SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

Task 53

Final report

State of the art of new generation commercially available products

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IEA Solar Heating and Cooling Programme (IEA SHC)

The Solar Heating and Cooling Technology Collaboration Programme was founded in 1977 as one of the first multilateral technology initiatives ("Implementing Agreements") of the International Energy Agency. Its mission is *"to enhance collective knowledge and application of solar heating and cooling through international collaboration to reach the goal set in the vision of solar thermal energy meeting 50% of low temperature heating and cooling demand by 2050.*

The members of the IEA SHC collaborate on projects (referred to as "Tasks") in the field of research, development, demonstration (RD&D), and test methods for solar thermal energy and solar buildings.

A total of 58 projects have been initiated, 50 of which have been completed. Research topics include:

- Solar Space Heating and Water Heating (Tasks 14, 19, 26, 44, 54)
- Solar Cooling (Tasks 25, 38, 48, 53)
- Solar Heat or Industrial or Agricultural Processes (Tasks 29, 33, 49)
- Solar District Heating (Tasks 7, 45, 55)
- Solar Buildings/Architecture/Urban Planning (Tasks 8, 11, 12, 13, 20, 22, 23, 28, 37, 40, 41, 47, 51, 52, 56)
- Solar Thermal & PV (Tasks 16, 35)
- Daylighting/Lighting (Tasks 21, 31, 50)
- Materials/Components for Solar Heating and Cooling (Tasks 2, 3, 6, 10, 18, 27, 39)
- Standards, Certification, and Test Methods (Tasks 14, 24, 34, 43, 57)
- Resource Assessment (Tasks 1, 4, 5, 9, 17, 36, 46)
- Storage of Solar Heat (Tasks 7, 32, 42, 58)

In addition to the project work, there are special activities:

- SHC International Conference on Solar Heating and Cooling for Buildings and Industry
- Solar Heat Worldwide – annual statistics publication
- Memorandum of Understanding – working agreement with solar thermal trade organizations
- Workshops and seminars

Country Members

Australia
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Belgium
Canada
China
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European Commission
France
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Mexico
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Task 53

Sponsor Members

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ECREEE
Gulf Organization for Research and Development
International Solar Energy Society
RCREEE

For more information on the IEA SHC work, including many free publications, please visit www.iea-shc.org

Current Tasks

Task 51 Solar Energy in Urban Planning
Task 52 Solar Energy and Energy Economics in Urban Environments
Task 53 New Generation Solar Cooling and Heating Systems (PV or solar thermally driven systems)
Task 54 Price Reduction of Solar Thermal Systems
Task 55 Towards the Integration of Large SHC Systems into DHC Networks
Task 56 Building Integrated Solar Envelope Systems for HVAC and Lighting
Task 57 Solar Standards & Certification
Task 58 Material and Component Development for Thermal Energy Storage

Completed Tasks

Task 1 Investigation of the Performance of Solar Heating and Cooling Systems
Task 2 Coordination of Solar Heating and Cooling R&D
Task 3 Performance Testing of Solar Collectors
Task 4 Development of an Insolation Handbook and Instrument Package
Task 5 Use of Existing Meteorological Information for Solar Energy Application
Task 6 Performance of Solar Systems Using Evacuated Collectors
Task 7 Central Solar Heating Plants with Seasonal Storage
Task 8 Passive and Hybrid Solar Low Energy Buildings
Task 9 Solar Radiation and Pyranometry Studies
Task 10 Solar Materials R&D
Task 11 Passive and Hybrid Solar Commercial Buildings
Task 12 Building Energy Analysis and Design Tools for Solar Applications
Task 13 Advanced Solar Low Energy Buildings
Task 14 Advanced Active Solar Energy Systems
Task 16 Photovoltaics in Buildings
Task 17 Measuring and Modeling Spectral Radiation
Task 18 Advanced Glazing and Associated Materials for Solar and Building Applications
Task 19 Solar Air Systems
Task 20 Solar Energy in Building Renovation
Task 21 Daylight in Buildings
Task 22 Building Energy Analysis Tools
Task 23 Optimization of Solar Energy Use in Large Buildings

SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

Task 53

Task 24	Solar Procurement
Task 25	Solar Assisted Air Conditioning of Buildings
Task 26	Solar Combisystems
Task 27	Performance of Solar Facade Components
Task 28	Solar Sustainable Housing
Task 29	Solar Crop Drying
Task 31	Daylighting Buildings in the 21st Century
Task 32	Advanced Storage Concepts for Solar and Low Energy Buildings
Task 33	Solar Heat for Industrial Processes
Task 34	Testing and Validation of Building Energy Simulation Tools
Task 35	PV/Thermal Solar Systems
Task 36	Solar Resource Knowledge Management
Task 37	Advanced Housing Renovation with Solar & Conservation
Task 38	Solar Thermal Cooling and Air Conditioning
Task 39	Polymeric Materials for Solar Thermal Applications
Task 40	Towards Net Zero Energy Solar Buildings
Task 41	Solar Energy and Architecture
Task 42	*Compact Thermal Energy Storage*
Task 43	*Solar Rating and Certification Procedures*
Task 44	Solar and Heat Pump Systems
Task 45	*Large Systems: Solar Heating/Cooling Systems, Seasonal Storages, Heat Pumps*
Task 46	*Solar Resource Assessment and Forecasting*
Task 47	Renovation of Non-Residential Buildings Towards Sustainable Standards
Task 48	*Quality Assurance and Support Measures for Solar Cooling*
Task 49	*Solar Process Heat for Production and Advanced Applications*
Task 50	*Advanced Lighting Solutions for Retrofitting Buildings*

Completed Working Groups

CSHPSS; ISOLDE; Materials in Solar Thermal Collectors; Evaluation of Task 13 Houses; Daylight Research

Contents

1. Executive Summary

The A2 activity is dedicated to building the state-of-the-art for new cooling and heating system configurations according to market available and close to market solutions (R&D level just before or during demo stage) at the start of SHC Task 53). This state-of-the-art is based on results from surveying SHC Task 53 participants, and no claim can be made for completeness. The survey results for both solar thermal and solar PV solutions are classified according different criteria: size, applications, etc.

The present report has been built so as to make a picture of the existing and future systems called "New Generation Solar Cooling and Heating Systems" and try to understand their main features. This picture cannot be completed but this can give an interesting fore view of this new generation. This survey is not including refrigeration systems.

The solutions are all pre-engineered systems with small to medium capacities for the following building types: single family houses, small multi-family buildings, offices, shops, commercial centres, factories, hotels. All of these buildings can be grid connected or off grid in case of PV cooling and heating. The cooling and heating power range will be from 1 $kW_{cooling/heating}$ to several tens of $kW_{cooling/heating}$.

The majority of the presented solutions can be driven by solar thermal or/and solar photovoltaic energy, which means these are all solar cooling solutions. 10 solutions are described in a summary set of tables giving technical comparative details as well as some economic indications (overall average end user price for instance) and a comparative square view of the principle scheme is presented. Additional details and pictures can be found in the Annex.

2. Work performed in Activity A2

2.1 Methodology :

A questionnaire was distributed to SHC Task 53 participants in 2015 to collect information on current innovative solar cooling solutions both in the market and close to the market. The questionnaires have differentiated PV and solar thermal approach so as to permit a global understanding of each of them. For each system, a scientific contact member of Task 53 is identified and permits to deepen the technical analysis of the solutions and further exploitation of the data.

The process will continue for the duration of Task 53, until June 2018, to allow for the incorporation of new solutions.

2.2 General overview of the different systems collected in the Task 53 survey:

Ten systems are presented in the following Table 1 and Table 2, to show overall and technical information and to present economical data, respectively.

Table 1 – Overall presentation of the data collection on innovative solar cooling and heating systems among IEA SHC Task 53

Logo	Manufacturer, country	Market status	Service	Solar input type	Nominal cooling capacity (kW or m^3/h)	Nominal heating capacity (kW)	Nominal solar input (Wp for PV and m^2 for ST	Cooling Storage	Target market area	Heat rejection	Back up	Other	Website
ATISYS Concept	ATISYS, France	R&D	Cooling/ heating	PV	4 kW	5.1 kW	4.6 kW	Sensible tank	France, Northern Africa	Air	Grid	R290 chiller, short term elec. battery	www.atisys-concept.com
ClimateWell	CLIMATEWELL, Sweden	R&D	Cooling/ heating/DHW	ST	40 kW	108 kW	180 m^2	Sensible tank	Europe, sunny countries	Air	Electric chiller (390 kW)	Adsorption (LiCl/H20)	www.climatewell.com
FREECOLD	FREECOLD, France	Commercial	Cooling	PV	2.5 kW	No heating	1.5 kW	-	Africa, developing countries	Air	Grid	solar input 24VDC, elec. battery possible	www.coldinnov.com/en
freescoo	FREESCOO, Italy	R&D	Cooling/ heating	ST/PV	500 m^3/h	1.44 kW	2.4 kW	-	Italy	Air		Desiccant technology	www.freescoo.com/solarinvent
GREE 格力	GREE. China	R&D	Cooling/ heating	PV	33.5 kW	37.5 kW	12.2 kW	None	China	Air	Grid	VRF	www.greeac.com
Kaysun by Frigicoll	KAYSUN, Spain	Commercial	Cooling/ heating	PV	3.5 kW	3.5 kW	0.7 kW	None	Spain, Europe	Air	Grid	Scroll, no battery	www.kaysun.es/es
PURIX	PURIX, Denmark	Commercial	Cooling/ heating	ST	2.5 kW	3.6 kW	4.8 m^2	None	Europe, sunny countries	Air	Boiler	Absorption (LiBr/H20)	www.purix.com
senr solutions énergies renouvelables DIFFUSION	SENR, France	Commercial	Cooling/ heating	PV	3.6 kW (split) 45 kW (VRF)	3.6 kW (split) 50 kW (VRF)	0.65 kW (split) 20 kW (VRF)	None	France, Europe, sunny countries	Air	Grid	Scroll, battery possible	www.senr.fr
SolabCool The best comfort with pure energy	SOLABCOOL, Netherlands	R&D	Cooling/ heating	ST	4.5 kW	8 kW	13.3 m^2	None	Europe, sunny countries	Air	District heating	Silicagel-water adsorption cooling machine	www.solabcool.com
YAZAKI	YAZAKI, Japan	R&D	Cooling/ heating	ST	35 kW	60 kW	0.1 kW	Sensible tank	China	Air	Electric chiller (29.3 kW)	Absorption (LiBr/H20)	www.yazaki-group.com/global

Table 2 – Economical data on innovative solar cooling and heating systems among IEA SHC Task 53

Manufacturer	Market status	Service	Total Investment price (€*)	Solar production investment (€*)	Cold/heating production investment (€*)	Storage investment (€*)	Other (€*)	Specific invest. Cost (€*/kW$_{cooling}$)	Annual maintenance cost (€*)	Contact
ATISYS	R&D	Cooling/heating	-	-	-	-	-	-	-	http://www.atisys-concept.com
CLIMATEWELL	R&D	Cooling/heating/DHW	-	-	-	-	-	-	-	http://www.climatewell.com
FREECOLD	Commercial	Cooling	3600	1500	2100	-	-	1 440	100	http://www.coldinnov.com/en/
FREESCOO	R&D	Cooling/heating	7500	1500	3500	-	2500	2 500	50	http://www.freescoo.com/solarinvent/
GREE	R&D	Cooling/heating	24600	12400	11800	-	400	734	300	http://www.greeac.com/
KAYSUN	Commercial	Cooling/heating	2500	700	1800	-		714	30	http://www.kaysun.es/es
PURIX	Commercial	Cooling/heating	4425	-	-	-	-	1 770	20	http://www.purix.com/
SENR - SRV	Commercial	Cooling/heating	97000	57000	25000	17000	3500	26944	1000	http://www.senr.fr
SENR - SPLIT	Commercial	Cooling/heating	2500	700	-	-	-	694	180	http://www.senr.fr
SOLABCOOL	R&D	Cooling/heating	-	-	-	-	-	-	-	http://www.solabcool.com
YAZAKI	R&D	Cooling/heating	-	-	-	-	-	-	-	https://www.yazaki-group.com/global/

** Note : end user price excluding VAT*

Table 2 shows that mainly the commercially available solutions are able to deliver economical data on the systems (indicative investment end user price).

2.3 Square view:

The "square view" developed in Task 53 A4 activity provides a common approach to compare different systems. Based on the "square view" developed in SHC Task 44: Solar and Heat Pump Systems", this concept provides a means to compare different configurations for integrating solar cooling and heating systems in buildings, microgrids and the central grid.

It permits to present in a common and easy to understand manner all the different configurations of solar cooling and heating systems, either they are PV driven or solar thermally driven for example.

Atisys (France) :

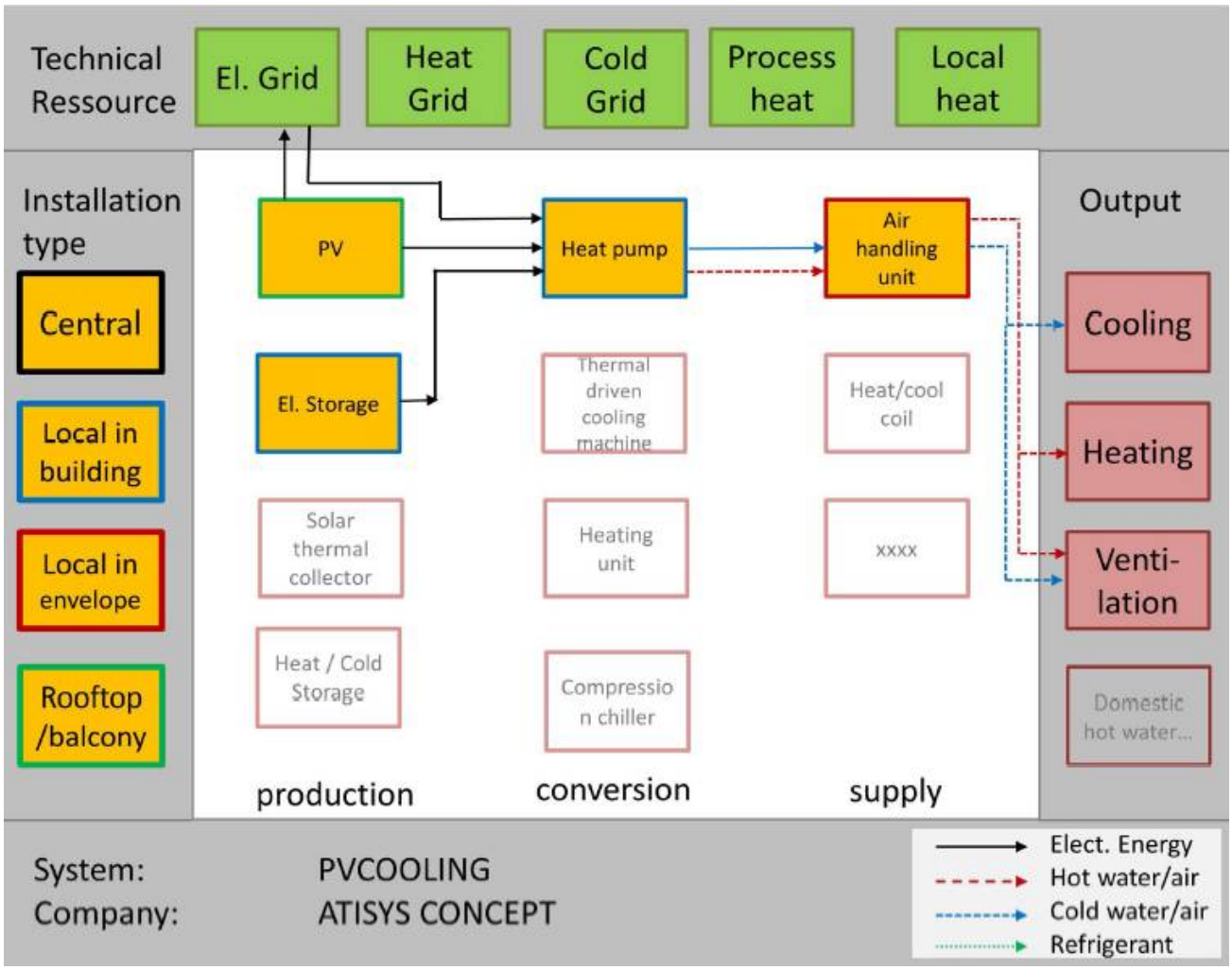


Figure 1: SquareView ATIsys - PVCOOLING

Climatewell (Sweden):

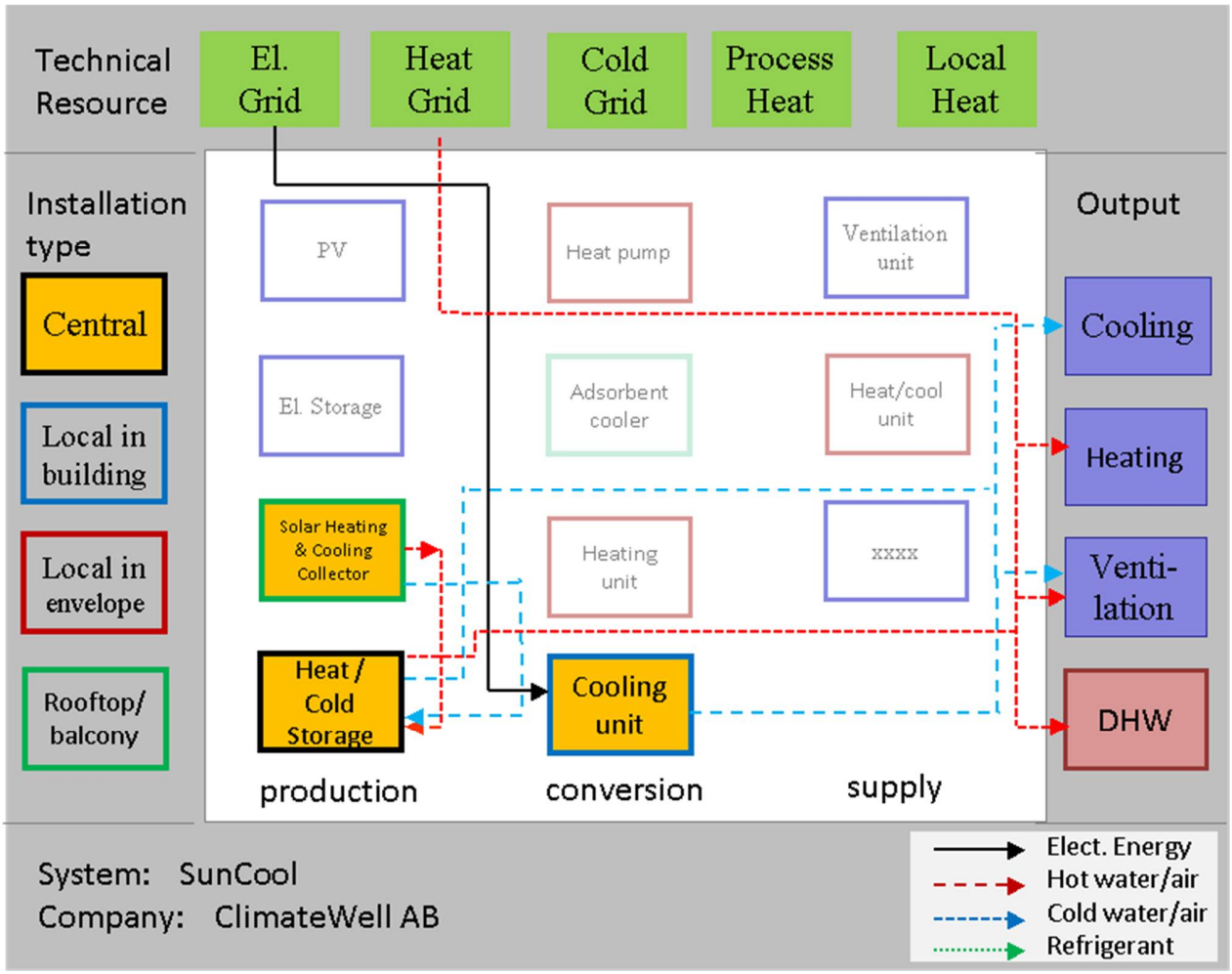


Figure 2: SquareView ClimateWell - SunCool

ColdInnov (France) :

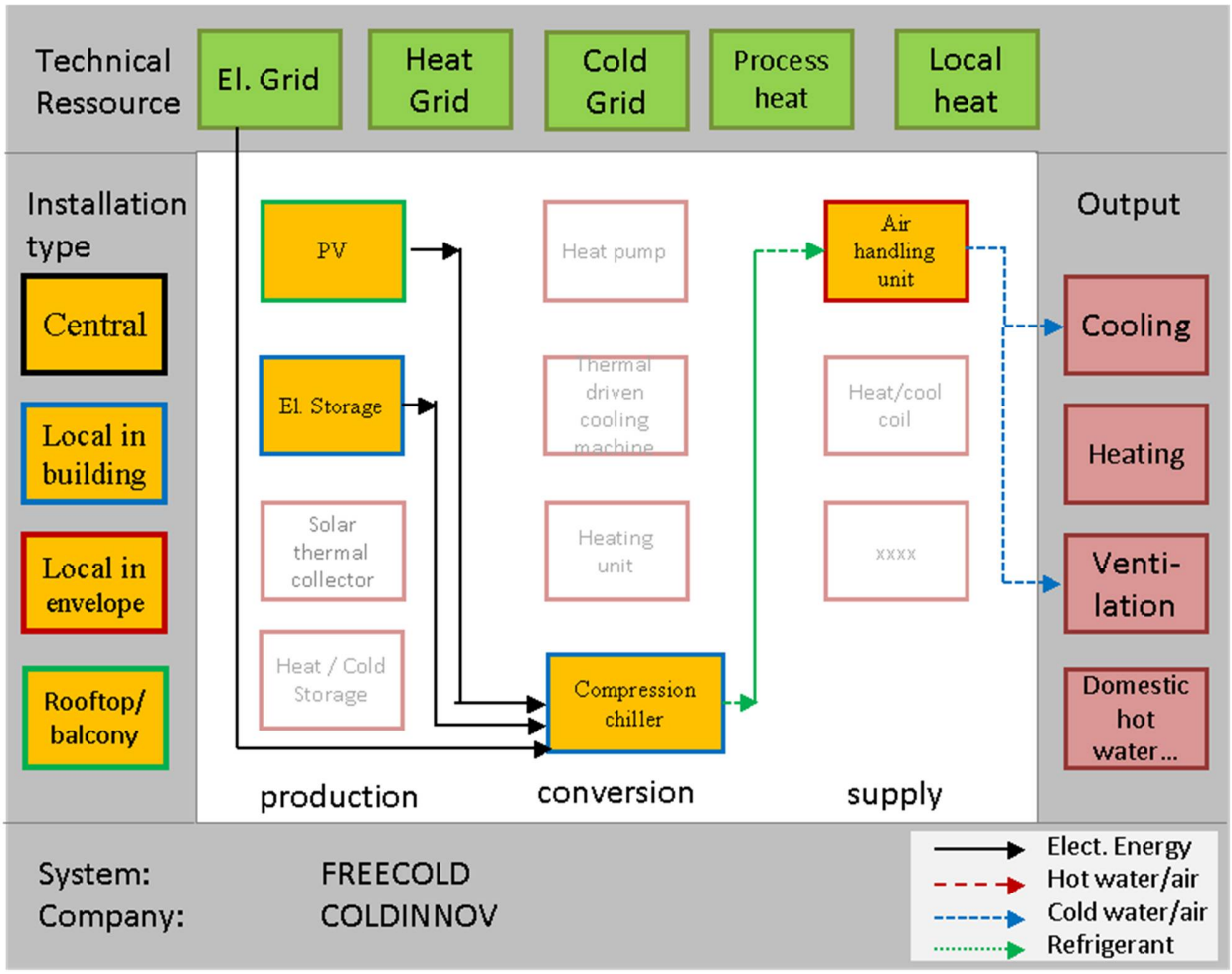


Figure 3: SquareView COLDINNOV - FREECOLD

Freescoo (Italy):

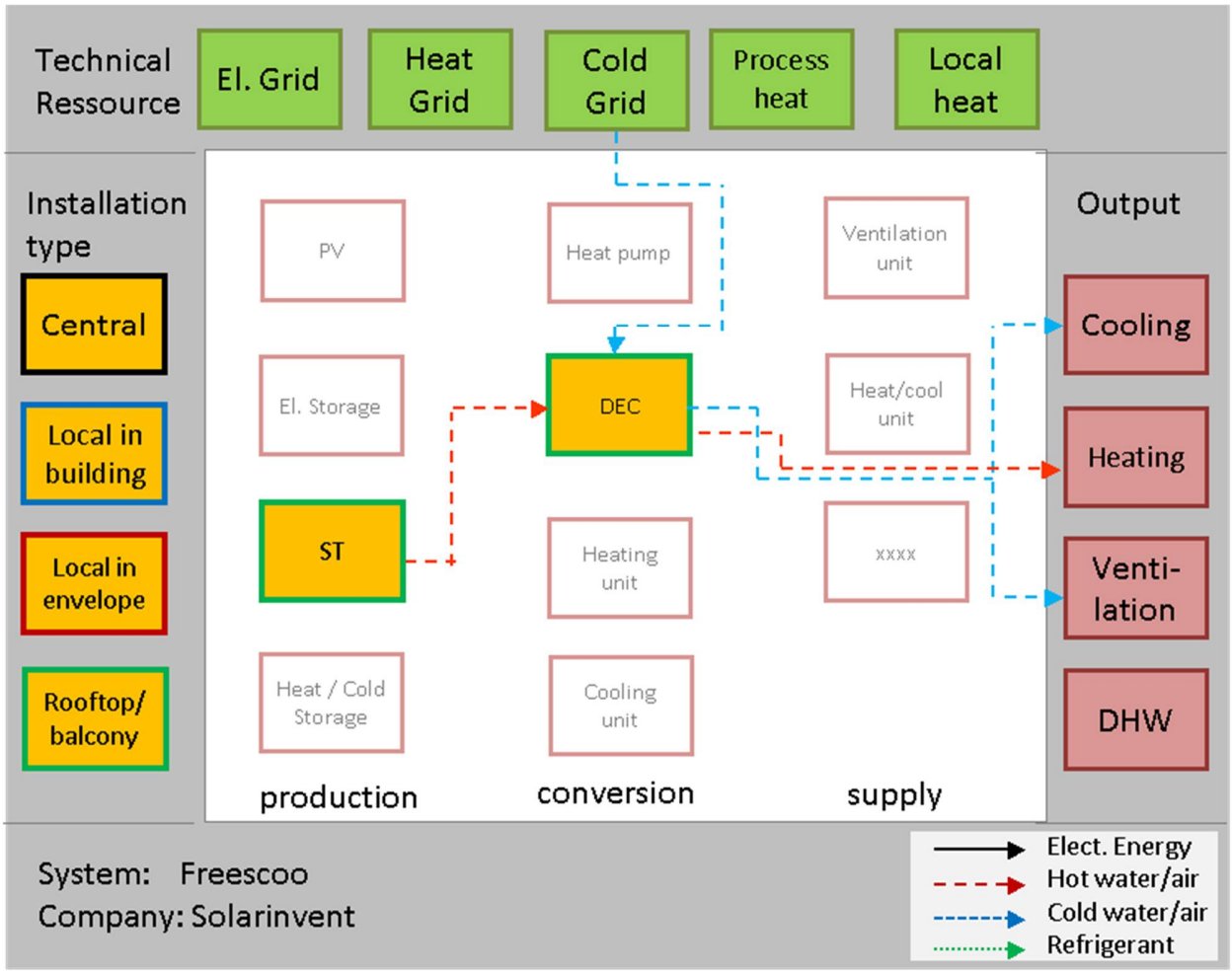


Figure 4: SquareView SolarInvent - Freescoo

Gree (China) :

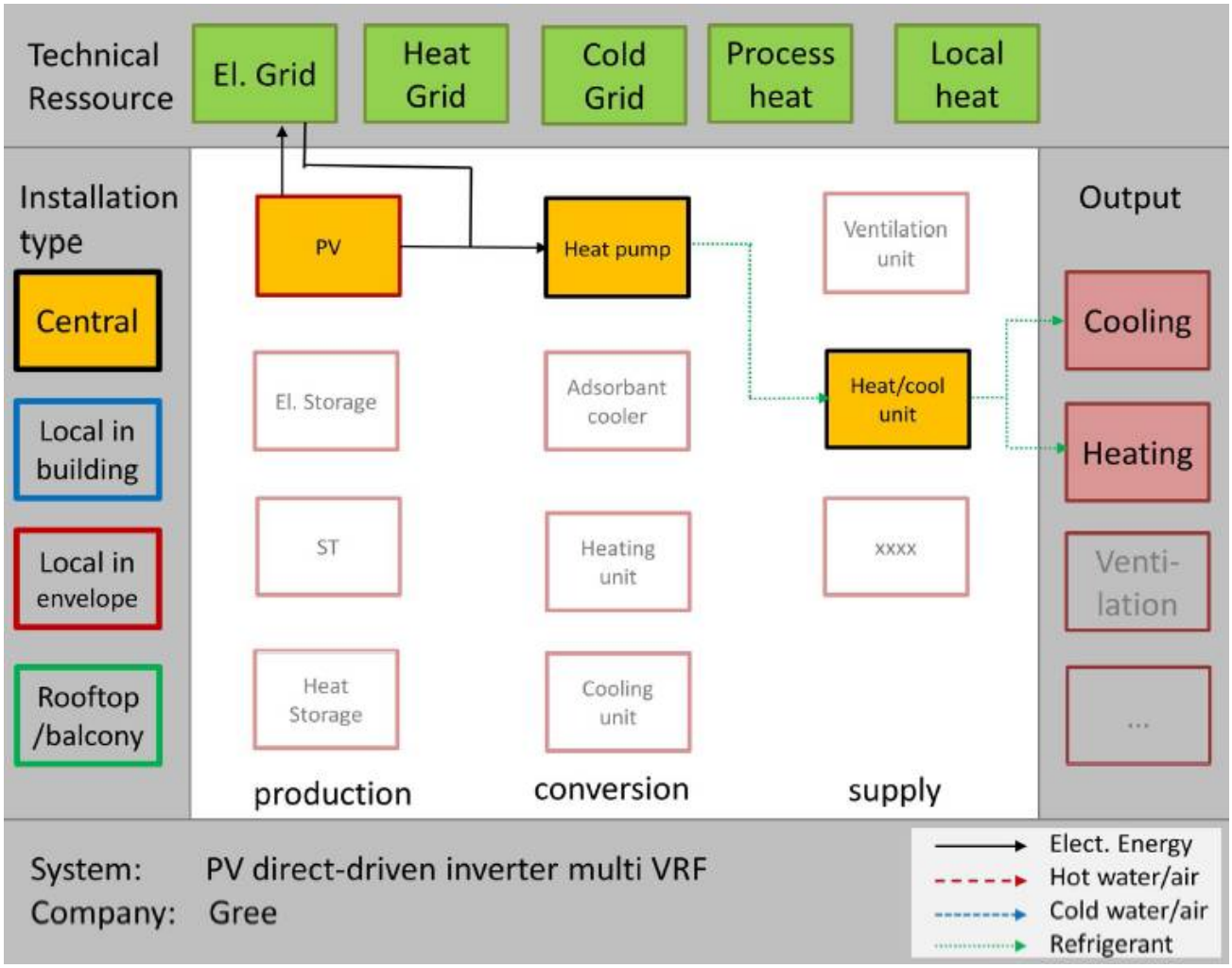


Figure 5: Gree - Gree

Kaysun (Spain):

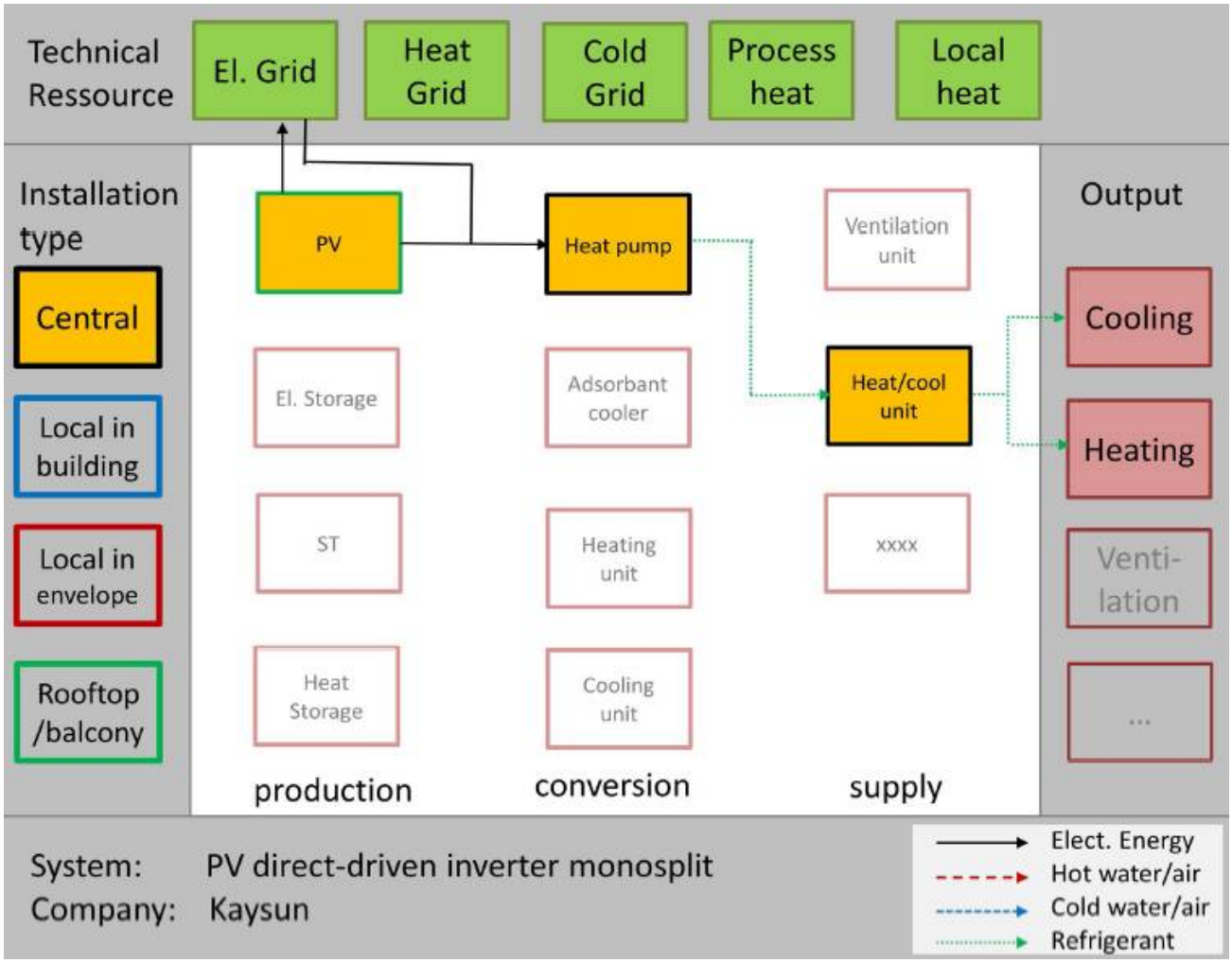


Figure 6: SquareView Frigicoll - Kaysun

Purix (Danemark): District cooling version

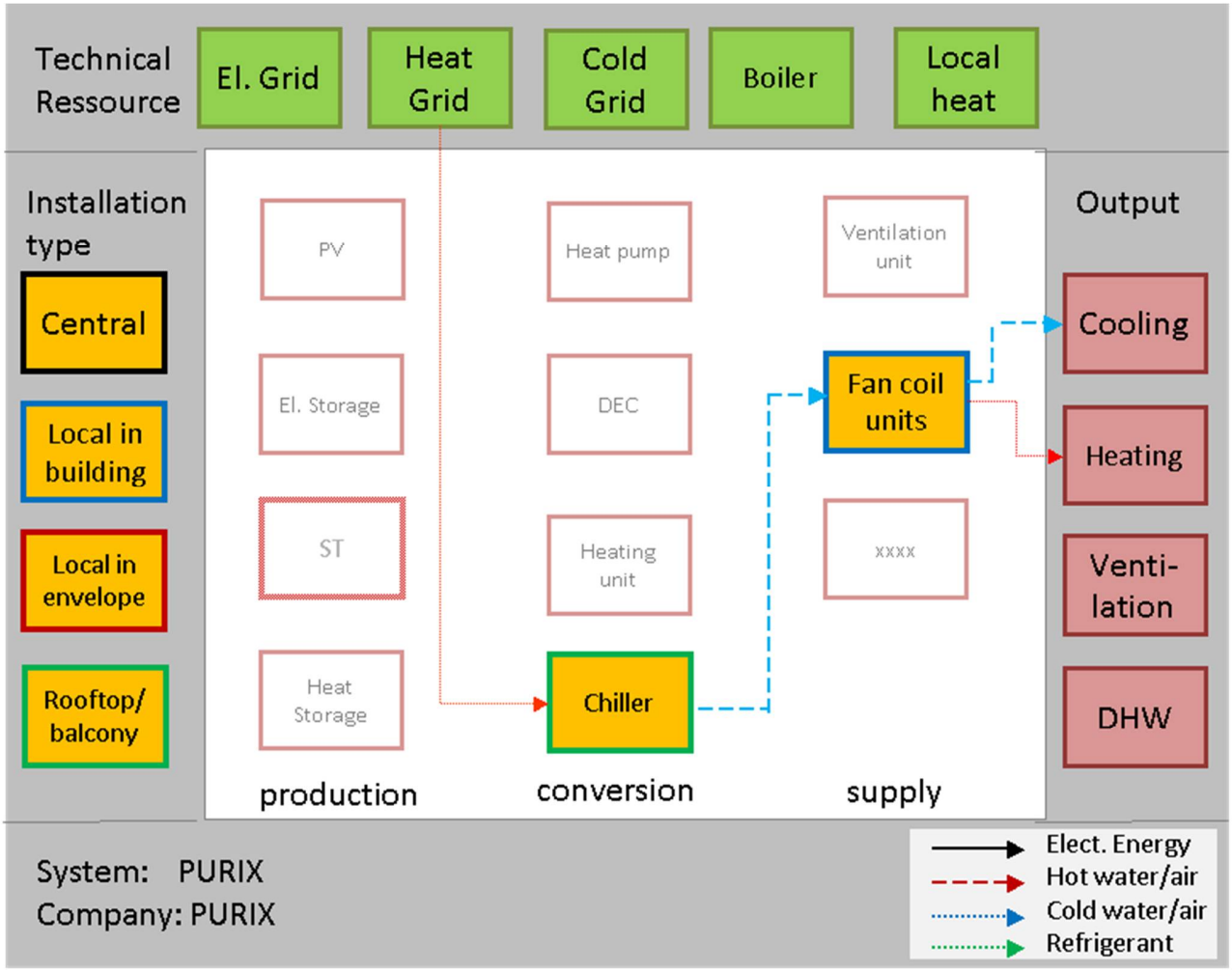


Figure 7: SquareView PURIX - PURIX (district cooling)

Purix (Danemark): Heat storage version

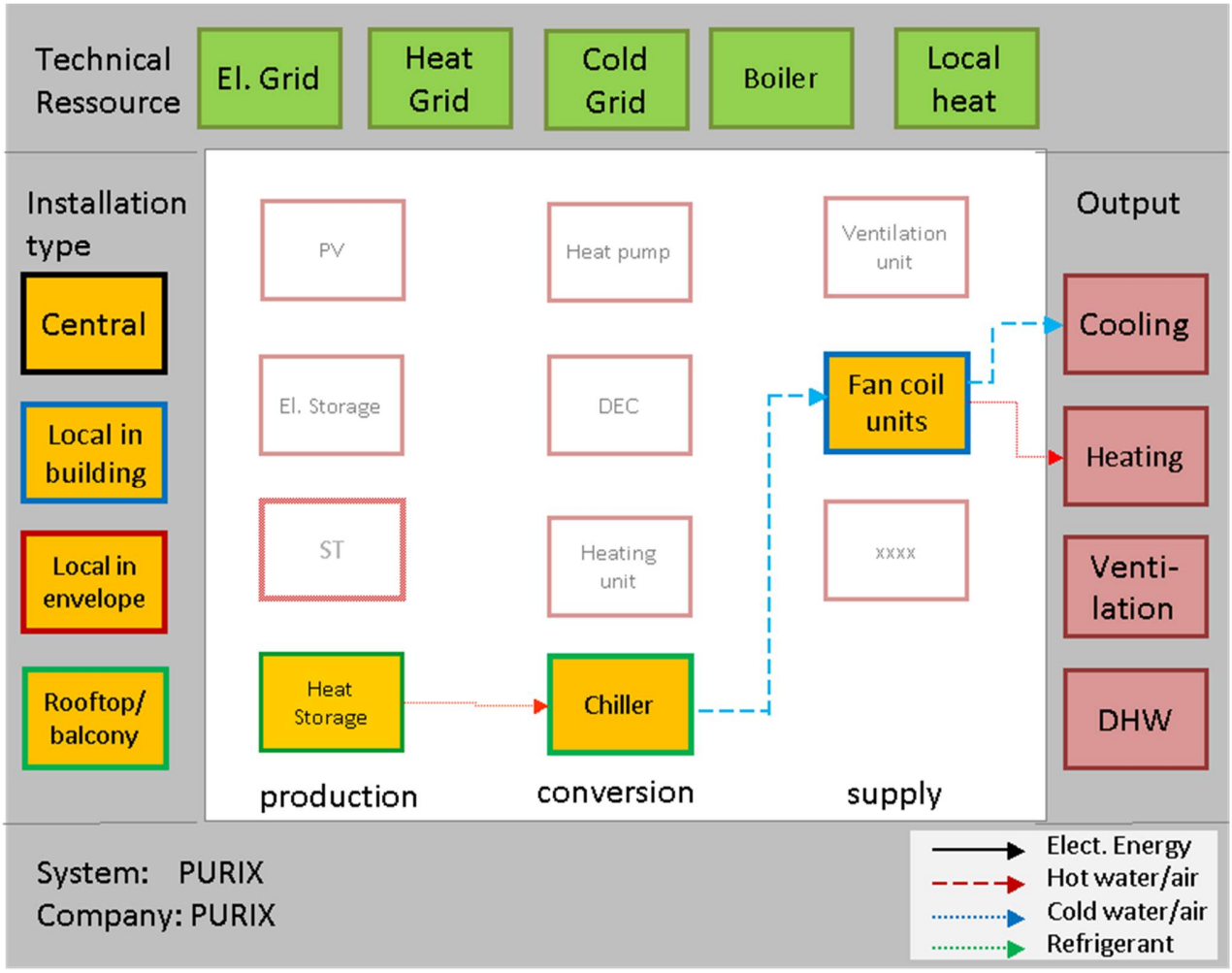


Figure 8: SquareView PURIX - PURIX (heat storage)

Purix (Danemark): Back up version

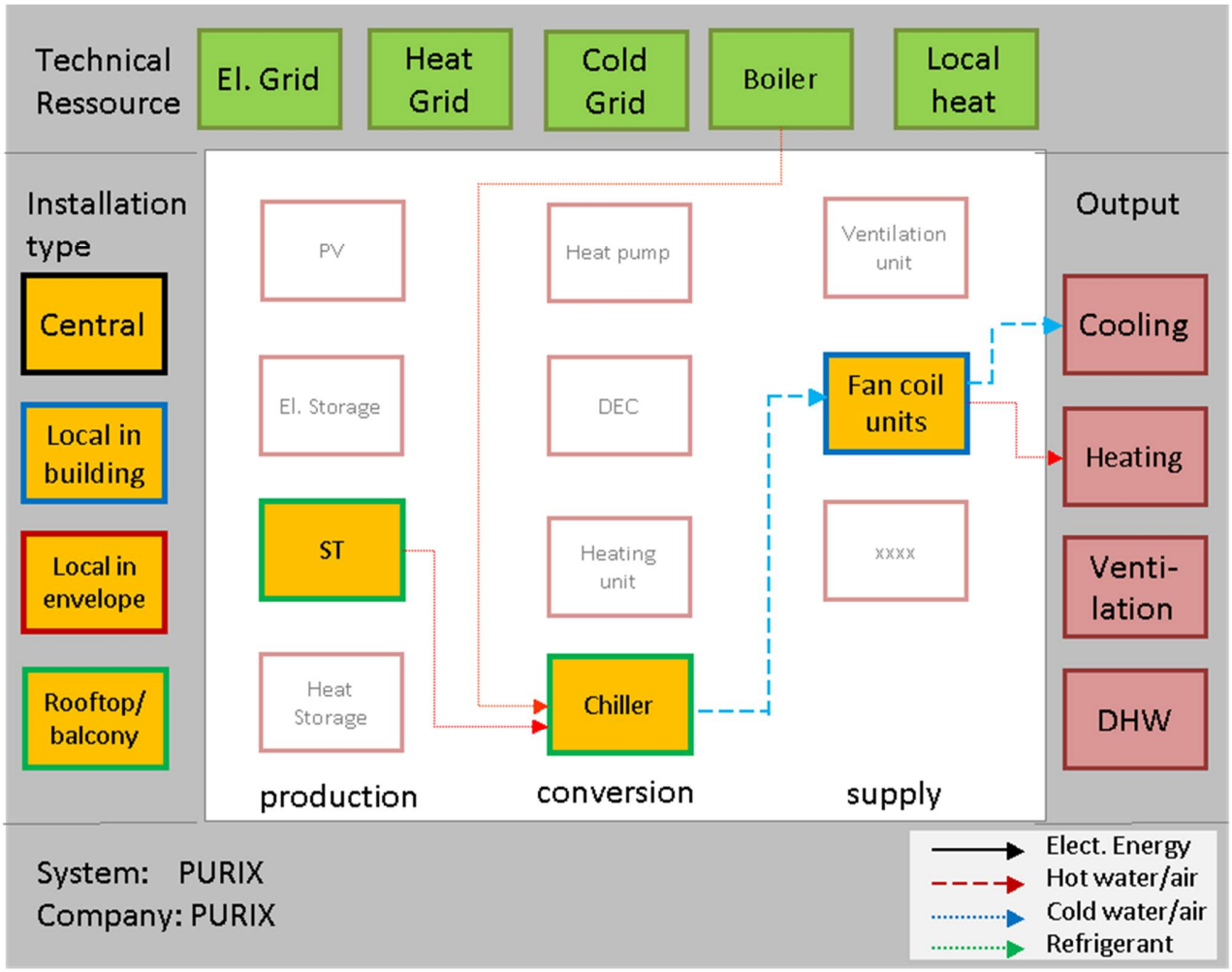


Figure 9: SquareView PURIX - PURIX (backup)

Purix (Danemark): No Back up version

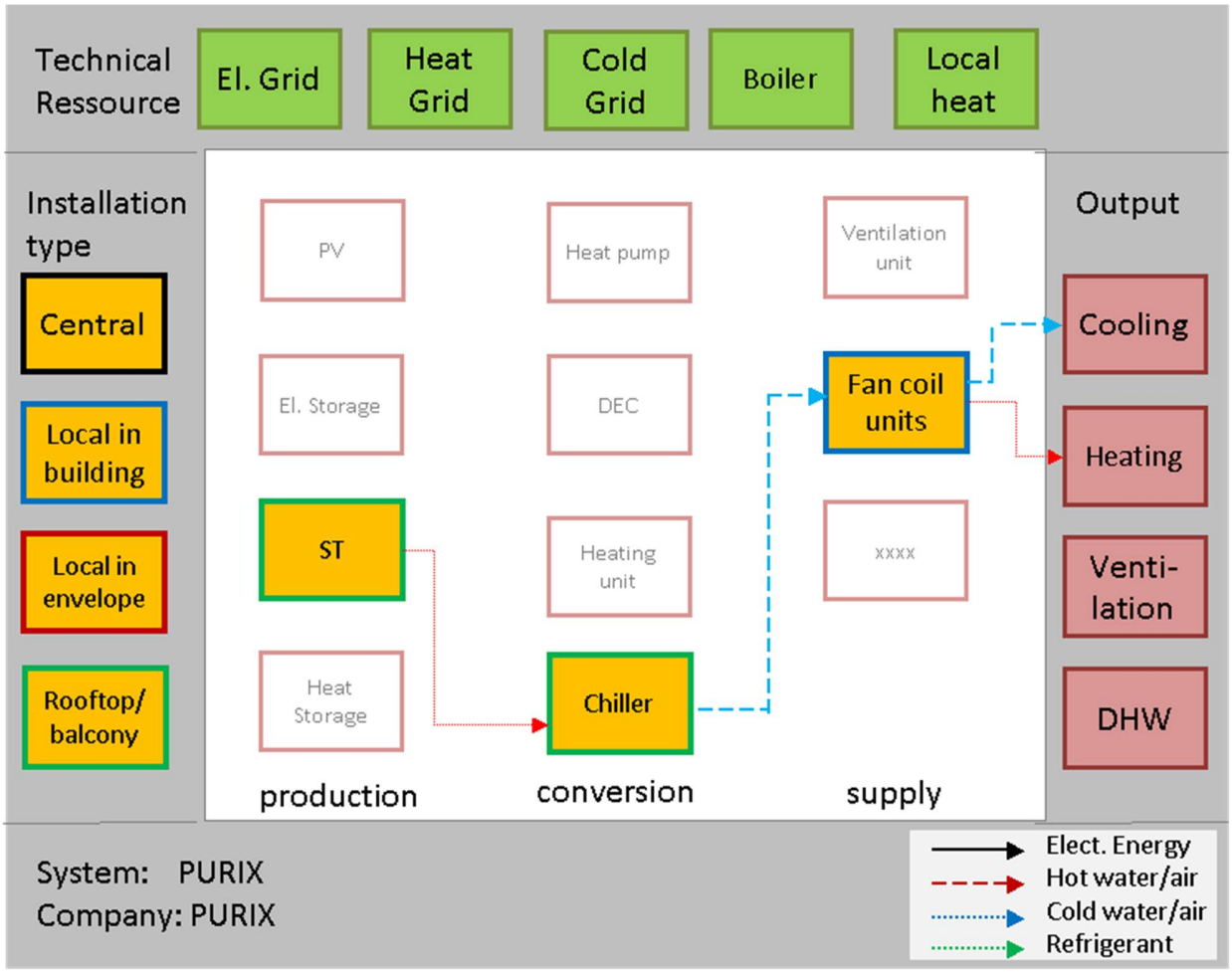


Figure 10: SquareView PURIX - PURIX (no backup)

Solabcool (The Netherlands):

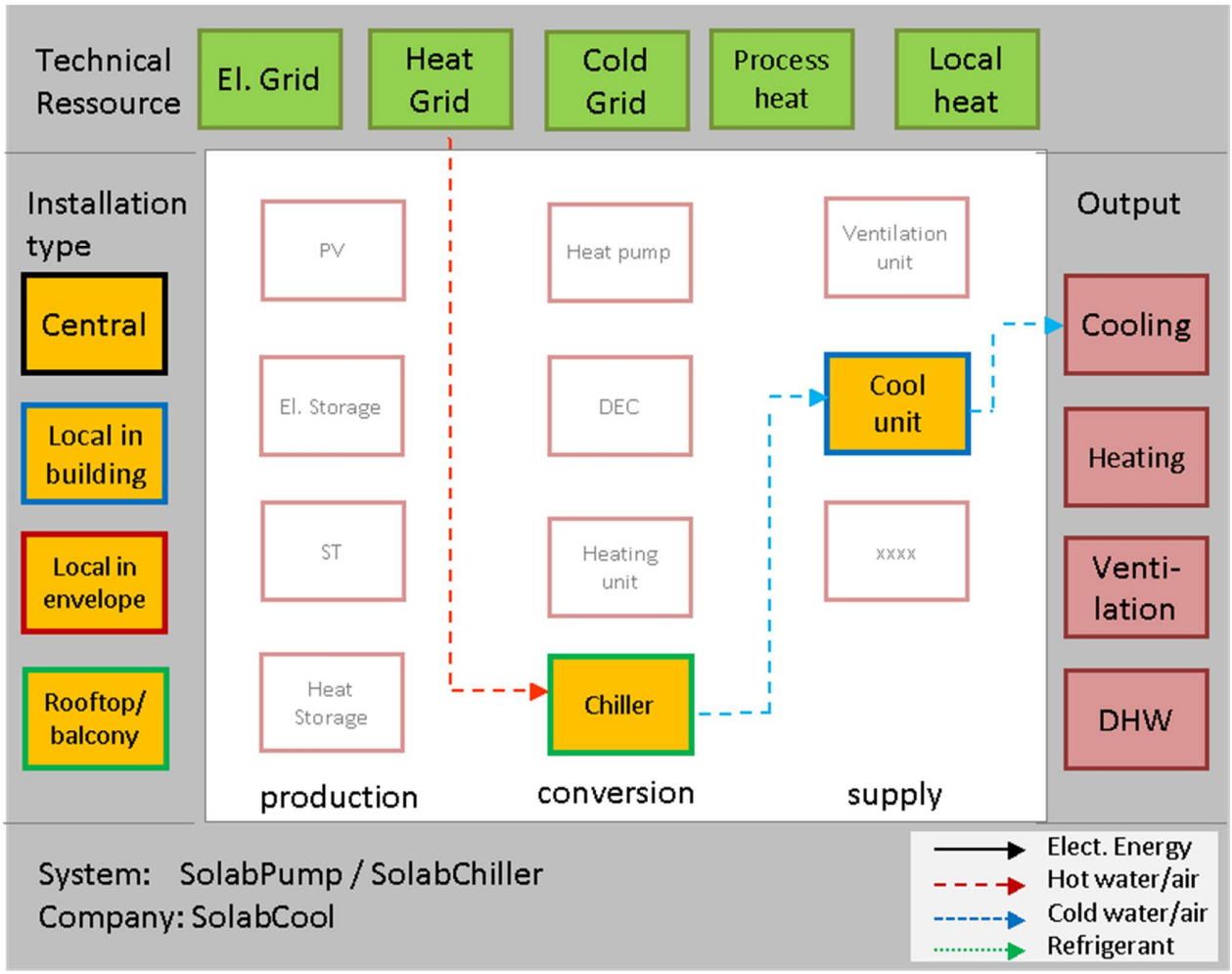
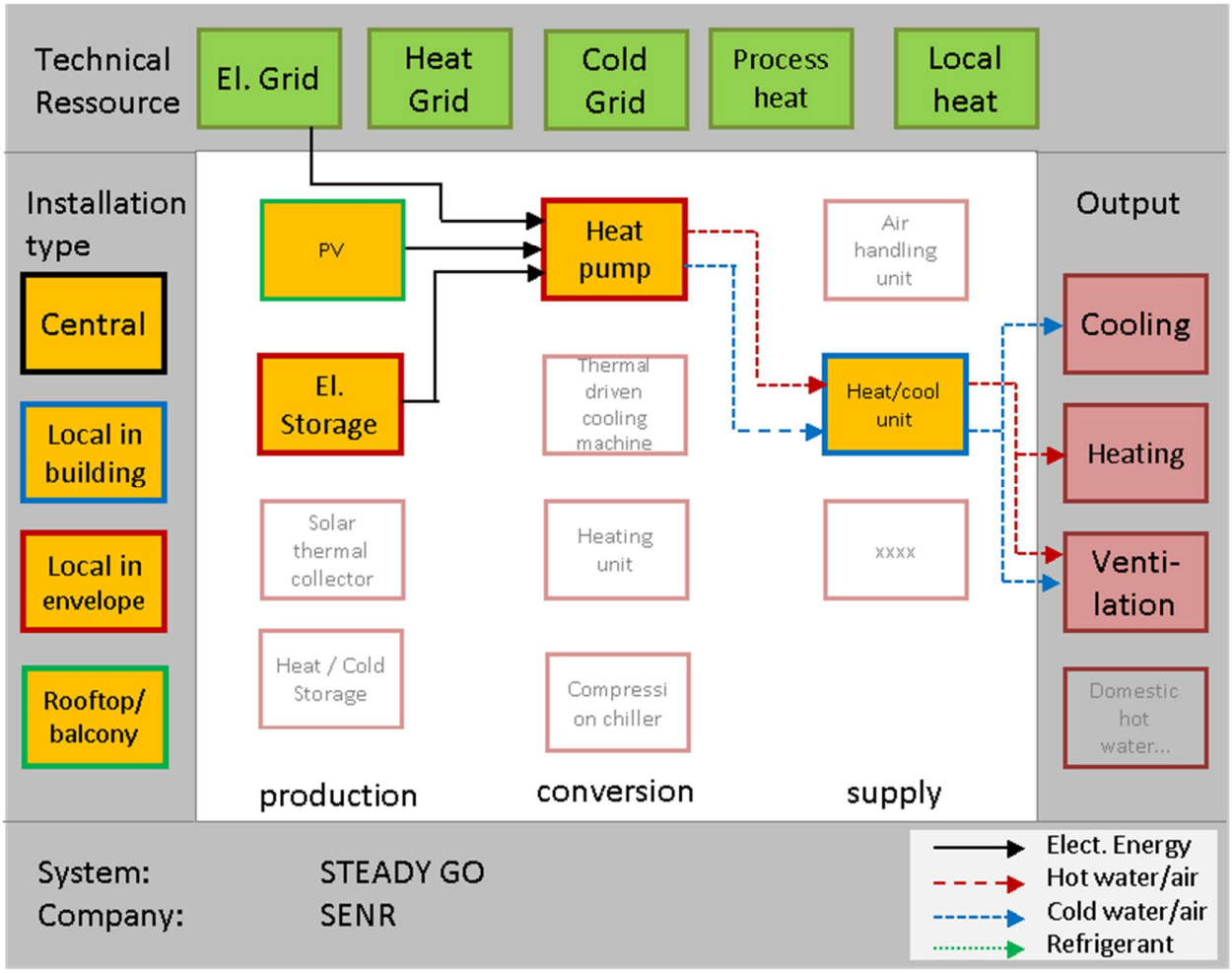


Figure 11: SquareView SolabCool – SolabChiller

SENR (France) :


Technical Ressource
El. Grid
Heat Grid
Cold Grid
Process heat
Local heat
Installation type
Central
Local in building
Local in envelope
Rooftop/ balcony
PV
El. Storage
Solar thermal collector
Heat / Cold Storage
Heat pump
Thermal driven cooling machine
Heating unit
Compressi on chiller
Air handling unit
Heat/cool unit
xxxx
Output
Cooling
Heating
Venti- lation
Domestic hot water...
production
conversion
supply
System:
STEADY GO
Company:
SENR
Elect. Energy
Hot water/air
Cold water/air
Refrigerant

3. Conclusions

The present report is dedicated at presenting the state of the art of the new system configurations for cooling and heating. It is realised according to existing market available and close-to-market solutions (R&D level just before and during demo stage).

This state of the art shows a large diversity in term of configurations and different stage of developments from prototypes to fully commercially available products.

It can be seen as well that the majority of the products are coming from Europe where the major business of solar cooling is not really present due to mild climates. Some systems are offered by Asian companies however.

Other reports from Task 53 will answer further questions raised by this first survey: real systems feedbacks and measurements (Subtask C), comparison with reference systems and intercomparison (Subtask B), life cycle analysis (Subtask A).

ANNEX

ATIsys:

Activity A2

Company	ATISys
Address	ZI de TOULON EST
	901 Avenue Alphonse LAVALLEE
Country	83088 TOULON CEDEX 9, France
Contact	Philippe ESPARCIEUX
	Tel. 04.94.48.25.63
	http://www.atisys-concept.com/
Brand name	PVCOOLING
Cooling power range	2 - 11 kW

System

PV COLLECTORS

Total area :	29,5	m² (aperture area)
Tilt angle :	24	° (0=horiz)
Orientation :	0	° (0=south ; 90 =west ; 270=east)
Typical peak power :	4590	Wc
Type :	Monocristalline	
Model :	BLACK 230/07	
Manufacturer :	SOLON ENERGY	
Country :	Germany	

SOLAR INVERTERS

Brand :	Sunny Boy	
Model :	5000 TL - 21	
Typical nominal DC power :	5,25	kW
Typical nominal AC power :	4,6	kW
Number of phases :	1	
Inverter efficiency :	96,5	%

BATTERIES

Capacity range :	166	Ah (C120)

AUXILIARY POWER SOURCE

Grid 230 V

HEAT PUMP

Type :	Piston Air to water				
Chilled fluid type :	R290				
Distributed chilled medium temperature :	4	°C			
Model :	HG12P/60-4 S HC				
Manufacturer :	GEA				
Country :	Germany				
Cooling capacity :	3,98	kW			
Electrical consumption in cooling mode :	1,11	kW			
EER :	3,56	-	Conditions :	Text = °C	Tint = °C
Heating capacity :	5,1	kW			
Electrical consumption in heating mode :	1,11	kW			
COP :	4,59	-	Conditions :	Text = °C	Tint = °C

COLD STORAGE

Type :	Sensible heat

ClimateWell:

Activity A2

Company	ClimateWell AB
Address	Instrumentvägen 20
Country	Sweden
Contact	Corey Blackman
	corey.blackman@climatewell.com
	46704995355
Brand name	SunCool
Cooling power range	500 W to 150 kW

Heat sources

COLLECTORS

Total area :	180	m² (aperture area)
Tilt angle :	40	° (0=horiz)
Orientation :	15	° (0=south ; 90 =west ; 270=east)
Type :	Flat plate ; 2 glazing	
Model :	SunCool	
Manufacturer :	ClimateWell + Hewalex	
Country :	Sweden + Poland	
Type of installation :	Flat roof	
Heat transfer medium :	Water + glycol	
Flow control :	Variable	

SOLAR HEAT STORAGE

Total volume :	1	m3
Number of storage tanks :	1	-
Storage medium :	Water	

AUXILIARY HEATING SYSTEM

Type :	External direct

COMMENTS

District heating is used for both space heating and domestic hot water (DHW). The SunCool system is only connected to provide a portion of the DHW.

Cooling Equipment

CHILLER		
Type :	ClimateWell proprietary sorption modules	
Model :	SunCool Gen 1	
Manufacturer :	ClimateWell	
Country :	Sweden	
Nominal chilling capacity :	40	kW
COP_thermal :	0,55	-
stributed chilled medium temperature :	10	°C
Nominal driving heat temperature :	NA	°C
Driven by :	solar thermal heat (solar autonomous operation)	

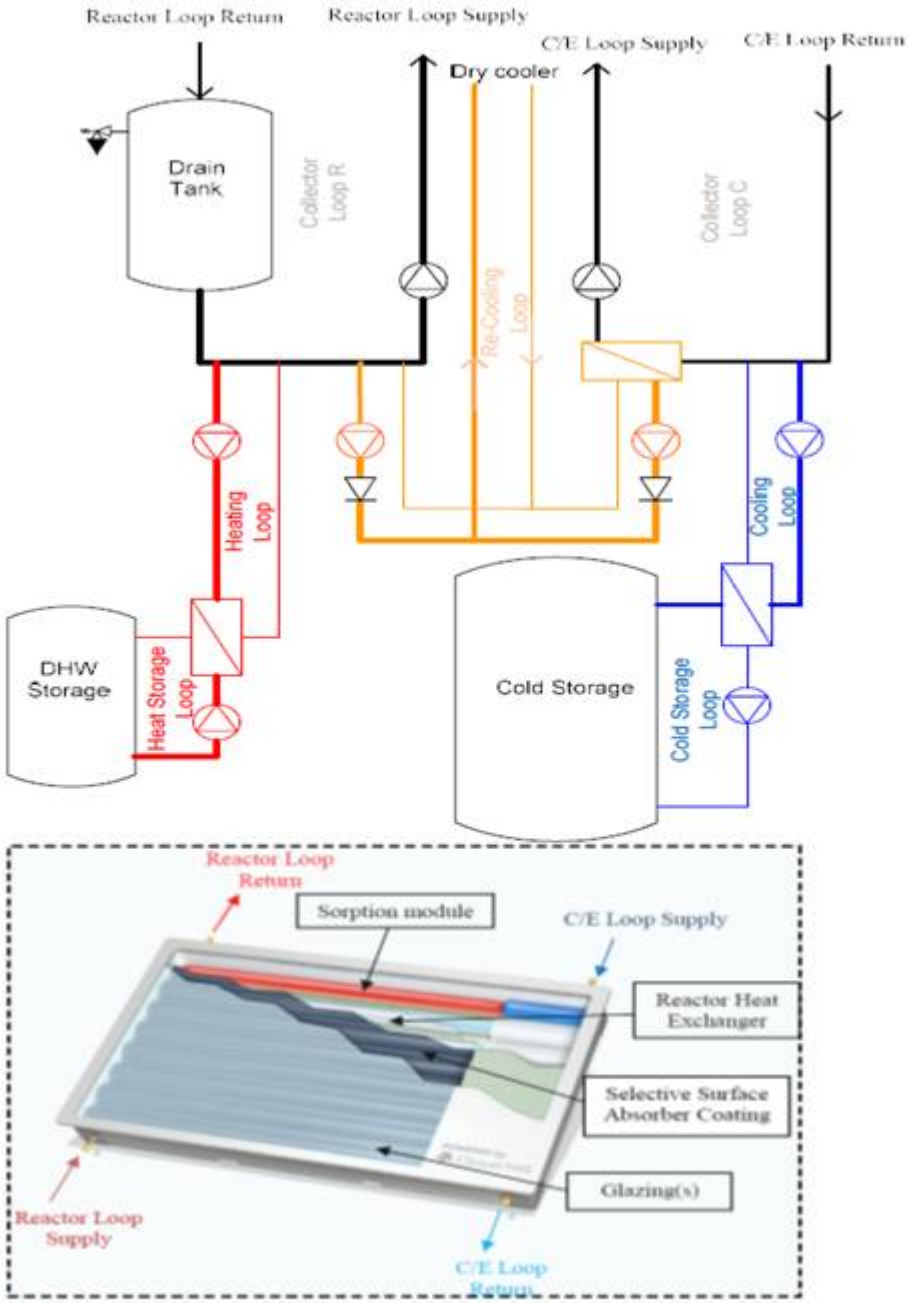
HEAT REJECTION		
Thermal heat rejection capacity :	50	kW
Nominal electricity consumption (fan) :	0,45	kW

BACKUP CHILLER		
Type :	Screw	
Model :	30HXC	
Manufacturer :	Carrier	
Country :	France	
Chilling capacity :	390	kW
COP_el :	3,3	-
Chilled medium temperature :	7	°C
Heat rejection :	Dry cooling	

COLD STORAGE		
Total volume :	12,6	m3
Number of storage tanks :	3	-
Storage medium :	Water	
Nominal exchange temprature :	7	°C

COMMENTS

Thermal coefficient of performance is an estimated value since it is difficult to determine since the cooling equipment is integrated directly into the collector.
Dry cooler was a modified unit (new fans) already installed on site at the start of the project.



COMMENTS

The demonstration plant comprised 130 SunCool collectors with a total aperture area of 180 m2 connected in parallel in banks of 8 to 13 collectors. These 130 collectors were connected to the cold store and hot store as shown above.

Results from system operation

MONITORING PERIOD		
From :	11th July 2014	
Until :	31st August 2015	
Periods of sytem/monitoring interruption :	August 2014	

COLLECTORS		
Radiation gain, collector surface :	454	kWh/m²

AUXILIARY HEATING		
Auxiliary heat for space heating/DHW :	1520	kWh

CHILLER		
Produced cold :	8446	kWh
Rejected heat :	19765	kWh

BACKUP CHILLER (electrically driven compression)		
Produced cold :	214000	kWh

AUXILIARY ELECTRICITY DEMAND		
Other :	1264	kWh

COMMENTS

Electricity includes controls, pumps and fans for the SunCool installation.

Cooling load for backup chiller includes total cooling load of the plant (i.e. industrial and space cooling). The system was dimensioned via simulations to cover about 10% of the cooling demand.

The solar radiation data is given only for sorption cooling delivery period (July 2014 and September 2014; April 2015 and May 2015). August 2014, June 2015, July 2015 and August 2015 were excluded due to operation issues with the collectors. Issues with the collectors also caused relatively low electrical COP during April 2015 and May 2015. Additionally, the system provided free cooling during the winter months which was not included here.

8	Qualitative assessment		SunCool

Task 53

GENERAL USER REACTIONS *(ease of use, controlability, ...)*

The user is an industrial plant (Löfbergs Lila coffee roastery) and well accustomed to special technology projects.
The user has been satisfied with being a part of the development of a new technology.

GENERAL ASSESSMENT

	satisfied or not YES	NO	*comments*
User / owner satisfied ?	☑	☐	Unique demonstration technology. One of a kind in the world. Good free cooling operation
User / Owner involved in the project?	☑	☐	
Qualitiy of comfort aspects	☑	☐	The installation only serves a portion of the cooling demand. Comfort conditions are always met by the existing compression chillers
Image and marketing aspects	☑	☐	Highly unique installation. Great marketing for Löfbergs Lila
Other aspects			

PERFORMANCE ASSESSMENT

	YES	NO	*comments*
Sufficient Energetic performance?	☑	☐	The system was designed to provide about 10% of the cooling load during the summer. During the relatively short evaluation the system performed well
Overall reliable operation?	☐	☑	System was tweaked due to various issues with the loss of pressure in the pressurised loop. Later there were issues with the SunCool collectors which are currently being resolved
Existing nuisance ?	☐	☑	Collector operation issues, leakage.
Potential for optimisation? *(e.g., system control)*	☑	☐	Collector re-design in progress, and being carried out in stages. Control system has been optimised.

ENVIRONMENTAL BENEFITS e.g CO_2 and energy savings?

MAJOR LESSONS LEARNT e.g more efficient design? Material? How to avoid nuisance? Etc...

*System performs with similar efficiency in medium and small applications (when collectors are performing well)
*Low electrical power consumption can be achieved with off-the-shelf system components
*Plastic piping can be used in the condenser/evaporator loop of the system
*Standard control settings can be employed for both medium and small systems

COLDINNOV:

Activity A2

Company	COLDINNOV
Address	HEAD OFFICE
	1 IMPASSE DE LISIEUX
Country	31300 TOULOUSE - France
Contact	LIONEL BATAILLE
	Tel. +33 (0)5 31 54 16 64
Brand name	FREECOLD
Cooling power range	2.6 Kw

System

PV COLLECTORS

Total area :	9,6	m² (aperture area)
Tilt angle :	45	° (0=horiz)
Orientation :	0	° (0=south ; 90 =west ; 270=east)
Typical peak power :	1500	Wc
Type :	Polycristalline	
Model :	A250-P	
Manufacturer :	Atersa	
Country :	Spain	

SOLAR INVERTERS None

BATTERIES None

HEAT PUMP

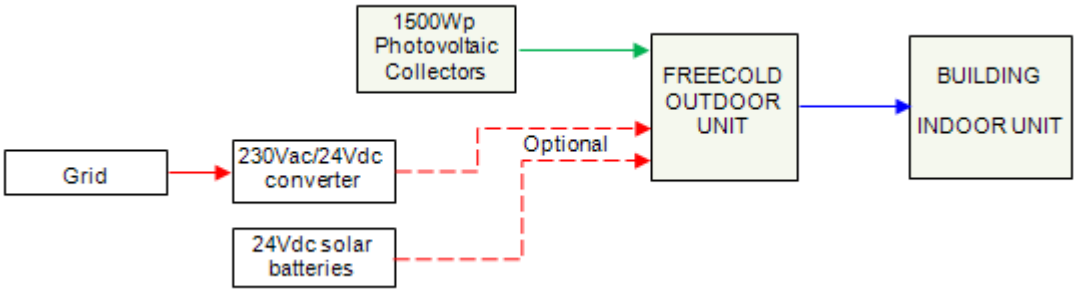
Type :	Piston Air to air	
Model :	S5H09	
Manufacturer :	SANDEN	
Country :	JAPAN	
Cooling capacity :	2,5	kW
Electrical consumption in cooling mode :	0,8	kW
EER :	3,1	-

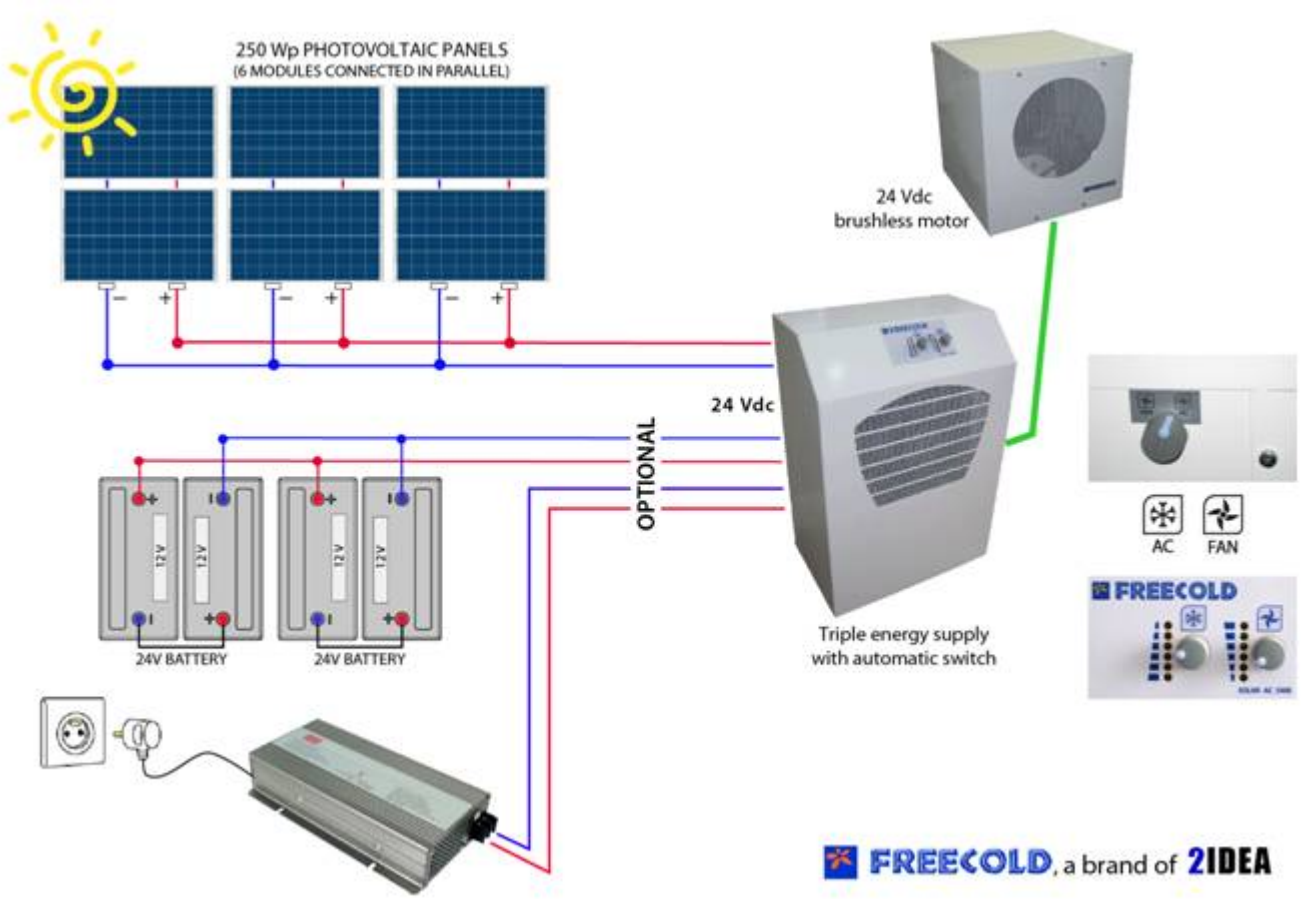
Conditions : Tout = 35 °C Tin = 20 °C

HEAT REJECTION STRATEGY	None
BACKUP CHILLER	None
COLD STORAGE	None
DISTRIBUTION SYSTEM	
Distribution fluid :	air
Nominal supply temp. :	16 °C
COOLING STRATEGY	full air conditionning (strict conditions)

COMMENTS

24V ELECTRICAL CONNECTION with triple energy supply and automatic switch
24 Vdc from PV panels
24Vdc from 230Vac/24Vdc converter
24Vdc from solar batteries





Investment - Material

TOTAL INVESTMENT COST

Total :	2100	€
Lifetime :	20	y
Annual cost :	105	€/y
Specific costs :	1400	€/kWp
	808	€/kWcooling

SOLAR PV COLLECTORS

Total :	1500	€
Lifetime :	25	y
Annual cost :	60	€/y
Specific costs :	1000	€/kWp
Not including :	installation 500 €	
	structure 150 €	
	other (wiring...) 50 €	

Investment - Planning & Design

FEASIBILITY STUDY

Total :	100	€
Specific costs :	67	€/kWp
	0	€/kW

PLANNING

Total :	100	€
Specific costs :	67	€/kWp
	0	€/kW

COMMISSIONING

Total :	100	€
Specific costs :	67	€/kWp
	0	€/kW

COMMENTS ON FEASIBILITY STUDY, PLANNING AND COMMISSIONING

VERY EASY TO INSTALL. IT CAN BE DONE BY AN USUAL AIRCONDITIONING INSTALLER: units are delivered ready to connect

ANNUAL MAINTENANCE

Total :	100	€
Specific costs :	67	€/y.kWp
	0	€/y.kW

Results from system operation

MONITORING PERIOD		
From :	1st March 2012	
Until :	28th February 2013	
Periods of sytem/monitoring interruption :	None	

PV PANELS		
Useful energy from collector :	5632	kWh
Specific PV yield :	1173,3	kWh/kWp

HEAT PUMP		
Drinving electric input :	19430	kWh
Produced cold :	2297	kWh
COP_elec :	0,12	-

CHILLER		
Produced cold :	8446	kWh
Rejected heat :	19765	kWh

AUXILIARY ELECTRICITY DEMAND		
Pumps, collector circuits :	5185	kWh

COMMENTS

OUR SOLUTIONS ARE MAINLY INSTALLED IN WESTERN AFRICA. WE HAVE NOT ANY OPERATING RESULTS FROM USERS

8	Qualitative assessment		COLDINNOV

Task 53

FREECOLD

GENERAL USER REACTIONS *(ease of use, controlability, ...)*

IT WORKS LIKE A USUAL SPLIT AIRCONDITIONING UNIT

GENERAL ASSESSMENT

	satisfied or not YES	NO	*comments*
User / owner satisfied ?	☑	☐	
User / Owner involved in the project?	☑	☐	
Qualitiy of comfort aspects	☑	☐	
Image and marketing aspects	☑	☐	
Other aspects			

PERFORMANCE ASSESSMENT

	YES	NO	*comments*
Sufficient Energetic performance?	☑	☐	
Overall reliable operation?	☑	☐	
Existing nuisance ?	☐	☑	
Potential for optimisation? *(e.g., system control)*	☑	☐	

ENVIRONMENTAL BENEFITS e.g CO_2 and energy savings?

YES

MAJOR LESSONS LEARNT e.g more efficient design? Material? How to avoid nuisance? Etc...

SOLARINVENT:

Activity A2

Company	Solarinvent srl
Address	Via dell'Autonomia 88 Sant'Agata Li Battiati (CT) 95030
Country	Italy
Contact	Pietro Finocchiaro
	info@solarinvent.com
Brand name	Freescoo
Cooling power range	2 - 10 kW

Heat sources

COLLECTORS

Total area :	2,4	m² (aperture area)
Tilt angle :	25	° (0=horiz)
Orientation :	0	° (0=south ; 90 =west ; 270=east)
Type :	Flat plate	
Model :	SunCool	
Manufacturer :	ClimateWell + Hewalex	
Country :	Sweden + Poland	
Type of installation :	Fully integrated	
Heat transfer medium :	Air	
Flow control :	Variable	

SOLAR HEAT STORAGE	None
AUXILIARY HEATING SYSTEM	None

COMMENTS

Water based solar collector can also be used with small changes in the configuration of the machine

Cooling Equipment

CHILLER	None

HEAT REJECTION	None

DESSICANT EVAPORATIVE COOLING SYSTEM (DEC)

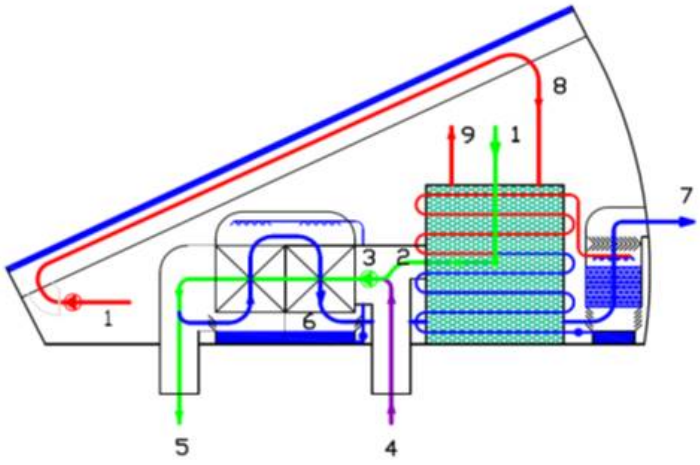
Sorption process :	Solid	
Sorption material :	Silicagel	
Manufacturer :	Solarinvent	
Country :	Italy	
Nominal air volume flow rate :	500	m3/h
Minimal air volume flow rate :	50	m3/h

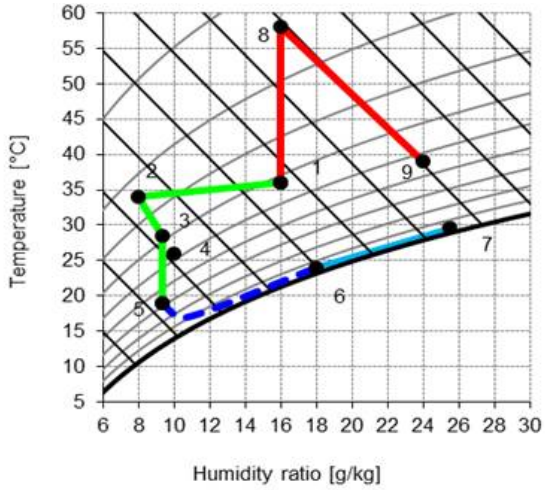
BACKUP CHILLER	None

COLD STORAGE	None

COMMENTS

The data refer to the stand alone solar autonomus Solar DEC machine





COMMENTS

The control strategy of the system is the following. If there is no need for cooling in the building, solar energy is used to regenerate the adsorption material of the desiccant beds. In particular, one bed is regenerated until the temperature difference between the air at the outlet of the solar collector and the air coming out from the bed is higher than a fixed threshold. If the difference is lower and the solar fan is at the minimum speed, the control system commutes to the other bed for its regeneration. If the system has to provide cooling, the main fan is used to provide fresh and dehumidified air to the building. Building temperature and humidity can be controlled independently. Temperature can be adjusted controlling the speed of the main fan and by the status of the recirculation pump of the wet heat exchangers. Humidity can be adjusted by controlling the status of the cooling tower pump and partially controlling the speed of the main fan. A variation in the temperature of adsorption material will result in a different dehumidification capacity and consequently, this property can be used to adjust the humidity in the conditioned space. When cooling is required, the operation of the two adsorption beds is based on the humidity of the return air. If the humidity set-point is exceeded, then the control system activates the commutation procedure from one bed to the other. Before the end of this phase a pre-cooling of the bed which was operated in regeneration mode is carried out, preparing it for the next operation in adsorption mode.

Results from system operation

MONITORING PERIOD		
From :	1st July 2015	
Until :	18th August 2015	
Periods of sytem/monitoring interruption :	from 17.07 to 23.07, 31.07, 13.08	

COLLECTORS		
Radiation gain, collector surface :	319	kWh/m²
Useful energy from collector for cooling operation (driving heat):	483	kWh

DESSICANT EVAPORATIVE COOLING SYSTEM (DEC)		
Regeneration heat input :	483	kWh
Produced cold :	533	kWh
Produced cold during desiccant wheel operation only :	533	kWh
COP_dessicant :	1,1	-
Solar coverage of regeneration heat :	1	-

AUXILIARY ELECTRICITY DEMAND		
Fans air handling unit :	29,1	kWh
Fans heat rejection, heat driven chiller :	10,4	kWh
Other :	2,1	kWh

COMMENTS

Data refer only to the cooling operation during the monitored summer period. The electricity consumption doesn't take into account the PV production of the PVT collector. The real electricity taken from the grid is 10,5 kWh for the considered time period.

Investment - Material

TOTAL INVESTMENT COST

Total :	7500	€
Lifetime :	15	y
Annual cost :	500	€/y
Specific costs :	3125	€/m²
	15	€/(m3/h)

SOLAR COLLECTORS

Total :	1500	€
Lifetime :	15	y
Annual cost :	100	€/y
	625	€/m²
Including :	installation, structure, PV panels, solar batteries, solar controller, piping, pumps, ...	

COLD PRODUCTION

Total cost :	3500	€
Lifetime :	15	y
Annual cost :	233	€/y
Specific costs :	1458	€/m²
	7	€/(m3/h)
Including :	installation, heat rejection, DEC, other	

ELECTRIC, CONTROL AND MONITORING

Total :	2500	€
Lifetime :	15	y
Annual cost :	167	€/y
Specific costs :	1042	€/m²
	5	€/(m3/h)
Including :	installation, monitoring, control, electric panels	

Investment - Planning & Design

COMMISSIONING

Total :	800	€
Specific costs :	333	€/m²
	1,6	€/(m3/h)

ANNUAL MAINTENANCE

Total :	50	€
Specific costs :	21	€/y.m²
	0,1	€/y.(m3/h)

8	Qualitative assessment		freescoo

Task 53

GENERAL USER REACTIONS *(ease of use, controlability, ...)*

GENERAL ASSESSMENT

	satisfied or not YES	NO	*comments*
User / owner satisfied ?	☑	☐	The unit whose data are presented was tested at research insitutions
User / Owner involved in the project?	☑	☐	
Qualitiy of comfort aspects	☐	☑	The unit was too small for the specific room to ensure an adeguate comfort in terms of temperature control. An additional conventional split unit has to be operated. In general ventilation rate and humidity control was ok.
Image and marketing aspects	☑	☐	In general, feedbacks and comments received are very positive, especially because of the compactness of the solution proposed. The interest from industry stakeholders is relevant.
Other aspects			

PERFORMANCE ASSESSMENT

	YES	NO	*comments*
Sufficient Energetic performance?	☑	☑	The global EER for the whole summer monitoring period was 12,8
Overall reliable operation?	☑	☐	
Existing nuisance ?	☐	☑	
Potential for optimisation? *(e.g., system control)*	☑	☐	There is space for optimizing the energy performances in terms of max cooling capacity and control of the desorption process

ENVIRONMENTAL BENEFITS e.g CO_2 and energy savings?

Energy savings are 77% in comparison to a conventional cooling system having EER=3. If the PV production of the PVT collector is considered in the calculation the energy savings rise up to 94%.

MAJOR LESSONS LEARNT e.g more efficient design? Material? How to avoid nuisance? Etc...

SJTU:

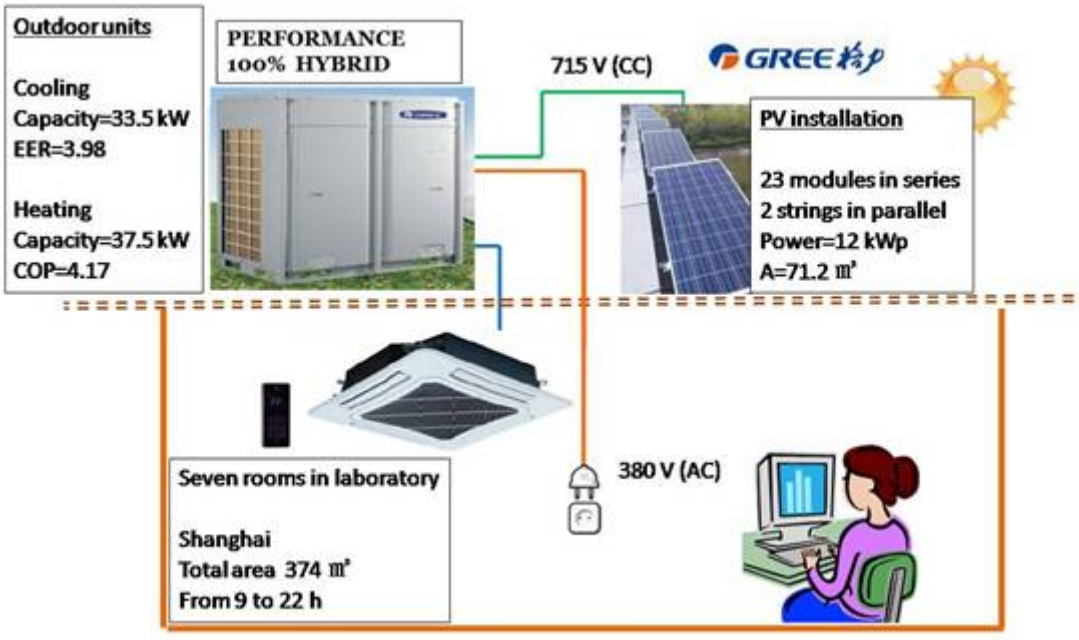
Activity A2

Company	SJTU
Address	Sino-Italian Green Energy Laboratory Shanghai Jiao Tong University 800 Dongchuan Road
Country	Shanghai 200240, China
Contact	Yanjun Dai
	E-mail: yjdai@sjtu.edu.cn
Brand name	Gree
Cooling power range	33.5 kW

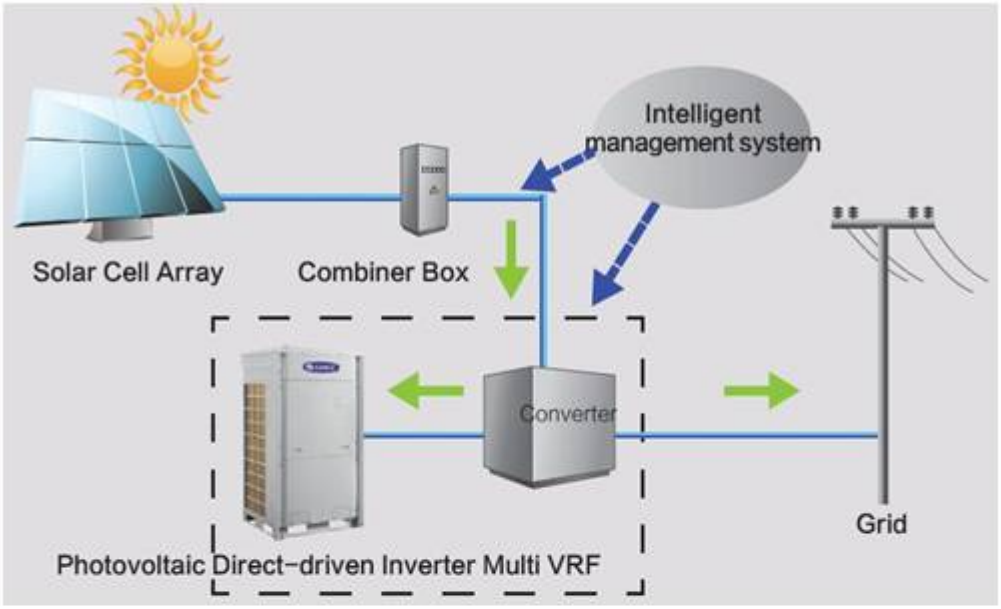
System

PV COLLECTORS			
Total area :	71,2	m² (aperture area)	
Tilt angle :	20	° (0=horiz)	
Orientation :	0	° (0=south ; 90 =west ; 270=east)	
Typical peak power :	12190	Wc	
Type :	Polycristalline		
Model :	JKM265P-60 & JKM260PP-60		
Manufacturer :	Jinko Solar		
Country :	China		
SOLAR INVERTERS			
Location :	Outdoor		
Brand :	Gree		
Typical nominal DC power :	12,5	kW	
Number of phases :	3	-	
Inverter efficiency :	97,6	%	
BATTERIES	None		
AUXILIARY POWER SOURCE	Grid (380 V)		
HEAT PUMP			
Type :	Scroll Brine to water		
Model :	GMV-Y335WM/A		
Manufacturer :	GREE		
Country :	China		
Chilled fluid type :	R410a		
Cooling capacity :	33,5	kW	
ectrical consumption in cooling mode :	8,41	kW	
EER :	3,98	-	Conditions Text = 35 °C Tint = 27 °C
Heating capacity :	37,5	kW	
ctrical consumption in heating mode :	9	kW	
COP :	4,17	-	Conditions Text = 7 °C Tint = 20 °C

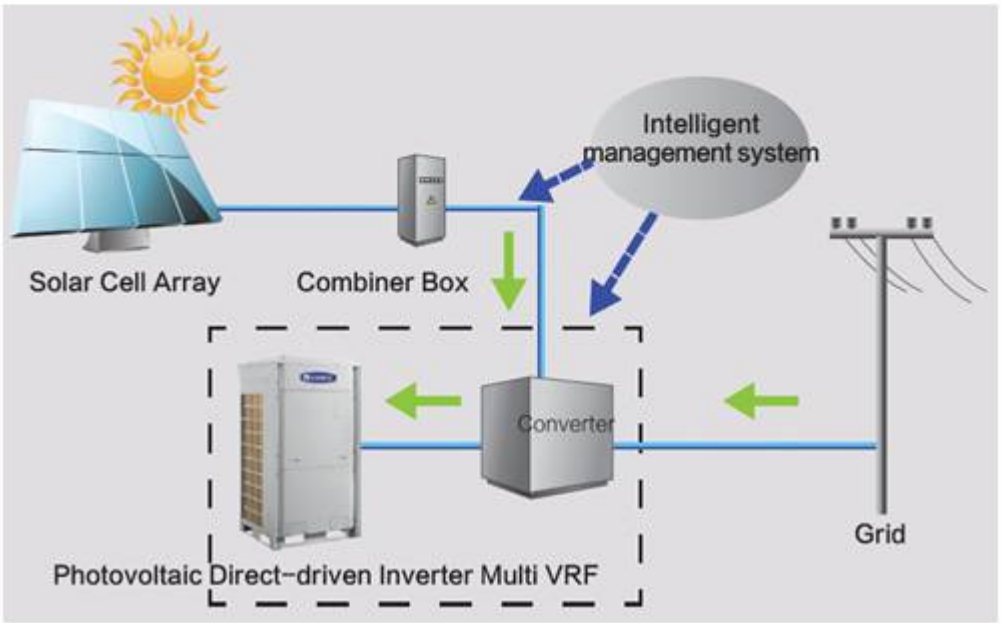
HEAT REJECTION STRATEGY	Air (open)	
BACKUP CHILLER	None	
COLD STORAGE	None	
BUILDING VENTILATION	Natural	
DISTRIBUTION SYSTEM		
Type :	VRF system	
Distribution fluid :	R410a	
COOLING STRATEGY		
Type :	top cooling	(no strict conditions with backup)
Design outdoor temp. :	31,3	°C
Design outdoor humid. :	60	%
HEATING STRATEGY		
Type :	top cooling	(no strict conditions with backup)
Design outdoor temp. :	-1,2	°C
Design outdoor humid. :	74	%



Working mode 1: photovoltaic air conditioning system & power generation mode



Working mode 2: photovoltaic air conditioning system and power comsuption mode



Investment - Material

TOTAL INVESTMENT COST

Total :	24600	€
Lifetime :	20	y
Annual cost :	1230	€/y
Specific costs :	2050	€/kWp
	734	€/kWcooling

SOLAR PV COLLECTORS

Total :	12400	€
Lifetime :	25	y
Annual cost :	496	€/y
Specific costs :	1033	€/kWp
Including :	installation (2000)	
	structure (2000)	
	other (wiring) (1400)	

COLD PRODUCTION

Total :	11800	€
Lifetime :	20	y
Annual cost :	590	€/y
Specific costs :	983	€/kWp
	352	€/kWcooling

ELECTRIC, CONTROL AND MONITORING

Total :	400	€
Lifetime :	15	y
Annual cost :	27	€/y
Specific costs :	33	€/kWp
	12	€/kWcooling
Including :	electric panels (400)	

COMMENTS

The PVAC system uses the "e controller" to demonstrate the power generation and comsuption, to controll all the indoor units, as well as to do some data processing.

Investment - Planning & Design

COMMISSIONING

Total :	200	€
Specific costs :	17	€/kWp

ANNUAL MAINTENANCE

Total :	300	€
Specific costs :	25	€/y.kWp

COMMENTS

When PV generated power is more than AC system consumption demand, PV power will give priority to the AC system, and then the residual power will be sent to the grid. When PV generated power is less than the AC system consumption demand, AC system will draw power from the grid in addition to the PV power generation system. The annual PV generated power almost cover the annual AC system consumption demand.

Results from system operation

MONITORING PERIOD		
From :	23rd April 2015	
Until :	31st December 2015	
Periods of sytem/monitoring interruption :	5	

PV PANELS		
Radiation gain, global horizontal :	720	kWh/m²
Radiation gain, collector surface :	874	kWh/m²
Gross energy production of collector :	9213	kWh
Useful energy from collector :	8752	kWh
Specific PV yield :	718	kWh/kWp

COMMENTS

1. During the monitoring period, the PVAC system has 5 periods of interruption manily because of the system upgrading or modifying. 2.When the PV generated DC power is no more than the AC system consumption demand, the AC system consumes the DC power directly instead of converting the DC power into AC power, resulting in almost no loss during the direct consumption. When the PV generated DC power is more than the AC system consumption demand, the residual PV generated power is sent to the grid and there is some loss from converting the DC power into the AC power.

8	Qualitative assessment		SJTU

Task 53

GREE

GENERAL USER REACTIONS *(ease of use, controlability, ...)*

IT WORKS LIKE A USUAL SPLIT AIRCONDITIONING UNIT

GENERAL ASSESSMENT

	satisfied or not YES	NO	*comments*
User / owner satisfied ?	☑	☐	VERY SATISFIED
User / Owner involved in the project?	☑	☐	CONSTANT CONTROL
Qualitiy of comfort aspects	☑	☐	very comfortable
Image and marketing aspects	☑	☐	
Other aspects			

PERFORMANCE ASSESSMENT

	YES	NO	*comments*
Sufficient Energetic performance?	☑	☐	GOOD PERFORMANCE
Overall reliable operation?	☑	☐	100% RELIABLE
Existing nuisance ?	☐	☑	
Potential for optimisation? *(e.g., system control)*	☑	☐	YES, THE CONTROL CAN BE OPTIMIZEED WITH THE AVAILABLE SOLAR RADIATION

ENVIRONMENTAL BENEFITS e.g CO_2 and energy savings?

YES

MAJOR LESSONS LEARNT e.g more efficient design? Material? How to avoid nuisance? Etc...

KAYSUN:

Activity A2

Company	FRIGICOLL
Address	OFICINA CENTRAL
	Blasco de Garay, 4-6
Country	08960 Sant Just Desvern (Barcelona), España
Contact	Eduardo Romano
	Tel. 93 480 33 22
Brand name	KAYSUN
Cooling power range	3.5 kW

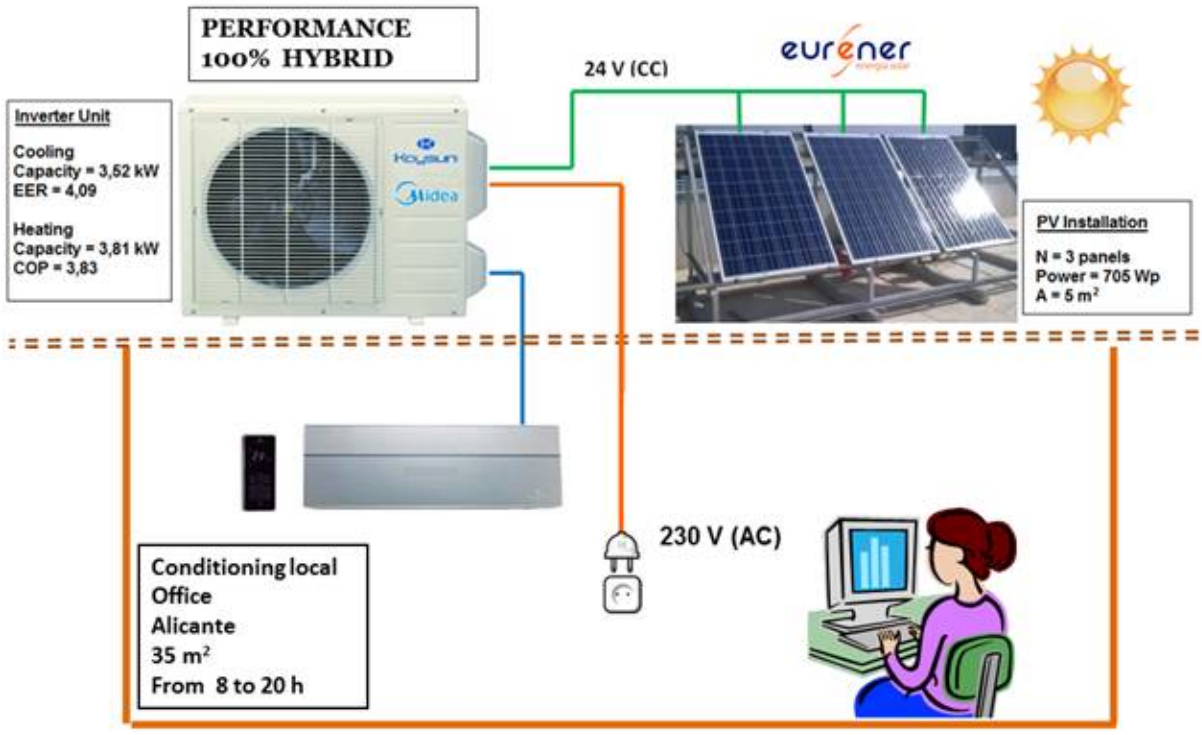
System

PV COLLECTORS				
Total area :	5	m² (aperture area)		
Tilt angle :	45	° (0=horiz)		
Orientation :	0	° (0=south ; 90 =west ; 270=east)		
Typical peak power :	705	Wc		
Type :	Monocristalline			
Model :	EUP-235W			
Manufacturer :	Eurener			
Country :	Spain			
SOLAR INVERTERS	None			
BATTERIES	None			
AUXILIARY POWER SOURCE	Grid (230 V)			
HEAT PUMP				
Type :	Scroll Air to air			
Model :	SUITE SOLAR			
Manufacturer :	KAYSUN			
Country :	SPAIN			
Cooling capacity :	3,5	kW		
Electrical consumption in cooling mode :	1	kW		
EER :	3,5	-	Conditions :	Text = 7 °C Tint = 20 °C
Heating capacity :	3,5			
Electrical consumption in heating mode :	1			
COP :	3,5		Conditions :	Text = 35 °C Tint = 27 °C

HEAT REJECTION STRATEGY	None
BACKUP CHILLER	None
COLD STORAGE	None
BUILDING VENTILATION	Natural
DISTRIBUTION SYSTEM	
Type :	split
Distribution fluid :	air
Nominal supply temp. :	16 °C
COOLING STRATEGY	full air conditionning (strict conditions)
HEATING STRATEGY	full air conditionning (strict conditions)

COMMENTS

DOUBLE ELECTRICAL CONECTION
24 V dc from PV panles
230 V ac from the grid



Investment - Material

TOTAL INVESTMENT COST

Total :	2500	€
Lifetime :	20	y
Annual cost :	125	€/y
Specific costs :	3546	€/kWp
	714	€/kWcooling

SOLAR PV COLLECTORS

Total :	700	
Lifetime :	25	y
Annual cost :	28	€/y
Specific costs :	993	€/kWp
Not including :	installation 500 €	
	structure 150 €	
	other (wiring...) 50 €	

COLD PRODUCTION

Total :	1800	€
Lifetime :	20	y
Annual cost :	90	€/y
Specific costs :	2553	€/kWp
	514	€/kWcooling
Including :	installation work, compression heat pump, heat rejection	

Investment - Planning & Design

FEASIBILITY STUDY		
Total :	100	€
Specific costs :	142	€/kWp
PLANNING		
Total :	100	€
Specific costs :	142	€/kWp
COMMISSIONING		
Total :	100	€
Specific costs :	142	€/kWp
	0	€/kW
COMMENTS ON FEASIBILITY STUDY, PLANNING AND COMMISSIONING		
VERY EASY TO INSTALL. IT CAN BE DONE BY AN USUAL AIRCONDITIONING INSTALLER		
ANNUAL MAINTENANCE		
Total :	30	€
Specific costs :	43	€/y.kWp
ANNUAL OPERARTIONS		
Total :	200	€
Specific costs :	284	€/kWp
	57	€/kW

Results from system operation

MONITORING PERIOD		
From :	31st September 2012	
Until :	1st October 2013	
Periods of sytem/monitoring interruption :	None	

PV PANELS		
Radiation gain, global horizontal :	1722	kWh/m²
Radiation gain, collector surface :	1877	kWh/m²
Gross energy production of collector :	1125	kWh
Useful energy from collector :	791	kWh
Useful energy electricity from panels for cooling operation :	436,5	kWh
Useful energy from panels for space heating / DHW :	354,4	kWh
Specific PV yield :	1122	kWh/kWp

AUXILIARY ELECTRICITY		
Electricity from grid :	678,9	kWh
Auxiliary electricity for cooling operation :	239,3	kWh
Auxiliary electricity for space heating / DHW :	439,6	kWh

HEAT PUMP		
Drinving electric input :	1470	kWh
Produced cold and heat :	6523	kWh
COP_elec :	4,44	-
Solar coverage of driving electricity :	0,54	-

AUXILIARY ELECTRICITY DEMAND		
Heat pump :	678,9	kWh

COMMENTS

The unit can work on heating and cooling mode. It takes the availabla electricity from PV panels and the needed electricity from the grid

Horario de 8 a 20 h	E_PV (kWh)	E_RED (kWh)	E_TOT (kWh)	E_PV,RED (kWh)	E_U (kWh)	EER_Maq (-)	EER_Inst (-)	Cont. Sol CS (%)	F. Prod F (%)	T_ext (ºC)	T_int (ºC)
MAYO	66,0	25,8	91,8	116,8	519,5	6,50	23,12	82,5%	64,9%	24,0	23,3
JUNIO	67,1	18,7	85,7	125,1	514,1	6,00	27,54	78,2%	53,6%	26,8	23,1
JULIO	95,1	75,6	170,7	129,5	720,0	4,22	9,52	55,7%	73,4%	31,1	25,0
AGOSTO	84,8	57,0	141,8	114,7	655,2	4,62	11,49	59,8%	73,9%	30,6	25,0
SEPTIEMBRE	68,2	29,9	98,2	101,0	545,1	5,55	18,21	69,5%	67,5%	27,8	24,3
OCTUBRE	55,4	32,2	87,7	83,6	524,4	5,98	16,26	63,2%	66,3%	26,1	24,1
MODO FRÍO	436,5	239,3	675,8	670,7	3478,4	5,15	14,54	64,6%	65,1%	27,7	24,2

Horario de 8 a 20 h	E_PV (kWh)	E_RED (kWh)	E_TOT (kWh)	E_PV,RED (kWh)	E_U (kWh)	COP_Maq (-)	COP_Inst (-)	Cont. Sol CS (%)	F. Prod F (%)	T_ext (ºC)	T_int (ºC)
NOVIEMBRE	49,36	65,31	114,64	56,49	465,24	4,06	7,12	43,1%	87,4%	14,9	25,9
DICIEMBRE	51,73	89,47	141,18	56,44	551,67	3,91	6,17	36,6%	91,7%	15,2	24,1
ENERO	61,88	84,97	146,84	70,36	575,30	3,92	6,77	42,1%	87,9%	15,1	25,4
FEBRERO	63,98	83,02	147,00	75,74	532,98	3,63	6,42	43,5%	84,5%	13,6	25,2
MARZO	68,87	72,00	140,87	93,02	531,46	3,77	7,38	48,9%	74,0%	16,8	25,7
ABRIL	58,53	44,79	103,32	101,76	387,67	3,75	8,65	56,6%	57,5%	19,1	24,0
MODO CALOR	354,4	439,6	793,8	453,8	3044,3	3,83	6,93	44,6%	78,1%	15,8	25,0

TOTAL	790,9	678,9	1469,7	1124,5	6522,7	4,44	9,61	53,8%	70,3%	21,7	24,6

8	Qualitative assessment		FRIGICOLL

Task 53

Kaysun by frigicoll

GENERAL USER REACTIONS *(ease of use, controlability, ...)*

IT WORKS LIKE A USUAL SPLIT AIRCONDITIONING UNIT

GENERAL ASSESSMENT

	satisfied or not YES	NO	*comments*
User / owner satisfied ?	☑	☐	VERY SATISFIED
User / Owner involved in the project?	☑	☐	CONSTANT CONTROL
Qualitiy of comfort aspects	☑	☐	OK
Image and marketing aspects	☑	☐	IT S A SPLIT ...
Other aspects			BETTER A DUCTS UNIT

PERFORMANCE ASSESSMENT

	YES	NO	*comments*
Sufficient Energetic performance?	☑	☐	GOOD PERFORMANCE
Overall reliable operation?	☑	☐	100% RELIABLE
Existing nuisance ?	☐	☑	NO
Potential for optimisation? *(e.g., system control)*	☑	☐	YES, THE CONTROL CAN BE OPTIMIZEED WITH THE AVAILABLE SOLAR RADIATION

ENVIRONMENTAL BENEFITS e.g CO_2 and energy savings?

YES

MAJOR LESSONS LEARNT e.g more efficient design? Material? How to avoid nuisance? Etc...

PURIX:

Activity A2

Company	PURIX
Address	Langogade 17
	2100 Copenhagen
Country	DK
Contact	Lars Munkoe
	lars.munkoe@purixcom
	+45 22353151
Brand name	PURIX
Cooling power range	2,5kW split system. Modular configurations available for 2,5kW – 25kW cooling capacity.

Heat sources

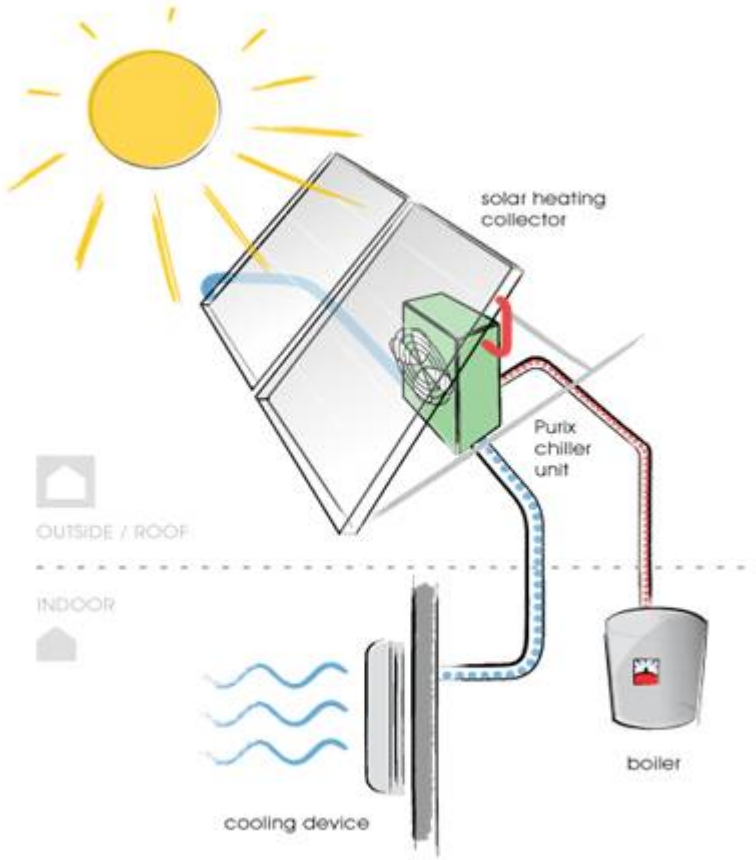
COLLECTORS		
Total area :	4,8	m² (aperture area)

AUXILIARY HEATING SYSTEM		
District heating :	3,1	kW
Central heating :	3,1	kW

Cooling Equipment

CHILLER		
Model :	PURIX A25S	
Manufacturer :	PURIX	
Country :	DK	
Nominal chilling capacity :	2,5	kW
COP_thermal :	0,8	-
Distributed chilled medium temperature :	13	°C
Nominal driving heat temperature :	80	°C

HEAT REJECTION	integrated in A25S chiller



Investment - Material

TOTAL INVESTMENT COST		
Total :	4425	€
Lifetime :	20	y
Annual cost :	221	€/y
Specific costs :	922	€/m²
	1770	€/kW

SOLABCOOL:

Activity A2

Company	solabCool BV
Address	Stenograaf 1 6921EX Duiven
Country	The Netherlands
Contact	h.debeijer@ares-rtb.nl
Brand name	SolabPump / SolabChiller
Cooling power range	3 - 5kW

Heat sources

AUXILIARY HEATING SYSTEM

District heating : 8 kW

COMMENTS

Several heat sources can be used. For this particular system district heating is used. Tests with Solar systems indicate similar performance.
District heating power is at nominal conditions

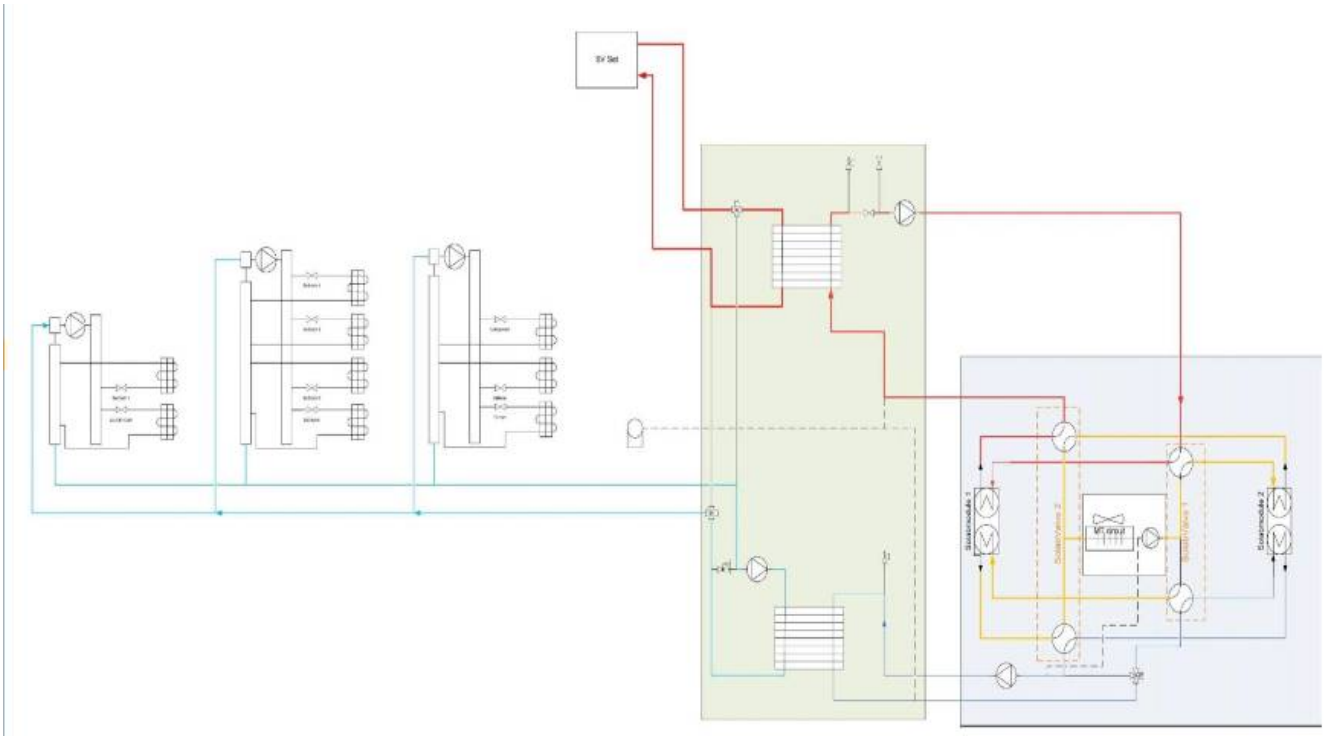
Cooling Equipment

CHILLER

Model :	SolabChiller	
Manufacturer :	SolabCool	
Country :	Netherlands	
Nominal chilling capacity :	4,5	kW
COP_thermal :	0,6	-
Distributed chilled medium temperature :	17	°C
Nominal driving heat temperature :	70	°C
Chiller is driven by :	solar thermal heat + auxiliary heat source	

COMMENTS

Silicagel-water adsorption cooling machine



COMMENTS

Situation before intallation: A domestic building which is connected to a district heating network (CHP). The 3 storey building has a 165m2 floor area. The building is completely heated by floor heating which is separated into respectively 3zones at ground floor, 4 at 1st floor &2 at 2nd floor.

A SolabChiller and freezing protection unit are installed to distribute cooling using the Floor heating system. The cooling system is protected against freezing by using a water-glycol mixture in the secondary circuit.

The Cooling demand is determined by a thermostat which is placed in the living room, a active dewpoint protection to prevent condensation risks which are caused by low water temperatures in specific conditions.

Results from system operation

MONITORING PERIOD	
From :	23rd July 2014
Until :	1st October 2015
Periods of sytem/monitoring interruption :	

CHILLER		
Driving heat input :	929	kWh/m²
Produced cold :	542	kWh
COP_thermal :	0,58	-

AUXILIARY ELECTRICITY DEMAND		
Other :	64	kWh

COMMENTS

The electric energy is considering all electric energy used. This is including drycooler and all pumps. No separate monitoring of individual components. Additional electric consumption which is used for monitoring equipment is not measured since it is not relevant to commercial machine.

Machine has cooled for 194hours

8	Qualitative assessment		SolabPump / SolabChille

Task 53

GENERAL USER REACTIONS *(ease of use, controlability, ...)*

GENERAL ASSESSMENT

	satisfied or not YES	NO	*comments*
User / owner satisfied ?	☑	☐	
User / Owner involved in the project?	☐	☑	
Qualitiy of comfort aspects	☑	☐	The unit was too smallfor the building to cover peak cooling loads in high ambient temperature. User did turn off machine during night which did not allow the machine to cool the buidlign during night.
Image and marketing aspects	☑	☐	
Other aspects			

PERFORMANCE ASSESSMENT

	YES	NO	*comments*
Sufficient Energetic performance?	☐	☐	
Overall reliable operation?	☑	☐	Machine had no problem during evaluated period.
Existing nuisance ?	☐	☐	
Potential for optimisation? *(e.g., system control)*	☑	☐	There is space for optimizing the energy performances in terms of max cooling capacity and control of the desorption process

ENVIRONMENTAL BENEFITS e.g CO_2 and energy savings?

MAJOR LESSONS LEARNT e.g more efficient design? Material? How to avoid nuisance? Etc...

YAZAKI:

Activity A2

Company	YAZAKI ENERGY SYSTEM CORPORATION
Address	2012, 2F Changfugong Office Building
	26 Jianguomen Wai Avenue, Beijing
Country	CHINA
Contact	PHONE: 0086-10-6513-4747（Ext：606）
	FAX: 0086-10-6513-4746
Brand name	WFC-SC10
Cooling power range	35.2kW

Heat sources

COLLECTORS

Total area :	100	m² (aperture area)	Total area 2 :	11	m² (aperture area)
Tilt angle :	19	° (0=horiz)	Tilt angle :	70	° (0=horiz)
Orientation :	0	° (0=south ; 90 =west ; 270=east)	Orientation :	90	° (0=south ; 90 =west ; 270=east)
Type :	Vaccum tube ; heat pipe		Type :	Vaccum tube ; heat pipe	
Model :	160-58-50Horizontal Type		Model :	160-58-25Gravity Type	
Manufacturer :	SANGLE		Manufacturer :	SANGLE	
Country :	China		Country :	China	
Type of installation :	Flat roof				
Heat transfer medium :	Water				
Flow control :	Low flow				

SOLAR HEAT STORAGE

Total volume :	5	m3
Number of storage tanks :	1	-
Storage medium :	Water	

AUXILIARY HEATING SYSTEM None

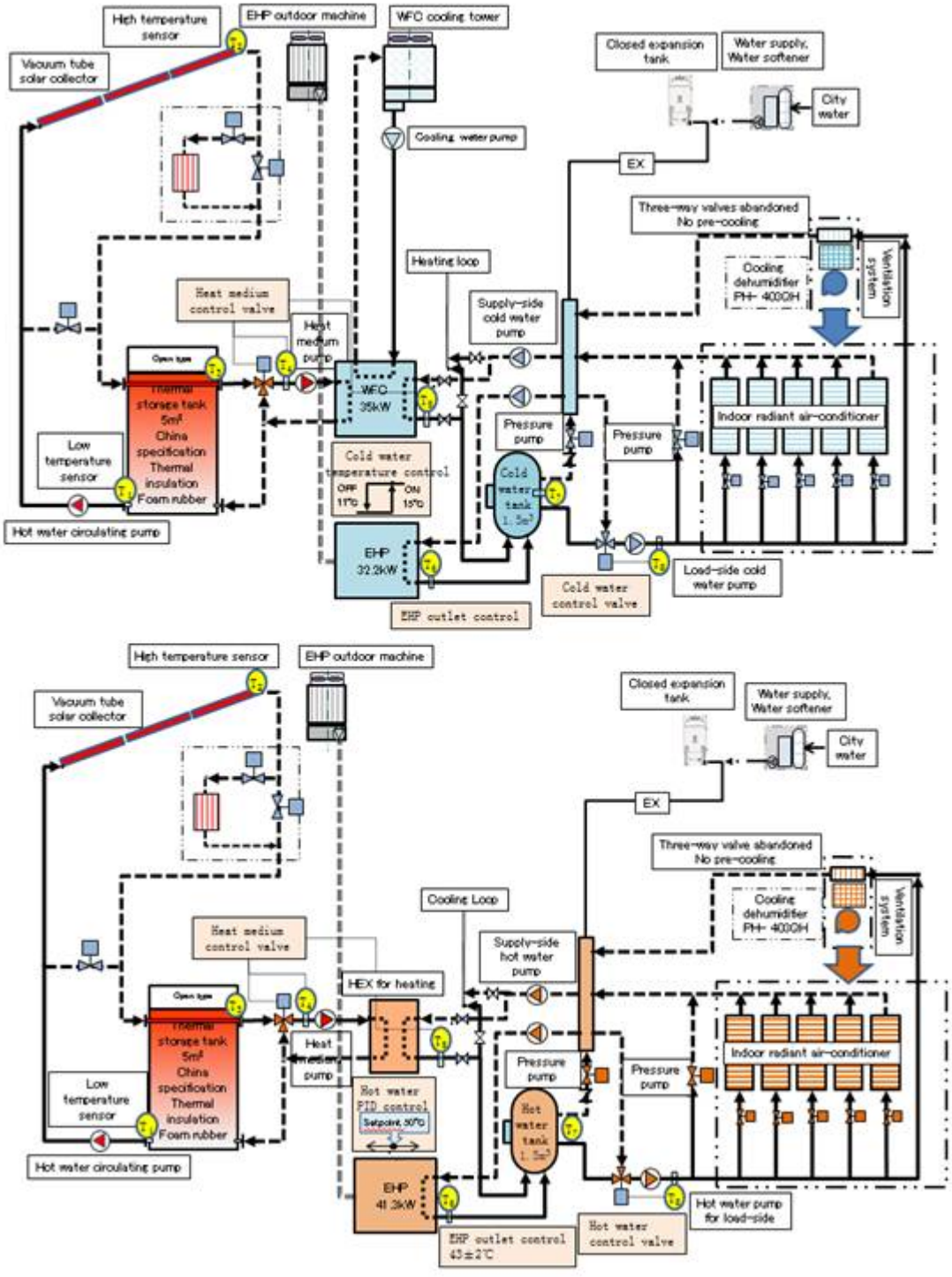
Cooling Equipment

CHILLER		
Type :	Absorption	
Model :	WFC-SC10	
Manufacturer :	YAZAKI ENERGY SYSTEM CORP	
Country :	JAPAN	
Nominal chilling capacity :	35,2	kW
COP_thermal :	0,7	-
Distributed chilled medium temperature :	11->15	°C
Nominal driving heat temperature :	70->95	°C
Driven by :	solar thermal heat (solar autonomous operation)	

HEAT REJECTION		
Type :	Dry cooling (closed)	
Model :	DHHC-20	
Manufacturer :	DAHUA	
Country :	CHINA	
Thermal heat rejection capacity :	50	kW
Nominal electricity consumption (fan) :	6,6	kW

BACKUP CHILLER		
Type :	?	
Model :	A-C12-AC-S2	
Manufacturer :	LIPMAN	
Country :	CHINA	
Chilling capacity :	29,3	kW
Chilled fluid type :	water	
COP_el :	2,84	-
Chilled medium temperature :	7	°C

COLD STORAGE		
Total volume :	1,5	m3
Number of storage tanks :	1	-
Storage medium :	Water	
Nominal exchange temprature :	15	°C


High temperature sensor
EHP outdoor machine
WFC cooling tower
Vacuum tube solar collector
Closed expansion tank
Water supply, Water softener
City water
Cooling water pump
EX
Three-way valves abandoned No pre-cooling
Heating loop
Cooling dehumidifier PH= 4000H
Ventilation system
Heat medium control valve
Heat medium pump
Supply-side cold water pump
WFC 35kW
Thermal storage tank 5m³ China specification Thermal insulation Foam rubber
Indoor radiant air-conditioner
Pressure pump
Low temperature sensor
Cold water temperature control
OFF 11°C
ON 15°C
Cold water tank 1.5m³
Hot water circulating pump
EHP 32.2kW
Load-side cold water pump
Cold water control valve
EHP outlet control
High temperature sensor
EHP outdoor machine
Vacuum tube solar collector
Closed expansion tank
Water supply, Water softener
City water
EX
Three-way valve abandoned No pre-cooling
Cooling Loop
Cooling dehumidifier PH= 4000H
Ventilation system
Heat medium control valve
Supply-side hot water pump
HEX for heating
Thermal storage tank 5m³ China specification Thermal insulation Foam rubber
Heat medium pump
Indoor radiant air-conditioner
Pressure pump
Low temperature sensor
Hot water PID control
Setpoint, 50°C
Hot water tank 1.5m³
Hot water circulating pump
EHP 41.3kW
Hot water pump for load-side
Hot water control valve
EHP outlet control 45±2°C

SENR:

Solution 1:

Activity A2

Company	SENR
Address	16 Av Jean Boutroux
	44500 La Baule
Country	France
Contact	Patrice AUBIN
	+33624821867
	www.senr.fr
	patrice.aubin@senr.fr
Brand name	STEADY GO
Cooling power range	3.5 kW

System

PV COLLECTORS

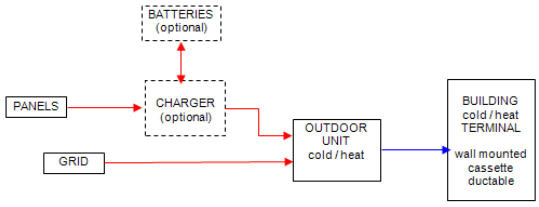
Total area :	5	m² (aperture area)
Tilt angle :	45	° (0=horiz)
Orientation :	0	° (0=south ; 90 =west ; 270=east)
Typical peak power :	650	Wc
Type :	Monocristalline	
Model :	STP195S	
Manufacturer :	SUNTECH	
Country :	France	

SOLAR INVERTERS None

AUXILIARY POWER SOURCE Grid 230V

HEAT PUMP

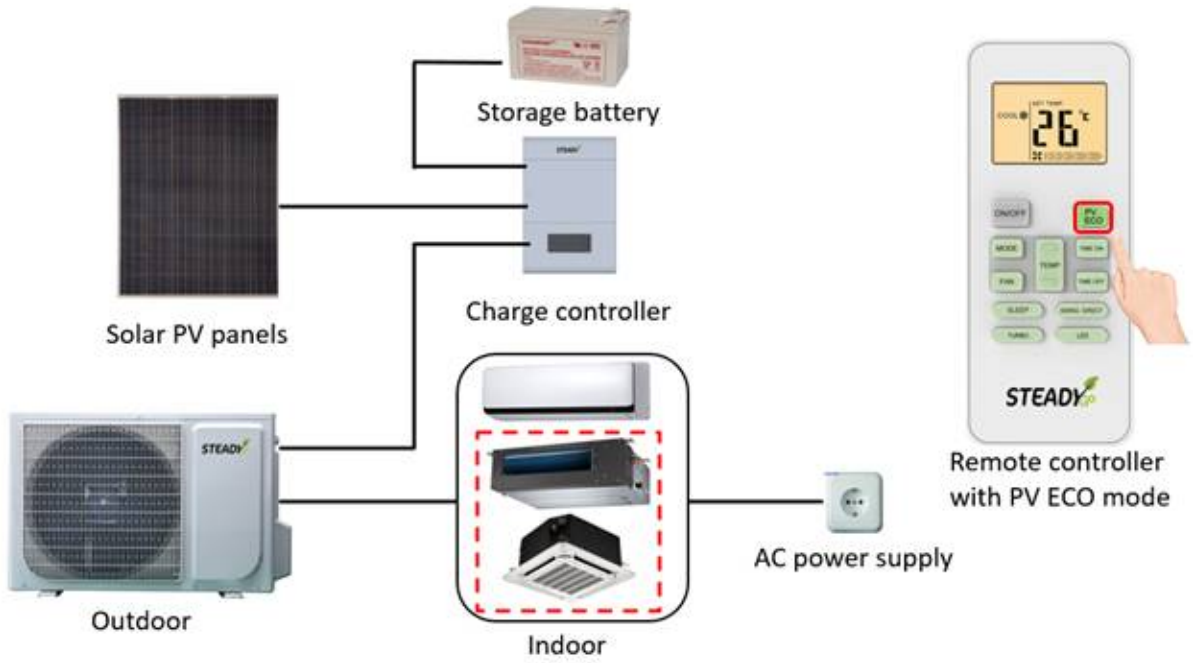
Type :	Scroll Air to air		
Model :	RO-12HS		
Manufacturer :	SENR		
Country :	France		
Cooling capacity :	3,6 kW		
Electrical consumption in cooling mode :	1 kW		
EER :	3,6 -	Conditions :	Tout = 7 °C Tin = 20 °C
Heating capacity :	3,6 kW		
Electrical consumption in heating mode :	1 kW		
COP :	3,6 -	Conditions :	Tout = 35 °C Tin = 27 °C



HEAT REJECTION STRATEGY	None			
BACKUP CHILLER	None			
COLD STORAGE	None			
BUILDING VENTILATION	Natural			
DISTRIBUTION SYSTEM	split			
Distribution fluid :	air			
Nominal supply temp. :	15	°C (cooling)	45	°C (heating)
Nominal return temp. :	24	°C (cooling)	20	°C (heating)
Nominal total air flow :	2000	m3/h		
COOLING STRATEGY	full air conditionning (strict conditions)			
HEATING STRATEGY	full air conditionning (strict conditions)			

COMMENTS

ECO function allowing user to consume only PV power
Optional charger for batterie backup



Investment - Material

TOTAL INVESTMENT COST

Total :	2500	€
Lifetime :	20	y
Annual cost :	125	€/y
Specific costs :	3846	€/kWp
	694	€/kWcooling

SOLAR PV COLLECTORS

Total :	700	€
Lifetime :	25	y
Annual cost :	28	€/y
Specific costs :	1077	€/kWp
Not including :	installation 500 €	
	structure 150 €	
	other (wiring...) 50 €	

Investment - Planning & Design

FEASIBILITY STUDY		
Total :	50	€
Specific costs :	77	€/kWp
	39	€/kW
PLANNING		
Total :	50	€
Specific costs :	77	€/kWp
COMMISSIONING		
Total :	100	€
Specific costs :	154	€/kWp

COMMENTS ON FEASIBILITY STUDY, PLANNING AND COMMISSIONING

Specifics studies for panels mounting

AC commissioning is the same as normal AC inverter

ANNUAL MAINTENANCE		
Total :	180	€
Specific costs :	277	€/y.kWp
ANNUAL OPERATION		
Total :	140	€
Specific costs :	215,38	€/kWp
	38,89	€/kW

Results from system operation

MONITORING PERIOD		
From :	15th January 2015	
Until :	1st December 2015	
Periods of sytem/monitoring interruption :	None	

PV PANELS		
Radiation gain, global horizontal :	2191	kWh/m²
Useful energy from collector :	1484	kWh
Specific PV yield :	2283	kWh/kWp

AUXILIARY ELECTRICITY		
Electricity from auxiliary energy sources (grid) :	154	kWh
Auxiliary electricity for cooling operation :	154	kWh

HEAT PUMP NB : only cooling		
Drinving electric input :	1528	kWh
Produced cold :	7442	kWh
COP_elec :	4,87	-
Solar coverage of driving electricity :	0,9	-

CHILLER		
Produced cold :	8446	kWh
Rejected heat :	19765	kWh

AUXILIARY ELECTRICITY DEMAND		
Pumps, collector circuits :	5185	kWh

COMMENTS

OUR SOLUTIONS ARE MAINLY INSTALLED IN WESTERN AFRICA. WE HAVE NOT ANY OPERATING RESULTS FROM USERS

8	Qualitative assessment		SENR

Task 53

senr solutions énergies renouvelables DIFFUSION

GENERAL USER REACTIONS *(ease of use, controlability, …)*

Pushed to its maximum ECO running mode may not allow single euro energy billing

GENERAL ASSESSMENT

	satisfied or not YES	NO	*comments*
User / owner satisfied ?	☑	☐	
User / Owner involved in the project?	☑	☐	
Qualitiy of comfort aspects	☑	☐	As good as high performance splits
Image and marketing aspects	☑	☐	Up to date with COP21 goals
Other aspects			With 3 indoor units available, easy to place in any room and / or application

PERFORMANCE ASSESSMENT

	YES	NO	*comments*
Sufficient Energetic performance?	☑	☐	
Overall reliable operation?	☑	☐	
Existing nuisance ?	☑	☐	Must be connected to Grid
Potential for optimisation? *(e.g., system control)*	☑	☐	Must be set independant from grid for isolated sites

ENVIRONMENTAL BENEFITS e.g CO_2 and energy savings?

Energies savings therfore CO_2 emission reduced

MAJOR LESSONS LEARNT e.g more efficient design? Material? How to avoid nuisance? Etc...

SENR:

Solution 2:

Activity A2

Company	SENR
Address	16 Av Jean Boutroux
	44500 La Baule
Country	France
Contact	Patrice AUBIN
	+33624821867
	www.senr.fr
	patrice.aubin@senr.fr
Brand name	STEADY GO
Cooling power range	14 to 246 kW

System

PV COLLECTORS

Total area :	114	m² (aperture area)
Tilt angle :	10	° (0=horiz)
Orientation :	0	° (0=south ; 90 =west ; 270=east)
Typical peak power :	20000	Wc
Type :	Monocristalline	
Model :	STP195S	
Manufacturer :	SUNTECH	
Country :	France	

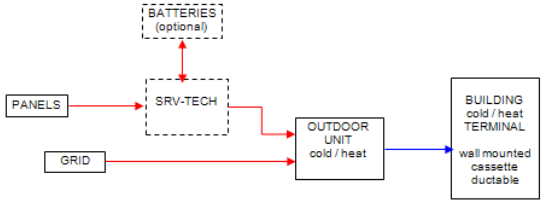
SOLAR INVERTERS

Brand :	ABB	
Model :	TRIO 20,0-TL-OUTD	
Typical nominal DC power :	20,8	kW
Typical nominal AC power :	22	kW
Number of phase :	3	
Converter efficiency :	98%	

AUXILIARY POWER SOURCE Grid 400/3V

HEAT PUMP

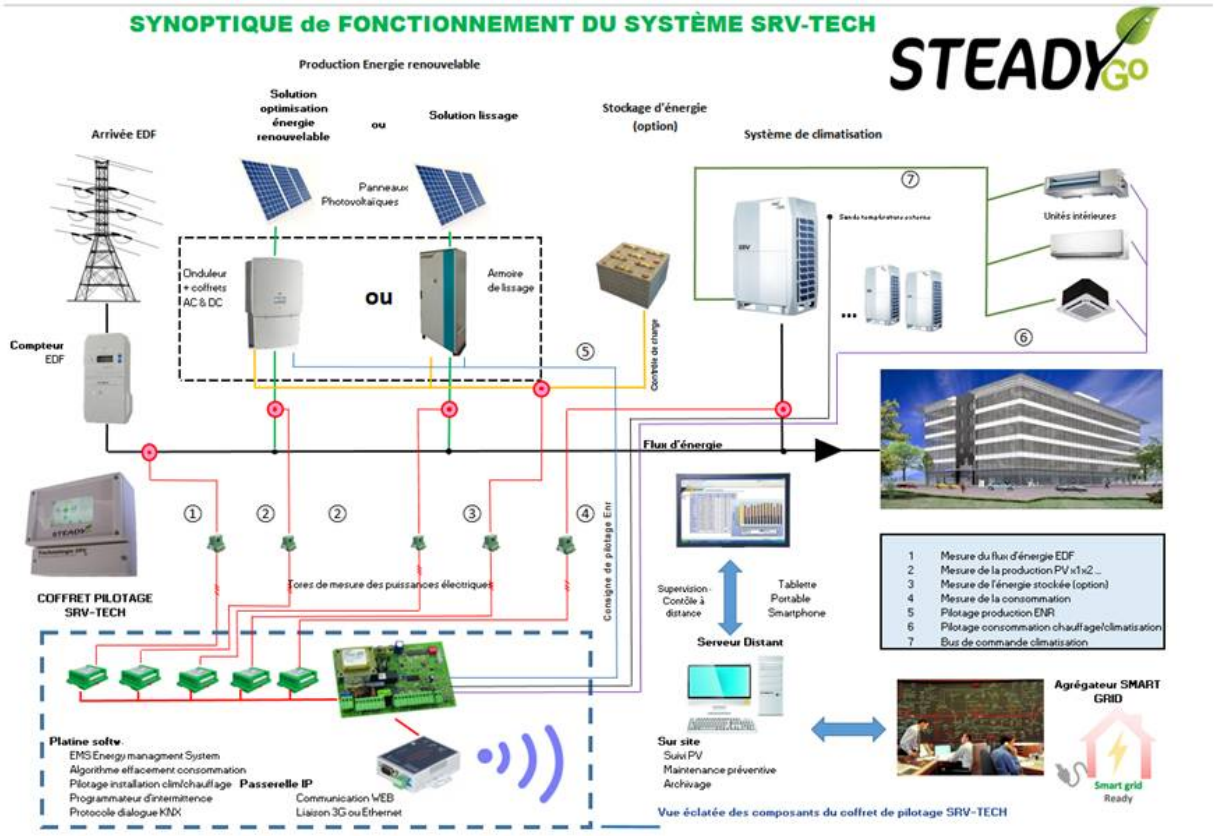
Type :	Scroll Air to air		
Model :	SRV-X450W		
Manufacturer :	SENR		
Country :	France		
Cooling capacity :	45	kW	
Electrical consumption in cooling mode :	14	kW	
EER :	3,21	-	Conditions : Tout = 7 °C Tin = 20 °C
Heating capacity :	50	kW	
Electrical consumption in heating mode :	12,8	kW	
COP :	3,91	-	Conditions : Tout = 35 °C Tin = 27 °C



HEAT REJECTION STRATEGY	None			
BACKUP CHILLER	None			
COLD STORAGE	None			
BUILDING VENTILATION	Natural			
DISTRIBUTION SYSTEM	8 model type indoor units			
Distribution fluid :	air			
Nominal supply temp. :	15	°C (cooling)	45	°C (heating)
Nominal return temp. :	24	°C (cooling)	20	°C (heating)
Nominal total air flow :	2000	m3/h		
COOLING STRATEGY	full air conditionning (strict conditions) top cooling (no strict conditions with backup) solar alone (no backup)			
Design outdoor temperature :	up to 46 °C			
HEATING STRATEGY	full air conditionning (strict conditions) top cooling (no strict conditions with backup) solar alone (no backup)			
Design outdoor temperature :	7	°C		
Design outdoor humidity :	95	%		

COMMENTS

ECO function allowing user to consume only PV power
Optional charger for batterie backup
Gird injection full control



COMMENTS

The core of our technology is earasing:

Erasing consumption by piloting the application may be defined as the act which aims to reduce or temporarily move the level of electricity consumption of one or more of consumption devices.

With a level of reference determined with the user as minimum service consumption, we use payable energy only if PV production decrease below this level. Otherwhile we monitor the demand to match consumption and PV production

Investment - Material

TOTAL INVESTMENT COST		
Total :	97000	€
Lifetime :	20	y
Annual cost :	4850	€/y
Specific costs :	149231	€/kWp
	26944	€/kWcooling
SOLAR PV COLLECTORS		
Total :	57000	€
Lifetime :	25	y
Annual cost :	1250	€/y
Specific costs :	1077	€/kWp
COLD PRODUCTION		
Total :	25000	€
Lifetime :	20	y
Annual cost :	1250	€/y
Specific costs :	38462	€/kWp
	6944	€/kWcooling
BACKUP (optional backup through LiPO)		
Total :	17000	€
Lifetime :	15	y
Annual cost :	1133	€/y
Specific costs :	26154	€/kWp
	4722	€/kWcooling
ELECTRIC, CONTROL AND MONITORING		
Total :	3500	€
Lifetime :	20	y
Annual cost :	175	€/y
Specific costs :	5385	€/kWp
	972	€/kWcooling

Investment - Planning & Design

FEASIBILITY STUDY

Total :	2000	€
Specific costs :	3077	€/kWp

COMMISSIONING

Total :	1500	€
Specific costs :	2308	€/kWp

COMMENTS ON FEASIBILITY STUDY, PLANNING AND COMMISSIONING

Specifics studies for panels mounting
AC commissioning is the same as normal AC inverter

ANNUAL MAINTENANCE

Total :	1000	€
Specific costs :	1538	€/y.kWp

Results from system operation

COMMENTS

All records made are not significant for analysis.
Our monitoring includes 8 steps.
Each steps reduce or delate the demand od specific indoor units.
Therefore the energy saving ration for each one can be seen on the charts beside.
The saving rate depends on the level of comfort wished by user. It may vary from 10% for high comfort level to 70 or 80% for high economic running.

8	Qualitative assessment		STEADY GO

Task 53

senr solutions énergies renouvelables DIFFUSION

GENERAL USER REACTIONS *(ease of use, controlability, …)*

Different reasons made user choose this solution:
Economic in order to manage precisely the consumption billing using PV or not.
Safety as PV production may decrease suddenly with cloud appreance, Erasing insure a continous service
Reliability when the installation is connected to unsecured power network

GENERAL ASSESSMENT

	satisfied or not YES	NO	*comments*
User / owner satisfied ?	☑	☐	
User / Owner involved in the project?	☑	☐	Yes to choose economies level
Qualitiy of comfort aspects	☑	☐	All avantages of VRF installations
Image and marketing aspects	☑	☐	Up to date with COP21 goals
Other aspects			

PERFORMANCE ASSESSMENT

	YES	NO	*comments*
Sufficient Energetic performance?	☑	☐	In accordance with users comfort choice
Overall reliable operation?	☑	☐	
Existing nuisance ?	☑	☐	Must be connected to Grid
Potential for optimisation? *(e.g., system control)*	☑	☐	Must be set independant from grid for isolated sites

ENVIRONMENTAL BENEFITS e.g CO_2 and energy savings?

Energies savings therfore CO_2 emission reduced
Improvment of renewable energies in tropicla area or weak power network.
Help to make safer environment in unsecured area such desert, epidemic diseases or war zone

MAJOR LESSONS LEARNT e.g more efficient design? Material? How to avoid nuisance? Etc...

Must obtain support from government institution or power network managers.