The research work under this theme has been aimed to develop and use advanced research methodologies for the analysis of complex systems and to promote the exchange of knowledge in advanced technologies for the optimisation of industrial processes and environmental systems. It involves 5 main topics, as follows.

1. Industrial Ecology Toolbox
   The research work developed is aimed at demonstrating the need to prepare the evolution to a new “Industrial Ecology stage”. The requirements to step up to this new stage are classified at three levels, the need for an appropriate “environmental analysis methodologies toolbox”, the establishment of a structured set of indicators to support sustainable policies and priority setting at a regional level, and finally, the development of a new organization of infra-structures, technologies, sectors and firms to promote cooperation between the various actors involved within an Industrial Ecology framework. The following papers were developed in this context:

Life Cycle Assessment – LCA:

Design for Environment – DFE:

Hybrid Economic Input-Output Life Cycle Assessment – H-EIO-LCA:

Material Flow Analysis – MFA:

System Dynamics – SD:

2. Industrial Ecology Systems
   The physical nature of the economy is emerging as a new paradigm, based on increasing public recognition of environment-economy interconnections. In this context, modern economies can be seen as ingesting raw materials, which are metabolised into products and services and also waste, in the form of materials/products without use and pollution. Environment-economy interconnections are dependent on economic activity fields or sectors, on the existing local infrastructures and future technological options, i.e. on the
time and length scales imposed by the local-regional interactions at different levels (economic, regulatory, technological). The research developed concludes that innovation in environmental technologies may shift the spirit of product-oriented regulations and give rise to more efficient approaches if a transversal, Industrial Ecology perspective, integrating different products life cycles is adopted.

The following papers were developed in this context:

**Automotive**

**Economy metabolism**

**Electric and electronic equipments**

**Packaging**
- Silva, P. (2002). Inovação ambiental na gestão de embalagens de bebidas em Portugal, Dissertação para a obtenção do Grau de Mestre em Engenharia e Gestão de Tecnologia, Departamento de Engenharia Mecânica, Instituto Superior Técnico. [In Portuguese]

3. Environmental Physics
The scientific activity in environmental physics has been developed within the framework of the project SAPIENS: POCTI/1999/CTA/35626 - Carbon Balance of Eucalypt Plantations in Portugal- the Kyoto Forest Problem. In the context of the Kyoto protocol, the activity developed is aimed at evaluating the magnitude, seasonality and reparation of the carbon fluxes and stocks in a Eucalyptus forest. Ultimately, the aim is to evaluate the potential of the eucalyptus forest to act as a carbon sink.

The research performed is mainly experimental and, as a consequence, a significant effort has been dedicated to set up an experimental rig at the Herdade da Espirra, Pegões, and now, a set of data taken from different sensors, during 2002, is available.

The following papers were developed in this context:
- Full carbon balance in an eucalypt plantation in Portugal. [P7.23] The Carbon Balance of Forest Biomes, University of Southampton during the annual meeting of the SEB from the 1st to 4th of April 2003. J.S. Pereira (Instituto Superior de Agronomia, Lisbon); G. Pita, J. Silva (Instituto Superior de Técnico, Lisbon); A. Fabião, M. Carneiro, C. Nogueira (Instituto
4. Low-Power burning Systems

The ultimate goal towards the design and promoting the use of eco-combustion systems is to burn under lean condition, regarding the pollutant emission regulation while maximizing the global system efficiency. This concept is valid for a complete range of burning systems going from the domestic appliances to gas turbine combustors. However, under lean operating conditions there are self-sustained flame instabilities limiting the range of operations, induced either by the weakness of the lean flame stabilization process or shear layer instabilities, which are the main limitation for practical implementation of the concept. On the other hand, the burning system can benefit from those instabilities if they are controlled, because extended stability limits can be achieved, through hysteresis effects, as well as turbulent mixture can be enhanced, through large vortex motion. The work developed in this topic then focus on unsteady flows and active control schemes studies, with the following main publications:

Unsteady Flows

- LPP-Combustor Technology

Liquid Film Instabilities

- V. Sivadas*, E.C. Fernandes and M.V. Heitor (2002) Acoustically excited air-assisted liquid sheets. Accepted for publication in Experiments in Fluids

Domestic Burning Systems

- Sérgio Almeida (2002), Estudo de um fogão industrial, Graduation Project, IST-DEM-SS
- Vanda Geraldes (2002), O efeito de introdução de ossicações na linha de combustível no desempenho energético de um fogão doméstico, Graduation Project, IST-DEM-SS

Active Control


5. Technical Change and Systems of Innovation

The work has drawn on recent conceptual approaches to economic growth, in which the accumulation of knowledge is the fundamental driving force behind growth. This fact is
reflected in the trend in developed economies towards an increasing investment in advanced technology, research and development, education, and culture. Concepts such as learning ability, creativity and sustained flexibility gain greater importance as guiding principles for the conduct of individuals, institutions, nations and regions. It is thus legitimate to question the traditional way of viewing the role that contemporary institutions play in the process of economic development and to argue for the need to promote systems of innovation and competence building based on learning and knowledge networks. Under the broad designation of “learning and knowledge networks”, the research results discuss the necessary balance between the creation and diffusion of knowledge and contribute to improve our understanding of the dynamics of the process of knowledge accumulation, which drives a learning society.

Main publications:

**Books:**

**Papers in Books and refereed journals:**