

**Ph.D in Systems Engineering, Energetics, Computer
Science and Telecommunications - XXXIII cycle.
Brainstorming 29th October 2019**



**THEME: MODELING OF INNOVATIVE SOLAR SYSTEMS
INTEGRATED IN THE BUILDING ENVELOPE FOR THE PRODUCTION
OF THERMOELECTRIC ENERGY**

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Supervisor:

Prof. Antonio Gagliano



Dipartimento di Ingegneria Elettrica, Elettronica e Informatica

OBJECTIVES

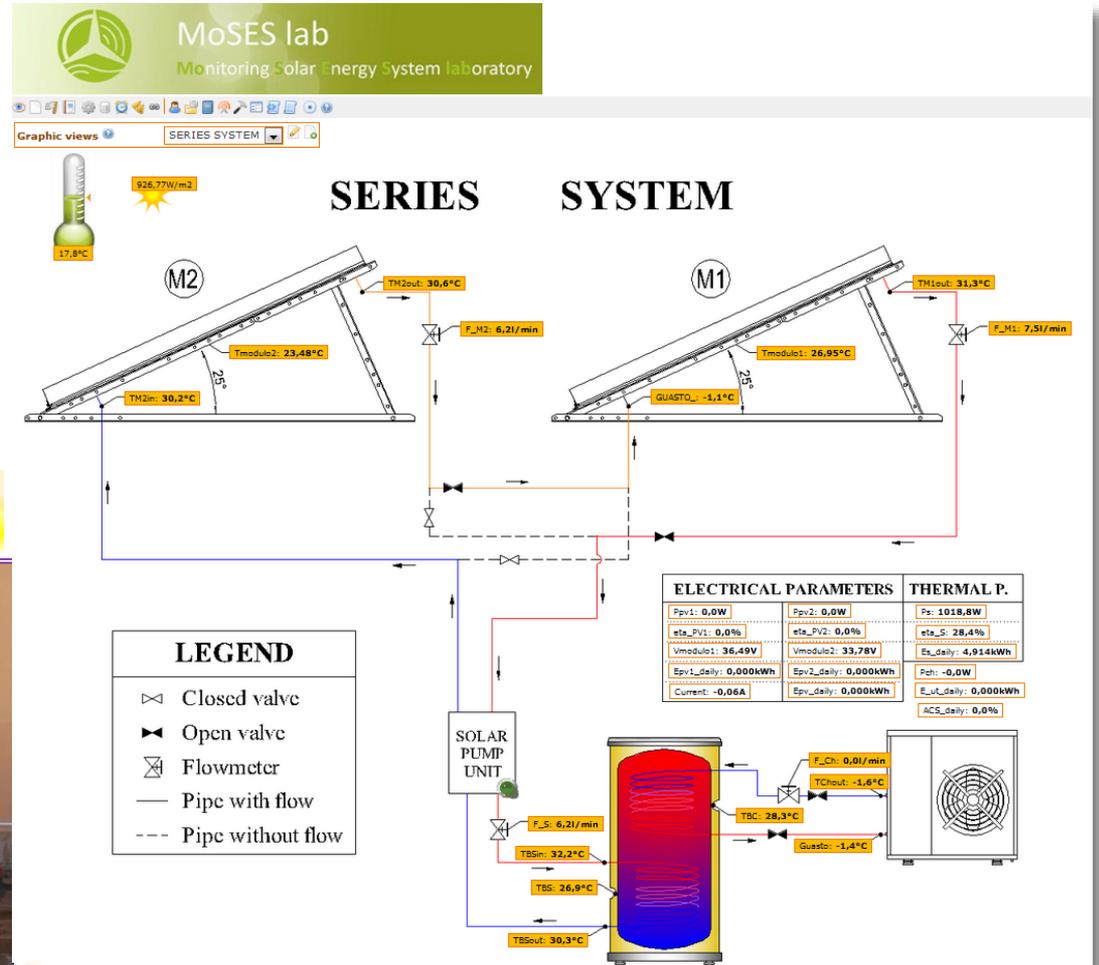
- ① Analyze, characterize and optimize the operation of a solar system for the simultaneous production of electrical and thermal energy (PV/T systems);
- ② Evaluate the performance of integrated solar systems in building components (ventilated facade and/or roof);
- ③ Evaluate the effect of the integration of solar panels into building components for the reduction of ambient climatization.

Objective 1: PV/T Plant at University of Catania

PV/T panels



Unit Pump



Electrical load



Solar Tank

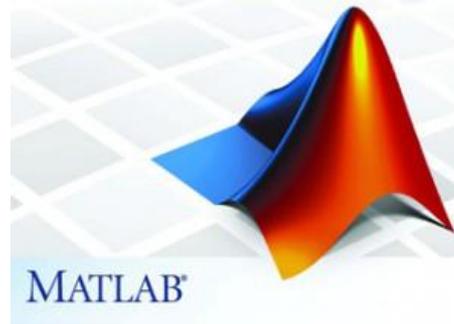
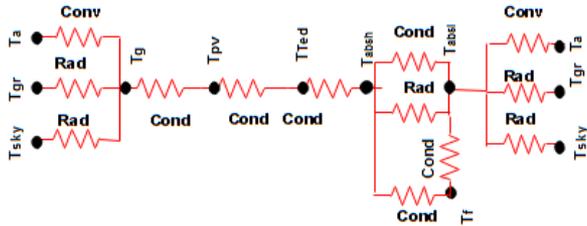
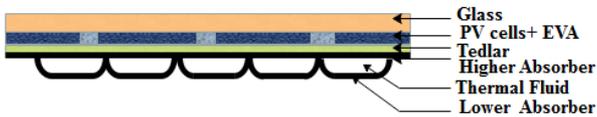


Heat pump

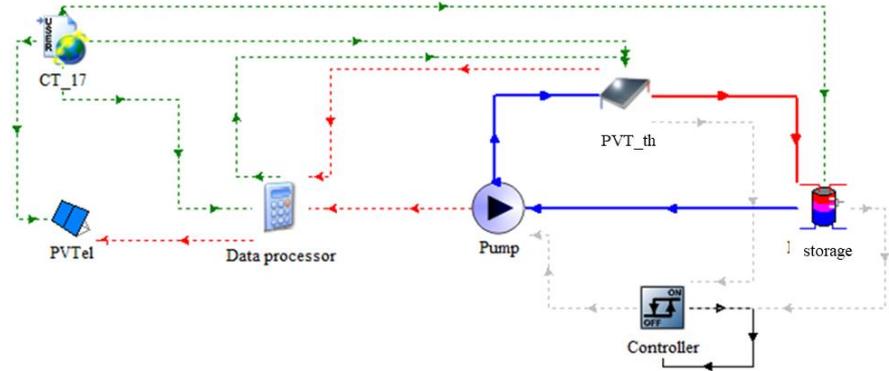


Objective 1: Simulation of PV/T system

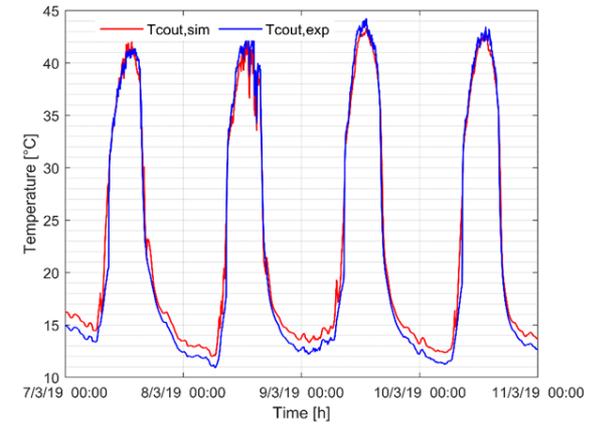
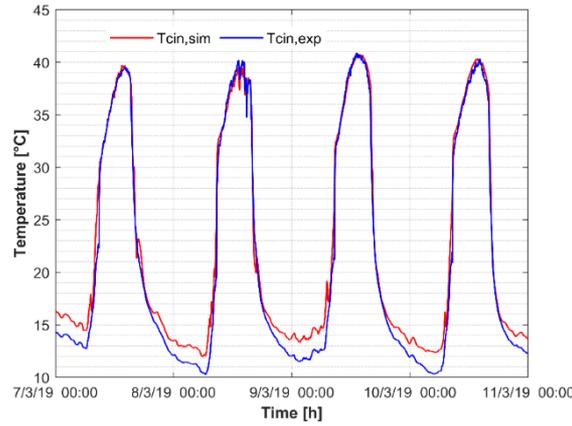
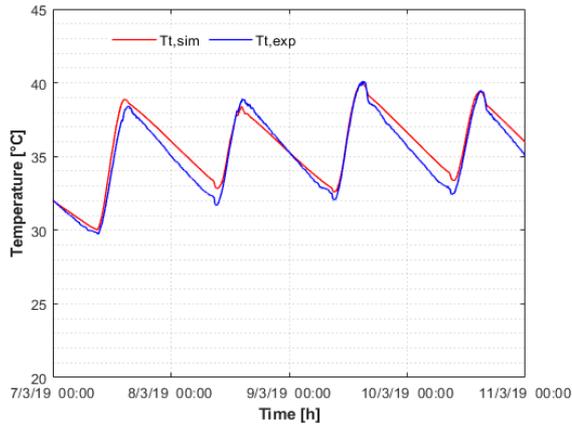
Digital model:



Layers	Equation
Glass	$(\rho_g \delta_g C_g) \frac{dT_g}{dt} = \alpha_g G + hr_{g,sky}(T_{sky} - T_g) + hr_{g,gr}(T_{gr} - T_g) + hv_{g,a}(T_a - T_g) + hc_{PV,g}PF(T_{PV} - T_g) + hc_{Ted,g}(1 - PF)(T_{Ted} - T_g)$
PV cells	$PF(\rho_{PV} \delta_{PV} C_{PV}) \frac{dT_{PV}}{dt} = [(T_g \alpha_{PV} - \eta_e) G + hc_{PV,g}(T_g - T_{PV}) + hc_{Ted,PV}(T_{Ted} - T_{PV})]PF$
Tedlar	$(\rho_{Ted} \delta_{Ted} C_{Ted}) \frac{dT_{Ted}}{dt} = (1 - PF)T_g \alpha_{Ted} \epsilon + (1 - PF)hc_{Ted,g}(T_g - T_{Ted}) + PF \cdot hc_{Ted,PV}(T_{PV} - T_{Ted}) + hc_{absh,Ted}(T_{absh} - T_{Ted})$
Absorber	$(\rho_{absh} \delta_{absh} C_{absh}) \frac{dT_{absh}}{dt} = hc_{absh,Ted}(T_{Ted} - T_{absh}) + (1 - PC)hc_{absl,absh}(T_{absl} - T_{absh}) + PC \cdot hr_{absl,absh}(T_{absl} - T_{absh}) + hc_{f,absh}(T_f - T_{absh})$ $(\rho_{absl} \delta_{absl} C_{absl}) \frac{dT_{absl}}{dt} = hc_{absl,f}(T_f - T_{absl}) + (1 - PC)hc_{absl,absh}(T_{absh} - T_{absl}) + PC \cdot hr_{absl,absh} \cdot (T_{absl} - T_{absh}) + hc_{f,absh}(T_f - T_{absh}) + hr_{sky,absl}(T_{sky} - T_{absl}) + hr_{gr,absl}(T_{gr} - T_{absl})$
Fluid	$(\rho_f \delta_f C_f) \frac{dT_f}{dt} = hc_{f,absh}(T_{absh} - T_f) + hc_{absl,f}(T_{absl} - T_f) + \dot{m} C_f (T_{out} - T_{in})$
Tank	$(M_t C_t) \frac{dT_t}{dt} = \epsilon_H \dot{m} C_f (T_{t,out} - T_t) - \dot{m}_i C_w (T_t - T_{sup}) - U_t S_t (T_t - T_a)$



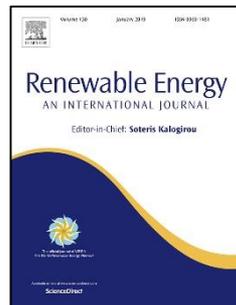
Objective 1: Validations



GOOD AGREEMENT

DESCRIPTION AND PERFORMANCE ANALYSIS OF A FLEXIBLE PHOTOVOLTAIC/THERMAL (PV/T) SOLAR SYSTEM.

A. Gagliano, G.M. Tina, F. Nocera, A.D. Grasso, S. Aneli.



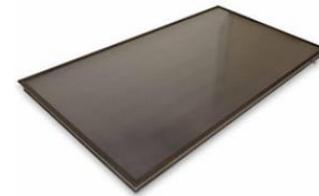
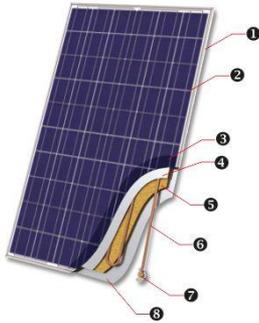
MODELING AND EXPERIMENTAL VALIDATION OF PV/T PLANTS FOR THE PRODUCTION OF RENEWABLE ENERGY IN HOT CLIMATES.

C. El Fouas, B. Hajji, A. Gagliano, G.M. Tina, S. Aneli.

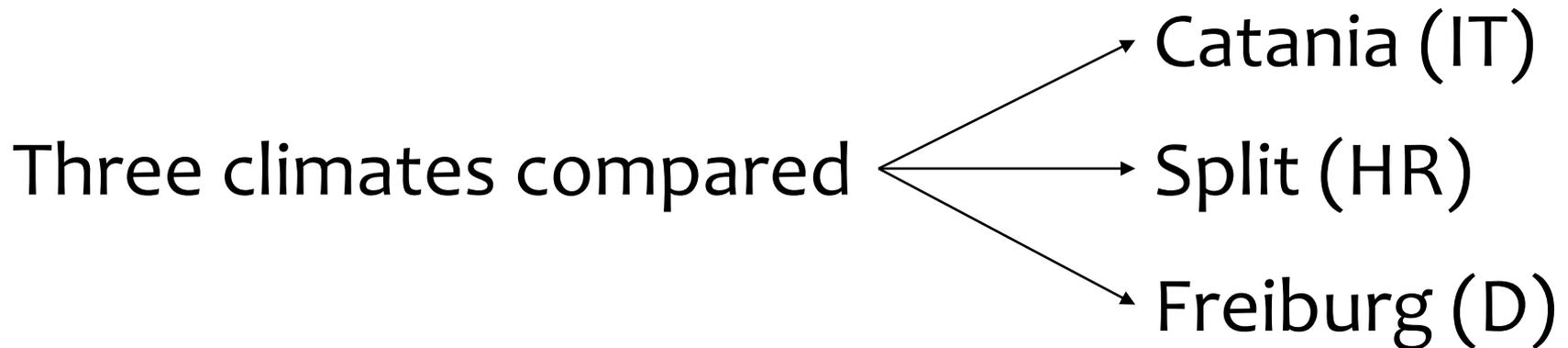


Objective 1: Comparison among PV/T and conventional solar plant.

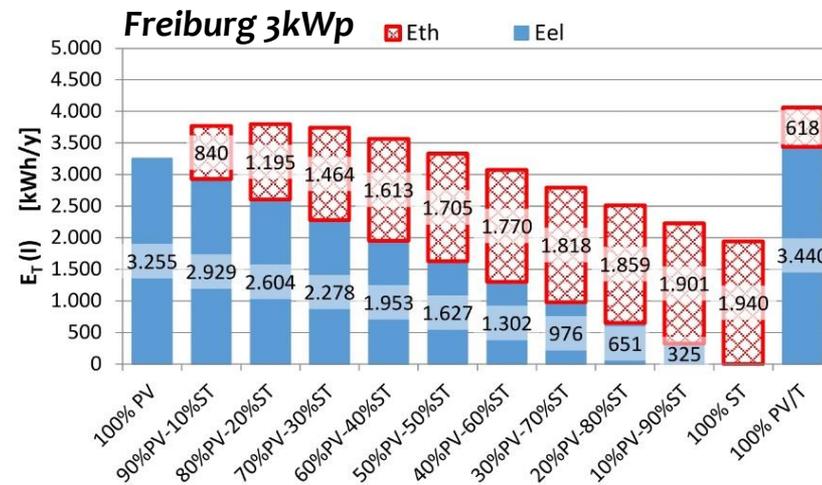
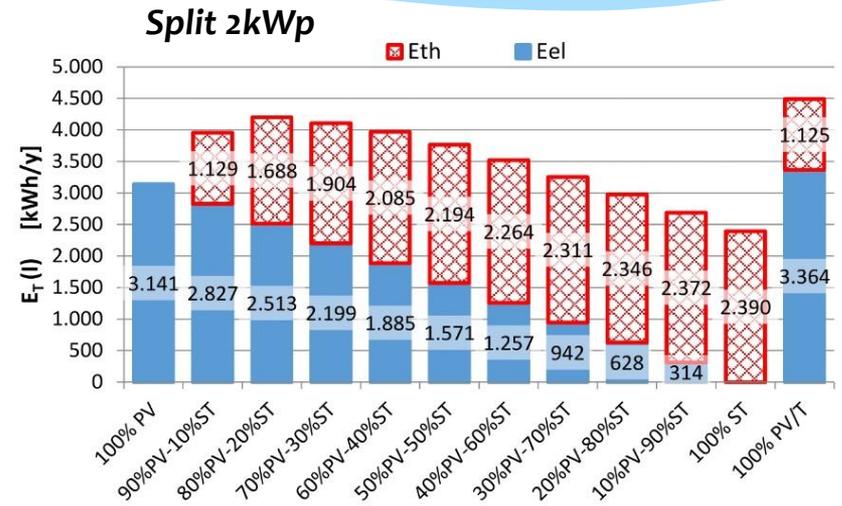
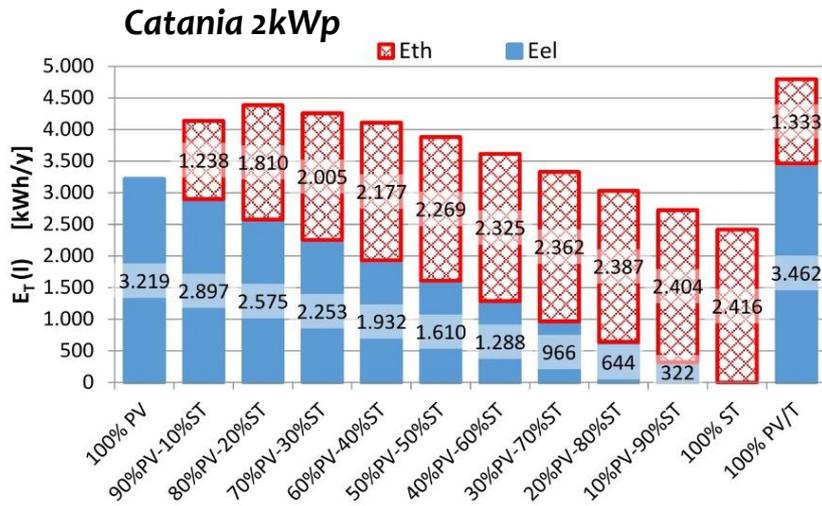
PV/T or PV + ST ???



Do we have enough space ?



Objective 1: Comparison among PV/T and conventional solar plant.

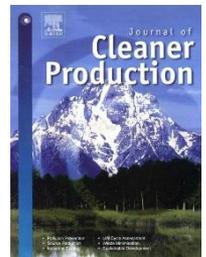


Results

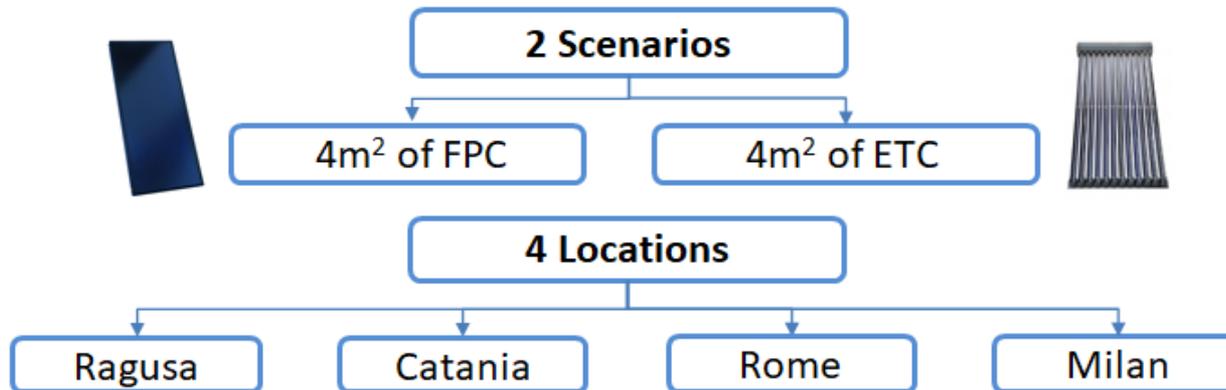
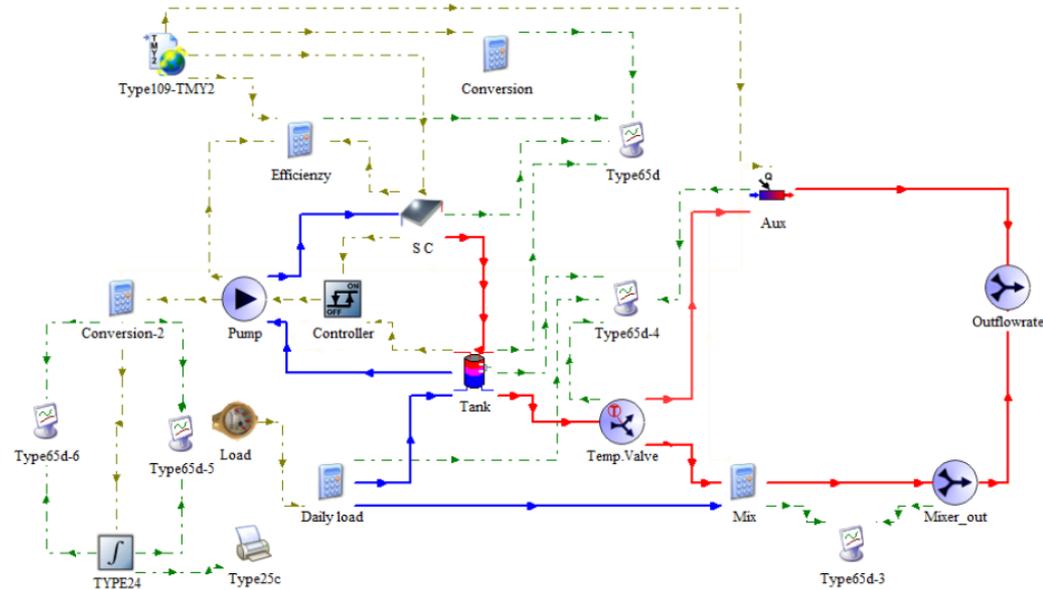
PV/T plants produce more energy than any combination of PV + ST plants, considering the same occupied surface.

COMPARATIVE ASSESSMENTS OF THE PERFORMANCES OF PV/T AND CONVENTIONAL SOLAR PLANTS.

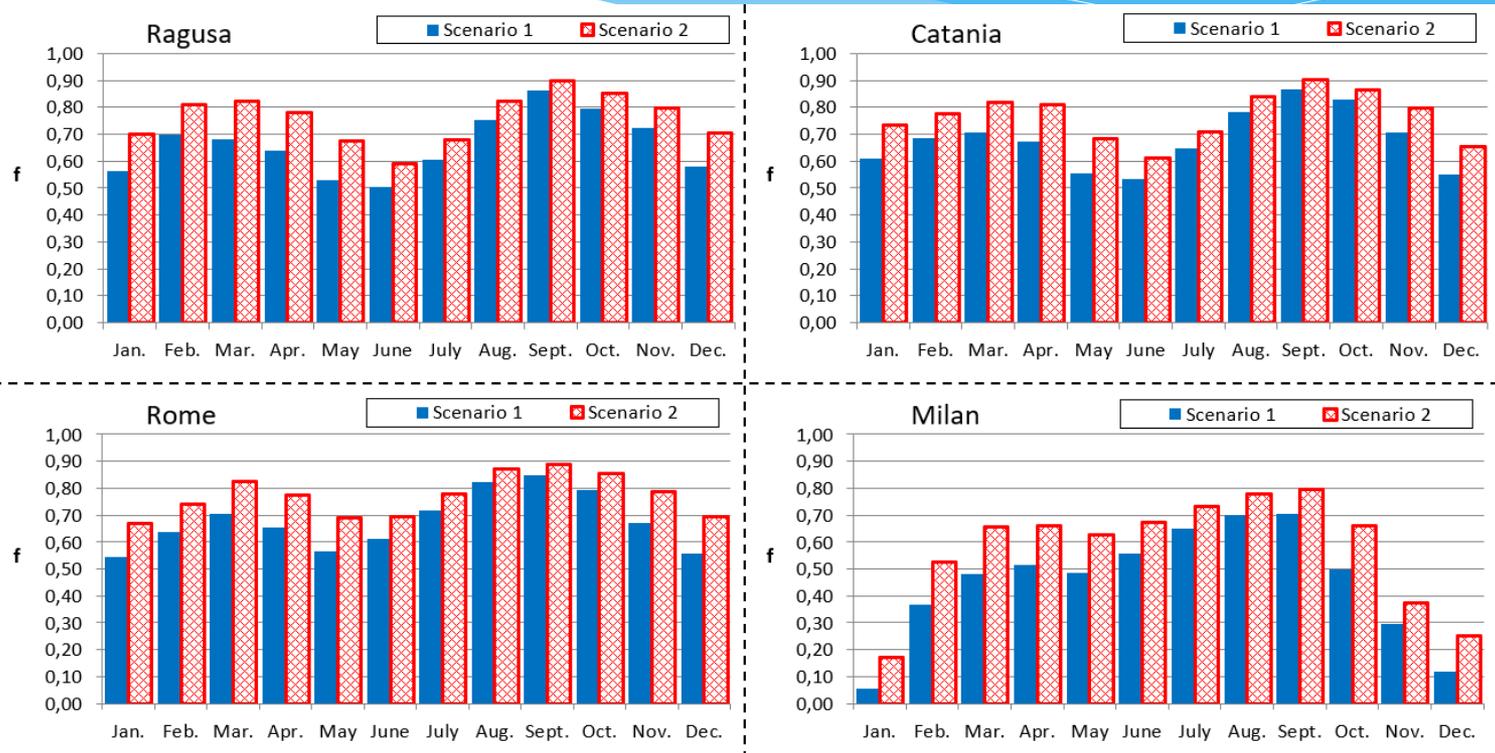
A. Gagliano, G.M. Tina, S. Aneli, S. Nizetic.



Objective 2: Building Solar Thermal Facade (BSTF)



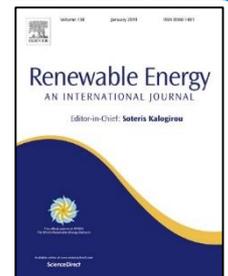
Objective 2: Building solar thermal facade (BSTF)



Conclusions

A BSTF constituted by just 4m² of FPC covers much more than 50% of the DHW demand in each cities except for Milan where ETC collectors are needed.

ANALYSIS OF THE PERFORMANCE OF A BUILDING SOLAR THERMAL FAÇADE (BSTF) FOR DOMESTIC HOT WATER PRODUCTION. A. Gagliano, F. Nocera, S. Aneli.



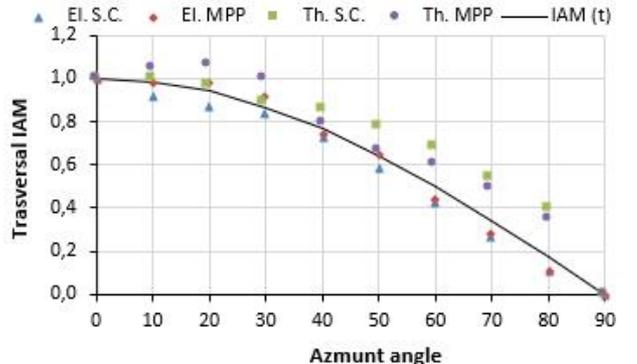
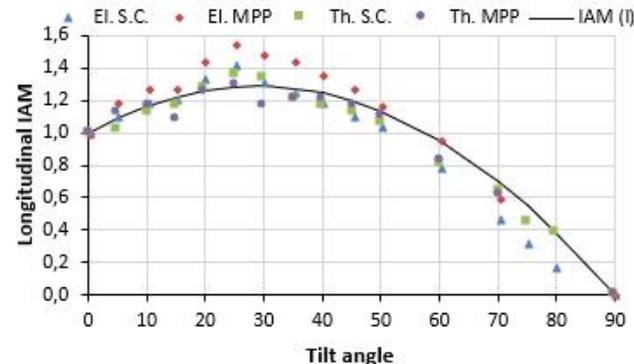
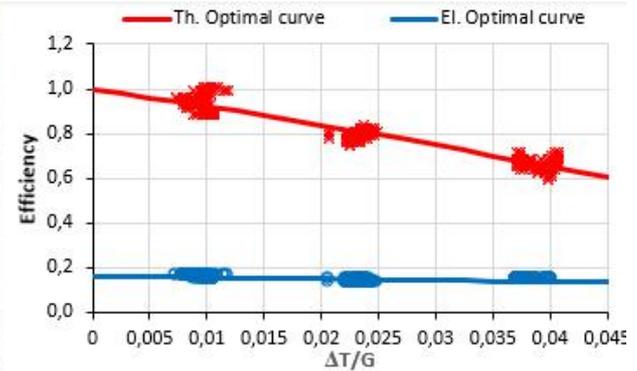
Other Activities: period abroad

Research activity at the University of Lleida (E)

Study a new PV/T panel technology, very similar to a vacuum tube solar thermal panel and able to easily integrate into the building facade.

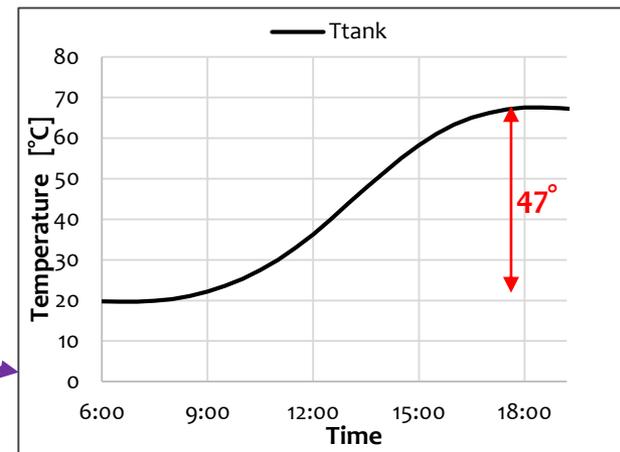
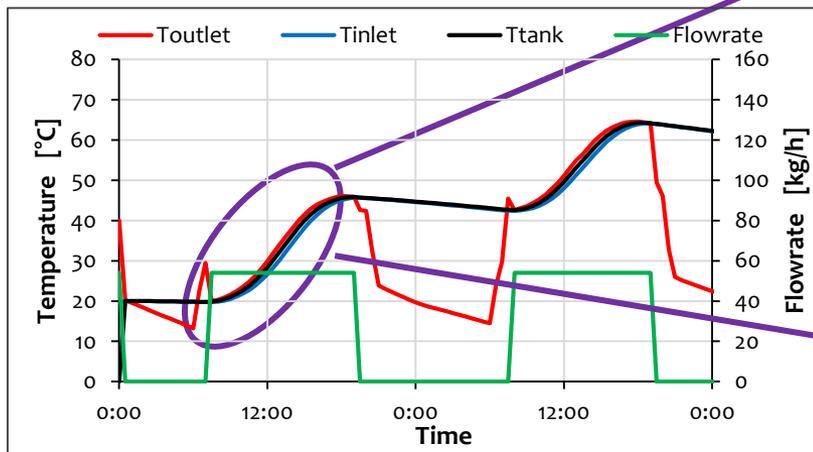
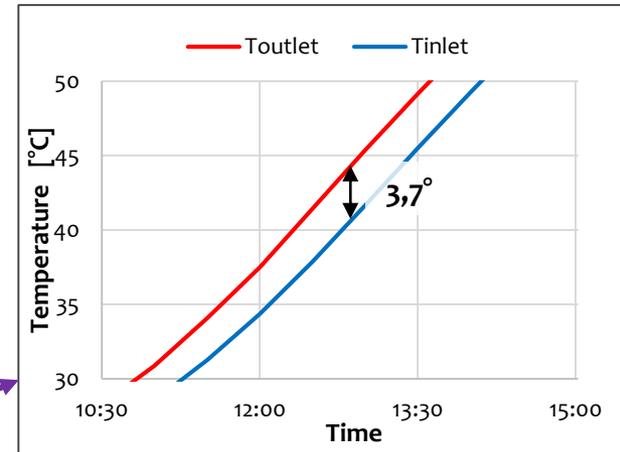
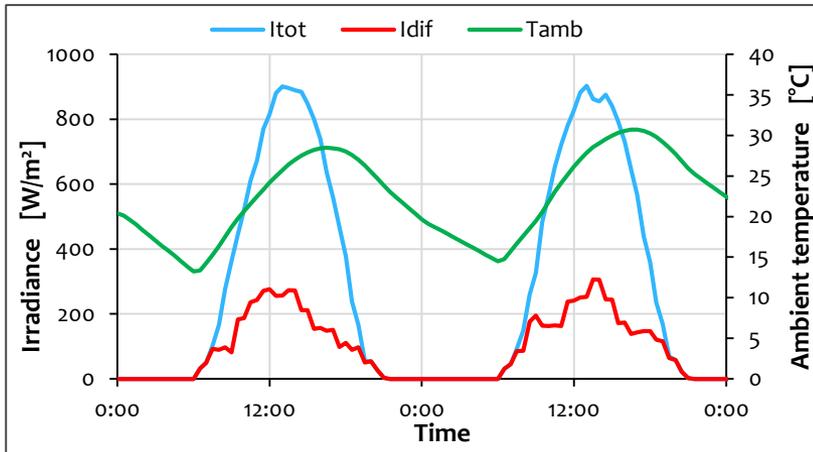


Characterization



Other Activities: period abroad

Simulation and design of a pilot plant



Activities:

PAPER

Modeling and experimental validation of PV/T plants for the production of renewable energy in hot climates. SDEWES 2019

Analysis of the performance of a Building Solar Thermal Façade (BSTF) for Domestic Hot Water production. RENEWABLE ENERGY

Description and performance analysis of a flexible photovoltaic/thermal (PV/T) solar system. JOURNAL OF CLEANER PRODUCTION

Analysis of the performance of building integrated solar thermal system (BIST) for Domestic hot water production (DHW). SDEWES 2018

A comparison among hybrid PV/T, PV and ST plants in a residential building facility. SPLITECH 2018

Description and performance analysis of a flexible photovoltaic/thermal (PV/T) solar system. RENEWABLE ENERGY

OFFICIAL REVIEWER

Reviewer of several papers for International Journal of Energy Research

Reviewer of papers for International conference: Spitech 2019

Reviewer of papers for International conference: Spitech 2018.

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Activities:

INTERNATIONAL CONFERENCE

SDEWES – 14th Conference on Sustainable Development of Energy, Water and Environment Systems – 1-6 October 2019, Dubrovnik (HR)

SDEWES – 13th Conference on Sustainable Development of Energy, Water and Environment Systems - 30th September – 4th October 2018, Palermo (IT)

SPLITECH - 3rd International Conference on Smart and Sustainable Technologies - 26-29 June 2018, Split (HR)

MEETING

International School on Informatics and Dynamics in Complex Networks – 15-19 October 2018, Catania (IT)

Research Activities at Laboratory of Thermodynamics and Energy Efficiency at the University of Split. S. Nižetić – 15th February 2018, Catania (IT)

Sustainability, surroundings and repercussions of the implementation of energy efficiency measures in buildings. S. Nižetić – 15th February 2018 Catania (IT)

Advanced Cooling Technologies in Steelmaking, or How We Started to Appreciate the Complexity of Boiling Heat Transfer. V. Prodanovic – 12th July 2018, Split (HR)

VVITA – Modernizing Learning and Teaching for Architecture through Smart and Longlasting Partnerships leading to sustainable and inclusive development strategies to Vitalize heritage Villages through Innovative Technologies

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Activities:

EQUIPMENT USED OR INSTALLED:

Sonic Anemometer

Sodar (wind profiler)

Rass (temperature profiler)

Monitoring systems

NEW COMPETENCES SOFTWARE:

Mango M2M

TRNSYS

TRNEDIT

THESIS CO-ADVISOR

Simulazioni dinamiche di impianti a pomap di calore elioassistita

Analisi dinamiche delle prestazioni energetiche di un sistema solare termico integrato (BIST)

Valutazione delle prestazioni di microturbine eoliche

Elaborazione di un modello matematico per la valutazione delle classi di stabilità atmosferica in funzione di dati meteoclimatici

Sostenibilità energetica, economica ed ambientale del solar cooling nella progettazione di edifici nZEB: un caso studio in Sicilia

Ph.D in Systems Engineering, Energetics, Computer Science and Telecommunications - XXXIII cycle.

**THANK YOU
FOR
YOUR ATTENTION**



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