Centre for Energy and Built Environment Research – CEBER

The efficient utilisation of energy resources and the reduction of the environmental impacts of energy consuming equipment are of vital importance to economic development and prosperity for both the developed and developing countries. The work of the Energy and the Built Environment Research Group includes research by professors S. A. Tassou, T. G. Karayiannis, M. Kolokotroni, D. B. R. Kenning, M.W. Collins, and Drs Y. Ge, Z. Dehouche, H. Jouhara, J. Lewis and P. Warren. The activities of the Group make a contribution in a number of fundamental and applied areas in the energy field which include:

- The design of more efficient systems to provide heating and cooling and achieve the required thermal environment for buildings and processes.
- The reduction of emissions of greenhouse gases and other pollutants to the atmosphere.
- Heat transfer and Thermal Systems.
- Refrigeration and Cooling Systems.
- The improvement of energy conversion efficiency from renewable sources.

Facilities

The Group has at its disposal substantial facilities, which include:

- An 80 m^3 environmental chamber.
- Refrigeration and heat pump test rigs.
- A tri-generation test facility.
- Heat transfer test rigs for boiling and condensation research including phase-change materials.
- Thermal imaging equipment.
- An advanced flow visualization facility.

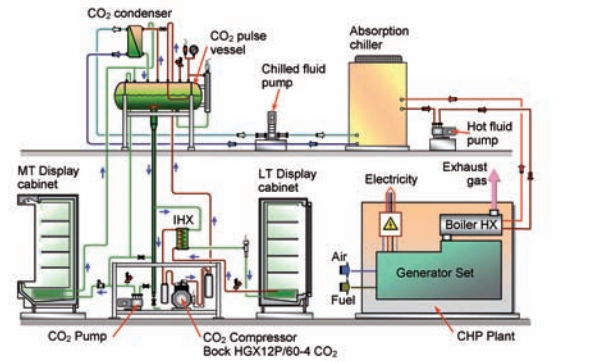
The experimental work is backed by theoretical work using in-house developed simulation programs and a suite of commercial packages including: the IESVE building services software which includes thermal simulation, acoustics, lighting, and other services design programmes; Computational Fluid Dynamics (CFD), TRNSYS and other fluid flow and heat transfer codes for flow and heat transfer modelling.

Heating, Cooling and Refrigeration

The design of more efficient systems to provide the required thermal environment for buildings and processes involves analytical system simulation for design and control optimisation studies and the application of advanced control techniques to minimise energy consumption. Research in refrigeration that is led by Prof. S. A. Tassou and includes the work of Drs Y. Ge and H. Jouhara is the most prominent in the UK and encompasses the following areas:

- The design of efficient display cabinets through the simulation of flows and heat and mass transfer between the controlled environment and surrounding spaces.
- Modelling the performance of cold stores and studies into the design and application of air curtains for refrigeration and heating applications.
- The development and application of software tools based on Artificial Intelligence for the more efficient and accurate control of environmental and process conditions in the food retail industry. These include demand defrost control systems, energy consumption prediction and control and refrigeration system diagnostics.

- Simulation and control of supermarket refrigeration and environmental control systems.
- Research into ice slurry systems and phase change materials for energy storage and transportation.
- Assessment of new refrigerants including natural refrigerants like CO_2 and the development of new and more efficient and sustainable refrigeration systems.
- Design and development of tri-generation systems (simultaneous production of electrical power, heating and refrigeration) for food engineering applications.



Simplified diagram of the integrated volatile/DX CO_2 refrigeration and trigeneration system

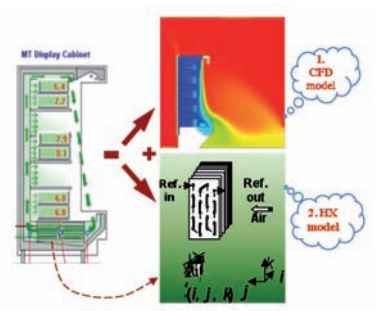
- Investigation and utilisation of the application of renewable energy technologies to the food industry and the built environment.
- Carbon footprinting of retail operations.

Subcritical CO_2 refrigeration

Major current projects include:

- Optimising Thermal Energy Recovery, Utilisation and Management in the Process Industries – OPTITHERM – funded by EPSRC.
- Integration of active and passive indoor thermal environment control systems to minimise the carbon footprint of airport buildings, funded by EPSRC.
- Integrated Thermal Energy Storage in Food Refrigeration Equipment for Energy and CO_2 Emissions Reduction, funded by Defra.

Dr Y. Ge, is also overseeing work in bubble behaviour in central heating systems sponsored by EPSRC and Spirotech (Netherlands). The work aims to elucidate bubble formation in central heating systems assess their effect on the performance of the system such as reduction in the system efficiency, blockages, corrosion and noise, and examine ways to eliminate this through dearation systems. The work involves both experiments in a purposely built rig including flow visualization and modelling.



Display cabinet model with the integration of CFD and cooling coil sub-model

Heat Transfer and Thermal systems: From Fundamentals to Design

Research in this area is led by Prof T.G. Karayiannis and includes the work of professors D.B.R Kenning and M.W. Collins and Dr J. Lewis. The Group carries out one of the largest heat transfer activities in the UK, which includes experimental and numerical single and two-phase heat transfer research and thermal systems. Technological advances and breakthroughs in many significant cutting-edge industries could depend on the ability of engineers to design thermal systems that can dissipate significantly higher heat transfer rates from increasingly smaller areas – hence the need for microscale heat transfer equipment. Current applications include cooling of high performance computers and electronic devices and compact and ultra-compact heat exchanges used in the refrigeration, process, automobile and aerospace industries. For instance, in microelectronic processors, heat transfer is becoming the limiting factor in relation to increasing performance. The additional benefits of enhanced thermal equipment include high overall system efficiencies, reduced fluid inventories and consequently a reduction in the impact of thermal processes and systems on the

environment. In single-phase heat transfer accurate experiments in convective heat transfer are backed by numerical simulation in a variety of applications including flows in buildings.

Flow boiling facility at CEBER

Confined bubble flow of in the boiling heat transfer experiments with R134a in a vertical tube 1.01 mm in diameter

In other systems, convective heat transfer with phase change offers significant performance improvements over single phase cooling systems. In response to this, staff of the Centre initiated long-term research in flow boiling in small to micro passages in collaboration with other leading UK universities and industrial partners. Passive and active heat transfer enhancement techniques in heat exchangers are also studied at the Centre.

Current projects in this area include:

- Flow boiling in micro tubes, funded by the government of Egypt.
- Passive and active techniques in enhancing pool boiling heat transfer, funded by the government of Pakistan and supported by Thermacore Europe – In collaboration with Kassel University, Germany.
- Fluid flow and heat transfer in compact thermal devices, funded by Thermacore Europe Ltd and EPSRC.
- Heat transfer and pressure drop in single and multiple passages of compact heat exchangers, funded by Aspentech and EPSRC .
- Flow boiling in small to micro diameter tubes, funded by the Thomas Gerald Gray Research Scholarship Scheme.

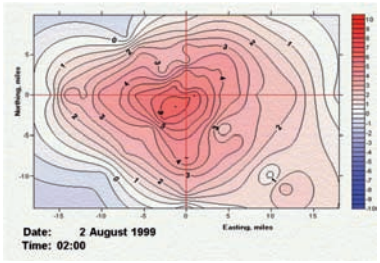
New research in the Centre is also focused on low energy cold plasma processing of heavy hydrocarbons, which can contribute both to better utilization and savings of fossil fuels and subsequently applied to renewable energy resources. This work is funded by Professional Scientific Ltd and EPSRC.

Microclimate and Environmental Design

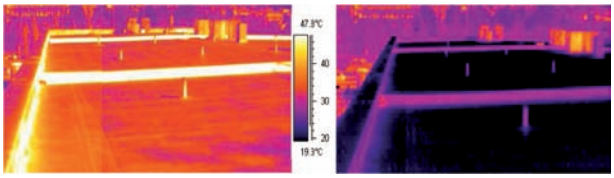
Work of this Group led by Prof Kolokotroni focuses on investigations of energy consumption, indoor air quality and natural ventilation strategies in operational buildings, including user satisfaction; and on experimental and computational studies of the Urban Heat Island and its effect on building design taking into account current and future climate change scenarios. Current projects in this area include:

- LUCID: The Development of a Local Urban Climate Model and its Application to the Intelligent Development of Cities funded by EPSRC with UCL and Reading Universities.
- CoolRoofs in the EU with a consortium of 13 European partners funded by the EU Intelligent Energy Europe Programme
- Building AdVent with a consortium of 9 European partners funded by the EU Intelligent Energy Europe Programme

In addition, current activities include an educational project (USE-Efficiency) funded by the Intelligent Energy Europe programme in partnership with 9 European universities to inform and teach university students current energy audit methods compatible with the European Directive on Energy Performance in Buildings (EPBD).



Night temperature contours over London



Surface temperatures of typical and cool roofs

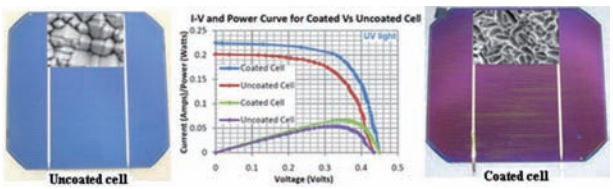
Phase change Materials and Fuel Cells

Dr Z. Dehouche leads work in phase change materials (PCMs) for sustainable buildings supported by EPSRC and Buro-Happold and fuel cells supported by EPSRC and BDSP Ltd. In the first project the energy and CO_2 saving potential of PCMs cooling systems are examined. They are used in panels or as an integrated component of an active thermal control system in new and retrofit applications to augment the thermal energy storage capacity of the building structure and provide passive control of the indoor thermal environment.

Experiments on PCM cooling systems in a custom-built test cell at CEBER

The work in fuel cells is looking to combine cell technology with a gas turbine as a flexible cogeneration unit to supply the electrical, heating/cooling needs of buildings. This is an integrated gasification fuel cell combined-cycle that synergistically provides high system efficiencies and ultra-low levels of pollution.

In addition the group carries out research in nanostructure materials for the development of advanced photovoltaic systems again in collaboration with BDSP Ltd and EPSRC.



Nanostructured Si-material for enhanced PV System

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