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NEWSLETTER DEL DIPARTIMENTO DI INGEGNERIA INDUSTRIALE DELL'UNIVERSITÀ DEGLI STUDI DI PADOVA

UNIVERSITÀ DEGLI STUDI DI PADOVA

DIPARTIMENTO DI INGEGNERIA INDUSTRIALE

COPERTINA

Fibre di collagene nel pericardio bovino

PAGINA

DIPARTIMENTO DI INGEGNERIA INDUSTRIALE

New PGM-free nanocomposites for TWC application

The pollutants removal from the exhaust of internal combustion engines is a major environmental catalysis challenge. In the three-way catalysts (TWC), the simultaneous oxidation of CO and unburned hydrocarbons (HCs), and reduction of NO has to be achieved efficiently, due to the progressive tightening of environmental regulations. K-INN Lab, the Prof. P. Canu's research group at DII in cooperation with Prof. A Glisenti's group at DiSC, have been supported by collaborative European projects (in 7th Framework and Horizon-2020 Programmes) to develop and test novel eco-friendly nano-structured automotive catalysts utilizing metal nanoparticles (Cu, Ni, Co, Zn, etc) that can partially or totally substitute the Platinum-Group-Metals (PGM), expensive and critical raw materials.
The activity focuses on the design and realization of an experimental lab-scale rig (Figure 1) for the evaluation of the activity of novel catalysts, in form of powders or monoliths, with simulated exhaust mixture, under steady and transient operations, including accelerated aging. The catalyst samples are tested in a tubular flow reactor and the effects of GHSV (contact time), temperature, inlet composition thoroughly studied. The setup is also used for other gas-solid reactions, including soot generation and oxidation. The recent work addressed transient and stationary experiments on perovskites, synthetized by Impact lab at DiSC and other European partners, with hydro-thermal aging treatments for the investigation of deactivation mechanisms (due to water vapor, sintering, cooking). The synthetic gas mixture fed approaches the actual exhaust composition, simulating stoichiometric, rich and lean conditions. Some of the samples studied are cobaltites and nickelates (LaCoO3 and LaNiO3) functionalized by a surface dispersion of different amounts of CuO nanoparticles. The % removal of each pollutant as a function of temperature (Figure 2) proves the effectiveness of the catalysts.

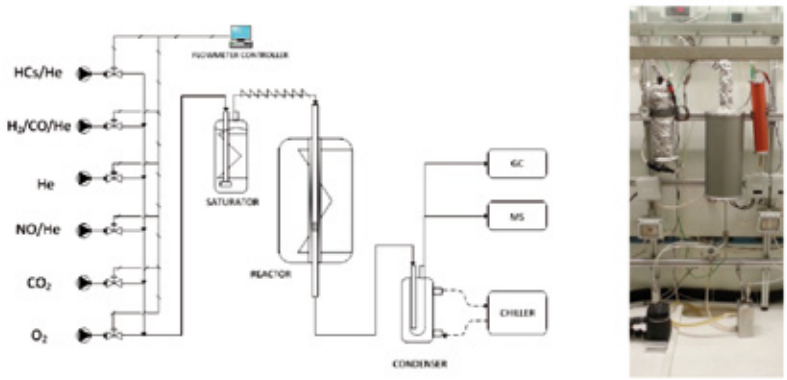

Figure 1. Experimental setup for the evaluation of catalytic activity.

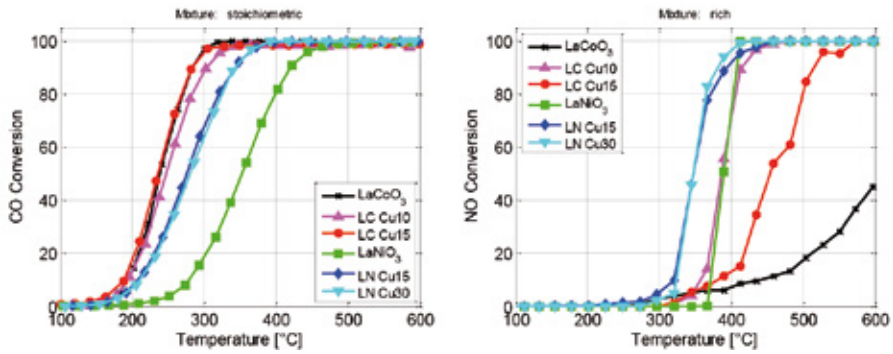

Figure 2. Conversion of CO over the temperature obtained in stoichiometric conditions (λ=1), on the left, and conversion of NO over the temperature obtained in rich conditions (λ=0.6), on the right.

Processi, prodotti e servizi
Processes, products and services

DII research group

K-innlab

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k-innlab kinetics innovation

PARTIAL-PGMs

NEXT GEN CATalysts

Main research topics:

- Development of catalytic technologies for the abatement of environmental pollutants
- Experimental investigation on the mechanisms involved in complex reactant systems, for relevant industrial reactions

Processi, prodotti e servizi
Processes, products and services

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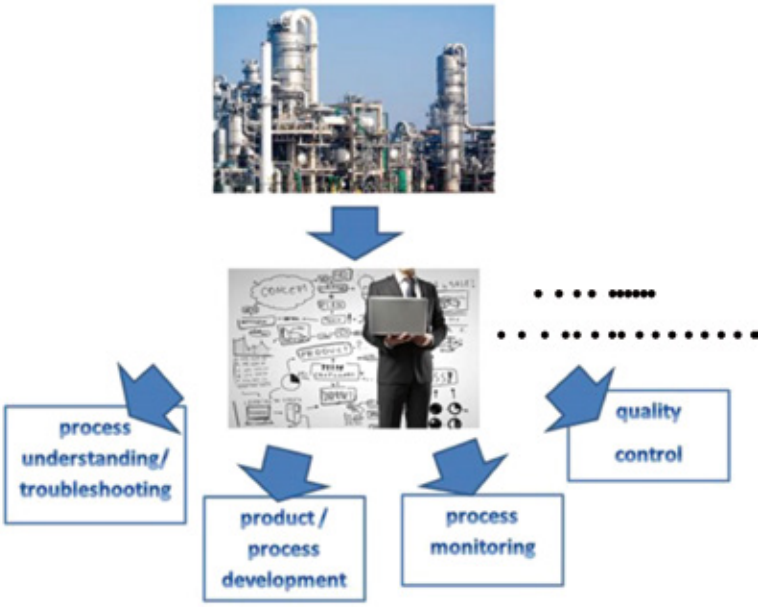
Data analytics for process industry 4.0

Nowadays process industry is experiencing its 4th industrial revolution, in which an intelligent manufacturing can be obtained through integrated digitalization: connected factories, cloud technologies, internet of things. As a consequence of this juncture, the process engineers are overwhelmed by enormous amounts of process measurements that are available in real time. Dealing with "big data" is of invaluable importance to assist several engineering tasks, such as process understanding/troubleshooting, and process and product quality monitoring. One of the main goals of this research activity is to develop fast, cost-effective, and non-destructive techniques to accomplish these tasks. To this purpose, data-driven models are utilized for both the online data treatment and the information retrieval from historical data. The main data analytics modelling techniques derive from the integration of different disciplines: signal processing, statistical process control, machine and statistical learning, patter recognition. These allow exploiting the knowledge hidden into the data to identify the critical parameters and the critical phases of a process, to promptly detect process faults, to diagnose the causes of malfunctions, to monitor the product quality in real time (for example by means of virtual-sensors or artificial vision systems) and to implement predictive maintenance.



However, not only the "big data", but also the "small data" pose serious challenges to research. In fact, several situations are present in the process industry in which very small amount of data are available. This is typically the situation when a new product and process has to be developed and scaled-up. In this context, statistical design of experiments and data-based modelling can support the design of new products, the development of new processes and the transfer of products, processes and the respective technologies from the laboratory scale, to the commercial scale plants. Data based techniques provide effective methodologies to accelerate time-to-market of a new product by aiding to design cost-effective and maximally informative experiments.
Last, but not the least, once a product is launched into the market, it is of paramount importance to protect it from adulterations and counterfeiting, especially in the food and pharmaceutical industry where health and safety are a must. One of the research aims is to develop anti-fraud and anti-adulteration technologies from data fusion of different analytical technologies and atypical sensors (i.e., spectrometers, digital cameras, etc…).
Future research directions will be oriented to the development of data-driven methodologies for genomics and for biopharmaceutical process scale-up.
All these research activities, whose effectiveness was successfully demonstrated in several applications within the fine chemicals, pharmaceutical, food, biomedical, electronic industries, are conducted in the CAPE-Lab (Computer-Aided Process Engineering Laboratory).

Main research topics:

- Data-based techniques and soft-sensing for process and quality monitoring
- Artificial vision systems for the characterization of materials
- Development of anti-fraud and anti-sophistication technologies for pharmaceutical and food industries
- Product, process and technology transfer among different production scales and sites
- Statistical design of experiments for quality improvement in the process industry

Environmental and Health-Safety Impacts Assessment and Management

The efforts of international community and scientific discussion about sustainable development involve organizations and people in order to adopt innovative methodologies for reduction of environmental impacts. Since '90 years, CESQA research group is involved in several research projects to support organizations in assess and improve of environmental performances. Coherently with the research topics of CESQA group, my research activities focus on the integrated assessment and management of environmental and health-safety impacts of industrial processes, plants and products. Sustainability measurement is the topic of several research financed projects, in which I collaborated at companies' and public authorities' level. My institutional teaching activity concerns policies, methods and tools to support private and public organizations in assessment and management of environmental and health-safety impacts of products and processes.
The main references that guide my research concern the life cycle approach, as environmental footprint tools of products and plants, and risk management approach, as management tools of processes, plants and projects.

I am continuously interested, through environmental and heatlh-safety performance assessment, to support companies in product innovation projects, marketing strategies, supply chain cooperation. Moreover, I can support public authorities to implement local sustainable strategies and actions.
Main research topics of my interest concern:
• sustainable assessment and management at local and regional level,
• environmental assessment and management in industrial processes,
• life cycle assessment projects of industrial and agrifood products,
• sustainable evaluation in waste management and recycling to support circular economy,
• quality assurance in testing and calibration laboratories and in higher education programs.
The results of my research activities are systematically discussed through publication in scientific journals and communication in national and international congresses.
For example, figure 1 represents an innovative integration model of environmental management system and life cycle assessment methodology that recently I have developed with other colleagues of CESQA group: from an applied research within an Italian Municipality, we propose the Life Cycle Impact Assessment method as framework to guide a public administration in the Environmental Impact Assessment phase at the territorial level (Mazzi et al, Environmental Impact Assessment Review 63 (2017) 59–71, http://dx.doi.org/10.1016/j.eiar.2016.11.004).

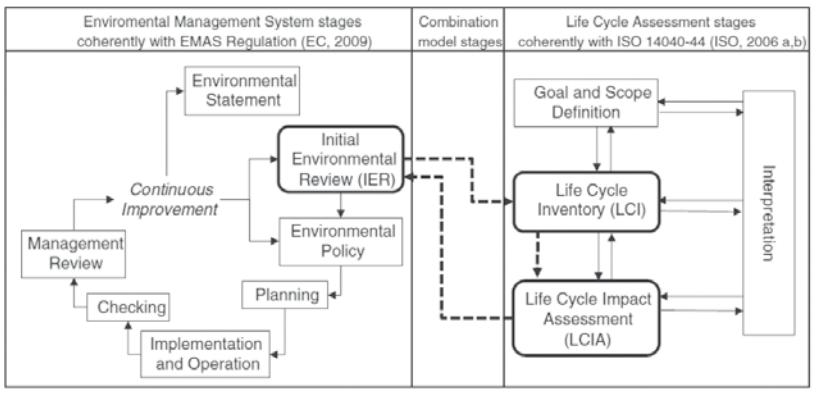


Figure 1: Combination model of EMS and LCA adopted in an Italian Municipality

Processi, prodotti e servizi
Processes, products and services

DII research group
CESQA-Quality and Environment Study Center

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The research in the field has been started with the cooperation of by Prof. Antonio Scipioni: it was my deepest privilege to have worked with him.
The research is ongoing and carried out in collaboration with the CESQA research group (Department of Industrial Engineering).

Main research topics:

- European project LIFE14 ENV/IT/000082 (Title of project: « LIFE M&M Man and Metal - New business model to increase efficiency of resources aimed at products great durability with use of recycled materials», Coordinator: Metallurgica Abruzzese S.p.A.)
- Partnership with Consorzio Cerea S.p.A. (Title of project: «Support in R&D projects related environmental performance evaluation, training on environmental legislation, sustainability studies […]»)
- Partnership with Comune di Malcesine (Title of project: «Implementation of an Environmental Management System and support to environmental legislation compliance […]»)
- University of Padova - TESAF Department (Title of project «Design of quality management system of testing laboratory […]»)
- University of Padova - PhD and Post Lauream service (Title of project «Desing and implementation of quality management system in Medical Specialization Schools […]»)

Materiali funzionali
e prototipi
Functional materials and prototypes

DII research group
CheMaMSE

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The research in the field of materials for electrochemical energy conversion and storage devices such as fuel cells was started more than 25 years ago by Prof. Vito Di Noto, founder and team leader of the research group «Chemistry of the Materials for the Metamorphosis and the Storage of Energy - CheMaMSE», where Dr. Negro is currently carrying out his research activities.

The research activity is funded by the European Union (GRAPHENE Flagship), other public institutions (e.g., the University of Padova) and private companies (e.g., BRETON).

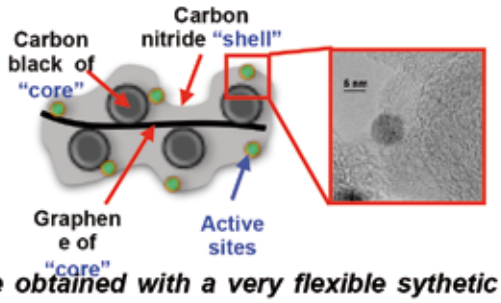
Main research topics:

- Synthesis of electrocatalyst materials for low-temperature fuel cells/electrolyzers
- Synthesis of electrolyte materials for fuel cells/electrolyzers
- Physicochemical characterization of the functional materials
- Advanced electrochemical characterization of the materials
- Fabrication of prototypes of electrochemical energy conversion and storage devices, to be tested for performance and durability

Low-temperature fuel cells- Functional Materials and Prototypes

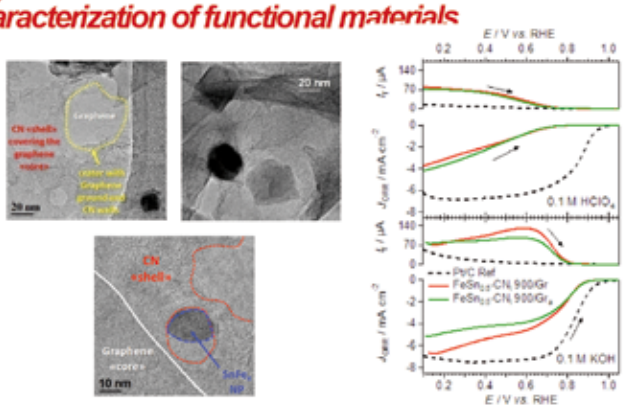
Low-temperature fuel cells (FCs) are a family of electrochemical energy conversion and storage (EECS) devices. EECS devices exploit electrochemical processes to directly convert chemical energy into electrical power, or to store the energy obtained from an external source. FCs exhibit a high efficiency, up to 2-3 times higher than competing technologies (e.g., internal combustion engines). EECS devices and FCs are playing a crucial role to implement in a large scale the renewable energy sources (e.g., the sun and the wind), renovate the power grid at the European level and electrify the surface transport.

Synthesis of electrocatalysts (ECs) for fuel cells



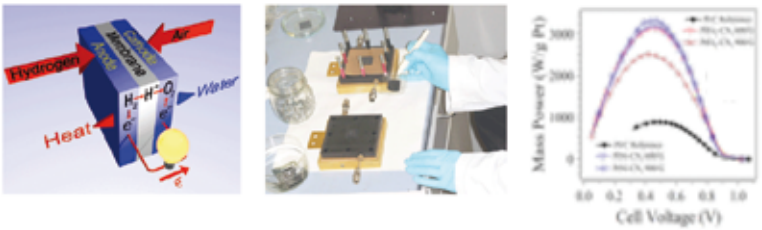
ECs are obtained with a very flexible sythetic route, that allows to modulate in detail the chemical composition and morphology.

Physicochemical and electrochemical characterization of functional materials



Advanced high-level studies enable the screening of the functional materials. Only the most promising systems are used in the fabrication of FC prototypes.

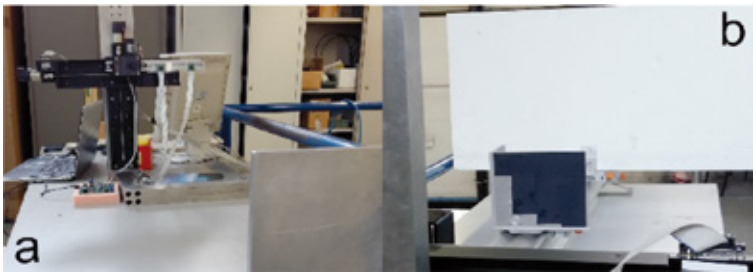
Fabrication and testing of FC prototypes



Nanocomposite electrocatalysts with a low loading of platinum (L-PGM), or entirely "Pt-free" (N-PGM) are studied. L-PGM ECs yield the same performance as commercial ECs, but with only 1/3 of the platinum

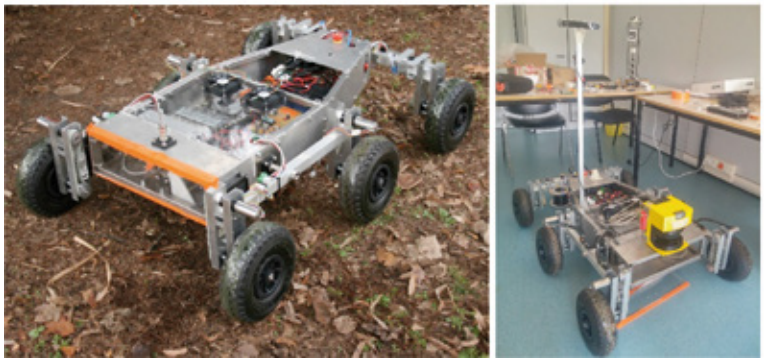
Vision based and hybrid navigation systems for vehicles, drones and satellites

In planetary exploration, the position and orientation measurement of a wheeled rover or a flying drone is a critical task, which can be performed by a stereo vision system using Visual Odometry (VO) or a Simultaneous Localization And Mapping (SLAM) algorithm. The employment of a monocular vision system, instead of a stereo rig, could be very interesting, since it is lighter and far more compact. However, monocular vision systems have the drawback that they are not able to properly evaluate the scale of the measured trajectory. For this reason, a sensor fusion (or hybrid) approach employing a monocular RGB camera plus an auxiliary sensor for scale evaluation seems particularly promising. In our laboratory, different hybrid systems comprising an RGB camera and depth sensors, such as a Time of Flight (ToF) camera or 2D/1D Light Detection And Ranging (LiDAR) systems, are investigated. Before the hybrid system can be used for navigation, each camera or sensor has to be individually calibrated, i.e. intrinsic parameter evaluation, and then also the extrinsic parameters have to be determined, i.e. the relative position and orientation between the ToF and RGB cameras. The figure below depicts an experimental set-up for the joint calibration of a stereo RGB camera and a ToF camera.



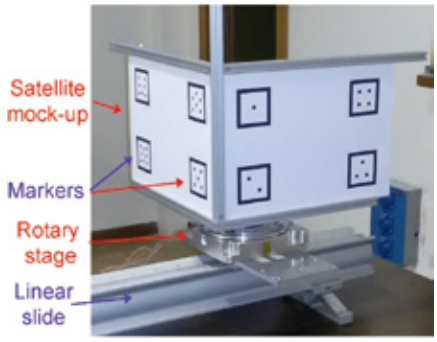
Several instrument calibrations have been carried out for hybrid systems.

Visual and depth instruments for navigation have been applied to a wheeled rover, developed together with engineering students and employed also in the PANGEA project of the European Space Agency.



In space, there are several scenarios that require an accurate measurement of the relative position and orientation (pose) between two spacecrafts, as the autonomous rendezvous and docking for on-orbit servicing, or between a spacecraft and a target, as position evaluation of a tip-mass during the deployment of an electro-dynamical tether. A vision based instrument able to measure the position and orientation of a spacecraft has been.

Calibrated from a metrological point of view. The instrument comprises a simple camera which observes the external surface of the satellite provided with fiducial markers and a software procedure which combines together a closed-form and direct solution of the Perspective from three Points problem, a non-linear optimization and bundle adjustment.



Misure per lo spazio
Measurements for space

DII research group

Mechanical and Thermal Measurement

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The research activities are carried out with the Mechanical and Thermal Measurement research group, at the Department of Industrial Engineering - Padova University, which is led by Prof. Stefano Debei and Prof. Enrico Lorenzini and comprises Dr. Sebastiano Chiodini, Dr. Riccardo Giubilato, Dr. Mattia Mazzucato, Dr. Andrea Valmorbida. Some research activities about position and attitude measurement are performed in collaboration with ALTEC s.p.a. - Torino.

Main research topics:

- Measurement of position and attitude of a vehicle or drone with hybrid measurement systems comprising cameras and other instruments such as ToF cameras, LiDARs, Inertial sensors, GNSS instruments.
- Metrological calibration of hybrid measurement systems.
- Analysis and development of algorithms for vehicle or drone navigation in GPS-denied environments, such as mono or stereo VO, and SLAM with vision systems or depth measuring instruments (e.g. ToF cameras, LiDARs).
- Measurement of relative position and attitude between two spacecrafts or between a spacecraft and a target using visual systems.

Energia
Concepts and technologies for an energy conscious and comfortable built environment

DII research group

BETA_Lab: Building Energy Technology Assessment

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The research activity was supported by the Interdepartmental Centre for Energy Technology and Economics "G. Levi Cases" of Padua University.

Main research topics

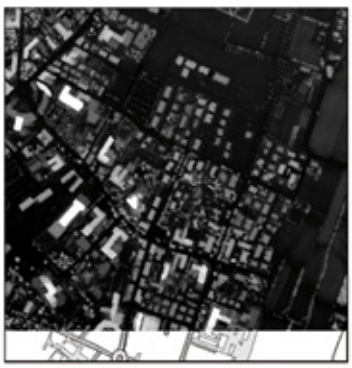
- Modeling and Field Measurements of Radiant Systems
- Ground Source Heat Pumps
- Solar Systems Design for Heating and Cooling
- Double Skin Facades
- Energy Analysis and Temperature Distributions in Large Spaces
- Simulations and Measurements in Buildings
- Energy Efficiency of Building Plant System
- Nearly Zero Energy Buildings (nZEB)
- Low Exergy Systems in Buildings
- Thermally Activated Building Systems
- District Heating and Cooling Networks
- Thermal Comfort
- Modelling and Development

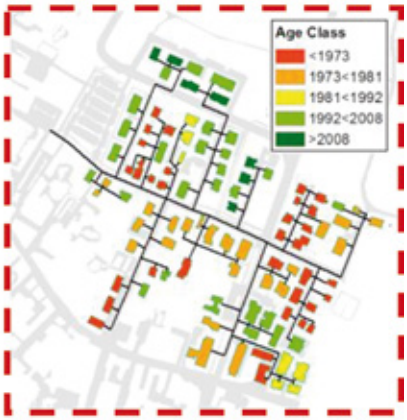
Evaluation of the Heat Load in District Heating Networks: a Simplified Approach

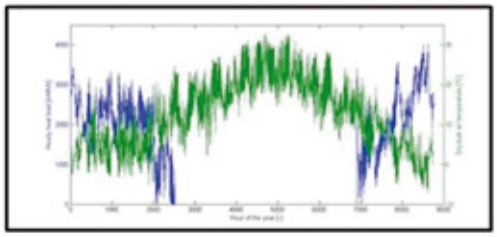
Simple, reliable building models have been receiving quite a bit of attention recently particularly with regard to diverse applications, such as building design for inexpert energy modellers, simulation of neigh-bourhood or city districts and model predictive control. The International Standard ISO 13790 and the German Guideline VDI 6007 use two different lumped-capacitance models (5R1C and 7R2C, respectively) based on deterministic, analytical procedures to identify their parameters.

The current research investigates the suitability of these models in calculating peak loads and seasonal energy needs and their accuracy in estimating buildings' dynamic behaviour. A room and an apartment were thus simulated using simplified models and with the benchmarked software TRNSYS. Four reference envelopes with different thermal insulation and heat capacities were examined in four climatic conditions. Each of the models was able to estimate quite precisely energy needs in both the heating and cooling modes, although the 7R2C model was slightly more accurate. The 5R1C model was, however, unable to follow the thermal response of the buildings during the cooling season, which in turn implied a systematic underestimation of the cooling peak load. The 7R2C model identified a significant reduction in the root mean squared error (RMSE) both in the indoor air temperature and in the heating/cooling loads with respect to the reference profiles. That model would seem then more suitable for the dynamic simulation of single thermal zones with hourly time steps in both heating and cooling modes.

In conclusion, both lumped-capacitance models appear to reliably calculate the overall energy needs of buildings in both heating and cooling seasons. As far as transient behaviour is concerned, the first-order model of ISO 13790 model seems inappropriate to calculate neither the hourly cooling load profile nor the cooling peak load. The second-order model proposed by VDI 6007 is more accurate in both the heating and cooling modes.



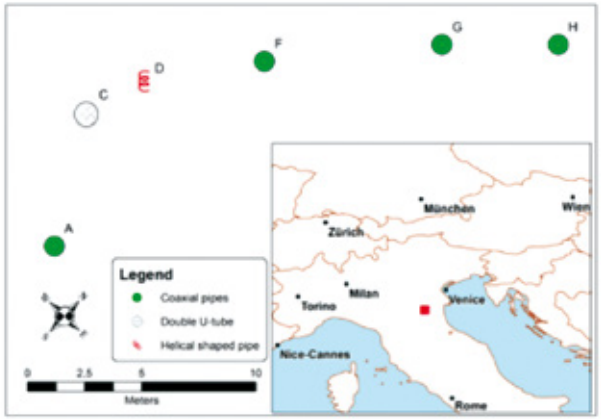


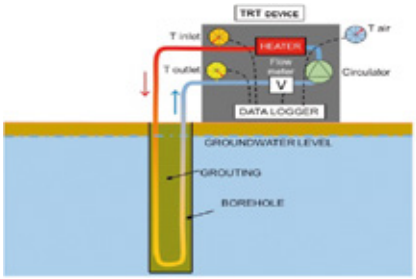


Hourly heat load of the district

Ground Source Heat Pump systems: Interpretation Methods of Thermal Response Testing Measurements

The design phase of Ground Source Heat Pumps (GSHPs) is an extremely important one as many of the decisions made at that time can affect the system's energy performance as well as installation and operating costs. The current research examined the interpretation of thermal response testing measurements used to evaluate the equivalent ground thermal conductivity and thus to design the system. All the measurements were taken at the same geological site located in Molinella, Bologna (Italy) where a variety of borehole heat exchangers (BHEs) had been installed and investigated within the project Cheap-GSHPs (Cheap and efficient application of reliable Ground Source Heat exchangers and Pumps) of the European Union's Horizon 2020 research and innovation program.
The measurements were initially analyzed in accordance with the common interpretation based on the first-order approximation of the solution for the infinite line source model (S-ILSM) and then by utilizing the complete solutions of both the infinite line and cylinder source models (ILSM, ICSM). An inverse numerical approach based on a detailed model (CaRM) that considers the current geometry of the BHE and the axial heat transfer as well as the effect of weather on the ground surface was also used. Thermal Response Tests (TRTs) were carried out on coaxial pipe, double U-tube and helical shaped pipe BHEs. The equivalent thermal conductivity provided by literature data depending on the ground type was about 20% higher than that found using the common interpretation of the TRT measurements conducted on the 96 m long BHE. In addition, the thermal response testing interpretation showed that in that same area the equivalent thermal conductivity ranged from approximately 1.35 to 1.60 W/(m K) for the same BHE depth. The minimum misfit between the experimental and calculated values of the mean fluid temperature was found using the inverse numerical procedure by means of the CaRM simulation tool which considers important phenomena that affect the thermal behavior of the borehole heat exchanger, e.g. the weather conditions at the ground surface, axial heat transfer and borehole thermal capacity.





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The research activity is ongoing and carried out in collaboration with:

Antonio Galgaro, Geoscience Department of Padua University;

Partners of Cheap-GSHPs project (http://cheap-gshp.eu/)

Main research topics:

- Modeling and Field Measurements of Radiant Systems
- Ground Source Heat Pumps
- Solar Systems Design for Heating and Cooling
- Double Skin Facades
- Energy Analysis and Temperature Distributions in Large Spaces
- Simulations and Measurements in Buildings
- Energy Efficiency of Building Plant System
- Nearly Zero Energy Buildings (nZEB)
- Low Exergy Systems in Buildings
- Thermally Activated Building Systems
- District Heating and Cooling Networks
- Thermal Comfort
- Modelling and Development

Achievements

Per ulteriori informazioni rivolgersi a: Prof. Roberto Benato (049 8277532, roberto.benato@unipd.it)

Roberto Benato elevato al grado di IEEE SENIOR MEMBER

Ogni anno l'IEEE (Institute of Electrical and Electronic Engineers) Board of Directors conferisce il grado di Senior Member a persone dell'Università e dell'industria che si sono distinte nel campo dell'ingegneria elettrica/elettronica.
Il grado di Senior Member è uno dei riconoscimenti più prestigiosi di IEEE ed è assegnato a chi ha dimostrato una straordinaria esperienza lavorativa, testimoniata da una significativa maturità professionale e da rilevanti risultati scientifici. Esso è detenuto da meno del 9% dei membri di IEEE.
In data 7 ottobre 2017, l'IEEE Board of Directors ha conferito il grado di IEEE Senior Member a Roberto Benato.
Nella foto a lato il prof. Roberto Benato con la targa ricevuta dall'IEEE per il grado di SENIOR MEMBER.

Contratti stipulati dal DII con Aziende nel 2017

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CHINELLATO GROUP srl	Andrea Lazzaretto
PENTAX spa	Nicola Bianchi
UNOX spa	Ugo Galvanetto
PT.GUDANG GARAM tbk	Giorgio Pavesi
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HDT srl	Nicola Bianchi
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BRETON spa	Vito Di Noto
ELECTROLUX ITALIA	Giovanni Meneghetti
USTEM srl	Nicola Elvassore
ESA-ESTEC (European Space Research)	Davide Del Col
SPIN APPLICAZIONI MAGNETICHE srl	Nicola Bianchi
CAREL INDUSTRIES spa	Paolo Bariani
LD 72 srl	Matteo Massaro
PRYSMIAN spa	Massimo Guglielmi
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Contratti stipulati dal DII con Aziende nel 2017

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AMBIENTE UFFICIO srl	Antonino Di Bella
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DANIELI & C OFFICINE MECCANICHE spa	Paolo Canu
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OSMOTECH srl	Luca Palmeri
BUSITALIA VENETO spa	Alberto Doria
RSE spa	Angelo Zarrella
TETRA PAK PACKAGING SOLUTIONS spa	Ugo Galvanetto
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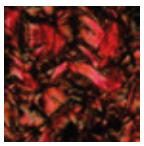
UNISMART srl (AGREX)	Andrea Santomaso
BLUE BOX GROUP srl	Antonino Di Bella
COMUNE DI MONTEGROTTO TERME	Michele De Carli
FRASCOLD spa	Davide Del Col
SALIN srl	Manuele Dabalà
SEALED AIR srl	Sara Spilimbergo
SIPA spa	Giovanni Lucchetta
SIT spa	Manuele Dabalà
T4I TECHNOLOGY FOR PROPULSION AND INNOVATION	Daniele Pavarin
PENTAX spa	Nicola Bianchi
WINGS srl	Nicola Petrone

UNIVERSITÀ DEGLI STUDI DI PADOVA

DIPARTIMENTO DI INGEGNERIA INDUSTRIALE

Cover story



Fibre di collagene nel pericardio bovino

La foto evidenzia il tipico aspetto ondulato che le fibre di collagene assumono all'interno della micro-architettura del pericardio bovino. Questo tessuto viene ampiamente studiato allo scopo di caratterizzarne le proprietà, anche meccaniche, in vista della sua applicazione come materiale per la fabbricazione di protesi valvolari cardiache biologiche.

La foto è stata ottenuta colorando le fibre di collagene con Picrosirius red ed è stata pubblicata, insieme ad altre, in: Bagno A, Aguiari P, Fiorese M, Iop L, Spina M, Gerosa G. Native Bovine and Porcine Pericardia Respond to Load With Additive Recruitment of Collagen Fibers. Artif Organs. 2017 Dec 27.

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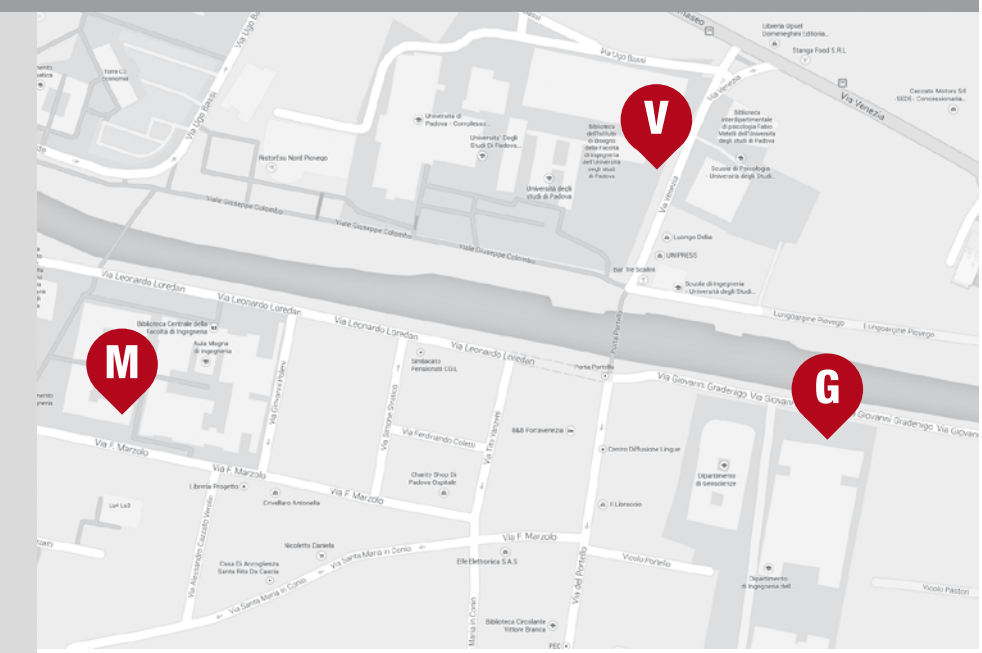

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