participantsparticipantsparticipantsparticipantsGeneral enquiries on this form should be made to:

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SID 5 Research Project Final Report

Note

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This form is in Word format and the boxes may be expanded or reduced, as appropriate.

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6.

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(a) When preparing SID 5s contractors should bear in mind that Defra intends that they be made public. They

What comes out very clearly is that maintenance is an area of weakness across the board. There is also a lack of optimisation of the operation of existing plant and a lack of installation of relatively simple augmentations such as curtains and other devices to reduce infiltration through doors. This all points to lack of understanding and skills.

Another recurring theme is the lack of good design of systems, including controls. This is again a reflection of a lack of understanding and skills. In many cases this lack of understanding starts with the original process specification for the total refrigeration system, which may only contain details of the peak load conditions in a system that may operate under part, or no load for much of the time.

Project Report to Defra

8. As a guide this report should be no longer than 20 sides of A4. This report is to provide Defra with details of the outputs of the research project for internal purposes; to meet the terms of the contract; and to allow Defra to publish details of the outputs to meet Environmental Information Regulation or Freedom of Information obligations. This short report to Defra does not preclude contractors from also seeking to publish a full, formal scientific report/paper in an appropriate scientific or other journal/publication. Indeed, Defra actively encourages such publications as part of the contract terms. The report to Defra should include:

    the scientific objectives as set out in the contract;

    the extent to which the objectives set out in the contract have been met;

    details of methods used and the results obtained, including statistical analysis (if appropriate);

    a discussion of the results and their reliability;

    the main implications of the findings;

    possible future work; and

    any action resulting from therich p-3(3)-2 78.

Initially the data available concerning UK production and consumption of food was analysed to identify 1) the major food commodities in the UK and 2) those which were most likely to consume substantial amounts of energy for refrigeration. In parallel to this, data on the different sectors throughout the food chain was analysed to determine the scale of refrigeration processes in use and the energy being consumed.
The final mapping exercise identified and ranked the that have the greatest potential for energy savings and are shown in Table 1.

The data and calculations used to produce Table 1 are presented in Energy use in reference 79.

Objective 2.1 Develop generic technologies and business practices that have the potential to reduce refrigeration energy consumption.

Within objective 2.1 all the academic partners have worked to:

- Review new and emerging technologies (objective 2.1.1).
- Assess energy savings potential from efficiency improvements of current technologies (objective 2.1.2).
- Development of system models (objective 2.1.3).
- Assessment of business practices upon equipment requirements & performance (objective 2.1.4).
- Development of dynamic food models (objective 2.1.5).

c	systems available.	20 kW		refrigerators, refrigerators for trucks, recreational vehicles; portable coolers; beverage can coolers
Thermoacoustic	R&D stage. Predicted commercialisation: 5-10 years.	Few watts to KW capacity	Up to 1.0	Domestic and commercial refrigerators, freezers and cabinets
Magnetic	R&D stage. Predicted commercialisation 10 plus years from now	Up to 540 W	1.8 at room temperature	Low capacity stationary and mobile refrigeration systems

Alternative technologies:
Reports have also been compiled by FRPERC on alternative chilling and freezing technologies (87) and

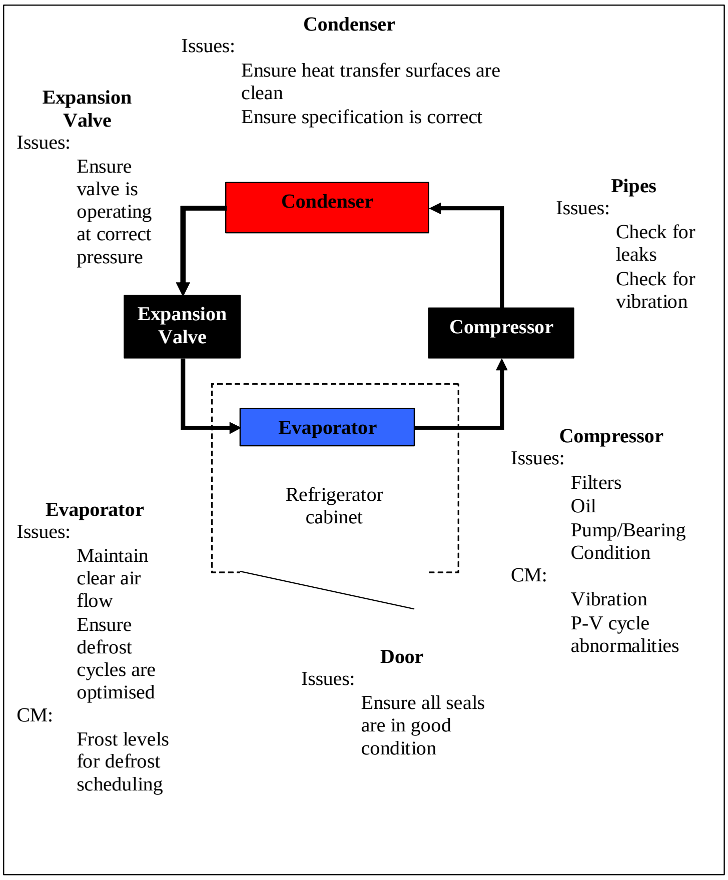

Figure 1 Maintenance and Monitoring in a Conventional Refrigeration System

Objective 2.1.5 Development of dynamic food models.

As already described in 2.1.3 the general objectives of the modelling study were to develop scientifically based models of refrigeration systems common across the food chain, so as to allow study of performance and component choice. The sequence of activities leading to the development of the final model is detailed in 2.1.3 and the following describes the final model.

A scientifically based transient to steady state computer based simulation model of a cold space cooled by a vapour compression refrigerator has been written and validated. A schematic view of the system model is shown in Figure 2.

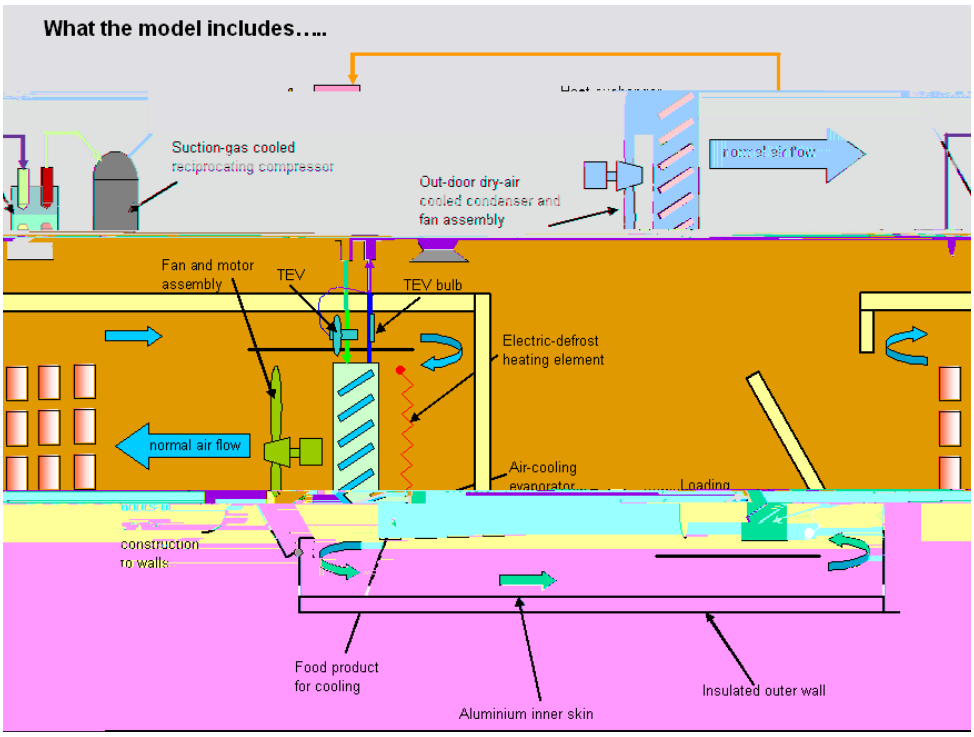

Figure 2: Schematic of refrigerated model cold space

The code has been debugged and guidance notes for users on how use the software has been provided through *HELP* pages and a *WIZARD* function, to assist new users to get started. This completely original piece of work proves industry with a tool for estimating the energy consumption and carbon generation resulting from refrigerated storage and refrigerated processing equipment in the food chain, ranging from small chill-cabinets to large cold stores.

The software provides the following functions:

A Run-time screen, shown below in Figure 3, is provided through which all design screens and other functions are accessed. If necessary a user can navigate through the data input function using the *WIZARD* function, accessed by the click of a button in the toolbar in the Run-time screen. The Run-time

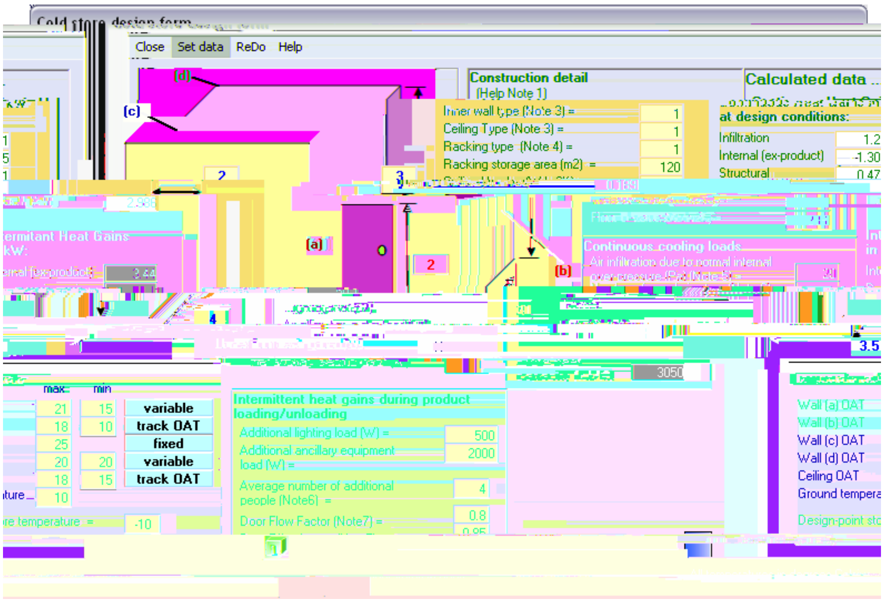

Figure 4: Cold store design screen

The refrigerator design screen, shown in Figure 5, allows users to specify design-point data either by default or individually or in any combinations, for the evaporator, condenser, compressor, fans and motors, thermostatic expansion valve and refrigerant pipelines. If catalogue data are available for the compressor or evaporator or condenser (or for any combination of these) special easy to follow data input screens are provided for each.

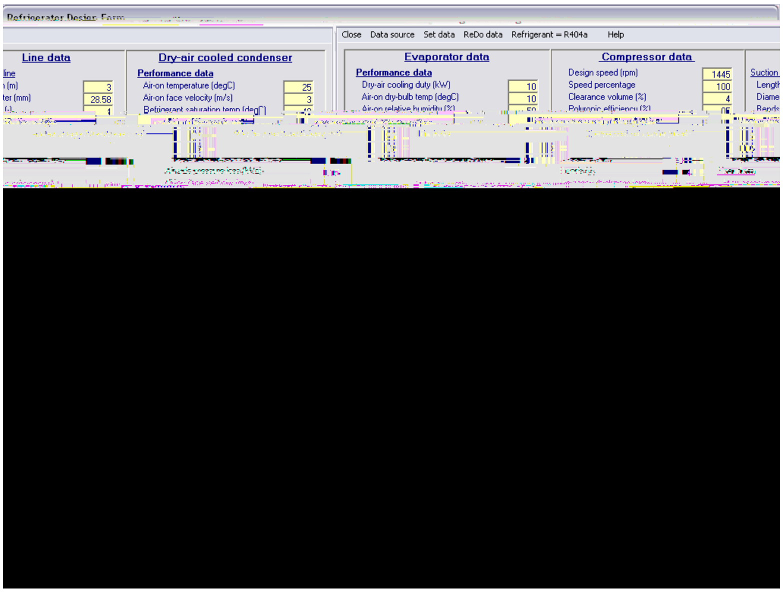

Figure 5: Refrigerator design input screen

The refrigerator design screen also allows users to choose between from a range of system control options, including six system thermostat control options, three evaporator fan speed control options (manual, automatic variable and automatic fractional), three compressor control selections, (manual speed control, automatic speed control based on temperature and staged, with up to six compressor stages available), two automatic electric defrost control options, (set either on by time and on by ATD), High and Low Temperature cut-out controls and compressor and fan motor start-up delay controls. In addition user can alter the time-constant and cooling capacity of the thermostatic expansion value to simulate the effects of both a badly positioned sensing bulb and an over or undersized valve, resulting in valve hunting and evaporator flooding.
VCR software allows users to select between fixed or simulated variable outdoor temperature and relative humidity. For the variable option a user must select both the location of the plant they wish to simulate (from a list of seven major UK mainland cities) and the month of the year for which they wish to simulate the operation of the plant. The variable weather screen is shown in Figure 6. With the variable outdoor weather option set, the model simulates the diurnal variation in ambient temperature and humidity ratio.

This simulation is based on published whether data for average monthly peak temperatures in seven UK cities taken over 30 years.

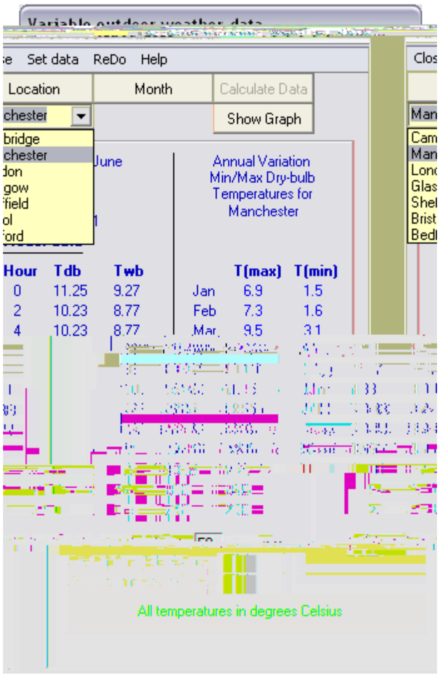

Figure 6: Variable ambient weather data screen

In the Run-time screen there is a facility, which allows all the necessary system design data, which has been entered during a session, to be saved for future use in a user named file. There is a library function provided for saved input data files so that, conversely, if project data has been previously saved it can easily found and reload into the VCR model and RUN without further inputs being required.

The Run-time screen allows model output data to be saved to a user named Excel file for later analysis

information to a WORD.DOC

At this time the software appears to be robust. As already mentioned the fully working model can now be access through the project website [72], a workshop was carried out on 21st June 2010 and publications/presentations made [27, 48, 57, 68].

Validation case study:

The LSBU team provided the FRPERC team with a list of Input data required to run the model. The LSBU team used this data to set- rformance data for the compressor. This was used to further develop the mathematical model of the compressor and its control. FRPERC recruited Pieminister Ltd for a Case Study. FRPERC recorded the electrical power consumption and temperatures around the the validation case was supplied to the LSBU team for comparison against the models predictions. Close correlation between the validation data and model predictions has been shown [94].

Objective 2.2 - Identify the features of the most efficient current systems and make them and their energy saving potential widely known to the industry.

Experience had shown that the factors leading to energy inefficiency can be broadly combined under three areas a) Inefficient extraction of heat or poor protection from heat ingress into the food; b) inefficient refrigeration plant; or, c) poor operational practices. Progress in this area was limited because the initial mapping exercise found few if any food refrigeration processes with sufficient data on energy consumption and throughput to accurately determine their efficiency let alone the reason(s) for inefficiency.

A lack of available researchers also limited the number of case studies that could be carried out however the following desk based studies was carried out by EBERC and desk/practical studies by FRPERC.

Dairy plant Energy Savings Potential of Liquid Picienr6b(m)ϸbaification

A case study waspderformed on the elation of the.

The results of the analysis reported in detail [76] have shown that VIPs are a very promising technology for

A large stakeholders group was set up at the start of the project and new members joined as the project progressed. A web site was established in the first few months and stakeholders were regularly informed of new additions and progress reports. Since the web site was re-established [72] more and more project reports, sector reports, case studies and dissemination presentations have been added and as it nears completion all the

72. Reducing energy use in food refrigeration - http://www.grimsby.ac.uk/What-We-Offer/DEFRA-Energy/

Project reports:
73. Bagless, D. Evidence that Maintenance has an Essential Role in Energy Saving, June 2009, 16pgs.
74. Hadawey A., Ge Y. T., Tassou S. A., Energy Savings Through Liquid Pressure Amplification in a Dairy Plant