CENTRE FOR RENEWABLE AND SUSTAINABLE ENERGY STUDIES

Dear Sir/Madam,

Herewith an invitation to our next forum:

Solar Concentrating Technology using Molten Salts – Chances and Challenges

by

Dr Luís Guerreiro

from University of Evora, Portugal.

Luís Guerreiro

SCIENTIFIC PROFILE

2016 Ph.D. in Mechatronic Engineering and Energy, Physics Department, Evora University „Energy Optimization of a Concentrated Solar Power Plant with Thermal Storage“
2011 Master of Business Administration, NOVA Business School-Lisbon & University of San Diego-California „Innovation-Case Study: Windfloat“

PROFESSIONAL CAREER

- since 2011 Researcher at Renewable Energies Chair, Uni.Evora, Responsible for EMSP
- 2006 – 2010 R&D Engineer and International Project Manager, Bosch Thermotechnik GmbH, Aveiro (PT) and Munster (D)
- 2005 – 2006 Photovoltaics Engineer and Business Developer, Donauer Solartechnik Lda, Lisboa (PT) and Munchen (D)
- 2001 – 2004 Researcher at Building Environment Institut, Kyoto (JP)
- 1998 – 2001 Trainee periods at Volkswagen (D), Galp Energia (PT), KEPCO and Eaton (JP)

RESEARCH TOPICS: Energy Storage, CSP, New materials for CSP applications, Heat Transfer

Presentation Outline

1. Renewable Energies Chair Structure
2. Infrastructures
3. Projects
4. Cooperation Long Term Agreements
5. Home country

Renewable Energies Chair @ University of Evora

Group Leader: Prof. Dr. Manuel Collares Pereira

RENEWABLE ENERGIES CHAIR

Scientific Council
A. Heitor Reis, J. Chaves

Board
Chairman: Manuel Collares Pereira
Members: Hugo Silva, Luis Guerreiro, Diogo Canavarro

Science Management

Units

Solar radiation
Director: H. Silva
Members: A. Cavaco, F. Lopes
- Resource evaluation
- Long term statistics
- Now-casting
- Design methods and tools

Advanced optics
Director: D. Canavarro
- Point focus concentrators
- Linear concentrators
- Secondary optics
- Design methods and tools

Solar thermal energy storage
Director: L. Guerreiro
Members: Dorin Golovca
- New storage concepts
- STE system integration
- New fluids
- Demonstration

Testing and certification of solar thermal systems and components
Coordinator: M. Collares Pereira
Members: T. Osório, J. Marchã
- Tests and standards
- Product development
- Systems and applications

Infrastructures

Site I - PECS
Solar Concentrators Testing Platform
Director: T. Osório
Medium temp. testing bench
Two-axis tracking platform with high temp. oil loop
Operational Responsible: J.Marchã

Site II - EMSP
Évora Molten Salt Platform
Director:
L. Guerreiro

Sites III, IV
PV + Advanced Batteries
Director: L. Fialho
Vanadium redox site
Li-Ion site

Systems engineering ,PV systems
Coordinator: Hugo Silva
Members: L. Fialho, R. Conceição
- Water and agriculture interfaces
- Electrical energy storage
- Other systems and applications
- Long term behavior of special components (glass/mirror soiling, ...)

Infrastructure

Site I - EMSP
Evora Molten Salt Platform

Testing of Linear Technologies
1,8MWth capacity
580C maximum operating temp.
2 MS tanks + drainage tank

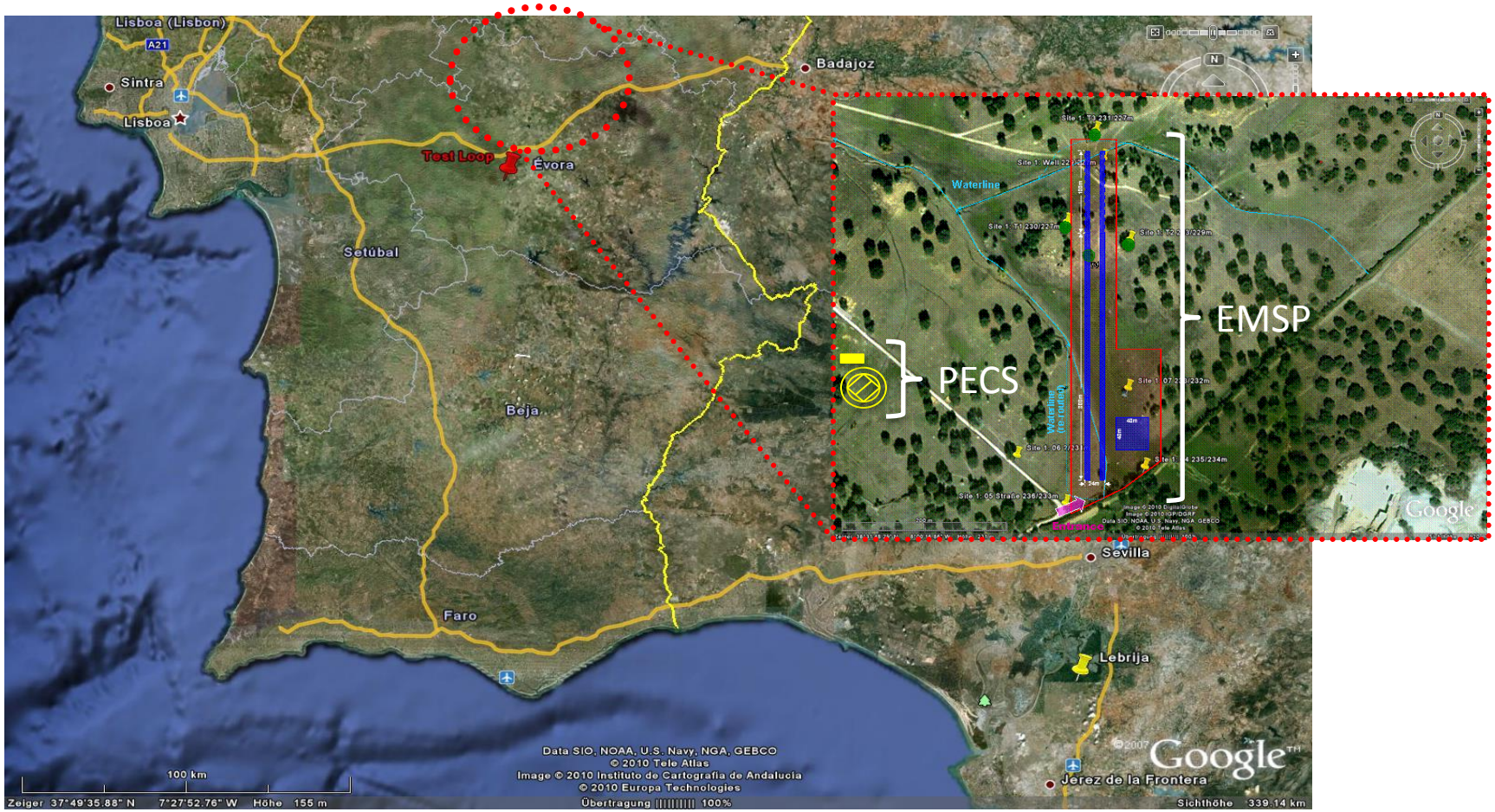
Site II - PECS
Solar Concentrators Testing Platform

Testing of Parabolic Through and Fresnel
270 degrees rotating Platform
400C Thermal Oil as HTF
18*13m test bench

Site III – PVS
Vanadium Redox storage
LI-Ion PV system

6.2 kW PV system on roof of building
5kW Vanadium Redox Flow Battery
6kW Lithium Battery
60KWh storage capacity

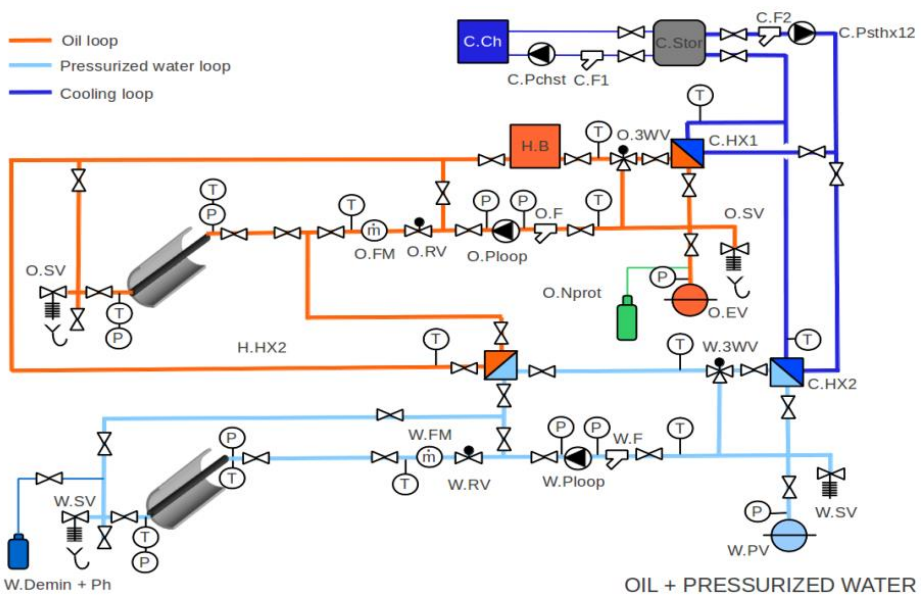
Location: Evora –PT (130km east of Lisbon and 110km SW of Badajoz)



EMSP= Evora Molten Salt Platform (T<580ºC)

PE CS: *"Plataforma de Ensaio de Coletores Solares"*

- Tracking Platform with 2 axes (13x18m2);
- Real size Solar Concentrators Testing
- HTF: Thermal Oil (T<400ºC)
- Linear Technologies (Parabolic, Fresnel) R&D and Certification (later stage)



EMSP

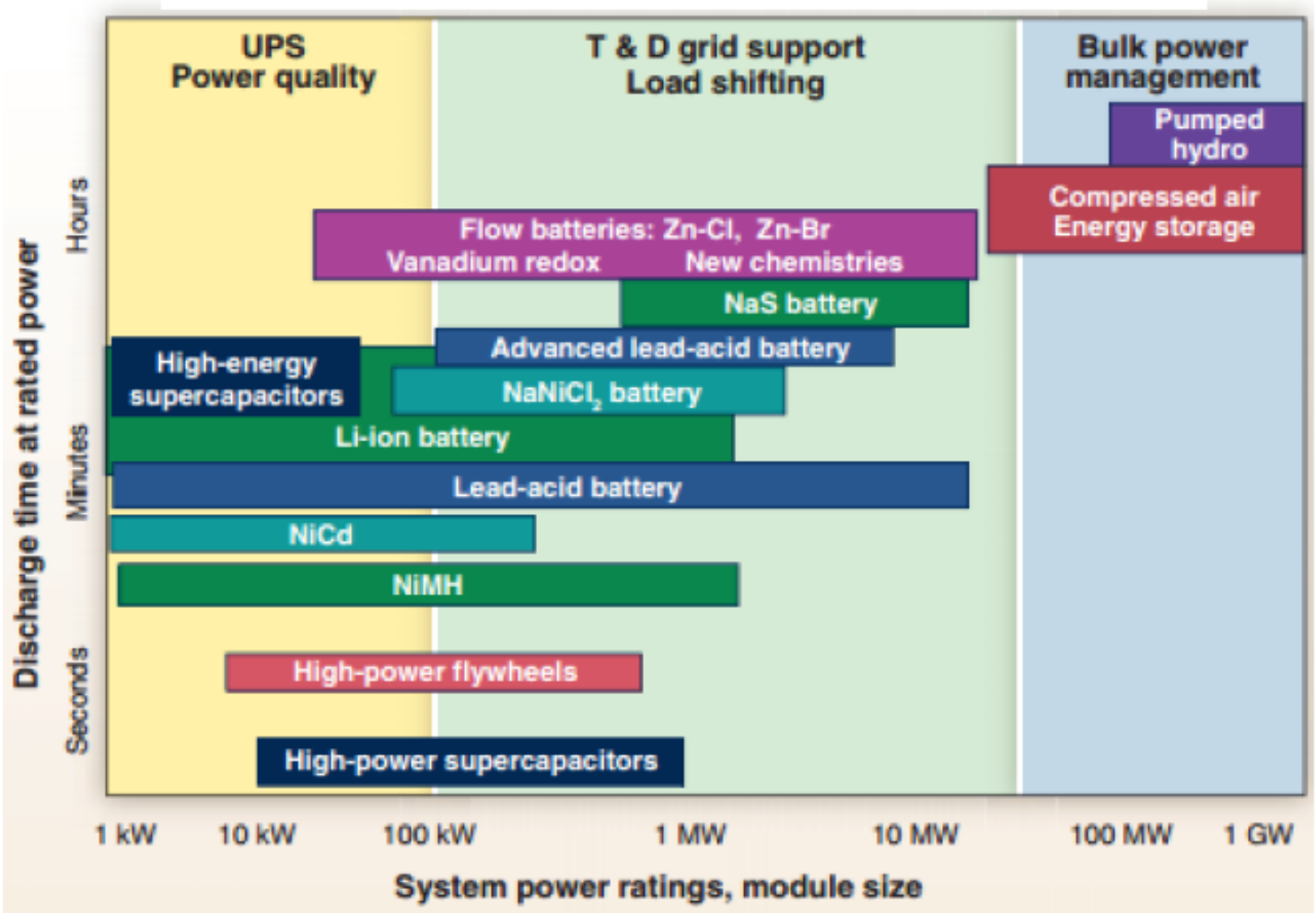
- Molten Salt T<580ºC
- Steam production (565ºC, 100bar)
- Solar Field foreseen:

- 1,6MWth- HelioTrough (Flagsol, Schott Receivers)
- 1.5MWth- LFR Etendue matched (MSALFR Project)

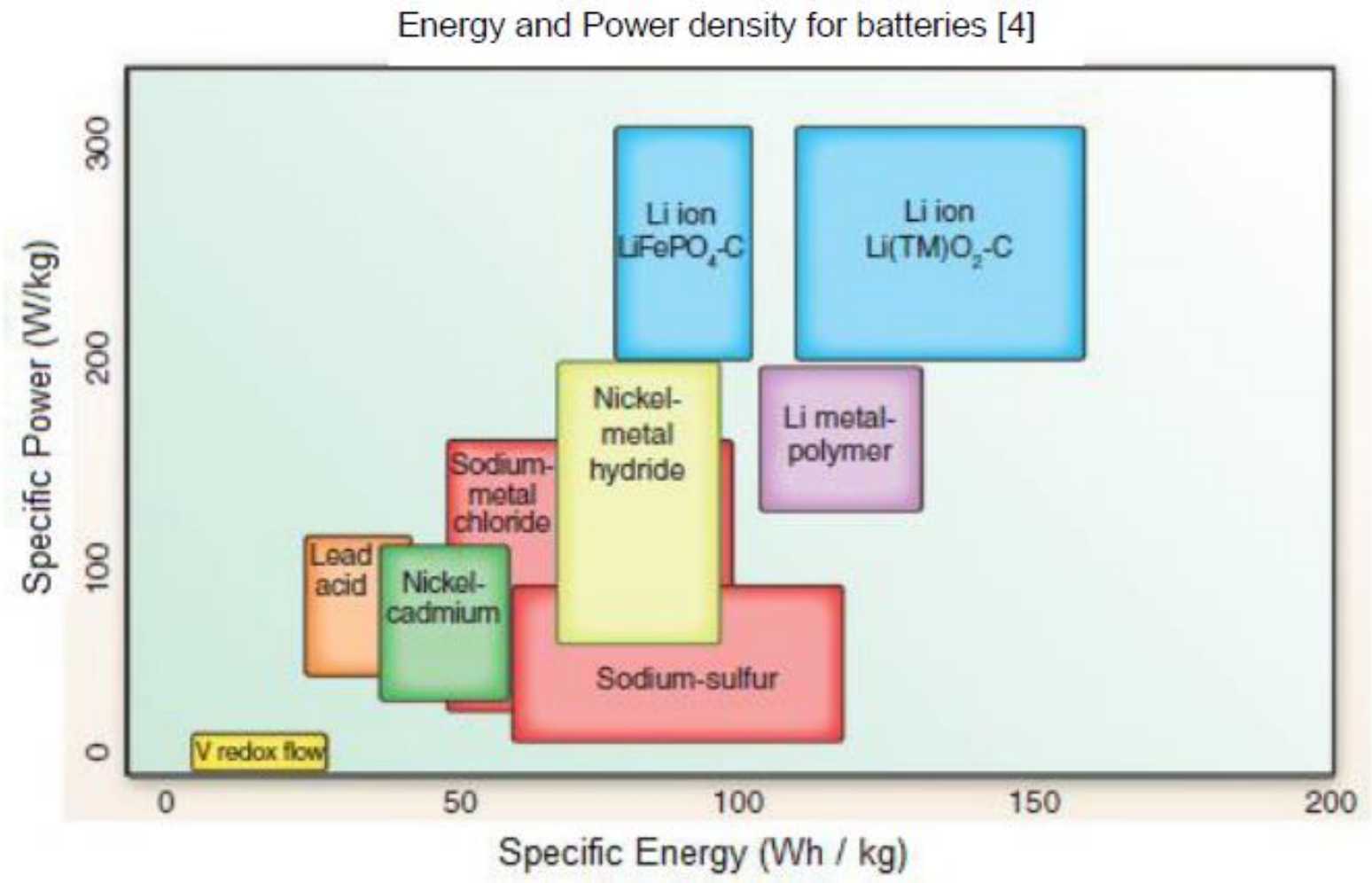
- Managed in co-operation with DLR

Energy Storage: a need to effectively run Energy Demand

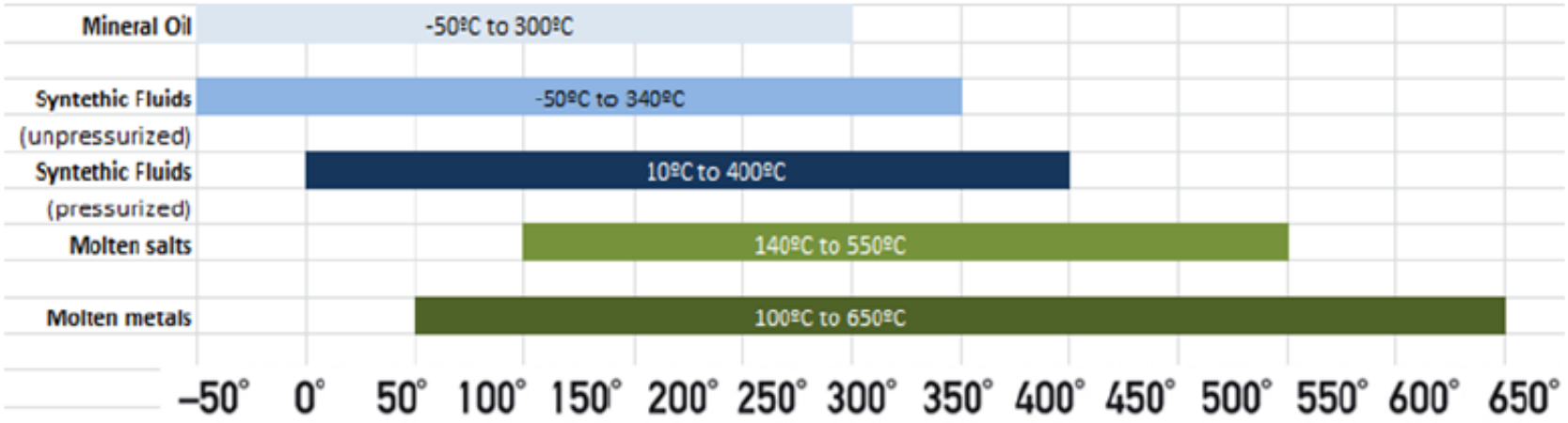
Energy Storage Technologies, discharge time and power ratings [13]



Energy Storage: the big advantage for Concentrated Solar Power



Molten Salts: the heat transfer and storage media



Molten salt	Minimum temperature	Maximum temperature
Salt 1: 60% Na NO_3, 40% K NO_3 (Solar Salt)	291ºC	600ºC
Salt 2: 7% $NaNO_3$, 53% K NO_3, 40%$NaNO_2$	170ºC	540ºC
Salt 3: 42% $Ca(NO_3)_2$, 15%$NaNO_3$,43%KNO_3	131ºC	560ºC
Salt 4: NaCl, Na NO_3, $NaNO_2$, KCl	140ºC	550ºC

Molten Salts: research ongoing

Molten Salts mixtures investigated for STE

$LiNO_3$	$NaNO_3$	KNO_3	$Ca(NO_3)_2$	-	Liq. T	
mol %	mol %	mol %	mol %	mol %	°C	
	50	50			223	Eutectic $NaNO_3$-KNO_3
	66	34			237	Hitec® Solar Salt
	7	44		49 $NaNO_2$	141	Eutectic comp. Hi-tec® HTF
	21	49	30		133	Eutectic comp. Hi-tec® XL
30	18	52			120	Eutectic $LiNO_3$-$NaNO_3$-KNO_3
31		58	11		117	Eutectic $LiNO_3$-KNO_3-$Ca(NO_3)_2$
31-27	20-11	38-50	12		<95	US 7,588,694
15	10	30	15	30 $CsNO_3$	65	J. W. Raade and D. Padowitz (Solar-paces 2010)

Project DNI -
Solar Radiation Ground Measurement

Uni Évora + IPES + AREANATEJO

And local companies:

Lógica

Enercoutim

Integrum Solar

Inegi

Generg

Measuring for 3 years:

Solar Global, Direct, Difuse

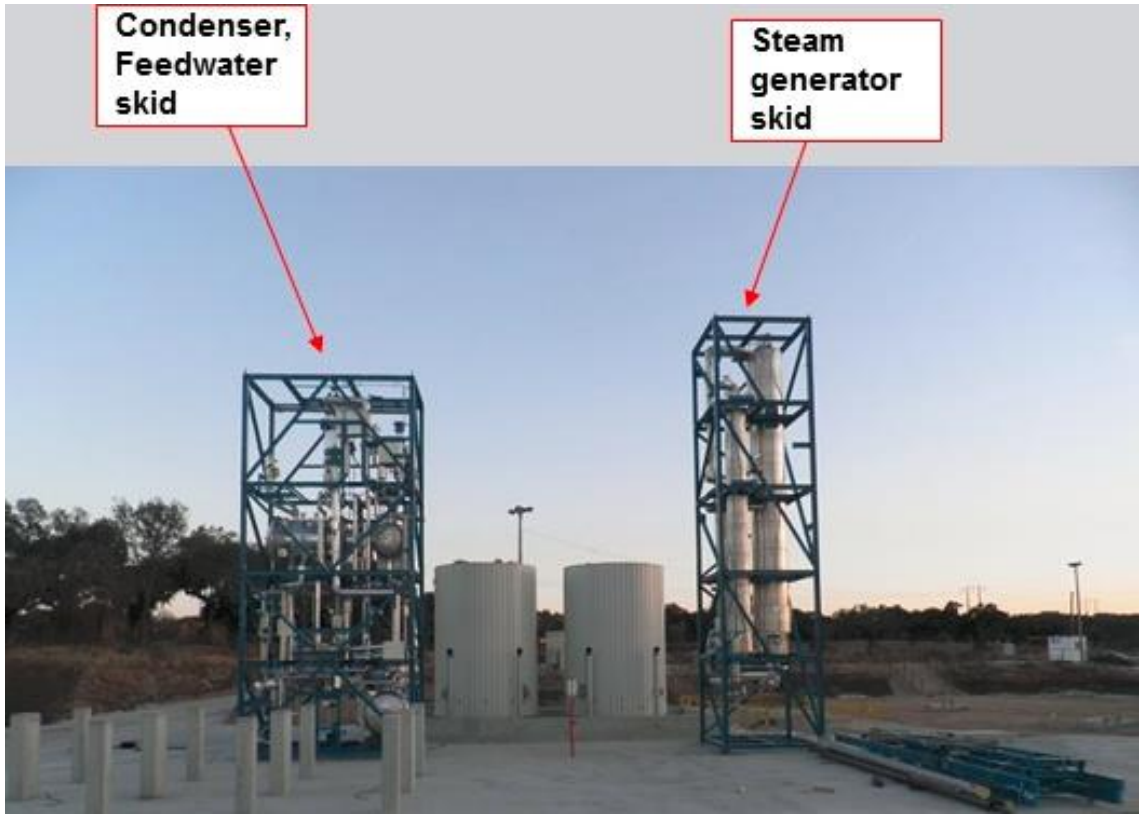
Number of Locations: 8

Project Maslowaten

- Optimize PV Operation with and without backup (diesel) system
- Agriculture applications: large PV irrigated systems (on / off-grid)
- 140kWp Demo at Olive tree farm (200ha) in Alentejo (PT)

Project HPS-2

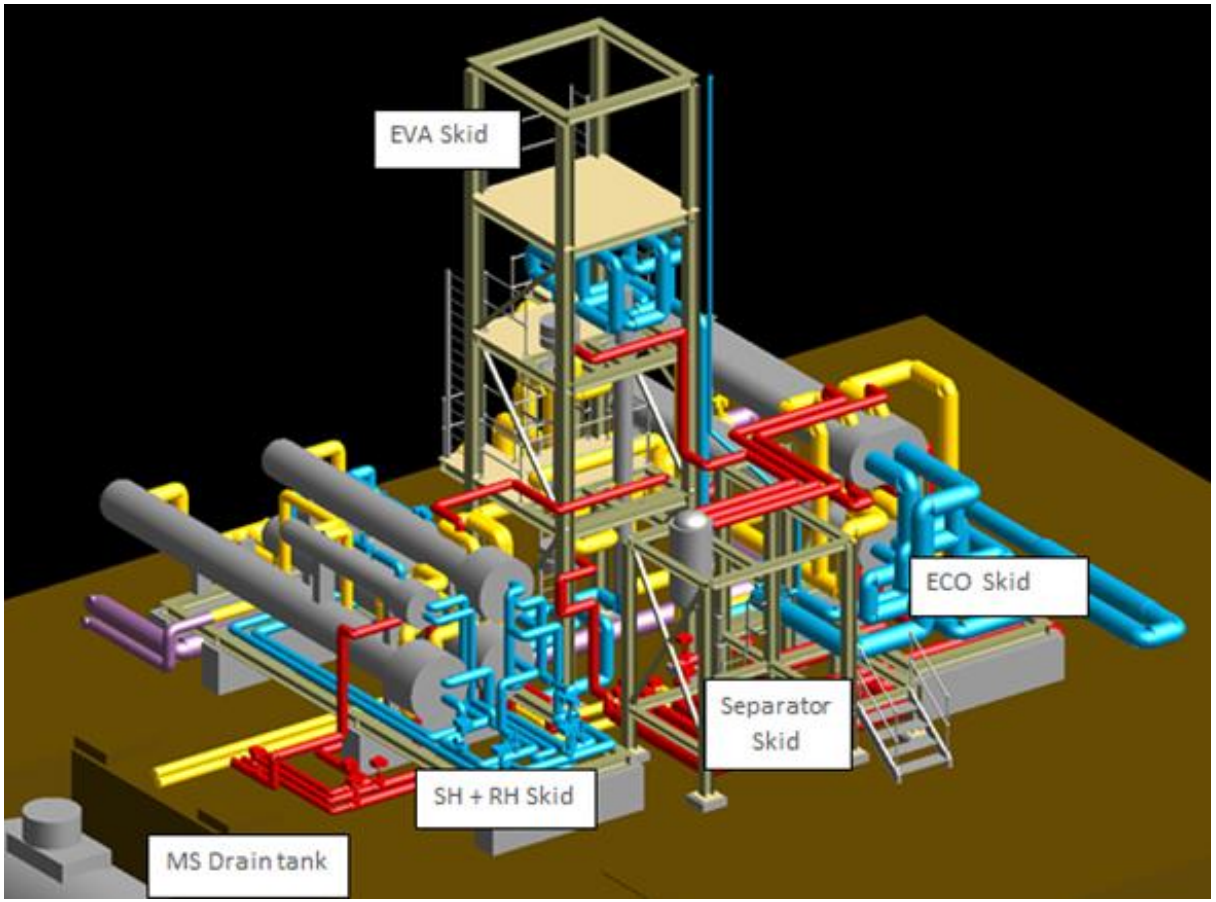
- Optimize Operation using Molten Salts in a direct system
- Heliotrough from Flagsol
- Test different drainage strategies;
- Test different molten salts with 150C and 220C melting temperature;



Partners:
DLR
Flagsol / TSK
Steinmuller
Yara
Eltherm
Eskom

Project PreFlexMS

- Design and operate a fast response MS/Steam heat exchanger
- Dispatchability and response similar to a Gas Power Plant
- Weather Forecast - Nowcasting



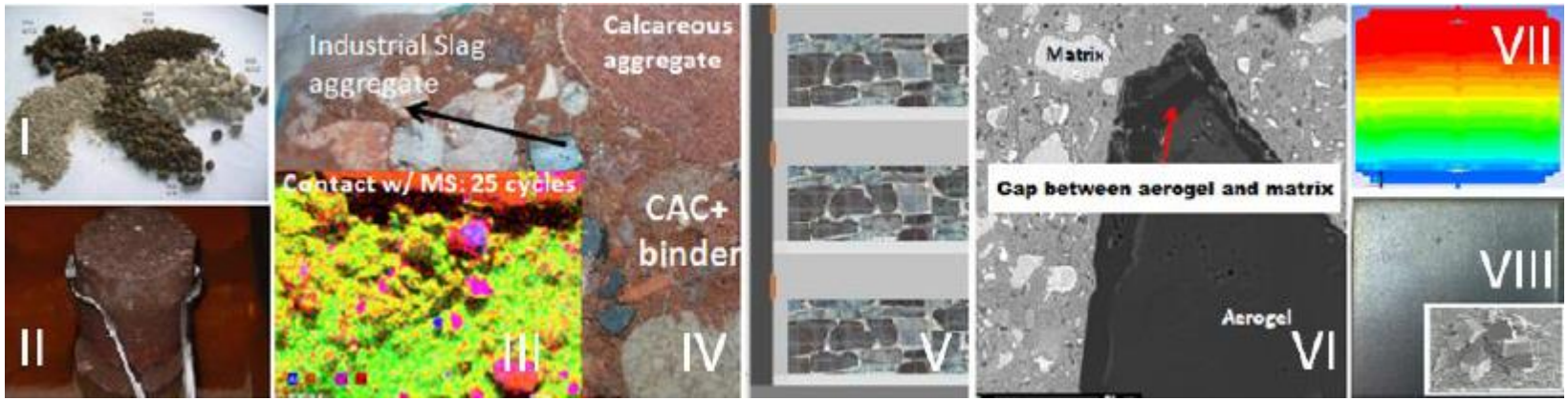
Partners:
DLR
GE
STF
ESE
CENER

Project NewSOL

- A broad team of experts from Academia and Industry
- Aim is to test and validate new storage concepts for CSP

Project NewSOL

- Storage up to 600C: Material durability and compatibility
- Thermocline type tank (new plant) and Concrete Module (retrofit)



R&D	Materials	State of the art	Breakthoughts
Binder	Concrete Mix	Concrete OPC till 400ºC validated for thermal storage Concrete CAC till 550ºC validated	Concrete mix till 550ºC w/ high thermal capacity Focus on OPC/CAC+ high minerals add. Incorporation of nanostructured carbon fibres
Filler and aggregates	Slag incorporation	Slag in concrete mix	Validation as filler material, direct contact slag / MS
PCMs	Heat storage	Non-incorporated into the tank	Incorporation of encapsulated PCMs into the tank
HTF	Molten Salts	Binary mixture of KNO_3 and $NaNO_3$	Ternary mixtures with reduced melting temperature Incorporation of nanoparticles with enhanced properties
Insulation materials	Insulation	Rockwool	Aerogel incorporated in the outer concrete wall and fundament
Sensor monitoring	functional coatings	only temperature/strain monitoring in harsh environments (550ºC)	Corrosion, pH, and pressure measuring in harsh environments (550ºC)

Cooperation Long Term Agreements

- Deutsche Luft- und Raumfahrt, DLR – Germany

  Projects at EMSP: HPS-2, PREFLEXMS, NEWSOL

- University of Esslingen – Germany

  Project: TERMSOL

- University of Stellenbosch, STERG – South Africa

  Linear Direct Molten Salt Systems, Thermal Storage

  Future: Molten Salt Fresnel Demo Project

  Advisory Board of NEWSOL

  Exchange of Students / Researchers

PORTUGAL

'n land met 'n groot landskap verskeidenheid

Noord: Minho + Tras-os-Montes
Port wyn en skouspelagtige Douro wingerde,
Aveiro ongelooflike kanale,
Braga met tradisionele kerke Barokke
Sentrum: Beiras + Ribatejo
Serra da Estrela berg met sneeu
Tipies dorpe van *Sortelha, Almeida, Monsanto*
Fado nasionale lied
Man te voet in die gesig staar 'n bul
Suid: Alentejo + Algarve
Ongelooflike strande
Riviere en Ria Formosa te verken met 'n kano
Ou dorpe(Monsaraz,Marvão)met pragtige uitsig
Açores eilande
Vulkaan en warmwaterbronne
Pynappel, tee en 'n groot kaas
Madeira eilande
Pragtige staproetes
Blomme in 'n tropiese klimaat
Uitstekende kos

1. Alentejo: *Vila Nova de Milfontes* en rivier *Mira*

Die kus van Alentejo is baie spesiaal, aangesien die meeste van hulle beskerm as 'n natuurreservaat. Alle gebiede moet wees soos hierdie met amazing strande, vissersbote en riviere met skoon water.

Rivier Mira is 'n awesome plek vir kano met kalm waters nooi vir 'n groot sonsondergang toe aankom na die see.


2. Alentejo: *Porto Covo* en *Ilha do Pessegueiro* (eiland van perske boom)
Wit huise met 'n pragtige blou of goue geel strepe, rus en vrede vlakke.
Almal weet die *Pessegueiro* eiland 'n mistieke plek wat 'n bekende en pragtige musiek verdien: www.youtube.com/watch?v=e5y76p4ksm8

3. Alentejo: Comporta

Lang sandduine, rys velde, die koninkryk van die Stork: sprakeloos

4. Monsaraz

‘n magie plek, natuur suiwer, megalithische kultuur en die donker lug vol sterre, een van die beste plekke in Europa om die skoonheid van die lug bewonder.

5. Alentejo: *Marvão*

Op die top van 'n berg, 'n juweel van menslike integrasie in die landskap. Pragtige natuurskoon is die beste waardeer in die nag, met ligte in die top van die berg asof vuurvliegies sou rus in die heel boonste.

Alentejo:
www.youtube.com
/watch?v=9IyNsusb7Zo&nohtml5=False

6. *Évora* en *Herdade do Esporão*

Evora, 'n muur stad waar huise lyk so goed inpas in die landskap. Romeinse ruïnes van “Diana”. Wingerde en heerlike plaaslike kookkuns kombinasie vis, aromatiese kruie, brood en olyfolie.

To all in STERG, specially to the research Partners Frank, Henk, Fady

Let's continue towards the **Cape of Good Hope** in Solar and CSP