⇨ A new TRNSYS type 1002 was developed, tested and is now available



Comparison between different configurations

Simulations were carried out for 3 different solar cooling systems, everyone with several configurations and control strategies, in order to compare a „standard configuration“ with optimized configurations in terms of covered cooling load and primary energy consumption:

- Air conditioning for buildings with DEC - Air Handling Unit
- Delivering of chilled water (base load) with Absorption Chiller H_2O/LiBr, 1470 kW
- Air conditioning for buildings with NH3/H2O chiller, 19kW

Comparison between different configurations by simulation – DEC AHU

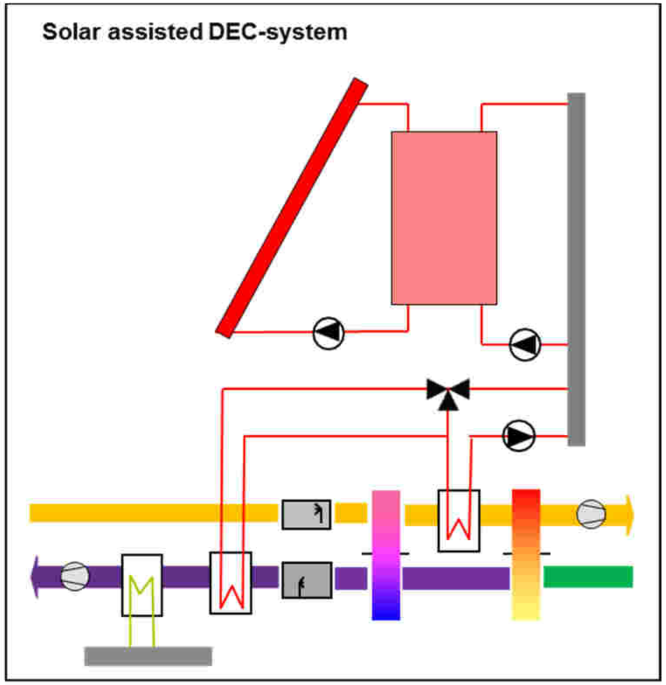
1. case:

DEC-AHU *(AIT)*

utilitiy: office and hotel, with climatic conditions of Vienna, Athens, Kairo and Honolulu

Details:

"Results of system configurations to optimize solar-driven Desiccant Evaporative Cooling Systems in full year operation"
Anita Preisler, Markus Brychta
SHC 2013 Freiburg



Quelle: AIT

Quelle: AIT

Comparison between different configurations by simulation – large system

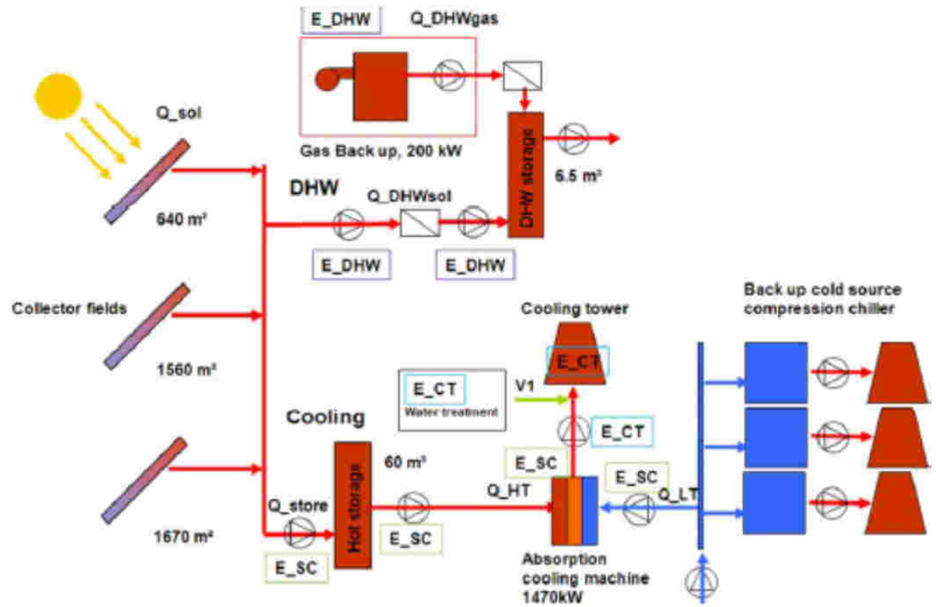
2. case:

United World Campus Singapur 1,5 MW Absorption Chiller

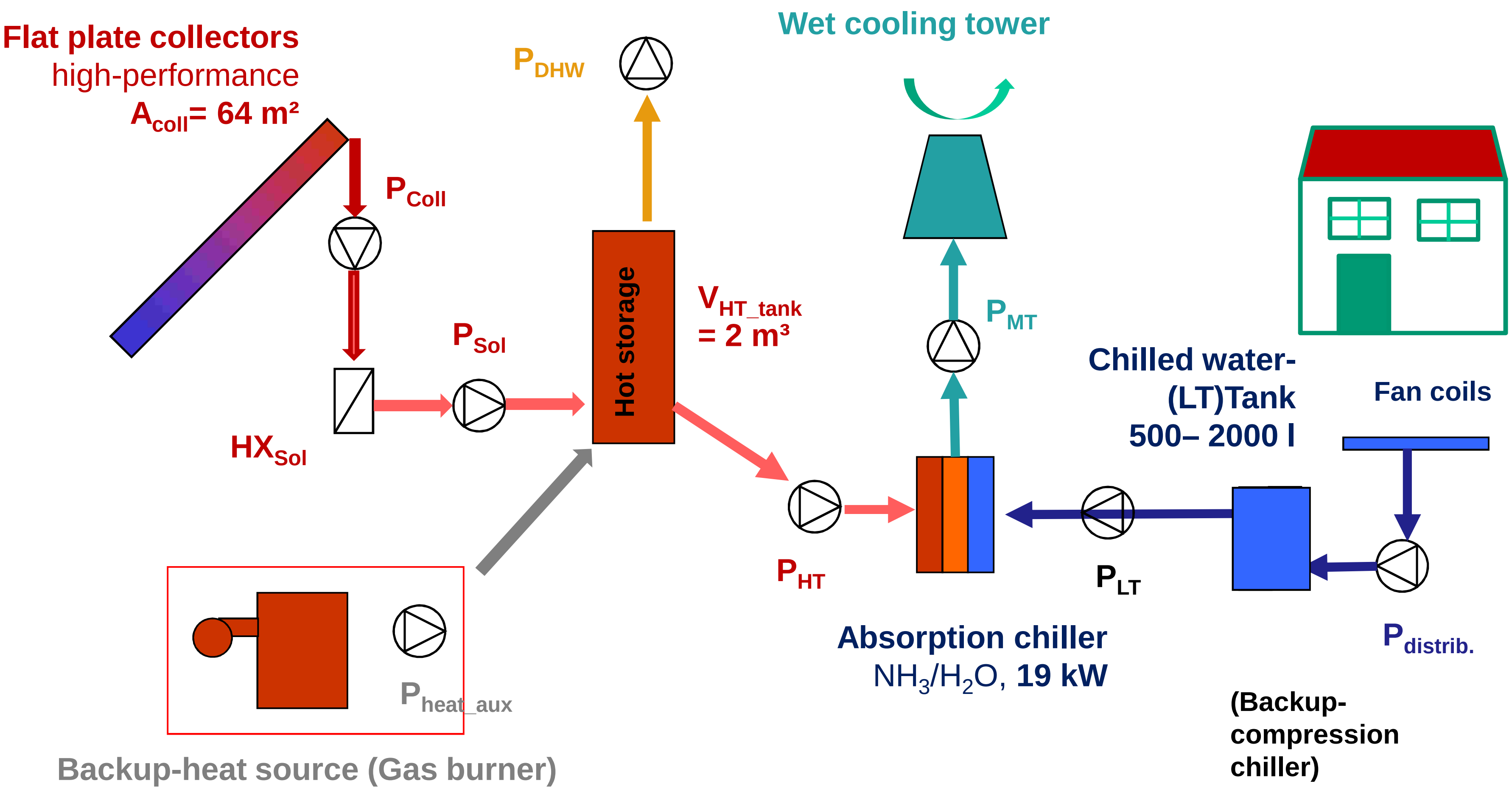
- Calculation of the suitable collector area (originally it‘s too small) and appropriate design of the whole solar plant
- Power control for part load operation

Summary: large SC systems (>1000kW) for base load can reach >50% PE-saving with optimized component design and simple control strategies in confront to a conventional chiller with $SPF_{el} \approx 6$.

Solar assisted systems in such size and application can reach $SPF_{el} > 12$ (at least)



Comparison between different configurations by simulation: small systems



Comparison between different configurations by simulation: small systems

Well known performance indicators : **SPF_{th}, SPF_{el}, PER**

New: SPF_el_equ

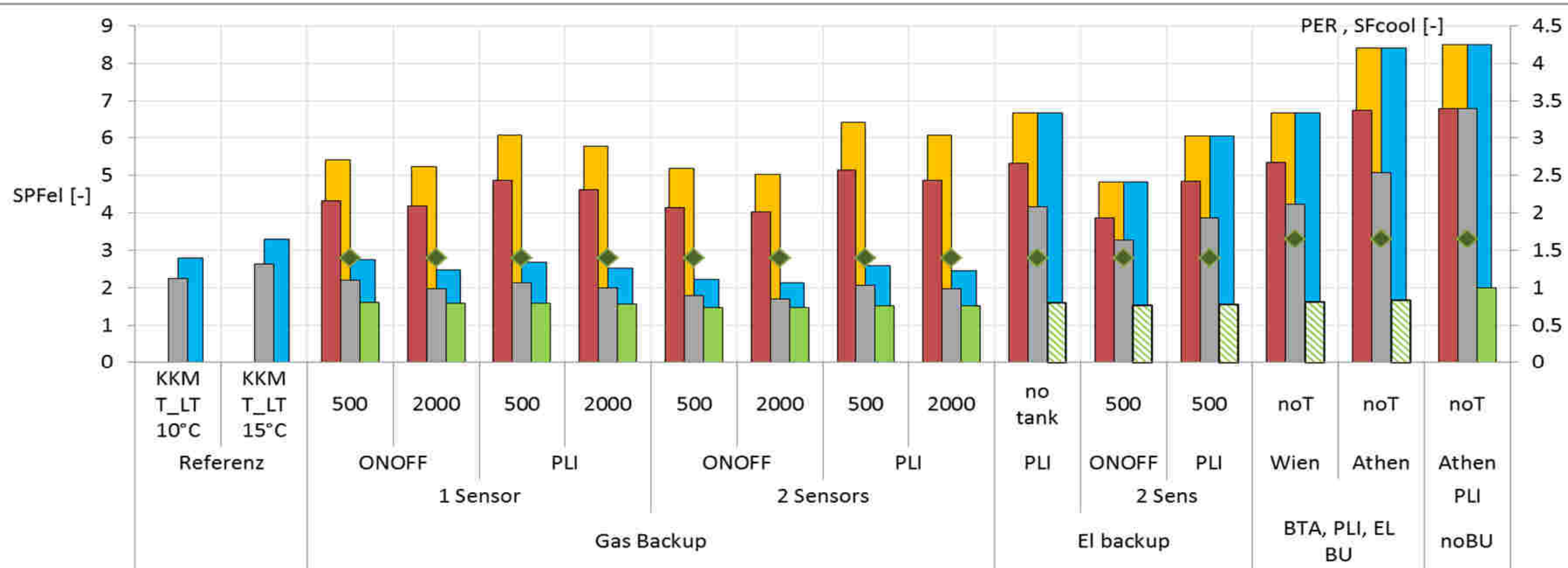
- the electrical Seasonal Performance Factor which should have a conventional chiller, for work with the same primary energy efficiency as the solar thermal cold production.

$$SPF_{equ} = \frac{PER_{sc\_only}}{\varepsilon_{el}}$$


=

Comparison between different configurations by simulation: small systems – validation of all investigated configurations

f_save			-02%	-13%	-05%	-12%	-26%	-32%	-09%	-14%	46%	32%	42%	37%	48%	61%

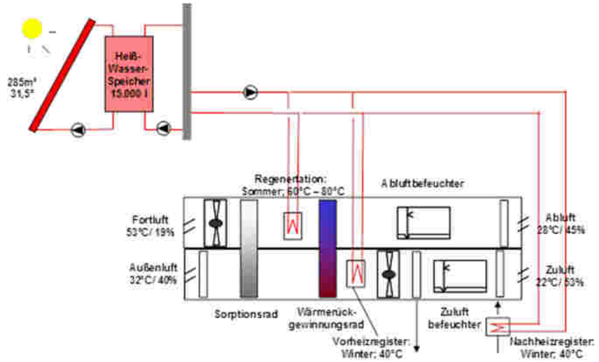


	Referenz KKM T_LT 10°C	Referenz KKM T_LT 15°C	Gas Backup 1 Sensor ONOFF 500	Gas Backup 1 Sensor ONOFF 2000	Gas Backup 1 Sensor PLI 500	Gas Backup 1 Sensor PLI 2000	Gas Backup 2 Sensors ONOFF 500	Gas Backup 2 Sensors ONOFF 2000	Gas Backup 2 Sensors PLI 500	Gas Backup 2 Sensors PLI 2000	El backup PLI no tank	El backup 2 Sens ONOFF 500	El backup 2 Sens PLI 500	BTA, PLI, EL BU Wien noT	BTA, PLI, EL BU Athen noT	Athen PLI noBU noT
SPFel_sc-only	0	0	5.41	5.24	6.07	5.78	5.18	5.02	6.42	6.08	6.67	4.82	6.05	6.68	8.42	8.49
SPFel_equ	2.8	3.3	2.74	2.47	2.67	2.51	2.21	2.12	2.58	2.44	6.67	4.82	6.05	6.68	8.42	8.49
PER_sc-only	0	0	2.16	2.09	2.43	2.31	2.07	2.01	2.57	2.43	2.67	1.93	2.42	2.67	3.37	3.40
PERc (inkl. Back-Up)	1.12	1.32	1.10	0.99	1.07	1.00	0.89	0.85	1.03	0.98	2.08	1.64	1.93	2.11	2.54	3.40
SFcool	0	0	0.81	0.79	0.79	0.78	0.73	0.73	0.76	0.76	0.80	0.76	0.78	0.81	0.84	1.00

Optimisation of operation of existing plants

Optimisation of the control strategy for solar assisted office Desiccant Cooling in Vienna (ENERGYbase)

(285m² collector area, 2x 8860 m³ air flow rate)



In spring 2013 the whole control system was re-programmed, to better regulate the temperature and humidity of the inlet air

The system works now without failure…

Life Cycle Analysis for optimised systems

- Two systems with absorption chiller (19 kW and 1450 kW) was investigated in „standard" and optimised configurations
- The non-renewable primary energy consumption and the greenhouse emissions in the whole life cycle was calculated in comparison to a compression chiller system and to ones fed by PV-panels
- Results: The optimised systems (with dynamic power control and adapted components), due to the PE-saving in their operational phase, are able to compense the higher environmental impact in their production phase and end-of-life phase (saving potential 35 – 50%)

Results of the research project

- new types for a sorption wheel and an absorption chiller with dynamic behaviour are available, able to present the features of the components which are relevant for control strategies.
- comparison of DEC systems in offices at various climatic conditions showed particulary high potential of Primary Energy saving in climates as Vienna thanks to recovery of humidity in the heating season.
- simulations of systems with small absorption chiller (20 kW) for office cooling shows ca. 30% higher energy efficiency in Athens (SPF_{el_SC} = 8,5) compared to Vienna(SPF_{el_SC} = 6,5).

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Results of the research project

- The optimisation potential of the system with small absorption chiller by means of dynamic power control, without LT-tank and without fossil hot BackUp was calculated with 40% (SPF_{el_SC} from 4,8 to 6,7, climatic conditions of Vienna).
- The optimisation potential of the system with large absorption chiller 1,5 MW by means of adaption of collector area, tank capacity and dynamic power control was calculated with 60% (SPF_{el_SC} from 7 to 11) errechnet.
- Improvements of monitored systems with small absorption chiller caused primary energy saving potential until 60%
- A prototype for an efficient and low-cost cooling tower (26 kW) was developed and tested.

Further necessity of research

- futher exhaustion of the dynamic power control
- Further reduction of primary energy consumption for thermal cooling can be reached with better interaction between building control and system control;
- Economical optimisation of system configurations
- Improvement of reliability of heat rejection including water treatment for open cooling towers
- Extension of the investigations of solar thermal systems to solarelectrical systems, and to combinations of both (hybrid cooling lsystems)

THANK YOU FOR THE ATTENTION!

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