

Developing advanced Concentrated Solar Technologies: an open innovation approach



CONSORTIUM FOR THE APPLICATION OF RESEARCH
AND CREATION OF INNOVATIVE ENTERPRISES

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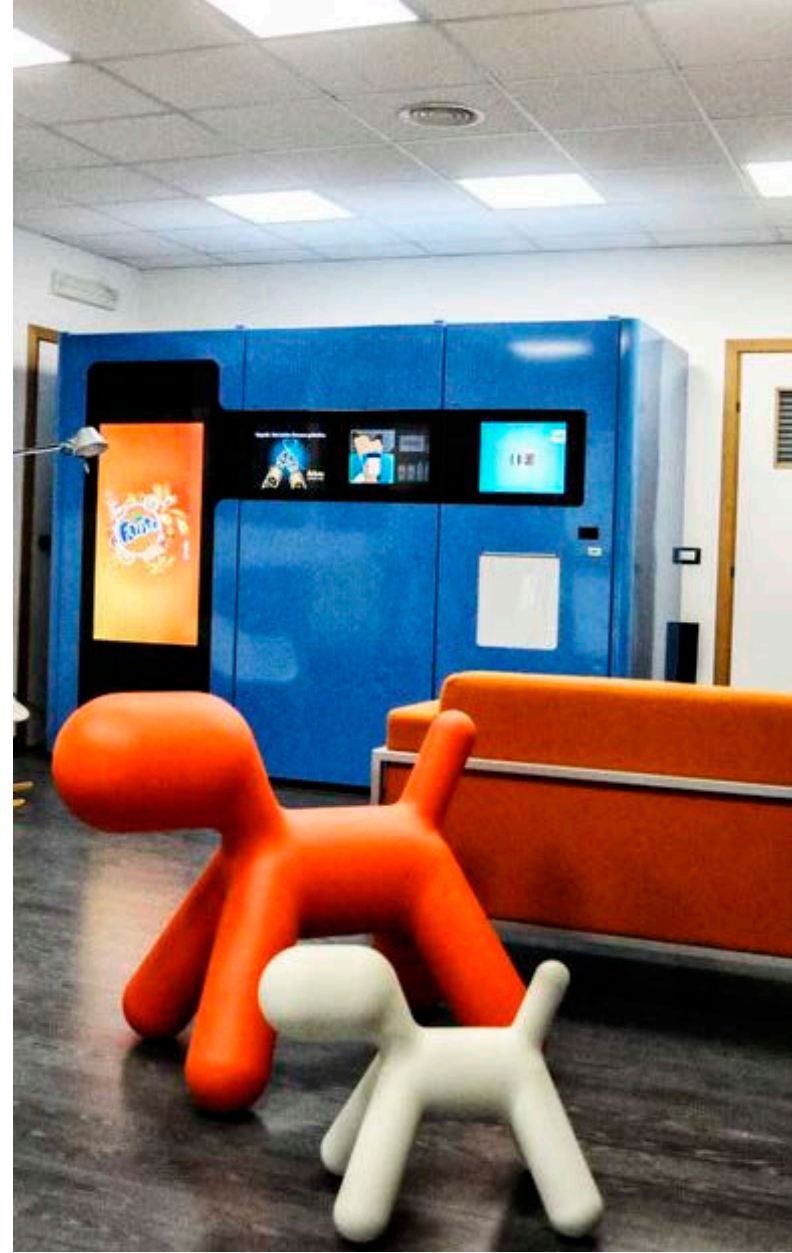
BUSINESS MISSION TO GABORONE, BOTSWANA - 5-6 July 2017

OUTLINE

- About ARCA
- Capacity building approaches and tools
- The Solar Living Lab
- Concentrating Solar technologies
- Cooperation opportunities

About us

ARCA is a **public-private consortium** established in 2003 by the University of Palermo and a private group founded by local researchers in mid 90s to promote innovative technology transfer processes.



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What we do

Business **incubation**

Technology transfer and development of **new products** with SMEs and clusters

Management of **capacity building** and **social innovation projects** involving local communities



Our methodology

- Create **multidisciplinary open innovation environments** to link startupperes, SMEs and clusters of SMEs, large enterprises, ...
- Run hybrid processes, mixing **scouting of ideas** with a bottom-up approach and **pathfinder RTD programs** able to generate competitive clusters
- Develop **international networks**
- Perform and promote a **Responsible Research and Innovation** approach



Our innovation hubs

- **High tech incubator** inside the university campus of Palermo
- **Creative industry hub** inside the cultural campus of the municipality of Palermo
- **Rural innovation hub** in the natural park of Madonie



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The Open Innovation platform

The screenshot shows the homepage of the 'wave' platform. The browser address bar displays 'wave.conorzioarca.it'. The website features a large red 'wave' logo and the tagline 'Innovation through collaboration'. A navigation bar includes links for 'ABOUT US', 'HOW IT WORKS', 'CONTACT', 'TERMS OF USE', 'SEARCH', and 'GO TO PLATFORM'. Below the main banner, a flowchart illustrates the user journey:

- Share your project** (top left)
- Catch a new contribution** (middle left)
- Post your update** (bottom left)
- Reach your goals** (bottom left)

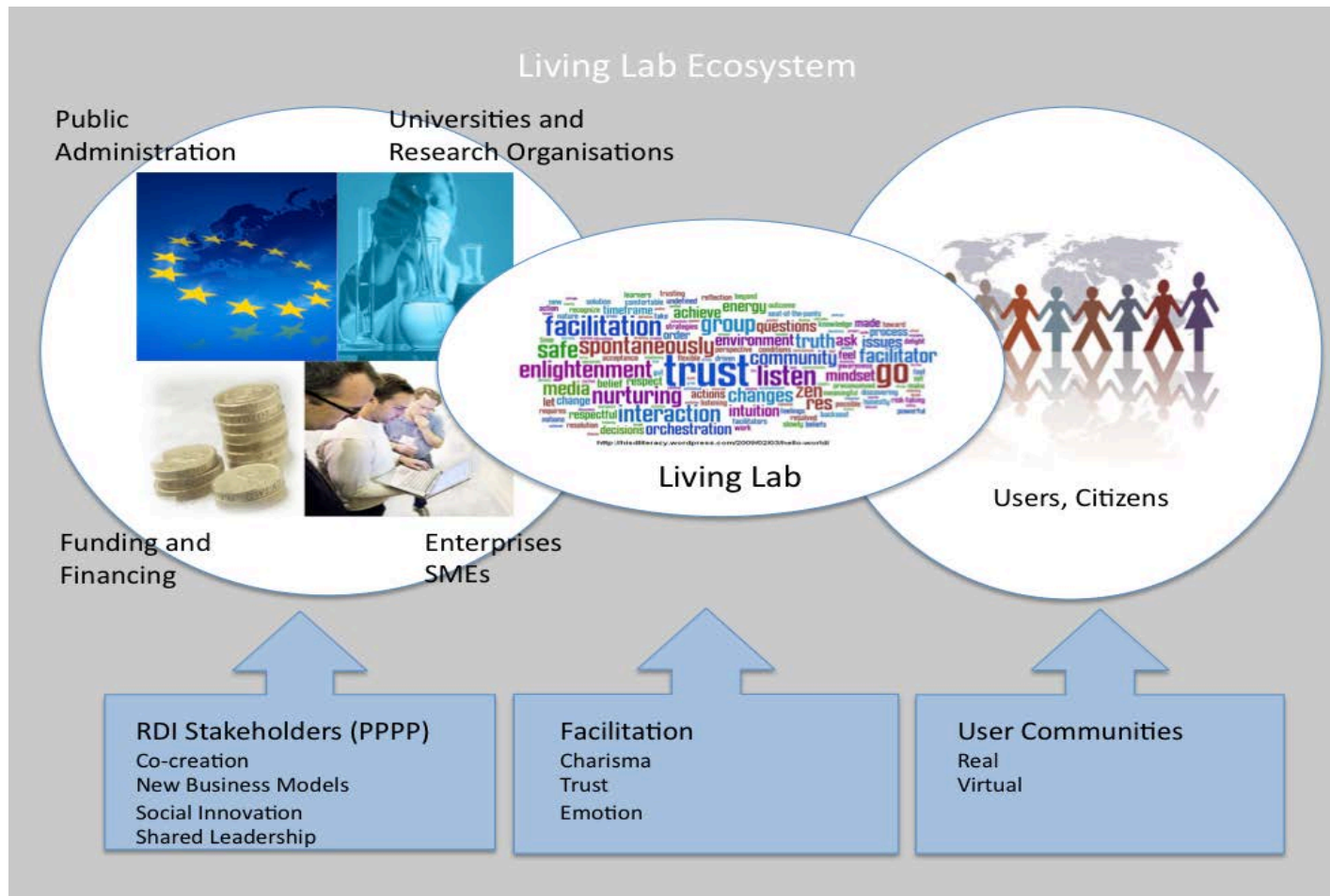
The central flowchart consists of several interconnected boxes:

- Challenge** (red box)
- Project** (orange box)
- Brainstorm** (red box)
- Read** (grey box)
- Comment** (grey box)
- Vote** (grey box)
- Share** (grey box)
- Idea** (blue box)
- How-to** (pink box)

On the right side, the flowchart leads to:

- Share your creativity and skills** (top right)
- Collaborate with other project** (bottom right)

The Living Lab model



ARCA hosts three Living Labs

Textile&Cloths LL

Madonie LL

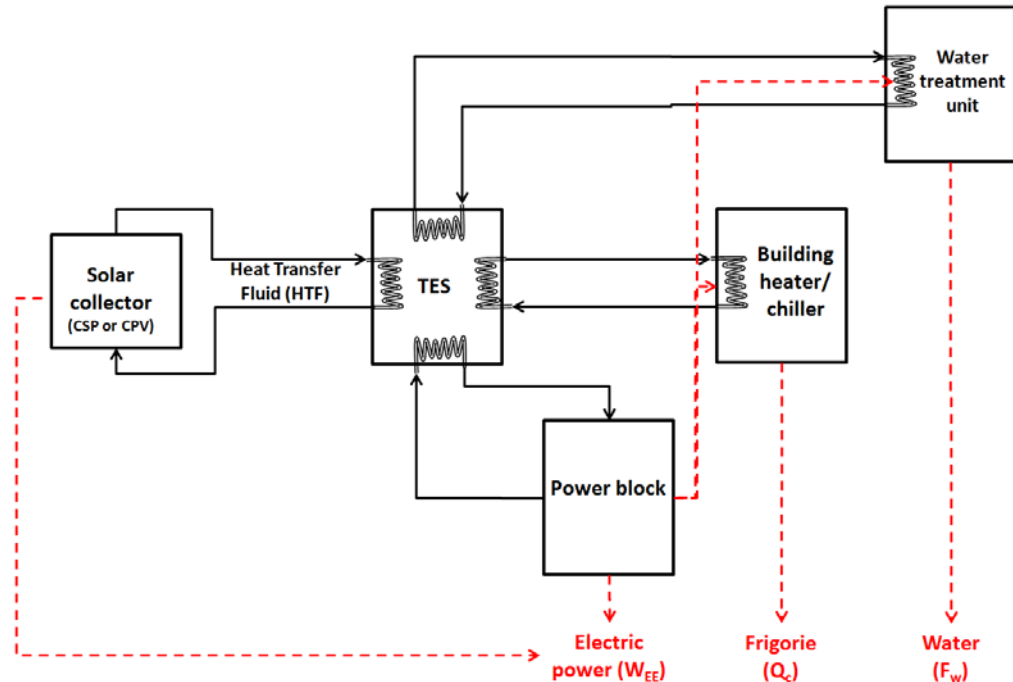
Solar LL

All acknowledged by the European Network of Living labs

European Network of Living Labs

The Solar Living Lab: background

- Solar radiation is a **relevant asset** of our region and an industrial specialization in this field is envisaged in our Smart Specialization Strategy.
- Opportunities were available in advanced solar systems specially designed for **distributed polygeneration** (heating, cooling, power, water treatment) based upon **innovative storage**.
- We needed **both local and international networking** for joint designing, prototyping and testing of solar components and systems.



What is SoLL doing?

- **Exploits** a research, innovation and educational demonstrative infrastructure within the university campus, open to citizens
- **Supports** knowledge and technology transfer to the productive system, competence development for better employability, self-employment and entrepreneurship in renewable energies
- **Hosts** a showcase of innovative projects generated in the research labs, bridging the gap between the research results, the technological development and the market
- **Coaches** promising entrepreneurial teams in the energy sector
- **Promotes** a larger ecosystem conducive to innovation and entrepreneurship, facilitating sustainable development transition



The cooperation network of SoLL

- ENEA (ITALY)
- CNR ITAE (ITALY)
- CNR ISSIA (ITALY)
- UNIVERSITY OF MESSINA (ITALY)
- UNIVERSITY OF PERUGIA (ITALY)
- UNIVERSITY OF FIRENZE (ITALY)
- UNIVERSITY OF CATANIA (ITALY)
- NATIONAL INSTITUTE OF ASTROPHYSICS (ITALY)
- LOCCIONI GROUP (ITALY)
- ARCHIMEDE SOLAR ENERGY (ITALY)
- ENEL INNOVATION LAB (ITALY)
- ABB (ITALY)
- ENGINEERING INGEGNERIA INFORMATICA (ITALY)
- ITALIAN CSP ASSOCIATION – ANEST
- TU DELFT (NETHERLAND)
- TU MUNICH (GERMANY)
- UNIVERSITY OF ATHENS (GREECE)
- TECHNICAL UNIVERSITY OF CRETE (GREECE)
- IASA (GREECE)
- NATIONAL UNIVERSITY OF SINGAPORE
- CEA (FRANCE)
- AVITEM (FRANCE)
- OPAC 38 (FRANCE)
- THE CYPRUS INSTITUTE
- TU OF CYPRUS
- GEORGE VASSILIOU LTD (CYPRUS)
- BEN GURION UNIVERSITY (ISRAEL)
- JORDAN UNIVERSITY OF SCIENCE AND TECHNOLOGY
- AL BAQA UNIVERSITY (JORDAN)
- ACADEMY OF SCIENCE RESEARCH AND TECHNOLOGY (EGYPT)
- NATIONAL RENEWABLE ENERGY AGENCY (EGYPT)
- ESPRIT UNIVERSITY (TUNISIA)
- SHEFFIELD UNIVERSITY (UK)
- OXFORD BROOKES UNIVERSITY (UK)
- BRUNEL UNIVERSITY (UK)
- UNIVERSITY OF ZARAGOZA (SPAIN)
- UNIVERSITY OF VALENCIA (SPAIN)
- UNIVERSITY OF SOUTH WALES (AUSTRALIA)
- TAI CRYSTAL (TAIWAN)
- UN – SUSTAINABLE DEVELOPMENT SOLUTIONS NETWORK
- INTERNATIONAL SOLAR ENERGY ASSOCIATION
- ...



Capacity building in Madonie

1. Vision, leadership, participation

2. Knowledge and governance tools

3. Awareness: the schools at the center of the transition process

4. Demonstration of appropriate technologies

5. Business and management models



- Very **ambitious but reasonable targets**
- Leverage on the **memory of energy** as a local renewable resource
- Hands-on educational model to be implemented through **energy fablabs** integrated in primary and secondary schools
- **Benchmarking** with similar communities going to 100% RES
- Workshops on the **RRI approach** setting a playground for visiting researchers



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TECHNOLOGY OUTCOMES FROM SOLL

HIGH PERFORMANCE CONCENTRATING SOLAR
THERMAL POLYGENERATION SYSTEMS

ULTRA HIGH CONCENTRATING
PHOTOVOLTAIC/THERMAL MODULES

OTHER TECHNOLOGIES FOR DISTRIBUTED
GENERATION

MONITORING SYSTEMS

FRESCO: DOWNSCALING CSP TECHNOLOGY TO DISTRIBUTED POLYGENERATION

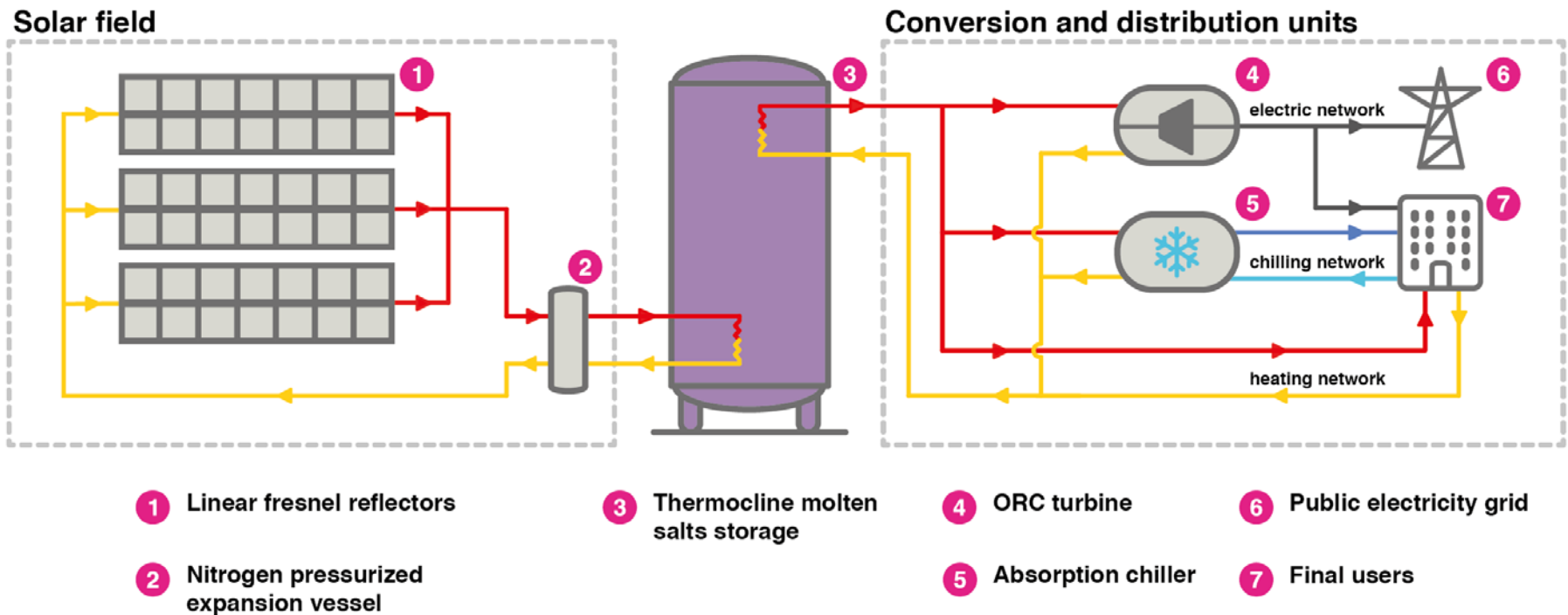
- Modular & cost effective
- Easy to mount and “roof ready”
- Integrated polygenerative modules
 - Double effect absorption solar cooling
 - High efficiency TES
 - ORC power unit
 - Low/mid enthalpy water treatment



Suitable for

- District Heating&Cooling
- Industrial thermal processes
- Food logistics
- Small CSP plants
- ...

A FURTHER DEVELOPMENT OF THE POLYGENERATION CONCEPT



FROM FRESCO TO STS-MED DEMOS



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SOLAR FIELDS







STSmed



Programme funded by the
EUROPEAN UNION



	Cyprus	Egypt	Italy	Jordan
				
Location	Aglantzia, on the roof of a school, next to the NTL	Markaz Belbes, nearby the Sekem medical center	University of Palermo, on the ground at ARCA premises	Irbid, roof a building of the Al Balqa University College
Latitude	35°08'28.1"N	30°25'05.5"N	38°06'01.0"N	32°29'13.2"N
Longitude	33°22'50.7"E	31°38'07.8"E	13°20'37.3"E	35°53'24.0"E
Elevation	176m	35m	50m	648m
DNI per year	2142 kWh.m ⁻²	1958 kWh.m ⁻²	1703 kWh.m ⁻²	2377 kWh.m ⁻²
Type of collector	LFR	LFR	LFR	PTC
Aperture area	184.32 m ²	299.50 m ²	483.84 m ²	163.2 m ²
Thermal oil	Duratherm 450	Therminol 66	Paratherm NF	Seriola eta 32 - Total Lubmarine
Peak power	70 kW	115 kW	190 kW	85 kW
Receiver length	32 m	52 m	84 m (3 x 28 m receivers rows)	38.56 m
Working temperature	170°C	140°C	280°C	240°C



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THERMAL STORAGE



STS^{med}



	Cyprus	Egypt	Italy	Jordan
Medium	Pressurized water	Thermal oil (Therminol 66)	Ternary molten salts mixture (CaNO ₃ NaNO ₃ KNO ₃)	Thermal oil (Seriola eta 32 - Total Lubmarine)
Storage Volume	2.0 m ³	2.8 m ³	8 m ³	1.3 m ³
Storage capacity	100 kWh	21 kWh	400 kWh	30 kWh
Average temperature	146°C	140°C	260°C	240°C



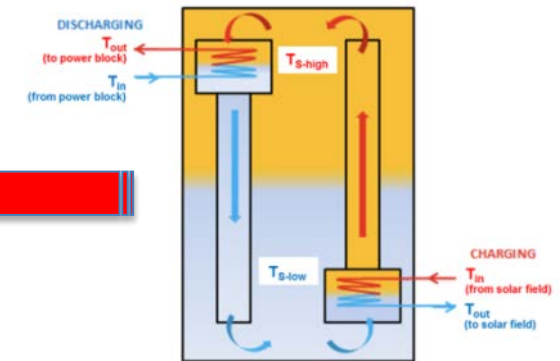
Thermal oil tank in Jordan



Pressurized water tanks at Cyl



Tank of molten salts and buffer of oil at ARCA



Molten salts storage designed by ENEA



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POWER GENERATORS AND CHILLERS



	Cyprus	Egypt	Italy	Jordan
Model	YAZAKI WFC-SC10	YAZAKI SH10	Broad BCT 23	Robur ACF 60-00 HT
Type	LiBr – Single effect	LiBr – Single effect	LiBr – Double effect	Ammonia – Single effect
Firing medium	Water	Thermal oil	Thermal oil	Thermal oil
Cooling capacity	35 kW	35 kW	23 kW	17.1 kW
Inlet temperature	88°C	88°C	200°C	240°C
COP cooling	0.7	0.7	1	0.6
Heating capacity		48.3 kW	23 kW	



Steam turbine at Al Balqa



Chiller at Cyl



Chiller at ARCA



Chiller at Al Balqa



ORC at ARCA

	Egypt	Italy	Jordan
Element	ORC	ORC	Steam turbine
Electric power	4.3 kW	10 kW	1.2 kW
Medium	Thermal oil	Thermal oil	Steam



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PLANNED DEVELOPMENTS

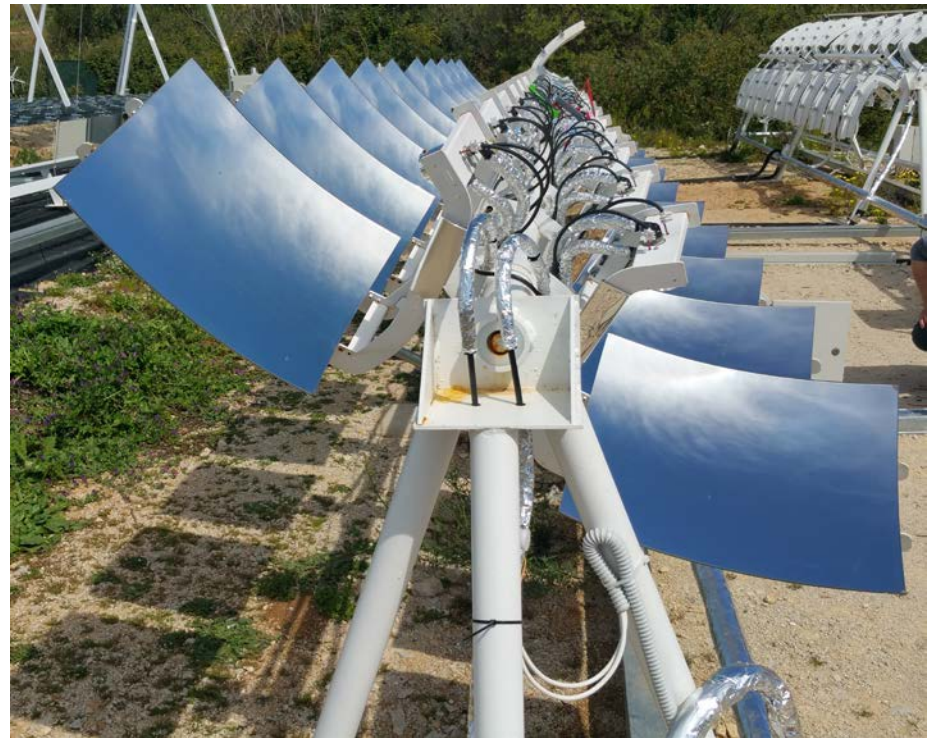
- Greenhouse/solar canopy integrated design
- Improvement of the integrated control system
- Scale-up projects
- Testing triple-effect absorption chillers
- Effective hybridization with biomass/gas



FAE - A RECORD UHCPV-T SYSTEM

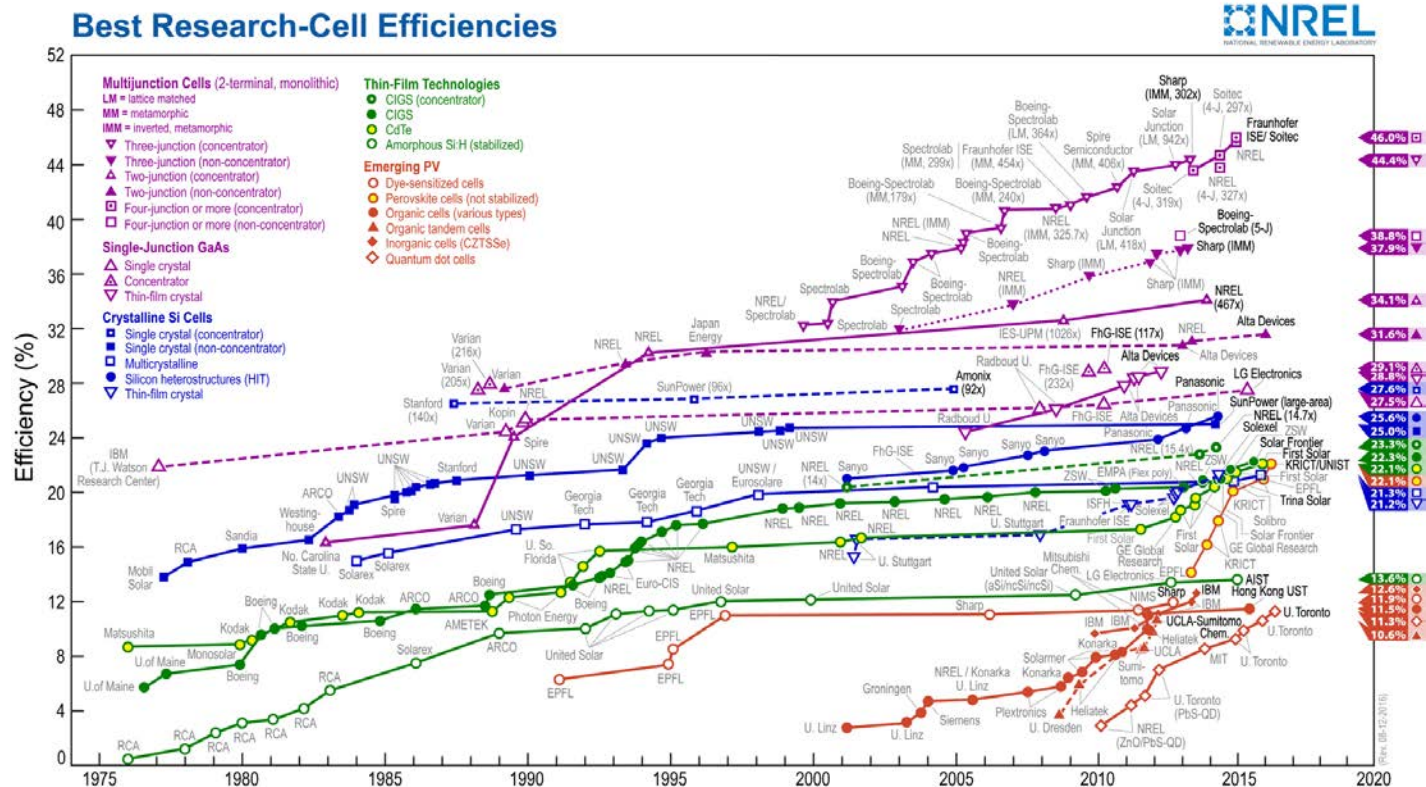
HCPVT can provide an unbeatable global efficiency **electricity + thermal energy**. As T_{out} can be raised up to 100°C, solar cooling and water treatment services can be integrated to PV/T generation.

Net surface single mirror	2,025 cm ²
Solar concentrator	≈ 2,000x
Optical efficiency	90%
Mirrors per module	20
Cells per module	20
Module elect. efficiency	≈ 30%
Module thermal efficiency	≈ 45%
Overall efficiency	≈ 75%
Peak electrical power	≈ 1.000 W _{ep}
Peak thermal power	≈ 2.000 W _{thp}
Tracking system	Alt-Alt
Dimension	1,4 x 6,5 m
Weight	280 Kg
Heat transfer fluid	glycol & water
Flow rate per module	4 l/min
Heating temperature	≈ 70°C

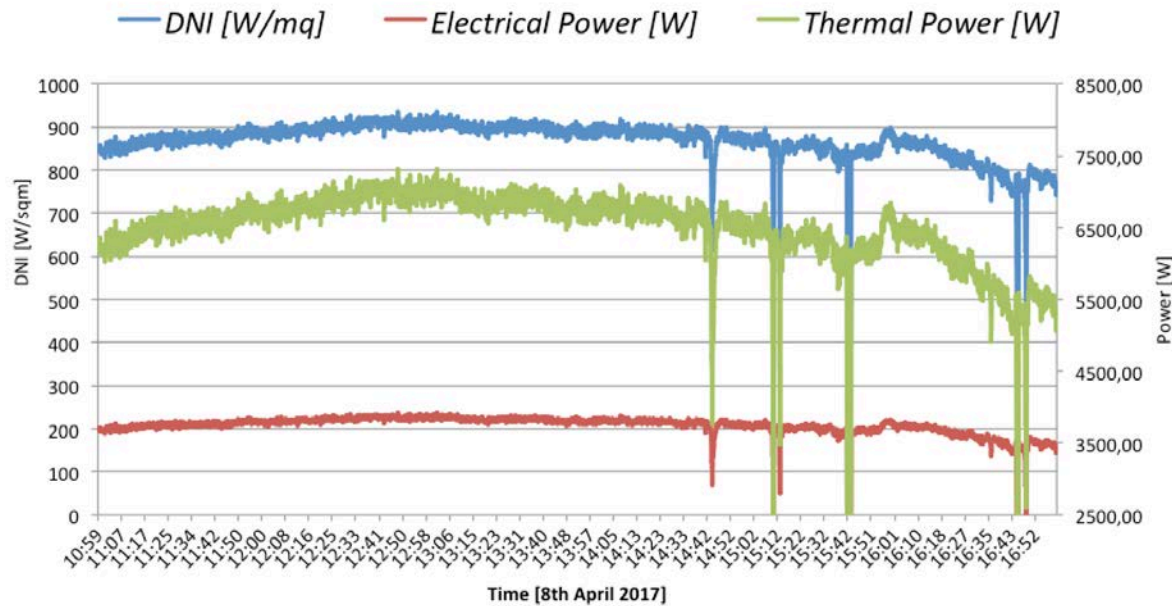
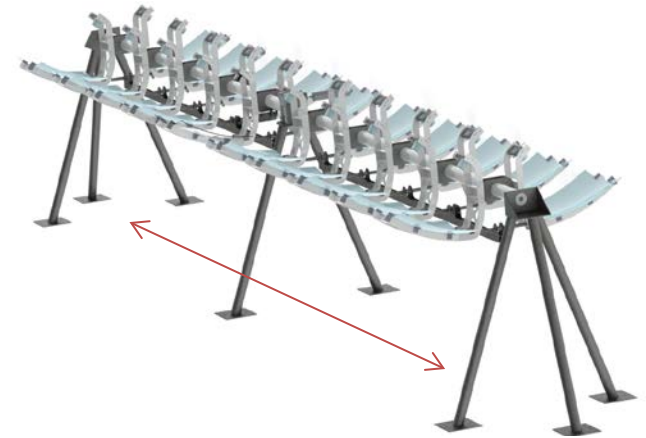


WHY CPV?

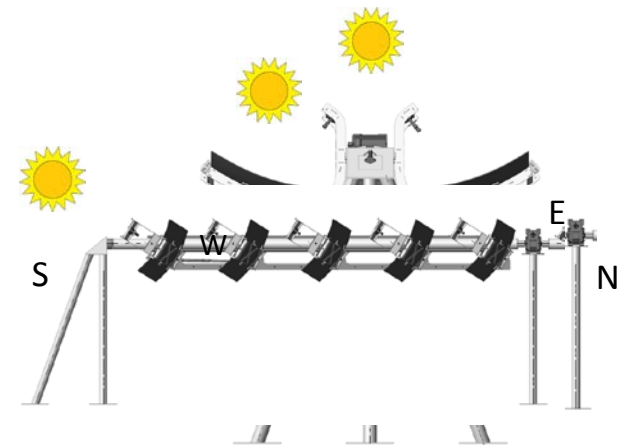
- The most efficient solar cells are MJ cells based on III-IV compound semiconductor materials
- In locations with **high DNI**, by concentrating the solar radiation onto these high efficiency cells, we can get an **higher energy density** per square meter than by traditional PV
- The latest generation of multi-junction solar cells already converts 46% of the solar light into electrical power. **The 50% target should be reached soon.**



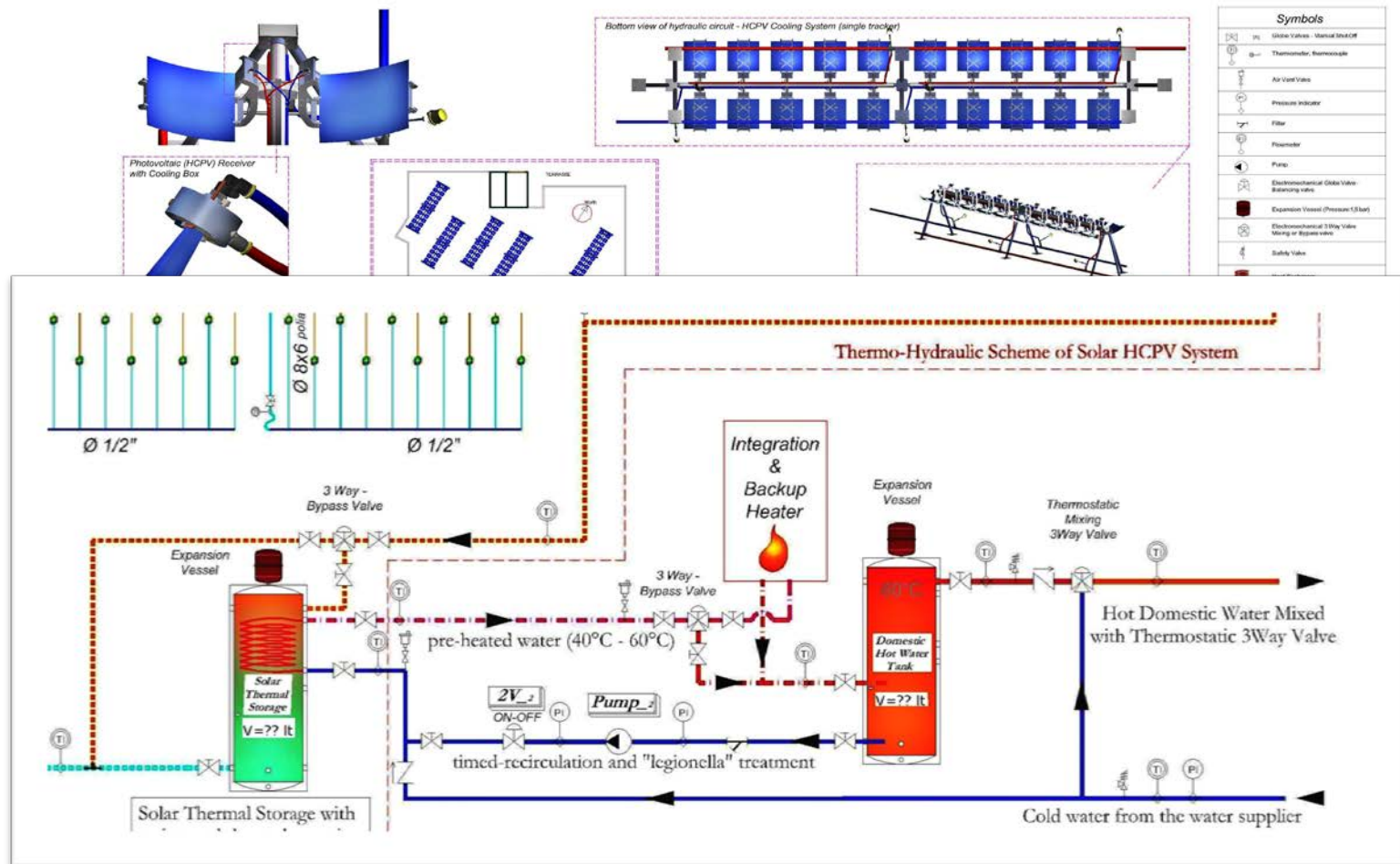
TRACKING CONFIGURATION AND PERFORMANCE



North - South
orientation



LAYOUT FOR HOME PW+DHW GENERATION



PILOTING INSTALLATIONS

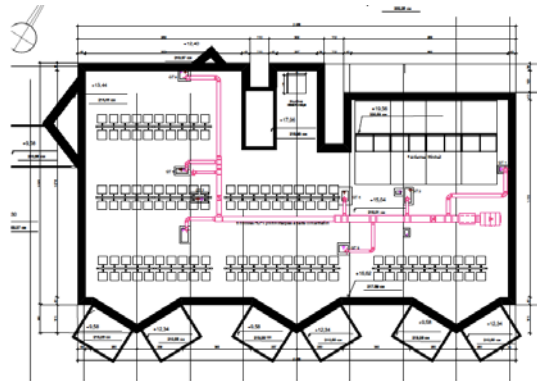
Horizon 2020 Zero Plus project: Achieving near Zero and Positive Energy Settlement in Europe using Advanced Energy Technology

- 16% initial cost reduction with the reference case
- Net regulated energy consumption of less than 20 KWh/m² per year
- Energy production by RES of at least 50kWh/m² per year

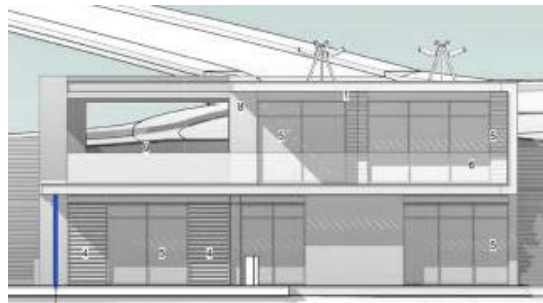


HCPV installations

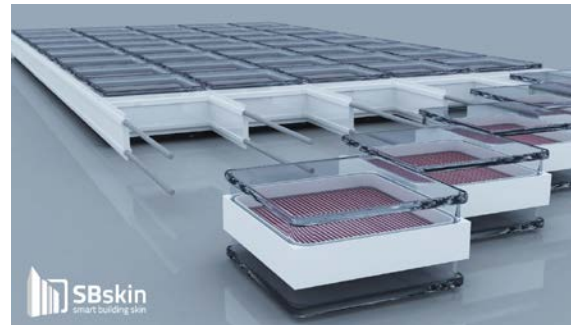
Voreppe (France)



Paphos (Cyprus)



Other SoLL technologies



What can we do together?


- Capacity building initiatives connecting the different stakeholders establishing a pathway towards a **Botswana RES living lab** for the development of new products/services/business models fitting into the **local priorities**, involving **young entrepreneurs and innovators**
- Joint projects in **high performance solar thermal and CPV** applications to civil and industrial sectors (process heat, SHC of public buildings, application to water pumping and treatment, ...) in cooperation with local SMEs and professionals




Thank you for the invitation and for your kind attention.

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