SOLAIR

Increasing the Market Implementation of Solar Air-Conditioning Systems for Small and Medium Applications in Residential and Commercial Buildings

Solar Cooling – una tecnologia pronta per il mercato

Catalogo di impianti realizzati in Italia e in Europa

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Intelligent Energy Europe

EIE/06/034/SI2.446612 SOLAIR

Work package 2: Market review and analysis of small and medium sized solar air-conditioning (SAC) applications

Task 2.2: Preparation of a web based database of best available examples

Best Practice Catalogue

June 30, 2008

Version 1.0

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1 Introduzione

Praticamente in tutti i paesi europei, è stata rilevata una forte crescita della domanda di raffrescamento ed aria condizionata negli edifici ed è previsto un continuo aumento nei prossimi decenni. Le ragioni di questa crescita generale sono molteplici: l'alto livello di comfort nelle abitazioni, i costi ancora contenuti dell'energia, i trend architettonici come, ad esempio, l'aumento di superfici vetrate negli edifici e il lento modificarsi delle condizioni climatiche. La crescente domanda di raffrescamento ed aria condizionata negli edifici determina un elevato consumo di combustibili fossili e problemi di stabilità nella domanda di elettricità nei paesi mediterranei, che a sua volta richiede costosi adattamenti della rete per sopportare i picchi di potenza.

Diventano quindi interessanti nuovi concetti di edifici, che mirano alla riduzione dei carichi di raffrescamento tramite misure passive ed innovative e l'utilizzo di soluzioni alternative per coprire la restante domanda di raffrescamento. Il condizionamento solare è proprio una di queste soluzioni.

Nel contesto del progetto SOLAIR, il solar cooling o solar air-conditioning viene utilizzato per processi solari alimentati *termicamente.* In questo senso il solar cooling può contribuire a:

- Sostituire i combustibili fossili con l'utilizzo di energia solare e, in questo modo, contribuire agli obiettivi europei sull'utilizzo di energie rinnovabili;
- Riduzione degli effetti dovuti alle emissioni di gas serra attraverso il risparmio di energia primaria e, allo stesso tempo, evitando l'utilizzo di refrigeranti dannosi per l'ambiente;
- Contribuire alla stabilità della rete elettrica riducendo la domanda di energia elettrica e i picchi di potenza;
- L'ottimizzazione dei sistemi solari tramite l'utilizzo combinato di calore solare per riscaldamento degli ambienti, raffrescamento e acqua calda sanitaria.

Il progetto SOLAIR fornisce utili materiali sul solar cooling, rivolti ad un pubblico variegato. Questo catalogo presenta esempi di buone pratiche a livello europeo. Molti di questi esempi sono entrati in funzione uno o due anni prima rispetto alla redazione di questo documento, pertanto non esistono, fino ad ora, esempi di impianti di lunga durata. La definizione 'Best Practice' si riferisce quindi a impianti realizzati correttamente e sulla base di approcci promettenti. La raccolta si prefigge di presentare l'applicabilità delle tecnologie di solar cooling all'interno di diverse tipologie di ambienti, in varie localizzazioni e con differenti soluzioni tecniche. All'inizio viene presentata una breve rassegna delle tecnologie di solar cooling.

Altre informazioni sul database di SOLAIR vengono fornite nel rapporto sulle soluzioni tecniche oggi disponibili e sugli impianti realizzati scaricabile da www.solair-project.eu.

2 Tecnologie

Tema centrale di SOLAIR sono gli impianti di condizionamento solare di potenza medio-piccola. La classificazione in “piccolo” e “medio” è in linea con i sistemi di raffrescamento esistenti; per piccole applicazioni si intendono impianti con una potenza nominale (di raffreddamento) sotto i 20 kW, mentre per impianti di media taglia si intendono sistemi di potenza intorno a 100 kW.

Gli Impianti di piccola potenza consistono di solito in sistemi di condizionamento ad acqua, alimentati da energia termica, mentre quelli di media taglia possono anche essere sistemi DEC (desiccant evaporative cooling). Se nel primo tipo di tecnologia il fluido di distribuzione è acqua fredda in un sistema a ciclo chiuso, nel secondo l’aria umidificata è trattata in un processo aperto. In Figura 2.1 sono riportati schematicamente i due tipi di applicazioni. Esistono anche casi in cui si fa contemporaneamente ricordo ad entrambe le tecnologie. Nei sistemi di condizionamento ad acqua, la rete centrale di distribuzione dell’acqua fredda serve le unità decentrate di raffreddamento come fan-coil (quasi sempre con deumidificatore), soffitti, pareti o pavimenti radianti; tuttavia l’acqua fredda può venire utilizzata anche per raffreddare l’aria in un sistema centrale collegato a singole unità ad aria. La temperatura dell’acqua dipende dal tipo di utilizzo ed è importante per definire il progetto e la configurazione dell’impianto, ma i dispositivi finali non rientrano nei temi trattati da SOLAIR e non vengono quindi presentati nel dettaglio.

La figura 2.2 mostra come ogni processo di raffreddamento alimentato da energia termica operi a tre diversi livelli di temperatura; il calore richiesto Q_{heat} ad una temperatura T_H, il calore viene prelevato dal lato freddo che produce il “freddo” utile Q_{cold} alla temperatura T_c. Entrambe le quantità di calore (Q_{reject}) devono essere rilasciate ad una temperatura intermedia TM. Il calore può essere fornito da un apposito sistema di collettori solare termico, sia da solo che abbinato ad una sorgente di calore ausiliaria.

Mentre nei sistemi a ciclo aperto l’espulsione di calore avviene con il flusso d’aria in uscita, i sistemi chiusi di raffreddamento ad acqua necessitano di un sistema di espulsione del calore esterno come, ad esempio, una torre di raffreddamento. L’interesse nei confronti del tipo di sistema di rilascio del calore attualmente sta aumentando, dato che questa componente è spesso responsabile di una grossa parte del restante consumo di energia nei sistemi solari di raffredamento.

Un numero fondamentale per determinare la qualità dei processi termici è il coefficiente COP (coefficient of per-formance), definito come COP = Q_{cold} / Q_{heat} , cioè la quantità di calore richiesto per unità di freddo “prodotto” (o meglio: per unità di calore asportato). Il COP e la capacità di raffreddamento dipendono dai valori delle temperature T_H, T_C e T_M. Questa dipendenza viene trattata in dettagli negli esempi [Henning, 2006].

Nelle macchine di condizionamento alimentate da energia termica attualmente disponibili sul mercato, il COP varia tra 0,5 e 0,8 nelle macchine a singolo effetto e raggiunge 1,2 nelle macchine a doppio effetto.

Nei sistemi DEC a ciclo aperto, è più difficile stabilire il COP, poiché esso dipende strettamente dal funzionamento del sistema stesso. È utile definire il COP solo per l'operazione di dessicazione, dato che è in questa fase che è richiesto il calore. Le esperienze di impianti DEC mostrano che si possono ottenere valori di COP paragonabili a quelli di condizionatori a singolo effetto.

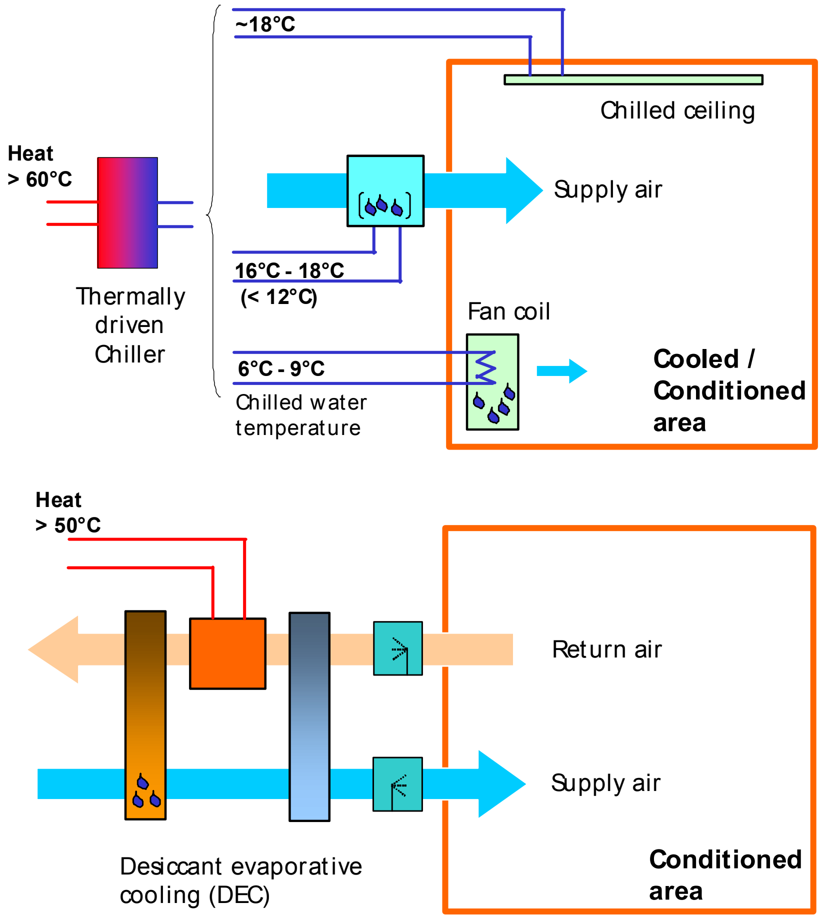


Figura 2.1 Schemi di tecnologie per il condizionamento alimentate da energia termica. Nella figura in alto l'acqua fredda nel ciclo chiuso è prodotta per applicazioni decentralizzate o per raffreddare l'aria per il condizionamento. Nella figura in basso l'aria viene raffreddata direttamente e deumidificata in un ciclo aperto. Fonte: Fraunhofer ISE.

Le tecnologie sono descritte più in dettaglio nel paragrafo successivo. Il calore è richiesto in entrambe le tecnologie per permettere un funzionamento continuo del sistema. Nelle applicazione studiate da SOLAIR una parte significante del calore viene prodotto da un sistema di collettori solari.

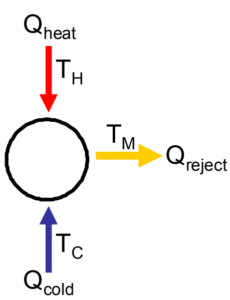


Figura 2.2 Schema di un processo alimentato da energia termica.

2.1 Sistemi ad acqua refrigerata

Condizionatori ad assorbimento

La tecnologia più diffusa tra i sistemi di condizionamento alimentati da energia termica si basa sul principio dell'assorbimento. Il processo fisico avviene tra almeno due elementi chimici, in cui uno è il refrigerante e l'altro l'assorbente. Le componenti principali di un condizionatore ad assorbimento sono mostrate in figura 2.3. Il processo è ben documentato in [ASHRAE, 1988]; perciò non verrà approfondito in questa sede.

La maggior parte dei condizionatori ad assorbimento utilizzano l'acqua come refrigerante e bromuro di litio liquido come assorbente. La potenza di raffreddamento solitamente è di alcune centinaia di kW. Principalmente sono alimentati con calore di scarto, da teleriscaldamento o da cogenerazione. La temperatura della fonte di calore solitamente è di 85 °C e il COP ha un valore compreso tra 0,6 e 0,8. Fino a pochi anni fa la più piccola macchina in commercio era di produzione giapponese con una potenza di 35 kW.

Le macchine a doppio effetto con due generatori necessitano di temperature maggiori di 140 °C, ma con valori di COP > 1.0. Il condizionatore più piccolo di questo tipo ha una potenza di circa 170 kW. Dati gli alti valori di temperatura richiesti questa tecnologia richiede un sistema di collettori a concentrazione. Questa scelta si adatta quindi a climi con alta frazione di radiazione diretta.

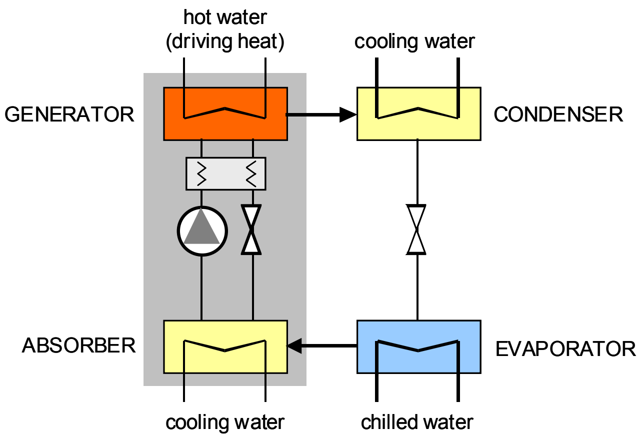


Figura 2.3 Schema di un sistema di condizionamento ad assorbimento. Confrontato con un condizionatore elettrico a compressione convenzionale, l'unità di compressione meccanica è sostituita da una unità di "compressione termica" con assorbitore e generatore. L'effetto di raffreddamento si basa sull'evaporazione del refrigerante (es. acqua) nell'evaporatore a bassa pressione. Durante il cambiamento di fase, elevati quantitativi di energia possono essere trasferiti. Il refrigerante viene assorbito nell'assorbitore e, di conseguenza, diluisce la soluzione refrigerante/assorbente. Il raffreddamento è necessario per rendere efficace il processo di assorbimento. La soluzione viene continuamente pompata nel generatore dove avviene la rigenerazione della soluzione, realizzata per mezzo del calore in ingresso (es. acqua calda). Il refrigerante che lascia il generatore condensa in seguito al passaggio di acqua fredda nel condensatore e circola nuovamente nell'evaporatore, per mezzo di una valvola ad espansione.

Figura 2.4a Esempi di piccoli condizionatori ad assorbimento che utilizzano l'acqua come refrigrante e bromuro di litio come fluido assorbente. Sinistra: condizionatori ad aria di potenza 4,5 kW della Rotartica (Spagna). Al centro: 10 kW di potenza per il condizionatore Sonneklima (Germania), dalla elevata efficienza a carico parziale e COP elevato. Destra: Condizionatore da 15 kW di potenza realizzato dalla compagnia tedesca EAW; questa macchina è disponibile anche nelle taglie da 30 kW, 54 kW, 80 kW e maggiori. Fonti: Rotartica, Sonnenklima, EAW.

Figura 2.4b Altri esempi di macchine ad assorbimento. Sinistra: condizionatore ammoniaca-acqua da 12 kW della compagnia australiana Pink. Al centro: questo condizionatore è ad acqua (fluido refrigerante) e cloruro di litio (fluido assorbente). Anche la fase cristallizzata del materiale assorbente viene utilizzata a volte, con degli effetti sull'accumulo di energia interno. Potenza di circa 10 kW; la macchina è realizzata da ClimateWell, Svezia, e può funzionare anche come pompa. Destra: Condizionatore ad assorbimento con fluidi di lavoro H_2O/LiBr e Potenza di 35 kW della Yazaki, Giappone. Questa macchina si trova spesso in impianti di raffrescamento solari, dato che è stata per anni il più piccolo condizionatore ad assorbimento disponibile in Europa, utilizzabile con calore solare. Attualmente un versione più piccola, 17,5 kW, della stessa casa è stata introdotta nel mercato europeo. Fonti: Pink, ClimateWell, Yazaki.

Recentemente la situazione è cambiata grazie ad alcuni nuovi prodotti di piccola e media potenza che sono stati introdotti nel mercato. In generale sono progettati per lavorare a basse temperature e quindi adatti a collettori solari stazionari. La taglia più piccola disponibile ora è di 4,5 kW. Alcuni esempi di condizionatori ad assorbimento di piccola e media taglia sono presentati in figura 2.4. Oltre ai fluidi tradizionali H_2O/LiBr, vengono utilizzati anche H_2O/LiCl e NH_3/H_2O. L'utilizzo di questi ultimi con ammoniaca come refrigerante è abbastanza nuovo nel raffrescamento degli edifici, dato che questa tecnologia era prevalentemente usata per il raffreddamento industriale al di sotto degli 0 °C e per grosse potenze. Questo sistema è vantaggioso per applicazioni in cui sia richiesta una grossa differenza di temperatura (T_M – T_C). Ad esempio nel caso di zone molto aride, dove è necessario un condizionamento a secco ad elevate temperature ambiente.

Condizionatori ad adsorbimento

Oltre a processi che utilizzano assorbenti liquidi, sono disponibili anche macchine che usano materiali assorbenti solidi. Il materiale adsorbe il refrigerante e lo rilascia se riscaldato.

La figura 2.5 mostra le componenti di un condizionatore ad adsorbimento. I sistemi disponibili sul mercato utilizzano acqua come refrigerante e silica gel come assorbente. Attività di ricerca interessano, inoltre, sistemi che impiegano zeolite come assorbente.

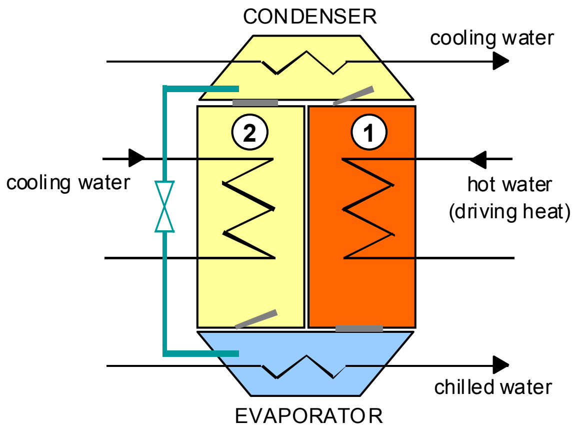


Figura 2.5 Schema di condizionatore ad adsorbimento. È composto da due scomparti di assorbimento, 1 e 2, un evaporatore ed un condensatore. Mentre il sorbente nello scomparto 1 è in fase di desorbimento (rimozione dell'acqua adsorbita), per azione dell'acqua calda dalla fonte esterna di calore, ad es. il collettore solare, il sorbente nello scomparto 2 adsorbe il vapore del refrigerante, che arriva dall'evaporatore; questo compartimento deve essere raffreddato per aumentarne il rendimento. Il refrigerante, condensato nel condensatore raffreddato, viene trasferito nell'evaporatore e vaporizzato a bassa pressione. In questo modo viene prodotto il "freddo" utile. Periodicamente gli scomparti di adsorbimento vengono invertiti, scambiando le funzioni di adsorbimento e desorbimento. Questo di solito viene fatto con un interruttore di controllo esterno.

Ad oggi solo poche ditte in Giappone, Cina e Germania producono condizionatori ad adsorbimento; una compagnia tedesca è sul mercato dal 2007 con una piccola unità da 5,5 kW e, ora, con una nuova versione potenziata da 7,5 kW (modello del 2008). Il COP ha valori tra 0,5 e 0,6. Alcuni dei vantaggi di queste macchine sono le basse temperature del calore in ingresso, a partire da 60°C, l’assenza di una pompa per la soluzione e la relativa silenziosità. In figura 2.6 vengono riportate ad esempio due macchine ad adsorbimento.


Figura 2.6 Esempi di macchine ad adsorbimento. Sinistra: condizionatore da 70 kW della casa produttrice giapponese Nishiyodo. Macchine di simile potenza sono prodotte da un’altra compagnia giapponese, la Mayekawa. Destra: Condizionatore ad adsorbimento di piccola taglia, circa 7,5 kW, della SorTech, Germania.

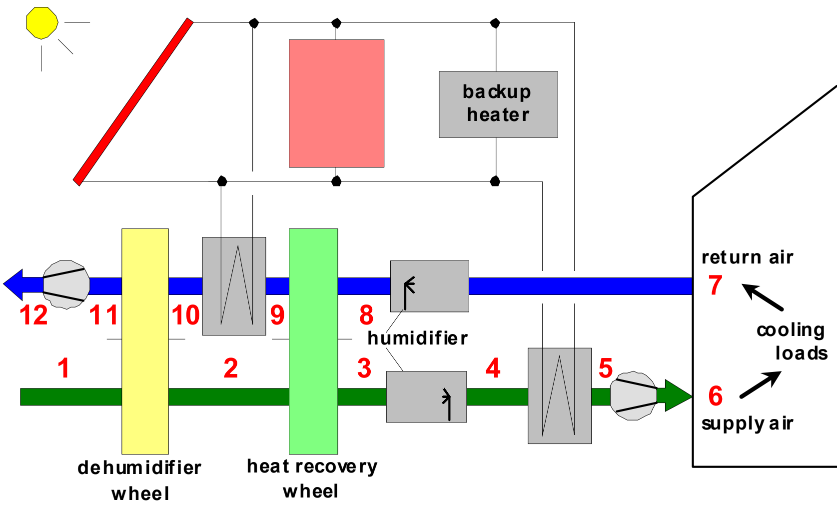
Una raccolta completa delle macchine ad acqua a ciclo chiuso è pubblicata in [Mugnier et al., 2008]

2.2 Processi a ciclo aperto

Mentre i sistemi di condizionamento alimentati da energia termica producono acqua fredda, che può servire qualsiasi tipo di dispositivo di condizionamento, i cicli aperti producono direttamente l’aria condizionata. I cicli aperti alimentati da energia termica si basano su una combinazione di raffreddamento evaporativo con aria deumidificata da una sostanza dessiccante ad es. un materiale igroscopico. Anche in questo caso possono essere utilizzati sia materiali solidi, sia liquidi. Il ciclo standard, nonché il più utilizzato oggi, utilizza ruote dessiccanti con silica gel o cloruro di litio quali materiali assorbenti. Tutti i componenti sono standard e vengono usati in impianti di condizionamento e deumidificazione negli edifici e nelle industrie già da molti anni.

Il ciclo standard con la ruota dessiccante è mostrato in figura 2.7. L’applicazione per questo tipo di ciclo è limitata a climi temperati, dato che la potenzialità deumidificante non è sufficiente a garantire il raffreddamento evaporativo dell’aria in ingresso, in condizioni di elevata umidità dell’aria esterna. Perciò in climi come quelli dei Paesi del Mediterraneo si ricorre a differenti configurazioni del processo dessiccante.

I sistemi che fanno uso di materiali assorbenti liquidi presentano numerosi vantaggi, come ad esempio una maggiore deumidificazione a parità di temperatura e la possibilità di accumulare energia per mezzo di soluzioni igroscopiche concentrate. Questi sistemi non sono ancora disponibili sul mercato, ma lo saranno a breve; molti progetti dimostrativi sono in atto per testare l'applicabilità delle tecnologie solari per l'aria condizionata. Un esempio di impianto di condizionamento e deumidificazione con materiale liquido è riportato in figura 2.8.



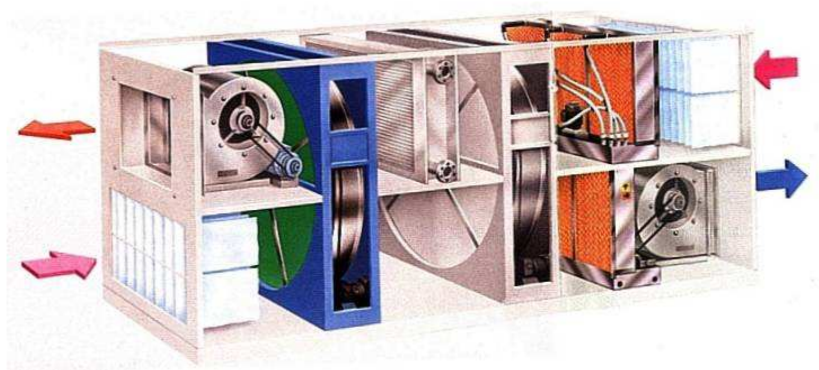


Figura 2.7 Schema di impianto solare alimentato da energia termica, con materiale dessiccante solido, DEC (Desiccant Evaporative Cooling), che utilizza una ruota di deumidificazione ed una di recupero di calore (fonte: Fraunhofer ISE) e sotto: schema di unità DEC (fonte: Munters). Le fasi in successione del percorso del flusso d'aria:

1→2 Deumidificazione dell'aria in ingresso (per assorbimento); il processo è praticamente adiabatico, l'aria viene riscaldata dal calore rilasciato dalla ruota dessicante

2→3 Pre-riscaldamento dell'aria in ingresso tramite scambio di calore con l'aria calda in uscita

3→4 Raffreddamento evaporativo per portare l'umidità dell'aria al livello desiderato per mezzo di un umidificatore

4→5 La ruota di riscaldamento viene utilizzata solo nella stagione termica per pre- riscaldare l'aria

5→6 Piccolo aumento di temperatura nel passaggio nel ventilatore

6→7 L'aria in ingresso viene riscaldata e ri-umidificata per mezzo dei carichi interni

7→8 La temperature dell'aria in uscita viene ridotta grazie al raffreddamento evaporativo (in prossimità del livello di saturazione)

8→9 L'aria in uscita pre-riscalda quella in ingresso per mezzo di una scambiatore aria-aria ad alta efficienza, es. una ruota per il recupero di calore

9→10 Il calore di rigenerazione viene fornito ad esempio da un collettore solare

10→11 L'acqua contenuta nel materiale essiccante della ruota dessiccante viene fatta evaporare per mezzo di aria calda

11→12 L'aria viziata viene rilasciata nell'ambiente esterno tramite un ventilatore.

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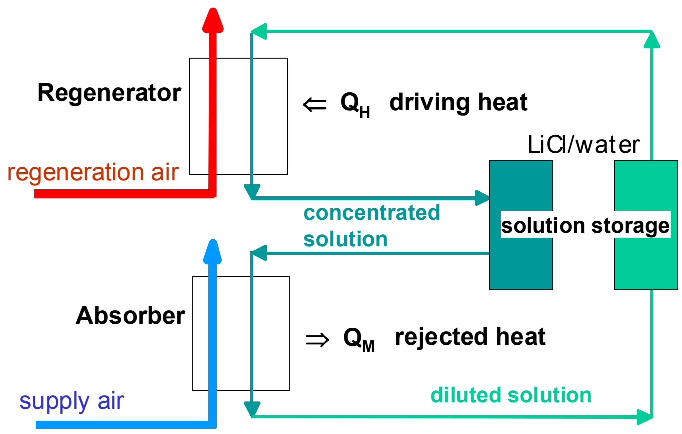

Figura 2.8 Schema generale di impianto con materiale dessiccante liquido. L'aria in ingresso viene deumidificata in una speciale zona spray dell'assorbitore, dove una soluzione salina concentrata viene diluita dall'umidità dell'aria in ingresso. Il rendimento del processo è migliorato dal rilascio del calore di assorbimento, ad esempio per mezzo di raffreddamento evaporativo indiretto dell'aria in uscita con recupero di calore. Se necessario si può aggiungere un successivo raffreddamento evaporativo dell'aria in ingresso (il recupero di calore e il raffreddamento evaporativo non sono rappresentati in figura). In un rigeneratore la soluzione viene riscaldata con calore proveniente, ad esempio, da un collettore solare per aumentarne la concentrazione. La soluzione concentrata e poi diluita può essere conservata in appositi accumuli, permettendo così di separare temporalmente il condizionamento dalla rigenerazione. Fonte: Fraunhofer ISE.

In generale i sistemi DEC rappresentano un'opzione interessante nel caso di impianti di ventilazione centralizzati. In siti con elevati carichi di condizionamento latenti e sensibili, il processo di condizionamento dell'aria può essere suddiviso in una fase di deumidificazione, per mezzo di un ciclo aperto alimentato da energia termica, ed un sistema aggiuntivo ad acqua fredda per contenere i carichi sensibili, ad esempio per mezzo di soffitti radianti con elevate temperature di funzionamento, per aumentare l'efficienza della produzione di acqua fredda.
Maggiori dettagli sui processi a ciclo aperto si trovano in [Henning, 2004/2008] e [Beccali, 2008].

2.3 Collettori solari

Esiste un'ampia varietà di collettori solari termici, molti dei quali sono applicabili ad impianti di solar cooling. In ogni caso la scelta del tipo appropriato di collettore dipende dal tipo di tecnologia di condizionamento e dalle condizioni al contorno del sito, ad esempio dalla radiazione disponibile. I principali modelli di collettori solari stazionari vengono mostrati in figura 2.9. L'utilizzo di collettori solari piani ad aria, economicamente vantaggiosi, è limitato a impianti DEC, poiché questa tecnologia richiede basse temperature di lavoro (a partire da 50° C) e, a certe condizioni, consente il funzionamento senza accumulo termico. Per funzionare, i sistemi di condizionamento alimentati ad energia termica da calore solare, necessitano di collettori piani di alta qualità (rivestimento selettivo, migliore isolamento, elevata protezione stagna). Vi sono inoltre, non presenti in figura, collettori a concentrazione e ad inseguimento, che possono fornire calore a temperature comprese tra 100 e 200 °C. Essi si abbinano, ad esempio, a condizionatori a doppio effetto o ad acqua e ammoniaca per un elevato aumento delle temperature.

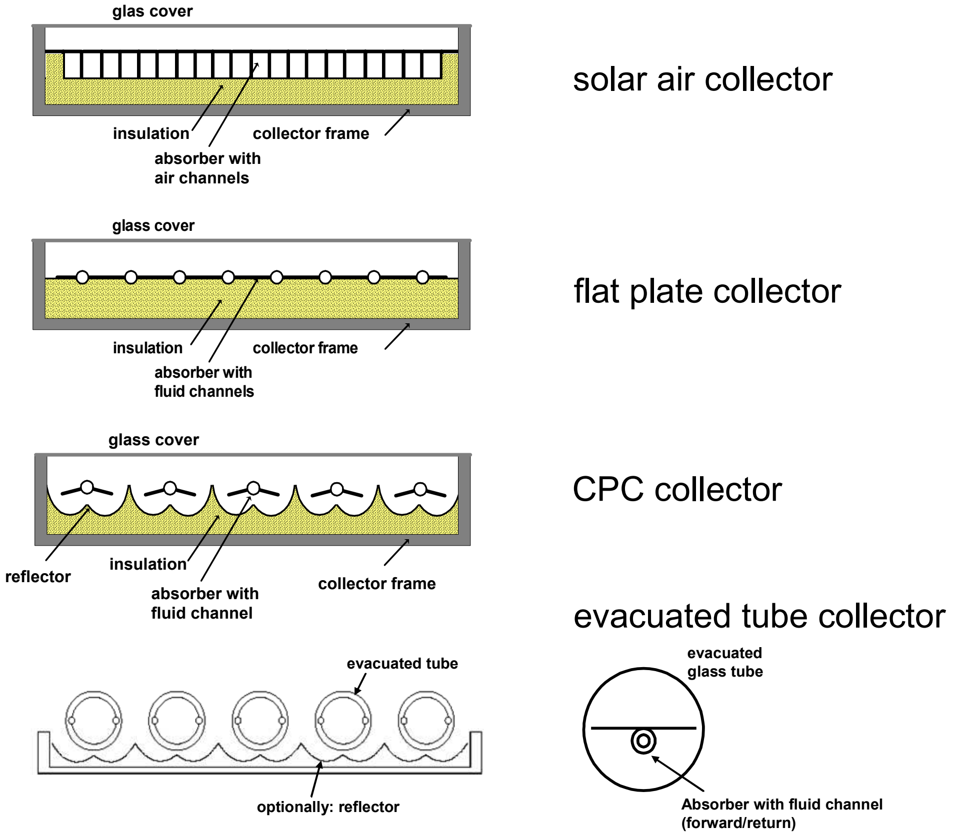

Figura 2.9 Esempi di collettori stazionari utilizzabili per il solar cooling. Fonte: SOLAIR didactic material base / Fraunhofer ISE.

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3 Il database di SOLAIR

All'interno del progetto SOLAIR sono stati raccolti i dati di impianti di "Best practice" esistenti, di piccola e media taglia. Nella tabella 3.1 vengono riassunti brevemente i contenuti del database. Maggiori dettagli sono contenuti nel rapporto sull'analisi comparata tra i diversi paesi partecipanti al progetto [SOLAIR: Review technical solutions, 2008]. Gli esempi di "Best Practice", estratti dal database, vengono presentati nel seguente paragrafo.

Tipo di applicazione	Esempi a catalogo	Tecnologia utilizzata	Potenza refrigerante [kW]	Paese
Ospedali (e case di riposo)	1	Ab	10	FR
Laboratori (per ospedali pubblici)	1	Ad	70	DE
Biblioteche pubbliche	1	DEC	81	ES
Uffici pubblici	3	DEC_{liq}, DEC	11-30	DE, AT, PT
Altri Enti Pubblici	2	Ad, DEC	5.5-6	DE, GR
Uffici commerciali	11	Ab	9-70	AT, FR, DE, GR, IT, PT, ES
Aule seminari	1	DEC	60	DE
Cantine vinicole	1	Ab	52	FR
Residenziale	3	Ab, Ad	4.5-10	AT, IT, ES
	totale: 24			

Tabella 3.1 Tipo di applicazione, tecnologia e potenza refrigerante degli impianti inclusi nel catalogo SOLAIR, suddivisi per Paese.

Abbreviazioni: Ab = assorbimento; Ad = adsorbimento; DEC = desiccant evaporative cooling; DEC_{liq} = liquid desiccant cooling.

4 Esempi di buone pratiche in SOLAIR

Molti degli esempi che vengono presentati in questo capitolo sono entrati in esercizio meno di due o tre anni prima della redazione del catalogo, per questa ragione non sono incluse esperienze di lunga durata. Perciò la definizione "Best Practice" si riferisce qui ad impianti realizzati correttamente e all'utilizzo di scelte tecniche promettenti per il solar cooling. La raccolta mira a presentare l'applicabilità delle tecnologie di solar cooling su diverse tipologie di utenza, in varie localizzazioni e con differenti soluzioni tecniche.

Gli esempi sono stati inseriti secondo l'approccio utilizzato nel sito web. Per alcuni impianti sono disponibili informazioni

SOLAIR

4.1 Impianti in AUSTRIA

1. Ökopark, Hartberg
2. Bachler, Gröbming
3. SOLution, Sattledt

SOLAIR

Ökopark Hartberg, Austria

Description of the application

Office building cooling (+ heating and hot water)

General description of the system

The 30.4 kW DEC system has a heat energy input from 12m² flat plate collectors and a 30 kW biomass boiler as auxiliary heat source. The peak cooling load of the building is 20 kW and the peak heating load is 24 kW. The number of heating demand hours is 3560 per year. The heating and cooling supply is distributed through air ducts with heat recovery.

Central air-conditioning unit

Technology	open cycle (DEC)
Nominal air volume flow rate	6,000 m^3/h
Minimum air volume flow rate	- m^3/h
Desiccant cooling system type	solid desiccant
Desiccant type	Silica Gel
Cooling capacity	30.4 kW (max)
Brand of desiccant unit	-

Solar thermal

Collector type	flat-plate
Brand of collector	Vacuum-tube collector
Collector area	12 m^2 gross area
Tilt angle, orientation	70° south
Collector fluid	water-glycol
Typical operation temperature	-

Configuration

Heat storage	3 m^3 water
Cold storage	-
Auxiliary heating support	biomass
Use of auxiliary heating system	heating & cooling
Auxiliary chiller	no

System performance

Annual cooling load/annual regeneration heat = annual COP = 0.6
kWh primary energy/kWh cooling = solar fraction = 1.66
Daily solar gain = 60 kWh, gain on collector surface 430 kWh/m² collector area
Daily electricity demand =65 kWh for AHU, pumps, water treatment etc.
Average collector efficiency is 40%.
The adiabatic operation mode, which does not need the regeneration heat, is important for the enlargement of the COP to 0.6.

General information

Type of building Office building
Location Hartberg, Austria
Auxiliary heating support Biomass
In operation since 2000-09
System operated by Ökopark Hartberg
Air-conditioned area 280 m^2
- capacity 30.4 kW max

Specific information

Further specific information about the system are included in the filled in technical questionnaire.

AT02_Hartberg.pdf 250 K

Contact

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Segue alla pagina successiva

SOLAIR

System reliability and overall success of the installation

The users and owners of the buildings are satisfied.
The use of the DEC plant is normal satisfying. In case of disturbances there are not yet the suitable persons available to repair, due to the not well known technology. Main problem is the hygiene of the open water basins. Biological cleaning of the water by a biocide and UV-light (254 nm) together with water quality checks is a practical way.
The centralized cooling system needs a large amount of electricity for ventilation. If renewable heat is used fort the regenerator, the CO_2 emissions are significantly reduced.
The following items could be learned at the Hartberg DEC:

1. The control strategy for all year round operation is not fully developed.
2. Water treatment have to include also the biologic cleaning (biocide and UV-radiation) of the water. Time by time, especially after long periods without operation, the air humidification facilities have to be cleaned.
3. Service intervals should be fixed and a staff of educated people is necessary.
4. Especially protections against lightning damages in the control have to be executed specially in the country side.
5. The temperature for the regeneration has to be high enough to avoid to high indoor air humidity.

Ökopark Hartberg, Austria

Bachler in Gröbming, Austria

Description of the application

The system is used for office cooling and heating and hot water preparation. The solar thermal system also heats up a swimming pool during summer time.

General description of the system

Closed cycle absorption with ammonia/water as working pair. The system has biomass as auxiliary heating for heating and for the absorption machine.
The building is an office building for a HVAC company with 700 m² cooled office area.
The peak cooling load of the building is 9 kW and the building is cooled via concrete core activation.
The building has mechanical building ventilation with heat recovery.
The heat rejection is wet, open EWK Axima refrigeratoin with 25 kW.

Central air-conditioning unit

Technology	closed cycle
Nominal capacity	9 kW_{cold}
Type of closed system	Absorption
Brand of chiller unit	PINK chillii PSC 9
Chilled water application	chilled ceilings
Dehumidification	no
Heat rejection system	wet open

Solar thermal

Collector type	flat-plate
Brand of collector	From the company "Neuma-Solar" in Kremsmünster, Austria
Collector area	46 m^2 aperture
Tilt angle, orientation	45°, south
Collector fluid	water-glycol
Typical operation temperature	80 °C (driving heat for cooling application)

The solar collectors are partly mounted on the ground, partly installed on the façade of the building. The system is operated with a variable flow control.

Configuration

Heat storage	3x4.5 m^3 water
Cold storage	none
Auxiliary heating support	biomass 150 kW
Use of auxiliary heating system	space heating in winter, heating & cooling
Auxiliary chiller	no

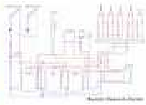
System performance

The absorption chiller has a COP of 0.64.

General information

Type of building Office building
Location Gröbming, Austria
In operation since 2007
System operated by Bachler HVAC company (own office building)
Air-conditioned area 700 m^2
Capacity 9 kWcold

Figures



Clicking an image opens the gallery view.

Specific information

Further specific information about the system are included in the filled in technical questionnaire.

AT01_Bachler.pdf 391 K

Contact

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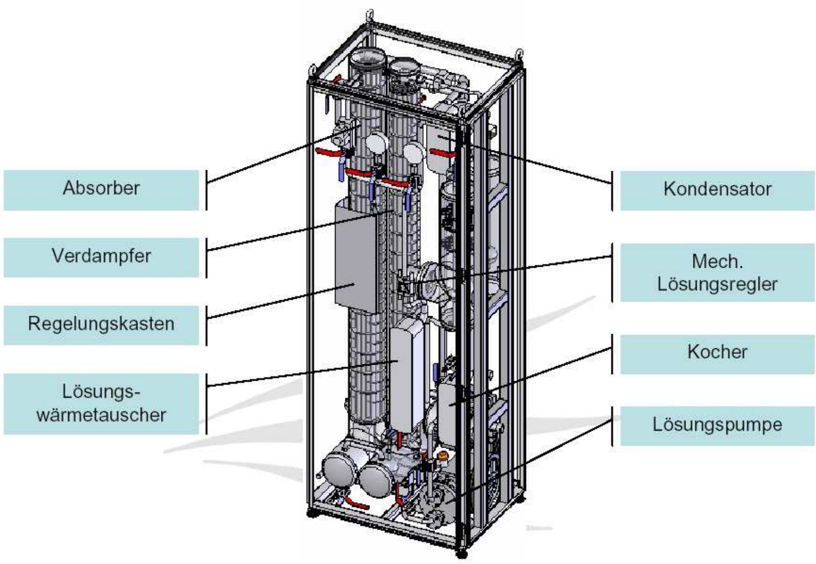
Segue alla pagina successiva

SOLAIR



Componenti del chiller ammoniaca/acqua, installato presso Bachler system, Gröbming, Austria.
Fonte: PINK Energie- und Speichertechnik.

SOLAIR

Absorption chiller SOLution, Sattledt, Austria

Description of the application

Absorption chiller with open wet cooling tower to cool 350 m² office building with a peak cooling load of 8 kW.

General description of the system

Auxiliary heating only for heating system: gas boiler with 9 kW. Solar thermal system serves to heat the domestic hot water.

Central air-conditioning unit

Technology	closed cycle
Nominal capacity	15 kW_{cold}
Type of closed system	absorption
Brand of chiller unit	EAW WEGRACAL SE 15
Chilled water application	chilled ceiling
Dehumidification	no
Heat rejection system	wet open

Solar thermal

Collector type	flat-plate
Brand of collector	SOLution
Collector area	40 m^2 aperture
Tilt angle, orientation	35°
Collector fluid	water-glycol
Typical operation temperature	75 °C driving temperature for chiller operation

Configuration

Heat storage	2 m^3 water
Cold storage	water, 0.8 m³
Auxiliary heating support	gas boiler, 9 kW
Use of auxiliary heating system	space heating in winter
Auxiliary chiller	no

System performance

No data is available yet.

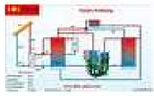
System reliability and overall success of the installation

The system works to the satisfactory of the building users.

General information

Type of building office building
Location Sattledt, Austria
In operation since 2005
System operated by SOLution Solartechnik GmbH
Air-conditioned area 350 m^2
Capacity 15 kW

Figures



Clicking an image opens the gallery view.

Specific information

Further specific information about the system are included in the filled in technical questionnaire.

AT03_SOLution.pdf 300 K

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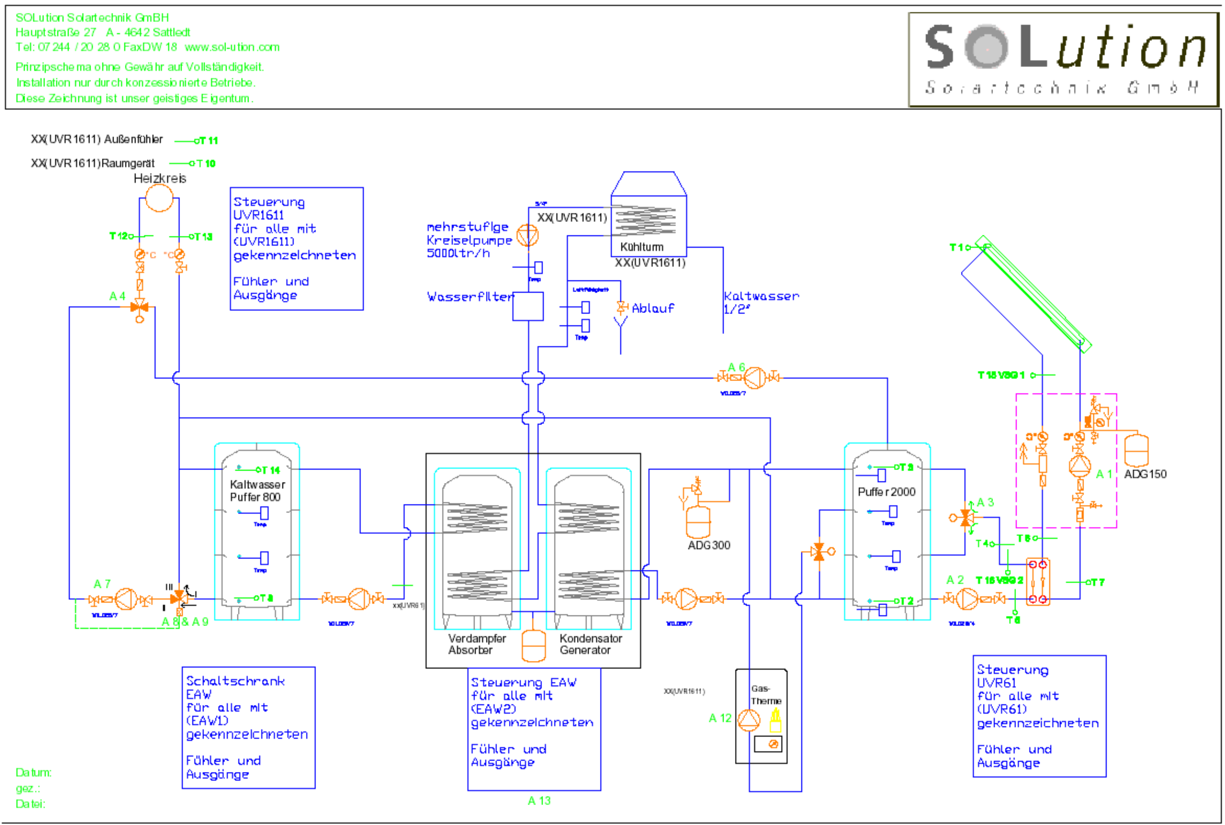
SOLAIR



Schema del sistema di solar cooling a Sattledt, Austria

4.2 Impianti in FRANCIA

1. Résidence du Lac, Maclas
2. Edificio GICB, Banyuls sur Mer
3. Edificio Kristal, Saint Denis de la Réunion

SOLAIR

Résidence du Lac, Maclas, France

Description of the application

The targeted building welcoming the solar cooling application is the Résidence du Lac, a building dedicated to retired people. This building is sitted in the village of Maclas in the Rhône Alpes area, close to Lyon. The village is in altitude, nearly 450 m high.
The building was created in the seventies and is of an average quality level for the energy efficiency. Only one small part of the building is cooled, the leisure space/restaurant which is compulsory since summer 2003 in retired buildings. This area is of 210 m² and includes a veranda oriented in the Southern direction. Efforts were made to increase the solar protection level in the veranda by adding dark thin protection films. Till 2007, the building owner used electric compression chillers (3 monosplits). Two of them were out of order in 2007 and the management took the decision with the help of the SIEL (Syndicat Intercommunal d'Energie de la Loire) to go for a solar cooling system. The owner of the system is the SIEL itself.

General description of the system

The system is based on an absorption chiller of 10 kW coupled with evacuated tube collectors. The system is in configuration of a quasi solar autonomous cooling system because only a small electric compression chiller (splite type) is used in case of failure of the solar system. The load of a part of the entire building is based on the following scenario: cooling demand from June to mid September and heating demand from mid October to end of May. The solar system is using fan coils for the cooling and heating modes but thanks to a buffer storage, it can be valorized as well in the heating mode through the central heating network of the Résidence du Lac. The heat rejection system is done by a drycooler sitted in the Northern facade of the building.

Central air-conditioning unit

Technology	closed cycle
Nominal capacity	10 kW_{cold}
Type of closed system	Absorption
Brand of chiller unit	Sonnenklima
Chilled water application	fan coils
Dehumidification	no
Heat rejection system	dry

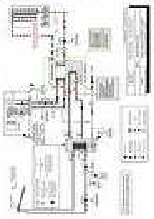
Solar thermal

Collector type	evacuated tube
Brand of collector	Thermomax Mazdon 20
Collector area	24 m^2 absorber area
Tilt angle, orientation	30 °, 15 ° west
Collector fluid	water-glycol
Typical operation temperature	75 °C driving temperature for chiller operation

General information

Type of building Retired people residence
Location Maclas, France
Auxiliary heating support fuel (central heating system)
In operation since 2007
System operated by SIEL
Air-conditioned area 210 m^2

Figures



Clicking an image opens the gallery view.

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Configuration

Heat storage	0.5 m^3 water
Cold storage	buffer water (80 litres)
Auxiliary heating support	none
Use of auxiliary heating system	-
Auxiliary chiller	yes
- type	el. compression chiller
- capacity	3 kW_{cold}

System performance

Energy production expectations:

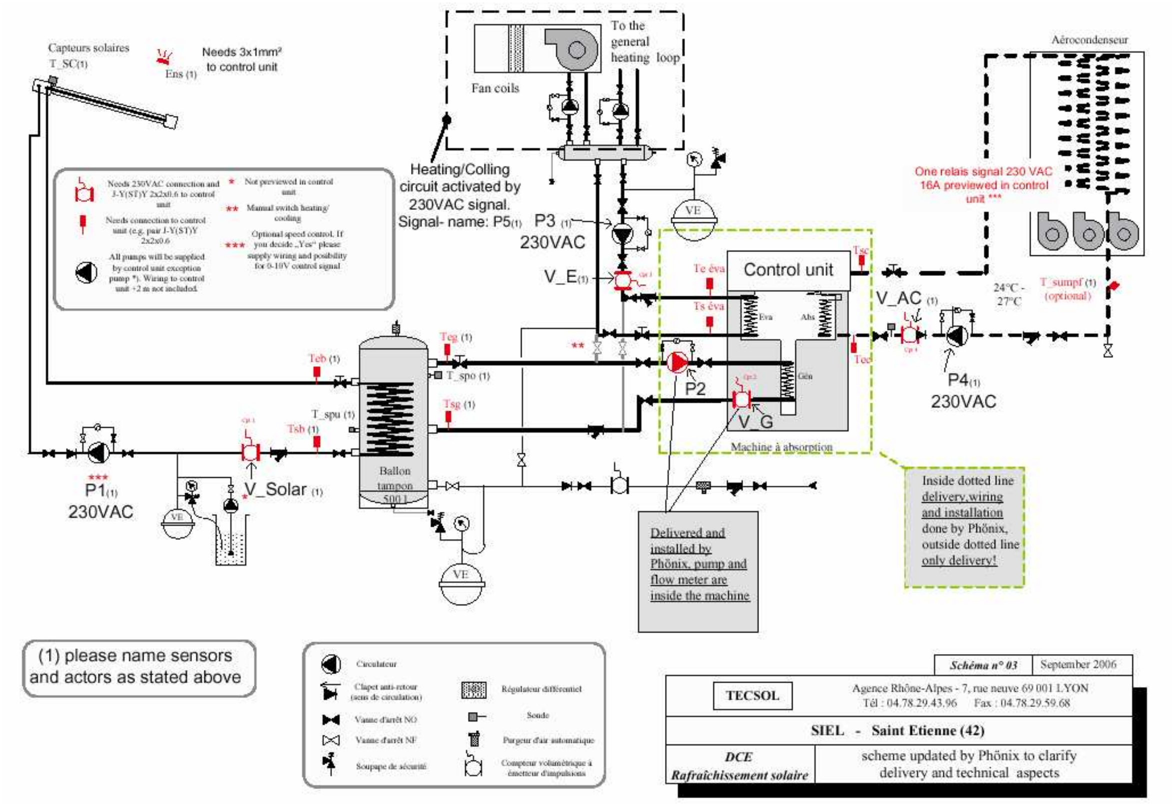
- Cooling : 4,300 kWh/year (4 months)
- Heating : 8,300 kWh/year (8 months)

TOTAL = 12 600 kWh/year

Energy savings:

- Cooling: 5 c€/kWh (EER = 2; bad quality split)
- Heating: 6 c€/kWh (fuel burner; 85 %)
- Electricity consumption : 845 kWh = 42 €/year

TOTAL = 1,150 €/year
(on the basis of an average increase of energy price of 5 %/year)



Schema del sistema di solar cooling a Maclas, Francia

SOLAIR

GICB building in Banyuls sur Mer, France

Description of the application

The targeted building welcoming the solar cooling application is the GICB building. This wine cellar is dedicated to wine conservation in the city of Banyuls sur Mer, in the seaside close to the Spanish border (Mediterranean sea). The ground floor is used for dispatching and the bottle storage is done in Level -1 and Level -2. Started in summer 1989 without cooling system, the wine cellar behaviour has been tested for two years. An ambient temperature continuous measurement in the three levels permitted to analyse their behaviour and to determine the best working conditions for cooling.
The important thermal inertia of Level -1 and Level -2 in comparison with the Ground Floor, which in addition the level where new bottles are transiting before being stored, has led to limit the Level-2 temperature to 17 °C, the Level -1 temperature to 19 °C, and, with the potential cooling energy excess the Ground Floor temperature to 22 °C.
Thermal gains are quite weak. They are mainly sensible gains by conduction through the walls or by infiltration. Latent gains are considered as negligible in comparison.
The cooling demand is fitting the solar resource evolution during the year.
Solar energy is able to be used for an heating system for occupant comfort in winter at the Ground Floor (≈18 °C) and potentially the pre-heating of water used on a new bottling process.
All of these points are favourable criteria for using solar energy on this site.

General description of the system

The cooling system is made of 130 m^2 of evacuated tube collectors (useful area) Cortec Giordano on the roof, oriented in South/South-West and directly fixed on the roof at nearly 15°, a technical premises situated in Level -2 and owning a buffer storage tank of 1 000 litres, a single effect indirect absorption chiller YAZAKI type WFC 15, with a nominal cooling power of 52 kW, several circulating pumps for the different loops, a general electrical managing chest, a open loop cooling tower with a nominal power of 180 kW, installed in the Northern front, three air conditioning units (one per level) having a filter, a cold exchanger for chilled water (+ an heat exchanger for the Ground Floor one) and a centrifugal fan with a 25,000 m^3/h flow. The distributed cooling power is between 25 and 35 kW, depending on the levels. The air conditioning units are working in full recycling (with exhausting through a ventilation shaft) the maximum difference between exhausting and re-using is nearly of 4 °C, avoiding thus any thermal shock risk. The primary loop (collector loop) is filled in with water, for a working temperature between 60 and 95 °C. All the other loops work as well with pure water. Balance valves 'TA Control' permit a precise flow adjustment in each loop and under-loop, which is essential for the good system management.

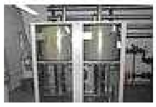
Central air-conditioning unit

Technology	closed cycle
Nominal capacity	52 kW_{cold}
Type of closed system	absorption
Brand of chiller unit	YAZAKI
Chilled water application	AHU
Dehumidification	no
Heat rejection system	wet cooling tower

General information

Type of building Wine cellar
Location Banyuls sur Mer
In operation since 1991
System operated by Dalkia
Air-conditioned area 4,500 m^2
Capacity 52 kW

Figures



Clicking an image opens the gallery view.

Contact

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Segue alla pagina successiva

SOLAIR

Solar thermal

Collector type	evacuated tube
Brand of collector	Giordano Cortec 2
Collector area	130 m^2 absorber area
Tilt angle, orientation	15°, 15° west
Collector fluid	water
Typical operation temperature	85 °C driving temperature for chiller operation

Configuration

Heat storage	1 m^3 water
Cold storage	none
Auxiliary heating support	none
Use of auxiliary heating system	-
Auxiliary chiller	no

System performance

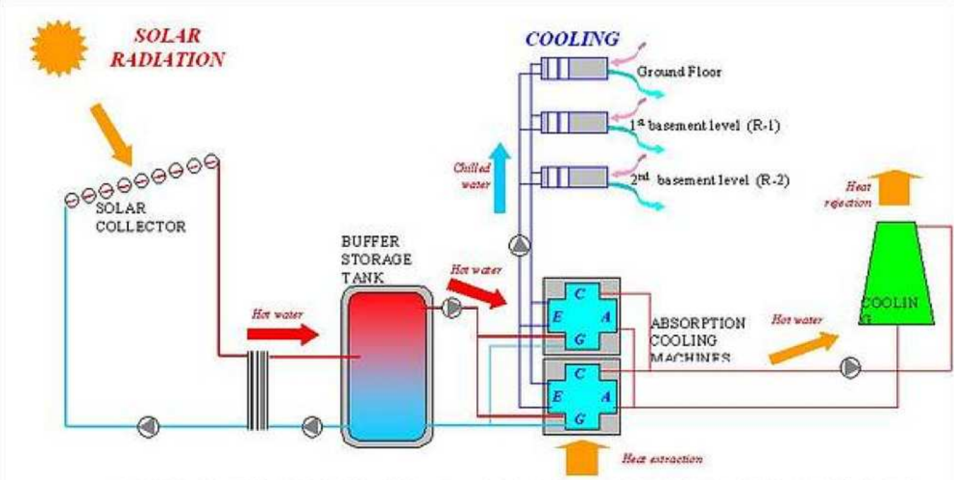
Energy production (2007)
Cooling only: 17,000 kWh/year (from May to end of September)

Energy savings
Cooling: 0.05 €/kWh (EER = 2)
Electricity consumption: 2,800 kWh = 280 €/year

TOTAL = 950 €/year
(on the basis of an average increase of energy price of 5 %/year)

System reliability and overall success of the installation

This installation is a very good success for the end user. The solar cold production is in adequation with the load of the building: decrease the temperature increase in the wine cellar. Adequation between solar production and cooling load of the 3 storage levels in the building. A lot of different articles, reports on TV, publications. The user is as well using the system as a marketing attraction for potential clients and visitors. The user is satisfied of the performances and do not need any back up. No major issues in the system since 1995. Change of the primary loop pump and of the crepuscular sensor by a irradiation sensor to decrease the electric COP of the system.



GENERAL LAYOUT DIAGRAM FOR THE AIR-CONDITIONING PLANT AT BANYULS

SOLAIR

Kristal building in Saint Denis de la Réunion, France

Description of the application

The targeted building welcoming the solar cooling application is the Kristal office building. It is dedicated to offices and residential in the city center of Saint Denis in the Réunion island (Indian Ocean, southern hemisphere). This building is made of 5 levels and the solar cooling system is on the top floor. The general orientation of the building is North/South therefore the roof (45° tilt) is oriented East/Weast.
The building was created in 2006 and is of good quality level for the energy efficiency. All of the building is cooled, this means the cooled area is of 875 m². The owner of the building is the SCI Cristal company belonging to the DIII Espaces contemporain holding.

General description of the system

The system is based on an absorption chiller of 35 kW coupled with 92 m² evacuated tube collectors. The system is in configuration of a solar assisted cooling system because a 115 kW compression chiller is used as a back up to face the cooling load (no heating demand in this place) all year long. The distribution system is a chilled water net using fan coils working at 10/14 °C temperature level. The heat rejection system is done by a wet cooling tower on the top of the building.

Central air-conditioning unit

Technology	closed cycle
Nominal capacity	35 kW_{cold}
Type of closed system	absorption
Brand of chiller unit	YAZAKI
Chilled water application	fan coils
Dehumidification	no
Heat rejection system	wet cooling tower

Solar thermal

Collector type	evacuated tube
Brand of collector	Thermomax Mazdon 20+30
Collector area	92 m^2 absorber area
Tilt angle, orientation	45°, 90° west and 90 east
Collector fluid	water
Typical operation temperature	80 °C driving temperature for chiller operation

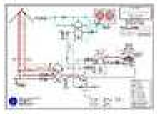
Configuration

Heat storage	0.5 m^3 water
Cold storage	buffer water (80 litres)
Auxiliary heating support	none
Use of auxiliary heating system	-
Auxiliary chiller	yes
- type	el. compression chiller
- capacity	115 kW_{cold}

General information

Type of building Office building
Location Saint Denis de la Réunion
In operation since July 2006
System operated by Alisea
Air-conditioned area 825 m^2
Capacity 35 kW

Figures



Clicking an image opens the gallery view.

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SOLAIR

System performance

Energy production expectations
Cooling only: 46,000 kWh/year (10 months out of 12)

Energy savings
Cooling: 0.05 €/kWh (EER = 2; bad quality split)
Electricity consumption: 7,600 kWh = 760 €/year

TOTAL = 2,550 €/year
(on the basis of an average increase of energy price of 5 %/year)

System reliability and overall success of the installation

Problem with cooling tower noise and commisioning delay due to issues on monitoring quality. The compression chiller is compensating the performance lacks of the solar cooling system. The building owner could communicate on the first solar cooling plant in operation on a demo site in Réunion Island. Issues to make work the system because no reliable phone line available till now. Machine works without problems. Minor problems occur with external control and measuring technology. It will be assessed after sufficient monitoring period.

Campo collettori e torre evaporative del sistema di solar cooling installato a Saint Denis de la Réunion, Francia

SOLAIR

4.3 Impianti in GERMANIA

1. Fraunhofer ISE, Freiburg
2. Ospedale universitario, Freiburg
3. Camera del commercio 'Südlicher Oberrhein' (IHK-SO), Freiburg
4. Edificio uffici Ott Ingenieure, Langenau
5. Solar Info Center SIC, Freiburg
6. Edificio uffici IBA AG, Fürth

SOLAIR

Fraunhofer ISE, Freiburg, Germany

Solar air-conditioning with adsorption chiller of the canteen kitchen area at Fraunhofer ISE, Freiburg, Germany

Description of the application

The Fraunhofer Institute for Solar Energy Systems (ISE) institute building is an energy efficient building with passive cooling measures. An exception is the canteen kitchen area, where due to high internal loads active cooling of the supply air is appropriate. This is done by means of a small size thermally driven chiller.

General description of the system

The system technology is a closed cycle chilled water system with an adsorption chiller. Heat is provided by a solar thermal system and by the heat network of the institute. During summer, the system runs in cooling mode. The medium temperature heat of the chiller is rejected by three ground tubes of 80 m each. In winter, the heat pump function of the machine is activated and the ground tubes act as low-temperature energy source. The system thus cools and heats the supply air into the kitchen.

Central air-conditioning unit

Technology	closed cycle
Nominal capacity	5.5 kW_{cold}
Type of closed system	Adsorption
Brand of chiller unit	SorTech ACS 05
Chilled water application	supply air cooling
Dehumidification	occasionally
Heat rejection system	dry, ground tubes

Solar thermal

Collector type	flat-plate
Brand of collector	Solvis FF 35s 3/2 FKY
Collector area	22 m^2 aperture
Tilt angle, orientation	30°, south
Collector fluid	water-glycol
Typical operation temperature	75 °C driving temperature for chiller operation

Configuration

Heat storage	2 m^3 water
Cold storage	none
Auxiliary heating support	Institute heat network, operated by CHP and gas boiler
Use of auxiliary heating system	Auxiliary driving source for chiller, auxiliary driving source for heat pump operation in winter
Auxiliary chiller	no

System performance

The thermal coefficient of performance (COP) for a 14-days cooling operation in June 2007 was 0.57. The low heat rejection temperature levels due to the ground tube application are of advantage. The solar thermal coverage of the total heat input into the chiller for this operation period was 56%.

General information

Type of building kitchen area of Institute
Location Freiburg, Germany
In operation since 2007
System operated by Fraunhofer ISE
Air-conditioned area 42 m^2

Figures

Clicking an image opens the gallery view.

Specific information

Further specific information about the system are included in the filled in technical questionnaire.

DE04_FhG-ISE-Freiburg.pdf

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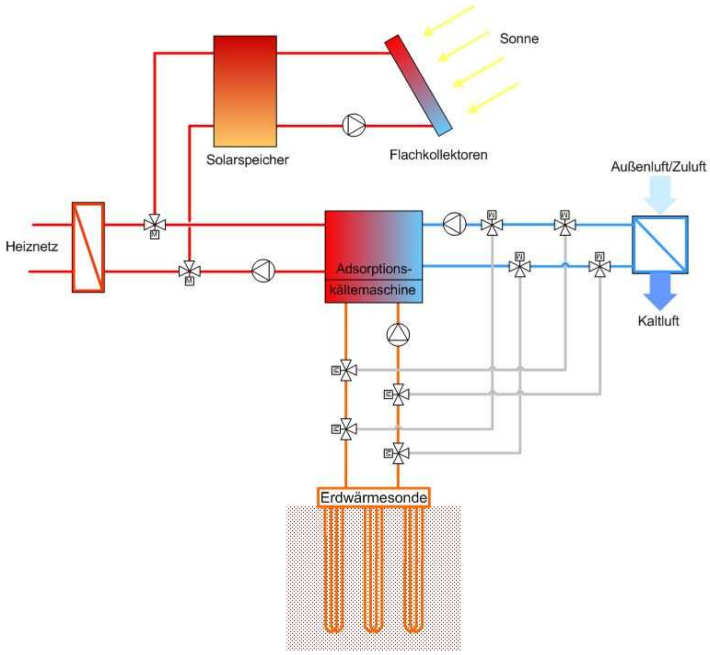
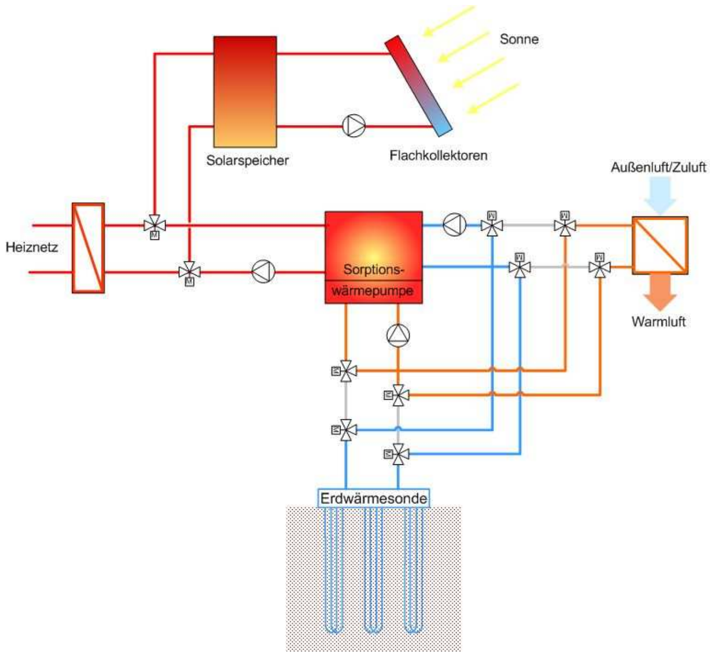
SOLAIR





Sistema di solar cooling presso il Fraunhofer ISE a Freiburg, Germania. In alto: funzionamento estivo. In basso: funzionamento della pompa di calore in inverno.

SOLAIR

University Hospital in Freiburg, Germany

Description of the application

During summer months, the supply air of a separate laboratory building at the University Hospital is cooled by means of a solar thermally assisted chilled water production. The chilled water temperature level is approx. 9°C and is used for supply air cooling in two air handling unit of the laboratory building, equipped with heat recovery. Due to the requirements on the laboratory room air temperature, cooling demand may occur during summer also during night. Additional heat to guarantee the chiller operation is provided by the locally operated steam network of the Hospital. In winter, the solar thermal system assists the laboratory heating.

General description of the system

The system technology is a closed cycle chilled water system with an adsorption chiller. Two heat sources exist to operate the chiller:

1. A solar thermal system, consisting of vacuum tube collectors (direct-flow type)
2. Heat from the steam network of the Hospital is used via a condensate heat exchanger

A closed wet cooling tower is applied for heat rejection from the chiller. Additionally to the solar hot water storage of 6 m³ volume (consisting of three storages connected in series), a buffer of 2 m³ volume is used in the return flow of the driving heat in order to smooth the periodically temperature peaks in the hot water circuit, thus allowing a stable control of the collector system. During winter, the supply air heating is directly assisted by the solar collectors.

Central air-conditioning unit

Technology	closed cycle
Nominal capacity	70 kW_{cold}
Type of closed system	Adsorption
Brand of chiller unit	Nishiyodo NAK 20/70
Chilled water application	supply air cooling
Dehumidification	occasionally
Heat rejection system	closed wet cooling tower

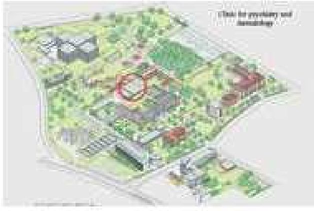
Solar thermal

Collector type	vacuum tubes
Brand of collector	Seido 2-16
Collector area	167 m^2 aperture
Tilt angle, orientation	30° and 45°, south
Collector fluid	water-glycol
Typical operation temperature	75 °C driving temperature for chiller operation

Configuration

Heat storage	6 m^3 water
Cold storage	2 m^2 water
Auxiliary heating support	condensating steam heat exchanger, driven by the Hospital steam network
Use of auxiliary heating system	Auxiliary driving source for chiller, auxiliary driving source for supply air heating in winter
Auxiliary chiller	no

General information



Type of building Laboratory building of the University Hospital
Location Freiburg, Germany (48° North, 7°50' East)
In operation since 1999
System operated by Energy Management of the University Hospital
Air-conditioned area 360 m^2

Figures

Clicking an image opens the gallery view.

Specific information

Further specific information about the system are included in the filled in technical questionnaire.

DE01_Hospital-Freiburg.pdf

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Segue alla pagina successiva

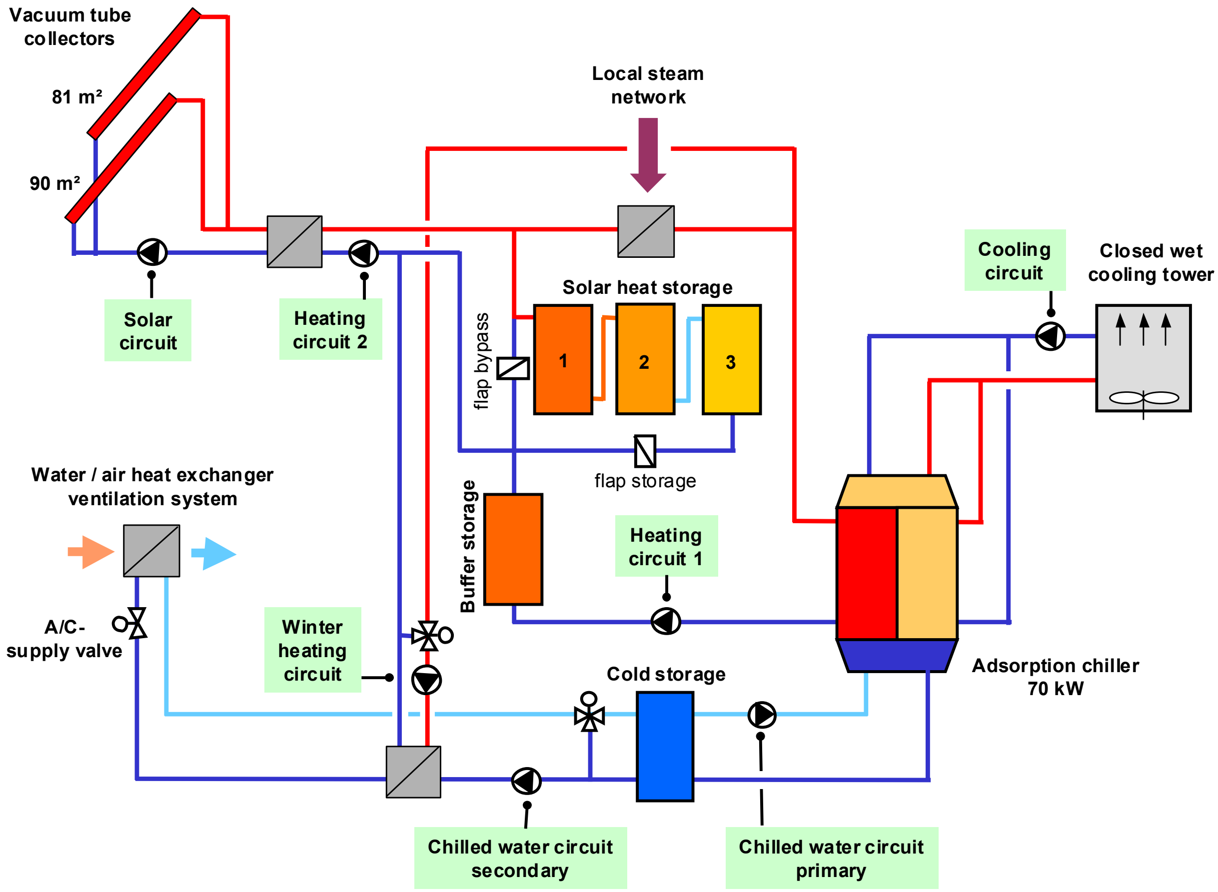
SOLAIR

System performance

The energy balance of 2003 stated an average thermal coefficient of performance (COP) of 0.42; the solar coverage of the total heat input (cooling and heating) was 28 %. The average COP is decreased through periods of part-laod operation during summer nights with low cooling demand. At clear sky summer days, a solar coverage of the driving heat input into the chiller of approx. 90 % may be achieved. The annual specific collector yield was 365 kWh/m²a.

System reliability and overall success of the installation

Due to the complex hydraulic system, an optimised system control is difficult to achieve. Important improvements in the control strategy have been made by varying the cycle length (period between two adsorption cycles or regeneration cycles respectively) according to the part load status of the chiller. The overall reliability of the sytem is good, the laboratory users are satisfied with the system.



Schema del sistema di solar cooling system presso l'ospedale universitario a Freiburg, Germania

Chamber of Commerce 'Südlicher Oberrhein' (IHK-SO) in Freiburg, Germany

Description of the application

A seminar room and a cafeteria area of the building, often used as seminar room as well, are connected to a desecant evaporative cooling system for air-conditioning of these areas. Although passive measures like external shading, high quality glazing etc. have been applied to prevent high solar gains, the large glazing fraction of the rooms requires for active cooling. During cooling and dehumidification use in summer, the system is solar thermally autonomous driven. Additional heat from a gas boiler is used in winter for supply air heating only.

General description of the system

The system technology is an open cycle desiccant evaporative cooling system, using solar thermal heat for regeneration of the desiccant wheel. The desiccant wheel contains silicagel as sorption material. The regeneration is driven solar autonomous by flat-plate air collectors, a heat storage is not applied. The air volume flow rate in the air handling unit varies in a broad range according to the requirements; the air volume flow rate through the air collectors is independent from the air-handling volume flow rate in order to allow an optimised operation of the desiccant wheel. During winter, the supply air is pre-heated by the collectors and heated according to the set values by a fossil back-up system.

Central air-conditioning unit

Technology	open cycle (DEC)
Nominal air volume flow rate	10,200 m^3/h
Minimum air volume flow rate	2,500 m^3/h
Desiccant cooling system type	solid desiccant
Desiccant type	Silica Gel
Cooling capacity	max. 60 kW
Brand of desiccant unit	DehuTech

Solar thermal

Collector type	air collector, flat-plate
Brand of collector	Grammer
Collector area	92 m^2 aperture
Tilt angle, orientation	0 °, south
Collector fluid	air
Typical operation temperature	70 °C regeneration temperature of sorption wheel

Configuration

Heat storage	none
Cold storage	none
Auxiliary heating support	gas boiler
Use of auxiliary heating system	supply air heating in winter
Auxiliary chiller	no

General information

Type of building Seminar and cafeteria room of the IHK-SO building
Location Freiburg, Germany (48° North, 7°50' East)
In operation since 2001
System operated by IHK-SO
Air-conditioned area 213 m^2

Figures


Clicking an image opens the gallery view.

Specific information

Further specific information about the system are included in the filled in technical questionnaire.

DE02_IHK-Freiburg_DEC.pdf

Contact

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Segue alla pagina successiva

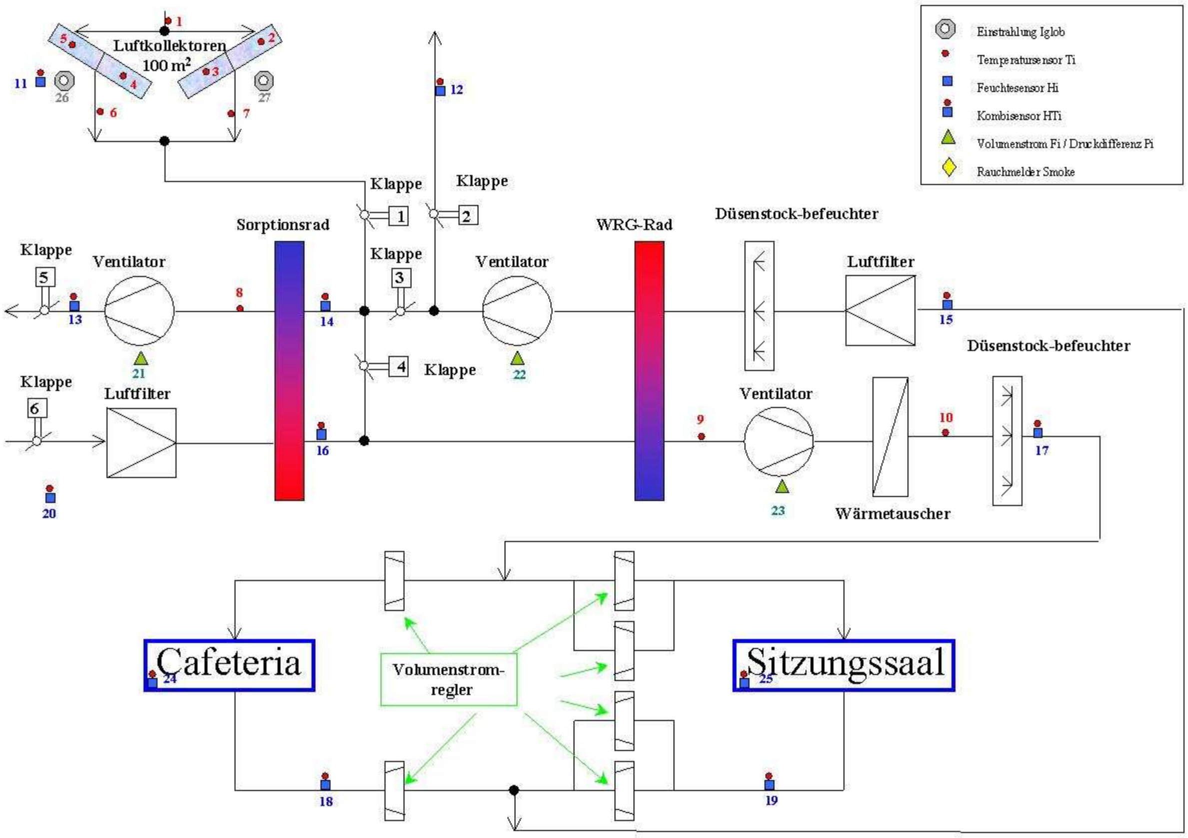
SOLAIR

System performance

In the desiccant cooling mode, an annual coefficient of performance (COP) of 0.43 was obtained. The solar coverage of the overall heat input (supply air heating and regeneration heat) was on an annual average 50%. A specific annual collector yield of 111 kWh/m²a was achieved. The performance of the system is limited due to the limited use of the seminar rooms and subsequently limited activation of the air handling unit (in 2004: 1080 hours).

System reliability and overall success of the installation

After the start of the system, improvements in the system control were necessary to allow a sufficient system operation. From this experience, a carefull initialization period is unavoidable. The system concept of autonomous cooling operation is an appropriate solution in this application. In less than 5 % of operation hours, the room air states exceed the set values. The acceptance of the system by the users is very good. As a consequence of the installed solar air collector system, the collector system contributes to 10 % of the total system cost only.



Schema del sistema di Desiccant Evaporative Cooling (DEC) presso IHK-SO, Freiburg, Germania

SOLAIR

Office building of Ott Ingenieure in Langenau, Germany

Description of the application

The office building of Ott Ingenieure in Langenau is air-conditioned during summer with a solar thermally assisted chilled water system. The chilled water is provided at a temperature of approx. 13 °C. It is mainly used for the chilled ceilings at the offices, but additionally for supply air cooling of the central air handling unit. Since the business of Ott Ingenieure covers also heating systems and solar thermal systems, the application is a demonstration of solar applications as well.

General description of the system

The system technology is a closed cycle chilled water system with a medium-sized absorption chiller. Three heat sources are available, providing heat for chiller operation and for space heating: a solar thermal vacuum tube collector system, a CHP unit and a gas boiler. The CHP unit runs on heat demand. The chilled water serves for supply air cooling of a central air handling unit and is used to operate the chilled ceilings in the offices. Heat rejection is done using an open wet cooling tower. Additional back-up systems on the cold side (e.g., electrically driven compression chiller) are not applied.

Central air-conditioning unit

Technology	closed cycle
Nominal capacity	35 kW_{cold}
Type of closed system	Absorption
Brand of chiller unit	Yazaki WFC 10
Chilled water application	Chilled ceilings, supply air cooling
Dehumidification	no
Heat rejection system	open wet cooling tower

Solar thermal

Collector type	vacuum tubes
Brand of collector	Seido 2-6
Collector area	30 m^2 absorber
Tilt angle, orientation	25°, 45° south-west
Collector fluid	water-glycol
Typical operation temperature	85 °C driving temperature for chiller operation

Configuration

Heat storage	2 m^3 water
Cold storage	1 m^3 water
Auxiliary heating support	CHP with 19.5 kW heating capacity, gas boiler with 50 kW heating capacity
Use of auxiliary heating system	auxiliary driving source for chiller, auxiliary driving source for space heating in winter
Auxiliary chiller	no

General information

Type of building office building
Location Langenau, Germany (48°30' North, 10°07' East)
In operation since 1997
System operated by Ott Ingenieure
Air-conditioned area 415 m^2

Figures

Clicking an image opens the gallery view.

Specific information

Further specific information about the system are included in the filled in technical questionnaire.

PDF DE03_Ott-Langenau.pdf

Contact

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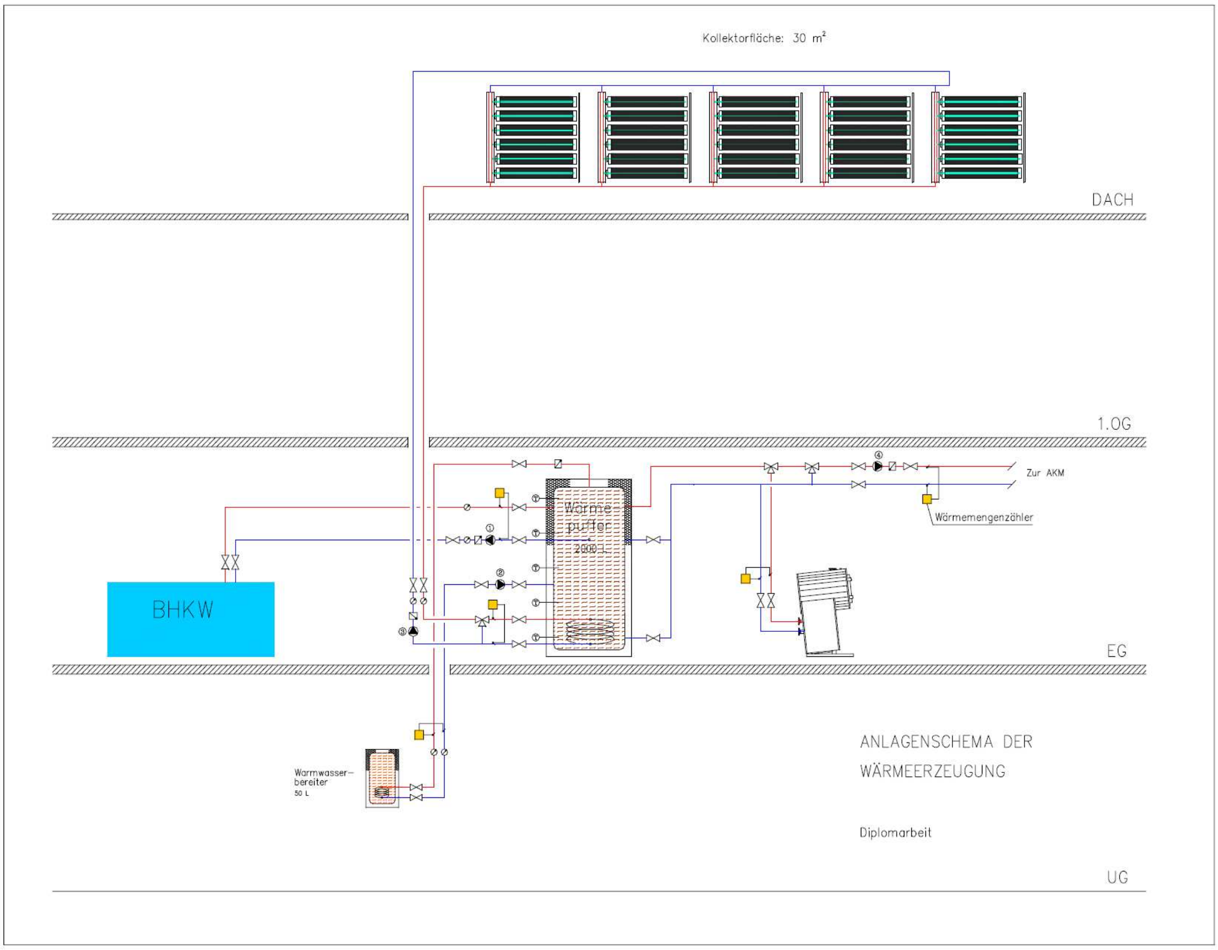
SOLAIR

System performance

From a monitoring period in 1999, an annual coefficient of performance (COP) of 0.50 was obtained. The solar thermal coverage of the total heat input for heating and cooling was 12 %; the contribution of the gas boiler and of the CHP to the heat input was 44 % each. From the energy balance, a specific annual collector yield of 286 kWh/m²a was determined.

System reliability and overall success of the installation

The system showed less solar coverage than expected, of which one reason is connected with the limitation in size of the collector array. A revision of the collector system is planned. The sufficient cooperation of three heat generation units requires some effort in the design of the system control. Some reliability problems are connected with the CHP unit, but the overall reliability of the solar thermally driven cold production is good; the overall concept is correct and promising.



Sistema di produzione del calore dell’impianto di solar cooling presso Ott Ingenieure, Langenau, Germania

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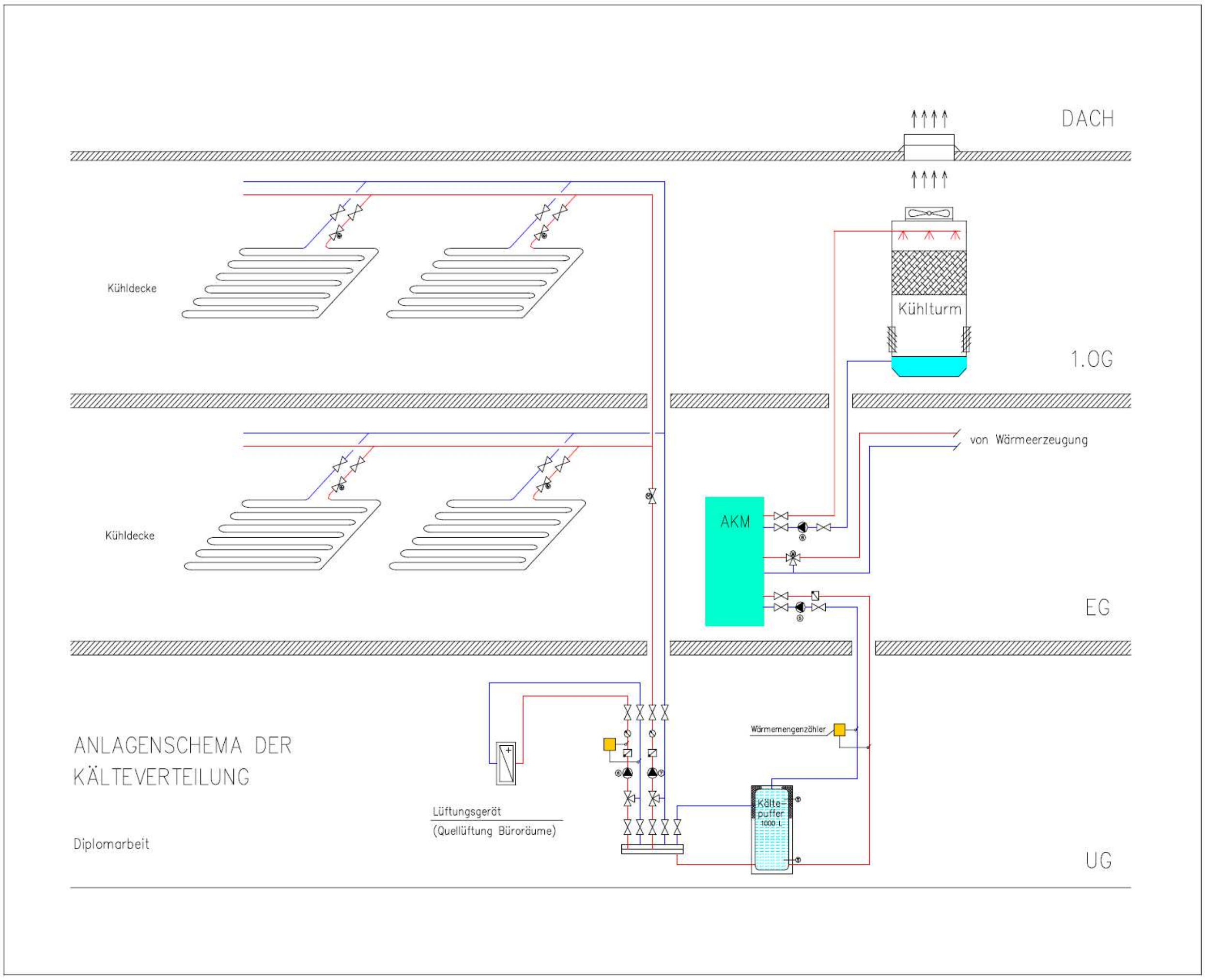

Sistema di produzione del freddo dell'impianto di solar cooling presso Ott Ingenieure, Langenau, Germania

SOLAIR

Solar Info Center SIC, Freiburg, Germany

Description of the application

The Solar Info Center at Freiburg hosts companies, active in solar energy business. A part of the building is rent to Fraunhofer ISE. Within this part, an area of offices and a seminar room is air-conditioned by a liquid dessicant cooling system, driven in a solar thermal autonomous cooling mode. It is a pilot system to demonstrate the applicability of this technology.

General description of the system

The system technology is an open cycle liquid desiccant evaporative cooling system, using solar thermal heat for regeneration of the diluted LiCl solution. Solar thermal heat is provided by a flat-plate collector. The sorption process is cooled, thus increasing the sorption efficiency. An advantage of the system is the storage of diluted and concentrated solution in separate storages, which allows a decoupling in time between the dehumidification and regeneration process to a certain degree. No back-up heating systems for the regeneration of the solution is applied. During winter, heat from the district heat network from the University hospital is applied for supply air heating.

Central air-conditioning unit

Technology	open cycle (DEC)
Nominal air volume flow rate	1,500 m^3/h
Minimum air volume flow rate	600 m^3/h
Desiccant cooling system type	liquid desiccant
Desiccant type	Lithium Chloride
Cooling capacity	10 kW
Brand of desiccant unit	Menerga

Solar thermal

Collector type	flat-plate
Brand of collector	Ufe Ecostar
Collector area	16.8 m^2 aperture
Tilt angle, orientation	30 °, south
Collector fluid	water
Typical operation temperature	55-70 °C regeneration temperature

Configuration

Heat storage	1.5 m^3
Cold storage	solution storages
Auxiliary heating support	district heating network
Use of auxiliary heating system	supply air heating in winter
Auxiliary chiller	no

System performance

Considering the overall cold production of the air handling unit (all operation modes: desiccant cooling, free cooling, adiabatic cooling) with relation to the total regeneration heat input, an average coefficient of performance (COP) of 1.0 was achieved. The specific annual collector yield was approx. 270 kWh/m²a.

General information

Type of building Seminar room and office area within the SIC
Location Freiburg, Germany (48° North, 7°50' East)
In operation since 2004
System operated by Fraunhofer ISE
Air-conditioned area 300 m^2

Figures




Clicking an image opens the gallery view.

Specific information

Further specific information about the system are included in the filled in technical questionnaire.

PDF DE05_SIC-Freiburg_LDCS.pdf

Contact

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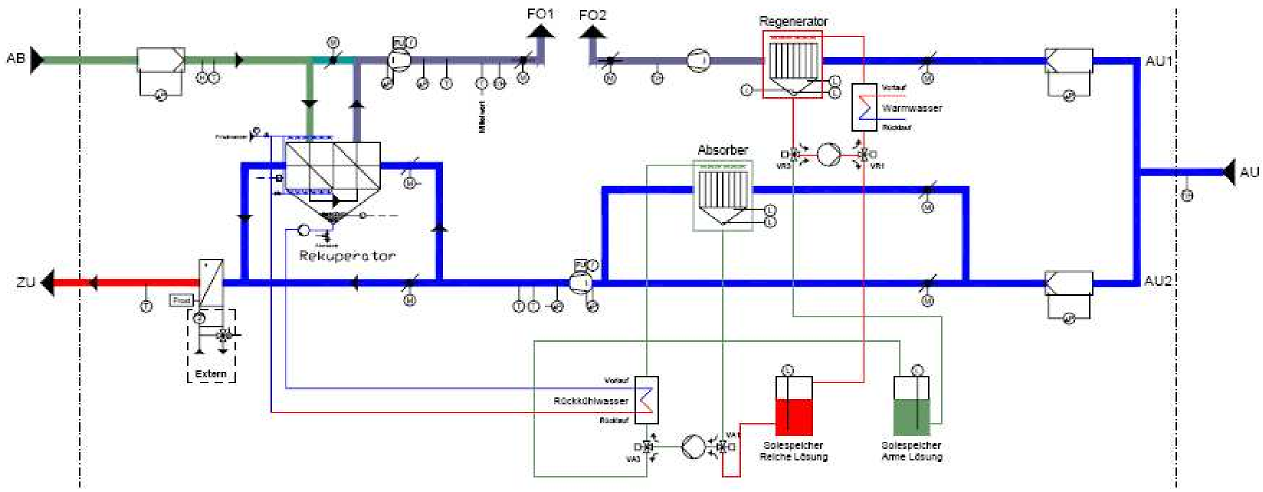
SOLAIR

System reliability and overall success of the installation

Many improvements in the system control were applied within the first year of operation, mainly adressing an optimised operation of pumps and fans. In between, the system operation is reliable and promising and the availability of the system is very high. A transfer of the solution into the supply air has never occurred.



Sistema liquid desiccant evaporative cooling presso il Solar Infor Center (SIC), Freiburg, Germania

SOLAIR

Office building of IBA AG in Fürth, Germany

Description of the application

To increase the room air comfort in the offices, a solar autonomous thermally driven chiller is installed. The chiller provides chilled water at a temperature level of approx. 9 °C for the operation of fan coils and chilled ceilings in the offices. The system is designed for top cooling.

General description of the system

The system technology is a closed cycle chilled water system with a medium-sized absorption chiller. Heat is provided by a solar thermal system only, a gas boiler is installed, but used for space heating in winter. The heat rejection circuit of the chiller is connected to an open wet cooling tower. To avoid stagnation situations in the collector and to increase the collector efficiency, surplus heat of the collector is supplied to a nearby spa.

Central air-conditioning unit

Technology	closed cycle
Nominal capacity	30 kW_{cold}
Type of closed system	absorption
Brand of chiller unit	EAW Wegracal SE 30
Chilled water application	chilled ceilings, fan coils
Dehumidification	in fan coils
Heat rejection system	open wet cooling tower

Solar thermal

Collector type	flat-plate
Brand of collector	Solvis F-802-S, F-652-D
Collector area	87.7 m^2 aperture
Tilt angle, orientation	25 °, south
Collector fluid	water-glycol
Typical operation temperature	86 °C driving temperature for chiller operation

Configuration

Heat storage	3.7 m^3 water
Cold storage	1.4 m^3 water
Auxiliary heating support	gas boiler
Use of auxiliary heating system	for space heating; not used for chiller operation
Auxiliary chiller	no

System performance

The system went into operation in August 2007; no monitoring data are available at present. Due to the operation mode of solar autonomous cooling, high environmental benefits are expected compared to a conventional system solution with an electrically driven compression chiller.

System reliability and overall success of the installation

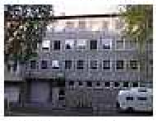
Due to the recent start of the system, no experience is available so far. The system is supported as a pilot installation in the frame of Solarthermie 2000plus, which is a federal funding scheme for large solar thermal applications. Monitoring of projects within this funding scheme is compulsory, thus, system experience will be made public available.

General information

Type of building Office building
Location Fürth, Germany (49°30' North, 11° East)
In operation since 2007
System operated by IBA AG
Air-conditioned area 920 m^2

Figures





Clicking an image opens the gallery view.

Specific information

Further specific information about the system are included in the filled in technical questionnaire.

DE06_IBA-Fuerth.pdf

Contact

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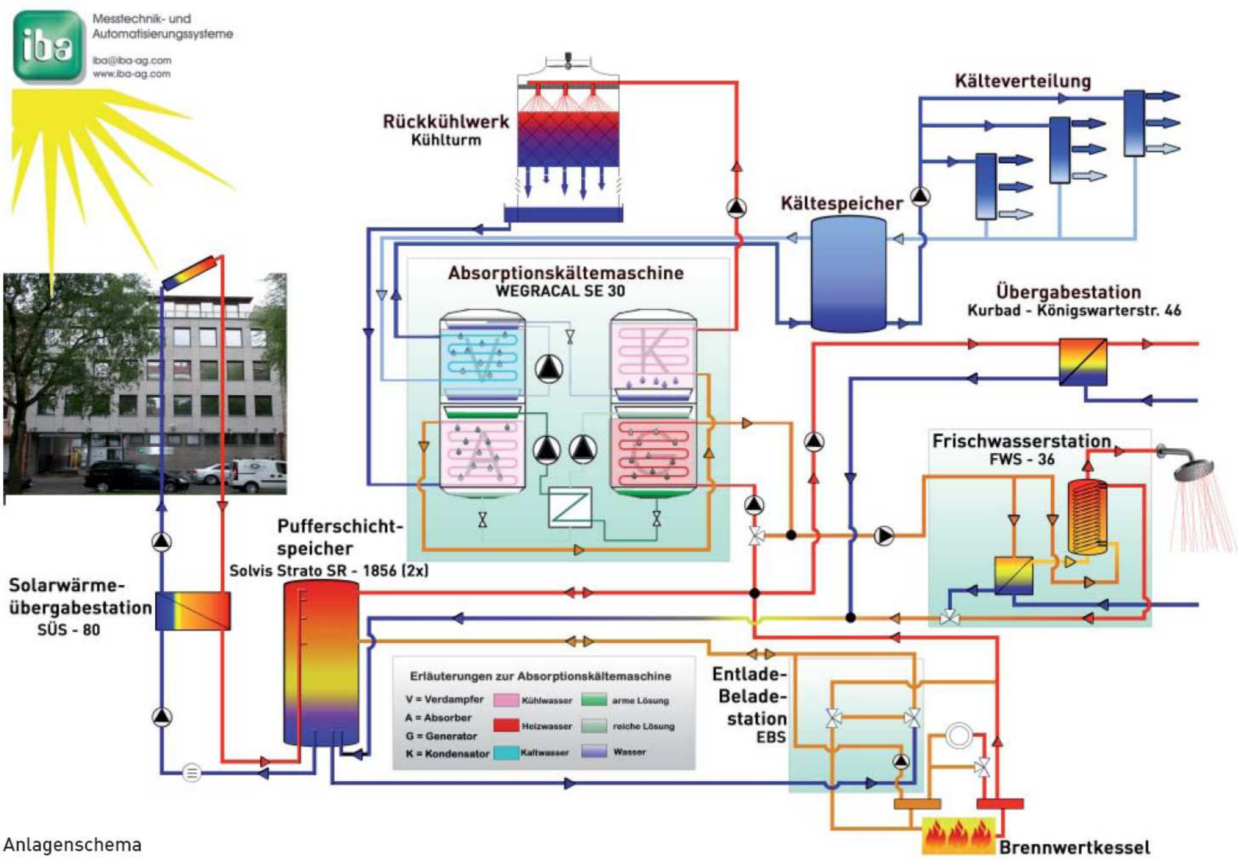


Schema del sistema di solar cooling presso IBA AG, Fürth, Germania

SOLAIR

4.4 Impianti in GRECIA

1. Center for Renewable Energy Sources, Koropi
2. Edificio Promitheus – Sol Energy Offices, Palaio Faliro

SOLAIR

Center for Renewable Energy Sources in Koropi, Greece

Description of the application

The open cycle desiccant evaporative cooling system is used for demonstration and research purposes. It is used to heat and cool the solar thermal building at the P.E.N.A. demonstration site of C.R.E.S.

General description of the system

The system technology is open cycle desiccant evaporative cooling system. Heat is provided by a solar thermal system and by a back-up electric heater installed directly inside the hot water storage tank. In winter the solar thermal system supplies a water-air heat exchanger installed in the DEC system in order to heat the room.

Central air-conditioning unit

Technology	open cycle (DEC)
Nominal air volume flow rate	1,100 m^3/h
Minimum air volume flow rate	373 m^3/h
Desiccant cooling system type	solid desiccant
Desiccant type	Lithium Chloride
Cooling capacity	- kW
Brand of desiccant unit	Klingenburg

Solar thermal

Collector type	flat-plate
Brand of collector	Calpak
Collector area	10 m^2 gross
Tilt angle, orientation	45°, 0° west/east
Collector fluid	water-glycol
Typical operation temperature	60 °C (driving heat for cooling application)

Configuration

Heat storage	0.5 m^3 water
Cold storage	none
Auxiliary heating support	electric heater
Use of auxiliary heating system	directly heats the hot water storage tank, used both for heating and cooling
Auxiliary chiller	no

System performance

This is a newly installed system, system performance has not been analyzed yet.

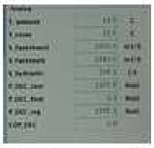
System reliability and overall success of the installation

The first weeks of operation have revealed a reliable system operation. No long-term monitoring data are available so far. The system is promising, since no special and expensive components are used. The low driving temperatures allow the use of low cost flat-plate selective collectors.

General information

Type of building Technology demonstration
Location Koropi, Attiki
In operation since 2007
System operated by CRES
Air-conditioned area 84 m^2

Figures






Clicking an image opens the gallery view.

Contact

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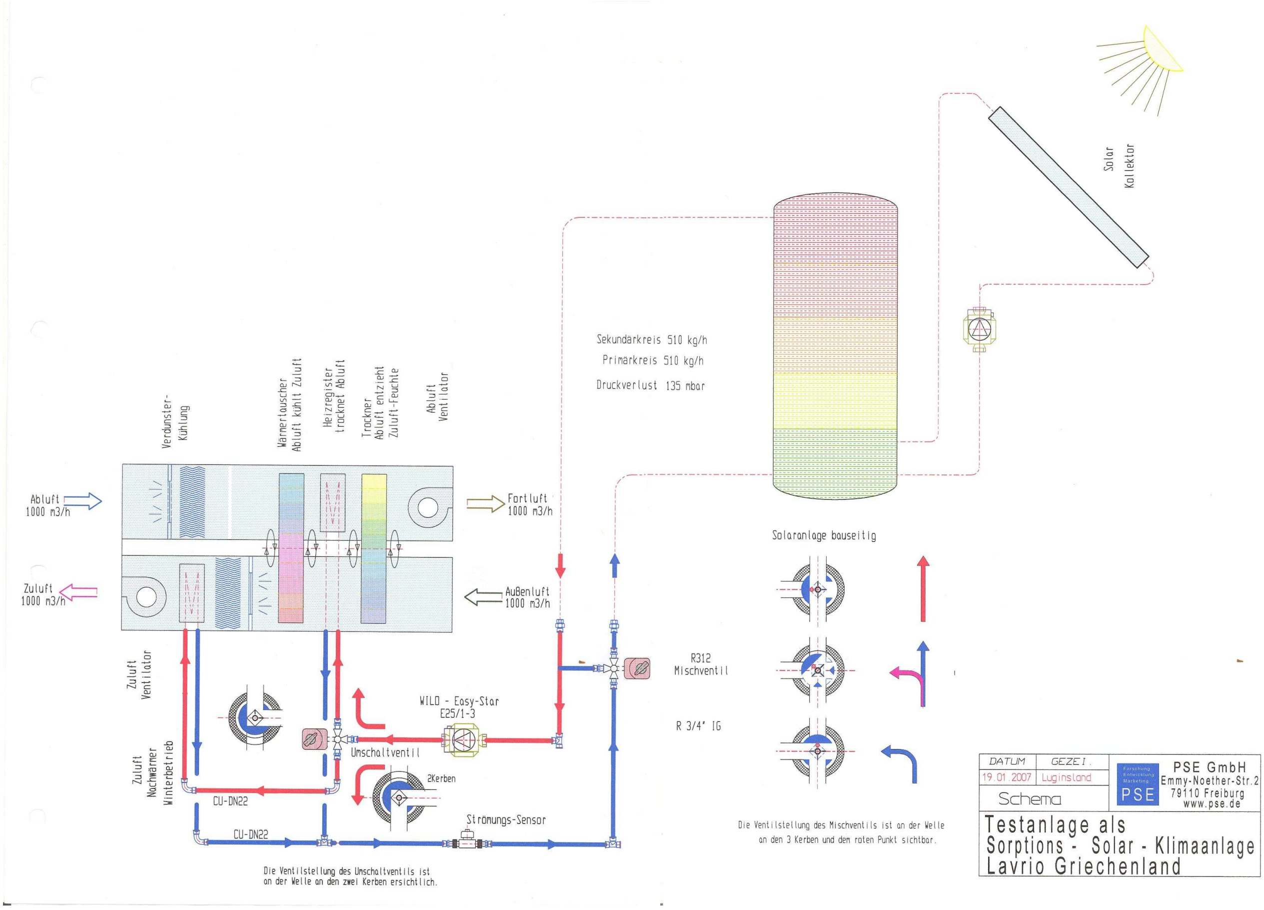
SOLAIR



Schema del sistema di desiccant evaporative cooling presso Lavrio/Koropi, Grecia

SOLAIR

Promitheus Building, Sol Energy Offices in Palaio Faliro, Greece

Description of the application

The closed cycle absorption cooling system is used to heat and cool the offices of the Sol Energy company.

General description of the system

The system technology is closed cycle absorption cooling system. Heat is provided by a solar thermal system and is backed-up by a ground source heat pump.

Central air-conditioning unit

Technology	closed cycle
Nominal capacity	35 kW_{cold}
Type of closed system	Absorption
Brand of chiller unit	Yazaki
Chilled water application	fan coils, chilled ceilings, supply air cooling, chilled floor
Dehumidification	yes
Heat rejection system	wet open

Solar thermal

Collector type	flat-plate
Brand of collector	Chromagen
Collector area	78.6 m^2 gross
Tilt angle, orientation	35°, 0° west/east
Collector fluid	water
Typical operation temperature	83 °C (driving heat for cooling application)

Configuration

Heat storage	2x180 m^3 water
Cold storage	1x180 m^3 water
Auxiliary heating support	ground souce heat pump
Use of auxiliary heating system	a geothermal heat exchanger is utilised for direct cooling of the building or as a heat rejection system for the cooling equipment
Auxiliary chiller	yes
- type	SCROLL
- capacity	61.5 kW_{cold}

System performance

This is a newly installed system, system performance has not been analyzed yet.

System reliability and overall success of the installation

The first weeks of operation have revealed a reliable system operation. No long-term monitoring data are available so far.

General information

Type of building Offices, residential
Location Palaio Faliro, Attiki, Greece
In operation since 2007
System operated by Sol Energy Hellas
Air-conditioned area 360 m^2
Capacity 63 kW cooling, 14 kW heating

Contact

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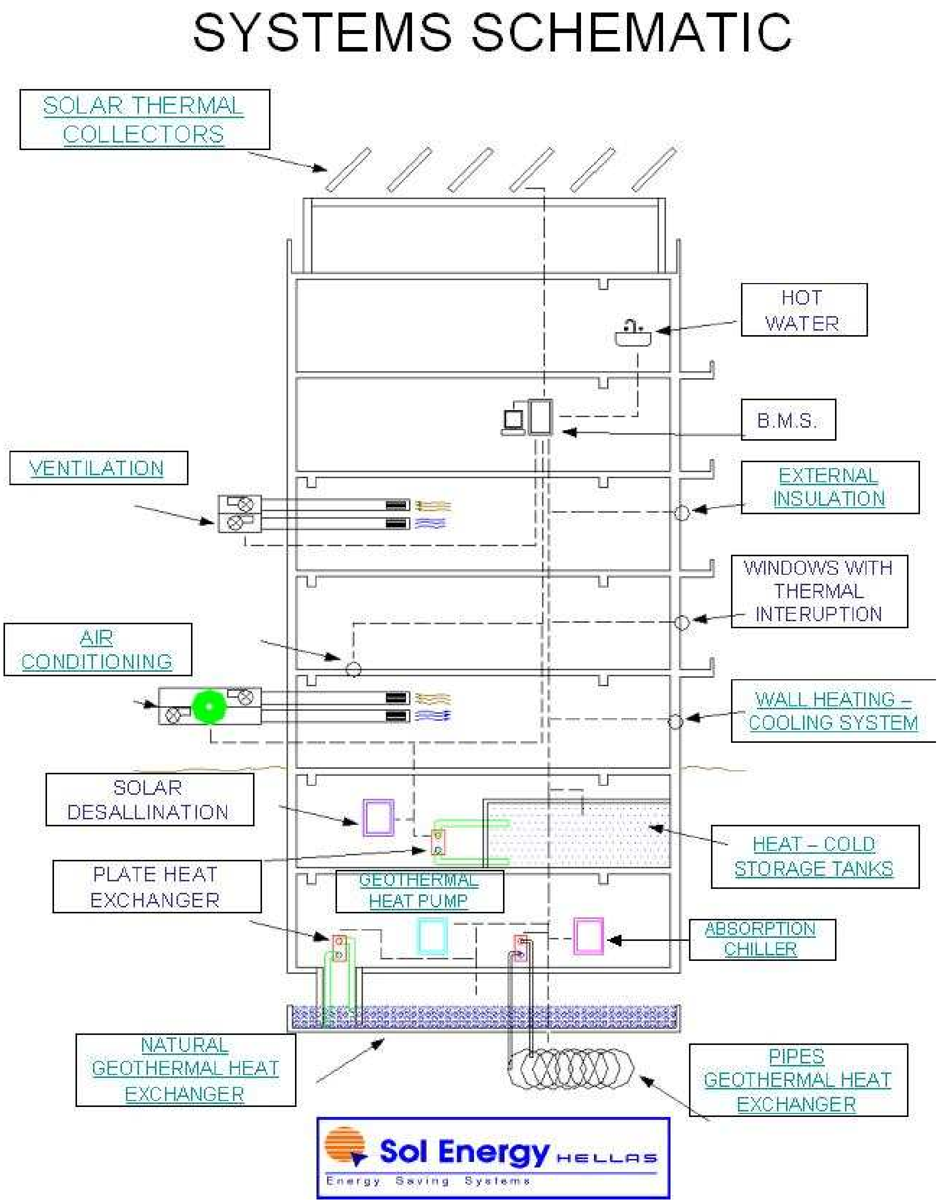
SOLAIR



Schema del sistema installato presso Palaio Faliro, Grecia

4.5 Impianti in ITALIA

1. Area industriale, Bolzano
2. Edificio residenziale, Milano
3. ISI Pergine business center, Trento

SOLAIR

Manufacturing area in Bolzano, Italy

Description of the application

In this manufacturing area in Bolzano, a need for cooling exists in the period from June till September.
The 400 m² building is naturally ventilated and heating and cooling is distributed through walls and floor.

General description of the system

150 square meters of flat plate collectors are connected with 15 kW absorption chiller, 3 tanks are installed in the system and they operate according to the season.
The system has two operation modes: winter and summer.

- In summertime only 9 m³ of storage buffers are available for cooling purposes and as auxiliary heater just the gas heater is used.
- In winter both 8 m³ storages work in series to satisfy the heating demand.

For both modes 0.6 m³ are used for DHW purposes, this can be heated by sun and oil heater.
The heat rejected from the system goes through a wet cooler.

Central air-conditioning unit

Technology	closed cycle
Nominal capacity	15 kW_{cold}
Type of closed system	absorption
Brand of chiller unit	EAW Energieanlagenbau GmbH
Chilled water application	wall and floor cooling
Dehumidification	no
Heat rejection system	wet open

Solar thermal

Collector type	flat-plate
Brand of collector	Ebner Solartechnik
Collector area	100 m^2 + 50 m² gross (two collector fields)
Tilt angle, orientation	60 °, south
Collector fluid	water-glycol
Typical operation temperature	90 °C (driving heat for cooling application)

Configuration

Heat storage	17.6 m^3 water (total volume of 4 tanks)
Cold storage	none
Auxiliary heating support	gas boiler
Use of auxiliary heating system	heating & cooling
Auxiliary chiller	no

General information

Type of building Industrial
Location Bolzano, Italy
In operation since 2005
System operated by EURAC research institute for renewable energy
Air-conditioned area 400 m^2
Capacity 15 kW

Figures




Clicking an image opens the gallery view.

Specific information

Further specific information about the system are included in the filled in technical questionnaire.

IT01_Bolzano.pdf

Contact

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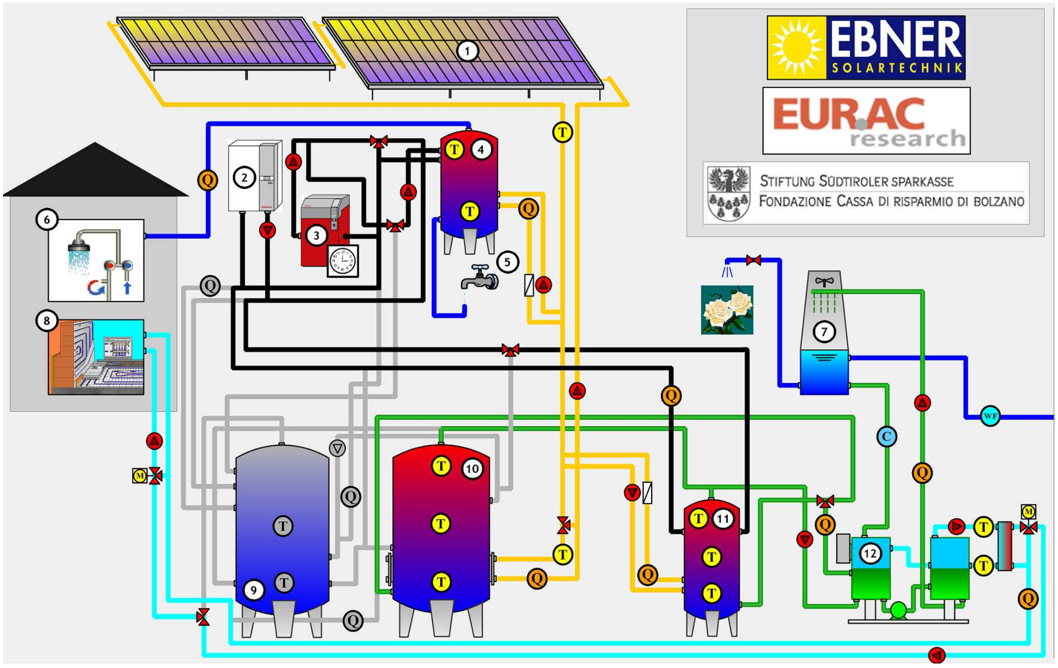
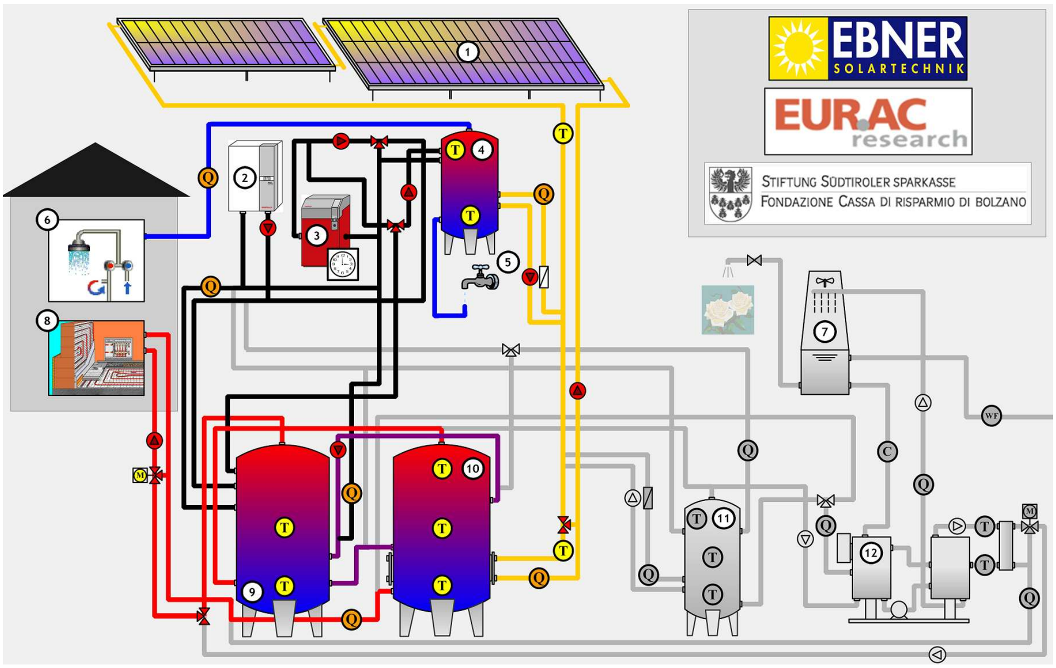




Schema del sistema di solar cooling a Bolzano, Italia.

In alto: operazione estiva; in basso: operazione invernale

SOLAIR

Residential Building, Milan, Italy

Description of the application

The residential building, where the system is installed, is situated in a border of a municipal park in Milan (North of Italy). This is a two floor building. The building is quite well insulated, in fact it has a ventilated and insulated roof with a U-value of 0.68 W/(m²K). The external walls are made with an air space (5 cm), a layer of insulating material (8 cm) and light bricks (25 cm). At the first floor there are two test rooms and a bathroom. They are both facing south with a large window of 1.38 m x 2.05 m.

General description of the system

The solar cooling plant is fed by a 20 m² of CPC collectors which deliver thermal energy used for driving a 4.5 kW absorption machine in summer and four fan-coils for the heating in winter.
The system is solar alone, it means that there isn't a back-up system so the chilled water production and the heating function in winter are assigned only to the collector field.

Central air-conditioning unit

Technology	closed cycle
Nominal capacity	4.5 kW_{cold}
Type of closed system	absorption
Brand of chiller unit	Rotartica Solar 045v
Chilled water application	fan coils
Dehumidification	no
Heat rejection system	dry

Solar thermal

Collector type	CPC
Brand of collector	Kloben CPC
Collector area	20 m^2 aperture
Tilt angle, orientation	30°, 0°
Collector fluid	water-glycol
Typical operation temperature	90 °C driving temperature for chiller operation

Configuration

Heat storage	2 m^3 water, two tanks
Cold storage	none
Auxiliary heating support	none
Use of auxiliary heating system	none
Auxiliary chiller	no

System performance

The system thermal coefficient of performance (COP) for operation in summer 2007 was ranging between 0.6 and 0.7.

System reliability and overall success of the installation

The system has showed a reliable operation. Moreover, a development of the control system is foreseen in summer 2008.

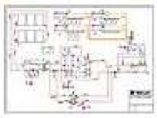
General information

Type of building residential
Location Milan, Italy
In operation since 2007
System operated by Politecnico di Milano
Air-conditioned area 90 m^2
Capacity 4.5 kW

Figures







Clicking an image opens the gallery view.

Specific information

Further specific information about the system are included in the filled in technical questionnaire.

IT02_Milano.pdf

Contact

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Segue alla pagina successiva

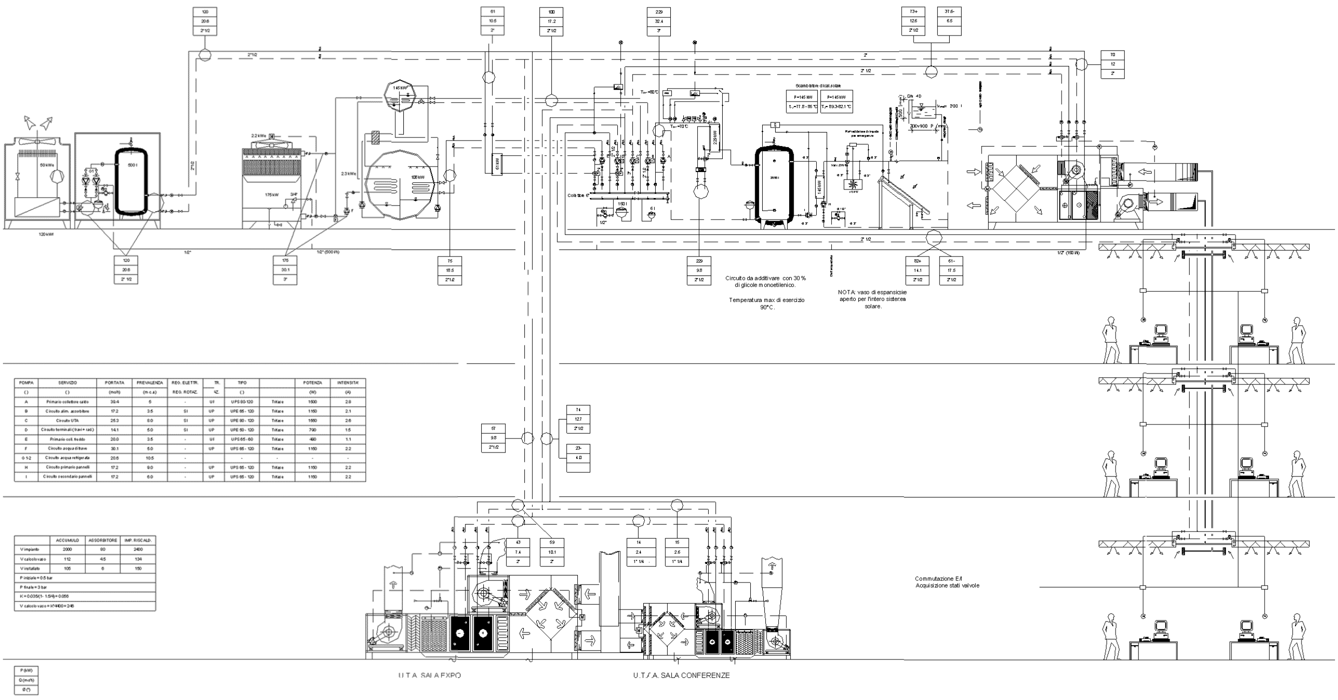
SOLAIR

System performance

(Estimation performance data because the plant has to be yet operational)
Overall nominal thermal loads: The nominal winter thermal loads will be of the order of 229 kW and for this capacity has been sized the district heating system.
Whereas the winter situation the sum of the thermal loads of each single space corresponds to the overall building load, during the summer period, as well known, the global loads result inferior to the algebraic sum (each space is valued during its most critical hour according to its solar exposure, the overall building will have a unique critical hour which will not necessarily correspond to the maximum thermal load of all spaces).
Thus the sum of the summer loads (excluding thermal heat recovery) is of 188 kW, having a maximum contemporary load of 170 kW.
Under these conditions the solar collectors supply 145 kW. With this thermal power the absorber can produce 108 kW.
When under cloudy sky conditions the thermal load (in absence of solar radiation) drops from 170 kW to 120 kW.
The compression refrigeration machine is thus selected to cover this capacity.

System reliability and overall success of the installation

Estimation: Generation of the 70 % of the site cooling utilising solar energy with CO_2 emissions saving.



Schema dell'impianto di generazione e distribuzione del freddo a Trento, Italia

SOLAIR

4.6 Impianti in PORTOGALLO

1. Edificio uffici INETI, Lisbona
2. Edificio uffici Vajra, Loulé

SOLAIR

INETI building in Lisbon, Portugal

Description of the application

The objective is to have air conditioning of 12 office rooms, located in the first floor of Building G of INETI Campus and belonging to the Renewable Energy Department.
The design chosen for the system optimizes users comfort in office rooms whom are well satisfied with system operation along the years.

General description of the system

The air conditioning system is an air handling unit of DEC type incorporating a heat pump and assisted by 24 CPC type solar collectors located in the flat cover of the building. A gas boiler is used as backup for the solar thermal system in winter.
Cooling is provided in summer months (between April-May and September-October) and heating in winter months (between October and March).

Central air-conditioning unit

Technology	open cycle (DEC)
Nominal air volume flow rate	5,000 m^3/h
Minimum air volume flow rate	2,000 m^3/h
Desiccant cooling system type	solid desiccant
Desiccant type	lithium chloride,...
Cooling capacity	36 kW
Brand of desiccant unit	MODULAIR AG SACHSEN

Solar thermal

Collector type	CPC
Brand of collector	Ao Sol
Collector area	46.1 m^2 aperture
Tilt angle, orientation	30°, 0° west/east
Collector fluid	water
Typical operation temperature	45-60 °C driving temperature for chiller operation

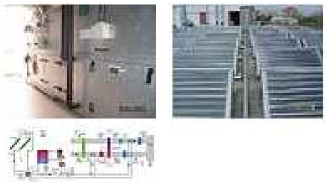
Configuration

Heat storage	2 m^3 water
Cold storage	none
Auxiliary heating support	gas boiler
Use of auxiliary heating system	space heating in winter
Auxiliary chiller	yes
- type	heat pump
- capacity	16.4 kW_{cold}

General information

Type of building office building
Location INETI Campus, Lisbon
In operation since 1999
System operated by -
Air-conditioned area 117 m^2
Capacity 597 m^3

Figures



Clicking an image opens the gallery view.

Specific information

Further specific information about the system are included in the filled in technical questionnaire.

PT01_INETI_DEC.pdf 848 K

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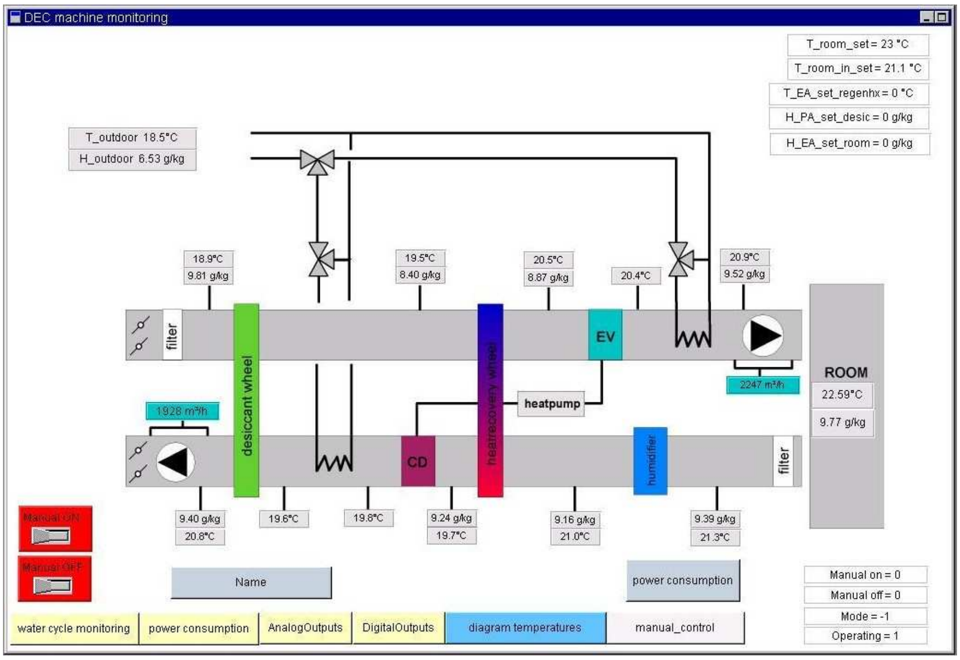
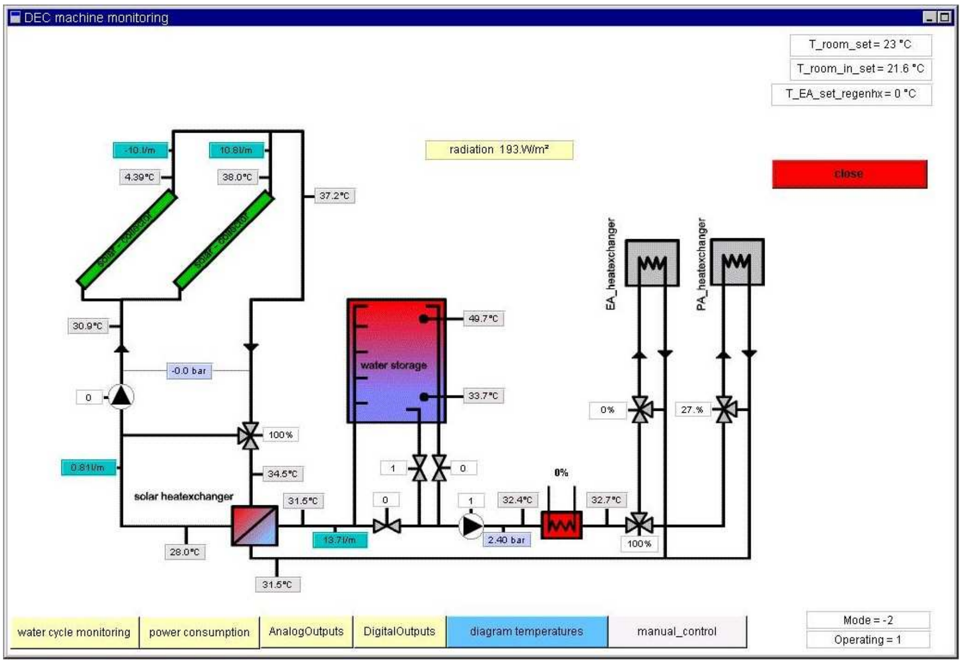
System performance

The standard design of the solar assisted desiccant evaporative technology incorporates two humidifiers: one for the process air, after heat recovery wheel, and another for the exhausted air, before heat recovery wheel.
The system that is installed at INETI was modified to incorporate a heat pump in the process air path (incoming new air path), substituting the humidifier in this path. The reason of this modification relies on the limited size of the air distribution system, which obliged to reduce the air flow rate in the design conditions and at the same time to introduce air in the rooms at lower temperature, to be able to cover the cooling load.
The analysis of system behaviour showed the need to introduce again a humidifier in the incoming air duct. This change was made (2007) but it is not yet operational and monitored.





Schema del sistema di desiccant evaporative cooling (in alto) e del sistema solare / ausiliario (in basso) presso INETI, Lisbona, Portogallo

SOLAIR

Office Building Vajra in Loulé, Portugal

Description of the application

Solar Heating and Cooling of the Head Office Building of Vajra – Solar Thermal Design and Distribution Company located in the south of Portugal, Algarve.

General description of the system

The thermal cooling system installed is an absorption chiller (yazaki). The solar thermal system is composed by flat plate collector and a storage tank. Auxiliary heat is provided by a gas boiler.
Cooling is provided in summer months (between April and October) and heating in winter months (between November and March). The system also provides hot water preparation.

Central air-conditioning unit

Technology	closed cycle
Nominal capacity	35 kW_{cold}
Type of closed system	absorption
Brand of chiller unit	Yazaki
Chilled water application	fan coils
Dehumidification	no
Heat rejection system	wet open

Solar thermal

Collector type	flat-plate
Brand of collector	Sonnenkraft
Collector area	128.8 m^2 aperture
Tilt angle, orientation	30°, 15° west
Collector fluid	water-glycol
Typical operation temperature	88 °C driving temperature for chiller operation

Configuration

Heat storage	12 m^3 water
Cold storage	none
Auxiliary heating support	gas boiler
Use of auxiliary heating system	space heating in winter
Auxiliary chiller	no

System performance

No monitoring data is available.
The overall performance of the system, evaluated by the owner in terms of conventional energy reduction of consumption, is good.

System reliability and overall success of the installation

The user is a company working in solar thermal (design and commercialisation). The system is installed in its office and they are satisfied with it.

General information

Type of building office building
Location Loulé, Algarve, Portugal
In operation since September 2005
System operated by Vajra
Air-conditioned area 670 m^2

Figures

Clicking an image opens the gallery view.

Specific information

Further specific information about the system are included in the filled in technical questionnaire.

PT02 VAJRA absorption.pdf 18!

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4.7 Esempi in SPAGNA

1. Libreria Pompeu Fabra, Mataró
2. Edificio CARTIF, Valladolid

'Pompeu Fabra' Library in Mataró, Spain

Description of the application

The Pompeu Fabra Library of Mataró is a building that was designed to integrate a photovoltaic and a solar thermal system in the own structure in order to produce electricity and heating, keeping the requirements of a public library. The optimal equilibrium between energy, comfort, natural lighting, aesthetical appearance and economical resources was applied in the conception of that building.

General description of the system

Between 2000 and 2002 a new project in the framework of JOULE III, called AIRCOOL, was carried out to develop a desiccant cooling unit integrated with the photovoltaic modules and a new solar air collectors field, with air as the only heating and cooling fluid, to provide air-conditioning to the audiovisual-children area. The responsible ones of this project were HfT Stuttgart, TFM S.A., Grammer, Loughborough University, Siegle+Epple and Sauter Ibérica.
This new system was designed to improve the global energy efficiency of the building, as well as comfort in the west side area, taking profit of the existing solar equipment.
The capacity of the new cooling unit is 55 kW with a solar air collectors field of 105 m², south oriented and with a tilt angle of 20º. The total airflow rate is 12,000 m³/h. A compression cooling unit and a gas boiler are the back-up systems to support the solar cooling and heating production.

Central air-conditioning unit

Technology	open cycle (DEC)
Nominal air volume flow rate	12,000 m^3/h
Minimum air volume flow rate	6,000 m^3/h
Desiccant cooling system type	solid desiccant
Desiccant type	silica gel
Cooling capacity	81 kW
Brand of desiccant unit	Siegle+Epple (ATU), Seibu Giken (wheel)

Solar thermal

Collector type	air collector
Brand of collector	Grammer
Collector area	88 m^2 aperture
Tilt angle, orientation	20°, 5° west
Collector fluid	air
Typical operation temperature	65 °C driving temperature for chiller operation

Configuration

Heat storage	none
Cold storage	none
Auxiliary heating support	none
Use of auxiliary heating system	-
Auxiliary chiller	yes
- type	el. compression chiller
- capacity	246 kW_{cold}

General information

Type of building library
Location Mataró, Catalonia, Spain
In operation since July 2002
System operated by the owner
Air-conditioned area 471 m^2
Capacity 81 kW

Figures

Clicking an image opens the gallery view.

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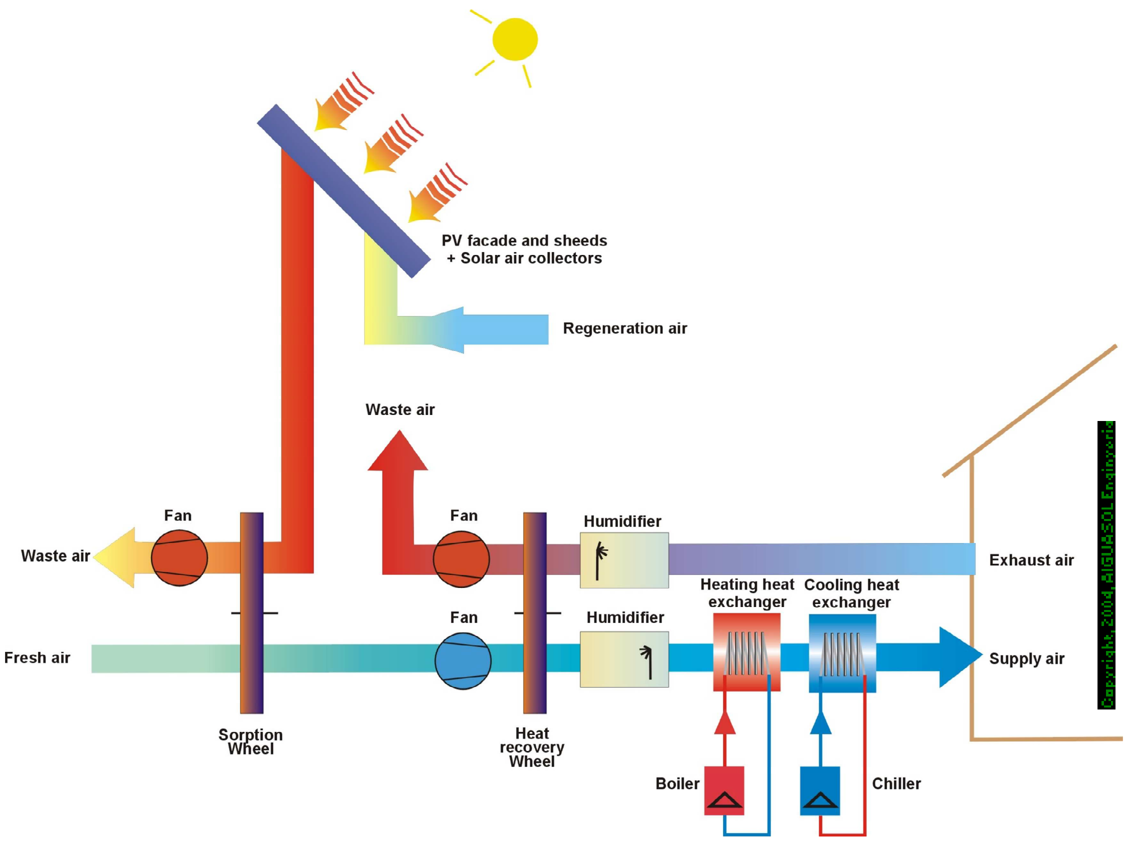
System performance

About environmental impact it can be noticed that noise problems detected in start-up period has been avoided. The technology guarantees a high primary energy savings using solar energy. The main environmental problem is the high water consumption. Humidifiers must be kept very clean to minimize this problem. Moreover, some proposals to recycle the water from humidifier should be considered by the owner. Water consumption is not registered by the system but a comparison in the bills before and after the installation of the system shows a increasing of 217 %.
Desiccant and evaporative cooling system with vapour compression back up for cooling is a technology that works properly in a humid and hot climate as the Mediterranean coast premises.

System reliability and overall success of the installation

The system is working properly, the indoor comfort conditions are better than the ones obtained with the previous installation, due to the fact that air cooling capacity has been increased and the load has been reduced using shading devices over west windows. The users are satisfied with the system. The users do not notice any incidence about uncomfortable air conditions during 2004 year operation.
Besides these improvements on the building air conditioning system, this installation consists on a demonstration of an environmentally friendly technology.



Schema del sistema di desiccant evaporative cooling (DEC) installato presso la libreria pubblica di Mataró, Spagna

Headquarter building of CARTIF in Valladolid, Spain

Description of the application

The solar installation is located in CARTIF Foundation Building 1, Boecillo, Valladolid, in the middle of Spain (Lat. 41º 32', Long -4º 45').
The weather of exposure is an extreme continental type, which characterises by its cold winters and warm summers and by the high temperature oscillations between day and night.
The building has a glass-front that foster heat gains by radiation mainly in those zones facing south.

General description of the system

Working hours in the building go from 7:00 to 15:00. This leads to a higher energy demand in the morning than in the evening. It must be taken into account that this regime penalizes this cooling application because when maximum temperatures are reached in the tanks, and best performances can be obtained, there is no cooling demand. This is precisely the reason that makes design be carried out with a high ratio of accumulation (50-75 l/m²). All the energy available that has not been used will be accumulated throughout all the afternoon to be used during the morning of the following day.
Regarding internal gains, it has been considered that there are 8 people seated typing (light working), with their own computers (400 W) and two copiers (2.5 kW). Artificial lighting is made with low consumption lamps (20 W/m²). The calculated daily energy consumption for each month is 199 kWh/day in June, 209 kWh/day in July, 199 kWh/day in August, and 169 kWh/day in September.
Thanks to an estimation of the hourly refrigeration loads, it can be seen that the highest cooling demand is 29 kW and takes place in August. The chosen machine has been a Yazaki WFC 10 (35 kW).
The solar system installed is an absorption one, working with two different solar fields.

Central air-conditioning unit

Technology	closed cycle
Nominal capacity	35.2 kW_{cold}
Type of closed system	absorption
Brand of chiller unit	YAZAKI
Chilled water application	fan coils
Dehumidification	no
Heat rejection system	wet closed cooling system

Solar thermal

Collector type	flat-plate
Brand of collector	Viessmann
Collector area	37.1 m^2 aperture
Tilt angle, orientation	40°, 0° west
Collector fluid	water-glycol
Typical operation temperature	-

Collector type	evacuated tube
Brand of collector	Viessmann
Collector area	41.2 m^2 aperture
Tilt angle, orientation	40°, tracking
Collector fluid	water-glycol
Typical operation temperature	-

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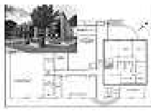
General information

Type of building ×
Location ×
In operation since ×
System operated by ×
Air-conditioned area × m^2

Figures



Clicking an image opens the gallery view.

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System performance

No data available.

System reliability and overall success of the installation

After one year working, the conclusions were the following ones:
The absorption machine did not show any problem. The next step should be to make it work out of the nominal conditions.
The efficiency of the evacuated tubs collectors is higher than the flat plate ones, but its installation is much more fragile (tracking system), above all because of the starting and stop phases of the system.
No comfort problems were detected.

5 Solar cooling: esempi di approcci avanzati

La maggior parte dei sistemi di solar cooling utilizza collettori stazionari, siano essi piani vetrati, oppure a tubi sottovuoto, come descritto nella sezione 2.3. Tali collettori sono adatti alla fornitura di calore per sistemi quali quelli presentati negli esempi della sezione 4.

Tuttavia esistono tecnologie più avanzate, che richiedono temperature di alimentazione dei chiller maggiori, oltre i 100 °C.

I motivi che possono portare all'esigenza di temperature così elevate sono i seguenti:

- le condizioni di radiazione del sito sono favorevoli e consentono l'utilizzo di processi termici ad elevata efficienza, per esempio chiller ad assorbimento a doppio effetto. Il COP maggiore di 1 consente di ridurre la superficie del campo collettori e la taglia del sistema di espulsione del calore. L'alimentazione deve raggiungere temperature superiori ai 150 ° C;
- il sistema viene utilizzato in un processo industriale o comerciale che richiede energia frogorifera a temperature inferiori a quelle tipiche del settore residenziale (es. < 0 °C). In questo caso si utilizzano chiller ammoniaca-acqua alimentati termicamente, che richiedono elevate temperature di alimentazione;
- il consumo di acqua del sistema di espulsione del calore può diventare critico in alcune zone mediterranee; in tal caso è necessario ricorrere al 'dry cooling', le cui temperature di espulsione superano i 40 °C. Per mantenere un'elevata differenza di temperatura tra fluido refrigerante e calore espulso, si ricorre a chiller acqua-ammoniaca con temperature di alimentazione oltre i 100 °C.

L'ultima casistica è studiata dal progetto MEDISCO [MEDISCO, 2006], coordinato dal Politecnico di Milano, con partner da Tunisia e Marocco e con il supporto della Commissione Europea. MEDISCO prevede l'installazione di due impianti ad assorbimento ammoniaca-acqua con collettori solari a concentrazione lineare, per il raffrescamento di una cantina vinicola in Tunisia e di un caseificio in Marocco. Il primo dei due impianti è entrato in funzione nell'aprile 2008.

In Spagna, presso l'università di Siviglia, è stato realizzato un sistema a concentrazione lineare con collettori Fresnel, installati sul tetto della Escuela Superior de Ingenieros (ESI), presso la Facoltà di Ingegneria. La superficie di apertura dei collettori è di 352 m^2. In figura 5.1 è mostrato il principio costruttivo dei collettori, forniti da PSE, Germania: gli specchi sono suddivisi in linee, ciascuna dotata di sistema a inseguimento a un asse. Gli specchi convogliano la radiazione verso un ricevitore statico, montato su un supporto sopra gli specchi. Il ricevitore è dotato di un riflettore secondario che minimizza le dispersioni. Alcuni vantaggi di questa tecnologia risiedono nella ridotta resistenza al vento e nell'elevata superficie di captazione. Ciò permette l'installazione su tetti piani, per esempio nel caso di edifici commerciali o industriali.

I collettori forniscono acqua calda in pressione (a circa 170 °C) al chiller a doppio effetto (174 kW). Questa è attualmente, tra le macchine a doppio effetto, quella con la minor potenza frigorifera disponibile. È prodotta da Broad, Cina. Il raffreddamento è ottenuto grazie all'utilizzo di acqua di fiume, che fluisce attraverso uno scambiatore di calore esterno. Non è quindi necessario utilizzare una torre evaporativa.

Maggiori informazioni su questa tecnologia sono disponibili in [Zahler, 2008].

Figura 5.1 I collettori Fresnel installati presso l'università di Siviglia forniscono energia termica a un chiller a doppio effetto. In alto: gli specchi in posizione di riposo per evitare la stagnazione. In basso: gli specchi in fase di funzionamento. A destra: il chiller a doppio effetto. Fonte: AICIA, Siviglia (in alto e a destra), PSE, Germania (in basso)

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