REDESIGN THERMOCHEMICAL ENERGY STORAGE REACTOR SYSTEM FOR THE APPLICATION OF WATER AND RESIDUAL SALTS FROM MINING ACTIVITY

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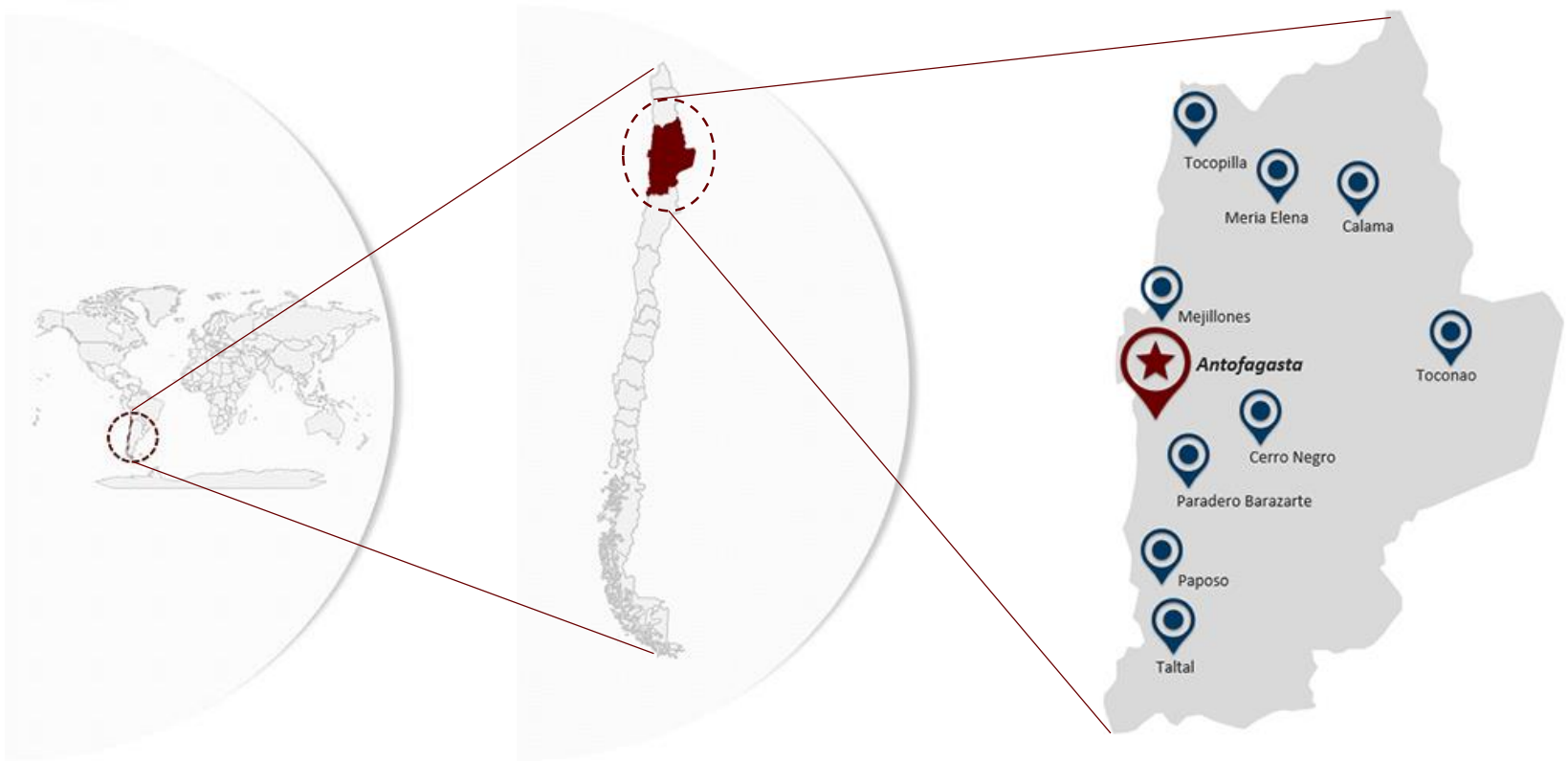
Warwick Sustainable Thermal Energy Technologies

Overview

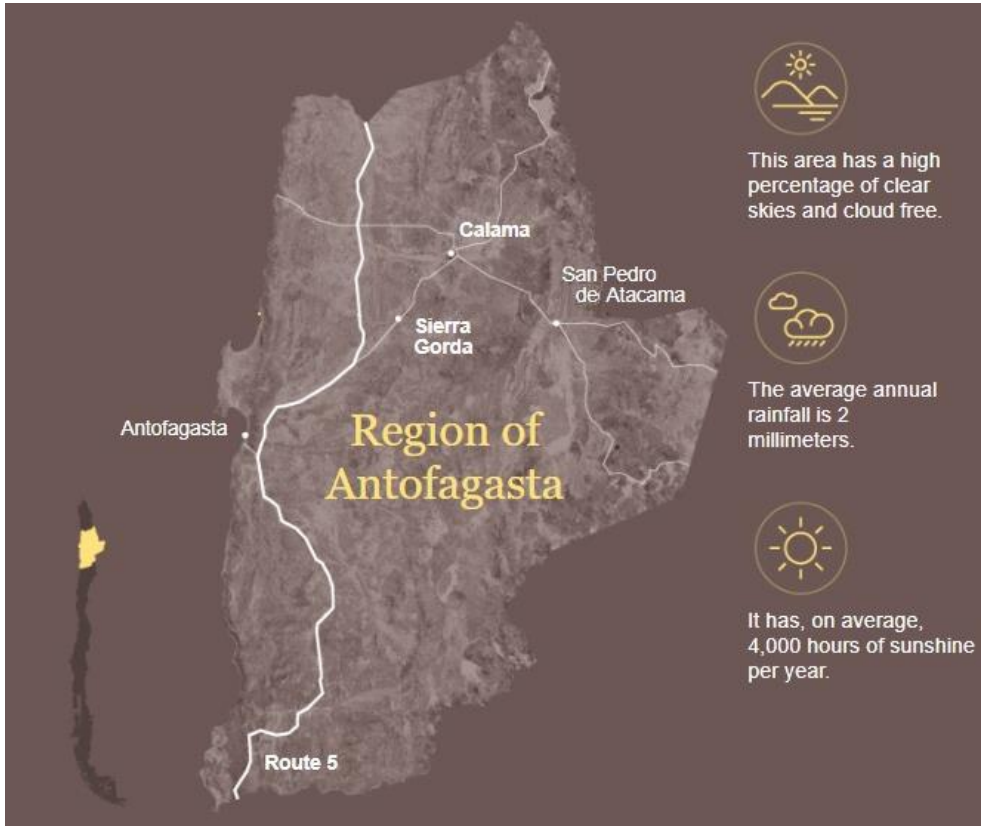
- **Background**
- PhD research
- Research proposal STET group

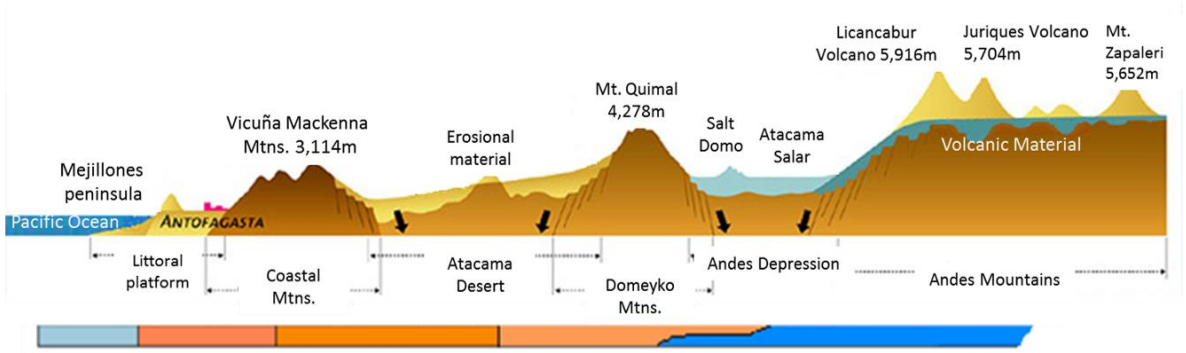
Chile, Antofagasta Region

Chile, located in South America, fills a narrow 2,880 miles strip between The Andes and the Pacific Ocean.

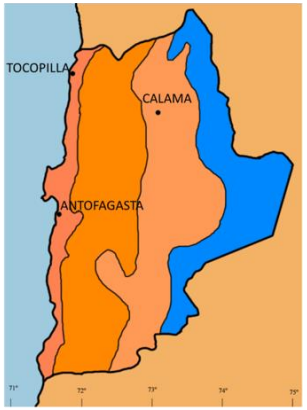


Climates of the Antofagasta Region





Climate	Height	Annual T mean			Rainfall
		min	max	δ	
Cloudy Desert	> 0 m	13 °C	22 °C	±7 °C	1.7 mm
Normal Desert	> 1000 m	8 °C	21 °C	±25 °C	3.1 mm
High Desert	> 2000 m	5 °C	24 °C	±20 °C	5.6 mm
High Steppe	> 3000 m	5 °C	24 °C	±20 °C	68 mm



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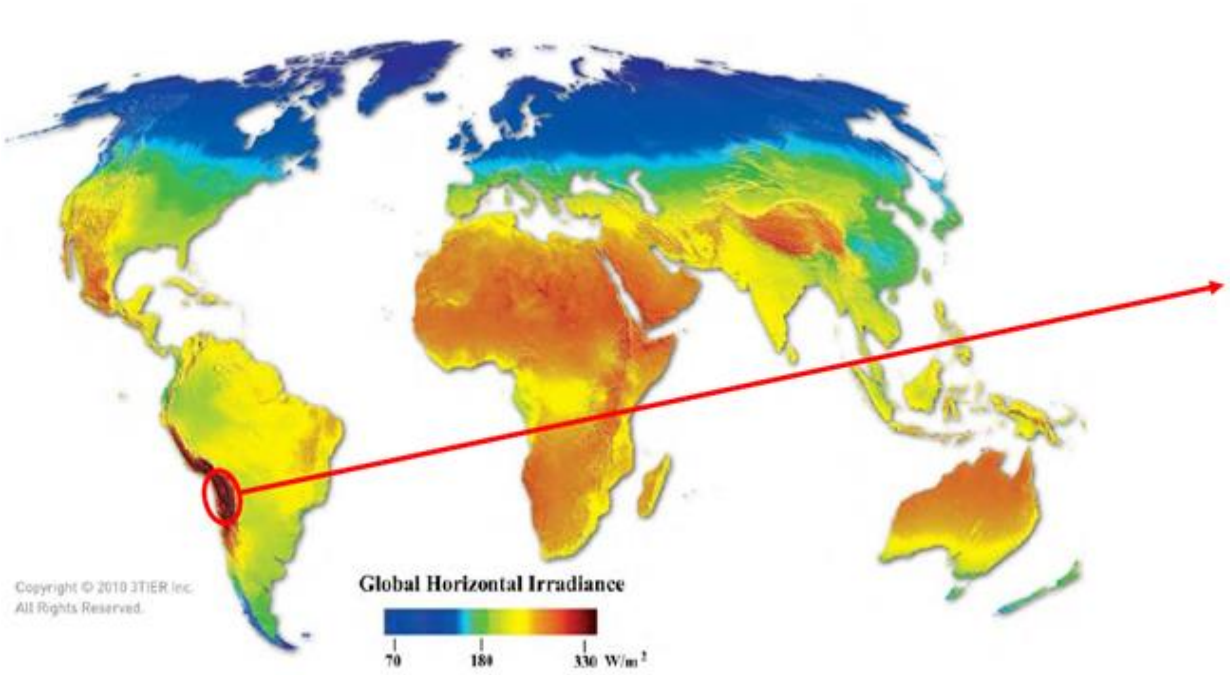
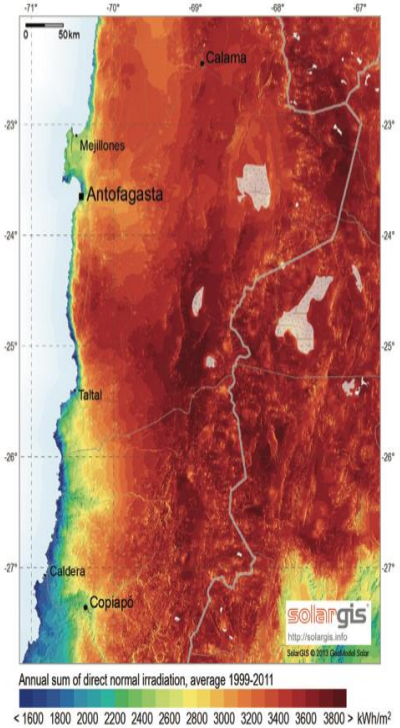
Antofagasta in the Global Solar Resource Map





High solar radiation > 2500 kWh/m2 (GHI) per year

Temperature fluctuations in the interior of the desert between -15°C to 50°C.

Mining, the main activity of the region

Several processes for mineral extraction

Residual salts
Bischofite ($MgCl_2 \cdot 6H_2O$)
Lithium carnallite ($LiMgCl_3 \cdot 6H_2O$)
Potassium carnallite ($KMgCl_3 \cdot 6H_2O$)
Kainite ($KMg(SO_4)Cl \cdot 3H_2O$)
Astrakanite ($Na_2Mg(SO_4)_2 \cdot 4H_2O$)
Lithium nitrate ($LiNO_3 \cdot 3H_2O$)

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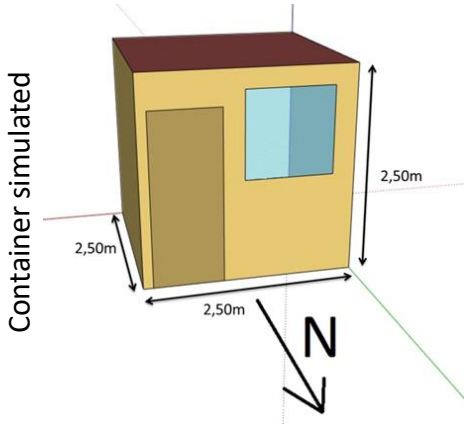
Energy Plus Simulations

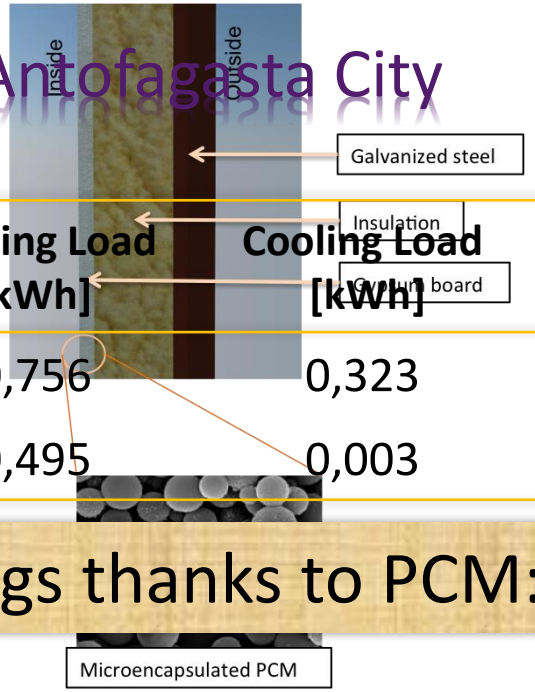


The objective of this study was to evaluate the thermal and energy performance of containers of 2.5×2.5×2.5 m^3.

Considering a theoretical geographical location:

- Antofagasta, Calama, Santiago and Concepción
- Containers: → with and without PCM
  → Distribution: north and south.
- Analysis of temperature fluctuations and energy consumption, for a period of one year.

Building Design: Different materials included in the wall



Antofagasta City

	Heating Load [kWh]	Cooling Load [kWh]	Total Load [kWh]
No PCM	0,756	0,323	1,079
PCM	0,495	0,003	0,497

Energy savings thanks to PCM: 53,89%

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Pilot-scale studies: Containers

Based on simulation results, containers had been constructed and sized with the same structural characteristics carried out in simulations.

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Collaborations

Universidad de Antofagasta

Solar Energy Research Center, SERC Chile.

National Commission for Scientific and Technological Research (CONICYT)

CELiMIN

Dr Svetlana Ushak

Co-oL Company, modular constructions

Mr. Carlos Loyola

University of Lleida, Spain

Research Team GREiA

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University of Auckland, New Zealand

Dr Mohammed Farid

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Research proposal

General objective

Determine the feasibility of applying a TCS reactor systems using water as sorbent together with salts of different nature as sorbent (*i.e.* commercial salts and residual salts from mining industry) and redesign the store/heat exchanger to reduce the thermal mass to obtain a better heat transfer yield.

Research proposal

- **Specifics objectives**

Residual salts
Bischofite ($MgCl_2 \cdot 6H_2O$)
Lithium carnallite ($LiMgCl_3 \cdot 6H_2O$)
Potassium carnallite ($KMgCl_3 \cdot 6H_2O$)
Kainite ($KMg(SO_4)Cl \cdot 3H_2O$)
Astrakanite ($Na_2Mg(SO_4)_2 \cdot 4H_2O$)
Lithium nitrate ($LiNO_3 \cdot 3H_2O$)

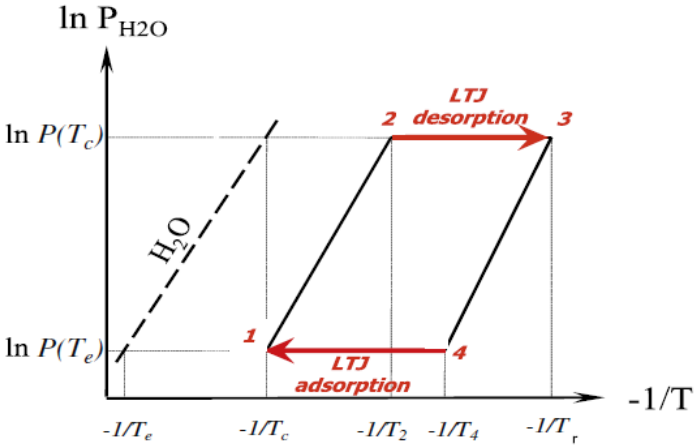
Theoretical evaluation of thermochemical sorption heat storage behavior of salts

Salts characterisation

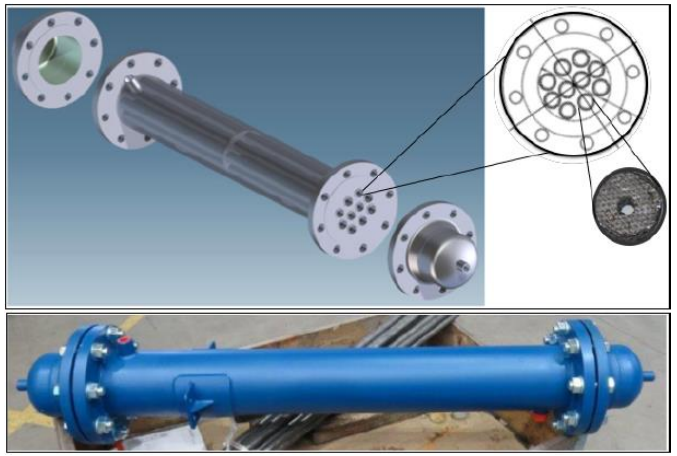
Preparation of composite materials

Research proposal

- **Specifics objectives**



Reaction rate test for the composite materials



Heat exchanger design

Heat exchanger tests

Work plan (Gantt chart)

Tasks	Year 1				Year 2			
Review of published articles								
Search for salts with appropriate reactions for application into TCS systems	×							
Prepare list of selected salts	×							
Determination of the energy storage capacity of salts. Chemical and Physical characterisation								
Chemical analysis of composition AA		×						
Identification of crystalline phases XRD		×						
Morphological analysis SEM		×						
Dehydration of samples TGA-DSC		×						
Thermal behaviour of the samples DSC		×						
Thermal stability and dynamic dehydration STA		×						
Determination of released gases and formation of solids TG-MS and XRD			×					
Determination of temperature limit conditions TG-MS and XRD			×					
Determination of the different stages of dehydration TG-MS and XRD			×					
Analysis of gaseous products MS			×					
Characterisation of thermal decomposition HT-XRD			×					
Preparation of composite matrix (ENG+salt)								
Conduct studies of conductivity, porosity, density and permeability to the ENG matrix				×				
Determine the best configuration of the ENG matrix					×			
Incorporate the sorbent (salt) into the ENG matrix					×			
Evaluation of dynamic reactions to the composite matrix using "large temperature jump" test								
Heat exchanger design								
Determination of design parameters						×		
Construction of the heat exchanger						×	×	
Test the heat exchanger (energy store) in the ThermExS lab facility								

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