RCUK CENTRE FOR SUSTAINABLE ENERGY USE IN FOOD CHAINS

1. SUMMARY

The Centre brings together multidisciplinary research groups of substantial complimentary experience and internationally leading research track record from the Universities of Brunel (led by Prof. Savvas Tassou), Manchester (led by Prof. Adisa Azapagic) and Birmingham (led by Prof. Peter Fryer), as well as key stakeholders to investigate and develop innovative approaches and technologies to effect substantial end use energy demand reductions. The Centre will engage both in cutting edge research into approaches and technologies that will have significant impacts in the future, leading towards the target of 80% reduction in CO_2 emissions by 2050, but also into research that will have demonstrable impacts within the initial five year lifetime of the Centre.

Taking a whole systems approach, the research themes include:

i) Simulation of **energy and resource flows** in the food chain, from farm-gate to plate. The most appropriate simulation methodologies will be used to construct an integrated dynamic food chain model to enable investigations of energy and resource flows between the stages of the chain and the external environment, and facilitate overall energy and resource use optimisation taking into consideration the impact of policy decisions, future food and energy prices and food consumption trends.

ii) Investigation of approaches and technologies for the **reduction of energy use** at all stages of the chain through reduction of the energy intensity of individual processes and optimisation of resource use. It is expected that a number of new innovative and more efficient technologies and approaches for energy reduction will be developed in the lifetime of the Centre to address processing, distribution, retail and final consumption in the home and the service sector.

iii) Study of **corporate and consumer behaviour** to identify drivers and barriers for reducing energy use in food chains. With respect to consumer behaviour, the impact of key influencing factors will be investigated, including changing demographics, increased awareness of the needs and requirements of sustainable living, economic factors and consumption trends on the nature and structure of the food chain and energy use.

Even though the focus will be on the food chain, many of the approaches and technologies developed will also be applicable to other sectors of the economy such as industry, commercial and industrial buildings and transportation of goods.

2 METHODOLOGY AND PROGRAMME OUTLINE

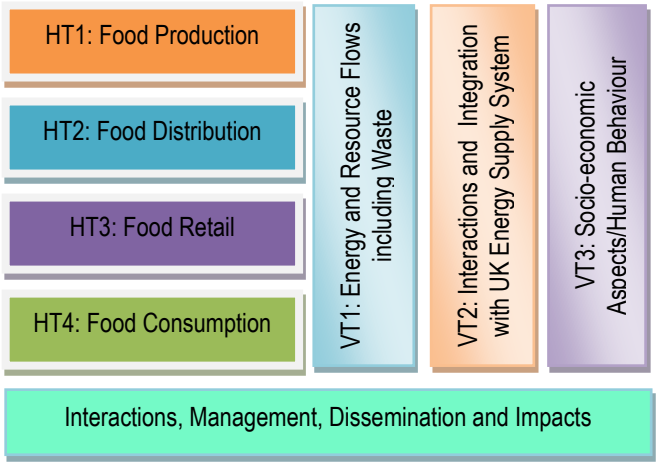
The Centre will undertake world class cross-disciplinary research to address the major challenge of reducing energy and resource use as well as related costs and environmental impacts in the food chain.

This will be achieved through several research themes and work packages as described below. Sufficient flexibility is built into the programme to allow exploration of new opportunities as they arise and are agreed by the Centre's Steering Committee.

As well as research activities the Centre will engage in an extensive programme of network and people-based activities through the Centre's Food Energy and Resource Network to engage the wider national and international research community and industry, particularly SMEs, encourage cross-disciplinary collaborations and develop new research initiatives. The research will address four major horizontal and three vertical themes that will interact and

inform each other. Spanning both the horizontal and vertical themes are activities related to interactions with both the internal and external environment, Centre management, dissemination and impact.

The work will be structured in a way that will provide identifiable energy demand reductions within the first five years of the Centre but also approaches and technologies that will have significant impacts in the future and contribute to the 80% reduction in emissions by 2050. The outline below provides the overall framework of the work and gives details of some specific projects formulated at the outset within the overall objectives of the Centre and interests and contributions of some of our key collaborators and stakeholders. The work of the Centre will focus on a number of key areas within the research themes mentioned above as follows:



Thematic Structure

i) **Quantification of energy demand in the food chain:** A comprehensive review of the literature and stakeholder surveys will enable the evaluation of the energy consumption at the various stages (processing, distribution, retail, consumption, etc) and sectors (dairy, meat, ready meals, fresh produce etc) of the food chain, based on available information and bottom–up assessments using mass and energy balance approaches. Stakeholder surveys (e.g. manufacturers, retailers and consumers) will also be aimed at better understanding of the barriers to end-use energy demand reduction.

ii) **Whole systems approach to energy use simulation and evaluation:** Current energy and process simulation approaches employed in each stage of the chain (micro level) as well as approaches than can be used for energy simulation of the whole sector at a macro level that can incorporate the impact of policy decisions, future food and energy prices and food consumption trends will be evaluated. The most appropriate simulation methodologies will be selected to construct an integrated dynamic food chain model to enable investigations of energy and resource flows, between the stages of the chain and the external environment, and facilitate overall energy and resource use optimisation.

iii) **Technologies for energy demand reduction:** For **food processing**, a range of energy intensive food processing operations will be selected and investigated in detail through plant monitoring and modelling, building on some of our previous work and in collaboration with our industrial partners, to establish the potential for energy savings and return on investment. Individual operations may include, thermal treatment and pasteurisation, mixing, drying, baking, frying, cooling and freezing. On processing lines and whole manufacturing plant, optimisation through approaches such as system integration, pinch technology, process intensification, heat recovery, thermal energy upgrading, CHP and tri-generation, waste heat to electrical energy conversion will be considered. Emerging and new technologies such as high pressure processing, vacuum frying, ohmic heating, microwave baking, that can be developed to operate over a wide range of capacities and generating both texture and flavour with significantly reduced energy input will also be considered.

For **food distribution,** supply chain optimisation will be investigated taking into consideration processing plant and distribution depot location, mode of transportation,

vehicle motive power technologies, as well as approaches to reduce refrigeration demand in both storage and distribution. For **retail,** the influences of consumer preferences and behaviours on retail food outlet design and location will be investigated alongside developments in refrigeration technologies, and approaches for energy reduction such as thermal and renewable energy integration, energy storage for load shifting amongst others. Because of their energy intensive nature and imbalances between electrical power, heating and cooling/refrigeration, the use of processing, storage and retail facilities as energy hubs enabling the use of biomass including food waste for power generation and export to neighbouring facilities will also be considered. For **food service facilities** and **home consumption**, the challenge will be the development of technologies for energy reduction in cooking, for example microwave technology with improved texture and flavour capabilities, and innovative refrigeration technologies.

An important sector to be considered is convenience and prepared foods which have experienced a rapid growth in recent years. Another area very relevant to this is low environmental impact packaging materials with improved thermal properties to increase the integrity of the cold chain. All of the above areas will be considered on a life cycle basis to help identify environmentally most sustainable options from 'cradle to grave'.

iv. **Corporate and consumer behaviour and impact on energy use:** Corporate and consumer behaviour and attitudes on energy use will be studied to identify key influencing factors that could lead to energy reduction. Behavioural economics will be employed to investigate the impact of behaviour on energy use in corporate environments, and consumer attitudes will be examined using psychological methods. Models will be developed of consumer demand and how this might change in the future as a function of the changing demographics of the population, broad economic factors as well as increased information about the needs and requirements of sustainable living. This will involve measuring implicit attitudes, as a way into developing a more coherent model of underlying attitudes to food consumption. It will allow greater insight into the nature of consumer habits and also help to understand and predict possible future trends in consumer choice, and how these may impact on food consumption and energy use.

v. **Integrated food chain energy and resource optimisation:** Using the integrated food chain model and applying life cycle thinking, the impact of technologies and approaches at each stage of the chain on the total energy consumption and resource use, farm-gate to plate, will be investigated. This will involve optimisation using a range of approaches such as Life Cycle Assessment (LCA) studies and computational tools to provide optimal solutions in terms of energy consumption, resource use and associated environmental impacts.

3. COLLABORATION WITH USERS AND PATHWAYS TO IMPACT

The Centre will involve extensive collaboration with the user community, including food and drink producers, manufacturers of technology, retailers, energy suppliers, food associations and other relevant research groups and networks. The partners will be closely involved in the Centre through participation in project meetings, representation on the Steering Committee, provision of data, projects and case studies as well as access to premises and facilities, technical advice and funding projects in their specific area of interest, through studentships, equipment contributions and equipment development in collaboration with the Centre. Benefits to the industry partners will include reduction in energy demand and emissions, increased product quality and shelf life, reductions in their cost base and improved competitiveness. The three partner universities will also make a significant investment in the Centre in lectureships, studentships and facilities and equipment.