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Short Bio

Massimiliano Renzi is Associate Professor for Fluid Machine and Energy systems at the Free University of Bozen/Bolzano.

He received his Master Degree in Mechanical Engineering in 2007 and his PhD in Energy in 2011 from the Polytechnic University of Marche. In 2009 he started his collaboration with a University spin-off, Strategie srl, working in the field of energy conversion and innovative energy systems. He is also shareholder of the company and owns patents on solar concentration devices. In 2012 he won a position as Assistant Professor at the Free University of Bolzano where he is in charge of the Laboratory of Fluid Machines and Electric Drives.

The main research topics include: cogeneration systems for distributed power generation fed by both traditional and alternative biofuels; hydraulic machines for small-hydropower, for energy recovery systems and pumped hydro storage; thermal management of powertrains with specific focus on combustion engines and battery systems for electric vehicles; combustion of alternative fuels and alternative combustion strategies in internal combustion engines and micro gas turbines; optimization strategies of hybrid energy systems and energy storage.

Contact and references

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Keywords

Fluid Machines and Energy Systems

Hydropower, Pump-as-Turbines

Thermal management in automotive powertrains

Electrification of vehicles

Biofuels and Hydrogen-enriched fuels

Cogeneration

Internal Combustion Engines

Micro Gas Turbines

Optimization of Energy Systems and Energy storage

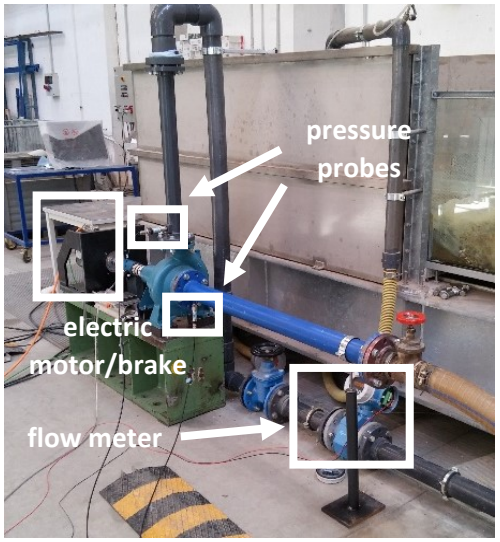
Research activities and Labs

HYDROPOWER – This research line aims at the development of novel solutions for energy recovery solutions with hydraulic machines in civil and industrial plants, as well as the study of mini and micro hydroelectric plants. Innovative design solutions are studied to adopt low-cost machines and to widen their operating range in energy recovery solutions and mini hydropower.

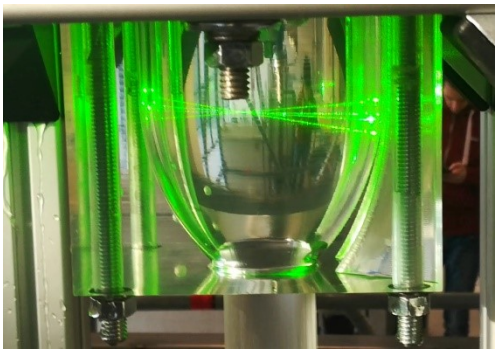
The labs are equipped with test benches for the analysis of the performance of hydraulic machines and the definition of hill diagrams of test scale machines. Also a detailed analysis of the fluid-dynamic behaviour of these machines is possible thanks to the use of optical, non-intrusive measurement techniques. Novel methodologies, also based on artificial neural networks, have been developed to forecast the performance of the machines and to provide an accurate design tool and to describe machine performance in design and in off-design working conditions. Fluid dynamics simulations with CFD software are also performed to predict the performance and optimize the design.

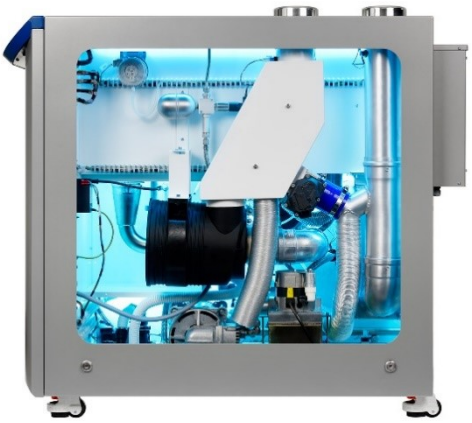
COGENERATION – Different cogeneration devices are studied with a specific focus on the use of alternative fuels and the application of innovative power cycles. One of the investigated technologies are the internal combustion engines run with biofuels and with novel combustion solutions (dual-fuel feed with producer gas from biomass gasification). The performance and the emissions of engines can be assessed with specific test benches, specifically studied for different applications, like cogeneration and engines for agricultural applications. The labs are also equipped with a test bench for micro gas turbines to assess their cogeneration performance and emissions when fuelled with traditional and alternative fuels. A specific focus is also dedicated to the analysis of hydrogen-enriched fuels. Also CFD simulations are developed to study the combustion process with biofuels and hydrogenated fuels.

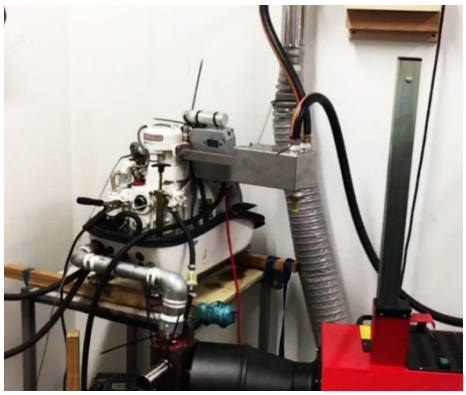
ELECTRIC AND HYBRID POWERTRAINS – This research topic aims at studying the energy flows in hybrid and electric powertrains with the primary objective of reducing the environmental impact and increasing the performance of the powertrain. One of the research projects aims at optimizing the design of lithium-ion battery modules in order to improve the thermal homogeneity and, as a consequence, the battery life and performance. A detailed model of the electric and thermal characteristic of the cell and of the module has been developed to forecast the behaviour of the battery and to design the required cooling system. Both experimental tests and CFD simulations have been carried out. The



PaTs test bench


LDA on a Pelton

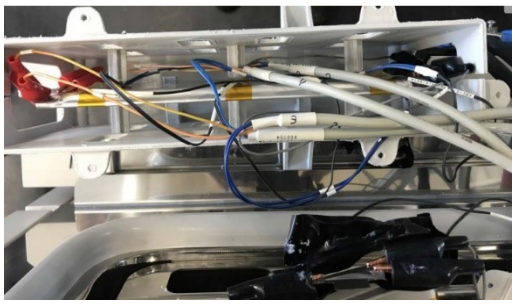

Micro gas turbine test bench


Cogeneration engine test bench
(dual fuel combustion)

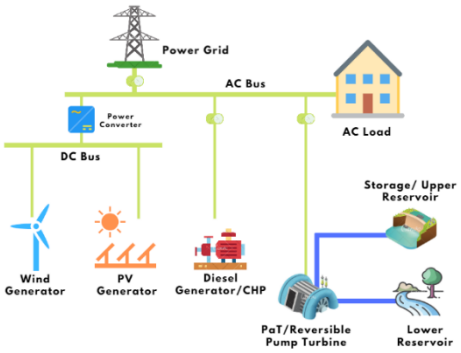
battery pack is then modelled and embedded within the whole thermal management system of the vehicle.
In a second research topic, the electrification of tractor engines and agricultural machines is studied. Specifically, a comprehensive model of the power flows of the tractor is developed and the analysis of the emission reduction potential is evaluated by analyzing the electrification potential of the implements and of the auxiliary systems within a tractor powertrain.

Engine test bench (alternative fuels)

OPTIMIZATION OF HYBRID ENERGY SYSTEMS WITH STORAGE – Optimization techniques are studied for the optimal design and management of hybrid networks powered by renewable sources and micro CHP systems. The optimal sizing and management of the power generation devices is fundamental to increase the penetration of renewable resources in the electric system. The availability of such resources is hardly predictable and other programmable resources should be able to supply the required power; storage solutions, like batteries and pumped hydro, also play a crucial role in fully exploiting renewable resources. Advanced optimization techniques are studied and developed together with models of different power generation devices. Specifically, Mixed Integer Linear Programming techniques and codes are used to identify the optimal management of power generation systems and to minimize cost function, like harmful emissions and the cost of production of energy. I also participated in the international research group of the International Energy Agency (IEA) in the context of Annex 54 "Integration of Micro-Generation Energy and Related Technologies in Buildings". In particular, I developed a model for determining the optimal size of the components of a hybrid generation system consisting of micro CHP plants and renewable generation.



Lithium-ion cell electric and thermal test for electric vehicles



Modelling and optimization of hybrid energy systems and storage solution

MAIN RESEARCH GRANTS AS PI OR CO-I

- **Third call for research, Law 14, Autonomous Province of Bolzano, project AI-ALPEN: Supply of drinking water in alpine regions: piping loss reduction and energy optimization for long-term sustainability (Principal Investigator for the workgroup of the Free University of Bolzano; grant for Bolzano € 148'703)** This project is made in collaboration with the Department of Hydraulics of the University of Trento. The purpose of the project is to define appropriate methodologies for the characterization of the water network losses and ensure the optimum utilization of the power production potential in water supply systems. A specific test bench has been used together with numerical CFD simulation tools for the description of the performance of hydraulic turbines (or Pump as turbines) that can be inserted into the water networks for energy recovery purposes.
- **Project "Design of more-electric tractors for a more sustainable agriculture" GREEN-SEED, founded by the Italian Ministry of Research PRIN (Progetto di Ricerca di Interesse Nazionale, grant for Bolzano € 102'000)**: PI of the work unit of unibz for the national PRIN project. This project

aims to create the background, currently missing, to face the design of a complete more electric tractor system, identifying, among the others, the best electrification structure topology to be adopted, the load requirement for different operations and the components currently used that need to be redesigned. These further steps could be implemented in a larger project with the objective to design and build a real scale prototype of more-electric tractor involving more partners also in the frame of EU project, since the topic is within the priorities of the European Agency for Horizon 2020 about sustainable growth, in the Flagship Initiative "Resource efficient Europe".

- **"Thermal management of the accumulator batteries in electric and hybrid cars: optimization strategies for performance enhancing and for a sustainable mobility" (2017, EU fund regional develop. 874.038 €);** In collaboration with Roechling Automotive AG. The purpose of this project is to study and optimize the thermal and energy flows of the car system with the primary objective of reducing the environmental impact, increasing the performance of accumulators. New innovative solutions for the battery pack cooling system of the electric vehicles, as well as for the powertrain thermal management will be proposed; in parallel, a numerical analysis will be carried out, using simulation software, in order to evaluate the possible optimization strategies in the management and control of the flows of refrigerant liquids within the battery pack.
- **"Turbine Idrocinetiche, ottimizzazione per una produzione sostenibile" (2017, EU fund regional develop. 884'600 €);** in collaboration with the local companies Troyer and AC-TEC. The project has the aim to develop, together with companies working on hydro turbines production, research activities for improvement of conventional and original hydro power turbines (mini-hydro). The research activities will include both Computational Fluid Dynamics studies and analyses on physical models of innovative solutions for mini hydro. The research results that will be obtained during the project, will not be solely submitted for publishing on scientific journals, but also "engineered" and applied to partner manufacturing machines. Therefore, this should enable to improve the competitiveness of the products of the industrial partners and to acquire new market shares.
- **Several internal projects of the Free University of Bozen/Bolzano on cogeneration systems**: "Design and study of the performance of a microcogeneration system using internal combustion engine fuelled by intermediate fuels from biomasses"; "Indirect energy efficiency and torque assessment of internal combustion engines based on exhaust gas temperature and O2 content" and "Direct evaluation of the performance of internal combustion engines with the measurement of the indicated thermodynamic cycle"; "Cogeneration system fed by solid fuels´ synthesis producer gas" and "Experimental measurement system of the heat recovered by micro cogeneration systems"; "Study of the combustion and of the engine management strategy of a dual fuel internal combustion engine fed with alternative fuels".

OTHER GRANTS AS PARTICIPANT

- **"Thermo Fluid Dynamics, infrastructures for applied research to business and industry in South Tyrol" (2016, EU fund for regional develop. 849.600 €).** The project involves the construction of a thermo-fluid dynamics laboratory in which test lines will be installed to test compressible fluids, incompressible fluids and combustion systems to be applied to the study of fluid machines. The laboratories are being set up in the NOI technology park. They will be provided with the instrumentation for the advanced study of hydraulic machines (pumps and turbines) and compressible fluid machines, as well as cogeneration. In addition to traditional methodologies, optical measurement techniques will be applied to study the fluid dynamics of fluid machines, thermo-fluid dynamics, sprays and combustion (PIV, LDV, PDPA).

EXTERNAL COMPANIES' COMMISSIONED RESEARCH

- Research on the role of coal in the context of the Italian energy system: regulation and technologies for energy production and for pollutants' removal (Ottanatuno Group);
- Study of the SCR systems for the abatement of NOx emissions in the automotive sector (Röchling Automotive);
- Fluid dynamic simulation of a refill circuit of an AdBlue tank of a Selective Catalytic Reducion (SCR) system for the abatement of NOX emissions from the combustion in automotive diesel engines (Röchling Automotive);
- Fluid dynamic simulation of a Kaplan hydraulic machine (AC-TEC Caldaro);
- Fluid dynamic analysis of kitchen hoods (Revolt srl);
- Consultancy in the design of two-phase scroll expanders for energy recovery (Tifeo srl).

Industrial PhD supervision on the development of novel solutions for the thermal management of electric and hybrid vehicles in collaboration with Röchling automotive.

INTERNATIONAL JOURNAL PUBLICATIONS

I'm author of 105 scientific works: 57 articles in international journals, 39 international conferences, 7 in national conferences, 2 technical reports.
Scopus database: Number of records: 65; Number of citations: 841; h-index: 17

List of the International Journal publications:

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12. Prando D, *Renzi M*, Gasparella A, Baratieri M. **Monitoring of the energy performance of a district heating CHP plant based on biomass boiler and ORC generator**. *Applied thermal engineering*. 2015:79;98-107. DOI: 10.1016/j.applthermaleng.2014.12.063:
13. Cioccolanti L, Savoretti A, *Renzi M*, Caresana F, Comodi G, **Design and test of a single effect thermal desalination plant using waste heat from m-CHP units**. *Applied thermal engineering*. 2015:82;18-29. DOI: 10.1016/j.applthermaleng.2015.02.047.
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MAIN COLLABORATIONS – UNIVERSITY

MAIN COLLABORATIONS – COMPANIES

Röchling Automotive

AC-TEC

Troyer

Strategie srl

Revolt srl