Petronilla Fragiacomo is an Associate Professor in Energy and Environment Systems at the University of Calabria.

She has qualified as a full professor in data December 22, 2014.

Teaching and academic activities

In the academic year 2017/2018 she holds the courses of Power Plants and Fundamentals of Fluid Mechanics, respectively, the former concerning the 2nd level of University Degree in Chemical Engineering, the latter concerning the 1st level of University Degree in Mechanical Engineering.

Over the years she has also held the courses of Complements of Power Plants and Energy Services, respectively, the former concerning the 2nd level of University Degree in Chemical Engineering, the latter concerning the 1st level of University Degree in Logistics and Management Engineering.

Her teaching activities have been carried out in the Engineering Faculty and Department of the University of Calabria since 1987, developing Mechanics Applied to Machines and Fluid Machinery course with reference to engines, machines, mechanical plants, internal combustion engines and special machines and energy systems.

She was appointed Researcher at the Engineering Faculty of the University of Calabria in April 1, 1992, in the area of Machines and Propulsion Systems.

She won two study grants awarded by the Administration of the Calabria Region for research into energy for two years (1987, 1988) at the Mechanical Engineering Department of the University of Calabria.

Member of the Committee of the Department of Mechanical Engineering from November 5,1992 to November 5,1993, from May 4, 2001 to November 14, 2005 to date, from November 17, 2006 to December 2012, and Member of the Committee of the Department of Mechanical, Energy and Management Engineering from February 2014 till 31 October 2015.

Member of the Academic Council of the PhD program in "Turbomachinery and Power Plants Engineering" based at the Technical University of Bari, for the academic year 1999/2000.

Member of the Academic Council of the PhD program in Mechanical Engineering for the present university from academic year 2000/2001 till 2015/2016.

Member of the Academic Council of the PhD program in Industrial and Civil Engineering for the present university from academic year 2012/2013 till now.

Member of various Department and Faculty committees and working groups.

She was also member of the Organizing Committee of the 44th and 66th ATI National Conference, held at the University of Calabria in 1989 and 2011.

She graduated in Industrial Engineering at the University of Calabria with a thesis entitled "Influence of Fuel on Detonation in Spark Ignition-Internal Combustion Engines".

At first her research activity revolved around internal combustion engines with controlled ignition. Specifically, she participated in the development of several methodologies to calculate the thermodynamic properties of fuels and has contributed to setting up a software based on a phenomenological model, able to simulate the detonation phenomenon. This model, coupled with the method of the four octane numbers, enabled the development of both a technique for determining the octane request for a spark ignition internal combustion engine, and the determination of the parameters of detonation for different fuels, including some commercial and unleaded gasoline. The model has been verified by comparing the expected results with those obtained experimentally on a single cylinder AVL engine operating with commercial unleaded gasolines.

During the period of regional scholarships, research activity was mainly directed towards the problems related to energy rationalization in Calabria. In this context, a preliminary investigation on the use of methane and on the energy needs for room heating in urban and rural areas was conducted and a method for the optimal location of a centralized cogeneration plant was developed. Later, a method for the technical and economic assessment of plant greenhouses utilizing the waste water of thermoelectric power plants for the heating of the soil and the sheltered plants, was developed.

Through energetic analysis of some industrial Calabrian sectors it was possible to perform an assessment of the main types of cogeneration systems according to the specifications required by users. The analysis focused on the use of indexes characterizing the energy performance of cogeneration plants and on their effective representation.

Then a model was elaborated to design optimally a cogenerative plant that was applied to the milk production cycle and its derivatives and set up a thermo-environmental evaluation model for cogenerative plants both of a traditional and an innovative type such as the fuel cell type SOFC (Solid Oxide Fuel Cell). In the context of fuel cells, as regards the low temperature FC, the possibility of using Proton Exchange Membrane Fuel Cells as propulsors for land traction was investigated. This typology of Cell and Phosphoric Acid Fuel Cell combined with heat pumps as trigenerative energy systems for auxiliary services of a Camper-van were taken into account. In order to evaluate the fuel cells in cogeneration set up, a comparison was made between them and traditional systems through the use of some parameters characterizing cogeneration plants.

Agricultural energy saving was achieved in the context of Calabrian olive oil production. To this purpose the olive oil working cycle was analysed, above all pointing out the energy input and defining its quality, quantity and its distribution over a period of time. The evaluation of energy consumption and the average yearly production of vegetable water was estimated from a preliminary analysis of the sector and of the characteristics of different extraction systems. Consequently, it was possible to compare the potential pollution, resulting from olives processing, with the emission of pollutants from municipal wastewater.

In order to quantify the global Calabrian energetic producibilty in the field of renewable energy sources, she has worked on hydroelectric micro-power plants involving the discussion of more than 100 rivers. In particular, for the river Aron of Cetraro (CS), a layout was developed in order to provide both hydroelectric energy and, in the summer period, water for irrigation to the farmers who operate near the mini- power plants. Then, the possibility of recovering a further energetic rate was considered by using the turbomachines outside normal project conditions.

Other themes developed over the years, concern the study, by means of a phenomenological model, of the combustion and the chemical kinetics of a turbogas burner. The proposed model falls into the category of models using complex kinetics and simple fluid dynamics approximating the real system by means of a series of ideal systems. The connection between fluid dynamics and kinetics in the burner is established using the Beta statistical function with four parameters.

Recently her research activity has focused primarily on the issues described below.

Optimization of Cogenerative Plants

In the field of cogeneration a trigeneration plant optimization model for both size and technological components has been developed in which a cogeneration plant (internal combustion engines and gas turbines) is integrated with a compression and/or absorption heat-pump. Based on the hourly electrical, thermal and cooling load diagrams of an user, the model was used to delineate the optimal running configuration of a trigeneration plant which maximizes short-term economic returns over a calendar year and calculates the savings over a traditional plant configuration. Subsequently, to determine the effects that initial investment costs and amortizations have on investment returns, economic indicators such as net present value (NPV) and present pay back period (PBP) were used to obtain long-term economic analyses which also take into consideration plant costs. The applications of the model are focused on the civil, industrial and tertiary sectors.

Then on the basis of a thorough technical energetic characterisation of a trigeneration plant, a mathematical programming model was developed, which allows the determination of the optimal dimensioning of a trigenerative system, not only in terms of technology and of size but also in terms of daily plant operation as a function of all the possible variables. For the formulation of the mathematical model, the complexity of the problem relative to the optimisation of a trigeneration system rendered necessary the use of Mixed Integer Non Linear Programming Models (MINLP). In the face of greater computational complexity, linked to the presence of binary decision variables and to the non linear nature of constraints and of the objective function, the model permitted the implementation of the main criticalities linked to the management of a trigenerative system with a greater degree of accuracy. The developed procedure proposes to supply a valid support tool in decision making in the evaluation of the technical and economic potential of trigenerative technology compared to the use of traditional type plants.

High and low temperature Fuel Cells

Fuel cells have occupied an increasingly important position in her research context.

With the increasing rationalization of energy sources, high conversion efficiencies, flexibility in the use of fuels, and restraint of pollutant emissions, reduced noise impact and cogeneration ability peculiarities, high temperature fuel cells have assumed a primary role in the field of distributed energy generation. Moreover, in the context of searching for energy and environmentally sustainable systems, high temperature fuel cells, possessing the great advantage of flexibility of fuel feeding, can be powered by gases derived from biological sources. Since the degree of development of a country is also related to the production of urban solid waste (USW), the standard of living of the populations of industrialized countries, as well as leading to the previously stated consequences, has caused an excessive volume of municipal solid waste. The possibility of extracting useful energy from the original USW volume has then been studied. The organic fraction contained in them, resulting in a high quality biomass, is strongly taken into consideration, as a high quality biofuel can be obtained from its anaerobic treatment. Therefore, the research activity has been focused in assessing the purely energetic and environmental point of view, in the expectation of being able to implement an opportunity for sustainable energy production, aimed also to provide a valuable contribution on the problem of storage, by reducing the final volume.

In the field of anaerobic digestion study has consisted of searching for the best quality of biogas, according to the raw material entering the process and according to the technology of the anaerobic reactor considered.

The object of extreme attention has been the transformation system of the primary gas into hydrogen rich stream. It has been studied under the most varied operating conditions in order to achieve its optimal operation also in the case of non-conventional power supplies, by minimizing, the undesired effects by the management of some process parameters. Given the type of primary fuel and the peculiarities of the Solid Oxide Fuel Cells (SOFC) and Molten Carbonate Fuel Cells (MCFC) the object of study has been the combination of Fuel Cells-biofuel.

Therefore, investigations on the energy performance of fuel cell systems have been carried out by considering processes of transformation of the primary fuel, internal to the fuel cells themselves.

The possibility of using the MCFC system as concentrator/disposer of carbon dioxide has in fact been optioned, realizing, along an integrated energy system with high energy-environment efficiency with an eventual anaerobic reactor (USW processor).

Consequently, stationary and zero-dimensional models have been formulated and implemented in Matlab language for simulating the behavior of high temperature fuel cells, (MCFC) fed by methane, biogas (gas produced by the anaerobic digestion of organic substances) or syngas (gas produced by coal or woody biomass gasification), in stand-alone and in hybrid plant configurations. In these hybrid plants the MCFCs were coupled to gas turbine or micro gas turbine, for the production of electrical and thermal energy, or also coupled to a steam bottom plant, for the production of electric energy. In reference to the hybrid plants in cogenerative arrangement, particular attention has been devoted to the development of an adequate separation system of the CO_2 produced.

These simulation models have been used to determine the optimal values of temperature and the air excess factor of the recirculation burner in electrical and/or thermal terms. At the same time an activity of more detailed modeling of high temperature fuel cell started and this activity has produced the formulation of a mono-dimensional and stationary simulation model of an MCFC fed by syngas with parallel (co-current and counter-current) feeding flows configuration for the determination of electrical and thermal output of the same MCFC.

High temperature fuel cells have been investigated and evaluated using biogas with variable composition of its constituent gases. In particular, the maximum carbon dioxide molar fraction has been evaluated for obtaining a good fuel cell performance.

The numerous simulation models formulated have been validated by comparing their results with the results obtained using simulation models with a similar level of detail or with experimental data, however, found in the literature.

Moreover, an Experimental activity on a Solid Oxide Fuel Cell/Electrolyzer (SOFC/SOE) test station is currently conducted and it focuses on:

- electrical performance testing of SOFC stack fed by H_2 rich stream gases or by syngas and possibility of fueling it with gas rich in methane;
- testing of H_2 and CO production by working in co-electrolysis modality, by fueling SOE with steam and CO_2.

She also carries out numerical research activities, in the field of land and sea propulsion systems with fuel cells.

These research activities are focused on numerical modeling of propulsion systems with low and high temperature fuel cells for hybrid terrestrial (on road and rail) and marine electric vehicles.

More recently A Matlab/Simulink model was set up to dimension the fuel cell (FC) as primary source of energy and to investigate the power flows during both motoring and regenerative braking of different fuel cell hybrid electric vehicles (FCHEVs): a bike in which the traction force is provided by both electric motor and the pedaling of the cyclist, a bike in which the traction force is provided only by an electric motor without pedaling and a motorcycle for 2 passengers.

Specifically, the consumption, the state of charge (SOC) of battery and the amount of energy generated by each source of energy have been monitored. The model validation was done by comparison between the theoretical data and experimental data found in scientific literature.

A Proton Exchange Membrane Fuel Cell (PEMFC) system model for locomotives was implemented ad hoc in MATLAB-Simulink environment for a standard drive cycle. The system is hybrid and it supplies the total energy demand. The energy store system (ESS) is composed of battery and supercapacitor (SC). The PEMFC is the primary energy source of the hybrid locomotive. A battery supplies the additional energy demand in acceleration and the SC delivers the power to fill the peaks. Moreover, a regenerative brake recuperates part of the energy lost in deceleration and stores it in the ESS. The hybrid locomotive is controlled by a hybrid strategy, fit for the purpose, composed of Fuzzy Logic Control and Equivalent Consumption Minimization Strategy; the PEMFC power and the other variables are calculated by means of IF-THEN rules in order to achieve best results from each energy source, high efficiency and low hydrogen consumption.

An innovative research activity on the low temperature fuel cell is conducted, in recent years. It regards numerical modeling of Anion Exchange Membrane Fuel Cells (AEMFC) for stationary plants and the possibility using them in hybrid electric vehicles.

Other research activities over the years have concerned Gas Turbines, Internal Combustion Engines and Hydroelectric Plants.

Professor Fragiacomo has published more than 85 scientific research papers.

Last years Research Projects

UNICAL scientific director of the project "PRIN" entitled "Intermediate Temperature Solid Oxide Fuel Cells fed by biofuels" started in 2012 (duration of 36 months).

Scientific Director of an Agreement with the University of Messina within the project "PON 04a2_F BE&SAVE" from 07/2014 to 12/2015.

Scientific director for research activities within the project "PON01_01840MICROPERLA - Programme for Renewable Energies and Micro-Cogeneration for Agro-Industry" started in 2012 (duration of 36 months).

Scientific director for research activities within the project "PON 04a2_E - RES NOVAE"started in 2012 (duration of 31 months).

Participation in the PON MATERIA project PONa3_00370/1.