AIM SEA Associazione Italiana delle Macchine a fluido e dei Sistemi per l'Energia e l'Ambiente

Mini Grid Day Sapienza University Rome
21st of June 2018
University of FLORENCE

Research *SOLAR-SOLUTIONS*

Maurizio DE LUCIA - Research Group Responsible

Giuseppe FRANCHINI: Univerisisty of BERGAMO (giuseppe.franchini@unibg.it)
Valeria GAMBINO: University of PISA (valeria.gambino@unifi.it)
Giuseppe TONIATO: KAYMACOR srl (giuseppe.toniato@kaymacor.com)
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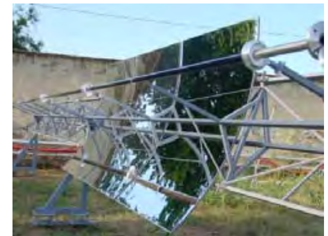
Univerity of Florence, Bergamo, Pisa – Kaymacor srl, ARCA&IDEA srl

Speaker: Maurizio DE LUCIA

UNIFI : Research History

Fig.2 – UNIFI – Recent progress and research journey in the frame of APOLLO project



FP6 REACt

Solar&Heating and Cooling with Parabolic trough collector (PTC). Installation in Mediterranean Area (JORDAN, MOROCCO)

1° SHC

www.crear.unifi.it/react

PARTNERSHIP
DLR, CRER, NERC, SOLITEM, SHAP

SALTO

Parabolic trough collectors (PTC) assembled at UNIFI : aperture area between 7,5 and 11m² each

1° PTC

Italian

PARTNERSHIP
CNR, several Italian COMPANY

PRIN2007
SOLIDE

Parabolic trough collector (PTC) improvement

Aperture 1.6m

Efficiency 60% (170°C)

PTC upgrade

PARTNERSHIP
UNIBG, UNILE, UNICA+Italian COMPANY

CESARE
SCOOP

Hybrid concentrated photovoltaic and thermal collector

Aperture Area: 14,5 m2

Power: up to 2.2 kWp

HEAT: 4,3 kWth

CPV-T

PARTNERSHIP
ENEL, CESI, POLIMI, UNIPD,CNR, ENEA, CNR Archimede Solar Energy several Italian COMPANY

FP7-ALONE
PIACE

New generation SHC with DSG (Direct Steam Generation)

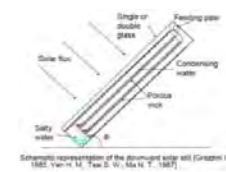
SHC upgrade

www.aloneproject.eu

PARTNERSHIP
DLR, EURAC, RIELLO several Italian COMPANY

APOLLO

M-PTC+ORC

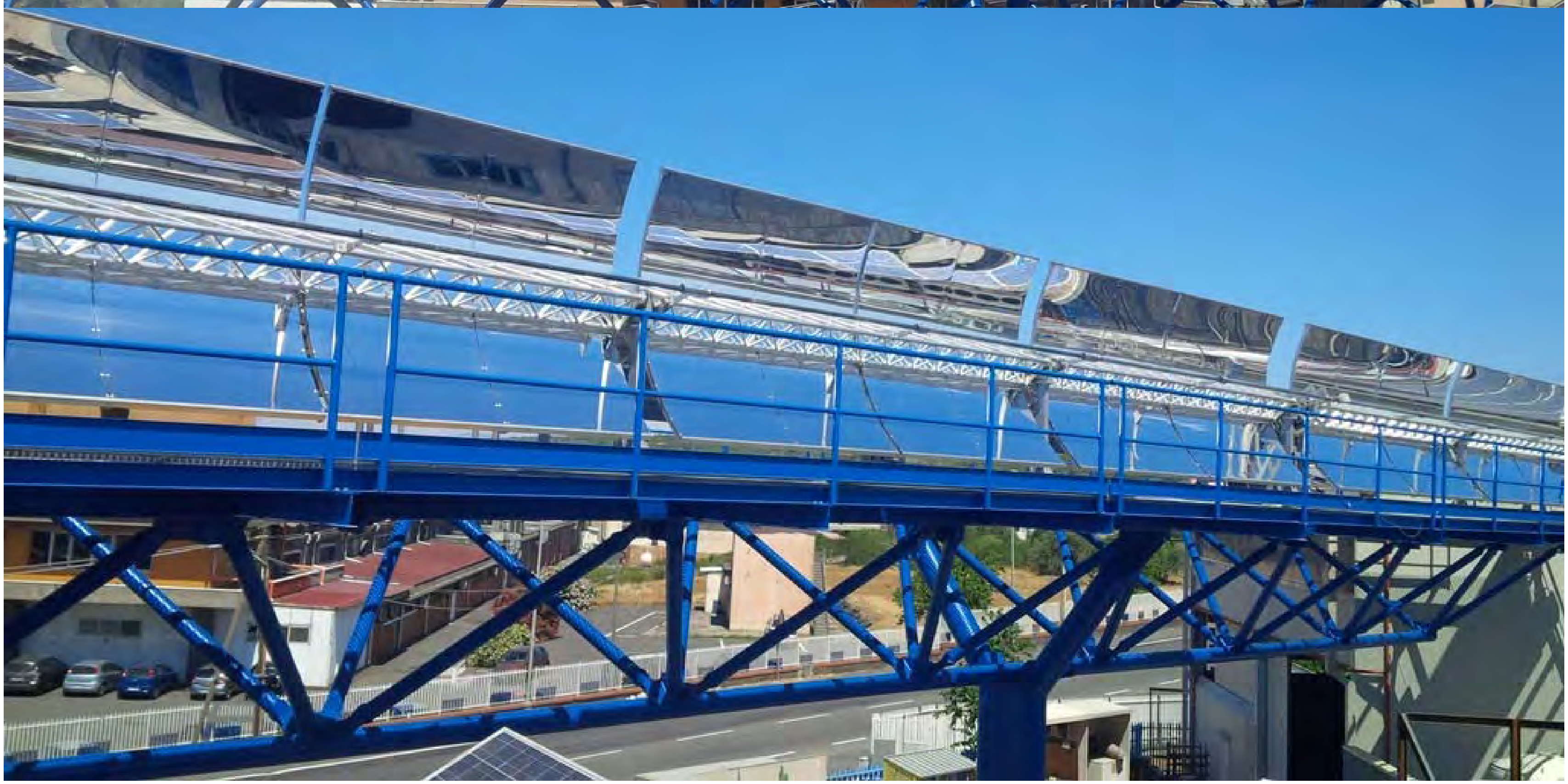


Desalter

Mini Grid Day Sapienza University - Rome 21st of June 2018

Speaker: Maurizio DE LUCIA


by UNIFI-FEROtech



PTC receiver tube

Controlled atmosphere/Vacuum

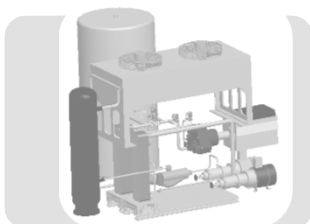
High energy efficiency

Solar concentrating system (M-PTC)

Miniaturized Optics

Same size of a standard flat-plate collector

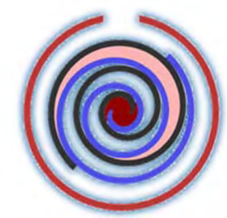
Integration in residential contexts

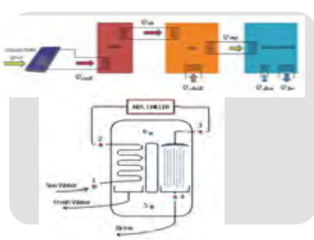


Innovative ORC system

Small size (1.8-2.5 kW-power)

Scroll expander;





Chiller LiBr (5-10 kWfr)

Size and potentialities adapted to the plant

Upgrade of the prototype already developed in correlated projects

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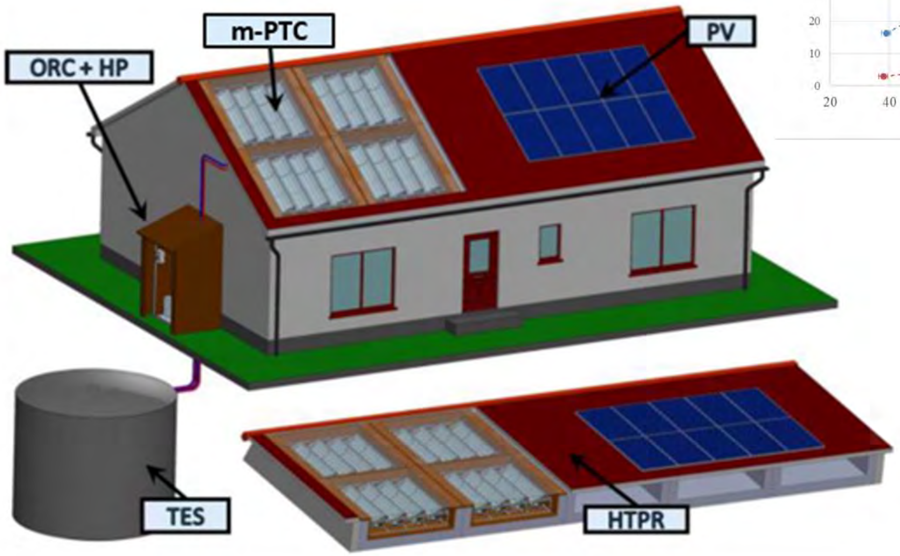
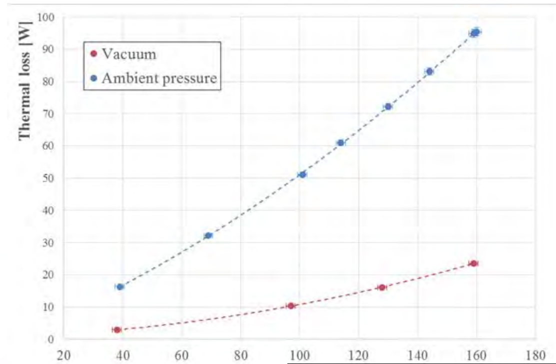
Fig.12– Measurable results of the APOLLO project - Prototypes and Components

Speaker: Maurizio DE LUCIA

Mini-Grid



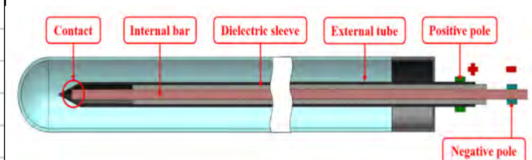


Vacuum				
T int [°C]	T amb [°C]	ΔT [°C]	P [W]	Err. [W]
60	22	38	2.9	0.0
120	23	97	10.3	0.2
150	23	128	16.1	0.2
179	20	159	23.5	0.3
210	22	187	33.5	0.5
240	23	217	46.0	0.6

DNI	1400	kWh/m2 y
Specific Demand	40	kWh/m2 y
Area (residential)	200	m2
Annual Demand	8000	kWh/y
m-PTC	12	m2
PV	4	m2
Net Useful Energy	5174.5	kWh/y
m-PTC SOLAR FRACTION	65%	
m-PTC+PV Solar Fraction	100%	

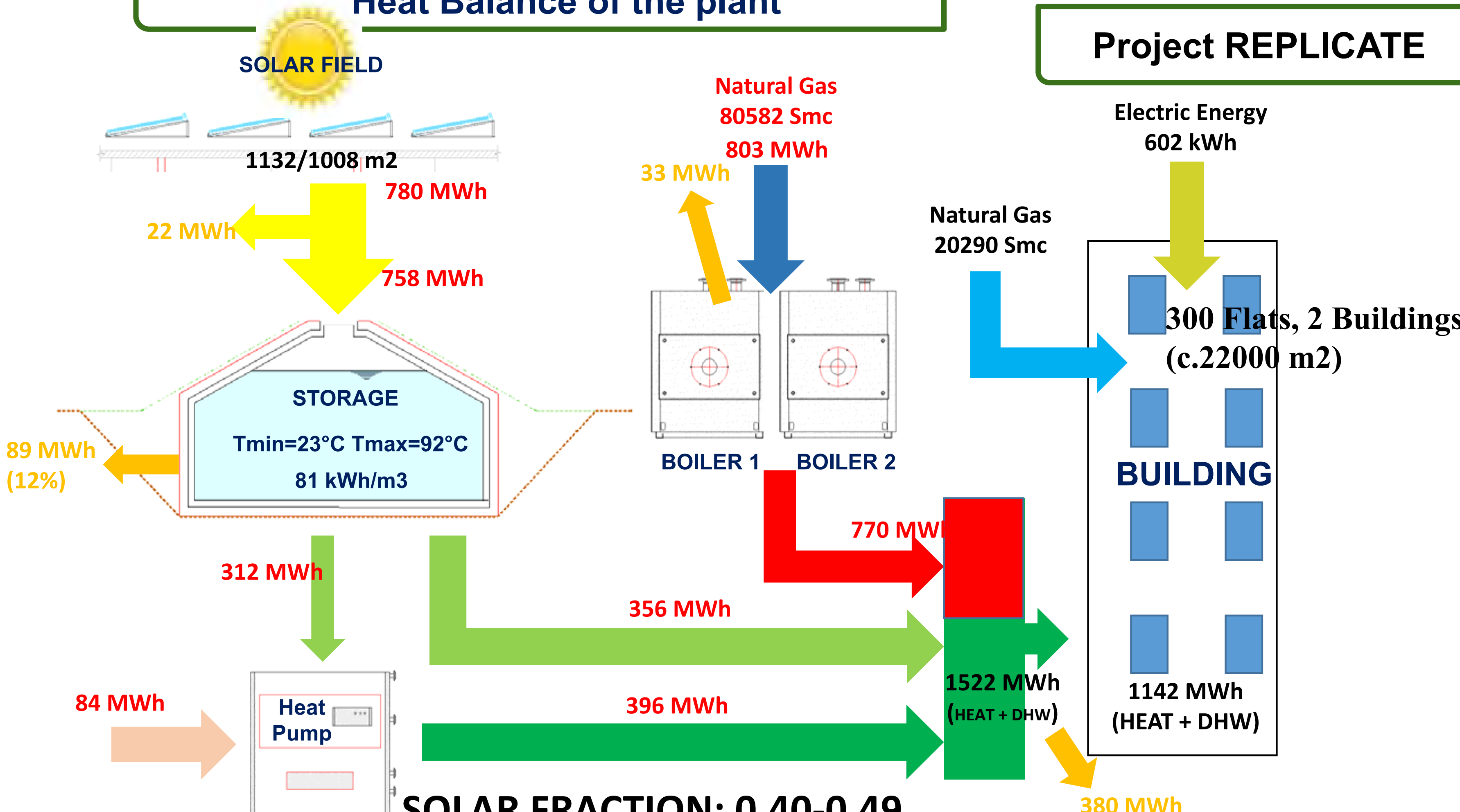
Annual costs for producing 8000 kWh/y with different technologies									Current	SyRENs
Standard Plant	Spec_cost		fuel cost		Other&DUE		TOT costs		PBT	PBT
Gas Boiler	0.098	€/kWh	€	784	€	196	980	€/y	17.49	9.55
Pellet Boiler	0.071	€/kWh	€	565	€	282	847	€/y	20.41	11.22
Heat Pump	0.071	€/kWh	€	391	€	293	684	€/y	20.31	10.21
Diesel Boiler	0.171	€/kWh	€	1.365	€	171	1535	€/y	10.92	5.85

Current COST		
PLANT	€	2.240
SOLAR FIELD	€	7.200
TES	€	4.000
HP	€	3.500
PV	€	714
TOTAL	€	17.654
Specific Costs	3 €/kWh	
Specific Costs	88 €/m2	

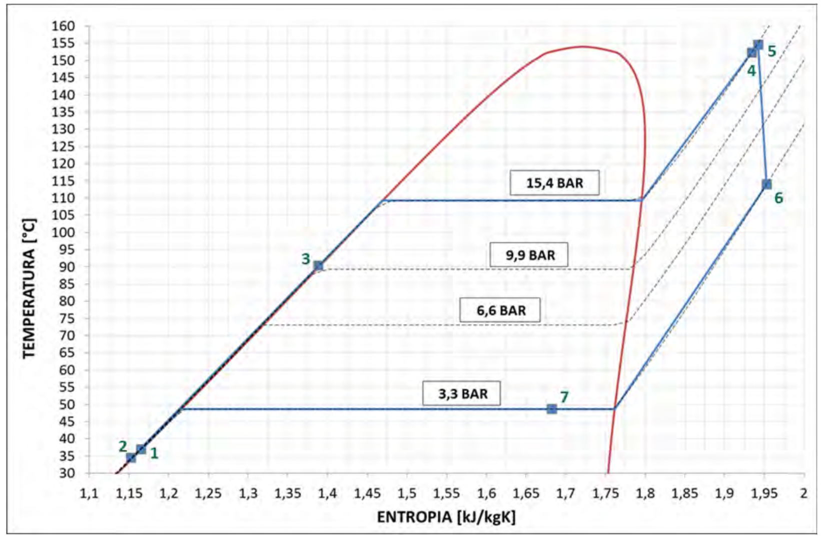


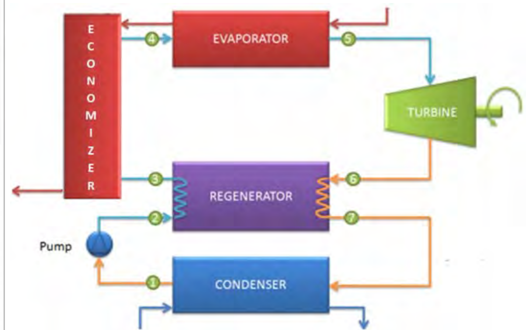
Optimized solution
Heat Balance of the plant

Project REPLICATE



SOLAR FRACTION: 0.40-0.49





KC-MORGANA **2000 kW**

KC-MORGANA **4000 kW**

KC-MORGANA **8000 kW**

ORC-PTC KAYMACOR srl (PIACE-ALONE)

site Misericordia in FLORENCE

www.kaymacor.com

	m [kg/s]	Tensione [V]	Corrente [A]	Potenza el. [W]	Potenza ther. [W]	eta TOT	eta MEC/EL	eta ENT	RPM	β	T scroll_i [°C]	T scroll_o [°C]	T cond_i [°C]	P scroll_i [bar]	P scroll_o [bar]
Media	0.0480	44	22	875	10534	0.084	0.57	0.15	3611	4.3	156	116	50	13.5	3.22
Average %	13%	94%	69%	21%	0.134	13%	13%	9%	71%	28%	3%	7%	6%	26%	10%
Max	0.0521	70	27	947	11142	0.089	0.60	0.16	5231	4.6	158	122	52	15.2	3.4
Min	0.0457	28	13	760	9751	0.078	0.53	0.15	2617	3.4	153	114	49	11.7	3.1

UNIVERSITY of BERGAMO.

ACTIVITIES of UNIBG in Arabia e E.A.U.

1. K.A.CARE (King Abdullah City for Atomic and Renewable Energy. Saudi Arabia)

مدينة الملك عبد الله للطاقة الذرية والمتجددة
K·A·CARE

- - Concentrated Solar Power Plant Performance Predictions
- - Techno-economic Analysis for Solar Cooling in Saudi Arabia

2. **DEWA (Dubai Solar Park Research and Dev. Department)**
   - MoU: Collaborative Research on Renewable Energy and Energy Efficiency

هيئة كهرباء ومياه دبي
Dubai Electricity & Water Authority

3. **ACWA Power (Dubai)**
   - Request for Energy Yield Validation CSP Dubai Plant

ACWA POWER

➢ **Platform-SW**

THERMOFLEX®

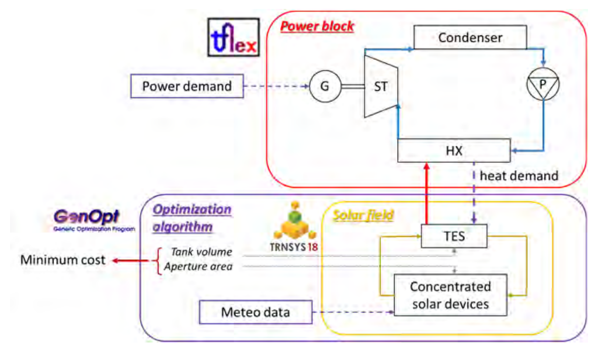
TRNSYS 18

TRNSYS®

GenOpt Generic Optimization Program

GenOpt

MATLAB®

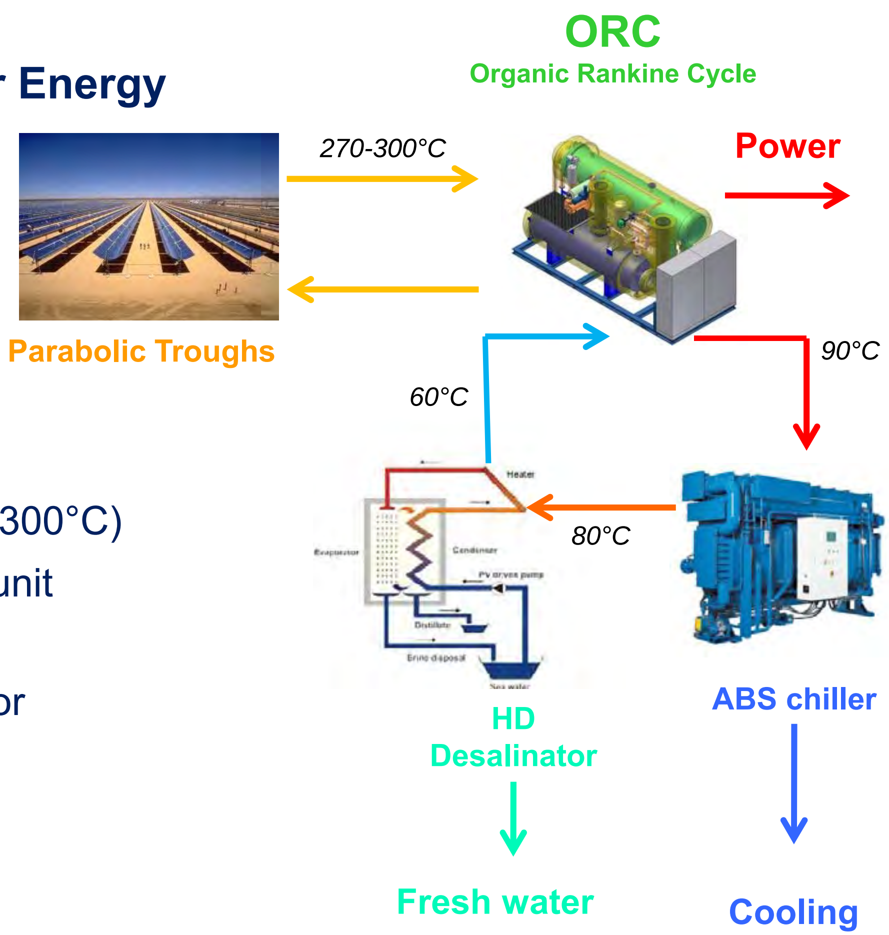


Responsable: Giuseppe FRANCHINI

Poly-source Model-plants

Integrated System using only Solar Energy

- providing:
  Power, Cooling, Fresh water
- mid-low power ORC unit
  (400 - 2000 kW_{el})
- stand alone system



- ➢ Solar Troughs- thermal oil (270-300°C)
- ➢ Organic Rankine Cycle (ORC) unit
- ➢ Li-Br Absorption Chiller
- ➢ Low temperature HD Desalinator

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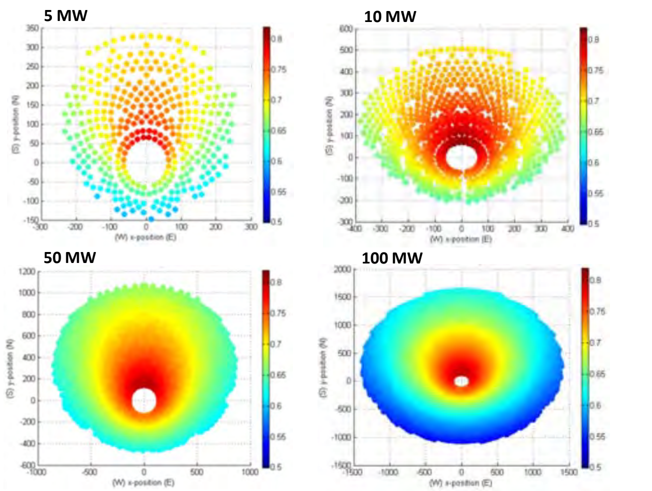
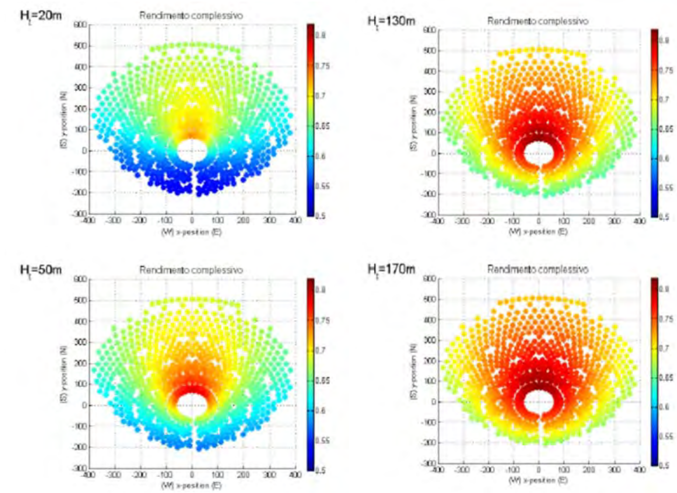
Solar field modelling

Solar Tower & Heliostat field

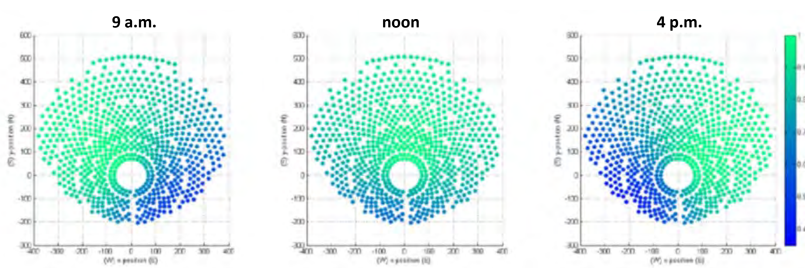
*Impact of plant **size** on optimal layout & efficiency*



*Impact of Tower **height** on overall efficiency*

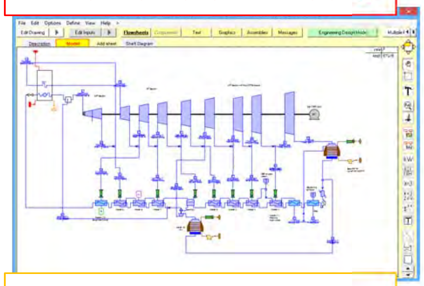


*Impact of **Cosine effect** on overall efficiency*

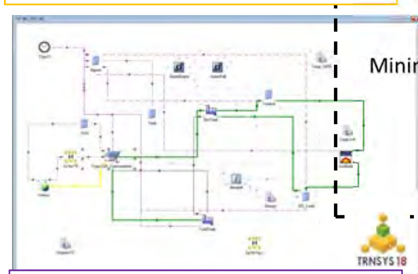


CSP plant modeling/optimization

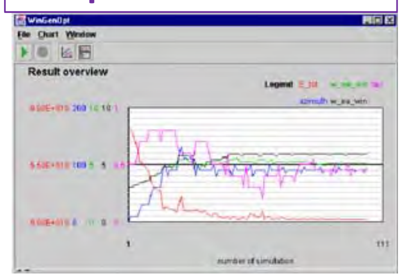
1. Power block model

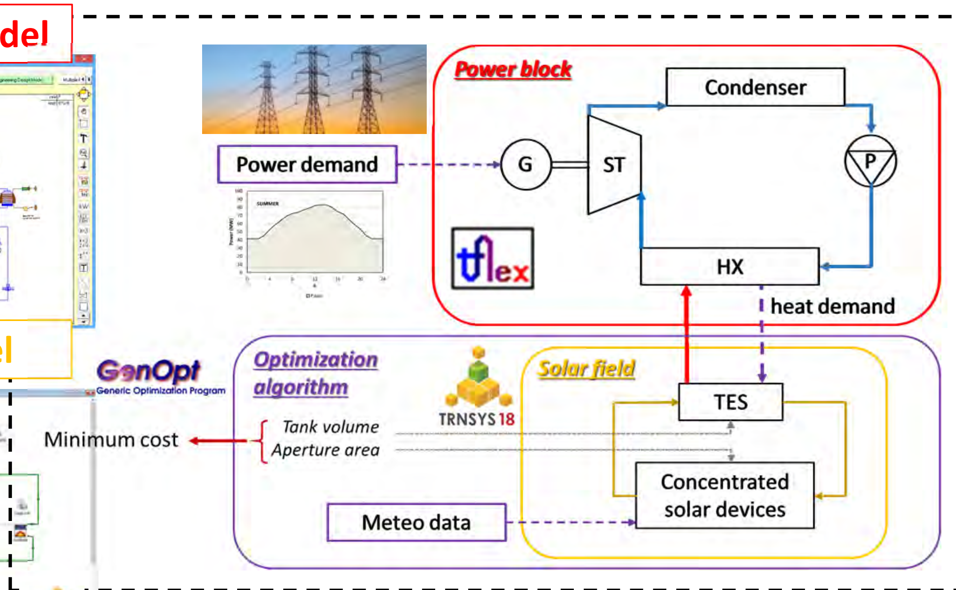


2. Solar field model



3. Optimization





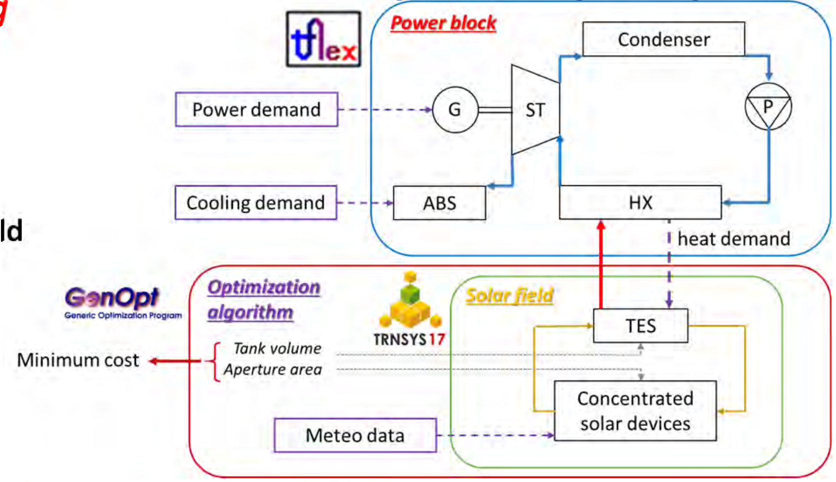
Case study: load-following CSP plant: optimization results

	PTC north-south	PTC east-west		Tower	
Solar field (m^2)	1,815,000	1,722,800	-5%	1,041,360	-43%
Storage (m^3)	49,800	37,000	-26%	35,600	-29%

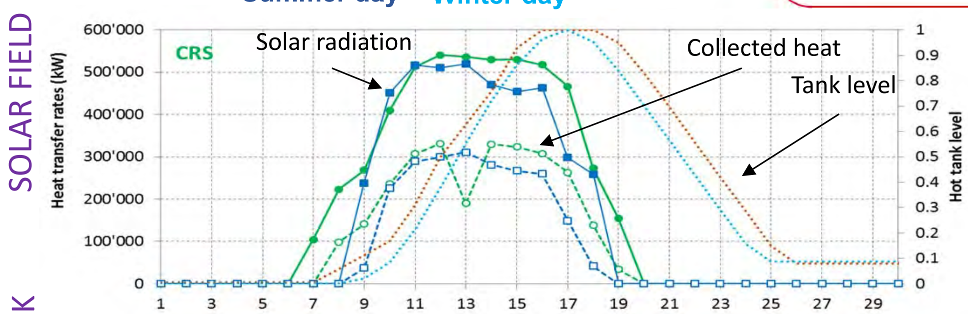
CSP Plant Design vs. Load Following

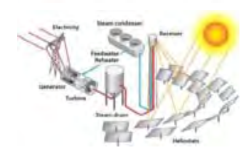
Steam Cycle: Thermal Energy Storage

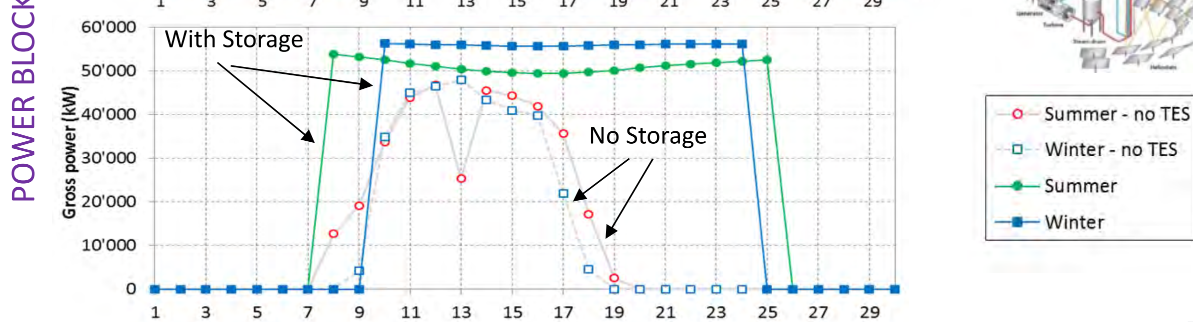
An **optimization algorithm** determines the optimal size (*cost minimization*) of **solar field** (aperture area) and **storage** tanks (volume) matching a defined **load**



Summer day Winter day







Idea LFR solar collector IFC-1832

IFC-1832 applications can include:
• industrial heat generation
• solar cooling plants
• district heating and cooling networks
• hybridization of other thermal sources

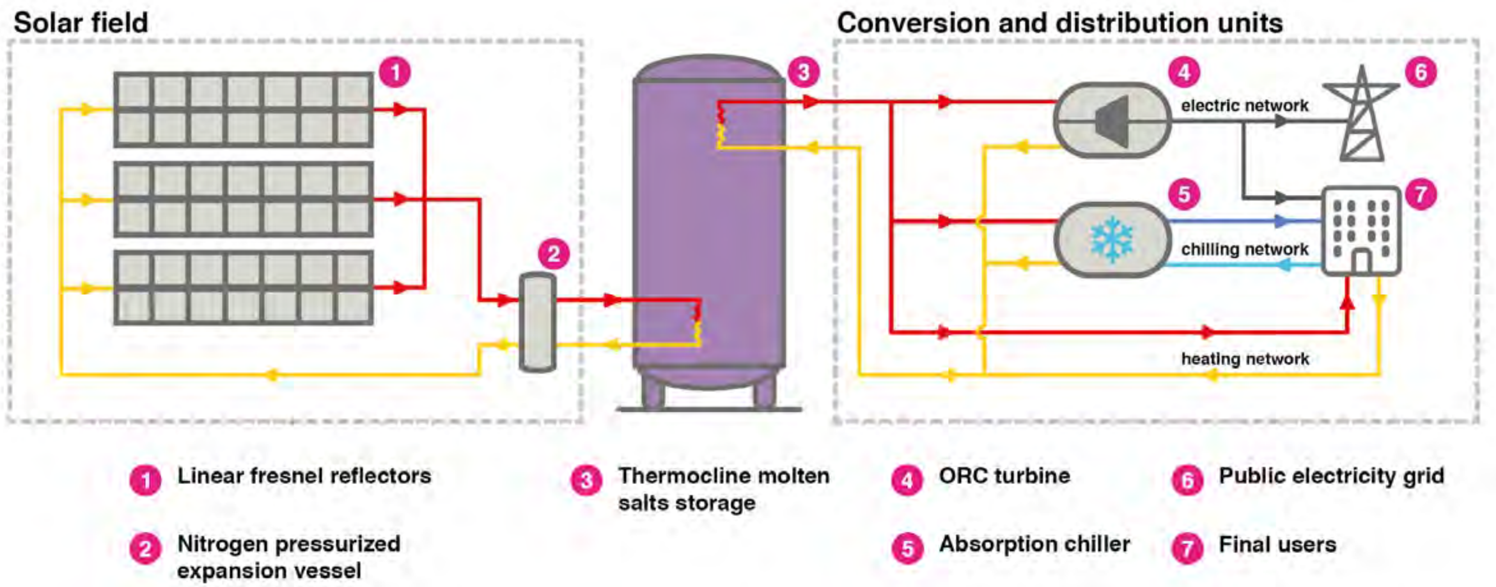
The collector is assembled on site from prefabricated components including:
• steel supporting structure
• primary glass reflectors
• secondary metal reflector
• vacuum glazed absorber tubes • solar tracking system
• heat transfer fluid circulation system

An integrated termocline molten salts heat storage is available.

General data of the basic module
Thermal peak power 12,2 kW
Length 4.06 m
Width 8 m
Aperture surface of primary reflectors 23 m2
Receiver height above primary reflector 4.0 m
Height of primary reflector above ground level 0.5 m
Specific weight 27 kg/m2
Maximum operational wind speed 100 km/h (180 km/h when stowed)

Life expectancy +20 years

Responsable: Fabio MONTAGNINO

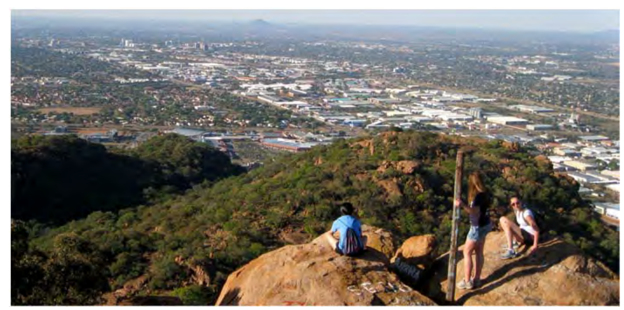

Solar field
Conversion and distribution units
electric network
chilling network
heating network
1 Linear fresnel reflectors
2 Nitrogen pressurized expansion vessel
3 Thermocline molten salts storage
4 ORC turbine
5 Absorption chiller
6 Public electricity grid
7 Final users

Idea hybrid solar collector IHC-2025

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

- Capacity building initiatives connecting the different stakeholders 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 systems and 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
- **Already established links in African countries (Egypt, Burundi, Botswana, Tunisia)**



TOPIC: Energy need assessment in developing rural areas

UNIVERSITY of PISA

- Main Objective is the formulation, testing and validation of an **effective methodology for data collection and data analisys** to provide reliable input data to improve the Mini-grid development.
- The relevance of the energy need assessment:

(i) from business perspective, allow to reduce the investment risk

(ii) from technical perspective, provide reliable inputs for load profiling and for energy management systems

- FS4MGO international research group is about to finalize the study, with Rome Sapienza (Micangeli, Del Citto) and MIT D-Lab
- Energy Assessment Toolkit by MIT D-Lab published in 2017 is taken as reference. D-Lab experts are taken part to the validation review.
- Paper is about to be submitted for publication: Title: *Effective data collection methodology for energy need assessment in developing rural areas: getting reliable inputs to improve load profiling of micro-grids.*

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Mini Grid Day Sapienza University - Rome 21st of June 2018

Speaker Name Valeria Gambino,

Energy need assessment in developing rural areas

- The most relevant outputs of the energy need assessment are:

Average consumptions & expenditures for electricity substitutes per each customer group

Ability and willingness to pay (relevant to set electricity tariff)

Inputs for load profiling, such as timing and types of lighting and electrical items

Suggestions for business model design and engineering design of energy management

- Methodology has been tested and improved since 2012.So far, it has been applied in 9 data collection campaigns for a total of 42 villages assessed. More than a minigrid has been already realized based on its results, such as Kitobo Project in Uganda.
- Today the methodology is in the final validation phase.

		Note 1: Average values given by data analysis																					
Total number of HHs	750	Note 2: Table below is referred to SINGLE USER																					
Household	% of current users	Max Power (W)	Lighting from (time)	Lighting to (time)	Lighting (hours/day)	Electrical Devices from (time)	Electrical Devices to (time)	Electrical Devices (hours/day)	Number of bulbs (n°)	Number of units/day (liters, batteries, etc)	Capacity per unit (Wh)	Mobile phone charging (charges/day)	Mobile phones (% of total customer group)	Radios (% of total customer group)	Other devices (number of devices per customer)	Power assumed for lighting (W/bulb)	Power for mobile phone (W)	Power for radio (W)	Power assumed for other electrical devices (W)	Energy for lighting (Wh)	Energy for electrical devices (Wh)	Total Daily Energy/ customer (Wh)	Total Daily Energy/ customer group (Wh)
Solar Home Systems	19,4%	66	17,9	20,4	2,5	13,3	20,0	6,7	3,0			0,3	57%	27%	0,57	8	6	10	66	60	275	335	48663
PV panels (without battery)	0,8%	35	17,9	20,4	2,5	13,3	20,0	6,7	3,0			0,3	57%	27%		8	6	10		60	19	79	499
PV panels with battery	1,4%	35	17,9	20,4	2,5	13,3	20,0	6,7	3,0			0,3	57%	27%	0,57	8	6	10	35	60	154	214	2241
Oxygen gas lamps	0,0%																						
Solar lanterns	16,2%	12	17,9	20,4	2,5	13,3	20,0	6,7	3,0			0,3	57%	27%		8	6	10	12	60	19	79	9643
Rechargeable torches	9,0%		17,9	20,4	2,5	13,3	20,0	6,7	3,0	0,1	12,2	0,3	57%	27%			6	10		1	19	20	1349
Torches with battery	26,4%		17,9	20,4	2,5	13,3	20,0	6,7	3,0	0,1	12,15	0,3	57%	27%			6	10		1	19	20	3971
Paraffin lamps	0,0%																						0
Kerosene lamps	0,0%																						0
Candles (only considering energy for lighting, exluding heating)	4,9%	4	17,9	20,4	2,5	13,3	20,0	6,7		2,0		0,3	57%	27%			6	10	4	20	19	40	1438
check	100,0%																	Average daily consumption from ELECTRICITY SUBSTITUTES per customer (Wh)					120