Earthcare Products

SUSTAINABLE COOLING: REFRIGERANTS BEYOND THE CRISIS

Presented to:

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1. Introduction

I would first like to thank Mr. Tim Dwyer for organising this discussion with you today. I will deal with the very considerable challenges posed by legislation and other pressures on the use of refrigerants in building services.

2. An Environmental Crisis with a Commercial Solution

The problem could not be simpler: cooling is the largest single demand on electrical consumption in the world and the synthetic refrigerants that are utilised by most cooling appliances add significantly to climatic change and ozone depletion. Further more, buildings account for around 45% of the energy consumption and greenhouse gas emissions in the UK.

Let me deal with the refrigerants first. Most modern cooling appliances use a class of chemical compound called hydrofluorocarbons, or HFCs, as the heat transfer medium that makes refrigeration work. HFCs were introduced to replace ozone-depleting HCFCs, which are still in widespread use in older equipment. HFCs are potent global warmers and UK leakage rates from HFC split systems remain high at some 15% per annum, typically about 0.15 KG per annum. As HFC410a has a GWP of 1900, this is the equivalent of 269 KG (i.e. 0.27 tonnes!) of CO_2 per unit per annum, the equivalent of driving the average car some 505 miles. You would need to plant 2.4 trees[1] to offset the global warming impact of HFC refrigerant emissions from each HFC410a split system currently being installed.

The environmental problems associated with HFCs extend beyond global warming. HFCs are a source of acid rain as the products of degradation include hydrofluoric acid and trifluoroacetatic acid (TFA), a biopersistant pollutant rapidly rising up the agenda for both environmentalists and legislators. Approximately 10% of the total HFC production weight is toxic waste, including vinyl chloride, ethylene dichloride (both of which are carcinogens) and other chlorinated organics.

Nor are HFCs genuinely ozone friendly. The production of HFCs uses the very same halogenated CFCs and HCFCs, which they were intended to replace, as emissions during the manufacturing process are inevitable. In 2001, the Environment Agency licensed the two UK HFC manufacturers Ineos and Rhodia to emit up to 8,646 kg of ozone depleting HCFCs during their manufacturing processes. Indeed, in a landmark judgement on the 14th June 2000, the Advertising Standards Authority declared that HFCs could not be advertised as “100% Ozone friendly”.

The powerful effects of HFCs have not gone unnoticed. Environmental NGOs, in particular Greenpeace, have been consistently vocal in their opposition to the use of global warming HFCs as substitutes for ozone depleting substances. Greenpeace regularly runs campaigns attacking users of HFCs, most notably the “Tesco Fiasco”

[1] The Edinburgh Centre for Carbon Management, ‘Estimation of Carbon Offset by Trees’, ECCM Technical Document No. 7, March 2000

campaign in 1996 and more recently the anti-Coca Cola "Enjoy Climate Change" campaign run at the time of the 2000 Sydney Olympics.

However, it is important to remember that refrigerants themselves are not the only problem: Although 20% of the contribution of the refrigerant sector to global warming is due to direct emissions of greenhouse refrigerant gases, the remaining 80% is a result of indirect emissions caused by the generation of the electricity to drive the equipment. Refrigeration, air conditioning and heat pumps together make up the largest electrical energy-using sector, consuming over 15% of global electricity consumption. As such, the process of cooling poses a double threat to the global environment – both to the world's resources and to its climate.

At its height, CFC emissions from all sources accounted for about 24% of increased radiative forcing or so-called global warming. Improved working practices and the switch to HCFCs with a lower global warming potential – GWP – have resulted in a significant improvement in this figure. However, we should not congratulate ourselves on account of this: The United Nations International Panel on Climate Change's Third Assessment Report (2001) stated statistics that account for all halocarbons, including those that are also ozone-depleting substances:

CO_2	60.1%
CH_4	19.6%
Halocarbons	14%
NO_x	6%

The proportion of global warming attributed to halocarbons has risen significantly since 1995 when the figure stood at 10%, despite controls under the Montreal Protocol.

It is no wonder, therefore, that we are being hit by legislation and regulation as governments seek to avoid this damage. The response must not be just to pay the bill; instead, it should be to find ways of avoiding extra costs and making real savings. How then does this translate into commercial policy? We believe there can only be one good reason why private and public bodies alike should consider alternative refrigeration technology: the reduction of cooling costs.

How is this possible? Well, the first and most obvious reason is that apparently cheaper products purchased now may well have to be replaced prematurely as new legislation kicks in. Therefore, ensuring that purchasing decisions take account of current and anticipated legislation is vital if good lifetime value is going to be achieved.

Secondly, the fact is that HFCs make bad commercial sense because they are poor refrigerants. Typically, HFC equipment produces only two and a half times the amount of cooling as electricity put in. HFC plant is, therefore, a voracious consumer of electricity. If we can remove HFCs from the equation, not only do we limit the direct damage they do to the environment but we can also help to reduce electricity consumption. In so doing you will not only be helping the pennies, you will be reducing your indirect carbon emissions as well.

I will firstly deal with the projected legislation that you should be seeking to comply with in the purchasing decisions you make now. I will then turn to those technologies that can be employed instead of damaging synthetic refrigerants like HFCs.

3. A Global Response to a Global Problem

Regulatory control of halocarbons used in the vapour compression refrigeration cycle is already well established. The use of CFCs and HCFCs was effectively put to an end by the signing of the Montreal Protocol in 1995. We are now almost halfway through a period of phase-out dates that the EU introduced to fulfil its obligations under the protocol. It is now illegal to use CFCs in any circumstances and the use of HCFCs is severely restricted. New HCFC equipment is now banned and it will be prohibited to use virgin HCFCs as a service refrigerant in existing equipment from the beginning of 2010 and recycled HCFCs will be banned as service refrigerants from 1st Jan 2015. HCFC phase out will be accelerated further by progressively reducing the size of the cap on supply to the market and it is to be expected that governments will bring forward the remaining target dates when they feel politically able to do so.

EU legislation on the handling, use and removal of ozone depleting refrigerants came into force in October 2000 in the snappily titled Directive EC2037/2000. Article 17 requires a "minimum competency" for anyone who handles ozone-depleting refrigerants, for example, a refrigerant safe handling certificate from CITB or City & Guilds. There is also a requirement for an annual leak test on any equipment that holds a refrigerant charge of 3 kg and above. The effect of these regulations is that there is now a legal requirement for a yearly planned maintenance visit for HCFC equipment, undertaken by a qualified engineer and logged in auditable records by the owner or operator.

On March 31st 2004, MEPs voted to ban all refrigerants with a GWP greater than 50 for mobile (i.e. car) air conditioning applications with a phase-out period starting from 1st January 2011. Furthermore, member states will be required to promote gases with a GWP of less than 150 and to restrict the use of fluorinated gases to applications where there is no alternative available.

4. UK legislation

In dealing with HFC use, the UK Government has adopted – as one would expect – a middle course between the laggards and the progressives. The UK programme on climate change was presented to Parliament on 17th November 2000. The key elements of the government's position on HFCs were:

- HFCs should only be used where other safe, technically feasible, cost effective and more environmentally acceptable alternatives do not exist;
- HFCs are not sustainable in the long term - the government believes that continued technological developments will mean that HFCs may eventually be able to be replaced in the applications where they are used;

- HFC emission reduction strategies should not undermine commitments to phase out ozone depleting substances covered by the Montreal protocol;
- HFC emissions will not be allowed to rise unchecked.

As the Government is aware that meeting its obligations under the Kyoto Treaty will be impossible without sustained action against fluorinated gases, these points were intended to give a clear signal to industry that HFCs have no long-term future. Given the increasing political problems of limiting other sources of global warming emissions, such as the internal combustion engine and fossil fuel electricity generation, it should not be doubted that the government will increasingly see refrigeration as an easy hit. Expect punitive taxation within the next five years and restrictions on use within the next ten.

In terms of positive financial action, the Government has funded alternative refrigeration projects and has provided direct incentives to encourage the take-up of new technologies. In order to offset the rise in electricity prices caused by the introduction of the Climate Change Levy in November 2001, a range of energy efficient refrigeration technologies now qualify for 100% capital allowances in the first year. They include evaporative condensers, liquid line pumps, leak detectors, control equipment, air purgers and absorption chillers used with CHP. On 8th March 2001, the Minister for the Environment stated in the House of Commons that a target of 10,000 MW of combined heat and power (CHP) would be met by 2010 – a commitment that will further speed the growth of CHP-powered green cooling systems.

5. Other Responses

Going even further, the BOCOG has announced that the 2008 Beijing Olympics will be "fluorine free" for all static cooling systems. A conference on climate-friendly refrigeration technologies on 22 June this year highlighted the commitments made by Coca-Cola, McDonald's and Unilever Ice Cream to phase out HFCs from their commercial refrigeration systems. In a speech to an environment forum on the 12th September the conservative party leader committed his party to phasing out the use of HFCs by 2014. Effectively this is the beginning of the end for HFCs.

6. What Alternatives?

Moves by the Government to limit the use of HFCs within the refrigeration industry, both by coercion and encouragement, have spurred the development of those refrigerants and so-called "Not in Kind" systems which will, in the end, replace synthetic gases. This graph shows an old but still largely correct projection of how this transformation might occur. What you will immediately notice is that the replacement of halocarbons such as HCFCs and HFCs will not be brought about by one single wonder solution but by a whole number of technologies which will offer different advantages in different applications to different clients.

Consultants should remember that the use of natural refrigerants gives an improved rating under BREEAM 2003. More importantly, the CIBSE Guide B4 Refrigeration and heat rejection states:

Section 3.4.2 Greenhouse gases:
"Use alternative refrigerants with zero or low global warming potential (GWP) such as ammonia and hydrocarbons."
Section 4.4.1 Refrigerant selection:
"However, HFCs have global warming potentials similar to most CFCs and HCFCs and as a result there is political pressure in Europe to minimise or phase out the use of HFCs."

Hydrocarbons

You will all, by now, be familiar with hydrocarbon cooling systems. Hydrocarbons are principally used in small domestic refrigeration units with hermetic compressors. Such units now dominate the market in Italy, Germany and Northern Europe and will soon dominate in Britain too. Increasingly, hydrocarbons, against all the best efforts of the HFC industry, are starting to be used in cooling applications from supermarket refrigeration and small split systems right the way through to 1030kW chillers. The use of hydrocarbons entails no on-cost to the end user, will guarantee lower running costs, increased efficiency, and reduced compressor wear.

Hydrocarbons have very similar physical properties to CFCs, HCFCs, and HFCs. However, they have zero ozone depleting potential and minimal global warming effect. They are proven refrigerants: plant operating with hydrocarbons has been in operation worldwide for many years. Hydrocarbons may be used as substitutes and in many cases as direct drop-in replacements for CFC12, CFC502, HCFC22, and most of the HFCs. There are no particular material problems with hydrocarbons and they are compatible with traditional mineral oil lubricants, which HFCs are not. Hydrocarbon systems boast superior energy efficiencies to HFC systems, as their heat transfer characteristics are far better.

There is already considerable knowledge and expertise in the use of hydrocarbons, with standards, codes of practice, and legislation in place. However, the relevant documentation is widespread and diverse. The Air Conditioning and Refrigeration Industry Board (ACRIB) has now published a guidance document covering all aspects of working with hydrocarbon refrigerants – *'Guidelines for the Use of Hydrocarbon Refrigerants in Static Refrigeration and Air Conditioning Systems'* – which has received the support of the Department of Trade and Industry. There are, inevitably, still some barriers to full market penetration. For instance, the recent introduction of the Pressure Equipment Directive temporarily restricted the use of hydrocarbons in a limited number of applications but new products have now remedied this situation.

Hydrocarbons outperform traditional halocarbon refrigerants in all aspects other than that of flammability. It is this one single issue which has to date prevented their widespread adoption. This is not entirely logical as hydrocarbons are extensively used in industry. Mains gas is used as boiler fuel and the higher hydrocarbons are used as fuel for vehicles. Furthermore, aerosols are stored in dry goods stores without undue problems. The use of hydrocarbon refrigerants does involve risk but such risk should not be thought of as any different from the many potentially dangerous applications that we have for flammable

substances in the home, office, motorcar and factory. It is possible to understand the risks, identify mitigating strategies and further consider how the risks can be managed.
I should add a brief addendum on the issue of risk. If you look at the hydrocarbon risk table, you will see a table of odds. You will notice that the risk of ignition from a hydrocarbon split system cooling appliance (ignition will not lead to fire in most instances) is less than the risk of ignition and fire from any other type of similar appliance in the home or office by a magnitude of three. Similarly, the risk of ignition during servicing – the moment of most danger in the use of a hydrocarbon cooling system, is comparable to the risk of dying in an aeroplane crash. Such a risk is less than that connected with any of the other appliances listed by a factor of ten.

Ammonia

Ammonia is the only one of the original refrigerants that has continued to be used on a widespread basis since the advent of halocarbons. It has been used for decades in industrial refrigeration plants and its continued popularity throughout the CFC era amply demonstrates its unique benefits. It has no ozone depletion potential and no global warming potential. Its energy efficiency is at least as good as, and in most applications better than, HCFC22.

There are, however, a number of drawbacks. Ammonia is not compatible with conventional lubricants and is highly corrosive to copper. It cannot therefore be used with hermetic or semi-hermetic compressors unless aluminium windings are used. Leakage from shaft seals is difficult to eliminate.

With halocarbons increasingly being unacceptable, ammonia has every opportunity to increase its market share. It is apparent that user industries are on the threshold of embracing halocarbon replacement technologies. They need to be persuaded to consider ammonia as their preferred refrigerant. There are several obstacles to further growth in the ammonia refrigeration market, principally the chronic lack of qualified ammonia engineers and the fact that ammonia is both toxic and flammable. However, as ammonia has been used in most industrial refrigeration – including food processing – for over a hundred years, the necessary expertise exists to minimise risk. As with hydrocarbons, given sensible precautions, ammonia will provide excellent, safe and reliable service well beyond the lifetime of a typical HFC packaged chiller.

The problem of cost needs to be met. Traditionally, ammonia was very expensive; however, in recent years new commercial models have been introduced which, whilst at the top end of the commercial chiller price range, are still affordable. Moreover, their efficiency is so good that they usually pay back the extra within two to five years, depending on the size and use of the system. This picture shows such a chiller in the Carlos III University in Madrid.

Absorption

At first sight, the prospects for gas-fired absorption refrigeration look good. Instead of using CFCs, absorption employs ammonia and water, or water and lithium bromide. Absorption chillers have few moving parts and therefore incur lower maintenance costs. They can also use natural gas as their fuel when it is more competitively priced than electricity. In practice, however, absorption refrigeration has a number of serious problems. Absorption systems are inherently inefficient, with a typical Coefficient of Performance (COP) of only 0.7 for single effect cycles and, at a push, 1.3 for double effect cycles. Although large users of electricity may be able to negotiate favourable tariffs directly from electricity generators, it is impractical for most consumers. It is often found that the electrical vapour compression option offers the lowest running costs and the electrical option almost invariably offers lower capital costs. There is also a wider range of electrically driven equipment on the market.

The economics for absorption refrigeration look much more favourable when coupled with a combined heat and power (CHP) system – a simple schematic of which is shown. By combining the on-site generation of electricity with the provision of refrigeration, heating and hot water services, combined heat, power and refrigeration (CHPR) systems provide a total energy service, which can dramatically reduce overall running costs.

Ice storage

Thermal energy storage is the storing of high or low temperature energy for later use in order to bridge the time gap between energy availability and energy use. Air conditioning thermal energy storage applications generally utilise conventional chillers to build ice. Current ice production technologies include static ice production methods such as ice banks or encapsulated ice modules. Alternatively, slurry ice machines offer reduced pipe sizing, reduced pump energy, steady leaving temperatures, a quick response to large loads, and a flexible ice storage system.

If one were to take a typical UK 400 kW air conditioning application then the application of slurry ice may yield a 16% capital cost increase but an overall running cost saving of 36%, thereby giving a nine-month payback period.

7. Improving Design - Integrated solutions

Chillers are generally designed to cope with peak load considerations without giving due regard to energy efficiency at part load applications. This is common practice within our industry and results in clients being reluctant to operate their plant at part load conditions in order to reduce running costs. A preferable solution would be as follows. Cooling requirements should be calculated over a 24-hour period to arrive at a peak night time cooling load in addition to a peak daytime cooling load. Electric chillers should be selected to provide the peak night time cooling load and absorption chillers selected to make up the difference to peak daytime cooling load. The absorption chillers should be powered by hot water and plumbed to receive their energy from either conventional boiler plant or from a CHP unit. An intelligent BMS system programmed to compare the relative costs of electricity and gas across a 24-hour period should integrate the system to provide a continuously optimised combination of electric chillers, absorption chillers and CHP. All cooling requirements could then be satisfied from the chilled water, safe in the knowledge that minimum running costs were being achieved.

Full load/part load – sizing plant correctly

For most of the year, a building cooling demand will be considerably less than design capacity. The average seasonal demand is likely to be 50% or less. At 50% capacity, the CoP of a high efficiency ammonia chiller may be up to 5.7. Using inverter drives, this can be increased to 6.4 (i.e. a 13% increase in CoP). At 37% capacity, the CoP of the fixed speed chiller will have dropped to no more than 5.0, whereas the inverter driven version will have risen to up to 7.5.

Controls

Optimising soft starters cut power consumption by supplying precisely the amount of energy required for the load demand. The optimising function regulates the electrical supply to match precisely what is needed. In this way the running costs and wear and tear on the unit are cut. The amount that can be saved will be a function of the load characteristics, duty cycle, supply voltage, motor type and rating of the appliance and application; however, typically savings of up to 10% of the motor rated kW may be achieved.

8. Buying Right

I want briefly to touch on the principle of "lifecycle cost value", the measure by which whole life efficiencies can e judged.

We have recently done some in-depth research work for a government-buying agency concerning lifecycle costs associated with small refrigeration appliances. For the purposes of this project, the lifecycle value of a product was expressed in terms of the initial capital cost and the Net Present Value (NPV) of the consequent energy costs.

In one instance, we took two units manufactured by two different companies. The annual energy cost of the Unit A was £113 compared to only £96 for that of Unit B, despite that the fact that the purchase price for A was considerably lower than that for B. The upshot was that after 7 years, unit A was far more expensive that unit B – even after a discount had been applied to the energy cash flows. Of course, lifecycle value translates neatly into environmental savings: Unit A had a total equivalent warming impact of 8.7 equivalent tonnes of CO_2 over 7 years, whilst Unit B returned only 7.4 tonnes. The difference, 1.3 tonnes, would require nearly eleven trees to be neutralised.

Transferring that kind of logic into procurement decisions is notoriously difficult, green policies often get forgotten on tender documents – an experience we have come up across all too often.

9. The Difference You Can Make

To finish off, I would like to share with you some figures, which give you a "live" idea of what can be achieved. We have been working with a large site on a fifteen-year plan to reduce revenue spent on capital equipment, electricity and maintenance. On this site – a university campus - there is a chronic energy problem. Cooling is a large demand upon electricity – accounting for over 35% of demand (this translates into an energy bill for cooling on that site alone of over £700,000). We believe that a radical re-think in the cooling strategy could enable cooling to make a considerable contribution to energy reductions. We estimate that the university has over nearly 7 MW of supply capacity tied up in cooling plant. We have modelled the effects of introducing all the technologies and ideas I have talked about – from simple energy savings through to large central absorption schemes – through a financing scheme. The last graphic (figure 6) gives you some idea of what can e achieved in the first five years of this plan in terms of electrical load reduction. Yet this is only a start: given proper planning it should in many instances be possible to obtain virtually free cooling; to everyone's benefit, cooling without electricity using waste heat is carbon neutral. All of this can be done – or degrees of it – even before the next generation of refrigeration technologies starts to enter the scene. As you will be aware, change is never an easy option: you will need good advice, some measure of confidence and a belligerent attitude towards those traditional consultants and manufacturers who will try to steer you towards what is easiest for them and most accepted in the industry. However, in our experience and given time, change can be effected. It may not be easy but it is right: not just right by the environment but right by those funding the services you are seeking to offer.

Appendix 1

Refrigerants beyond the Crisis

BANNED CFCs High Ozone Depletion High Global Warming	SHORT TERM HCFCs Low Ozone Depletion High Global Warming	MEDIUM TERM HFCs Ozone Friendly High Global Warming	LONG TERM NIKs Ozone Friendly Low Global Warming
R11	R123 R141B	R134A R245CA	R718 (WATER)
R12	*R401A + B* *R405A* *R409A* *R142B*	R134A R152A R413A R407D	R729 (AIR) R717(AMMONIA) R744 (CARBON DIOXIDE) *CARE 30*(HC BLEND) *R600A* (ISOBUTANE) *RC270* (CYCLO-PROPANE)
R13/R503		R23 R14 R508B	*R170* (ETHANE)
R114	R124	R236FA	R717(AMMONIA) R744 (CARBON DIOXIDE)
R500	*R401B* *R409B*	R134A R407D R413A	R717(AMMONIA) R744 (CARBON DIOXIDE)
R502	*R402A + B* *R408A* *R403A + B* *R411B*	R404A R407A + B R507 R32	R717(AMMONIA) R744 (CARBON DIOXIDE) *CARE 50* (HC BLEND) *R1270* (PROPENE)
R13B1	*R403B*	R125 R32 R410A *Isceon 89*	*R170* (ETHANE) *R1270* (PROPENE)
Practical drop in replacement refrigerants are shown *in light italic type*	R22	R407C R410A R32 *Isceon 59* *HR50* *G2032*	R717(AMMONIA) R744 (CARBON DIOXIDE) *R290* (PROPANE) *CARE 50* (HC BLEND)

Appendix 2

Characteristics Of Common Refrigerants

Refrigerant	*Refrigerant examples*	*Ozone depleting potential* [2]	*Global warming potential* [1]	*Number of trees required to offset the release of 1KG of refrigerant*[3]
Chlorofluorocarbons (CFCs) (halogenated hydrocarbon molecules formed by replacing hydrogen atoms in a hydrocarbon molecule with chlorine and fluorine)	R12 R502	0.82 0.221	8,500 6,200	76.5 55.8
Hydrochlorofluorocarbons (HCFCs) (similar to CFCs but are only partially halogenated and therefore retain some hydrogen)	R22	0.034	1,700	15.3
Hydrofluorocarbons (HFCs) (formed by partially fluorinating hydrocarbons. They retain some hydrogen and are totally chlorine free)	R134a R404a R407c R410a	0 0 0 0	1,300 3,800 1,600 1,900	11.7 34.2 14.4 17.1
Hydrocarbons (HCs) (naturally occurring organic substances; generally, they are stable and unreactive. They are however, flammable and they react with halogens).	R600a R290 R1270	0 0 0	3 3 3	0.027 0.027 0.027
Ammonia Can be toxic and flammable so not suitable for all uses.	R717	0	0	0

Natural refrigerants, including Hydrocarbons and Ammonia are often grouped together for convenience as 'Not In Kind' (NIK) refrigerants. In effect this simply means they are not synthetic and have a consequently lower environmental impact.

[2] *Source:* IPCC 3rd (2001) Assessment Report

[3] *Source:* the Edinburgh Centre for Carbon Management Ltd, "Estimation of Carbon Offset by Trees" ECCM Technical Document No. 7,March 2000

Appendix 3

Earthcare Products

Earthcare Products was created in response to the growing demand for environmentally friendly refrigeration and air conditioning. It has helped to force the pace of change in the industry by encouraging both government and business to come to terms with the very serious global warming impact that synthetic refrigerants produce. It has also struck a chord with those companies and public bodies who are increasingly concerned with the energy efficiency of their operations. Our belief in alternatives to damaging refrigerants was vindicated by the Government's response to the Kyoto Protocol, which makes clear that HFCs are unsustainable in the long term. Earthcare has demonstrated that these alternatives can deliver significant energy savings over conventional equipment.

Entirely independent of manufacturers or producers, Earthcare is free to recommend the most effective and dependable solutions to clients, amongst which are now numbered some of the world's most respected names. In the public sphere, this has included the European Commission, the former Department of Environment, Transport and the Regions (DETR), the Middlesex, Warwick and London Hospitals, Imperial College of Science and Technology, HM Customs and Excise, Great Ormond Street Hospital and many other NHS trusts, and a number of local authorities. Our experience of working with private sector clients is similarly widespread: HP Bulmer plc, the Co-operative Bank, Body Shop, Glaxo Smithkline and McDonalds all number amongst our many customers. Our advice and equipment has been sought at the Millennium Dome and the Earth Centre.

Earthcare is fully incorporated within the Sancroft Group, a major corporate social responsibility consultancy, on whose behalf we conduct refrigerant and energy audits. We also offer these services independently.

Earthcare has helped many businesses and organisations realise the "green dividend" of reduced costs brought by better environmental practice. We will continue to strive to show that the finest cooling services need not compromise either budgets or the environment.

Earthcare Products is registered with Constructionline, the UK Government online referral service for approved contractors and consultants. Earthcare is also registered with Greentie, the International Energy Agency (OECD) sponsored register of contractors and consultants specialising in technologies that aid greenhouse gas reduction. Earthcare is a corporate member and signatory of E Mission 55, the European-wide business association that supports ratification of the Kyoto Protocol. Earthcare has worked extensively with EA Technology under the Government's Partners in Technology Scheme.

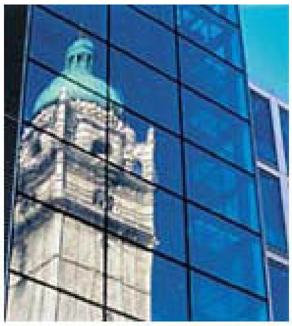
Earthcare has been a finalist and winner of a number of awards, including:

- ACR News Awards 1999: "Environmental Initiative"
- H&V News Awards 1999: "Marketing Initiative"
- Hertfordshire Business Awards 1999: "Greening Supply Chain"

Environmental Initiative **WINNER** | Marketing Initiative **WINNER** | Greening the Supply Chain **WINNER**

1999: McDonalds Education Centre, Millennium Dome – hydrocarbon chillers

1999-2000: Middlesex University Ice Storage System – ammonia chiller



2001: Imperial College, London and associated sites – major refrigerant audit and equipment plan

2001: Bath University Mechanical Engineering – air blast cooling system

2001: HM Customs & Excise, Wolverhampton – hydrocarbon chiller

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