

Industrial refrigeration equipment

A guide to equipment eligible for
Enhanced Capital Allowances



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Introduction

ECAs are a straightforward way for a business to improve its cash flow through accelerated tax relief. The scheme encourages businesses to invest in energy saving plant or machinery specified in the ETL to help reduce carbon emissions which contribute to climate change.

The Energy Technology List (ETL) is a register of products that may be eligible for 100% tax relief under the Enhanced Capital Allowance (ECA) scheme for energy saving technologies¹. The Carbon Trust manages the list and promotes the ECA scheme on behalf of Government.

This leaflet gives an overview of industrial refrigeration equipment specified on the ETL and aims to help businesses present a sound business case for purchasing energy saving equipment from ETL manufacturers and suppliers.

Background

The ETL comprises two lists: the Energy Technology Criteria List (ETCL) and the Energy Technology Product List (ETPL). The ETCL defines the performance criteria that equipment must meet to qualify for ECA scheme support; whereas the ETPL is a qualified list of products that have been assessed as being compliant with ETCL criteria.

Further information

For more information visit www.carbontrust.co.uk/refrigeration or download the Carbon Trust's Refrigeration technology overview (CTV002).

Setting the scene

There are two primary applications of industrial refrigeration equipment:

- Cooling, freezing and temperature maintenance during storage, transportation and distribution of food products.
- Air conditioning systems.

Other applications of industrial refrigeration can be found in chemical plant (for example, for the separation of gases), in manufacturing and construction, in ice and snow sports and in environmental test chambers.

Industrial refrigeration systems use large amounts of energy and typically cost 7-10 times as much to run over their lifetime as they do to buy². The use of energy efficient industrial refrigeration equipment, such as that listed on the ETL, can result in significant energy savings and, therefore, reduced energy bills.

¹ Eligibility for ECAs is based on a number of factors. Visit www.eca.gov.uk/energy to find out more.

² Food and Drink Industry Refrigeration Initiative, Guide 2, Purchase of efficient refrigeration plant, IOR, July 2007.

Benefits of purchasing ETL-listed products

A system using an ETL-listed industrial refrigeration product can use significantly less energy than a typical system using non-ETL products. ETL-listed products have a number of energy efficiency advantages, including higher efficiencies of specific components such as compressors; better combinations of components in packaged chillers and condensing units; the use of free cooling; improved controls; and better operation achieved through the use of refrigerant leak detection and automated air purgers.

When replacing equipment, businesses are often tempted to opt for that with the lowest capital cost; however, such immediate cost savings can prove to be a false economy. Considering the life cycle cost before investing in equipment can help reduce costs and improve cash flow in the longer term.

The ECA scheme provides businesses with 100% first year tax relief on their qualifying capital expenditure. This means that businesses can write off the whole cost of the equipment against taxable profits in the year of purchase. This can provide a cash flow boost and an incentive to invest in energy saving equipment which normally carries a price premium when compared to less efficient alternatives.

Using this leaflet you can calculate the benefits of investing in qualifying ETL energy saving equipment over non qualifying equipment. The calculation includes the benefits of accelerated tax relief, reduced running costs, increased efficiency, lower energy bills and reduced Climate Change Levy payments (if applicable), which in turn helps reduce payback periods.

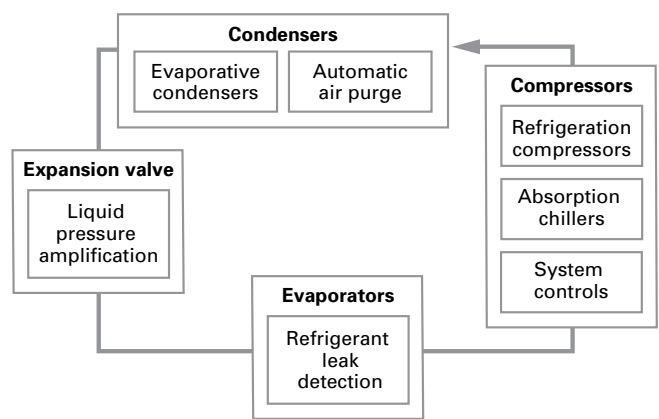
Important

Businesses purchasing equipment must check the ETPL at the time of purchase in order to verify that the named product they intend to purchase is designated as energy saving equipment. Industrial refrigeration equipment that meets the ETL eligibility criteria but is not listed on the Energy Technology Product List (ETPL) at the time of purchase is not eligible for an ECA.

Industrial refrigeration equipment eligible under the ECA scheme

The following sections describe the refrigeration equipment specified as energy saving under the ECA scheme. The diagram below illustrates these ECA-eligible components and their relationship to each other.

Figure 1 Industrial refrigeration equipment eligible under the ECA scheme



Using the baseline scenario below, where appropriate the potential financial (£), energy (kWh) and carbon savings (tonnes CO₂) have been calculated for replacing component parts of a refrigeration system with ETL-qualifying equipment to highlight the potential benefits that can be achieved.

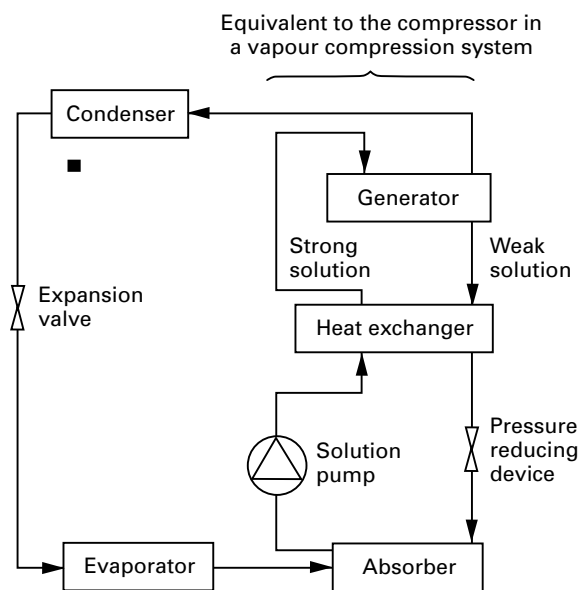
Baseline scenario:

- Refrigeration plant with an installed cooling capacity of 400kW
- Producing chilled water at 5°C
- Compressor power demand of 100kW
- Annual operating hours: 8,000
- Electricity price 7.9p/kWh
- Electricity CO₂ emission factor: 0.43kg CO₂/kWh
- Annual savings do not degrade.

Absorption chillers

Absorption chillers (chillers) are heat-driven (as opposed to electrically driven) machines used in industrial refrigeration to cool a process or product. They operate using an absorption refrigeration cycle. In this cycle, two fluids are used – a refrigerant in conjunction with an ‘absorber’ – which have a high mutual solubility. Most commercially available absorption chillers use either ammonia and water or water and lithium bromide. Figure 2 shows the absorption refrigeration cycle. The compressor of the conventional system is replaced by an absorber and generator. The refrigerant vapour from the evaporator is absorbed at low pressure and low temperature. The resulting solution is then pumped to high pressure and heated in the generator where the refrigerant is released. The remainder of the cycle is conventional.

Figure 2 Absorption refrigeration cycle



Absorption chillers may be driven by waste heat from thermal processes, and in particular from combined heat and power (CHP) systems. This offers significant benefits to CHP schemes since the additional heat load may increase the CHP plant running hours and the plant size, and also the electrical demand of the site will be reduced.

ECAs are available for absorption chillers used in conjunction with a CHP scheme that has been awarded a certificate from the CHP Quality Assurance (CHPQA) Programme³.

By installing an ETL-listed absorption chiller in place of a baseline scenario refrigeration system (400kW chiller), the potential annual savings are calculated as:

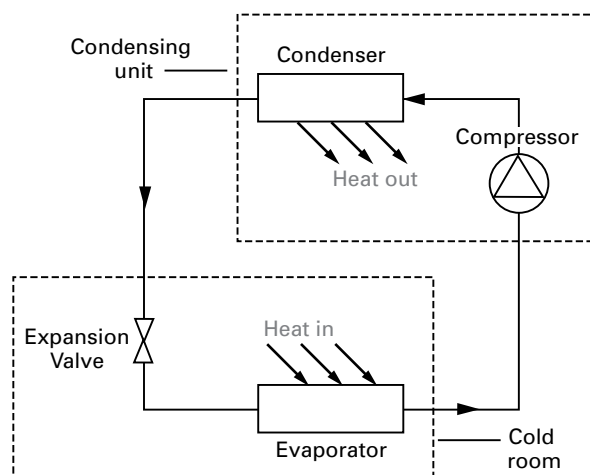
- £63,000
- 800,000kWh
- 344 tonnes CO₂.

In this scenario the absorption cooler is using waste heat from a CHP plant. The heat is assumed to be free.

Air-cooled condensing units

An air-cooled condensing unit consists of a compressor and an air-cooled condenser combined with various ancillary components such as a liquid receiver, shut off valves, filter drier, sight glass and controls. The unit is factory assembled and wired as a complete unit. It provides a convenient method for ‘powering’ a cold room or other cooling equipment that has an evaporator with expansion valve control. Refrigerant vapour from the evaporator is compressed and condensed for return to the evaporator as a high pressure liquid. This process is shown in Figure 3, below.

Figure 3 Simple refrigeration circuit showing condensing unit linked by two pipes to a typical cooling load



³ CHP Quality Assurance (CHPQA) Programme (www.chpqa.com)

Medium and low temperature condensing units are widely used for frozen and chilled food storage. Evaporating temperatures are typically -35°C for frozen product and -10°C for chilled product. High temperature units are used in air conditioning applications. Figure 4 shows a typical air-cooled condensing unit.

Figure 4 Condensing unit showing compressor compartment



Image courtesy of Hubbard Products Ltd

The energy efficiency of an air-cooled condensing unit is dependent on refrigerant and operating conditions and is expressed as a Coefficient of Performance (COP)⁴. The rating conditions for condensing units are set out in EN 13215⁵. The threshold eligibility values for COP for low and medium temperature applications with refrigerant R404A and for high temperature applications with refrigerant R407C are specified in the ECA criteria. In order to be eligible for an ECA, the unit must be rated at one or more of these conditions.

Efficiency can be enhanced by liquid sub-cooling within the unit. This can be achieved by using either additional dedicated coils in the condenser or two-stage or economised cycles. In order to be eligible for an ECA, the additional sub-cooling method and liquid temperature must be stated.

By installing an ETL-listed air-cooled condensing unit in place of one that is 25% less efficient, the potential annual savings are calculated as:

- £890
- 11,300kWh
- 4.8 tonnes CO₂.

Based on the following scenario:

- 11kW continuous load at -20°C with the condensing unit running approximately 20h/day
- Refrigerant R404A
- No condensing pressure control i.e. pressure allowed to fall at low ambient conditions.

Automatic leak detection

Automated permanent refrigerant leak detection systems are products designed to continuously monitor the atmosphere in the vicinity of refrigeration equipment and, in the event of detection of refrigerant, raise an alarm. The early warning of refrigerant leaks allows repairs to be carried out early. This improves the energy efficiency of the refrigeration system and reduces carbon emissions and other greenhouse gases.

The majority of industrial refrigeration systems currently use either an HCFC or HFC refrigerant. Some systems use ammonia; however, ammonia detection devices are currently outside the scope of the ETL.

Refrigerant leakage may lead to a reduction in the efficiency of refrigeration equipment by causing a direct reduction in COP. Leaking systems can therefore contribute twice to climate change; once through the direct emission of refrigerant, and secondly through increased emissions from higher electricity consumption.

A recent estimate suggested that average refrigerant leakage rates are around 20% of total charge per year, and that typically a leaking system experiences an 11% reduction in COP⁶.

Automatic permanent leak detection systems are usually multi-point or single point sensing devices. A single point detector is a self-contained device installed in a plant room in a location where it is likely to detect the early onset of leakage. Multi-point detectors are often aspirated (they draw or suck air down tubes from each sample point to a central detector unit and control panel) and can typically monitor up to 16 locations.

⁴ Defined as the ratio of cooling capacity to electrical power input, (including both compressor condenser fan power).

⁵ European Standard EN13215 Condensing units for refrigeration – Rating conditions – tolerances and presentation of manufacturer's performance data, 2000.

⁶ Gartshore J. Energy Efficiency and Leakage Reduction. Refrigeration: Optimising refrigeration systems for building services engineers. CIBSE 2008.

Automatic leak detection systems eligible for ECAs must be able to continuously and permanently monitor the refrigeration system for refrigerant leakage by detecting the presence of one or more specified refrigerants. They must also raise an audible alarm when the level of refrigerant in the atmosphere exceeds a specified level.

By installing an EPTL-listed automatic leak detection system in a plant room with a chiller, based on the baseline scenario provided, and assuming an 11% reduction in EER due to undetected refrigerant leakage, the potential annual savings are calculated as:

- £7,811
- 98,876kWh
- 42.5 tonnes CO₂.

Automatic air purgers

Automatic air purgers continuously purge non-condensable gases (such as air) from the condenser and receiver of a refrigeration system in order to reduce condenser pressure (also known as head pressure). This reduces compressor power use and increases the cooling capacity of the plant.

The presence of non-condensable gases increases head pressure in two ways: the partial pressure of the non-condensable gas adds to the partial pressure of the refrigerant gas to increase the total head pressure, and the non-condensable gases reduce the heat transfer rate in the condenser. These non-condensable gases may become introduced during maintenance and can leak into the system, or they may result from the breakdown of refrigerants and oils.

Automatic air purgers are generally suited to larger refrigeration plant, where the build up of non-condensable gases is a recurring problem.

The potential annual savings achieved as a result of the installation of an automatic air purger in a cold store plant consuming 70kW on average are calculated as:

- £6,920
- 87,600kWh
- 38 tonnes CO₂.

Refrigeration system controls

Refrigeration system controllers vary enormously in function and complexity. The simplest control is a thermostat which simply controls the temperature of the cooled space. More complex refrigeration systems, such as those with multiple compressors, ideally require more sophisticated control. When used in the right way, these controls can significantly reduce the amount of energy a refrigeration system uses.

The ETPL currently includes system manager controls (with optimisation and energy log) and anti-condensation heater controls. System manager controls are computer-based systems that integrate and monitor the other control devices in the system to optimise performance and monitor energy consumption. For example, some controls monitor ambient temperature and/or load to determine optimum condensing and/or evaporating pressures.

Using the baseline scenario below, the potential financial (£), energy (kWh) and carbon savings (tonnes CO₂) have been calculated for the use of an ETL-listed refrigeration system controllers.

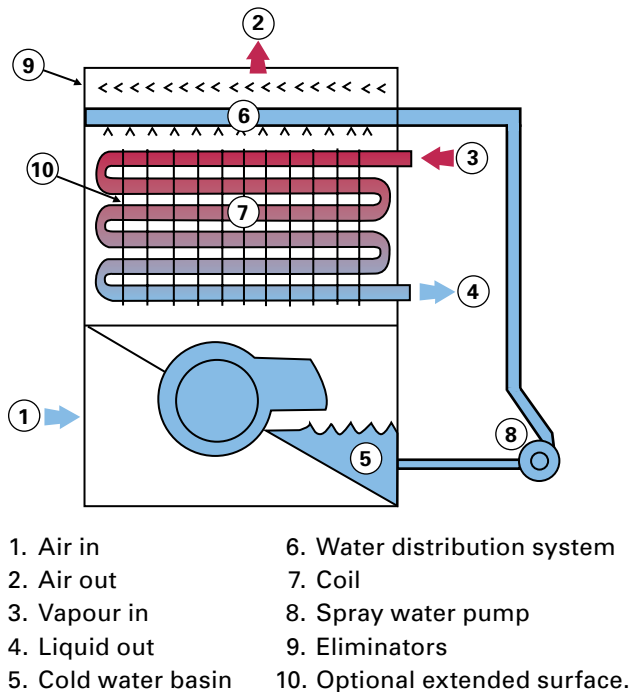
The potential annual savings achieved as a result of the installation of ETL-listed refrigeration system controls at an industrial site running 25 evaporators and three cold rooms are calculated as:

- £3,250
- 41,133kWh
- 17.7 tonnes CO₂.

Evaporative condensers

Condensers are used in a refrigeration system to liquify the refrigerant gas discharged by the compressor. Most condensers used are air-cooled, i.e. ambient air is used to remove the heat from the condensing refrigerant. In an evaporative condenser, the gas to be condensed flows through a coil which is continually wetted on the outside by recirculated water. Air is drawn over the coil, evaporating some of the water. This improves the rate at which heat is rejected from the refrigerant gas, allowing it to condense at a lower temperature relative to the air temperature.

Figure 5 Diagram showing typical evaporative condenser operation



By installing an ETL-listed evaporative condenser in place of an air-cooled condenser on a system with 500kW heat rejection, the potential annual savings are calculated as:

- £6,470
- 81,866kWh
- 35.2 tonnes CO₂.

Assuming that the minimum condensing temperature in both systems is 20°C, fan and pump power are the same and the cost of water treatment for the evaporative condenser is not included.

Liquid pressure amplification

Liquid pressure amplification (LPA) involves the use of a pump between the condenser and the expansion valve in a refrigeration system. This pump raises the liquid pressure at the expansion valve allowing the head pressure to be lowered. This reduces the power required by the compressor (increasing the COP) to achieve a given amount of cooling.

Many refrigeration systems operate with higher head pressures than necessary. Without controls, head pressures would be lower in mild and colder weather compared with hotter days. However, because of constraints on the pressure, systems generally have controls that maintain the head pressure at high levels by, for example, cycling condenser fans on and off.

LPA provides a means of operating at lower head pressures while still satisfying the constraints on liquid pressure. On a typical installation, test data shows that savings of 20% of power use (average over a whole year) are typical⁷.

It is estimated that head pressure control is present on some 80% of all installed refrigeration systems. However, LPA is only cost effective on the larger systems using more than approximately 250,000kWh a year of electricity (worth £20,000 a year)⁸.

The potential annual savings shown are based on comparison between a conventional refrigeration system with head pressure controls and one fitted with an ETL-listed LPA system.

- £13,120
- 160,000kWh
- 69 tonnes CO₂.

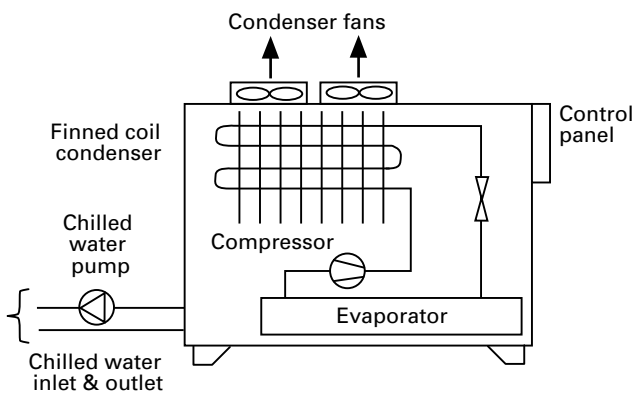
⁷ ECA LPA Technology Review.

⁸ ECA LPA Technology Review.

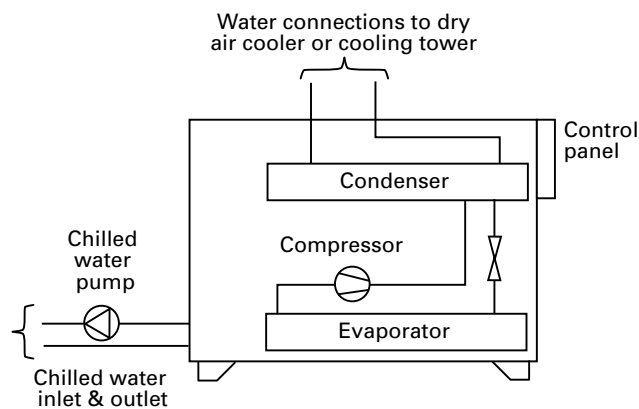
Packaged chillers

Packaged chillers are factory assembled refrigeration units that are designed to cool liquid using a self contained, electrically-driven mechanical vapour compression system. A packaged chiller includes the refrigeration compressor(s), controls and the evaporator in the packaged unit. The condenser may be built-in or remote. Some packaged chillers may also include a hydronic unit comprising a chilled water buffer tank and a chilled water circulation pump.

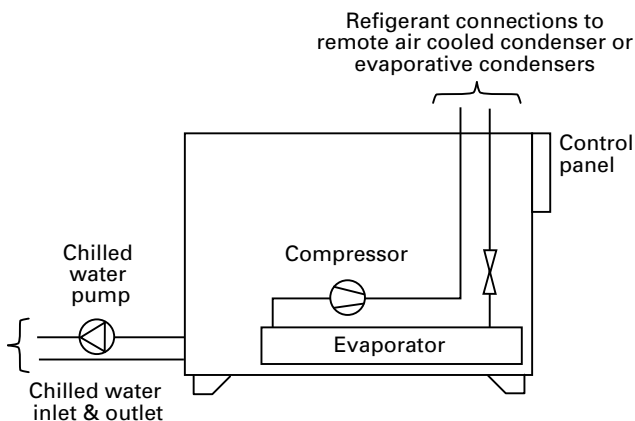
- Air-cooled packaged chillers



- Water-cooled packaged chillers



- Packaged chillers with remote air-cooled condensers



Packed chillers eligible for ECAs include chillers designed for the following air conditioning and refrigeration (including process cooling) applications:

- Air conditioning, with a leaving chilled water temperature of +7°C
- Medium brine, with a leaving brine temperature of -5°C
- Low brine, with a leaving brine temperature of -15°C.

These chillers may operate with any type of electrically driven compressor, use any refrigerant, and can be air-cooled, water-cooled, evaporatively-cooled or have a remote condenser. They may be cooling-only or reverse cycle.

By installing an EPTL listed 500kW air cooled packaged chiller the potential annual savings are calculated as:

- £878
- 11,111kWh
- 4.78 tonnes CO₂.

Based on the following scenario:

- Installation of one 500kW capacity air cooled packaged chiller with an average EER of 2.5.
- Replacement of a 500kW air cooled packaged chiller which has an average EER of 2.25.
- The chiller serves an air conditioning load and operates for 500 hours per year.

Note that an EER of 2.25 is the minimum EER value for compliance with the current Building Regulations ADL guidance and also corresponds to Eurovent class F.

Refrigeration compressors

The compressor in a refrigeration system compresses the refrigerant gas from the low pressure of the evaporator to a higher pressure so that it can condense in the condenser, thus rejecting heat to ambient air or water.

The following most common compression methods are included on the ETL:

Reciprocating – where pistons in bores compress the refrigerant gas.

Rotary scroll – where an orbiting scroll moves against a fixed scroll, thus continually compressing the gas.

Screw – where one or two screws mesh together to continually compress the gas.

The compressor and motors are housed either in a hermetic enclosure which is welded tight, or in a semi hermetic enclosure which has gasketed removable covers. Both types are eligible for ECAs.

By installing an ETL-listed compressor instead of a 15% less efficient one, the potential annual savings are calculated as:

- £1,010
- 12,800kWh
- 5.5 tonnes CO₂.

Based on the following scenario:

- 40kW continuous load at +5°C with the compressor running approximately 20h/day.
- Refrigerant R404A.
- Condensing temperature 10K above ambient, with pressure allowed to fall at low ambient conditions to a minimum condensing condition of 20°C.

Information for purchasers

For further information about the ECA scheme, the Energy Technology List (ETL) and other Technology Information Leaflets in the series please visit www.carbontrust.co.uk/eca, contact the Carbon Trust on **0800 085 2005** or email customercentre@carbontrust.co.uk

Calculating the payback of your investment

Based on the operating conditions above, indicative savings can be calculated for replacing your existing equipment with either ETL-listed equipment or non-ETL-listed equipment.

The accelerated tax relief and cash flow benefit provided by the ECA, together with the life cycle cost savings from ETL-listed equipment, aid in bridging the price premium and shortening the investment payback period⁹.

To calculate the payback period for ETL-listed equipment and non-ETL-listed equipment for comparison you will need:

- The unit price (kW) of the energy your business consumes.
- Estimated energy usage (kW) for the ETL proposed equipment solution(s), which the manufacturer or supplier should be able to help you with.
- Estimated energy usage (kW) for the non-ETL proposed equipment solution(s), which the manufacturer or supplier should be able to help you with.
- Estimated annual maintenance costs incurred by your business for the ETL-listed equipment (your manufacturer or supplier should be able to help you with estimates).
- Estimated annual maintenance costs incurred by your business for the non-ETL-listed equipment (your manufacturer or supplier should be able to help you with estimates).
- The value of the proposed capital expenditure.
- Your business's corporation tax rate.

In addition, the following information is also required:

- A copy of the Carbon Trust fact sheet *Energy and carbon conversion* (CTL004).
- Incorporation of the fact that capital allowance (CA) tax relief for non ETL equipment is 20% (10% if allocated to the 'special rate' pool) and that enhanced capital allowance (ECA) tax relief for ECA equipment is 100%.

Step 1: To prepare your business case for investment you first need to estimate annual energy consumption of the ETL-listed equipment and non-ETL-listed equipment.

$$\text{Annual energy consumption (kWh/y)} = \text{Equipment consumption (kW)} \times \text{Number of operating hours/year}$$

Additionally, you can calculate the carbon emissions associated with the energy consumption using either the Carbon Trust fact sheet *Energy and carbon conversion* (CTL004) or by using the tool at www.carbontrust.co.uk/conversionfactors by simply multiplying the energy consumption by the carbon emission factor for that fuel type.

$$\text{Carbon emissions} = \text{Annual energy consumption (kW)} \times \text{Emission factor (kg CO}_2\text{/kWh)}$$

Step 2: Calculate the annual running cost (ARC) of ETL-listed equipment and non-ETL-listed equipment.

$$\text{ARC} = \text{Annual energy consumption (kW)} \times \text{Pence/kWh} + \text{Annual maintenance cost}$$

Step 1 and 2 can also be done for your existing equipment to calculate an ARC, in order to allow comparisons of the annual saving (step 3) between the existing equipment, the ETL-listed equipment, and the non-ETL-listed equipment.

Step 3: Calculate the annual saving between the ETL-listed annual running costs and non-ETL-listed annual running costs.

$$\text{Annual saving} = \text{ARC of new equipment} - \text{ARC of existing equipment}$$

⁹ The values used in the examples given are for illustrative purposes only and do not reflect specific case studies. Anyone considering purchasing this type of equipment would be advised to also analyse the benefits that would be available based on their own circumstances. It should also be noted that the use of formally trained heating, ventilation and air conditioning equipment technicians can provide significant energy saving benefits.

Step 4: Calculate the tax allowance for ETL-listed equipment and non-ETL-listed equipment which will be business-specific based on the following:

- The value of your capital expenditure
- Capital allowance (CA) tax relief for non-ETL equipment is 20%. If allocated to the special rate pool it is reduced to 10%.
- Enhanced capital allowance (ECA) tax relief for ECA equipment is 100%
- The rate of corporation or income tax for your business.

$$\text{CA tax allowance} = \text{Capital expenditure} \times 20\% * \times \text{Rate of corporation tax}$$

$$\text{ECA tax allowance} = \text{Capital expenditure} \times 100\% \times \text{Rate of corporation tax}$$

To calculate the available CA tax allowance on capital expenditure beyond Year 1 you need to decrease the capital expenditure by 20% per year (10% if allocated to the special rate pool) on a reducing balance basis. Over the nine years the available CA tax allowance are shown in the table below.

Table 1 The cash flow boost to your business of an ECA over a CA for a capital investment of £10,000

	Year								
	1	2	3	4	5	6	7	8	9
Capital Expenditure (£)	10,000	8,000	6,400	5,120	4,096	3,277	2,621	2,097	1,678
Capital Allowance (CA) @ 20% (£)	2,000	1,600	1,280	1,024	819	655	524	419	336
CA Tax Allowance	560	448	358	287	229	184	147	117	94
Enhanced Capital Allowance @100% (£)	10,000	0	0	0	0	0	0	0	0
ECA Tax Allowance	2,800	0	0	0	0	0	0	0	0

Calculations are based on 28% corporation tax/income tax and a capital allowance rate of 20%.

Step 5: Calculate the pay back for ETL-listed equipment and non-ETL-listed equipment.

$$\text{Payback period} = \frac{\text{Capital expenditure} - \text{Tax allowance}}{\text{Annual saving}}$$

* 10% if allocated to the special rate pool

Go online to get more

The Carbon Trust provides a range of tools, services and information to help you implement energy and carbon saving measures, no matter what your level of experience.

Carbon Footprint Calculator – Our online calculator will help you calculate your organisation's carbon emissions.

→ www.carbontrust.co.uk/carboncalculator

Interest Free Loans – Energy Efficiency Loans from the Carbon Trust are a cost effective way to replace or upgrade your existing equipment with a more energy efficient version. See if you qualify.

→ www.carbontrust.co.uk/loans

Carbon Surveys – We provide surveys to organisations with annual energy bills of more than £50,000*. Our carbon experts will visit your premises to identify energy saving opportunities and offer practical advice on how to achieve them.

→ www.carbontrust.co.uk/surveys

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→ www.carbontrust.co.uk/apt

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→ www.carbontrust.co.uk/casestudies

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→ www.carbontrust.co.uk/events

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→ www.carbontrust.co.uk/publications

Need further help?



Call our Customer Centre on 0800 085 2005

Our Customer Centre provides free advice on what your organisation can do to save energy and save money. Our team handles questions ranging from straightforward requests for information, to in-depth technical queries about particular technologies.

The Carbon Trust was set up by Government in 2001 as an independent company.

Our mission is to accelerate the move to a low carbon economy by working with organisations to reduce carbon emissions and develop commercial low carbon technologies.

We do this through five complementary business areas:

Insights – explains the opportunities surrounding climate change

Solutions – delivers carbon reduction solutions

Innovations – develops low carbon technologies

Enterprises – creates low carbon businesses

Investments – finances clean energy businesses.

www.carbontrust.co.uk

0800 085 2005

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