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Energy Efficiency in Horticulture

INTRODUCTION

Efficient energy use has never been more crucial than it is today, particularly with increasing energy prices and with energy taxes like the Climate Change Levy (CCL). It vitally important to constantly review where, how and why energy is being consumed in your business and what sensible economy measures can be made.

The following sections give some indication where savings in energy can often be made in horticulture.

BOILER EFFICIENCY

This should be checked using a flue gas analysis kit. These kits consist of a Carbon Dioxide ($C0_2$) gas analyser, a flue gas thermometer and a smoke tester. They are simple to use and with the information gained the burner can then be set up for optimum operation. The following table gives target values for CO_2 and Oxygen (O_2). These targets are only a rough guide as individual boilers might have specialist requirements.

Target flue gas composition for boilers

Fuel	**Theoretical CO2 % (dry basis)**	**Target CO2 % (dry basis)**	**Target 02 % (dry basis)**
Bituminous coal	16.6	12.0	7.4
Dry steam coal	19.2	13.0	7.9
Coke	19.5	13.0	7.0
Natural gas	11.7	10.7	2.1
Propane	13.5	12.4	2.1
Butane	14.1	12.7	2.1
35 sec fuel oil	15.4	12.7	3.8

Boilers that are used on low demands often operate at very low efficiencies. In this situation the fitting of an automatic air inlet or flue dampers improves performance somewhat. As an alternative, consideration could be given to installing a smaller auxiliary boiler or electric flow boiler to heat restricted areas of the glasshouse instead of using the main boiler plant.

INSULATION

Boiler and Distribution Pipes

The boiler, hot water tanks and distribution pipe-work should all be adequately lagged, kept weatherproof and in good repair. If pipe insulation is allowed to become wet its insulation properties virtually disappear. A 1m length of un-insulated 100mm pipe carrying water at about 80° C can waste 200kWh of heating fuel a week. Pipe runs are best made above ground in visible areas - underground pipes make it difficult to inspect for leaks or breakdown in insulation.

Oil storage

Where fuel oil is stored in pre-heated tanks these should also be adequately lagged and weatherproofed.

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Soil warming

Where hot water pipes or electric cables are used to heat ground level beds within the greenhouse, it is important to insulate the beds with 25 - 50mm thick expanded or (preferably) extruded polystyrene sheet. This will minimise heat loss downwards into the ground.

Greenhouse Structure

Improvements in the greenhouse structure itself present the biggest opportunity to save energy.

Air leakage

By reducing air leakage from the structure a 10 - 30% wintertime fuel saving can be made. Windy weather increases heat loss greatly, so attention to draught proofing and air leaks is very important. If the air change rate changes from say, 0.5 to 5 changes per hour, then the greenhouse heat loss can increase by as much as 45%.

All openings to the greenhouse should be inspected to see that they make a good seal when closed and all cracked, broken or displaced glass should be replaced. Glass to glass joints should be sealed with clear silicone sealant. Such measures will reduce the number of air changes per hour dramatically and this will be reflected in savings in heating costs.

Traffic in and out of the greenhouse should be minimised and personnel instructed to keep access doors closed.

Thermal screens

Screens have been used in greenhouses for many years. Originally their use was restricted to blackout and shading for specific crop production. As energy saving measures have become more important, retractable screens have been developed as a means of improving energy efficiency. Vertical (sidewall) screens have also been developed for the same purpose. Depending upon the material used, screens can have a large impact on the energy consumption of a greenhouse by reducing ventilation, infra red radiation and convection. Manufacturers of thermal screens claim up to 60% energy savings - although 35% is more typical. Producers of high energy greenhouse crops should seriously consider the economics of installing thermal screens.

Simple polythene lining or bubble plastic is a cheaper but less effective alternative to a purpose-built retractable screen system. Incoming light loss may however cause problems with some crops.

Air circulation

Internal air circulation by means of low powered axial fans will reduce vertical temperature gradients within the greenhouse. Even temperatures (both vertically and horizontally) will produce more uniform crops and save on energy input. A temperature only 1°C higher than that required can increase fuel bills by 7.5% or more.

Generally ten fans per hectare are installed, each giving about 1.5m^3/sec. air flow.

Controls

The control of the heating system to the greenhouse must obviously be as accurate as possible. Heating controls may range from simple rod type thermostats right through to fully integrated climate control computer systems. Whatever the level of sophistication, checks should be made on dial settings or read-outs against 'benchmark' instruments e.g. a simple but accurate thermometer. Sensors to control systems must receive a representative sample of air to be able to produce accurate readings. An aspirated screen should be used for this. Response time is faster

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using this arrangement and therefore a more accurately controlled environment is achieved.

Controls should also extend to other equipment such as thermal screens and lighting installations (where used). Automatic operation of these facilities will ensure that optimum environmental conditions are maintained and crop performance maximised.

LIGHTING

Supplementary lighting

Where supplementary lighting is used in crop production, cleaning of the reflectors and lamps should be carried out on a regular basis. A programme of re-lamping after an appropriate number of hours use (see manufacturers' recommendations) will ensure the target light level is maintained. It is important to re-lamp complete sections, as piecemeal replacement will result in an uneven light pattern. This will lead to corresponding variation in the crop being produced.

To ensure target light levels are achieved any lighting scheme should be properly designed in the first instance. Reputable manufacturers and suppliers will provide this service.

The electrical supply voltage should also be checked as small variations can significantly affect light output. Induced harmonics can also be problematic and lead to light levels which are considerably less than the target value. The solution of both voltage and harmonic problems is complex and should only be tackled by a qualified electrical engineer.

It should also be remembered that the best way to optimise energy use on a lighting installation is to make the best use of free natural light. Regular cleaning of the glass and/or plastic cladding components will help to optimise light transmission and reduce the dependence on light from artificial sources.

Task lighting

For large areas where the lamps are left on for long periods, high intensity discharge lamps such as High Pressure Sodium, Metal Halide and Mercury Vapour are suitable. These lamps have a long life and are cheap to run.

Low Pressure Sodium lights are suitable for all night security lighting. The light emitted is monochromatic yellow. High Pressure Sodium should be used if better colour rendering or appearance is required. For colour sensitive tasks, high quality colour rendering lamps such as Fluorescent lighting can be used to obtain light quality close to daylight.

Where any food or drink product is involved, all fittings should be totally enclosed to avoid glass hazards.

ALTERNATIVE APPROACHES

Crop schedules

It may be possible to reduce energy consumption by reorganising the timing of crop production i.e. planting later in the season. However, before adopting a strategy like this, the knock-on effects of marketing and prices should be thoroughly investigated.

Reduced temperature

Operating the greenhouse at a reduced temperature for part or all of the growing season can cut energy costs but this is often at the expense of both crop yield and quality. This approach rarely offers a practical way to improve the energy efficiency of a greenhouse.

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Plant spacing and shelving

Where it is feasible, plant densities can be increased. Crops can be grown on high level shelves or under benches - any of these configurations improve the use of greenhouse space and make for more efficient use of fuel.

Wind breaks

External wind speed has a great effect on the heat loss from a greenhouse. Wind breaks can be a shelterbelt of trees or plastic mesh. Trees are cheaper than plastic mesh but obviously take longer to establish. Reducing wind speed by 30% can give a fuel saving of up to 10%. Wind-breaks also go some way to protect greenhouse structures from damage during stormy weather.

MAJOR REDESIGNS

Combined Heat and Power (CHP)

In the Netherlands, CHP installations are quite common in greenhouses which grow high energy input crops (e.g. salad vegetables, pot plants, etc.). Gas fuelled engines driving an electric generator are the most usual configuration. Heat from the engine oil, cooling system and exhaust is reclaimed and used to heat the greenhouse. CO2 can also be recovered from the engine exhaust and used for atmosphere enrichment.

Partnerships are drawn up between growers and power companies where heat and some electricity is supplied to the greenhouse. Any surplus generated electricity is exported off site into the national grid network. This approach is still in its comparative infancy here in the UK, but has become more popular over the last two to three years. It is therefore quite possible to engineer and design economically viable installations in the UK, but the economics of any proposal need close scrutiny. Any CHP scheme should be subject to an in depth feasibility study with particular attention being given to the use of the heat produced and the cost and retail price of the power being exported.

Boiler 'bolt on' improvements

It may be possible to improve the efficiency of older boiler plant by fitting various devices.

Chimney isolators, boiler tube turbulators, economisers and flue gas condensers for gas fired equipment can all produce fuel economies of between 4 - 12%. However, the assessment and engineering of such devices is specialist work.

Finally

Fuel prices seem set to increase over time, so energy efficiency in whatever form should be a high priority. FEC Services produces specialised energy audit documents designed to focus on efficient energy use and assist in prioritising your actions. Please contact us for further information.

The table below gives an indication of areas of potential energy reduction and cost for some categories mentioned in this publication.

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Potential Energy Reduction and Cost

Description of Measures	Potential Energy Reduction (%)	Cost Category
Monitoring & targeting	up to 10%	Low
Energy awareness train-ing	up to 10%	Low
Efficient light sources	80%	Low/Medium
High efficiency motors	3%	Medium
Variable speed drives	40%	Medium
Improved controls	15%	Medium
Thermal screens	35%	High
New greenhouse designs	25%	High
Flue gas condensers	15%	High
De-centralised boiler plant	15%	High
CHP	30%	High
Thermal storage	20%	High
Heat pumps	30%	High

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