National Study Day on Mini Grids
for Urban, Rural and Industrial Development

Research activities on Energy Systems at the University of Calabria

pietropaolo.morrone@unical.it

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

UNIVERSITÀ DELLA CALABRIA
DIPARTIMENTO DI
INGEGNERIA MECCANICA, ENERGETICA E GESTIONALE
DIMEG

Research team

Sergio Bova, Full professor

Angelo Algieri, Associate professor

Petronilla Fragiacomo, Associate professor

Mario Amelio, Associate professor

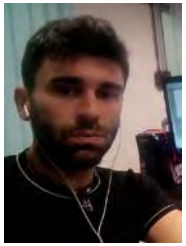
Research team

Teresa Castiglione,
RTD ‘A’

Pietropaolo Morrone,
RTD ‘B’

Diego Perrone,
Research fellow

Silvio Barbarelli,
Research fellow



Orlando Corigliano,
Research fellow

Giuseppe De Lorenzo,
Research fellow

Francesco Rovense,
phd student

Lines of research

Pumps as Turbines (PAT)

Recovery of micro-hydro resources (<100 kW)

Compressible-flow small turbines

Recovery of waste energy for small power (< 20 kW)

Energy conversion of sea waves and tidal currents

Combined Cooling, Heating and Power Systems

- Biomass CHP systems based on Internal Combustion Engines
- Hybrid systems

  Fuel cells
  Micro-turbine in CSP plants
  PTC/Biomass ORC integrated system

Pumps as Turbines for micro-hydro plants

Energy recovery from small hydraulic resources (< 100 kW).

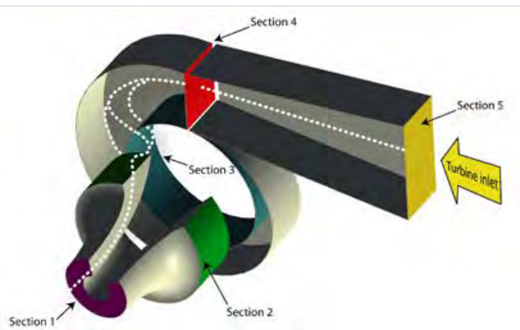
This is the case of aqueducts, water purifiers for the public net, watering pipelines

Advantages

- Low installation costs
- Easy maintenance
- Great variety of models and sizes

Disadvantages

- Low efficiency
- Lack of characteristic curves

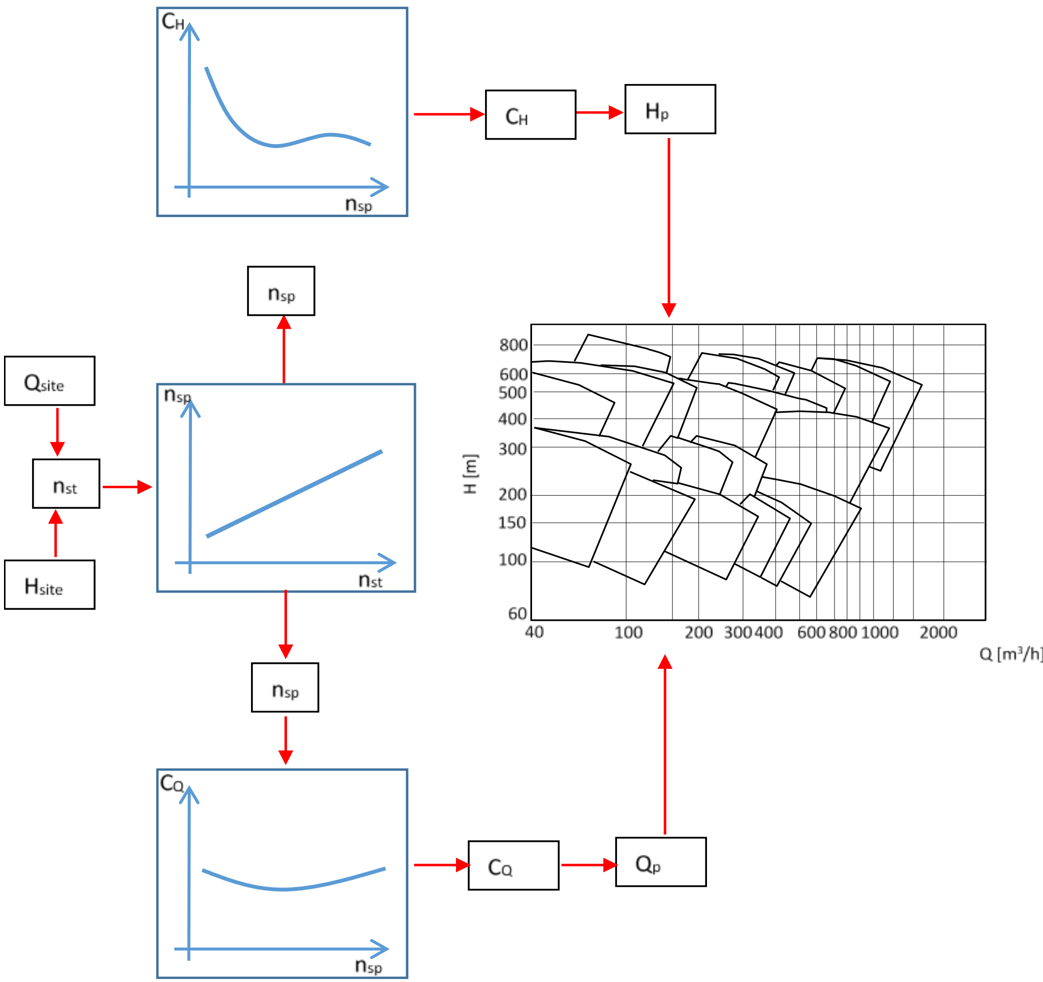


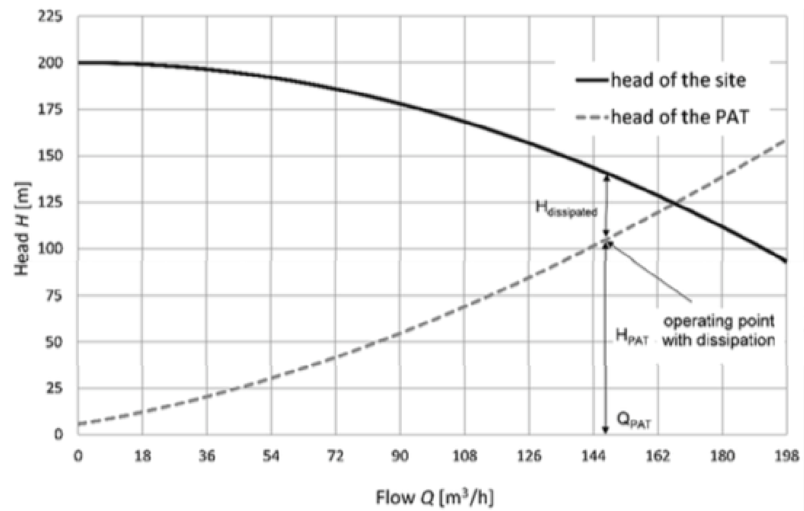
Test bench

contact: mario.amelio@unical.it

Pumps as Turbines for micro-hydro plants

Prediction of the characteristic curve of the PAT from the manufacturer data



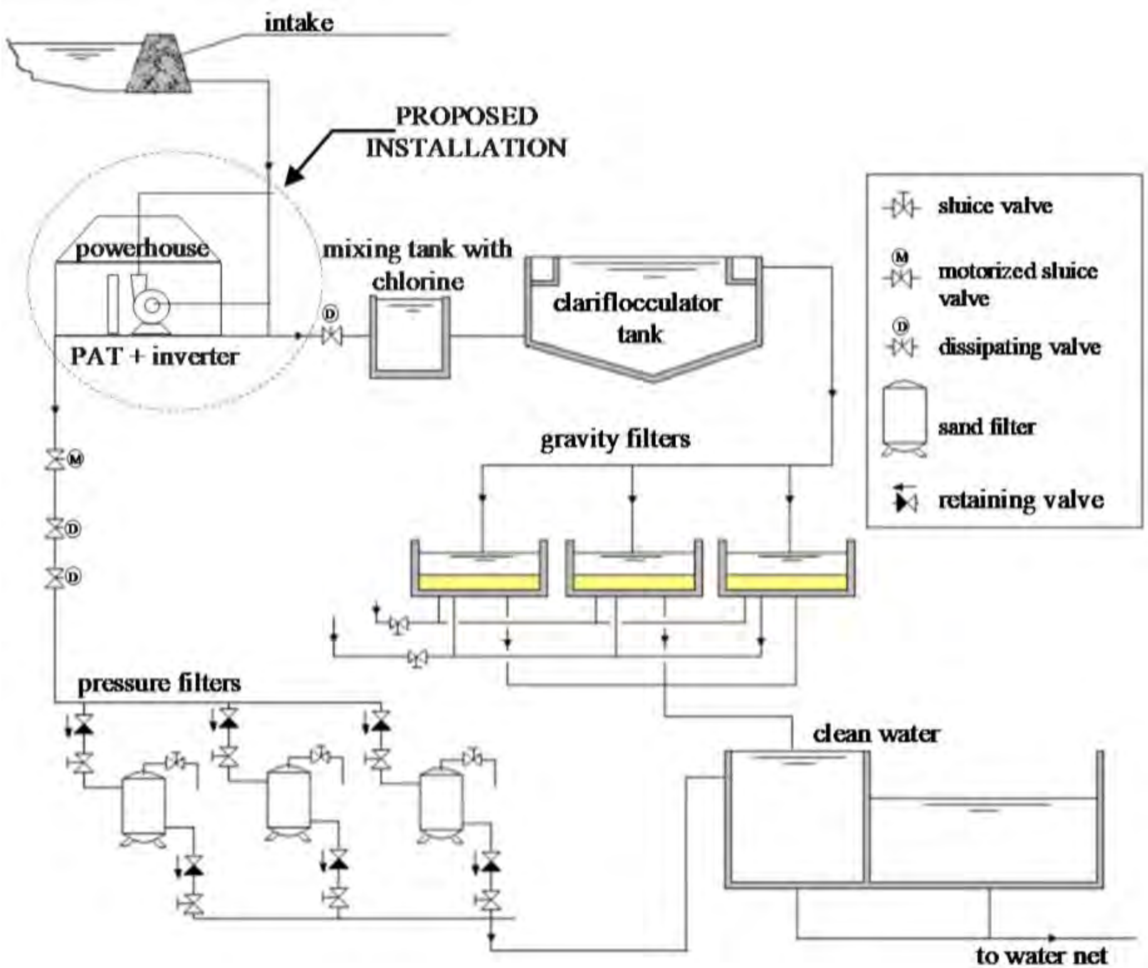


contact: mario.amelio@unical.it
University of Calabria

Pumps as Turbines for micro-hydro plants

- Application:

  Water purifier plant in Casali and Sersale (Calabria)



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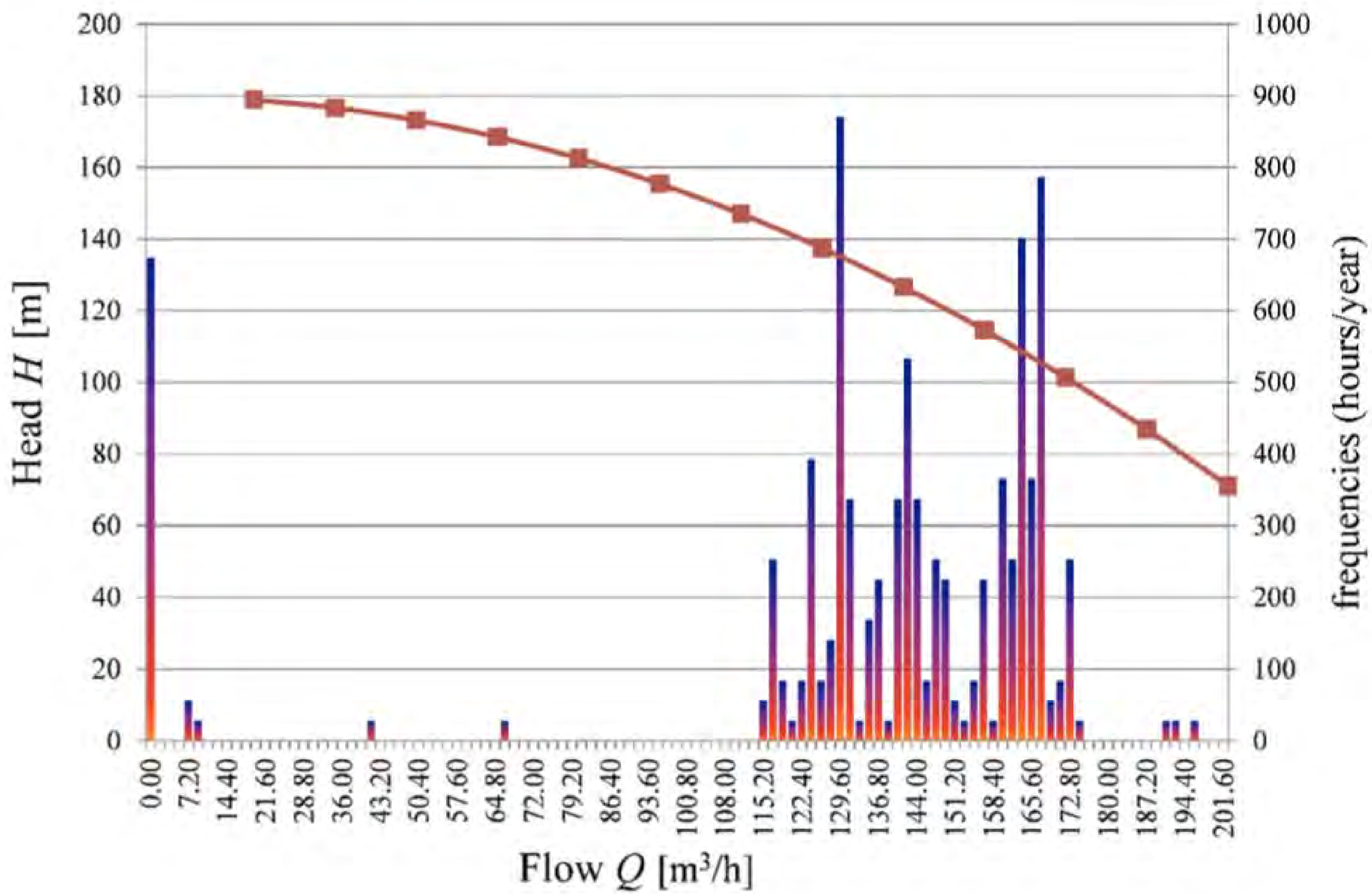
Pumps as Turbines for micro-hydro plants

Head characteristic curve of the site and yearly frequencies of flow rates



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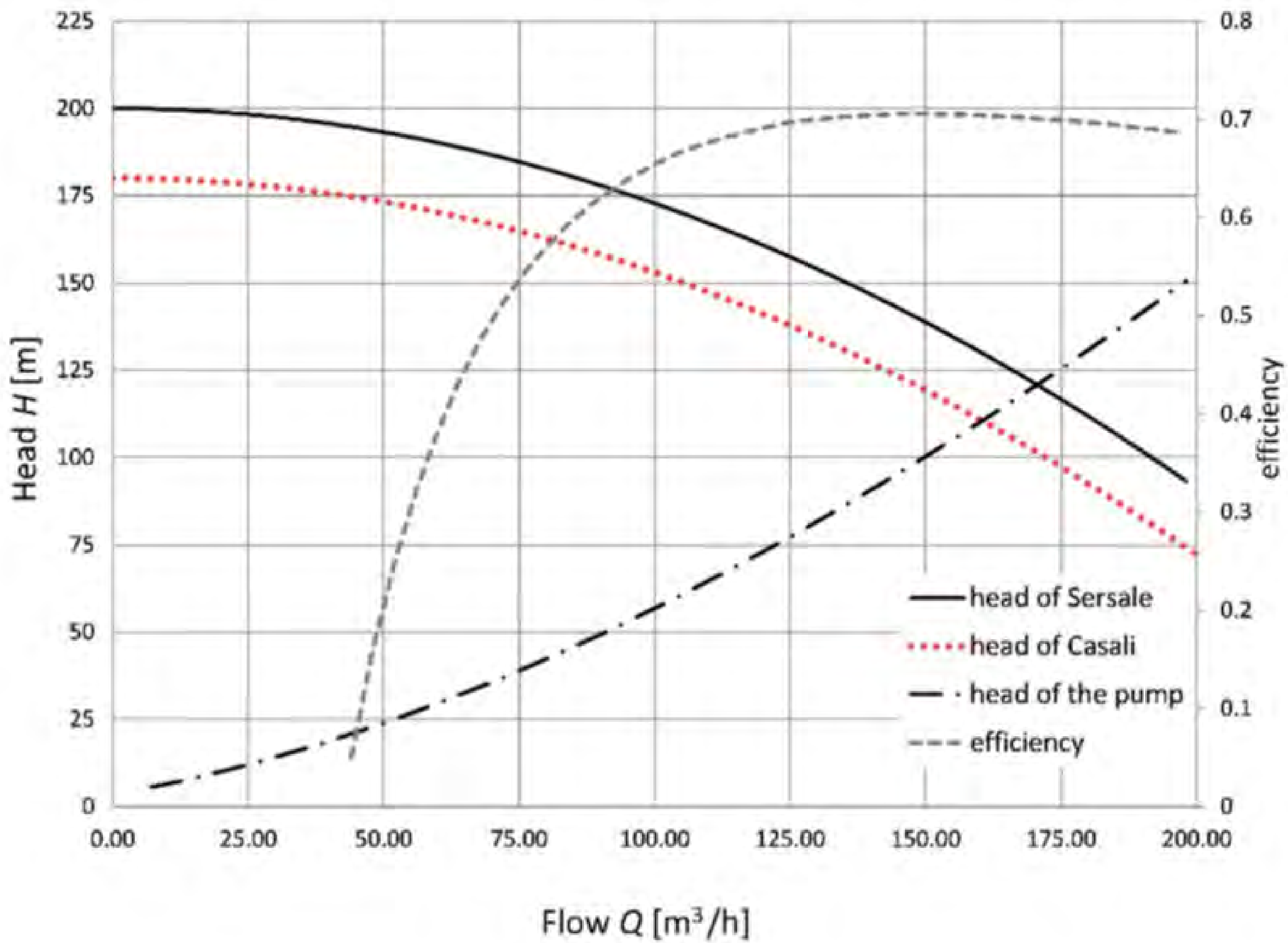
Pumps as Turbines for micro-hydro plants

Estimated characteristic curve and operating point

Annual energy production: 123 MWh/year



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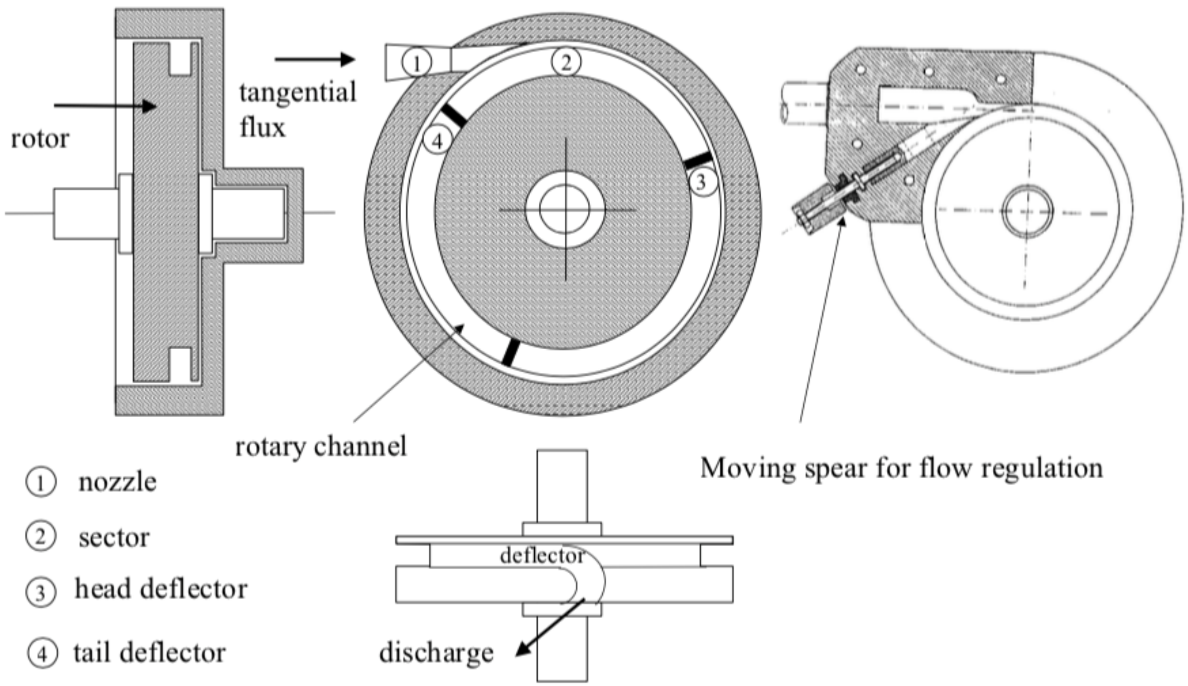
Compressible-flow small turbines

- Waste energy recovery from industrial processes (low enthalpy steams, exhaust gases), let-down pressure stations, micro solar plants producing power and thermal energy
- Wide range of operating conditions
- Good performance in off design conditions



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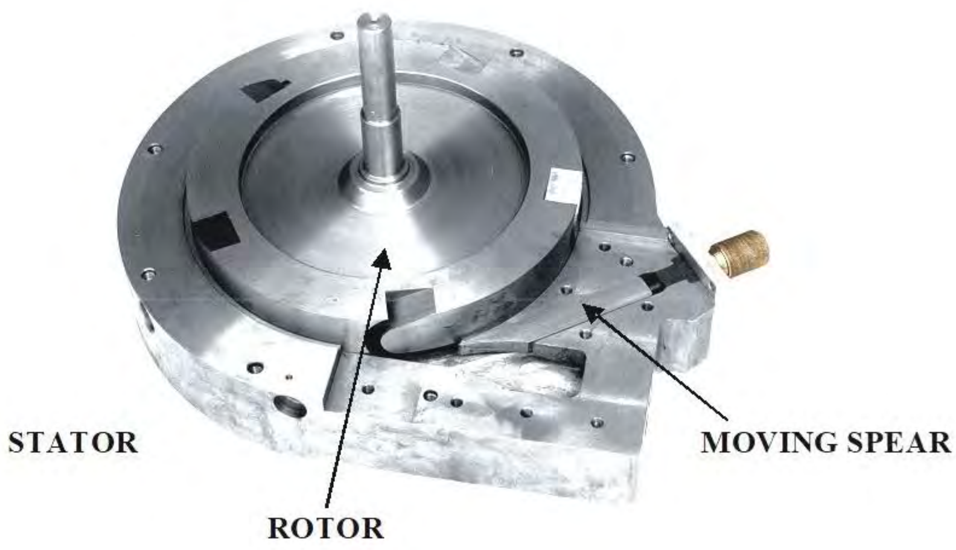

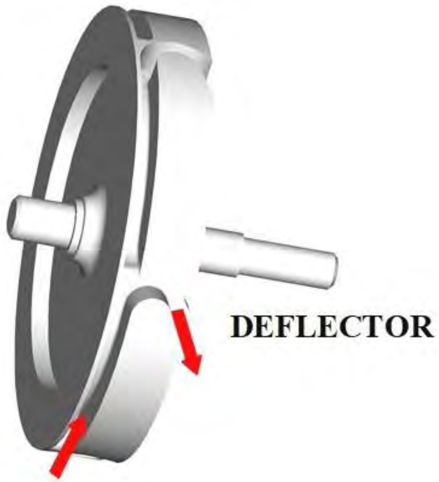

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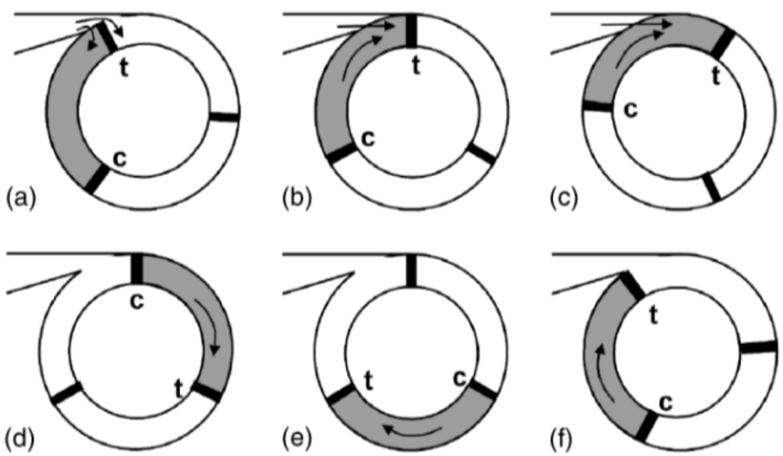
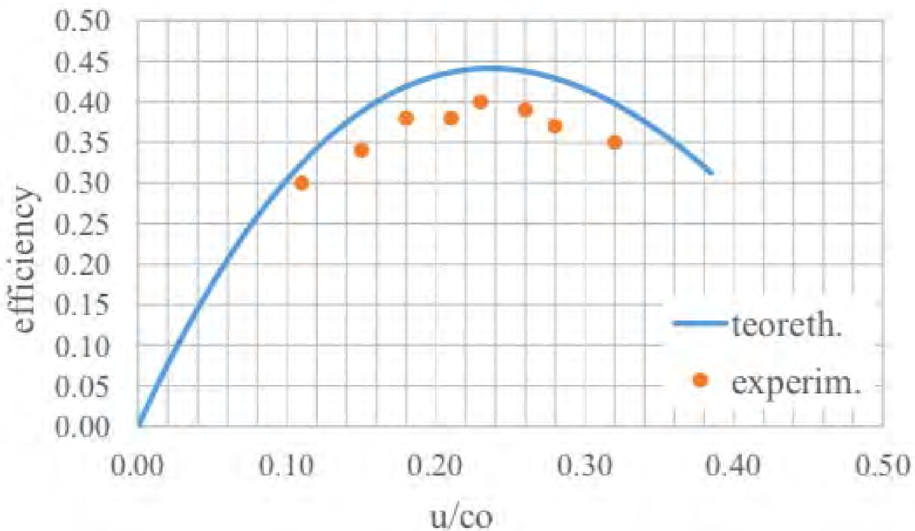
Compressible-flow small turbines

- Pelton configuration
- Tangential flow
- Rotary channel with 3 deflectors
- Diameter 30 cm
- Maximum power 16 kW
- Peak efficiency 50%



Sequence of the flowing phases

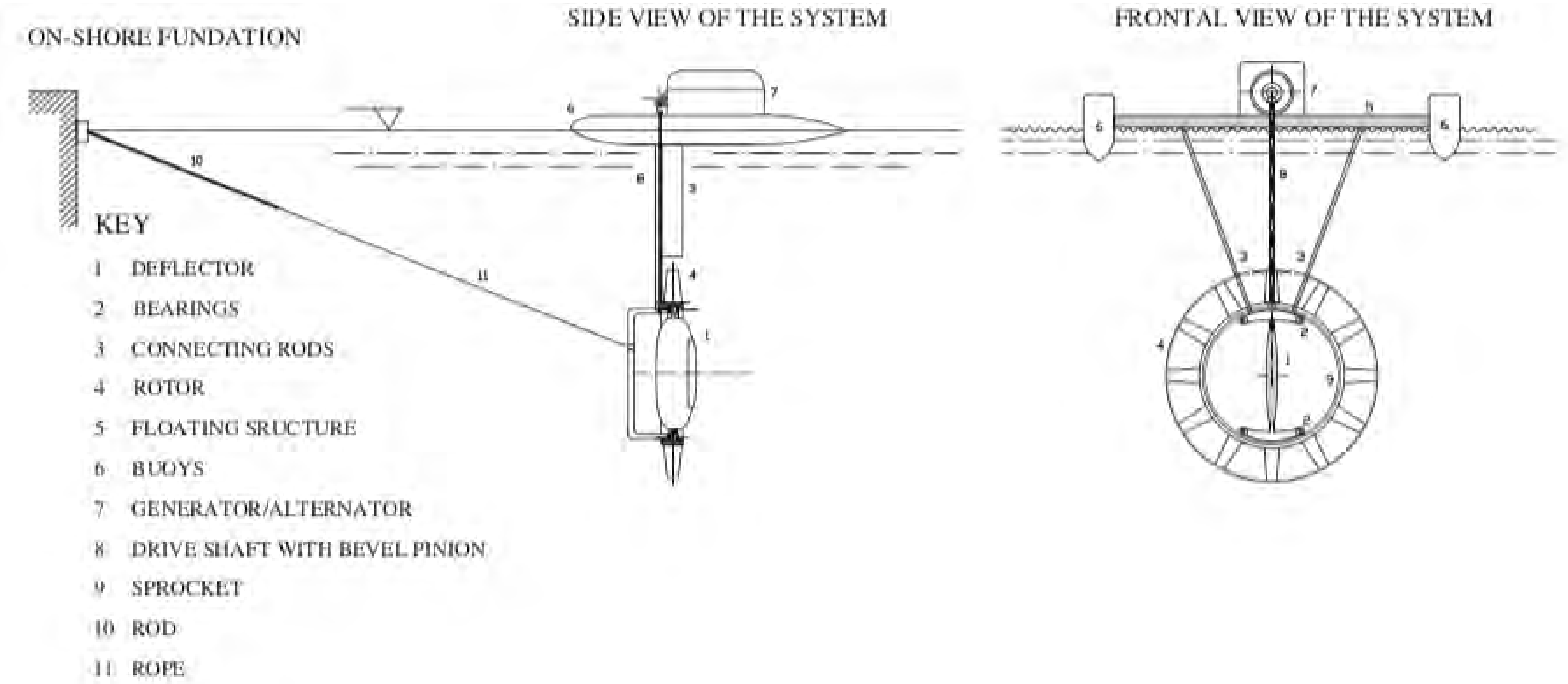


Comparison between theoretical efficiency curve and experimental data

contact: michele.scornaienchi@unical.it

Innovative tidal turbine for the exploitation of river and sea currents

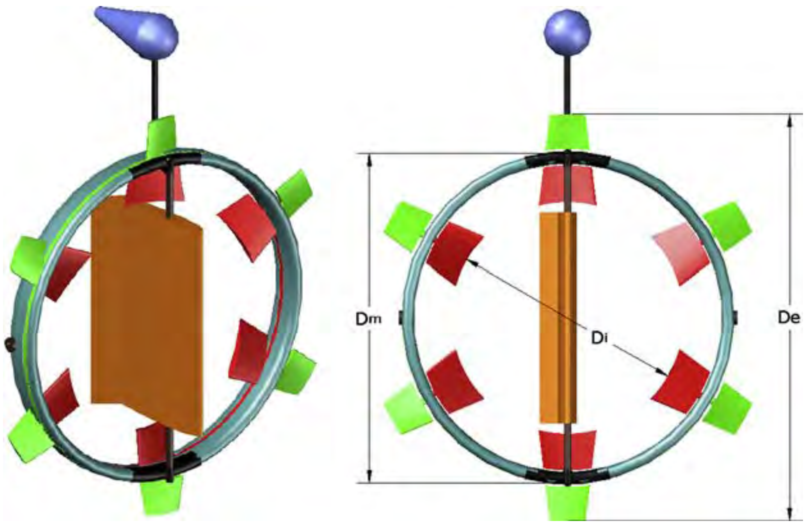
- Self-balancing turbine
- Ability to maintain equilibrium position in the current



contact: silvio.barbarelli@unical.it

Innovative tidal turbine for the exploitation of river and sea currents

- Self-balancing turbine
- Ability to maintain equilibrium position in the current
- Operation with bidirectional flows



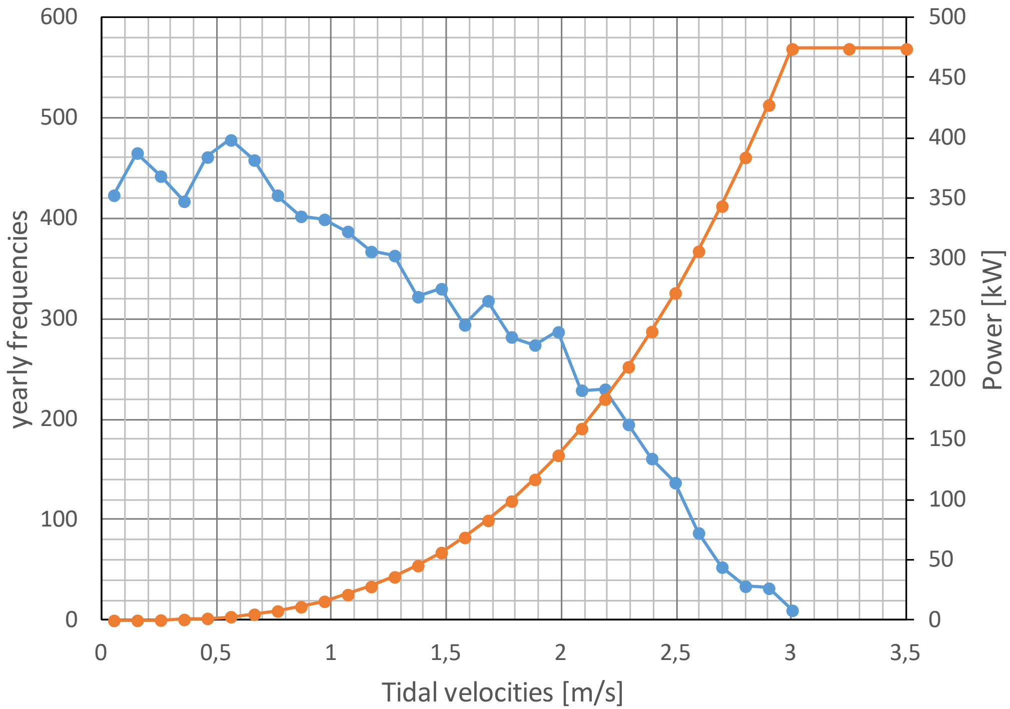
Double rotor turbine prototype

contact: silvio.barbarelli@unical.it

Energy recovery from tidal currents

Turbine power as a function of tidal current velocity in the Strait of Messina

Collaboration with Sintenergy Ltd. and Develpack srl (RC)



Energy yield estimation: 0,5 MW peak
500 MWh/year

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Wood gasification in a Trigeneration Plant

PROJECT funded by REGIONE CALABRIA in collaboration with SILPA s.r.l

Waste heat recovery from Internal Combustion Engines (ICEs) to produce simultaneously:

- **refrigeration power** for an absorption chiller
- **hot water** for thermal user
- **electrical power** (fed into the grid)

ICEs characteristics:

- Fueled with syngas obtained on-site
- from the gasification of solid wood chips
- 200 kW_{el} electrical power
- 400kW_{th} thermal power

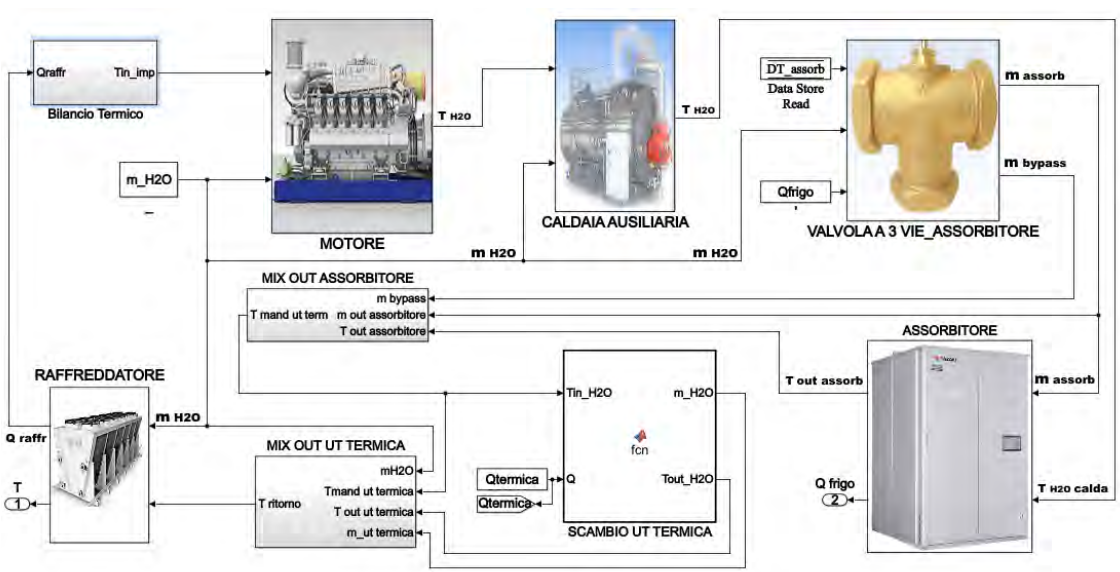
contact: teresa.castiglione@unical.it

Wood gasification in a Trigeneration Plant

PROJECT funded by REGIONE CALABRIA in collaboration with SILPA s.r.l

POR Calabria
2014-2020
Fesr-Fse
il futuro è un lavoro quotidiano

- Development of a lumped-parameters model of the plant
- Development of a controller
- Model validation with experimental data in order to manage the water flow rates for the optimal operation of the adsorption chiller and to satisfy transient thermal and refrigerating loads



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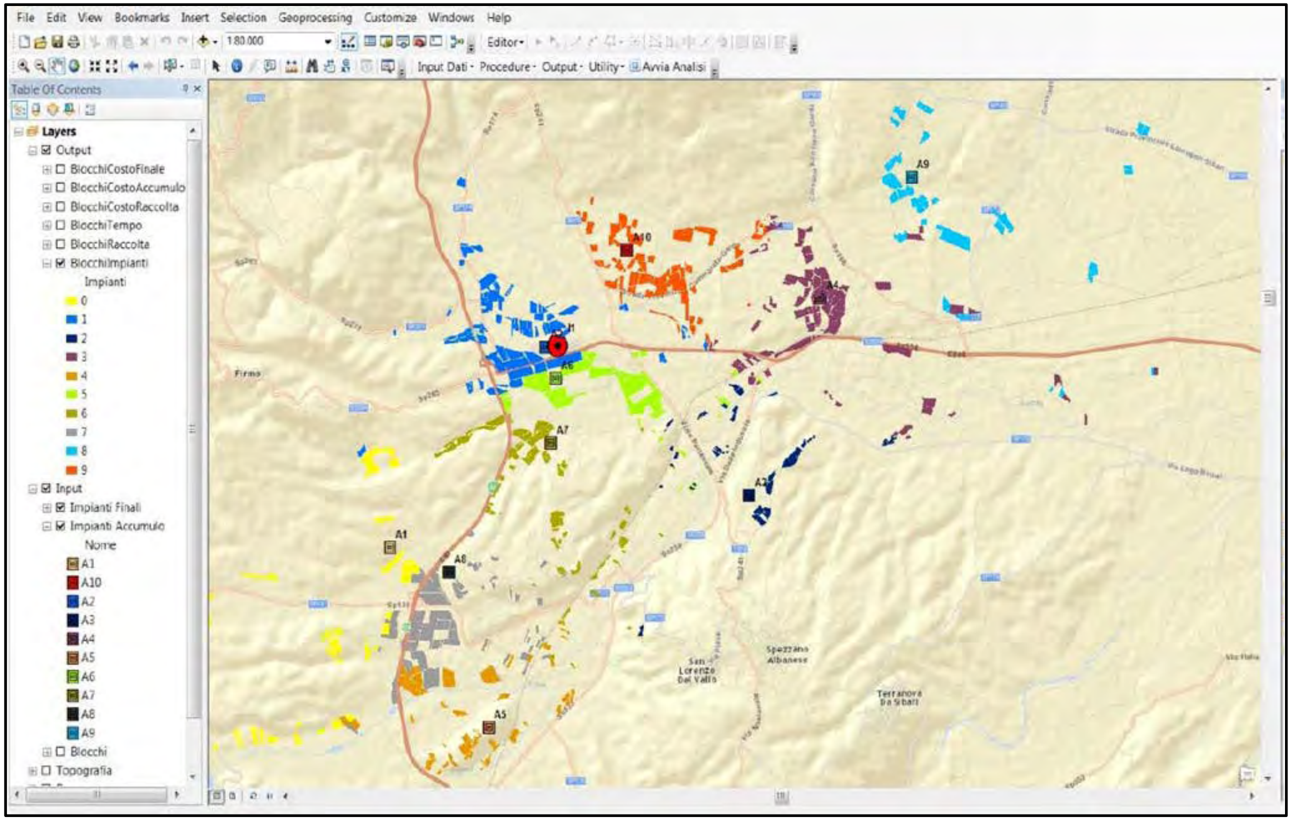
GIS-based models development

PROJECT funded by MIUR - PON01_01840 (μPERLA)

PON Ricerca e Competitività 2007-2013

- Biomass distribution
- Harvesting and transportation times and costs
- Optimal location of the conversion plant



contact: angelo.algieri@unical.it

University of Calabria

Fuel cells integrated systems

- Fuel Cell based energy systems (SOFC, MCFC, PEMFC, AEMEC)
- Hydrogen generation systems (Reforming, Electrolysis)
- Development of hybrid electric vehicles
- Development of hybrid trigenerative systems fuelled by bio-fuels
- Experimental studies: SOFC, SOE

Supply system

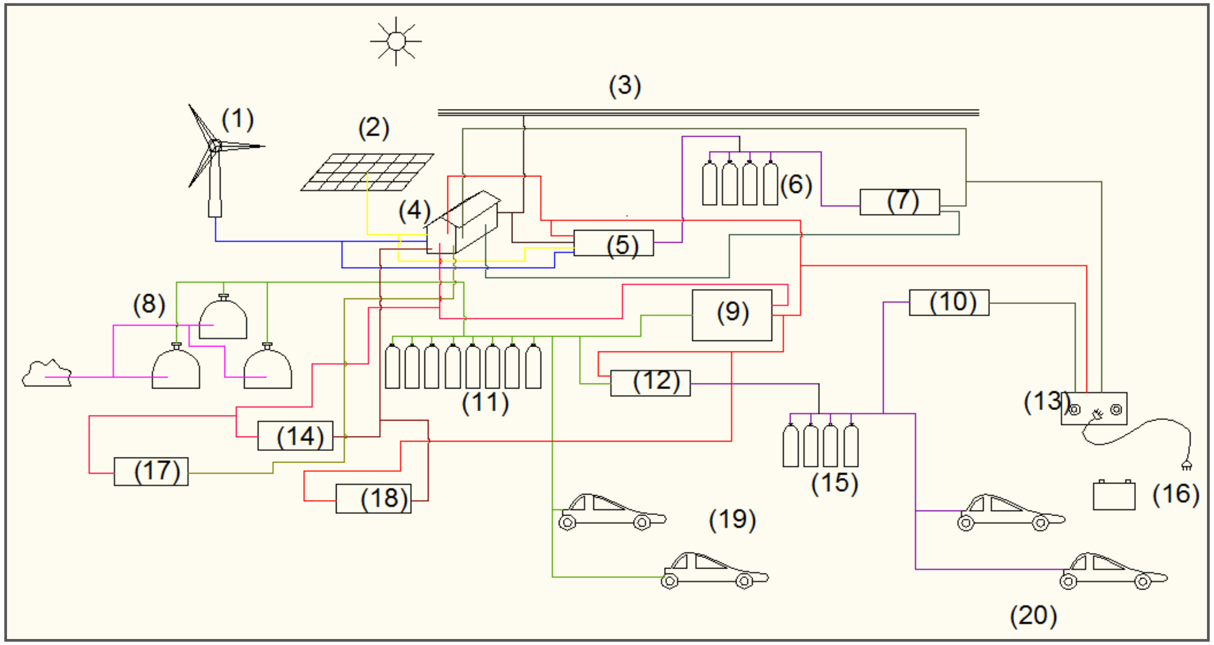
Test bench

Stack SOFC

contact: petronilla.fragiacomo@unical.it

Fuel cells integrated systems

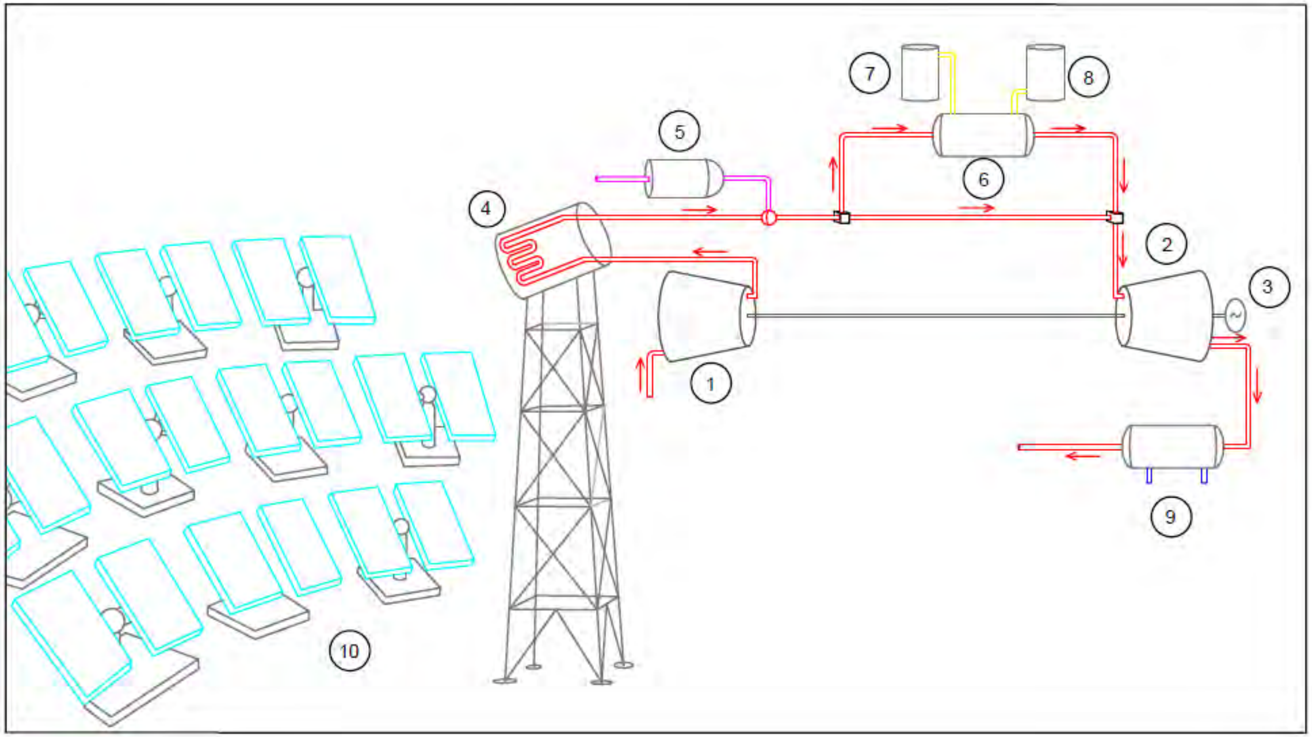
Integrated application in smart grids



(1) Eolic Plant
(2) Photovoltaic Plant
(3) Central Electric Grid
(4) User
(5) Electrolysis Plant
(6) Hydrogen Storagefor Stationary Fuel Cell
(7) Low Temperature Fuel Cell (LTFC)
(8) Anaerobic Digester Plant
(9) High Temperature (Reforming) Fuel Cell System (HTFC)
(10) Low Temperature Fuel Cell (LTFC) for Propulsion Electrical Energy Service
(11) Biogas Storage
(12) Reforming System
(13) Electrical Energy Station for Charging
(14) Absorption Heat Pumps
(15) Hydrogen Storage for Propulsion Fuel Cell Vehicle
(16) Vehicle Battery Charging
(17) Hybrid HTFC/Turbine System
(18) Compression Heat Pumps
(19) Engine Vehicle Propulsion Biogas fed
(20) Electrical Fuel Cell Vehicle Propulsion Hydrogen Fed

Hybrid micro-turbine in a CSP plant

Combined heat and power generation with particle thermal storage in a open Brayton Cycle

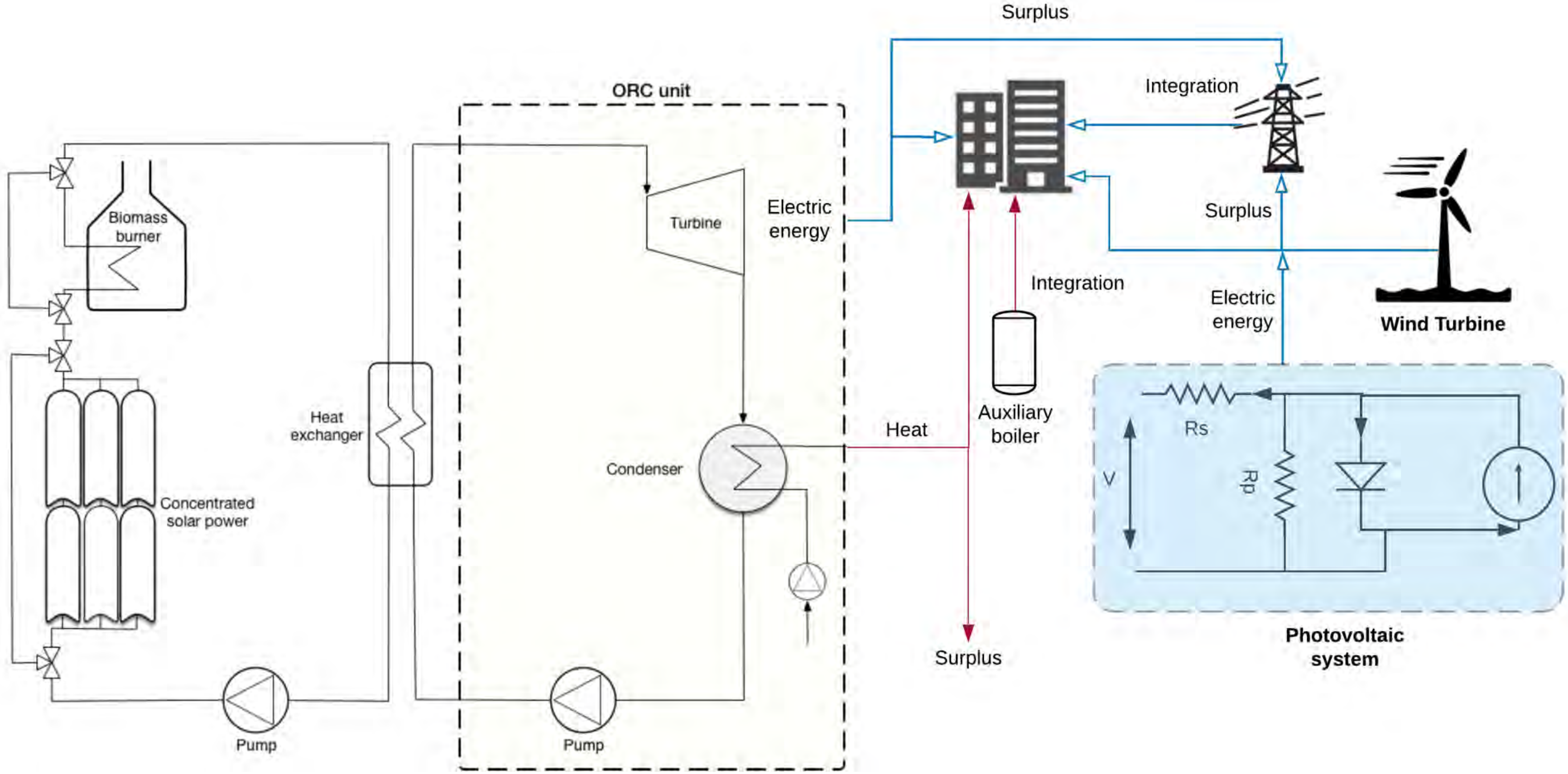


1. Compressor
2. Turbine
3. Generator
4. Solar receiver
5. Combustor
6. Particle heat exchanger
7. Cold Tank
8. Hot Tank
9. Heat Exchanger
10. Heliostat field

contact: francesco.rovense@unical.it

Hybrid Solar / Biomass Organic Rankine Cycles (ORC) systems

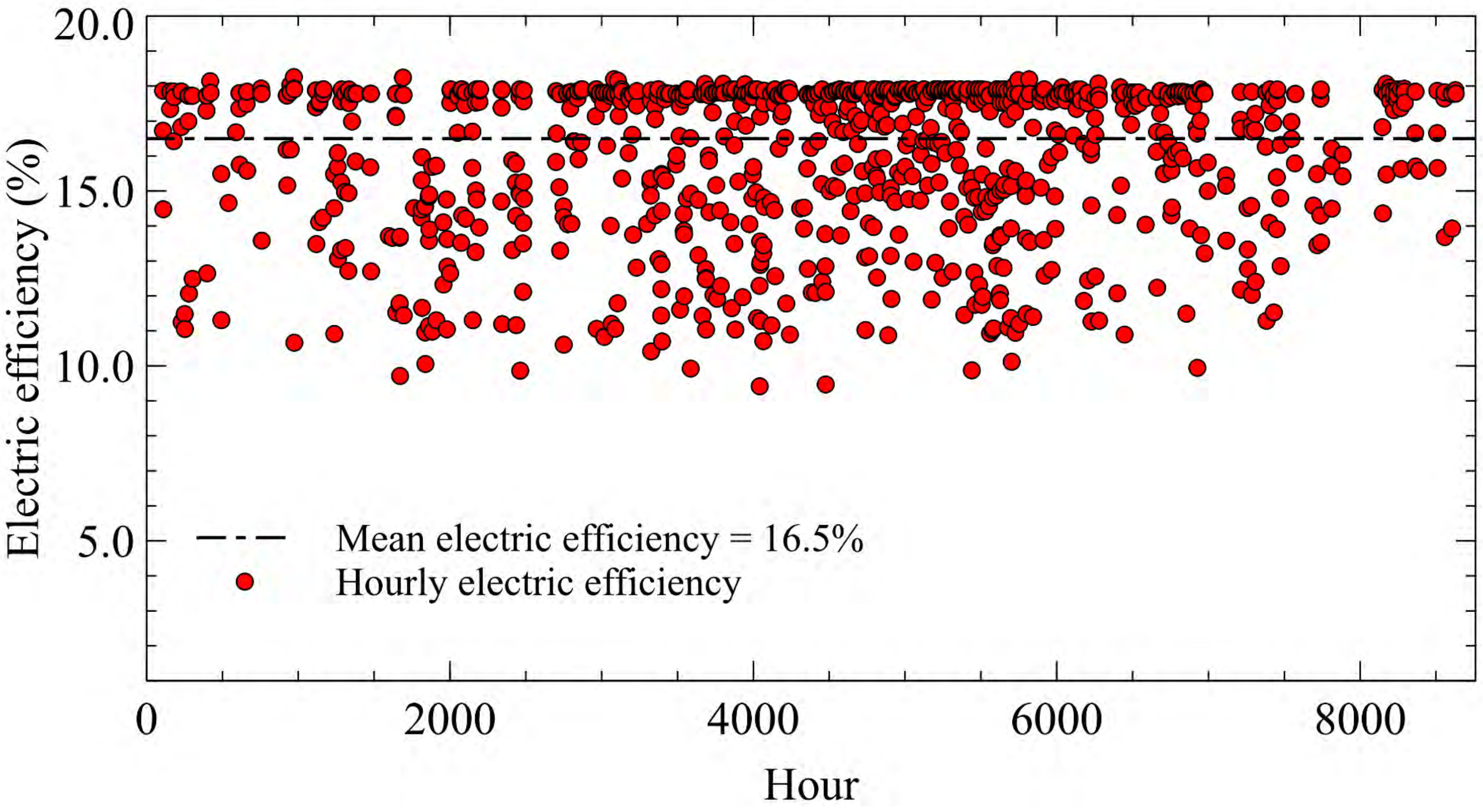
- Characterization of the system at partial load
- Comparison between fully solar, fully biomass and hybrid systems



contact: pietropaolo.morrone@unical.it

Hybrid Solar / Biomass ORC systems

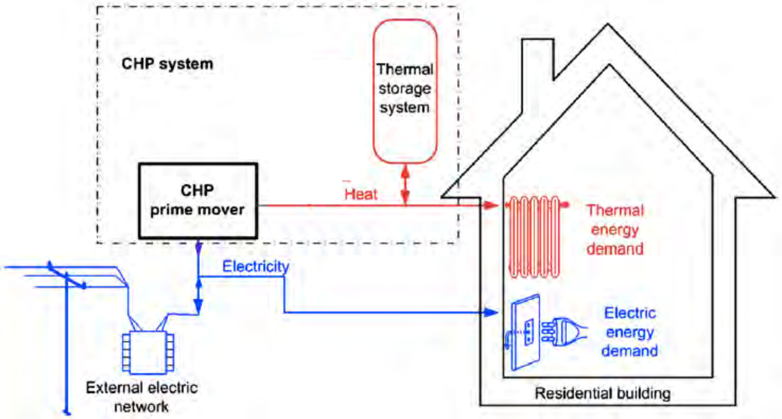
Hourly electrical efficiency of Solar only ORC system

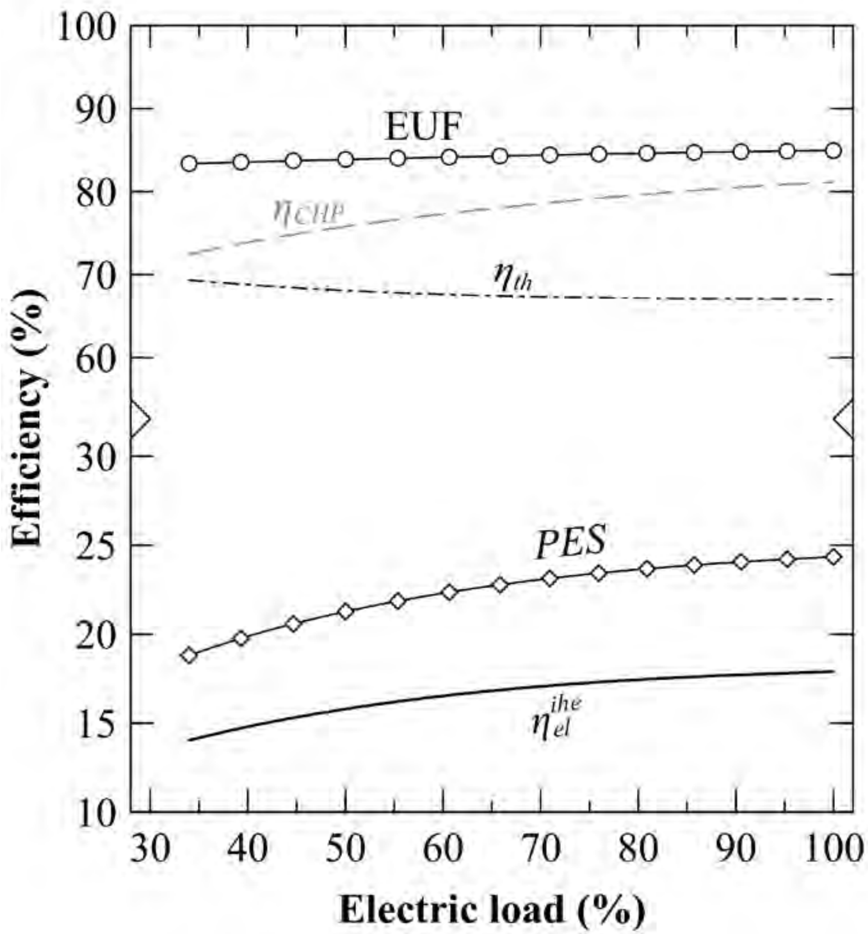


Hybrid Solar / Biomass ORC systems

Performance parameters of the hybrid system at partial load:

- Energy Utilisation Factor
- Thermal
- Electric efficiency
- Thermal power





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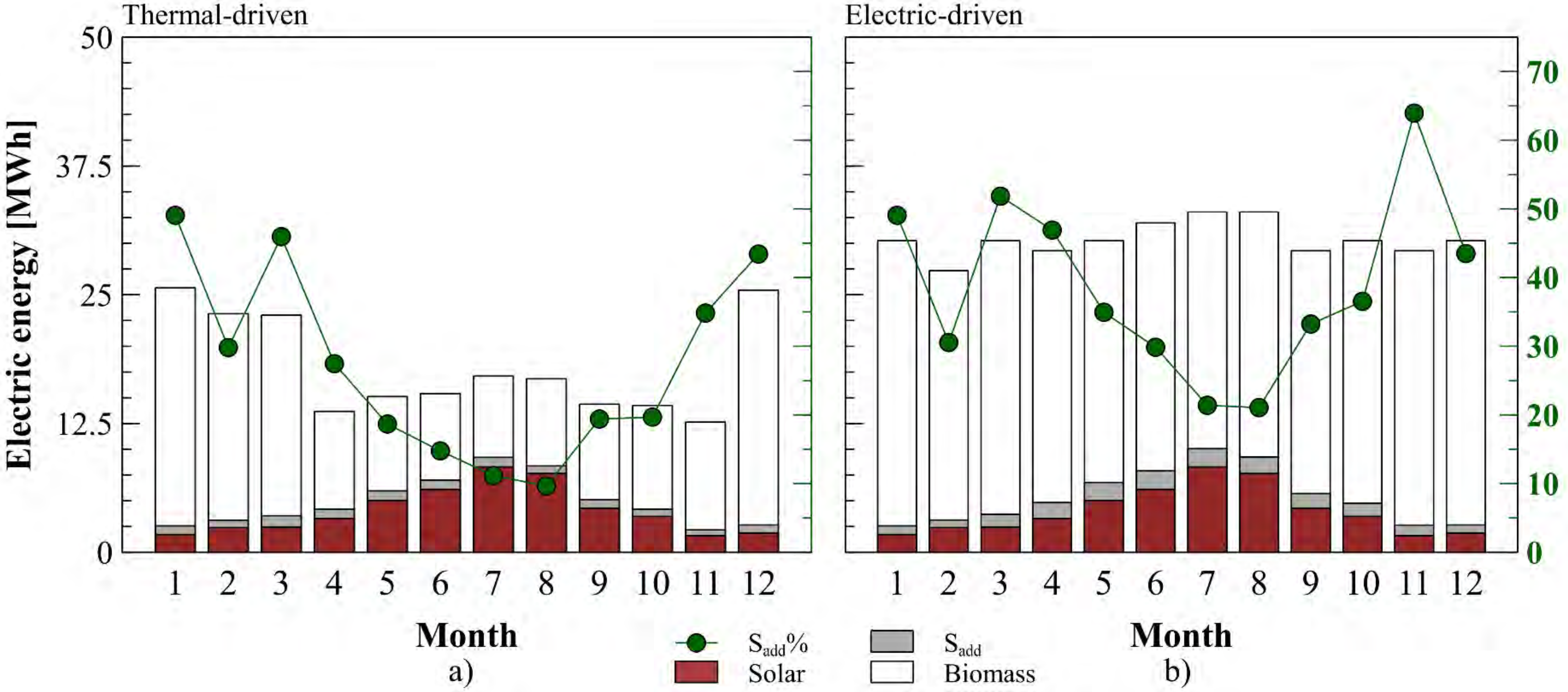
Hybrid Solar / Biomass ORC systems

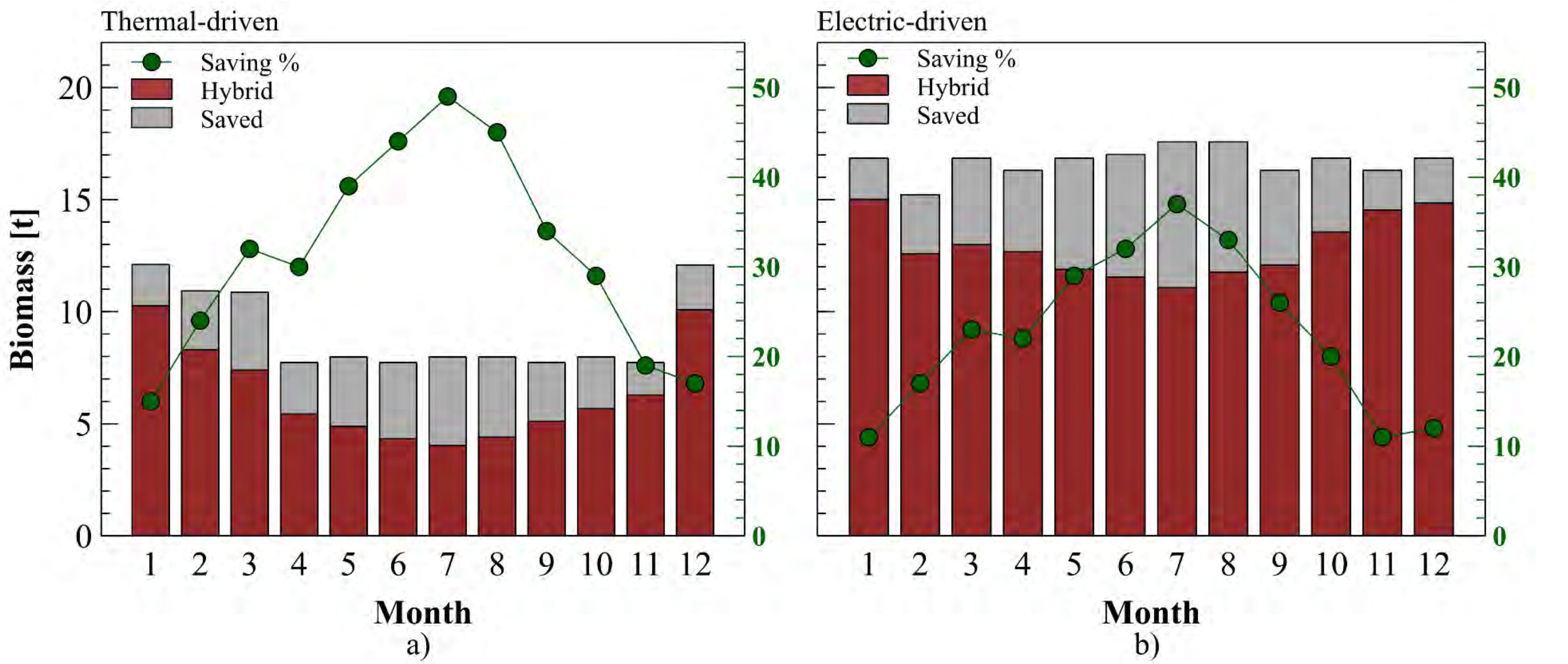
Comparison with full solar and full biomass equivalent power units



- Monthly energy production due to solar and biomass sources
- The solar gain (S_{add}) due to hybridisation is highlighted

Hybrid Solar / Biomass ORC systems

Comparison with full solar and full biomass equivalent power units

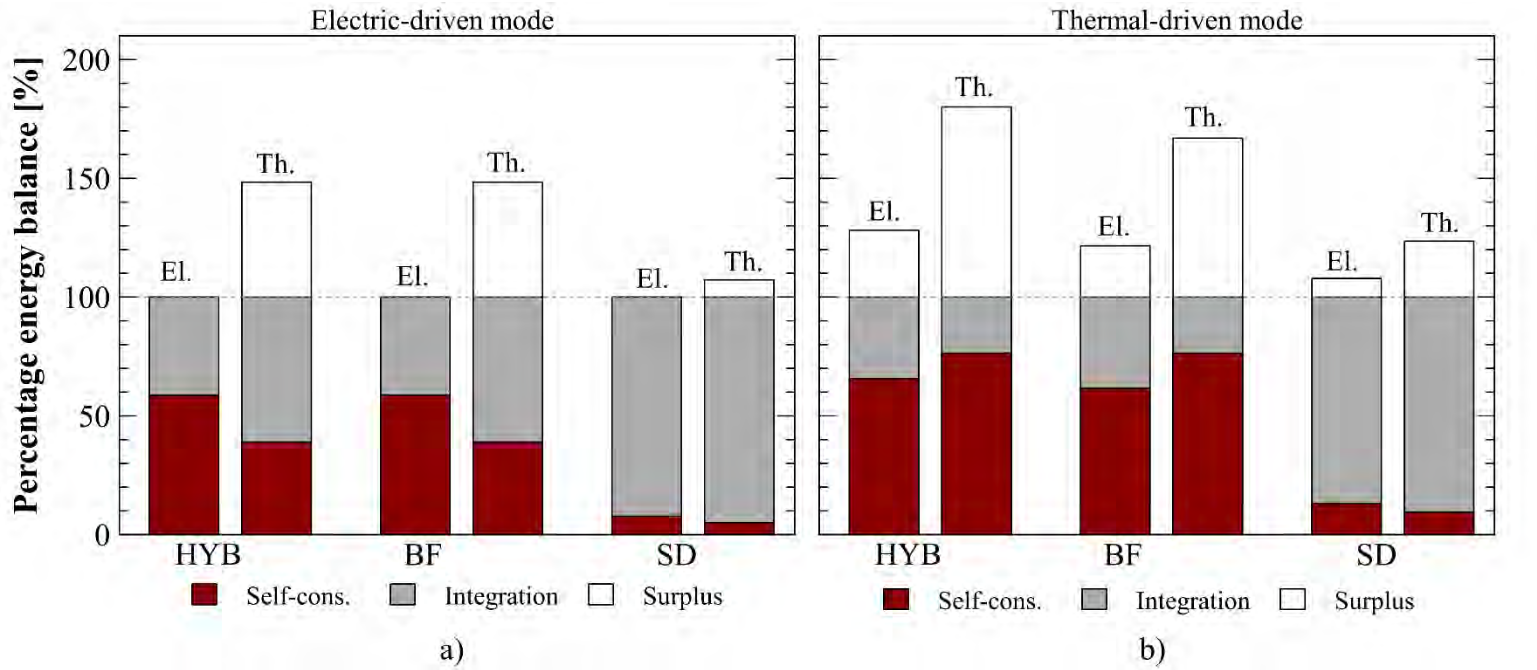


- Monthly biomass saving

contact: pietropaolo.morrone@unical.it

Hybrid Solar / Biomass ORC systems

Annual energy production due to solar and biomass sources



Comparison in terms of self-consumed, integrated and surplus energy

contact: pietropaolo.morrone@unical.it

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THANK YOU
for your attention

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