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Engineering in Sustainability and Innovative Development of Controlled Environments: a UK perspective on refrigerants, achieving efficient systems and energy management.

- Introduction
- A UK perspective
- Refrigerants
- Technologies
- System Management
- Financial management

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Introduction

- George Waimann
- Controlled Environment Engineer
- Refrigeration and Controls
- Service, maintenance and new installations
- Develop existing and new systems, incorporate innovative ideas where possible and practical.

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The UK perspective

What are the drivers influencing the UK

?

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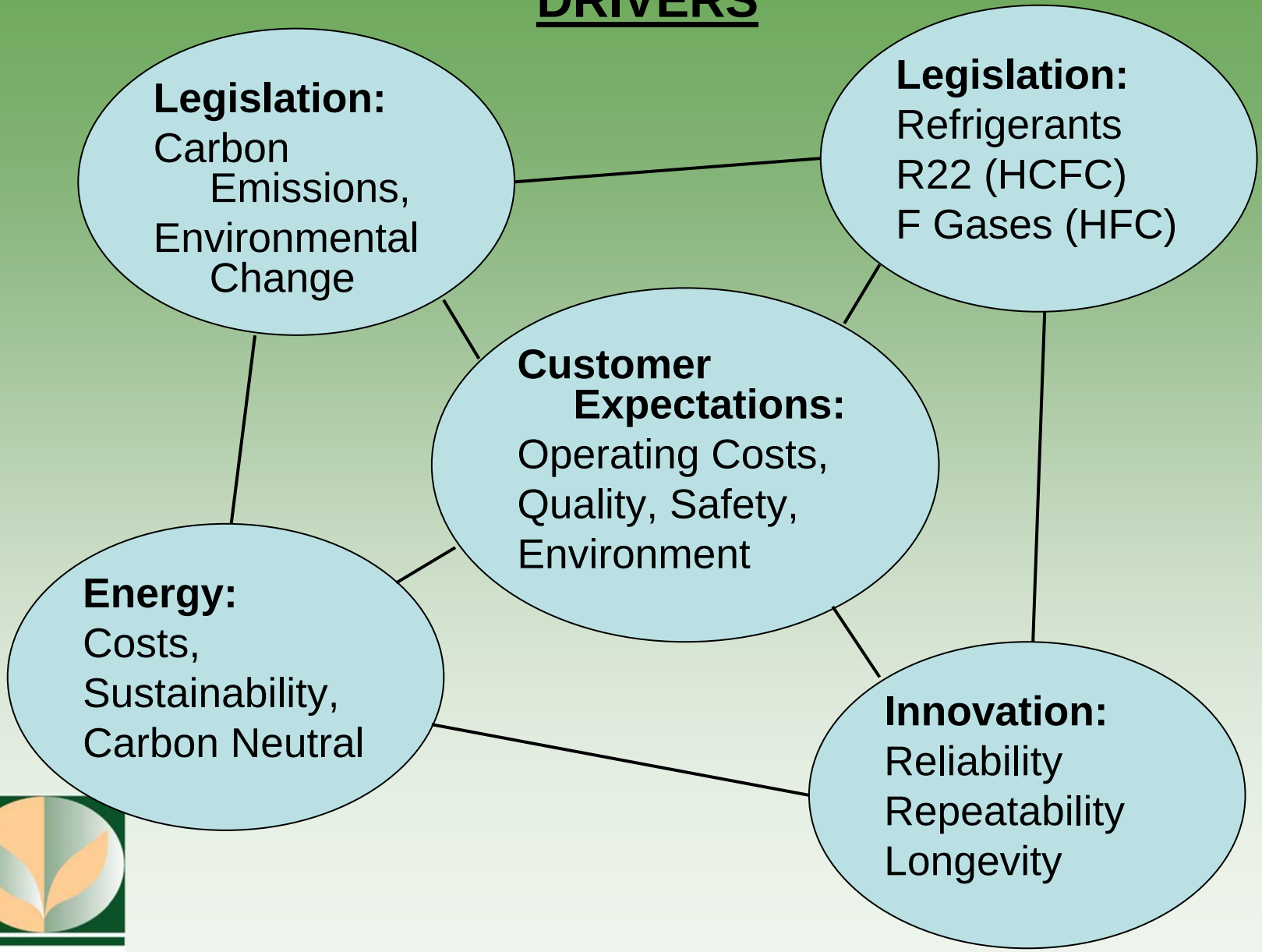
DRIVERS



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UK Refrigeration and Air Conditioning is currently responsible for:

5 million tons of Carbon (2003) levels.

11% of all UK electricity is for commercial and industrial RAC.

10% of greenhouse emissions.

In just one hour enough Solar energy reaches the Earth's surface to meet all of our energy needs for an entire year – if we could harness it.

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Summary of regulations:

Climate Change Bill: UK target 26%-32% CO_2 reduction by 2020.

Energy and the Energy Performance of Buildings Directive.

Ozone depleting and greenhouse gases regulations.

Regulations are appearing and being amended almost weekly!

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http://europa.eu/index_en.htm

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IN THE SPOTLIGHT

- Joint Employment Report 2008
- Managing our borders together
- Debate Europe - have your say on the EU

THE EU DAY BY DAY 22/02/2008

- EU jobs outlook upbeat, but progress uneven
- VAT fraud: The European Commission presents possible far-reaching measures on VAT to better combat fraud
- Sharing excellence: Regional stakeholders gather in Brussels for two-day exchange of ideas on sustainable development, competitiveness

All the news...

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European law
- EUR-LEX, the portal to European Union law
- ŒIL, the Legislative Observatory
- Pre-Lex, monitoring of the decision-making process between institutions
- Case law
- Summaries of legislation

Documents common to all the institutions
- EU Bookshop
- Bulletin of the European Union
- General Report on the Activities of the European Union
  - One year of Europe
- Historical Archives of the European Union
- Glossary

Documents of individual institutions
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- European Parliament
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http://europa.eu/index_en.htm

Map of the world

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"Climate change is a global problem that requires local action," said former President Clinton. http://www.ashrae.org/pressroom/detail/16295

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http://veimages.gsfc.nasa.gov//2429/globe_west_540.jpg

Refrigerants

HCFCs – Ozone Depleting gas, Kyoto and Montreal Protocols.
HFCs – Green House gas, EU - F Gas regulations.

<u>Natural Refrigerants</u>

- Ammonia (NH_3) and Carbon Dioxide (CO_2) are two of the original refrigerants going back some 100 years and have stood the test of time.

- Ammonia has a GWP of 0 (zero) and CO_2 has a GWP of 1 (one).
  Both = Zero Ozone depletion.

- Since January 2007 Denmark has prohibited the use of HFCs in systems greater than 10kg. Therefore natural refrigerants such as Ammonia, CO_2 and Hydrocarbons are playing an important role.

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Refrigerants, three important terms

- **Ozone Depletion.**
  - Gases with the potential to deplete the Ozone, HCFC's
- **GWP: Global Warming Potential.**
  - Gases with Green House Warming Potential if released to atmosphere, 'F gases' for the purposes of this presentation.
- **TEWI: Total Equivalent Warming Impact.**
  - TEWI methodology, which identifies both the 'direct' effect of Greenhouse gas emissions and the 'indirect' effect of carbon dioxide emissions related to energy consumption of the system during its operational life.

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- HCFCs are being phased out, in Europe and the USA.

  - Which? Predominantly R22 however there are also a number of drop-ins for R12 (CFC) which are in use and will also be phased-out.

  - **When Europe?**
    - HCFC phase out from the **1st January 2010**.
    - HCFC complete banning by the **1st January 2015**.
  - What do we mean by Banned? After **1st Jan 2015** it will illegal to replace and/or recharge HCFC refrigerant into a system, whether reclaimed or not.

  - **When USA?**
    - HCFC new production for new equipment **2020.**
    - HCFC new production for servicing equipment **2030**.
    - HCFC stockpiled, recovered and reclaimed: **Indefinite use!**

      http://www.ashrae.org/docLib/20070808_TC0205FAQ33.pdf
  - The Montreal Protocol actually restricts “consumption” rather than use of ozone-depleting substances.

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The following web sites provide more specific information:

Montreal Protocol treaty requirements:

- http://www.unep.org/ozone/treaties.shtml
- Ratification status by country: www.unep.org/ozone/ratif.shtml

- General information and links: www.unep.org/ozone
- Phase out activities: www.uneptie.org/ozonaction.html
- Canadian regulations: www.ec.gc.ca/ozone/tocregs.htm
- U.S. regulations: www.epa.gov/ozone/title6/phaseout/hcfc.html
- Other countries: www.arap.org/regs

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F Gas regulations:

Commission Regulation (EC) No 1516/2007 of 19th December 2007, pursuant to Regulation (EC) No 842/2006.

Systems containing certain fluorinated greenhouse gases

In a nutshell:

- 4th July 2008

  Under the F gas regulation: It will be offence (in Europe) to handle HFCs for installation, maintenance or servicing unless personnel are suitably qualified.

  – Operators will be legally obliged to prevent HFC leakage, to repair leaks as soon as possible and to keep full service records.

  – Systems within the scope of the regulation are subject to regular inspection.

  – The USA, and other developed countries around the world, have a requirement for licensing of personnel working with refrigerants.

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Technologies

New systems

- **Sustainability:** The Holy Grail of Energy: to achieve Zero Carbon, via the use of sustainable energy, often referred to as renewables.
- **Technology Integration:** Integration of new technologies with innovative building methods to optimise building performance and savings.
- **Emerging Technologies:** Research and development of the next generation of energy-efficient components, materials, and equipment.

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Technologies

Emerging Technologies

- The majority of Refrigeration systems are vapour compression.
- Magnetic Refrigeration, >10 years.
- Thermoacoustic Refrigeration, well away from commercialisation.
- Stirling Cycle Refrigeration, heat transfer side is inefficient.
- Thermoelectric Refrigeration, COPs are poor at the moment.
- Air Cycle Refrigeration, used in aircraft, and in development for commercial and industrial systems 11 – 700 kW.
- Absorption Refrigeration is well known, increasingly Adsorption is also being applied, COPs of 0.7 (above 0°C) are typical.
- Tri-generation, (CHP) Combined Heat and Power further combined with Refrigeration.

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Technologies

Advancing technologies

Natural refrigerants

Heat Pumps and heat recovery: electrically driven systems are capable of achieving zero carbon, oil and gas driven systems are not!

Compressor technologies are advancing rapidly to meet the demands for increased efficiencies and alternative refrigerants.

Heat exchanger technologies are also advancing, efficient heat exchange is vital in transferring heat between mediums and minimising losses.

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Technologies that can be applied today:

- Free Cooling
- Heat Recovery
- Heat Pumps
- Thermal storage
- Ground Source
- Do not undersize heat exchangers.
- Do not oversize compressors, pumps and fans.
- At design stage use and run simulation programmes to prove performance with different combinations of plant and settings to determine optimum performance and efficiency.

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A brief selection of recent projects at Rothamsted Research:

Glass Houses, application of single packaged Heat Pumps.

Optimising the inverters on the district heating pumps.

Dry cooler on the district chilled water.

Building 24: application of innovative systems utilising inverter driven compressors, also applied to an installation on building 25.

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Glass House 28

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Building 61, CHP Energy Centre

37 kW district heating pumps, running 24/7.

By optimising the Inverters on the pumps the power absorbed reduced from 37kW to 3.4kW the full duty is only required for about 15% of the year. Electricity costs savings of **$122.00 per day**.
If we assume this is achievable for 70% of the year we will save **$33554.00 per year** on electricity costs alone!
ON ONE PUMP!

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Dry cooler installation on B61 Energy Centre, Chilled Water Circuit

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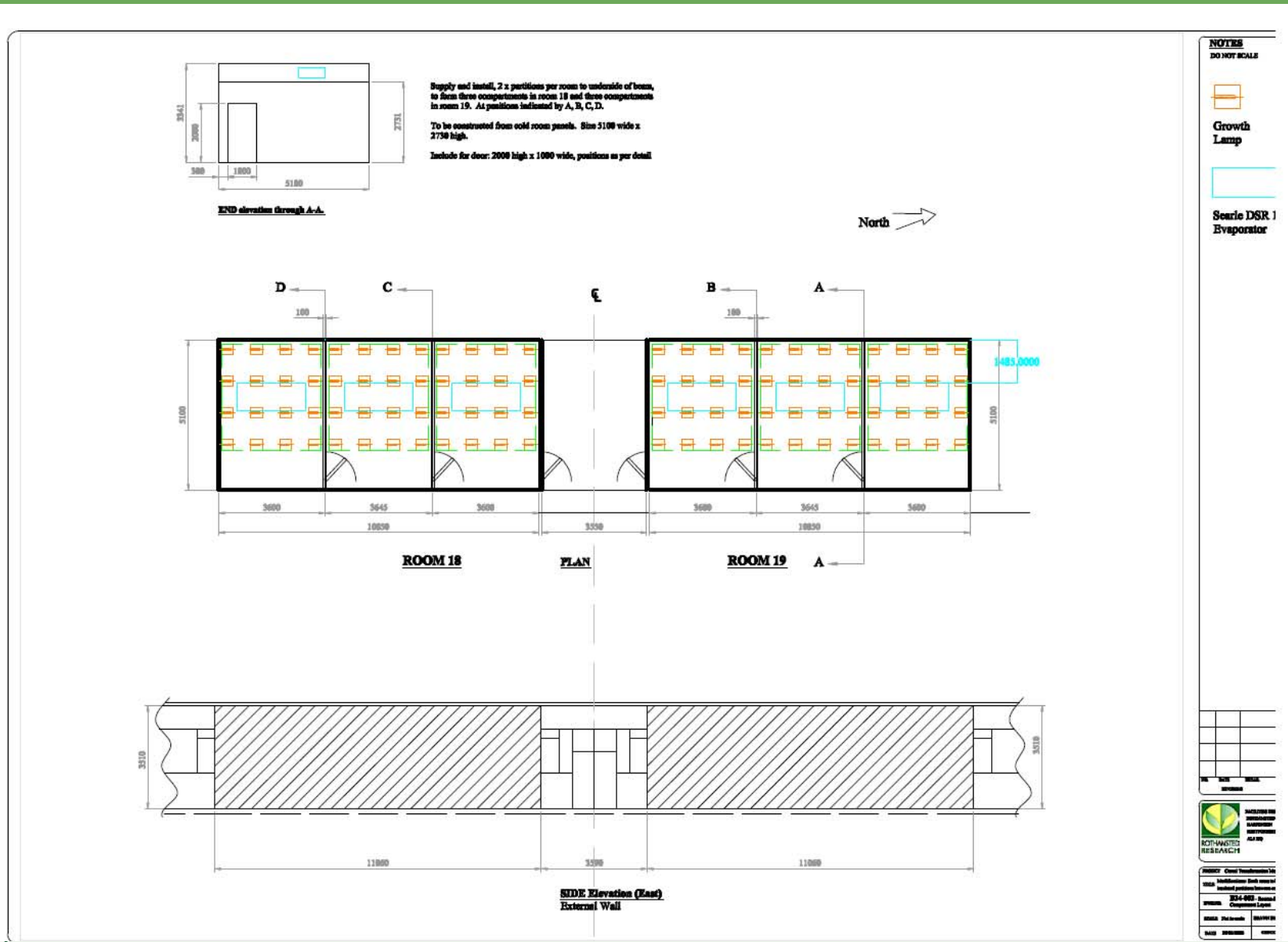

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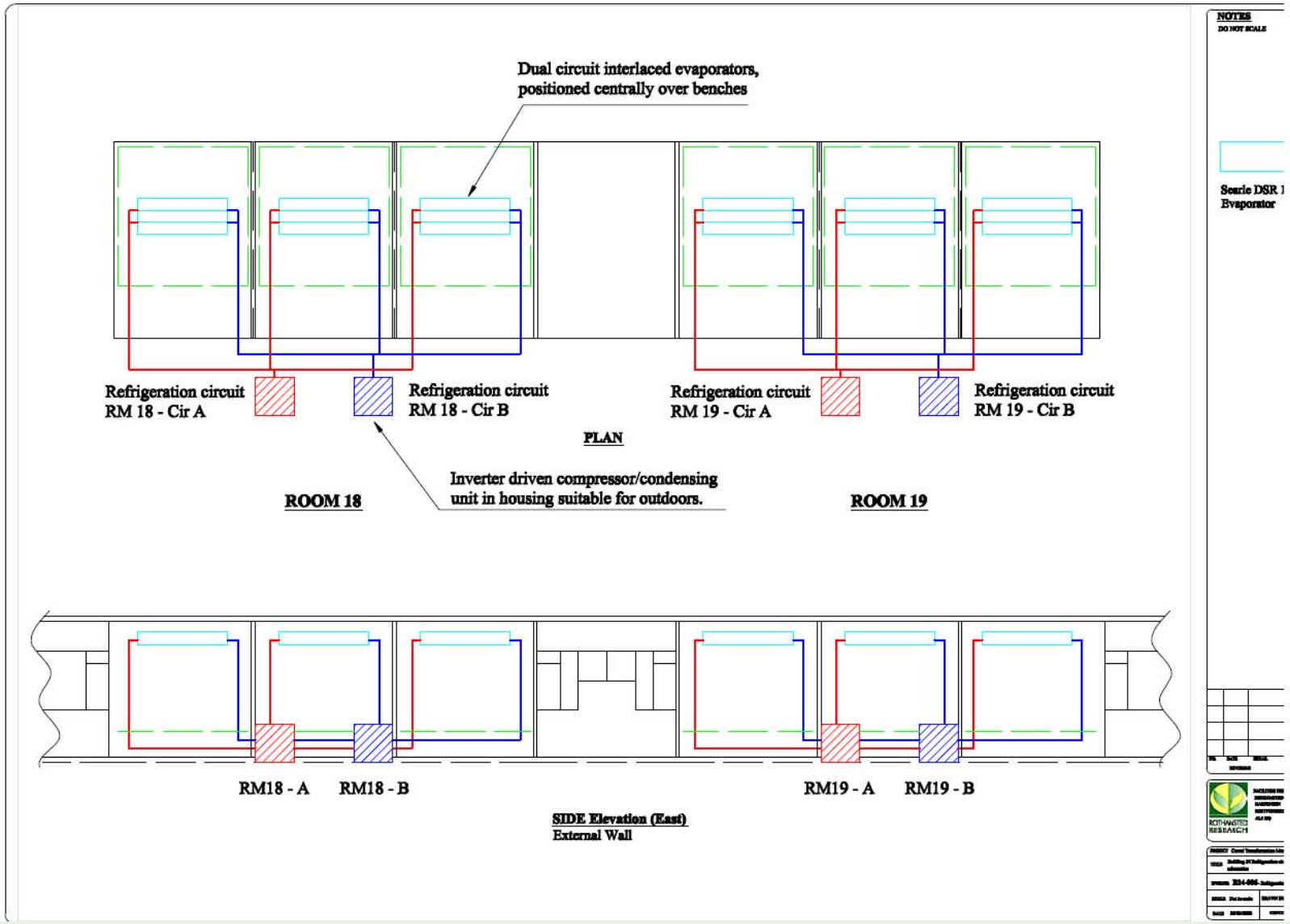
Building 24 Rooms 18 & 19 project
Cereal Donor Rooms



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Refrigeration Schematic Drawing

Building 24 Rooms 18 & 19 project Cereal Donor Rooms

Building 24, Rooms 18 and 19

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Single-stage compressors

Bock Innovations

EFC Electronic Frequency Control

The EFC System
Electronic Frequency Control

Continuously variable speed control using frequency converter technology

Optionally available for all Pluscom compressors
HG(HA)12P, 22P, 34P

With the EFC system Bock offers the most efficient means of adapting the capacity of the compressor to current refrigeration plant requirements: “Progressively adjustable speed control using frequency converter technology“.

Up to 25 % less power consumption!

The equipment is compactly mounted on the compressor, wired and connected ready for use. It is activated by a pressure transducer mounted on the suction side. The adjustment range can be set individually.

Thanks to the oil pump lubrication, Pluscom compressors are ideal for speed control, in particular also for low frequencies.

HG34P with mounted EFC system and connected programming and readout hand-held terminal.

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Bock refrigeration compressor applied to a number of CE facilities at Rothamsted Research.
http://www.bock.de/en/home.html

System Management
Energy Optimisation in existing systems

- Many existing systems are not operating efficiently and are likely to be working outside of the original design.
- Measuring system operation is fundamental to achieving, and maintaining, efficiencies if you cannot measure you cannot move towards optimising the system.
- BMS and SCADA control systems enable control and monitoring.
- Energy Mapping.
- Assessing a system
    - Methodology:
        - Take a snap shot
        - Compare with expected results
        - Look for discrepancies
        - Diagnose and rectify faults!

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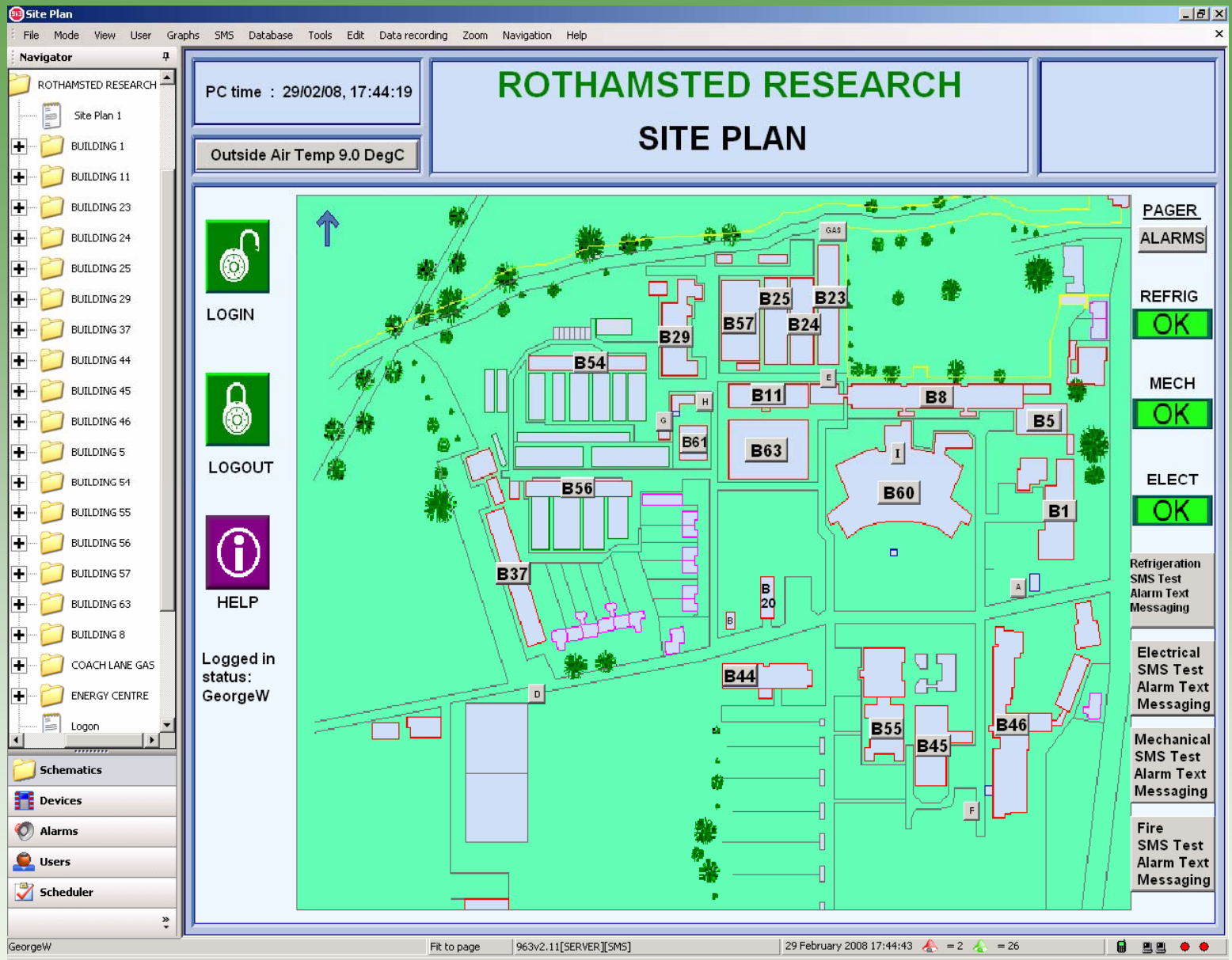

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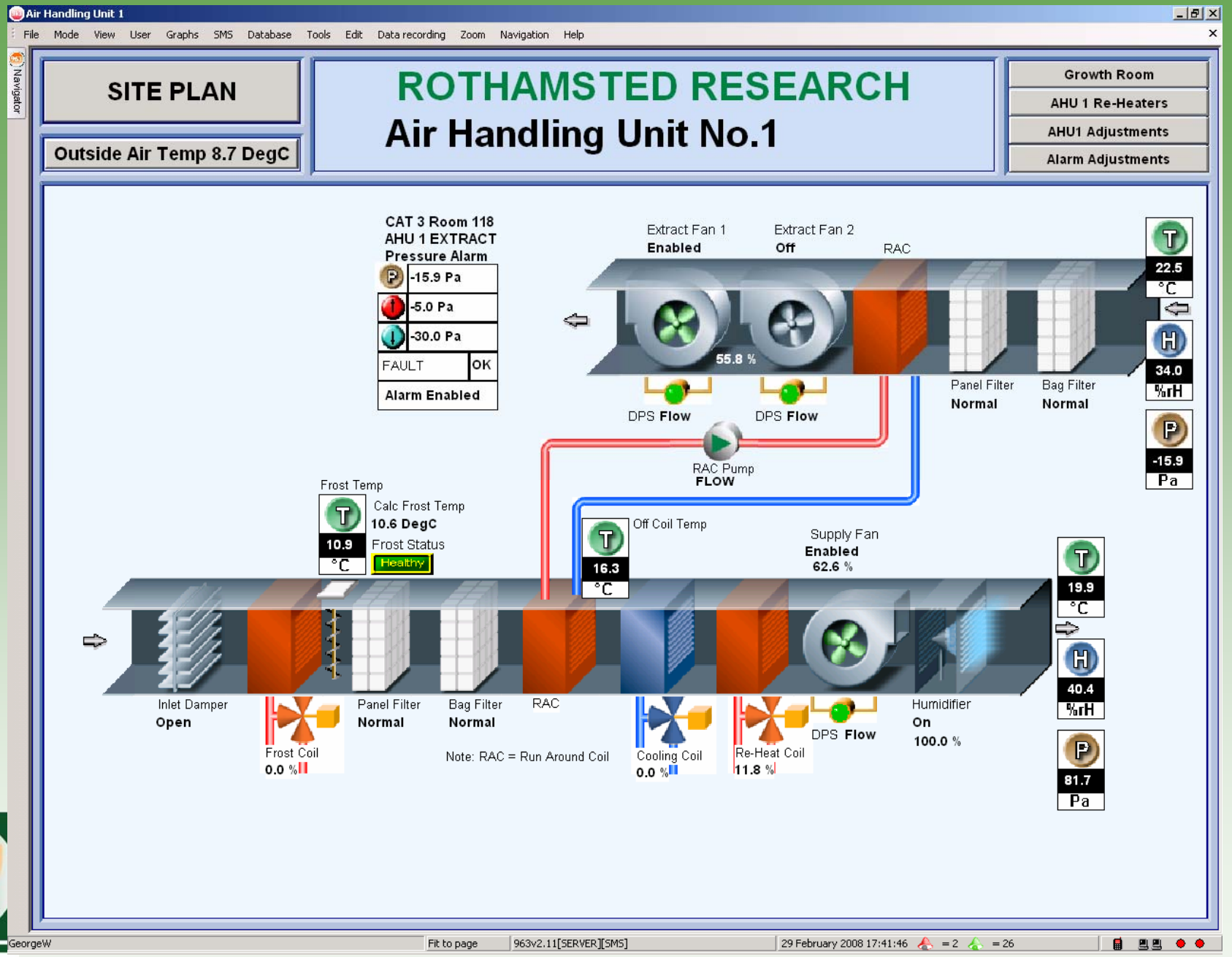
TREND Building Management System

http://www.trend-controls.com/wps/portal/trend/



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Building 63 TREND Building Management System

System Management

Energy Optimisation in existing systems

1 C° degree change in temperature can return 2%-4% savings.

- Ensure space temperatures are set correctly and are controlling correctly, do not use dead bands that are closer than necessary, check that there is no conflict with other energy users.
- On refrigeration systems ensure Condensing temperatures are not operating higher than necessary and Evaporating temperatures are not operating lower than required.
- Ensure refrigerant charge is correct.
- Coils must be clean and free from frost.
- Control of Compressors, fans and pumps, ensure they are not running excessively or running over duty, utilise inverters.

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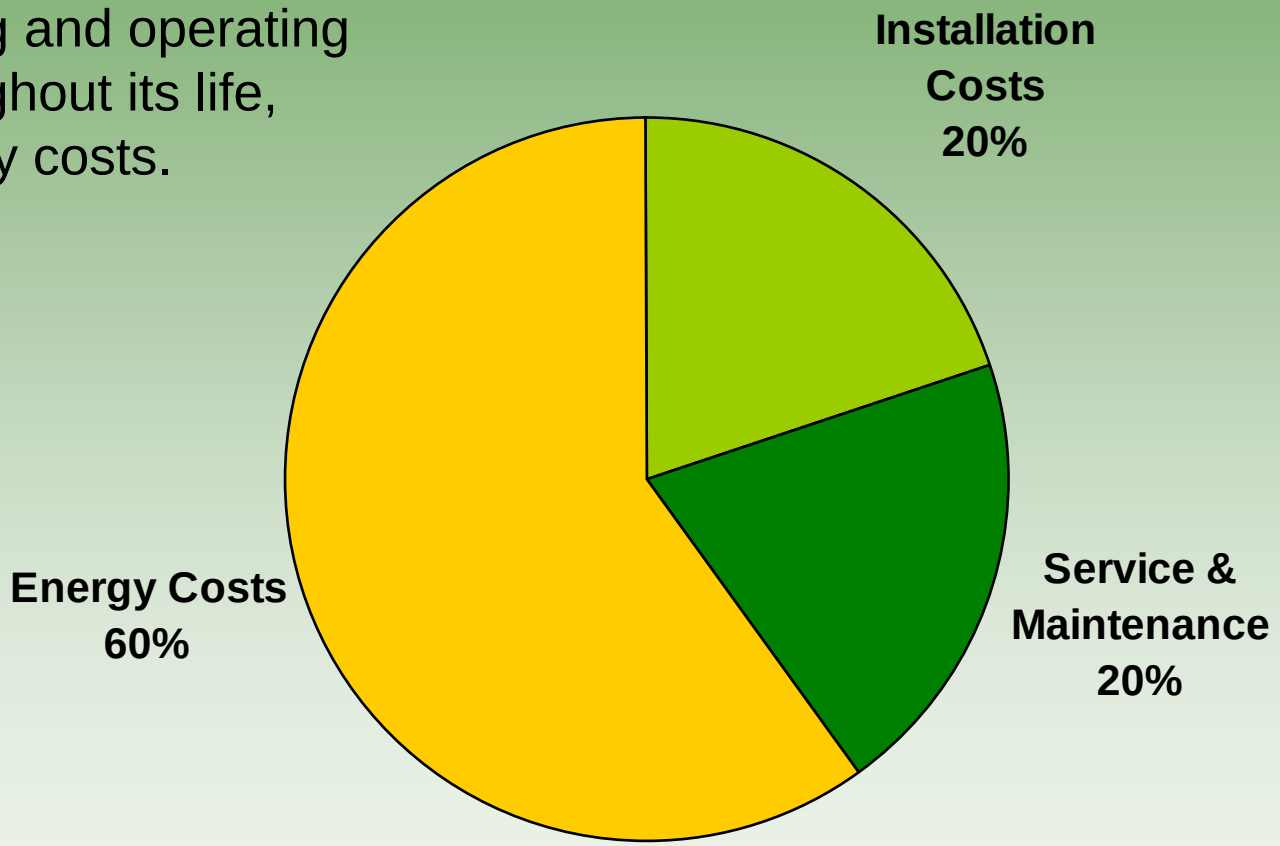
Financial management

- **Life Cycle Costs:** The total cost of installing and operating a system throughout its life, including energy costs.



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Financial management

- Design
- Energy monitoring and Mapping
  - Electricity
  - Gas
  - Water
- Effective facility usage management
- Planned maintenance
- Control & Monitoring

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Conclusion

Useful links:

http://www.ashrae.org/

http://www.rses.org/main/index.cfm

http://www.ior.org.uk/

http://www.sirac.org.uk/

http://www.acrib.org.uk/

http://www.defra.gov.uk/

- http://www.defra.gov.uk/environment/climatechange/index.htm
- http://www.defra.gov.uk/environment/climatechange/uk/fgas/index.htm
- http://www.defra.gov.uk/environment/climatechange/internat/fluorinated.htm

http://www.cibse.org/

http://europa.eu/index_en.htm

http://www.figaroo.org/en/

http://en.wikipedia.org/wiki/Chlorofluorocarbon#_note-0

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Julian Franklin, CE manager at Rothamsted

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