IN+

CENTER for INNOVATION, TECHNOLOGY and POLICY RESEARCH

Report of activities 2015-2016

Strategic Plan 2017-2018

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Preamble

The Research Centre for Innovation, Technology and Policy Research, IN+, draws from the talents of researchers from various academic backgrounds, including Engineering (mechanical, chemical, environmental, materials, physics), as well as Social and Economic Sciences, who join efforts on the issues of sustainability, in terms of the needs to secure the quality of the environment, together with the management of energy resources and the economic development.

In the context of the current structure of Science and Technology in Portugal, IN+ is part of the **Associate Laboratory LARSyS** funded by the **National Science Foundation (FCT)** and which comprises four Research Units with a total of 152 Doctorate Researchers and 248 Researchers. Since its foundation in 2000, LARSyS has been classified in the evaluation ratings of FCT as "Excellent". Despite the wide scientific spectrum background of its research team, IN+ has 35 Doctorate Researchers and 70 Researchers

The Science and Technology system is passing through a reform projected to reinforce the links between the scientific network and the technological, economic and social development, while improving the conditions of scientific employment, until now precarious. This reform is expected to enter in force in 2018, thus compelling Research Units to rapidly respond to new funding issues. This is particularly important for IN+ because the wide-spectrum of its scientific background and simultaneously small number of senior researchers, calls for an even greater effort to be able to aggregate internal and external synergies.

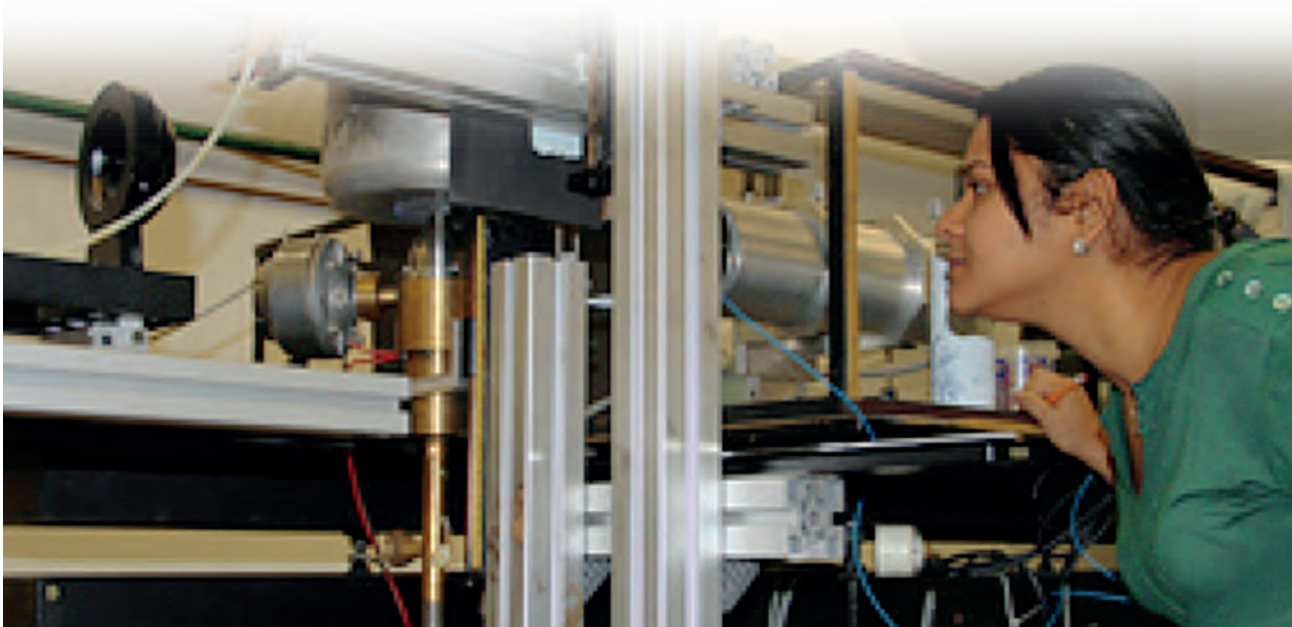
The present document aims at reporting the activities of the Center in the last two years, from January 2015 to December 2016, but also to support the deep discussion of a strategy to respond to the latest challenges. To accomplish with this task, however, it is also central to take into consideration the historical path that brought IN+ to the current scientific status, as well as the institutional support of **Instituto Superior Técnico**.

António Luis Moreira
Professor and Director of IN+

1 INTRODUCTION

In the present context of the national scientific and technological progress, it is necessary to react to the stimulus being given to the modernization of the S&T system in Portugal.

This document was prepared in February 2017 as a report of activities, but above all to also incite, inside IN+, the discussion and criticism necessary to identify guidelines to respond to new scientific challenges.



1.1 Historical background

A better understanding of the past is the key to a successful future. In this context, in finding our path into a sustainable future it is important to place the current skills and competences of IN+ in a historical perspective.

The activities at IN+ have derived from those developed between 1986 and the mid 90's within the scope of the Combustion Laboratory of the Department of Mechanical Engineering at IST which have been extended to integrate competencies at the level of sustainable energy systems, technology policy and advanced socio-economic research methods.

This is because the successful development and subsequent exploitation of energy and environmental technologies requires, apart from improved knowledge of basic thermofluid science, the understanding of policy issues and innovation strategies, in a context that promotes the sustainable development. The goal is to improve the process of industrial and societal assimilation of knowledge, through a stepwise and interactive approach considering the overall values chain associated with industrial, corporate and social processes.

In addition, the activities developed in the last years have contributed to understand and optimise the complex processes that underlie world-class Science and Technology research, commercialisation and management, including the protection of intellectual property, and the integration of knowledge in a context of enhanced economic wealth and shared prosperity.

The concepts presented above are the result of a strong involvement of several researchers in a considerably large number of international R&D projects since 1986 and in the early 90's. These projects were developed in the scope of national projects and the BRITE/EURAM, Science, STEP, Environment, Joule and Esprit Programmes of the European Commission, as well as an increasing involvement with Portuguese and European industry. Apart from the national sectors of glass and crystal, R&D links have been established for several years with major European aeronautical companies (Rolls Royce, SNECMA, TURBOMECA, MTU, Rolls-Royce- BMW) and process industries (Saint Gobain). Briefly, the work evolved from basic research on turbulent fluid mechanics and combustion, namely through several master and doctorates programmes.

Moreover, the research work has gained considerably from the successive organisation of the International Symposia on Applications of Laser Techniques to Fluid Mechanics, which have been held in Lisbon since 1982. The symposia have contributed significantly to promote a series of international contacts and research activities in international cooperation.

In the late 90's and the early 2000's, the development of competencies in the area of science, technology and innovation policy has been successfully achieved following three main lines of development, namely:

i. advanced training of young researchers in leading American universities, through Ph.D. Programmes in key and emergent topics;

ii. launching in IST of the Master programme on "Engineering Policy and Management of Technology" in 1998 and of the Master programme on "Engineering Design" in 2002, which has allowed to train young people in new areas of education at IST and promote new links with Portuguese companies; and

iii. the organization of the International Conferences on Technology Policy and Innovation, ICTPI, which were launched in July 1997 and carried out in close collaboration with a number of leading research groups worldwide.

In 2000 the Centre was a co-founder of the Associate Laboratory LARSYS, "Robotics and Systems in Engineering and Science", bringing together a research network of several research centres, which was further extended in 2010 and recently re-structured and focused in 2014.

The Centre coordinated in 2002-2003 a national initiative and exhibition on the history of engineering in Portugal in the 20th century, which won the Dibner Award of the Society for the History of Technology, SHOT. The Center was named in 2005 one of the top 50 global research centers in technology management by the International Association of Management of Technology, IAMOT.

Since 2006, the Centre has extended and enlarged its activities in close association with three new PhD programmes launched at IST in close national and international cooperation, namely in "Sustainable Energy Systems, SES" and "Technical Change and Entrepreneurship, TCE" and in "Engineering and Public Policy, EPP". These programs have gained from several government-driven international partnerships with the Massachusetts Institute of Technology, MIT, and Carnegie Mellon University, CMU, which has also allowed to drive several new industry- science relationships in Portugal and abroad. In 2011, the Centre launched "IRGC-Portugal", as a network of research laboratories in close cooperation with the "International Risk Governance Council". From 2013, the Centre has become also involved in Innoenergy, one of the Innovation Communities (KICs) supported by the European Institute of Technology, which are partnerships that bring together businesses, research centres and universities to allow the development of innovative products and services in the energy area imaginable, the creation of new companies and the training of a new generation of entrepreneurs. Within Innoenergy, IN+ leads the PhD School in the Iberia region.

In 2014, under the re-organization of LARSyS in the context of a national research assessment, the Centre was re-focused on its initial 3 Research Areas. Among other international activities, the Centre launches the networks "Step4EU - Science, Technology, Education and Policy for Europe" and "OIPG - International Observatory for Global Policies for the Sustainable Exploration of Atlantic.

1.2 Current overview

Presently, IN+ is established as a cross-disciplinary research venue to enhance the integration of scientific activities in technology, innovation and policy with applications in science, industry and society. The research agenda is set with the aspiration of achieving a sustainable society through cooperation with both industry and community, fostering the scientific and technological culture in the socio-economic, as well as of university students and other researchers

interested in discussing challenges and new opportunities for engineering systems and related policy implications.

The activities are multidisciplinary and link three major research areas: *i)* thermofluids, combustion and energy systems design, *ii)* industrial ecology and sustainability and *iii)* Technology Management and Policy, pointing at:

- Developing and use advanced techniques for the analysis, monitoring and control of processes at laboratory and industrial scale, the later including technology and risk assessment, together with advanced and strategic technologies with emphasis on turbulent mixing and combustion processes, which have the potential to optimize the environment and the rational use of energy in industry;
- Deriving science and technology policies and innovation strategies, namely in terms of modern opportunities of knowledge for development, together with environmental protection, rational use of energy, waste management and economic growth;
- Stimulating the exchange of knowledge in the management of technology and innovation, to promote competitive advantages at the corporate level, including advanced technologies for the optimization of industrial processes.

The most recent research work in these areas, which is reported in the current document, have been oriented towards:

- The optimization of energy processes in terms of new research on microscale thermal phenomena and multiscale transport phenomena in energy systems, including interfacial transport in view of enhanced heat and mass transfer, fuel/liquid atomization, lean-combustion, burning biomass and gun-powder under unsteady combustion;
- The sustainable development of cities, including the complex interactions between people, technology, policy and urban infrastructures, to promote "smarter citizens"; considering the metabolism of urban areas to support decision making in energy and waste management networks;
- Fostering science, technology and industry policies to help increase significantly the export of engineering products and services from Portugal in a time horizon of 2020 by deepening the understanding of new science, technology and business dynamics along the full value chain of emerging industry fields, including aeronautics and the sustainable exploration of Atlantic

The scientific program of IN+ unfolds around partnerships with national and international postgraduate programmes, including:

- The MIT-Portugal Program, through its overall coordination and an active involvement of researchers in the areas of Sustainable Energy Systems (SES) and Engineering Design and Advanced Manufacturing (EDAM);
- OIPG, International Observatory for Global Policies for the Sustainable Exploration of Atlantic, through the coordination

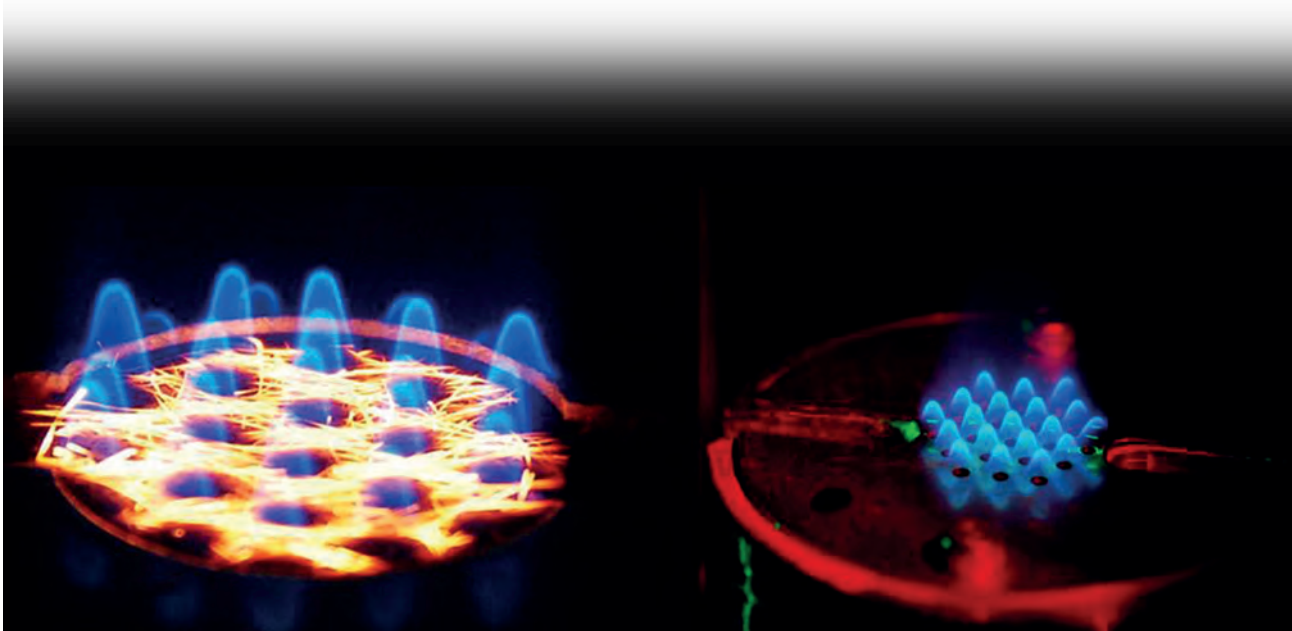
of an international network in Europe and Brazil, including the development of the "+atlantic" agenda.

- The EIT Innoenergy, a knowledge innovation community in sustainable energy, that involves actors of the knowledge triangle in the energy sector: industry, research and higher education.

II ORGANIZATION

IN+ is structured into three Research Areas (often called Laboratories), corresponding to the three areas of research, from which an interdisciplinary "space" dynamically evolves around experimental facilities and several other related activities and projects, to address contemporary issues in innovation, technology and policy, with applications in engineering, science and society.

Institutionally, IN+ is one of the four members of the Associate Laboratory LARSyS, funded by the National Science Foundation (FCT). The activities in the Centre are organized based on projects which provide the necessary external funding, namely from national and international funding agencies and/or private companies from which research areas emerge. Fundamental research builds the scientific knowledge necessary to give function a sustainable and human-oriented form, thus harmonizing technology with the environment, while application studies pursue the functionality of advanced technologies and their results (products and services) from a user perspective.



2.1 Research Areas

2.1.1 Thermofluids, Combustion and Energy Systems

Research in Thermofluids, Combustion and Energy Systems Design is aimed at improving knowledge in advanced fields of strategic technologies with emphasis on the principles of transport and reaction phenomena. The final goals include:

- To improve knowledge in advanced fields of strategic technologies with emphasis on turbulent mixing and combustion processes, which have the potential to optimise the environment and the rational use of energy in industry;
- To develop and use advanced techniques for the analysis, monitoring and control of processes at laboratory and real scales.
- To promote the exchange of knowledge in advanced technologies for the optimisation of industrial processes and energy systems

The core goal of fundamental research is the innovation of new engineering concepts and is addressed as a driving force for new technologies. It covers interdisciplinary scientific fields, such as multi-scale thermo-fluid-dynamics and combustion including interfacial transport phenomena, advanced techniques for flow measurements and control engineering.

Application studies are conducted which benefit from most recent advances in engineering fields to integrate them in advanced functional systems.

2.1.2 Industrial Ecology and Sustainability

Research activities in this area aim to improve the design of complex sustainable systems by understanding and modelling relationships between population dynamics, energy and materials use, ecosystem services, environmental impacts of human activities and economic growth.

The goal is to promote a holistic view of engineering systems, which requires the development of a set of tools to bridge different scales, from site or product specific analysis to the whole economy and ranging across the economic, the social and environmental dimensions. These tools are used to design and promote new policy instruments that may contribute to improve the environmental performance of products and services through their life-cycles, as well as more efficient economic metabolisms at different scales. Cooperation with industry and governments gives rise to innovations in sustainable buildings, in designing more efficient renewable energy-based systems and intelligent transportation systems, and in managing ecosystem services.

To accomplish with these objectives, the activities pursued seek to:

- develop fundamental theory for sustainability assessment and translate this theory in operational tools;
- develop and empirically calibrate modelling tools for environmental processes, and for integrated environmental-energy-economic processes;
- develop and use advanced research methodologies for the analysis of sustainable energy systems;
- promote the exchange of knowledge in advanced technologies for the optimisation of industrial processes and environmental systems.

2.1.3 Technology Management and Policy

The research agenda for this area aims at policy analysis, through multidisciplinary activities, namely in terms of science, technology and industry policy formulation and the need to secure sustainable development. The conditions for the social construction of technological systems in both developed and developing societies are addressed in terms of their impact on the emergence of new social realities, and their potential as factors of economic and social change and development on a global scale.

To achieve these goals, science and technology development case studies are developed worldwide, including in Portugal and Europe. The emphasis is on issues in which the interaction of technology, humans and institutions is of central importance to foster the quality of life. Enabling technologies will be developed and assessed under a system view, comprising the use and environmental implications of materials, energy, and products in modern societies. The ultimate goals are:

- To derive science and technology policies and innovation strategies, namely in terms of socio- economic development.
- To develop and use advanced research methodologies for the analysis of techno-economic systems.
- To promote the exchange of knowledge in advanced technologies and the management of technology and innovation for the optimisation of industrial processes, to promote competitive advantages at the corporate level;

2.2 Laboratory Infrastructures

Research at IN+ has a background on analytical but also on experimental tools. The experimental research is in the genesis of IN+ and is today supported

on laboratory infrastructures that constitute the core space and the main assets of the Centre. These include:

Laboratory of Thermofluids and Combustion

Activities in this laboratory deal with the fundamental relations between concurrent thermodynamic transport phenomena involved in energy conversion processes. Experimental facilities, as well as diagnostic techniques have evolved alongside funding programs as determined by technological development, economic and social needs and, more recently, oriented towards the downsizing of energy conversion systems in a variety of fields. These include rich-lean strategies and/or thermo-acoustic oscillations for low emission combustion in domestic and industrial burning systems, as well as the control and monitoring of a variety of industrial processes for optimum efficiency and emissions.

The available experimental techniques include Laser diffraction for the fluid dynamics, *e g.*, Laser-Doppler and Particle Imaging Velocimetry; microphone and pressure transducers; CCD cameras for high speed visualization and spectroscopy; spectrometers UV-Vis. Besides the use of standard equipment, an important objective of the activities in this laboratory is to contribute to the development of tools tailored to monitor and control a variety of energy conversion processes.

Laboratory of Micro-Scale Interfacial Phenomena

The Laboratory of Micro-Scale Interfacial Phenomena provides an infrastructure to study the underlying physics of microfluidics and micro-scale transport processes at interfaces. This space opened very recently providing a new area of research at IN+ supported by a multidisciplinary team, which has been growing continuous expertise in a variety of subjects, mostly related to bioengineering, chemical engineering and micro-fabrication. The emphasis is put on fluid/solid interfaces, where the problem deals with the interactions between the fluid and the solid phase determining the interfacial energy, or wettability, which is used to manipulate the physical regimes associated with micro-scale devices to achieve new functionalities. The transport processes under analysis include mass, momentum, energy or entropy and encompass the varied fields of biotechnology, biomedical engineering, chemical engineering, material handling and thermal management of electronic devices/systems. Contributions include the cooling technology of electronic devices/chips where two-phase flows and surface engineering have been used to control the microstructure and composition of the interface to optimize the rates of heat transfer.

Parallel novel studies are being conducted aimed towards understanding the fundamental issues by which the interfacial energy is altered by the application of an external source, either an electric or electromagnetic field. Together with surface engineering, this provides unlimited sources of technological applications, namely to achieve further miniaturization and portability of chemical assays. This approach is now a centre of attention due to the advent of many nanomaterials and is one of the greatest engineering challenges.

Furthermore, the Laboratory is prepared with demo facilities to teach basic concepts in pool and flow boiling and to show practical in situ applications

for cooling and refrigeration systems to support the teaching of subjects in fluid mechanics (micro fluidics and biomicrofluidics), heat transfer and thermodynamics of macro and microelectromechanical systems.

The available equipment includes microscopic techniques of laser diffraction for the characterization of a variety of microfluidic and interfacial transport phenomena, such as:

- Laser Scanning Confocal Microscope
- Modular optical goniometer
- High-resolution inverted microscope
- High-speed micro PIV/LIF 2D
- Photron HighSpeedStar high-speed camera
- High-speed thermal camera Onca-mw ir-insb-320
- Phase Doppler Anemometer
- High-speed camera

Waste Processing and Management Laboratory

The activities of the Laboratory are directed towards leading-edge developments and to promote the learning ability of graduate engineering students and young researchers aiming to conserve and manage resources and acknowledge the potential impact of waste on public health and the environment, promoting the recycling and valorisation of residues.

In recent years, a substantial research effort has been dedicated to recycling and valorisation of residues, which has required to spread existing capacities in domains like materials characterisation, physical-chemical and environmental analysis, physical separation (minerallurgical and other related techniques), chemical and metallurgical engineering, modelling, process development and design.

Recycling processes of metallic residues in the scope of mercury removal from waste sources, recycling of sealed Ni-Cd and Zn-Mn type batteries, valorisation of residues from military activities, waste of electric and electronic equipment and other waste streams were developed with scientific success. Main goals for coming years consider enlarging research activities to other class of materials and end-of-life products.

This Laboratory is an infrastructure equipped with modern equipment, including:

- magnetic separator;
- particle size analyser by laser diffraction;
- optical microscope;
- stereoscope microscope with photography equipment;
- electric arc furnace;
- mechanical shredder;

- centrifugal ball mill, sample splitter, electromagnetic sieve shaker;
- several precision electronic balances, for determining the moisture content of the samples
- miscellaneous equipment for hydrometallurgical testing (reactors, process control equipment).

Energy Laboratory at Tagus Park

This experimental facility consists of a room (1.58) and a set of offices (2N14) equipped with a KNX system to control the lighting and HVAC system remotely and a platform that enables researchers to test new control algorithms to minimize energy consumption and maximize users comfort.

Polygeneration Energy Container at Tagus Park

This is a portable experimental facility consisting of a 1.2 PV solar system, a 720 Ahour battery system, a 400 W micro-wind turbine and complementary systems to generate electricity to the Energy Laboratory. With this facility, it is possible to implement demand response algorithms to maximize the use of renewable energy.

IST Design Studio

IN+ has been involved since 2002 in promoting engineering design, at a research and teaching level, in close cooperation with other centres at IST and in Portugal. These activities have been launched and developed through the installation of the "IST Design Studio", which aims at renewing and strengthening research and education in engineering design in a way to improve manufacturing competitiveness and innovation.

The studio was initially centred on activities developed through the IST's M.Sc. on "Engineering Design", http://in3.dem.ist.utl.pt/mscdesign/, in close collaboration with industry, bringing together staff, researchers and students from the IST's Department of Mechanical Engineering, as well as from the Department of Engineering and Management Science, the Department of Civil Engineering and Architecture and the Department of Informatics.

Currently, the IST Design Studio is a multidisciplinary physical and virtual studio specialised in innovation and entrepreneurship through design thinking. The Studio welcomes students, researchers, creative professionals, and corporate decision-makers, to help them create, develop, improve or re-design their products or processes through disruptive solutions.

IST Design Studio provides access to a network of stakeholders and resources for industrial design, engineering, product and business development services. Our key services include: assistance on conceptual generation and development of innovative ideas, design, cost, and performance goals; research on user demographic and cultural contexts in product/business design practices; visualization techniques; CNC machining and prototyping; 3D printing and implementation into production.

IST Design Studio is based at the IN+ Center (Mechanical Engineering Building II, IST Alameda) and is directly connected to three Research Laboratories: "Technology Policy and Management", "Thermofluids, Combustion & Energy Systems" and "Industrial Ecology and Sustainability".

2.3 Integration in the Associate Laboratory LARSyS

The Center is a co-founder of the Associate Laboratory LARSYS, "Laboratory of Robotics and Systems in Engineering and Science", which is funded through Portuguese Science and Technology Foundation, FCT. Under the context of a previous national research assessment exercise, LARSYS undergone a new organization in the period starting in November 2015, which extends up to March 2021. By now, LARSyS brings together a research network of four research centres, as follows:

- Institute for Systems and Robotics at Instituto Superior Técnico (ISR/IST);
- Center for Innovation, Technology and Policy Research at Instituto Superior Técnico (IN+/IST);
- Madeira Interactive Technologies Institute, at the University of Madeira (MITI/UM);
- Centre for Maritime Technologies at Instituto Superior Técnico (MARETEC/IST)

Team-based research at LARSyS is fostered by an organization in thematic areas, which allow exploiting synergies, resources, and organizations of the various centres to explore new frontiers of knowledge in emerging themes. Currently, LARSyS is organized in six thematic areas. These areas, as well as the participation of the research units and of IN+ in particular, are shown in the table below:

Thematic Area	Participating Research Units			Participation of IN+
T1 - Oceans Exploration and Exploitation	ISR	M-ITI	MARETEC	Technology Management and Policy
T2 - Urban Systems	ISR	M-ITI	MARETEC	Industrial Ecology and Sustainability
T3 - Aeronautics and Space Systems		M-ITI		Thermofluids, Combustion and Energy Systems Technology Management and Policy
T4 - Engineering for and from the Life Sciences	ISR	M-ITI		Thermofluids, Combustion and Energy Systems Technology Management and Policy
T5 - Cognitive Robots and Systems for Assisted Living and Working	ISR	M-ITI		Technology Management and Policy
T6 - Distributed information processing and decision making	ISR	M-ITI		Technology Management and Policy

III R & D ACTIVITIES

This section describes the main results of activities performed by IN+ researchers in recent years, with emphasis on 2015 and 2016. The results are presented in terms of the activities performed under the various groups involved in the three scientific areas established at IN+

3.1 Research Activities

3.1.1 Thermofluids, Combustion and Energy Systems Design

Activities in this area, during the reported period, were directed to:

Measures towards NOx zero emissions

Rich-lean technologies

In the present study, we evaluate an expanded version of a practical rich-lean burner consisting of lamella geometry with lean flames in the central part and surrounded by two slits of rich flames (to prevent peripheral lean flames from lifting). The central part of this burner was studied in the search for an optimal geometry that maximized the stability of a methane-air lean flame, especially regarding peripheral rich-lean flame interaction. In this rich-lean interaction, the lean flame was contaminated by diffusion of heat and radicals forcing the laminar flame speed to increase (improving overall burner stability) and we derived an analytical expression that showed how the apparent equivalence ratio of contaminated lean flames is linearly dependent on the equivalence ratio and velocity gradients as the driving forces of the mechanism of triple flame interaction. Experimental results validated the analytic expression, giving support to a holistic view of rich-lean flame interaction. In addition, recent results have shown that global NOx is controlled by global equivalence ratio not depending on the rich lean stratification parameter.

Lean Combustion: the thermoacoustic barrier

The present work evaluates impinging lean disc flames, stabilized on a Helmholtz resonator, under thermoacoustic oscillations. This is a novel concept were the lean to ultra lean flames are not stabilized on burners but attached to the target to be heated. Based on the experimental data and the above mathematical model, it was found that the system (burner-fame) oscillates with one or two frequencies depending on the ratio between burner-to-plate distance and mixture velocity. For the fame-burner resonance with a single frequency f , the coupling is controlled by the entire flame. On the other hand, when it oscillates with f and 2f , the coupling is controlled by the bottom part of the flame.

Surface & Catalytic reactions

Preliminary activities on the research of surface reactions were divided in two domains:

- Catalytic reactions: The objective is to analyse the impact of the use of non-noble catalytic material deposition in micro reactors for the development of a hybrid combustor (flame and catalytic reaction simultaneously). The study here is towards the surface deposition of catalytic non-noble material, such as Cobalt, by electrodeposition techniques.

— Flame surface interaction: here the problem of quenching reaction and air entrainment was studied in multi-perforated plate burners. The focus is at the anchoring region of the flame and the aim is to analyse the local dynamics between flow and heat interactions and the impact of local surface manipulation on flame stability and the flammability limits.

Optimization of Exhaust Air Systems

An exhauster allows for local ventilation, removing both thermal loads and unwanted substances created by a certain pollutant/toxic source, avoiding any health and environmental related problems. In this context, the work developed here focused on characterising both experimentally and numerically the airflow created by kitchen hood to apply changes leading to an improvement in its energetic efficiency. After identifying the main phenomena responsible for the pressure losses across the system and observing that these were related to the geometry of the scroll casing, the numerical solver was used to test new casing geometries in order to lessen or even eliminate these phenomena. This new fan was experimentally tested and its performance showed improvements of 10.5% on the maximum air flow, 44.4% on the fluid dynamic efficiency and a reduction of 4 to 7 dB on noise production.

Spectrometer Instrument

The work was conducted in a multi-disciplinary context, involving Physics, Electronic and Mechanical Engineering Departments and a Portuguese Industry (Sarspec) with the objective of development and commercialize a Spectrometer for the UV-Vis region. To achieve this objective, a joint optimization of the optical components v.s. New physical / mathematical models of signal interpretation v.s. Control of the CCD signal sensor was developed.

Interfacial Transport Phenomena

The research activities performed within this year focused on the transport phenomena occurring at liquid-solid interfaces. The influence of wettability was inferred on flow boiling in multi-microchannel heat exchangers and on pool boiling, both with application to micro-cooling systems. The conditions tested covered extreme wetting regimes, from superhydrohphilicity to superhydrophobicity, searching towards the maximization of the convection heat transfer coefficients and/or delay (in terms of superheat) of the critical heat flux. The analysis involved the simultaneous use of high-speed visualization and micro-PIV and development of other diagnostic techniques such as time resolved infrared thermography to relate the heat transfer phenomena with nucleation and bubble dynamics.

Experimental activities were complemented with the development of a numerical model for pool boiling heat transfer in collaboration with the School of Computing, Engineering and Mathematics of the University of Brighton. The most accurate quantities were derived, namely defining the accurate contact angles to be measured and considered to include the effect of wettability in bubble dynamics and consequently in the heat flux and heat transfer coefficient

calculations. Surfaces with engineered wettability were developed making use of micro-and-nano structured patterns derived from this research, which were used to design microprocessor cooling system.

The research activities are well-sustained by a national and international network, including the Key Laboratory of the Ministry of Education for Bionic Engineering in Jilin University, China, INESC Microsystems and Nanotechnologies : INESC-MN, the Institute for Bioengineering and Biosciences - iBB, Universitaet Stuttgart, the University of Nottingham, ITV Denkendorf-germany, Liverpool John Moores University, Università di Roma Tor Vegata, Università Politecnica delle Marche, Ancona-Italy, Università degli study di Bergamo, University of Brighton, among others and provide the mandatory stages for students pursuing the "Master in Micro and Nanotechnologies for Integrated Systems" from Institut National Polytechnique de Grenoble, from Politecnico di Torino and from Ecole Polytechnique Fédérale de Lausanne.

Transport and handling of biofluids

The transport and handling of biofluids is a new area of R&D fostered by the knowledge of interfacial transport phenomena which aims the development of microfluidic devices (lab-on-a-chip) for clinical diagnostics, in the context of the thematic area **"Engineering from and for Life Sciences"**. Contrarily to most of the configurations for lab-on-a-chip applications, which are based on closed configuration systems, using microchannels to handle the samples, the current work addresses the use of an open configuration system, in which the samples are handled inside microdroplets, by means of electrostatic actuation (electrowetting). Despite a few authors report the successful transport of physiological fluids on open configuration systems, sparse information is still reported in the literature concerning the transport of biofluids, so that it is still not clear which are the most suitable electrochemical properties of the fluids or the most important parameters governing biofluids transport and manipulation. Hence, the design of efficient chips for the transport of these biosamples required a prior investigation to identify the phenomena altering the local wettability and how they affect droplet spreading and displacement. This analysis allowed determining the main configuration and experimental conditions to devise test chips, incorporating micrometrically interdigited electrodes. These chips were then assayed, searching for the configuration that optimizes the samples transport. At this stage of the work, the chip configuration is now becoming more complex to integrate the diagnostic and sorting areas, which are currently under development.

3.1.2 Industrial Ecology and Sustainability

Urban sustainability and innovative solutions for smart cities

The research focused on strengthening knowledge on the drivers of cities' metabolism, support sustainable management of urban-driven flows and defining policies for urban sustainable management. A multidisciplinary assessment of the urban area was fostered, including impacts of energy and

materials use, energy generation within the city, mobility flows, urban spaces outdoors' quality and issues of materials sustainability, namely by applying life cycle assessment methods. Projects developed within this topic include the nationally funded Suscity and the light-house EU funded Sharing Cities, which aim at sensoring the city's flows on an open data environment, in order to develop innovative services for the city.

Sustainable energy systems modelling

The research focus on the development, modeling and planning of energy systems, either on short-term (operation and management) or long-term horizons. We deepen the research on the integration of renewable and storage technologies on present energy systems, as also smart grid mechanisms, with special emphasis on microgrids interaction and optimization, either isolated or connected. Examples of Projects are the Azorean islands modeling within Vulcano Project, or the development of a strategic energy action plan for the municipality of Odemira. Furthermore, regional and country-scale energy scenarios are developed, and we are also motivated in delivering solid research to external partners as industry, municipalities and governments.

Intelligent Energy Management Systems in Buildings

In the current context in the energy field, the building sector - the largest final energy consumer - is the one where energy efficiency has been harder to achieve. The main challenges and opportunities are identified and it is concluded that the development of energy management systems that focus on the integration between supply and demand technologies and have a deeper understanding of the design and operation of buildings are the key to increase the adoption of energy efficiency in buildings. With an integrated approach to energy modeling, energy demand management and energy supply integration, it is possible to develop a coordinated design and operation in to minimize energy consumption whilst maximizing indoor comfort. This requires the development of a new generation of complex modeling and management algorithms - Intelligent Energy Management Systems. This research has been levered on a European Project called SmartCampus in which IST participated from 2012 to 2015 and in the Sustainable Campus project at IST, an innitiave promoted by IN+ at the IST campi level to increase energy efficiency.

Sustainable Materials and Technologies

The research focus on understanding the material consumption that support economic activities. The main objectives of this research area are to promote a more efficient use of resources and a better management for the waste produced from that use. This research supports the design of waste management plans and the public policies on resource efficiency.

Active and Online Learning

For the first time in the research group and at the IST, in 2016, we launched a Massive Open Online COURSE (MOOC), in the topic of Energy Services, which

had around 500 participants and a success rate of 40%. We are committed in continuing to foster these kind of activities that gather interest among students to study and research at IN+.

The potentials of biogas as a renewable energy

An area of research has been opened to address the potentials of biogas as a renewable energy source in Portugal. Preliminary work, supported by the Portuguese energy company Galp-energia in partnership with a swine farm, showed the potential economic and environmental benefits of implementing anaerobic digestion for biogas production in this industry, despite the low biogas yield of pig manure. Nonetheless, greater benefits can be obtained from co-digestion with higher-producing substrates, namely through the use of mixtures of pig and horse manure in co-digestion to produce biomethane. This happens at the same time that the possibility of upgrading the biogas to biomethane is being considered at a regulatory level. IN+ participates, with ITG (Technological Institute of Gas) and other experts, in the technical commission created to study the normalization of the biomethane to be injected in the natural gas grid. The work is being developed in close collaboration with industries and at a multidisciplinary level, involving all three areas of research at IN+ in partnership with the Instituto Superior de Agronomia (School of Agriculture).

3.1.3 Technology Management and Policy

Innovation dynamics in aeronautics and Embraer in Évora: towards a distributed platform for entrepreneurial initiatives, new employment and skills development

This project looks at the increasing complexity and uncertainty of technological advances and related value chains and business configurations in modern aeronautics. It is motivated by the recent installation of two new Embraer plants in Évora, Portugal. It has the ultimate goal of securing the role of Portuguese firms as centers of excellence in aeronautics. The two plants in Évora are a singular case: although being fully Embraer, both plants are also considered first tier suppliers of Embraer Brazil. This requires the full integration of their activities within the needs of Embraer Brazil while also keeping a competitive edge with respect to other suppliers in Embraer's supply chains. Nowadays, ICT is crucial to addressing supply chains issues between manufacturers and suppliers. ICT systems are essential to anticipating problems and opportunities in the supply chain management, supporting decision-making at five levels:

i. identification, capacitation and qualification of new technology based suppliers (for specialized products and services);

ii. monitoring suppliers performance in order to pro-actively address risky situations or opportunities, such as the increase in production pace

iii. identification of backup suppliers,

iv. assessing network effects that endanger or synergize the supply chain, and

v. supporting the implementation of advanced methods of manufacturing.

Much of the work of this project focuses on managing large data sets, culled from direct and indirect indicators, and ICT-based logistic platforms among OEMs and suppliers. Namely, it focus on the creation, integration and development of new technology and technology-based firms in the value chain of the aeronautics sector that can serve as key economic agents to foster and facilitate technological innovations. The emphasis is on value-added platforms to facilitate the necessary technological advances including opportunities for new employment and skills development and their impact on regional development.

The geography of industrial production is continuously shifting towards most cost effective locations, being particularly associated to increasing uncertainty. The relative inadequacy of existing frameworks to capture complexities of emerging distributed supply chains is addressed in our research, focusing the analysis on aeronautics due to its strategic importance for industrial dynamics, innovation, human capital and socioeconomic development.

Metal Additive Manufacturing

On of the technologies we have focused is the introduction of Metal Additive Manufacturing (MAM), as an example of a recently developed technology with the potential of enhancing the performance of certain components, changing the industrial landscape by optimizing supply chains and bringing manufacturing closer to the final user. We look at the introduction of this technology in aeronautics in different contexts, going from the perspective of a technology leader, to that of a modest innovator.

To understand how this process is undertook, we look at the introduction of MAM, as a new emerging technology in Portugal. We analyze the historical roots of the current implem entation of MAM in the country by studying the introduction of rapid prototyping technologies in the late 90s. In addition, we analyze the opportunities and challenges to further introduce MAM in the Portuguese industry.

The introduction of a production technology such as MAM may produce new challenges for the Portuguese industry, challenging its competitive position in the Molds industry, its supply position in Automotive, and a position in Aeronautics. Thus, Portugal may need to develop its ability to adopt and use MAM. We use a case study methodology to identify and analyze the challenges Portuguese firms face in adopting MAM. The lack of know-how among Portuguese firms with respect to MAM has deep historical roots. To explore those problems, we compare the history of MAM in Portugal with the history of Polymer Additive Manufacturing (PAM). In both cases, Portugal invested in the technology relatively early, but while the current state of introduction of MAM has been modest, the research community has been able to move towards high-tech applications of PAM. We find that, while PAM enjoyed continuous institutional support, the history of MAM has been plagued with institutional instability and a six-year discontinuity in MAM-related research. MAM is more expensive,

less technically mature, and requires longer learning periods than PAM. MAM products usually also have more stringent specifications than PAM products. Our results suggest that specific stable industrial policy for technology adoption in this case may be needed to keep following the technological development occurring in MAM.

Skills for industrial development

In this research we look at the evolution of skills in manufacturing, by comparing different industries in different regions, enabling the identification of capabilities used to produce different products, and looking at trends in career paths of individuals. The focus on people and skills needs to take into account the availability of capabilities and the existence of users with the ability to create and commercialize products, engaging directly in the production processes, and contributing to new industrialization processes. The proposed analysis is done making use of the Quadros de Pessoal Dataset, a longitudinal matched employer-employee dataset built from mandatory information submitted annually by all firms with at least one wage earner to the Portuguese Ministry of Employment and Social Security since 1986.

Entrepreneurship in An Ageing Society

In Portugal 39% of the population are aged over 50 years old and 19% over 65 years (INE, 2012). The UN (2011) ranks Portugal as the 8th most ageing country in the world in 2011 and 2nd in 2050. Evidence shows that many older (or retired) workers want and/or need to become entrepreneurs. Research for countries like USA (Zhang, 2008), UK (PRIME, 2004), Finland (Kautonen, 2008) and the OECD (Quinn, 1996) shows higher rates of entrepreneurial activity among individuals aged 50 or more years.

Are older individuals really creating and developing new firms? What are the key goals, motivations and barriers for older entrepreneurs? How well do firms started and managed by older entrepreneurs perform (turnover, job generation, survival)? Can entrepreneurship among the older be seen as and active ageing process and a social positive outcome? What type of public policies can be designed to address labour market integration, self-employment and active ageing among older individuals?

The need to shed new light on the questions above (both at the national and international level) and support the development of socioeconomic and labor market public policies aimed at the older, constitutes the basic motivation for this research project.

This ongoing reseach has led so far to the publication of the following book: Matos C., Amaral, A.M. & Santos, M.J. (2015). "Empreendedorismo Após os 50 anos - um estudo sobre Portugal" *(Entrepreneurship over age 50 – a study about Portugal)*, Rh Editora. ISBN: 978-972-8871-59-8

3.2 Dissemination Activities and Conferences/events (2015-16)

18th **International Symposia on Applications of Laser and Imaging Techniques to Fluid Mechanics**, 4 – 7 July 2016, Lisbon, Portugal

There is no doubt that laser techniques now represent the most important diagnostic tools in experimental fluid mechanics. Technological developments in lasers, detectors, electronics and computers have continued to be the source of new techniques, improved accuracy, higher spatial or temporal resolution and new applications. In this context, the International Symposia on Applications of Laser Techniques to Fluid Mechanics, held biennially in Lisbon since 1982, have been a continually renewed source of state-of-the-art experimental fluid mechanics for three decades. This series, often referred to simply as the "Lisbon Symposia", was conceived and founded by James H. Whitelaw in 1981. The organization in Lisbon was initially chaired by Dimantino Durão and, then, by Manuel Heitor for the period 1992-2004 and by António Luis Moreira since 2006. All the papers presented since 2000 are available for download in http://www.lisbonsimposia.org.

The last symposium (17th Symposium) was organized in the period 7-10 July, 2014 and a new edition is now being prepared for the period 16 – 19 July 2018 thus promising a continuous progress.

4rd BioApproNFS-Wett Workshop, Lisbon, 4 - 5 June 2015.

Organized in the context of the project Marie Curie (FP7-People-2011-IRSES, Ref.: 295224, 2012-2016, this workshop was held at Instituto Superior Técnico, in Lisbon (4-5 June 2015). Despite being organized under the specific context of this project, it gathered nearly 30 researchers from several research fields, such as chemistry Bioengineering, Physics, Mechanical Engineering and Materials Engineering, gathered towards the development of bioinspired complex surfaces with extreme wetting behaviour.

ThermoCup 2016- Steam Boat Regata at Maristas College of Lisbon

Development of "scientific toys" by students in the context of active-learning to exploit knowledge between theory, practice and free trials. The optimization of a handmade steamboat is supported by the general skills acquired and being acquired within the Physics-Chemistry of High Schools and 1st cycle of University studies and in particular in the course of "Thermodynamics I".

Programme GALP 20-20-20

Beyond the research activities, the internship programme GALP 20-20-20, funded by the Portuguese energy company Galp-Energia, consists of an academic partnership aimed at identifying rational energy systems and attitudes in industry. The programme is an industry-based training program which partners with industries of any economic activity, from the primary to the tertiary sectors. During six months, seven final year master students live in seven

companies to develop an energy efficient project. Besides a funding, the student takes part in a competition that rewards the three best studies at each university.

Innoenergy Renewables Bootcamp (2012, 2013, 2015 and 2016)

The Renewables BootCamp is a course organized by CC Iberia for PHD students and MSc students to foster innovation in the renewable technologies field. The course objective is to develop renewable energy related prototypes (floating solar PV power plants, solar benchs to charge mobiles, etc.) The course is divided in three activities: ideation, 3D prototyping and Arduino Prototyping. The students were divide in groups and develop prototypes, test them and present them in a competitive way.

IV ADVANCED TRAINING

R&D activities progress in close collaboration with various post- graduation programmes at IST, with emphasis on several mechanical and environmental engineering related degree programmes. Members of IN+ directly coordinate PhD programmes and an Executive master, and these programmes have been particularly developed making use of IN+ resources.

PhD in "Sustainable Energy Systems"

https://fenix.ist.utl.pt/cursos/dsse; also at: http://www.mitportugal.org/sustainable-energy-systems/ses-doctoral-program-structure-at- utlfcul.html

Coordination: Antonio Moreira

The Sustainable Energy Systems Doctoral Program (SES PhD) was launched in 2006 and considers a three- to four-year degree jointly offered at each of the Portuguese Institutions participating in the MIT Portugal Sustainable Energy Systems Program. The objective of the PhD Program on Sustainable Energy Systems is to use a multi-disciplinary approach to educate a new generation of sustainability-aware leaders with expertise in energy systems and economics. A focus on energy system design and analysis, research, and leadership and entrepreneurship provides graduates with the tools to be at the forefront of sustainable energy systems development.

The PhD Program emphasizes the policy and technology development necessary for the successful design and implementation of alternative energy strategies. Students have the opportunity to learn about the practical application of energy strategies through real-world case study research in conjunction with corporate and industry partners or affiliates.

The Program includes one year of coursework, including doctoral seminars. Students conduct dissertation research for 2 to 3 years, in the following areas:

- Sustainable Built Environment
- Energy Planning, including Economics
- Smart Energy Networks

The SES Doctoral Program welcomes candidates with engineering or management backgrounds. Candidates must be highly motivated to conduct innovative research activities, and must also demonstrate strong communication, leadership and entrepreneurship skills. SES PhD graduates will have the tools to play leadership roles in implementing sustainable energy policies and developing new business opportunities.

The SES Doctoral Program is a joint initiative offered by four universities in Portugal collaborating in the context of the MIT Portugal Program including the Technical University of Lisbon (Instituto Superior Técnico - IST, and Instituto Superior de Economia e Gestão - ISEG), the University of Porto (Faculty of Engineering, FEUP), the University of Lisbon (Faculty of Sciences, FCUL), and the University of Coimbra (Faculty of Economy – FEUC, and Faculty of Sciences and Technology - FCTUC). All the universities share a common core curriculum, and students can personalize their Program by selecting elective courses at any of the five schools that meet their specific interests and course requirements.

Master in "Sustainable Energy Systems

http://www.mitportugal.org/sustainable-energy- systems/ses-executive-masters-program-structure-at-utl.html

Coordination: Antonio Moreira

The SES Executive Masters program was launched in 2006 (together with the PhD programme described before) as a one-year program offered at the Technical University of Lisbon and the University of Porto. The objective of the Executive Masters program is to educate mid-career professionals in energy systems and economics using a multi-disciplinary approach. With a focus on energy system design and analysis, as well as leadership and entrepreneurship, graduates will be at the forefront of sustainable systems development.

The program focuses on the policy and technology development necessary for the successful design and implementation of alternative energy strategies. Students have the opportunity to learn about the practical application of energy strategies through real-world case study research conducted in conjunction with industry partners. The Executive Masters helps students to develop an entrepreneurial spirit and to extend their professional and academic networks, promoting new job opportunities for them.

SES Executive Masters graduates will have the tools to play leadership roles in implementing sustainable energy policy and developing new business opportunities. Students may proceed to the PhD program as long as they fulfill the requirements and are approved by the SES Educational Committee.

The Executive Masters Program is a one-year (280-hour) program addressing multidisciplinary core areas in energy systems, including:

- Economics, management science and policy
  Environmental analysis and assessment
- Energy systems
- Energy technologies

The executive Masters corresponds to an Advanced Studies Program in the Technical University post-graduation system (the graduate is awarded a Bologna 3rd Cycle certificate). Each student in the Executive Masters Program creates a unique curriculum to fulfill her/his individual interests. Guided by a faculty member, the student is allowed to choose from a pool of optional courses (O) in order to complete 48 to 60 credits (ECTS).

Coordination of InnoEnergy MSc RENE (Renewables Energy) at IST: Edgar Fernandes

MSc RENE is an international programme for an international industry. It joins students from all over the world for two years at two different universities and two of Europe's leading business schools. After successfully completing

the programme and thesis, they receive a Master's degree from two of the following institutes in the form of a double diploma: IST, KTH, UPC, ParisTech. MSc RENE is a programme accredited by the European Institute of Innovation and Technology (EIT).

Innoenergy PhD School

http://www.innoenergy.com/education/phd-school

Coordination for CC Iberia: Carlos Santos Silva

Innoenergy PhD School is a complementary education program for PHD applicants doing applied research in the energy field to develop their skills and competences in innovation and entrepreneurship by providing insights into the economy and industrial outlook of the energy field. With Innoenergy PHD school, PhD applicants can learn how energy businesses are created and run, can stay one step ahead of other PhD students when developing new products and services and bringing them to market and have the support for international mobility across Europe to provide them an multi-national perspective. Further, the applicants have access to a new network of contacts from high-level industry representatives to fellow research partners. The final objective it to make the PhD applicant more attractive to the job market, making it easier to find a highly qualified international job or pursue a career in academia.

V STRATEGY and PLAN

The Strategic Research Plan states the central commitments of IN+ to ideas, innovation, sustainability, collaboration and partnership as well as to social engagement in research. It lays the basis for IN+ to enhance its research capacity, build and strengthen its strategic alliances and relationships and emphasizes knowledge exchange. However, it remains a living document to be revised and adjusted as new challenges and opportunities arise.

5.1 Horizontal strategy

A horizontal strategy across the core competencies of the scientific areas of IN+ has been established aimed at leveraging the synergies and exploring interrelationships which, in turn, is expected to also contribute to increase competitive research of the Center.

For example, the strategy addressed at the bioenergy sector of an increasing use of biogas opens up new fields of applications. Biogas is a renewable energy source which can be used as high-tech process energy for industries, effective small scale power generation and transportation fuel. Technological advances in recent years have raised the capabilities for upgrading biogas to biomethane which can be injected into the grid, thus contributing to the de-carbonization of the economy, helping the transition to an energy system based on sustainable resources and to meet the European Union renewable energy targets. In this context, and according to the new regulation framework, many countries in Europe have already set incentives to increase the presence of biomethane which, in turn, raised the need to create standards concerning the specification of gas quality. The establishment of those standards would enhance the free flow of gas within the internal EU market, in order to promote competition and security of supply, minimizing the negative effects on gas infrastructure and gas networks, efficiency and the environment and allowing appliances to be used without compromising safety. However, Portugal has not considered yet the potentials of supplying the natural gas network by local and decentralized production. With this in mind, a multidisciplinary and multi-task group of researchers and industrial partners headed by IN+, has been recently created aimed at establishing a biogas task-force in Portugal.

Activities span from fundamental to applied research, including assessment of the potentials of biogas production, definition of tools to optimize the quality of biogas yield based on co-digestion with different substrates and upgrading to biomethane, taking into account the need for standardization and the development of accurate instrumentation for monitoring and control the composition of biogas. Some more specific activities are described next.

- The option of being used by the producer to produce heat and electricity for its own purpose will be compared aside with the possibility of upgrading to characteristics compatible with natural gas (Biomethane). In this context, the benefits of co-digestion are numerous and the current availability of waste residues and variety of possible substrates will generally improve the economic factors for an anaerobic digester plant. But the benefits that can be realized from co-digestion, as well as the potential downsides that can be encountered, need to be carefully evaluated. Experimental data obtained in small-scale and pilot-scale reactors, of the co-digestion of mixtures of different manures will be conducted aimed at developing simulation tools to assist the design of practical systems, including life cycle analysis to assess the potential environmental impacts of producing and using biogas.
- Survey of national available resources of biomass substrates, geographical distribution taking into account their supply substrate.

- Experimental characterization of the burning characteristics such as laminar burning velocity, flammability limits, flame temperature, ignition temperature, flame stability, Methane Number (MN) and heating value of both pure biogas and biogas mixtures with other fuels. The combustion characteristics will be quantitatively studied either in domestic applications and internal combustion engines.
- Development of spectroscopic instrumentation easy to use, reliable, and accurate within the range of accuracy required by standards able to monitor the quality of the gas injected in the grid but also to control and monitor anaerobic digesters.
- Contribute to define specifications, as wide as possible and within reasonable costs, for the development and implementation, at a European scale, of a common standard on biomethane taking advantage of the involvement of IN+ in the national technical commission for normalization at ITG.

Besides the contribution for the "Bioenergy Strategy", each scientific area will continue following well-established agendas in specific research fields, as follows.

5.2 Thermofluids, Combustion and Energy Systems Design

Special attention will continue to be put on the fundamentals of transport phenomena near interfaces which are relevant in many energy transport processes with application to energy systems. This involves surface catalysis with non-noble materials for low-temperature combustion systems and wettability studies for low temperature heat recovery. The former encompass experiments to study the coupling between surface coatings with wall/flame and thermal/chemical interactions which determine flame stability; while the second encompass experiments in extreme wetting regimes, from superhydrohpilicity to superhydrophobicity, together with the use of nanofluids, in the search for maximizing the convection heat transfer coefficients and/or delay the critical heat flux in multi-microchannel heat sinks and pool boiling systems.

- The reaction/combustion activities will be conducted aimed at promoting the control of poluttant emissions, while burning green-fuels at low-temperature, i.e. at lean conditions, in the context of the LARSyS thematic area **Urban Systems.** Special attention will be given to the analysis of hybrid combustor. i.e. catalytic+combustion, for burning low calorific fuels such as biogases from biomass gasification process
- Besides the application to low temperature heat recovery systems, the fundamental knowledge developed through basic research also inspires new methods for the transport and handling of micro amounts of biofluids and will be used for the development of microfluidic devices (lab-on-a-chip) for clinical diagnostics, in the context of the thematic area **"Engineering from and for Life Sciences".**

The Laboratory activities programmed for the next year for the research area of transport phenomena at liquid-solid interfaces follow an interdisciplinary approach to cope with two main goals: i) merging the expertise acquired in microfluidics, surface physics and chemistry, life sciences and micro-fabrication and deepening the description and knowledge of the fundamental physics governing the transport mechanisms to devise and/or improve products and conversion processes. Main emphasis is given to the transport of mass, momentum, energy and entropy through and along fluid/fluid and solid/fluid interfaces, including interfacial kinetics in reactive flows (e.g. heterogeneous combustion systems); ii) establish a well-grounded group providing training and performing research activities within an interdisciplinary policy, concerning the project of fluid/fluid and fluid/solid interfaces and their application in engineering sciences.

Within the scope of the thematic area "**Engineering from and for the Life Sciences**" the main activities programmed to the following year address the required steps towards the development of a Lab-on-a-Chip for clinical diagnostics. The main focus for the next year is on the development of a system allowing the early diagnosis of lung cancer. Besides dealing with the actual development of the microchip, which requires continuous investigation on the effect of the wettability of the chosen materials and use of alternative methods to alter the surface properties, as well as a deep study of the fluid dynamics involved in the efficient transport of the samples, the work planned also considers exploring the flow rheology and particular characteristics to be used as diagnostic tools. To support this plan, an international and multidisciplinary consortium is being formed, with formal collaborations established between IN+ and INESC-MN, the Nanotechnology Research and Application Center (Turkey), the Center for Integrated Sensor Systems in Danube University (Austria) and the Leibniz Institute fur Analytische Wissenschaften – ISAS (Germany). This consortium is the basis for a wider network which is preparing a proposal to be submitted for financing under a H2020 call, at the end of January 2017 - FET-Open research and innovation actions - FETOPEN-01-2016-2017.

Since this small consortium is already active and the work has secured financing through the project DINAMICS, while ISAS supports the interchange between researchers (PhD students), research activities are planned to be complemented with the organization of a small workshop, to be held in Lisbon in the Summer (2017), gathering experts from the various relevant fields (Bioengineering, Mechanical Engineering, Materials Science, among others).

(Bio)m imetic fluids are planned to be devised and their mechanics to be fully characterized. This part of the work, directly involved with the thematic area "**Engineering for and from Life Sciences**" is also strongly linked with the current applications on heat and mass transfer at liquid solid interfaces. In fact, flow boiling in mini and microchannels is being studied for cooling (refrigeration) applications using nanofluids. Fundamental studies on the effect of the nanoparticles on the local thermo-physical properties of these fluids and on the wettability, are vital to describe the actual fluid flow and heat transfer processes. Furthermore, the influence of the fabrication methods and protocols in these properties is also addressed for the sake of experimental validation and reproducibility of the working conditions. This is again a strongly multidisciplinary subject, which is supported by national collaborations (e.g. Universidade do Minho) and international research groups. Within the **Nanouptake – Overcoming Barriers to Nanofluids Market Uptake** (COST Action CA15119) aiming to create a Europe-wide network of leading R+D+i

institutions, and of key industries, to develop and foster the use of nanofluids as advanced heat transfer/thermal storage materials to increase the efficiency of heat exchange and storage systems. Combining fundamental studies with applied research, the work performed in the Laboratory is planned to follow one major goal of Nanouptake: developing nanofluids up to higher Technological Readiness Levels (TRL) and overcoming commercial application barriers, to achieve the European Horizon 2020 Energy and Climate objectives (Societal Challenges 3: Secure, efficient and clean energy; and 6: Climate action, environment, resource efficiency and raw materials). Also, another European Consortium has been organised which will to start research in 2017 on drop break-up and transport phenomena in structured fluids for advanced industrial applications.

In addition, the development and full characterization of complex surfaces with reversible wetting properties is planned to be continued, based on the collaborations identified in the previous paragraphs and particularly with the Key Laboratory of the Ministry of Education for Bionic Engineering in Jilin University, thorough Project SMART HEAT – FCT -MOST(JICAM): Surfaces Micro And nanometRically Treated for HEAt Transfer enhancement. It is worth mentioning that many of these surfaces can be prepared to enhance heat and mass transport phenomena, while having catalytic properties, thus joining the two main research areas of this laboratory: Transport phenomena at liquid-solid interfaces and The Dynamics of Low-Temperature chemical reaction towards the development of low temperature sustainable energy conversion systems.

5.3 Industrial Ecology and Sustainability

The LEIS has the vision of become an international reference in the design of policies for sustainability at multiple scales (national, regional and urban) in order to increase the natural resources productivity. Our mission is to develop robust methodologies to integrate tools to characterize, model and optimize the productivity of natural resources. The main contributions for the society are:

- Develop scientific knowledge (disseminated through journal papers, books);
- Develop training and pedagogic materials to better enable knowledge transfer;
- Contribute to Public Policies (by developing policy briefs);
- Share data and information (using web applications or platforms).

The main research areas of LEIS cover Urban Sustainability, Sustainable Energy Systems and Sustainable Materials and Technologies, which are described in detail next.

Urban Sustainability

The LEIS-US research focuses on strengthening knowledge about the drivers of cities' metabolism, support sustainable management of urban-driven flows and defining policies for urban sustainable management. A multidisciplinary assessment of the urban area will be fostered, including impacts of energy and materials use, energy generation within the city, mobility flows, urban spaces outdoors' quality and issues of materials sustainability, by applying a life cycle assessment approach to account for environmental impacts.

The research examines the potential of applying a variety of strategies that have emerged from the field of Industrial Ecology to the design and planning of cities. Through current work in tracking the material and energy flows devoted to urban centers, this study identifies networks for symbiotic resource exchanges and productive reconfigurations of primary elements of urban form and infrastructure for sustainable city planning.

- The research objectives until the end of 2017:
- Improve the MEMO Webmap with 1940's cartography;
- Develop a project proposal within the F3 college – Foodsheds group;
- Monitoring *Mercado de Arroios* thermal confort;
- Develop a pilot hydroponics greenhouse with(in) ISA (a testbed for urban food production assessement);
- Develop and test smart solutions in Olivais (e.g. watering system linked to meteo stations);
- Have an online webmap platform with resource and energy flows for the Suscity area;
- Create a tool for calculating urban metabolism for world cities; and
- Create a database with urban metabolism studies.

Sustainable Energy Systems

The LEIS-SES research focus on the development and modelling of energy systems planning, either on short-term (operation and management) or long-term. We also work on the integration of renewable and storage technologies on present energy systems, as also smart grid mechanisms. Microgrids interaction and optimization are also deep in our research. In LEIS-SES we build energy scenarios and are motivated to deliver solid research to external partners as industry, municipalities, or governments. The research goals for 2017 are:

Provide an open-source base of demand profiles using real data; Continue to develop an adaptable modelling tool for hybrid microgrids and make it open source, also by creating a user-friendly interface for the modelling tool;

Develop and maintain an up-to-date European TIMES model that can evaluate different policies ranging from demand-side management to electric mobility, etc;

- Promote a project in intelligent energy management area: Engaging partners to the consortium, writing the proposal, as leader or participant of the consortium;
- Finalizing the repair of remote MIT laboratory, replaced the sensors and damaged components. This lab can be used for technological exhibition developed by the group, especially for visitors;
- Complete the electricity meters installations, in the context of Suscity project and consider the collected data in order to publish in relevant international journals;
- Thermal Storage: Simulate and monitor an office in IST Tagus Park with and without, phase change materials plates. Supervising a graduate student, get results, published in relevant international Journal;
- Buildings entrance radiation control: Simulate and monitor an office in IST Tagus Park, with and without polarized films to control the radiation entrance. Supervising a graduate student, get results, published in relevant international Journal;
- Build a rhythm of improving each ones skill with regular workshops on different topics as matlab, LaTeX, and take advantage of MOOC courses (as Coursera); and
- Promote a 1 hours lecture about Energy Storage to the LEIS group members and generate discussion about the subject.

Sustainable Materials and Technologies

The LEIS- SM&T research focus on understanding the material consumption that support economic activities. The main objectives of this research area are to promote a more efficient use of resources and a better management for the waste produced from that use. This research can support the design of waste management plans and the public policies on resource efficiency. The research goals for 2017 are:

- Create a tool for estimating resource use by economic activity at the national level;
- Propose indicators to measure resource efficiency; and
- Establish a database of resource efficiency indicators for several world countries.

5.4 Technology Management and Policy

The Technology Management and Policy Laboratory's (TMP Lab) agenda will continue to draw on multidisciplinary activities, namely in the socioeconomic, science, technology and industry, domains., envisioning policy analyses and

recommendations to key decision-makers. In 2017 the TMP Lab plans to develop its activities in three central lines: Research, Education and University-Industry collaboration, as follows:

- In 2017 the TMP Lab will continue to develop research on Technology Change and Industrial Dynamics and Science and Technology Policy and Innovation analysis, with particular emphasis on specific industrial sectors, such as Aeronautics (through the E4Value Project) and Deep Sea (through +ATLANTIC Project, in order to maximize the economic, environmental and social benefits of deep sea exploration and oil and gas development in the South Atlantic Region).

- A new research project will be prepared in articulation with recent developments in Portugal in the domains of the Space industry; namely, the creation of the AIR Center in Azores.

- The TMP Lab plans to reinforce its human resources and positioning on the policymaking field, in order to provide a relevant contribution to Public Policy through the writing and circulation of policy briefs based on sound research findings.

- A new research project, now in its initial stages, will be developed with the Director of R&D of the Fraunhofer Institutes, concerning the capacity of various academic organizations around the works to generate spin-off companies, and the initial factors that hep determine the success of such companies.

- A new research line, stemming form currently on-going Master's theses (Miguel Guimarães / Francisco Nunes) work, will be explored concerning the early-stage funding of technology-based ventures in Portugal, compared to other regions.

- New research aimed at a better understanding of New Technology Adoption will be developed – What are the key constraints & opportunities in the introduction of new technologies in Industry? How can regions and nations take advantage of technological changes in manufacturing? – Emerging technologies present an opportunity for latecomer countries to reduce that gap through technological leapfrogging, especially in technologies that promise future substantial productivity improvements but are initially unappealing due to the low performance while they are immature. Examples of leapfrogging countries who took advantage of the rise of semiconductors during the late 20th century are South Korea and Taiwan. However, following the wrong strategy and failing to catch up may lead to the ´middle-income trap´, a situation where rising costs cause a decline in competitiveness which does not allow a country to reach the high-income economies. To avoid the trap, continuous investment in equipment and human capital is required, but sustaining investment levels in periods of crisis is challenging. This ongoing process brings into question firms' abilities to adopt new technologies and the diffusion processes between technology leaders and latecomers. In line with the existing literature, the proposed research focuses on the introduction of new

technologies, and the path leading to their diffusion, in different contexts.

- UAVs – With the increase development of technologies and production of unmanned aerial vehicle (UAVs), and approaches of these vehicles for different uses, including agriculture surveillance, infrastructure surveillance and emergency situations, among others. This increase leads to issues related to the use of the air space and safety, which poses additional challenges on regulation. Regulation in Europe and the US has been suffering changes, and there is some pressure for regions to introduce additional changes, as comercial UAVs gain space in the market. In this research we will address the impact of regulation on the evolution of UAVs manufacturing, considering both the US and Europe.

- Cell Therapies – The goal is to extend the methodological framework developed for aeronautics, and apply it to the analysis of other sectors. Attention should be focused on knowledge flows along the value chains of emerging industries (e.g., oil & gas; aeronautics; space; biotech), together with the necessary competences and capacities to devise policies to promote a sustainable future. It will include analysis of "technology infrastructures", consisting of science, engineering, and technical knowledge available to industry. One of the sectors to be considered is that of Cellular therapies, which has similar characteristics to aeronautics, including a very tight regulation, a long time to market, and high technology dependence.

- In recent years, cell therapy has shown a favourable market growth and received increasing attention from patients, academia and the medical community. Despite the growth in sales, there are still challenges and barriers that should be clarified in order for the market to achieve its full potential.

- The study of this industry has been developed in the master thesis of Tânia Agostinho on Biomedical Engineering, where the Establishment of supply chains in cellular therapy industry was addressed.

University-Industry collaboration

The TMP Lab is fostering the development of IST Design Studio. This Project is at is (re)launching stage and, in the short/medium term (in 2017), aims to (i) Provide the necessary technical assistance to project promoters (both on product design and development skills); (ii) Facilitate connections between students, faculty, alumni and industry; (iii) Stimulate industry participation and sponsorship and; (iv) Prepare proposals for calls for public and/or private competitive funding.

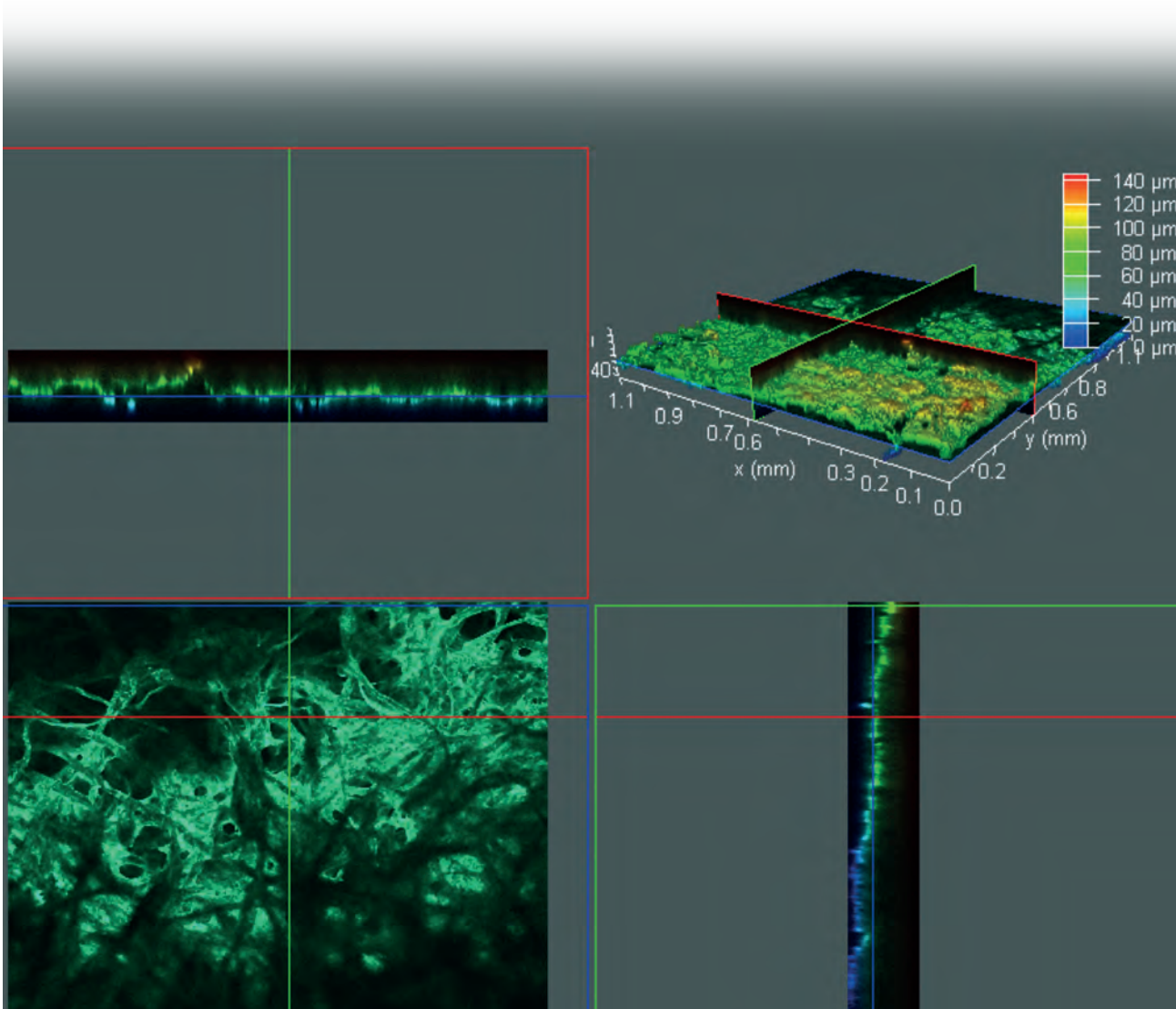
The TMP Lab also plans to strengthen the network between the Design Studio and other organic Units at IST with potential to develop engineering &design and technology transfer activities.

In addition the TMP Lab will be involved in the organization of the upcoming *International Industry Roundtables* (IIR), in articulation with the MIT Portugal Program and in collaboration with the Fraunhofer Institutes, in particular the IIR on "New Technologies for Health" to be held at IST with the participation of multiple industry decision-makers and entrepreneurs.

VI OUTCOME

In the period 2015-2016, research at IN+ have contributed to 148 peer-reviewed publications, including 6 edited books, 10 contributions for chapter books, 82 papers for peered reviewed journals and 50 for the proceedings of international conferences.

Overall, research at IN+ also provided substantive educational opportunities for graduate and undergraduate students from a range of science and engineering disciplines, significantly enhancing a number of master's and PhD thesis projects. In this period, 9 PhD and 60 Master theses were completed.



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Rodrigues, C., The European Electricity Generation Sector: analysing CO2 reduction efforts and the introduction of electric vehicles, Master Thesis (Mechanical Engineering), Instituto Superior Técnico, UL, 2016.
Supervisor: Pina, A., Co-supervisor: Baptista, P.

Rodrigues, F., Cost analysis of energy production from anaerobic digestion in an intensive swine livestock farm, Master Thesis (Mechanical Engineering), Instituto Superior Técnico, UL, 2016.
Supervisor: Moreira, A.L.N.

Rodrigues, H., Life Cycle Assessment of Commingled Al alloys, Master Thesis (Mechanical Engineering), Instituto Superior Técnico, UL, 2016.
Supervisor: Margarido, F.

Rodrigues, P., A Valorização do Conhecimento: O caso do programa COHiTEC, Master Thesis (Economy), Faculdade de Economia, UC, 2016.
Supervisor: Preto, M.T.

Sampaio, F., Uma Visão dos Empreendedores por Necessidade – Caso do PAECPE, Master Thesis (Management), Faculdade de Economia, UC, 2016.
Supervisor: Preto, M.T.

Santiago, M., Assessing the potential of electric vehicles for commutes in Portugal, Master Thesis (Mechanical Engineering), Instituto Superior Técnico, UL, 2016.
Supervisor: Baptista, P., Co-supervisor: Pina, A.

Santos, T., Recuperação de Indio em Monitores de Cristal Líquido, Master Thesis (Materials Engineering), Instituto Superior Técnico, UL, 2016.
Supervisor: Margarido, F., Co-supervisor: Silva, C.S.

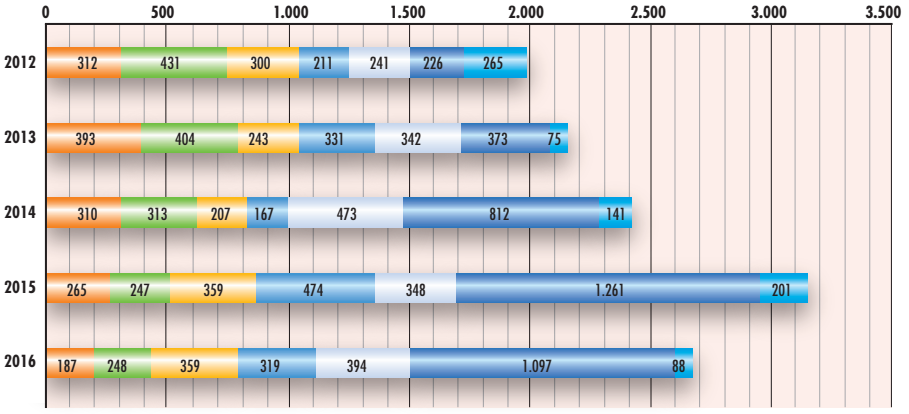
Silva, D., Sistemas sustentáveis de energia na ilha Terceira: o contributo da modelação e gestão da procura, Master Thesis (Mechanical Engineering), Instituto Superior Técnico, UL, 2016.
Supervisor: Silva, C.S., Co-supervisor: Ferrão, P.

Sousa, V., Reabilitação Energética da Piscina Coberta da Academia Militar de Lisboa, Master Thesis (Civil Engineering), Instituto Superior Técnico, UL, 2016.
Supervisor: Gomes, M. (IST, UL), Co-supervisor: Silva, C.S.

Vieira, J., Assessing the resource productivity in the European Economic Sectors, Master Thesis (Mechanical Engineering), Instituto Superior Técnico, UL, 2016.
Supervisor: Pina, A., Co-supervisor: Ferrão, P.

VII EXTERNAL FUNDING

As it is current practices in many other research centres, the main organizational element at IN+ is based on "Research Projects", in particular those resulting from external and competitive funding sources. The funding sources are diverse, as it is a mix of national public funding, European funding and private funding from companies. The following paragraphs list the main projects under developed by IN+ researchers and identifies main funding sources.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2016
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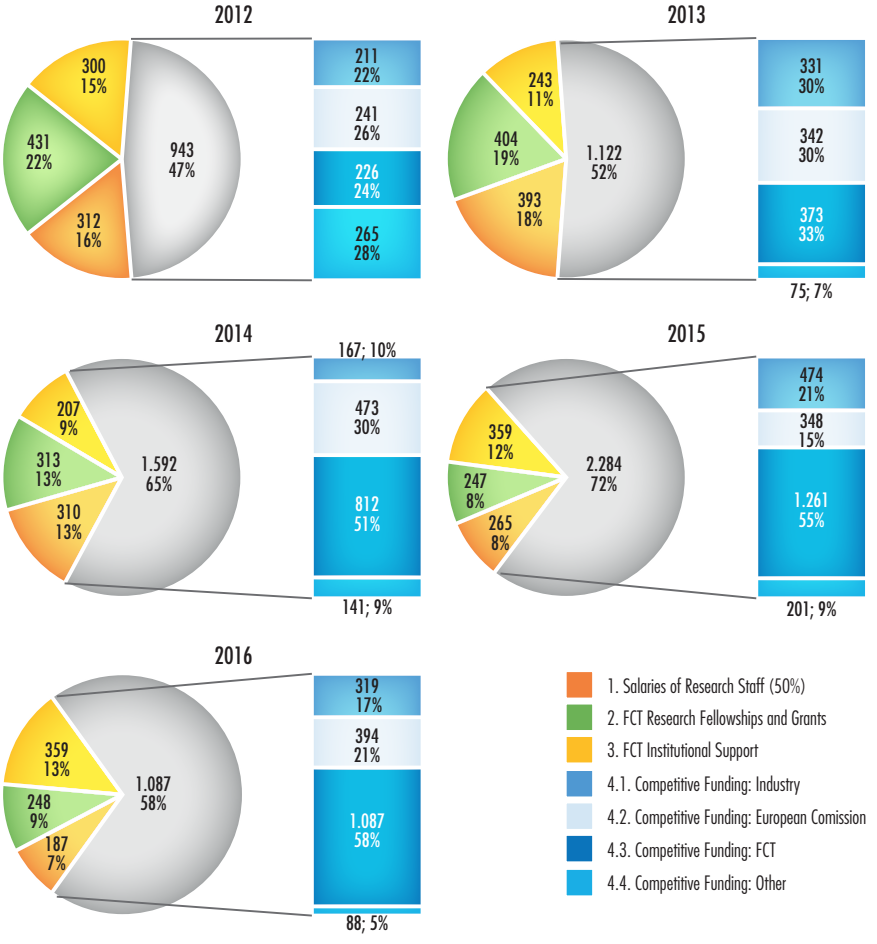
2012
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211 22%
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226 24%
265 28%
2013
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1.122 52%
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342 30%
373 33%
75; 7%
2014
207 9%
313 13%
1.592 65%
310 13%
167; 10%
473 30%
812 51%
141; 9%
2015
359 12%
247 8%
2.284 72%
265 8%
474 21%
348 15%
1.261 55%
201; 9%
2016
359 13%
248 9%
1.087 58%
187 7%
319 17%
394 21%
1.087 58%
88; 5%
1. Salaries of Research Staff (50%)
2. FCT Research Fellowships and Grants
3. FCT Institutional Support
4.1. Competitive Funding: Industry
4.2. Competitive Funding: European Comission
4.3. Competitive Funding: FCT
4.4. Competitive Funding: Other

Overview of main sources and funding levels

Funding Source: 1. Industry

PROJECT	PRINCIPAL INVESTIGATOR	DURATION
APA – Plano Nacional de Gestão de Resíduos (2973), Definição de uma estratégia global para a gestão de resíduos em Portugal. (Funding: National, Public)	Ferrão, P.	07/11/2008 to 07/06/2015, 79 months
A sua casa a sua energia (4425), Contribuição para o aumento da eficiência energética do sector residencial através da disponibilização de informações para a promoção de comportamentos de consumo mais eficientes aos participantes da iniciativa. (Funding: National, Public)	Silva, C.S.	01/01/2014 to 01/01/2017, 24 months
ADB-FEUZ (AD0024), Elaboração de roteiros de desenvolvimento para os serviços urbanos (Resíduos, Água e Saneamento, Aquecimento e Mobilidade) do Cazaquistão e Uzbequistão. (Funding: International, Public)	Ferrão, P.	06/02/2012 to 28/06/2015, 40 months
AFBOSCH (4711), Acção de formação em técnicas de diagnóstico não intrusiva. (Funding: National, Private)	Fernandes, E.C.	01/04/2015 to 01/08/2015, 4 months
Atlântico + (AD0150), Mobilização da Capacidade Tecnológica e de Valorização Industrial para a Exploração Sustentável do Atlântico. (Funding: National, Private)	Heitor, M.	18/09/2014 to 18/03/2015, 6 months
Crescer com eficiência (4424), Promover a melhoria do desempenho energético de 40 lares de crianças e jovens de Portugal através da realização de avaliações energéticas às instalações onde funcionam as instituições. (Funding: National, Public)	Silva, C.S.	01/01/2014 to 01/01/2017, 24 months
EDP - ACV (3196), Coordenação científica do desenvolvimento do projecto ACV (Análise do Ciclo de Vida). (Funding: National, Private)	Ferrão, P.	15/05/2009 to 15/12/2016, 91 months
EDPP – OTGEN (4742), Consultoria técnica no âmbito da evolução e impactos do sector solar fotovoltaico e solar de concentração no futuro dos sistemas elétricos. (Funding: National, Private)	Ferrão, P.	01/06/2015 to 01/03/2016, 9 months
EVORA -MOBILIDADE (1967), Desenvolvimento de uma estratégia de mobilidade sustentável no EVORA resort. (Funding: National, Private)	Ferrão, P.	01/02/2006 to 01/06/2015, 112 months
GALP 20-20-20 (3809), Estágios não curriculares para primeiras experiências profissionais de 10 finalistas no programa GALP 20-20-20 cujo objectivo é promover a eficiência energética em empresas clientes da GALP energia. (Funding: National, Private)	Moreira, A.L.N.	25/03/2011 to 31/08/2017, 77 months
IGNITION (3251), Mathematical and experimental modeling of flame ignition process, under lean combustion condition. (Funding: National, Private)	Fernandes, E.C.	28/10/2009 to 28/10/2019, 120 months
Laboratório Colaborativo de Mobilidade (AD0154), Concepção do modelo de cooperação transfronteiriça em I&D. (Funding: National, Private)	Heitor, M.	20/01/2015 to 20/07/2015, 6 months
LOWNOX (3253), Mathematical and experimental modelling of partial premixed burners for lean combustion condition. (Funding: National, Private)	Fernandes, E.C.	28/10/2009 to 28/10/2019, 120 months
PMEA Programa para a Mobilidade Eléctrica nos Açores (AD0042), Prestação de serviços no âmbito do programa para a mobilidade eléctrica dos Açores. (Funding: National, Private)	Ferrão, P.	03/04/2012 to 01/04/2016, 48 months
RAES (3473), Desenvolvimento de ferramentas de modelação e análise de sistemas energéticos em locais remotos e isolados. (Funding: National, Private)	Ferrão, P.	01/04/2010 to 01/03/2017, 59 months
ROLLS ROYCE (4707), Prestação de serviço à ROLLS ROYCE. (Funding: International, Private)	Ferrão, P.	11/11/2014 to 11/09/2015, 10 months
SDMP-AEP (3478), Desenvolvimento de um conjunto de orientações que incorporam as melhores práticas tendo em vista a sustentabilidade do empreendimento Algarve Energy Park. (Funding: National, Private)	Ferrão, P.	15/03/2010 to 15/07/2015, 64 months
SmartGalp (3822), Realização de estudo técnico na árera de Smart Metering, com o objetivo de demonstrar e quantificar o potencial que a monitorização de consumos em tempo real. (Funding: National, Private)	Silva, C.S.	01/10/2010 to 31/12/2015, 56 months
TEKA-AIR (AD0141), Apoio técnico e científico ao desenvolvimento de um laboratório para testes de sistemas de exaustão de ar. (Funding: National, Private)	Fernandes, E.C.	21/04/2014 to 21/02/2015, 10 months

Funding Source: 2. European Commissison

PROJECT	PRINCIPAL INVESTIGATOR	DURATION
BIOAPPRONFS WETT (4168), Biomimetic Approaches of Natural Functional Surfaces with hierrarchial micro & nano structure and the extreme Wettability. (Funding: International, Public)	Moreira, A.L.N.	01/04/2012 to 01/04/2016, 48 months
KIC EBA (4918), Application of Energy in Buildings Academy. (Funding: International, Public)	Silva, C.S.	01/02/2016 to 01/07/2016, 5 months
Sharing Cities (4843), The Sharing Cities 'lighthouse' programme is a proving ground for a better and common approach to making smart cities a reality. (Funding: International, Public)	Silva, C.S.	01/01/2016 to 01/01/2021, 60 months
SHREDDERSORT (4388), Selective recovery of non-ferrous metal automotive shredder by combined eletromagnetic tensor strectoscopy and laser indiced pasma strectoscopy. (Funding: International, Public)	Margarido, F.	01/12/2013 to 01/01/2017, 37 months
Smart Campus (4210), Building-User Learning Interaction for Energy Efficiency. (Funding: International, Private)	Ferrão, P.	01/08/2012 to 01/05/2015, 33 months
SOUTH ZEB (RD0366), Concepção e desenvolvimento de módulos de formação Edifício de Balanço Energético quase Zero (nZEB) para profissionais da construção nos países do Sul da Europa. (Funding: International, Public)	Niza, S.	01/03/2014 to 01/03/2017, 30 months
SUSCITY (RD0462), Modelação de sistemas urbanos para a promoção de transições criativas e sustentáveis. (Funding: International, Public)	Silva, C.S.	01/01/2015 to 01/01/2018, 36 months

Funding Source: 3. FCT: Portuguese Science and Technology Foundation (Research Projects)

PROJECT	PRINCIPAL INVESTIGATOR	DURATION
DINAMICS (RD0294), Dynamics of INterfacial transport phenomenA in Micro scale energy Conversion Systems. (Funding: National, Public)	Moreira, A.L.N.	01/06/2013 to 01/06/2017, 36 months
E4value (RD0430), Dinâmicas de inovação em aeronáutica e na Embraer em Évora: uma plataforma distributiva para iniciativas empresariais, emprego e desenvolvimento de capacidades. (Funding: National, Public)	Amaral, A.M.	01/06/2014 to 01/06/2018, 48 months
EntHuCap (RD0156), The mpacto f Entrepreneurial Human Capital on Careers, Earnings and Hiring Decisions. (Funding: National, Public)	Preto, M.	01/03/2012 to 01/09/2015, 42 months
IN+ 2015-2017 (RD0474), PROJECTO DO IN+ DO LA0009. (Funding: National, Public)	Moreira, A.L.N.	01/01/2015 to 01/01/2018, 36 months
Integersum (RD0162), Modelo integrado e geo-referenciado para a promoção da sustentabilidade do metabolismo urbano. (Funding: National, Public)	Ferrão, P.	01/02/2012 to 01/02/2015, 36 months
MEMO (RD0289), Evolução do metabolismo da área metropolitana de Lisboa. Lições para um futuro urbano sustentável. (Funding: National, Public)	Niza, S.	02/05/2013 to 02/08/2015, 27 months
MIT GESTÃO COORDENAÇÃO 2015 (4625), Acordo de colaboração para a gestão e coordenação do programa MIT Portugal. (Funding: National, Public)	Ferrão, P.	01/01/2015 to 01/01/2016, 12 months
MIT GESTÃO COORDENAÇÃO 2016 (4833), Acordo de colaboração para a gestão e coordenação do programa MIT Portugal. (Funding: National, Public)	Silva, C.S.	01/01/2016 to 01/01/2017, 12 months
MIT GESTAO COORDENAÇAO 2016 (RD0543), Acordo de colaboração para a gestão e coordenação do programa MIT Portugal. (Funding: National, Public)	Silva, C.S.	01/04/2016 to 01/01/2017, 9 months
MIT INSTITUIÇÕES 2015 (4628), Projeto aberto com a finalidade de centralizar e canalizar a receita de vários parceiros do programa MIT Portugal em 2015. (Funding: National, Public)	Ferrão, P.	01/01/2015 to 01/01/2016, 12 months
MIT INSTITUIÇÕES 2016 (4897), Projeto aberto com a finalidade de centralizar e canalizar a receita de vários parceiros do programa MIT Portugal em 2016. (Funding: National, Public)	Silva, C.S.	01/01/2016 to 01/01/2017, 12 months
MIT SES 2015 (4632), SUSTAINABLE ENERGY SISTEMS PhD. (Funding: National, Public)	Ferrão, P.	01/01/2015 to 01/01/2016, 12 months
MIT SES 2016 (4899), SUSTAINABLE ENERGY SISTEMS PhD. (Funding: National, Public)	Silva, C.S.	01/01/2016 to 01/01/2017, 12 months
MIT-Pt/ EDAM 2015 (4631), EDAM 2015. (Funding: National, Public)	Heitor, M.	01/01/2015 to 01/01/2016, 12 months
PLATAFORMAS BIOMEDICINA (4423), Plataformas tecnológicas e modelos de negócio emergentes. Novos modelos de criação e apropriação de valor na indústria biomédica. (Funding: National, Public)	Pádua, M.	01/02/2014 to 01/08/2015, 18 months
Trajectórias (RD0278), Trajectórias profissionais de doutorados: um aprofundar de conhecimento sobre tipos de mobilidade. (Funding: National, Public)	Horta, H.	01/06/2013 to 01/06/2015, 24 months

Funding Source: 4. Others

PROJECT	PRINCIPAL INVESTIGATOR	DURATION
Balanço de Materiais do Concelho de Lisboa (1750), Elaboração de um estudo de análise de fluxos de materiais para a cidade de Lisboa, o qual deve resultar na construção de uma matriz de balanço de materiais do Concelho de Lisboa. (Funding: National, Public)	Ferrão, P.	01/09/2005 to 01/09/2015, 120 months
CIE (AD0160), Apoio à implementação da estratégia do domínio da competitividade e internacionalização na área de empreendedorismo e inovação no âmbito do conselho estratégico de COMPETE 2020. (Funding: National, Public)	Amaral, A.M.	12/05/2015 to 31/12/2015, 8 months
E-UNIVERSITY (RD0608), Entrepreneurial University: the case of Portuguese higher education and his impact on regional competitiveness. (Funding: National, Public)	Preto, M.	17/06/2016 to 17/06/2018, 24 months
FOGOS FLORESTAIS (1729), Factores de risco associados a danos económicos e ambientais. (Funding: National, Public)	Ferrão, P.	01/09/2005 to 01/09/2015, 120 months
Industrialização Nordeste Transmontano (4733), Plano de industrialização do Nordeste Transmontano. (Funding: National, Public)	Heitor, M.	10/08/2015 to 10/02/2016, 6 months
L3 - Lisboa Laboratório Comum (4730), Designing a new education paradigm where engineering, design and social sciences come together to solve societal challenges. (Funding: National, Private)	Heitor, M.	01/07/2015 to 01/01/2017, 15 months
LISBOA: cidade de empreendedores (1110), Estudo de análise sobre as implicações do istema das dinâmicas regionais de mudanca tecnológica e económica sobre a inovação em Lisboa. (Funding: National, Public)	Heitor, M.	01/06/2004 to 01/07/2016, 133 months
MNC (AD0198), O fecho de subsidiárias de empresas estrangeiras multinacionais (MNC). (Funding: International, Private)	Preto, M.	27/04/2016 to 01/02/2018, 23 months
Odemira Sustentável (4664), Concepção e análise de cenários para o desenvolvimento de um istema de energia sustentável para CMO. (Funding: National, Public)	Ferrão, P.	24/02/2015 to 24/08/2015, 6 months
SEEK (4484), Análise do impacto da crise econoómica no perfil dos empreendedores em Portugal - comparação com a Alemanha. (Funding: International, Public)	Mendonça, J.	01/04/2014 to 01/10/2015, 18 months
Vulcano Project (4802), Designing sustainable strategy for future energy scenarios for the Island of Terceira (Azores). (Funding: National, Private)	Silva, C.S.	01/07/2015 to 01/04/2016, 9 month

Table: Brief IN+ financial Report for 2012, 2013, 2014, 2015 and 2016

(excludes equipment depreciation and instalations)

Executed Values	2012			2013			2014			2015			2016		
	10^3 (€)	%	Observations	10^3 (€)	%	Observations	10^3 (€)	%	Observations	10^3 (€)	%	Observations	10^3 (€)	%	Observations
1. Salaries of Research Staff (50%) IST Faculty	312	16%	Full Professors (Manuel Heitor; Paulo Ferrão) Associate Professors (Fernanda Margarido) Assistant Professors (António Moreira; Miguel Amaral; Carlos Silva; Carlos Freitas; Edgar Fernandes; Gabriel Pita; José Mendes Lopes; Tânia Sousa; Tiago Domingos)	393	18%	Full Professors (Manuel Heitor; Paulo Ferrão) Associate Professors (Fernanda Margarido) Assistant Professors (António Moreira; Miguel Amaral; Carlos Freitas; Carlos Silva; Edgar Fernandes; Gabriel Pita; José Mendes Lopes; Tânia Sousa; Tiago Domingos)	310	13%	Full Professors (Manuel Heitor; Paulo Ferrão) Associate Professors (A Luís Moreira; Fernanda Margarido) Assistant Professors (Carlos Santos Silva; Miguel Amaral; Edgar Fernandes; Gabriel Pita; Tânia Sousa; Tiago Domingos)	265	8%	Full Professors (Manuel Heitor; Paulo Ferrão) Associate Professors (A Luís Moreira; Fernanda Margarido) Assistant Professors (Carlos Santos Silva; Miguel Amaral; Edgar Fernandes; Nuno Arantes Oliveira)	187	7%	Full Professors (Paulo Ferrão) Associate Professors (A Luís Moreira; Fernanda Margarido) Assistant Professors (Carlos Santos Silva; Miguel Amaral; Edgar Fernandes; Nuno Arantes Oliveira)
2. Research Fellowships and Grants supported by FCT PhD and Pos Doc Fellowships and Doctoral Contratcts	431	22%	PhD Fellowships (Anabela Reis; Miguel Amador; Nuno Clímaco; António Lorena; Gonçalo Pereira; Gonçalo Cardoso; Vasco Portugal; Michal Monit; Pedro Fazenda; Hana Gerbelová; Vasco Granadeiro) Pos Doc Fellowships (Ana Moita; Miguel Panão; Vânia Proença) Doctoral Contracts (Ana Dias; Helena Reis; João Rodrigues; Muriela Pádua; Samuel Nisa)	404	19%	PhD Fellowships (Anabela Reis; Miguel Amador; Nuno Clímaco; António Lorena; Gonçalo Pereira; Gonçalo Cardoso; Vasco Portugal; Michal Monit; Hana Gerbelová; Joana Rafael; Luciana Barbosa) Pos Doc Fellowships (Ana Moita; Miguel Panão; Vânia Proença) Doctoral Contracts (Ana Dias; Helena Reis; Joana Mendonça; João Rodrigues; Muriela Pádua; Samuel Nisa)	313	13%	PhD Fellowships (Anabela Reis; Miguel Amador; António Lorena; Gonçalo Pereira; Vasco Portugal; Michal Monit; Joana Rafael; Luciana Barbosa) Pos Doc Fellowships (Ana Moita; André Pina) Doctoral Contracts (Joana Mendonça; João Rodrigues; Muriela Pádua)	247	8%	PhD Fellowships (Anabela Reis; Ana Patrícia Oliveira; Diana Neves; Emanuele Teodori; Felix Diawuo; Henrique Pombeiro; Jaime Roca; João Pires; Joana Pedro; Khadija Bennis; Laura Olasciaga; Luciana Barbosa; Miguel Amador; Tiago Palma; Paulo Maia; Ricardo Gomes) Pos Doc Fellowships (Ana Moita; André Pina) Doctoral Contracts (Joana Mendonça)	248	9%	PhD Fellowships (Anabela Reis; Ana Patrícia Oliveira; Emanuele Teodori; Felix Diawuo; Henrique Pombeiro; Jaime Roca; João Pires; Joana Pedro; Khadija Bennis; Laura Olasciaga; Luciana Barbosa; Miguel Amador; Tiago Palma; Paulo Maia; Ricardo Gomes) Pos Doc Fellowships (Ana Moita; André Pina) Doctoral Contracts (Ana Moita)
3. Institutional Support to IN+ by Foundation for Science and Technology, FCT	300	15%	Covers Doctoral Contracts (Hugo Horta; Carlos Silva), Research Fellowships (João Campos, Carlso Tribuna, Jose Rodrigues, Gonçalo Marques, António henriques, Gonçalo Cardoso, Daniela Couto), administrative and technical support and overall basic expenditures, including travel.	243	11%	Covers Doctoral Contracts (Hugo Horta), Research Fellowships (Jose Rodrigues, Sandra Hasanefendic e Farzaneh Eftekhari), administrative and technical support and overall basic expenditures, including travel.	207	9%	Covers Doctoral Contracts (Samuel Niza) and Research Fellowships (José Rodrigues), administrative and technical support and overall basic expenditures, including travel.	359	11%	Covers Research Fellowships (João Santos, Luísa Canelas, Paulo Maia), administrative and technical support and overall basic expenditures, including travel.	359	13%	Covers Doctoral Contracts (Patrícia Baptista), Research Fellowships (Basar Seçkin, Dalila Vieira, Diana Neves, Filipe Rodrigues, Karine Gharibyan, Rui Neto, Sandra Dias), administrative and technical support and overall basic expenditures, including travel.
4. Competitive Funding by Source	943	47%		1.122	52%		1.592	66%		2.284	72%		1.887	70%	
4.1. Industry	211	11%	(EDA; RAES; Smart Galp; Inteli; Green Campus; GALP Centro de ID; REN; OCDE- Carbon Prices; EDP; EcoAgro; Ecoprogresso)	331	15%	(EDA; RAES; Smart Galp; Inteli; Green Campus; M2CE; MSCE; GALP Centro de ID; REN; Hidromod; OCDE-Carbon Prices; EDP; EDP-CDP 2013; EcoAgro; Ecoprogresso; EDP-EVI Tua)	167	7%	(ADB – II, TEKA-AIR, APA - GESTAO RESIDUOS, APA CIRVER, APA-PNGR, EDPP, EVORA-MOBILIDADE, RAES, SDMP-AEP, SmartGalp, TEKA-S)	474	15%	(ADB-FEUZ, AFBOSCH, ATLANTICO +, CCE - CRESCER COM EFICIÊNCIA, EDP – ACV, EDPP – OTGEN, EVORA-MOBILIDADE, GALP 20-20-20, IGNITION, INTELI, LabCoMobilidade, LOWNOX, PPEC ENERGIA, RAES, ROLLS ROYCE, SDMP-AEP, SMARTGALP – INVESTIGAÇÃO, TEKA-AIR)	319	12%	(CCE - CRESCER COM EFICIÊNCIA, EDP – ACV, EDPP – OTGEN, GALP 20-20-20, IGNITION, INTELI, LOWNOX, PPEC ENERGIA, RAES)
4.2.European Comission (R&D programmes)	241	12%	(INSCAN; Energy Wars; Life Engining; PIRSES-GA; Agreem. 12/0034-L/4850; CitySDK; Smart Campus; KIC Innoenergy; Kic Explore)	342	16%	(INSCAN; Energy Wars; PIRSES-GA; Agreem. 12/0034-L/4850; CitySDK; Smart Campus; ShredderSort; INALENTEJO - Rede secundária EFMA; KIC Innoenergy; Kic Explore)	473	20%	(CitySDK, INSCAN, SHREDDERSORT, Smart Campus, SOUTH ZEB)	348	11%	(BIOAPPRONFS WETT, SHREDDERSORT, SMART CAMPUS, SOUTH ZEB, SUSCITY)	394	15%	(BIOAPPRONFS WETT, KIC EBA, SHAR-LLM, SHREDDERSORT, SOUTH ZEB, SUSCITY)
4.3.Foundation for Science and Technology (FCT)	226	11%	Intergersum; Netzero; Resit; MM6; Mesur; IRGC Portugal; EnTuCap; Minorias; Exit; CINHEKS; MUST; EEN-ISA; SURWET-COOLS)	373	17%	Intergersum; Netzero; Resit; MM6; Mesur; Memo; IRGC Portugal; EnTuCap; Minorias; Exit; CINHEKS; MUST, Trajectórias, RECI/EMS-SIS/0147; EEN-ISA)	812	34%	(DINAMICS, E2web, EntHuCap, EXIT, Integersum, IRGC Portugal, MEMO, Mesur, MIT – Gestão da Coordenação, MIT – Sistemas Sistentáveis de Energia 2013, MIT-Pt/ EDAM 2014, PLATAFORMAS BIOMEDICINA, SURWET-COOLS, Trajectórias)	1.261	40%	(DINAMICS, E4value, EntHuCap, IN+ 2015-2017, InteGerSUM, MEMO, MIT GESTÃO COORDENAÇÃO 2015, MIT INSTITUIÇÕES 2015, MIT SES 2015, MIT-Pt/ EDAM 2015, PLATAFORMAS BIOMEDICINA, TRAJECTÓRIAS)	1.087	41%	(DINAMICS, E4value, IN+ 2015-2017, MIT GESTAO COORDENAÇAO 2016, MIT GESTÃO COORDENAÇÃO 2016, MIT INSTITUIÇÕES 2016, MIT SES 2016)
4.4. Others Sources	265	13%	(MA - Aval. PRODER 2007-2013; 24 th Eur. Conf. on Liquid Tomization and Spray Systems; 16 th LASER)	75	3%	(E2; CML; MA Aval. PRODER 2007-2013; Programa A+)	141	6%	(Atlântico +, Ensino Experimental, FLUX, Programa A+)	201	6%	(BM LISBOA, CIE, CMO SUSTENTÁVEL, Fogos Florestais, INSCAN, L3, Lisboa: Cidade de Empreendedores, Nordeste Transmontano, SEEK, VULCANO)	88	3%	(E-UNIVERSITY, L3, Lisboa: Cidade de Empreendedores, MNC, Nordeste Transmontano, VULCANO)
5. Total	**1.987**	**100%**		**2.161**	**100%**		**2.423**	**100%**		**3.155**	**100%**		**2.682**	**100%**	

VIII The Team

IN+ is coordinated by a board of directors headed by a Director and gathering one representative of each Laboratory and one representative of the students. Strategic orientation is given by a scientific council formed by all doctorate members and headed by a President. Research is conducted by a body of faculty, post doc researchers and students, supported by a team of administrative and technical staff.

Recognition is given to talented young researchers working toward their PhDs and Master thesis. PhDs come from various countries and spend between three and five years at IN+. They are associated, either with the several international PhD programs in which Instituto Superior Técnico participates (MIT, CMU, Austin University) or the national PhD programs running at IST in several areas, such as Mechanical Engineering, Sustainable Energy Systems, Environment Engineering, Biomedical Engineering, Engineering and Management. Master students generally spend between six and twelve months at IN+, some are students at the Instituto Superior Técnico, others come on student exchange programs set up with European projects in which IN+ participates.

Invited Researcher Scientists strength inter-institutional relationships with international research centres in related scientific areas.

Total human resources include:

8 professors

7 invited research scientists

33 postdocs

80 trainees (average/year) – PhD and Master students

9 administrative and technical staff

Coordination

President of the Scientific Council: António Luis Moreira, Associate Professor with Habilitation, IST
Director: António Luis Moreira, Full Professor, Associate Professor with Habilitation, IST
Deputy Director: Miguel Amaral, Assistant Professor, IST
Board of Directors:

António Luis Moreira, President

Miguel Amaral, Deputy President

Edgar Fernandes, Director of the Lab. of Thermofluids, Combustion and Energy Systems

Carlos Silva, Director of the Lab. of Industrial Ecology and Sustainability

Miguel Amaral, Director of the Lab. of Technology Policy and Management

André Pina, Doctorate Researcher

Anabela Reis, Research Student

Coordination of Research Programmes:

Research Program - Urban Metabolism and Sustainable Cities (UMSC)

Research Director: Samuel Niza, Doctorate Researcher

8.2 Doctorate Researchers

Ana Moita
André Pina
António Vasconcelos
Basar Seçkin
Bernardo Pimentel
Carlos Santos Silva
Catarina Rolim
Cátia Sousa
Diana Neves
Edgar Fernandes
Fernanda Margarido
Filipa Amorim
Gonçalo Duarte
Hana Gerbelová
Helena Reis
Hugo Horta
Joana Mendonça
João Ventura
Luís Moreira
Manuel Heitor
Maria João Corte-Real
Maria João Rodrigues
Miguel Amaral
Miguel Preto
Muriela Pádua
Nuno Arantes Oliveira
Nuno Ferreira
Patrícia Baptista
Paulo Ferrão
Rui Costa Neto
Samuel Niza
Sílvia Castro
Teodoro Trindade

8.3 Researchers

Alejandro González
Alexandra Almeida
Alexandre Amado
Ana Duarte
Ana Filipa Madeira
Ana Patrícia Oliveira
Anabela Reis
André Almeida
António Lorena
António Ornelas
Artur Ginsheimer
Beatriz Guimarães
Bernardo Fonseca
Bernardo Salvador
Bruno Abrantes
Bruno Cintra
Carlos Gomes
Carlos Raposo
Catarina Laurência
Catarina Matos
Cátia Reis
Cláudia Carvalho
Cláudia Monteiro
Cristiano Rodrigues
Dalila Vieira
Daniela Santos
Dao Hang
David Silva
Davide Almeida
Diogo Cabral
Diogo Carmo
Diogo Cotrim
Diogo Fernandes
Diogo Santiago
Edson João
Emanuele Teodori
Fábio Sampaio
Felix Diawuo
Filipa Mata
Filipe Ferreira
Filipe Paulino
Filipe Rodrigues
Francesco Guzzi
Francisco Barreiros
Francisco Benavente
Francisco Matos
Francisco Monteiro
Francisco Mota
Francisco Cunha
Gisela Mendes
Gonçalo Brás
Gonçalo Mendes
Gonçalo Pereira
Gonçalo Rego
Guido Lorenzi
Guilherme Farinha
Hélder Rodrigues
Henrique Pombeiro
Hugo Ribeiro
Hugo Silva
Inês Castelão
Ivan Andrić
Jaime Roca
Joana Pedro
Joana Pereira
Joana Rafael
Joana Vieira
João Condesso
João Cunha
João Garcia
João Marcelino
João Pires
João Santos
José Cruz
José Rodrigues
José Silva
Karine Gharibyan
Khadija Benis
Laura Olascuaga
Leonardo Santos
Luciana Barbosa
Luís Silva
Luísa Canelas
Madalena Lopes
Maria João Carrilho
Mariana Marques
Mário Gamas
Mário Martins
Mexitli Reyes
Michal Monit
Miguel Amador
Miguel Batista
Miguel Ferreira

Miguel Gordinho
Miguel Lopes
Miguel Macedo
Miguel Machado
Miguel Moura
Miguel Santiago
Moritz Franke
Natalia Kabalina
Nathália Vieceli
Nelson Alves
Nuno Costa
Nuno Pereira
Olga Savchuk
Paula Rodrigues
Paulo Maia Loureiro
Paulo Quental
Pawel Torbus
Pedro Costa
Pedro Domingues
Pedro Luz
Pedro Pontes
Pedro Rolim
Ricardo Gomes
Ricardo Manso
Ricardo Moreira
Ricardo Vicente
Rita Marteleira
Rita Paleta
Ruben Guerra
Rui Palhais
Rui Ximenes
Sara Fonseca
Sara Silva
Sónia Cunha
Tamrat Gelu
Tânia Agostinho
Teresa Fernandes
Tiago Palma
Tiago Santos
Tomás Lúcio
Tomás Valente
Trang Nguyen
Ulrike Eilhauer
Vânia Silvério
Vasco Abreu
Vitor Sousa

8.4 Senior Research fellows

Armando Pires
Carla Costa
Eduardo Beira
Georg Rosenfeld
Giorgio Sirilli
Marco Marengo
Tiago Brandão

8.5 Support

Alexandra Frazão
Ana Quaresma
Daniela António
Duarte Ferreira
João Fumega
Margarida Suárez
Mariana Carmo
Renata Ramalho
Sandra Dias


IN+
CENTER for INNOVATION,
TECHNOLOGY and POLICY RESEARCH


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