



THERMAL SYSTEMS FOR ENERGY CONVERSION AND STORAGE: RESEARCH ACTIVITIES AT CNR-ITAE



**National Research Council of Italy -
Institute for Advanced Energy Technologies «Nicola Giordano»**



Consiglio Nazionale delle Ricerche





WHAT: The Institute for Advanced Energy Technologies «N.Giordano» is part of the National Research Council of Italy.

WHERE: The Institute is located in Messina and is divided into 2 buildings: the main section, with offices and laboratories devoted to basic research, and the **CENTROPROVE**, where the technologies with higher TRL are tested.

MISSION: To promote and develop research activities on materials, components and energy systems.



Fuel Cells

Hydrogen and
eco-fuels



Storage and rational
use of energy

New technologies and
integration of renewable
energies



MAIN RESEARCH TOPICS

- Sorption heat pumps/chillers
- Waste heat re-use
- Heat storage and recovery
- Solar cooling
- Heat Transfer

FACILITIES

- 1 x Chemical LAB
- 1 x Components development LAB
- 2 x Testing bench for thermal technologies
- 1 x Testing bench for PCM Storages
- 1 x Climatic CHAMBER

STAFF AND ACTIVITIES

STAFF

| | |
|------------------|-----------------------------|
| Enza Brancato | <i>Researcher</i> |
| Antonino Bonanno | <i>Researcher</i> |
| Fabio Costa | <i>Lab Technician</i> |
| Giuseppe Dino | <i>Researcher</i> |
| Andrea Frazzica | <i>Researcher</i> |
| Davide La Rosa | <i>Researcher</i> |
| Walter Lombardo | <i>Researcher</i> |
| Valeria Palomba | <i>Researcher</i> |
| Alessio Sapienza | <i>Researcher</i> |
| Salvatore Vasta | <i>Researcher</i> |
| Lucio Bonaccorsi | <i>Associated Professor</i> |
| Luigi Calabrese | <i>Associated Professor</i> |
| Guido DI Bella | <i>Engineer @ NAVTEC</i> |



LATENT HEAT STORAGE: ACTIVITIES AT CNR ITAE

TESTING OF LAB-
SCALE
PROTOTYPES

6

MATERIAL
SCREENING

1

DESIGN OF
STORAGES

5

LATENT HEAT
STORAGE

2

MATERIALS
CHARACTERI-
ZATION

MATHEMATICAL
MODELING AND
SIMULATION

4

3

MATERIAL CYCLING



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ADSORPTION STORAGE AND HEAT PUMPS: ACTIVITIES AT CNR ITAE

**MATHEMATICAL
MODELING AND
SIMULATION**

**TESTING OF
EVAPORATORS**

**TESTING OF LAB-
SCALE AND
COMMERCIAL
SYSTEMS**

**TESTING OF
SMALL-SCALE
ADSORBERS**

**ADSORPTION
SYSTEMS FOR
STORAGE AND
HVAC**

**MATERIAL
CHARACTERIZ-
ATION:
ADSORPTION
CAPACITY**

**MATERIAL
CYCLING**

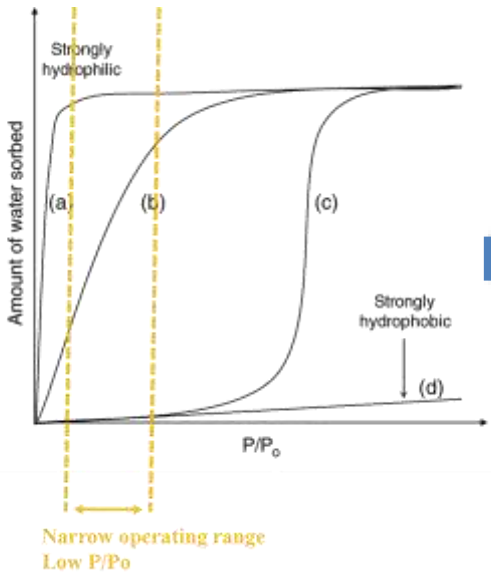
**ADSORPTION
DYNAMICS**



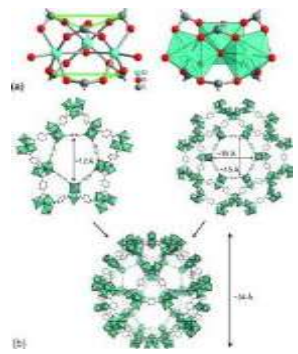
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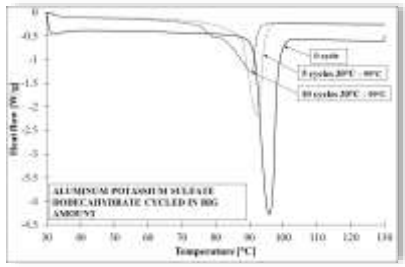
SORBENTS



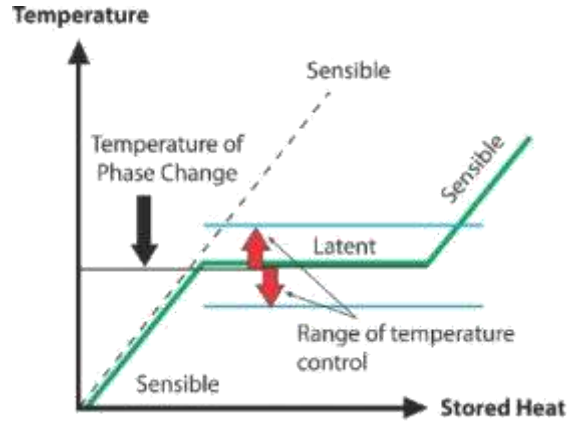
- De-aluminated Zeolites
- Silico-alumino-phosphates
- Composite sorbents
- MOFs
- Activated Carbons



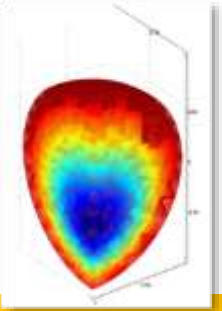
In cooperation with: **UniME, UniRC, Boreskov IC, Uni Edinburgh, Fraunhofer ISE**



- Cycling stability analysis
- Increasing of thermal conductivity
- Development of high temperature salt mixtures



PCMS



In cooperation with: **Uni Lleida, Uni PG, Fraunhofer ISE, IEA SHC Task 58 / ECES Annex 33**



Materials characterization equipment @ ITAE



DVS Vacuum: absorption / co-absorption of vapour on solids and liquids

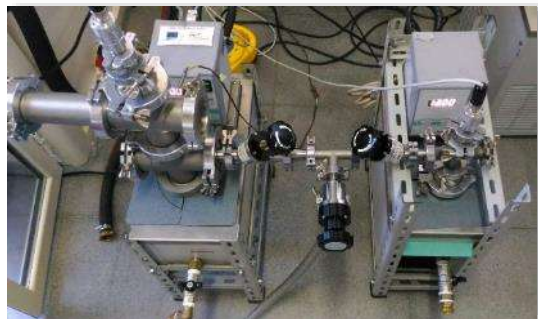


Mettler DSC 1: melting enthalpy and specific heat measurements for PCMs

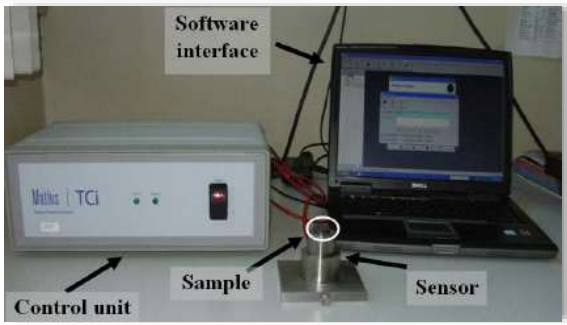


Labsys Evo: TG/DSC under saturated vapour pressure conditions

Hydrothermal ageing of sorbent materials under real working boundaries



Customized thermo-gravimetric system for sorption of alcohols on porous materials



Mathis TCi: Transient plane thermal conductivity measurement



Testing of adsorbers



- *Single adsorber adsorption chiller*
- *1 kW peak cooling power capacity*
- *Real boundary conditions, VCP, COP, management strategy*

Sorption kinetics measurements



- *G_LTJ method*
- *Testing of real small scale adsorber*

- *Evaporation/condensation driven by adsorption/desorption*
- *Testing of different Hex layout*
- *Water, ethanol, methanol*



Study of evaporation/condensation under vacuum conditions

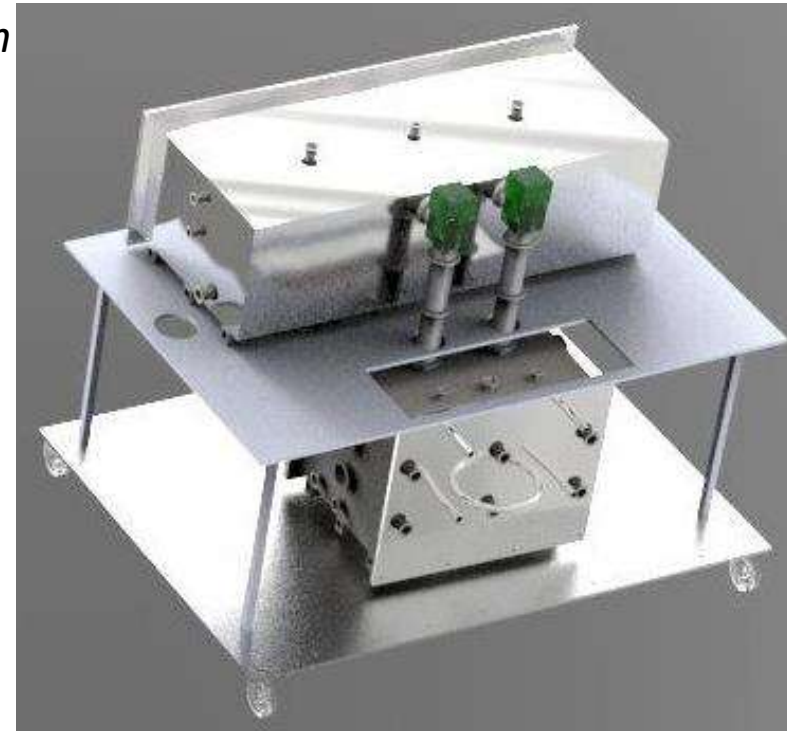




Existing testing rig for testing of evaporation under vacuum of tubes and representative pieces of fin-and-tube HEXs

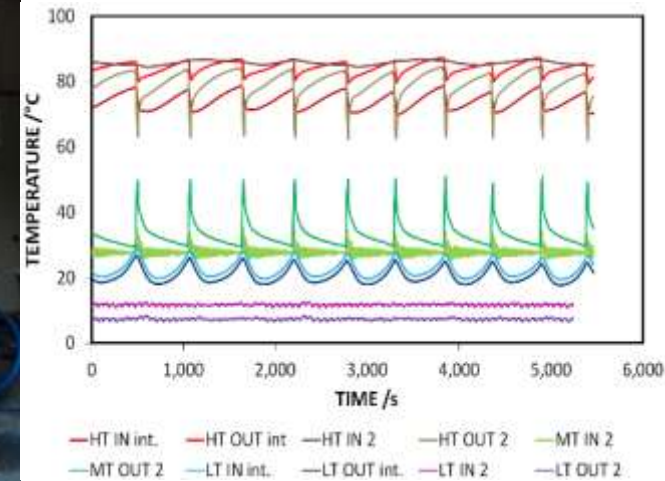
TESTING RIG UNDER CONSTRUCTION

- Expected evaporation power: 2-4 kW.
- Maximum dimensions of the heat exchanger: 350 x 350 x 100 mm.
- Connections: straight tubes $\Phi 12$.
- Flow rates: 5-40 kg/min.
- Pressure drops allowed : up to 100 kPa.

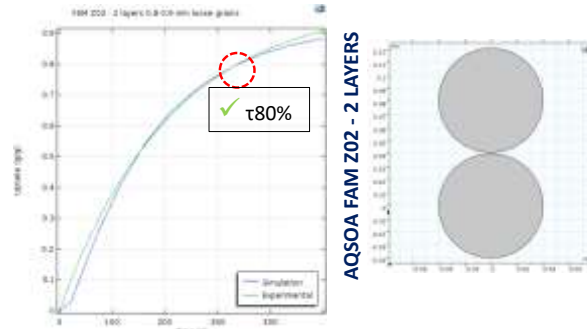




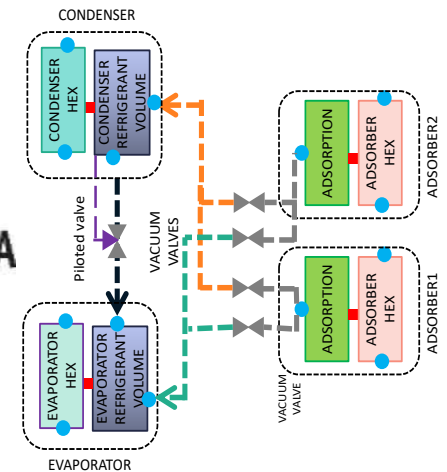
- ✓ Suitable for systems with power of 35 kW
- ✓ Thermal and hybrid system testing possibilities
- ✓ Class A Electric meter for measurement of electric consumption



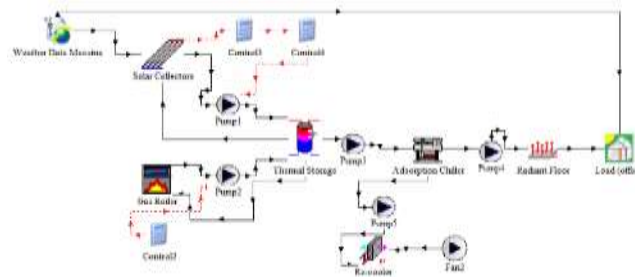
MATERIAL MODELING IN COMSOL® MULTIPHYSICS



ADSORPTION MODULE MODELING IN MODELICA/DYMOLA



SYSTEM MODELING IN TRNSYS

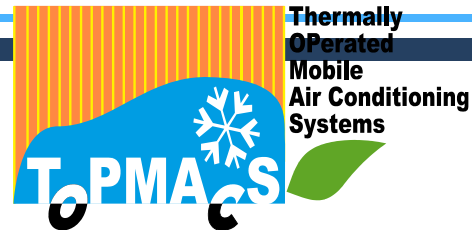




STRALIS 520

- ✓ Automotive competitions
- ✓ «Friction» reduction
- ✓ Possible different installation

| | |
|----------------------|---------|
| Overall volume | 150 L |
| Overall weight | 59 kg |
| Chilling capacity | 2,3 kW |
| Min, air temperature | 9 °C |
| COP | 0,2 |
| Regeneration temp. | 80 °C |
| Adsorbent | Zeolite |



Thermally Operated Mobile Air Conditioning Systems

○ **SCP: up to 600 W/kg**

○ **Very competitive weight considering commercial products!**

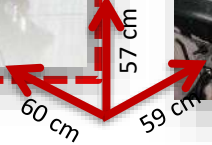
○ **Volume density higher than 10kW/m³!**



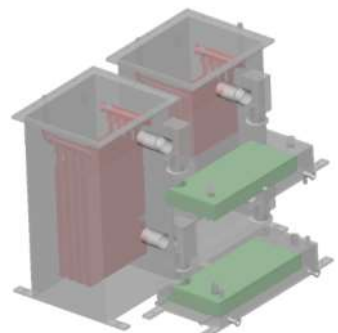
Prototype



Cabin installation

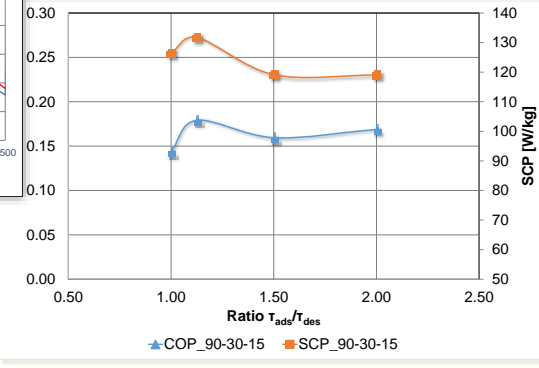
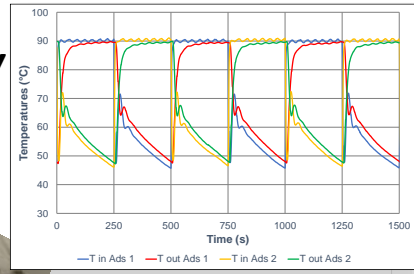


Ethanol-activated carbon refrigeration – 0.5 kW

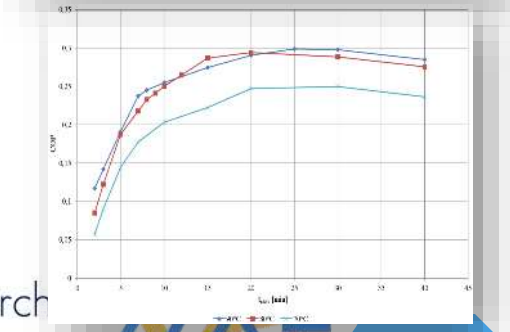
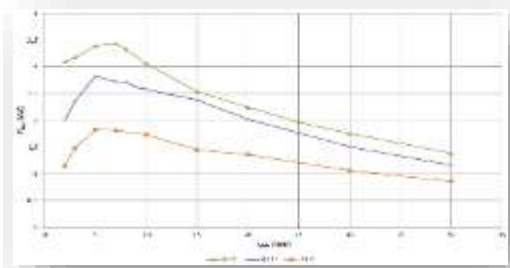
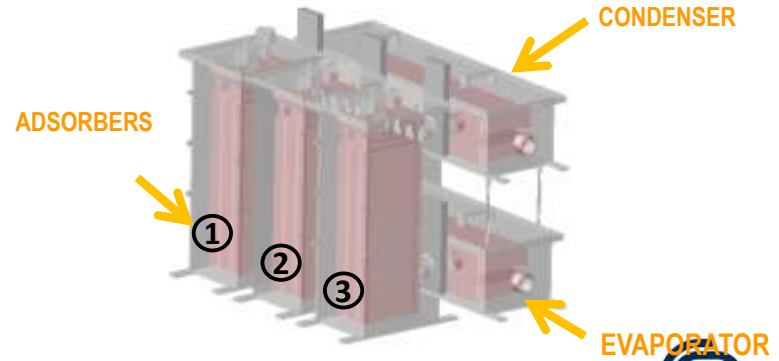


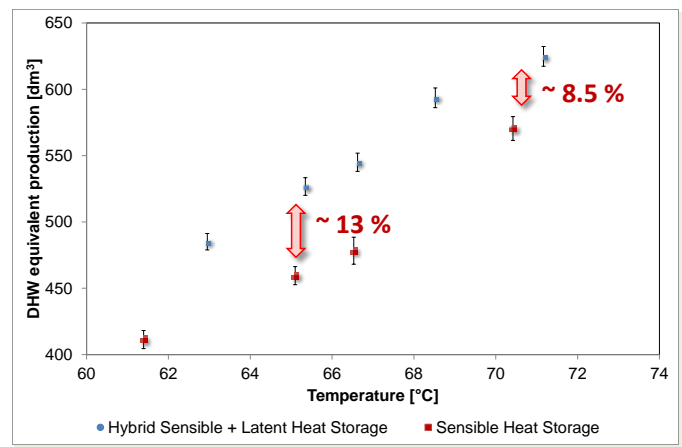
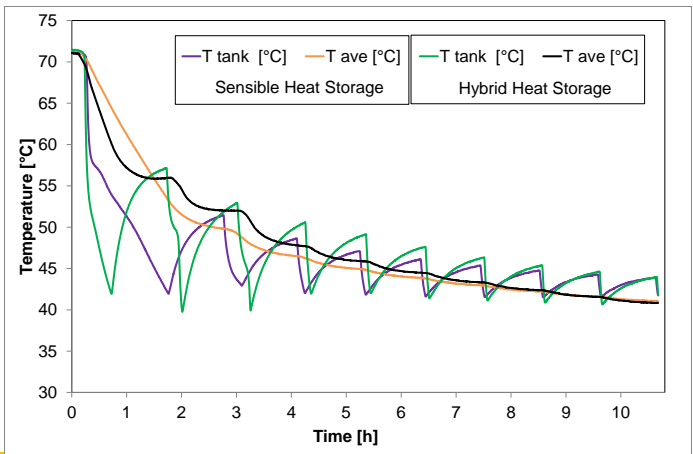
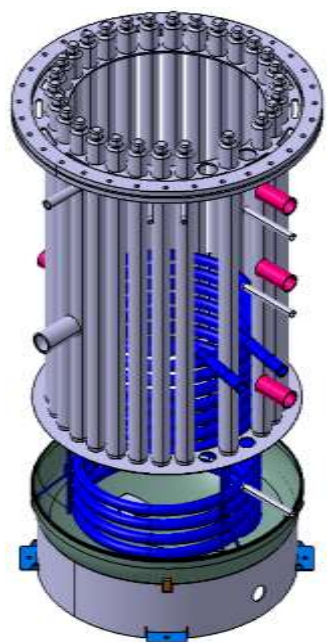
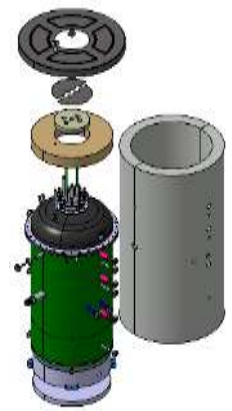
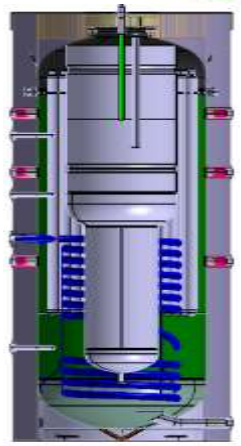
3D model

Full scale prototype



Chiller acqua/AQSOA Z02-silica gel – 4 kW

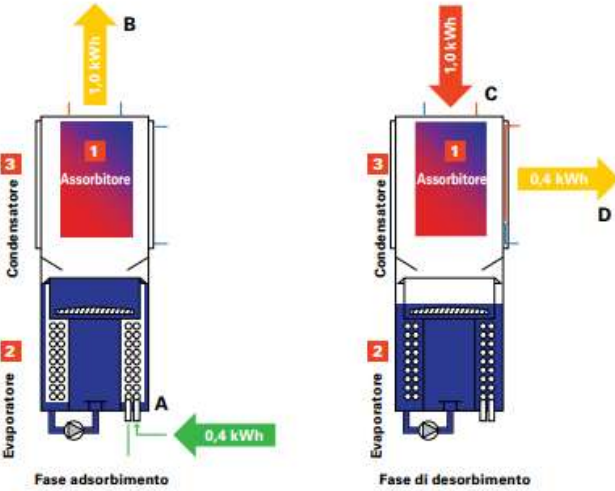




Adsorption heat pump 10 kW



- ITAE activity: collaboration in the development and characterization of the adsorber reactor
- Efficiency: 140% respect to the methane LCV



2013-machine commercially available

2010-first design of adsorber

2007- first study on coatings

Adsorption module developed @ ITAE

New coating technique under development

Milano Comfortexpo- 18/21 March 2014

“VITOSORP 200 F”



ZEOSOL

06/2017- 11/2019



OBJECTIVES



Thermally driven chiller with zeolite coating

Integrated unit: thermal chiller + heat pump + dry cooler



Advanced solar thermal collectors



Target cost 2000 €/kW (with solar field and cooling, heating and thermal storage included)



Demo-site installation in Athens



Title: Integrated solar heating and cooling unit based on a novel zeolite chiller and heat pump
 Duration: 2017-2019
 Start date: 1st of June 2017
 Budget: about 2.74 mil. €
 Call: FTIPilot-01-2016 - Fast Track to Innovation Pilot
 Type of Action: Innovation Action (IA)
 Project Coordinator: National Technical University of Athens



<http://zeosol.eu/>



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10/2017-09/2021



HYBUILD storage solutions will be demonstrated across 3 pilot sites.

• Bordeaux France



• Aglantzia Cyprus



• Almatret Spain



FUNDED BY THE EU



The HYBUILD project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 768824.



<http://www.hybuild.eu/>

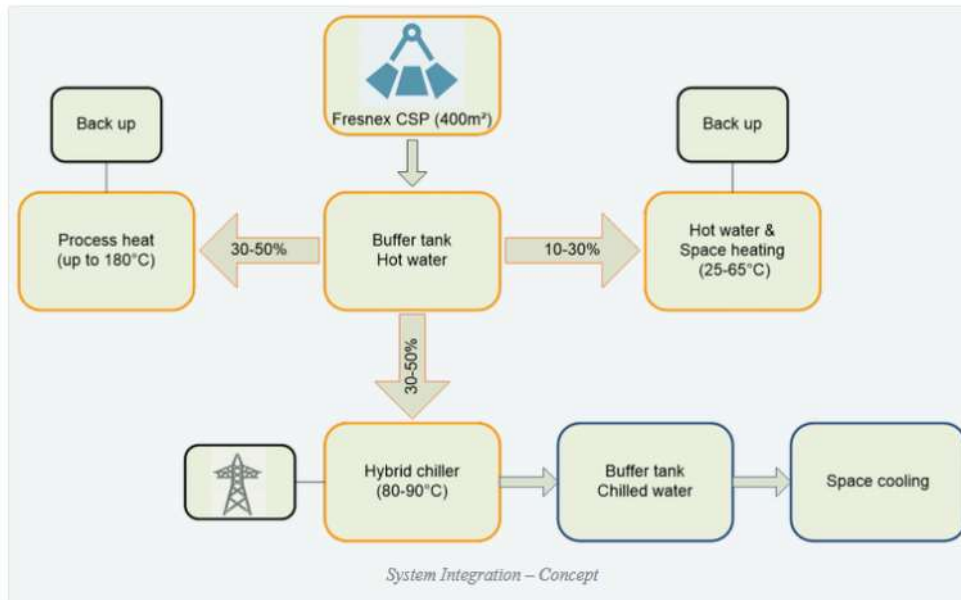


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Industrial Cooling through Hybrid system based on solar heat.



2 pilot plants:

- **Food industry:** utilization of solar heat for air conditioning of plant building
- **Chemical industry:** utilization of solar heat for steam production and cooling of process equipment

ROLE OF CNR-ITAE: system modelling, design review of sorption chiller, testing of full-scale prototype

<http://www.hycool-project.eu/>



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Deployment of novel GEOthermal systems, technologies and tools for energy efficient building retroFITting.

PARTNERS



Pilots in Four EU Countries of Different Building Types with Different Soil Conditions



San Cugat Site
Primary School



Talence Site
Office Space



Aran Islands Site
Residential Dwellings

Sant'Apollinare Site
Historical Building
Conference and Office
Center



Galway Site
NUIG Kingfisher
Sport Center



ROLE OF CNR-ITAE:
system modelling,
hybrid sorption-
compression heat
pump design, testing
of full-scale
prototype

<http://www.geofit-project.eu/>



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The SWS-HEATING project concept is to develop an innovative Seasonal Thermal Energy Storage (STES) unit with a novel sorbent storage material embedded in a compact multimodular sorption STES unit.

ROLE OF CNR-ITAE: system modelling, sorbent development and production, small-scale prototypes testing



SWS
heating



AhoTec



TEABE ETE

Fahrenheit

PCM

OTH

AIREC

fy



US
UNIVERSITY
OF SUSSEX



ITAE

<http://www.swsheating.eu/>



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The main objective of SunHorizon is to demonstrate up to TRL 7 innovative and reliable Heat Pump solutions (thermal compression, adsorption, reversible) that acting properly coupled and managed with advanced solar panels (PV, Hybrid, thermal) can provide heating and cooling to residential and tertiary building with lower emissions, energy bills and fossil fuel dependency

An Industry Driven Consortium



Third Parties involved:

- IES UK (LTP of IES Ireland)
- GNSE and GNS (LTPs of GN)



ROLE OF CNR-ITAE: system modelling, prototype testing

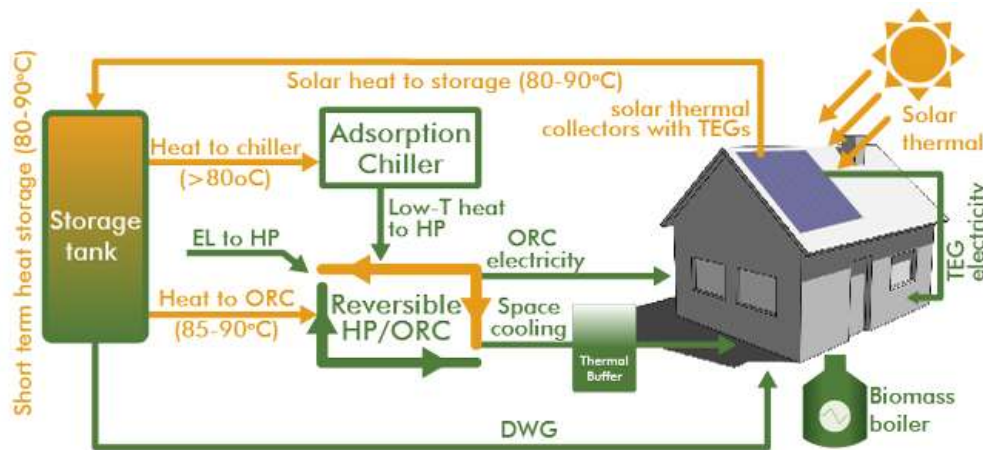




Solar-Biomass Reversible energy system for covering a large share of energy needs in buildings

<http://www.solbiorev.eu/>

The SolBio-Rev project concept is to develop a configuration based on renewables that allows covering all heating and cooling demand and a variable electricity demand (from zero up to even 100%) in a cost-effective manner. This configuration is based on solar, ambient and bioenergy, while it is suitable to be installed in various buildings types and sizes without any geographical restriction.



ROLE OF CNR-ITAE: system modelling, prototype testing



VIESSMANN



TOYOTA

 **MITSUBISHI
CHEMICAL**

 **FAHRENHEIT**

 **SorTech**

