Technology information leaflet ECA778

CARBON TRUST

Uninterruptible power supply

A guide to equipment eligible for Enhanced Capital Allowances

Contents

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 technologies. The Carbon Trust manages the list and promotes the ECA scheme on behalf of government. This leaflet gives an overview of uninterruptible power supply (UPS) 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.

Setting the scene

An uninterruptible power supply (UPS) is an electrical system capable of supplying high quality electrical power without interruptions. The mains electrical supply is connected to the input of the UPS and the output is connected to the customer electrical load. Within the UPS system there are power supply storage systems such as batteries and flywheels which are capable of providing a high quality electrical supply.

A UPS not only provides protection against all types of power supply failure, but can also filter a vast range of disturbances found in the mains supply, thus providing more sensitive loads with a clean power supply.

A UPS can provide power to a critical load while an alternative supply, such as a stand-by generator, is brought on-line. In this case, the UPS may only need to support the critical load for a short period, perhaps five to 10 minutes. However, a UPS can also be designed to support the critical load for much longer - possibly up to one hour. In this case, significant extra storage capacity will be needed.

The growth in voice and data communications and online processing, such as mobile phones, email and online banking, has made having a secure power supply an increasingly important issue. A UPS is now common in computer rooms, data centres and server areas, and plays a significant part in maximising the availability of systems.

UPS systems can be supplied in modules for use in industrial and commercial applications, and range in size from 10kVA to 2.2MVA. The largest computer data centres sometimes require power supplies of 50MVA, and for these often more than one module is needed to supply this level of power.

A UPS is often operated in parallel to give extra security of electrical supply to the equipment connected to them. This is known as operating in 'redundant configuration' which means that if one module fails or is removed for maintenance, the other connected modules can support the critical load. Under these circumstances, each UPS operates at a reduced power level and shares the supply.

It is important that UPS systems not only avoid reducing the quality of the electrical supply, but also smooth out any peaks or spikes in the power supply which could damage the equipment.

Benefits of purchasing ETL-listed products

New UPS technology, such as that listed on the ETL, can deliver 3%[1] savings or more over old UPS systems. For large UPS it has been estimated that savings can be over 20MWh/year[2].

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. UPS 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.

UPS equipment eligible under the ECA scheme

There are two sub-technologies and three power bands within the UPS technology category included in the ECA scheme:

- Rotary UPS units or packages
  - over 100kVA.

Rotary UPS tend to be much bigger than static UPS and now come in sizes up to 2.2MVA. Rotary systems are generally used to support high power requirements which, when operated as multiple modules, can supply a critical load of 50MVA. This might be industrial or military applications.

- Static UPS units or packages
  - over 10kVA and equal to 200kVA
  - greater than 200kVA.

Static UPS are used for supplying critical loads such as smaller computer systems, and for the industrial and commercial market will start at about 100kVA (up to a maximum of 1MVA/module). Static UPS are usually mounted in electrical cabinets inside a building close to the electrical load and take up much less space than rotary systems. Often they use a battery storage system which is mounted inside the same cabinet or sometimes in adjacent units. The size of the UPS is directly proportional to the size of critical electrical load which they support.

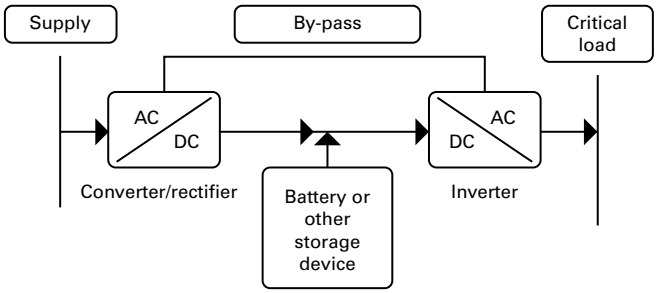
ECA-specified UPS must meet defined energy efficiency levels under various load conditions.

While the basic circuit of the UPS is similar for both static and rotary UPS (as shown in the figure opposite), the technology for providing the back-up power can be different. Rotary-format UPS is based on motor/generator technology. Static UPS may feature a flywheel instead of a battery.

[1] Carbon Trust Long Scoping Study Report, Uninterruptible Power Supplies, December 2008

[2] Carbon Trust Long Scoping Study Report, Uninterruptible Power Supplies, December 2008

Figure 1 *Simple UPS system (also could be a single UPS module)*



The connection of the components shown will vary depending on the type and manufacturer.

Using the baseline scenario below, the potential financial (£), energy (kWh) and carbon savings (tonnes CO_2) have been calculated for comparison unless otherwise indicated:

- UPS operates continuously, 8,760 hours a year
- All UPS operate at unity power factor
- Fuel price for electricity 7.36p/kWh[3]
- Carbon emissions for electricity 0.537 kgCO_2/kWh[4].

Static UPS

A static UPS usually consists of three main component parts:

1. **A rectifier/battery charger** - This changes the mains supply AC voltage and current into the levels of DC voltage and current needed in order to charge the battery and power the inverter.
2. **A storage unit** – This is normally a battery which stores DC electrical energy and power for periods from several minutes to many hours. The most common battery used by UPS manufacturers is the sealed or valve regulated lead acid battery (VRLA). This is because it is seen as environmentally friendly, has low maintenance requirements, is self-contained and reasonably inexpensive. Energy storage for UPS can come from batteries, very high speed flywheels, or a combination of both. They can provide the electrical supply to a critical load through the inverter for a short period.
3. **A static converter** (inverter) – This converts the stored DC supply into an AC voltage waveform - stabilised, filtered and regulated to supply the connected load(s).

There are three main types of static UPS eligible for ECAs. These are described below. The most efficient technology is the VFI double conversion unit and is most likely to be included on the ETL.

VFD (voltage and frequency dependent), more commonly known as 'off-line', which is a UPS where the output tracks the mains power supply in terms of voltage and frequency.

VI (voltage independent), commonly known as 'line interactive', which is a UPS where voltage is stabilised and regulated by built-in passive/electronic devices. It is similar to the off-line system except that it offers a higher performance by adding voltage regulation features in the by-pass system (sometimes known as 'buck-boost').

[3] Prices for fuel purchased by non-domestic consumers in the UK (average price for medium consumers in 2008 provisional), Energy Statistics www.berr.gov.uk

[4] Carbon Trust Energy & Carbon Conversions, CTL018 2008 update

VFI (voltage and frequency independent) more commonly known as 'on-line' or 'double conversion'. For this type of UPS the output is independent of any fluctuation in the power supply voltage (mains) or frequency variations. The primary source of supply is the UPS battery (or flywheel) and the mains supply is the back up. Therefore, in normal operation the load is always supplied from the battery while the mains supply provides the battery charging. In this type of system it is the battery that maintains the output voltage at all times and when there is a mains interruption, the battery charging is stopped and the battery discharges.

An advantage of this type of system is that the output is always isolated from the input mains supply, and therefore any mains fluctuations or disturbances are only seen by the battery charger. The components of an on-line UPS are always active, and therefore need to be much more robust than those used for an off-line UPS which is only asked to provide output intermittently.

The most common UPS is the VFI on-line system because it is the only true provider of power without interruption. This type of UPS is the most appropriate type for use for computers and data centres applications as it is independent of both variations in mains supply voltage and frequency. Many systems now go beyond a single on-line system and provide parallel or redundant configurations. Often a UPS system is made up of a number of UPS modules, connected in parallel.

For two static UPS units or packages selected from the ETL of 100kVA, operating in parallel and supporting a critical 80kVA data centre load, with an efficiency 3% better than a non-specified product, the potential annual savings are calculated as:

- £1,922
- 26,104kWh
- 14.01 tonnes CO_2.

Rotary UPS

A rotary UPS uses the inertia of a large, high-mass spinning flywheel to provide short-term energy to the critical load in the event of power supply loss. The flywheel also acts as a buffer against power spikes and sags. It is traditionally used in conjunction with stand-by diesel generators or motor generator sets, where the flywheel provides the back-up power only for the brief period of time required for the rotating systems to start up or be brought into circuit and stabilise its output.

The rotary UPS is generally reserved for applications that require more than 100kVA of protection, for example where high power is required such as industrial or military applications. Rotary UPS systems are normally extremely large and heavy power systems that can only be transported by forklift or crane. A larger flywheel or multiple flywheels operating in parallel will increase the reserve running time or capacity.

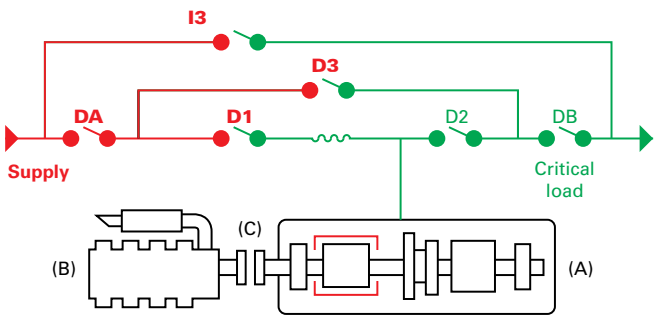
Rotary systems are used where the power system being supported is large and the potential for faults is high, because they are more robust they are able to handle these situations better than solid state static systems.

In *Figure 2*, when mains supply is available breakers DA, D1, D2 and DB are closed feeding the critical load. The automatic bypass D3 is open. The motor/generator (A) acts as a motor and drives a flywheel providing rotating energy storage. The motor/generator acts an ideal power factor correction device and smoothes out minor transients in the supply. If there are any micro breaks in supply the flywheel can maintain the supply to the critical load.

If there is a longer break in electrical supply the input breaker D1 opens, the diesel engine starts (B), the clutch closes (C) and the critical supply is maintained through the generator all within seconds.

There is a manual isolator (I3) that allow the unit to be bypassed.

Figure 2 *Rotary UPS featuring flywheel, generator and diesel engine*



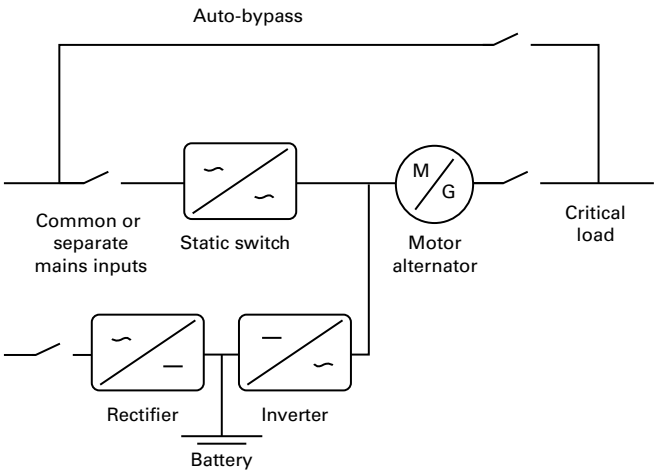
Two rotary UPS units, both of 500kVA, providing critical energy supply support to an industrial process with a normal operational electrical load of 400kVA are selected from the ETL. The UPS units selected have an efficiency of 3% greater than a typical non-specified product. The potential annual savings are calculated as:

- £9,420
- 1.28GWh
- 68.73 tonnes CO_2.

Hybrid systems

Modern UPS systems can feature new technologies such as small fast-speed flywheels or perhaps a combination of both static and rotary UPS. Hybrid systems use a combination of static systems, flywheels and motor generator technologies to provide a robust and high power UPS system. These hybrid systems can be very efficient and provide high levels of security. *Figure 3* shows that when the supply from the utility network is good, the UPS operates by allowing the incoming electrical network to supply the critical load. In addition, a high efficiency motor/generator set is also online to provide supply back-up. If there is a short interruption or complete outage from the supply, the critical load is supported by a battery. Systems of this type are eligible for ECAs.

Figure 3 *Hybrid UPS featuring motor/generator set and batteries*

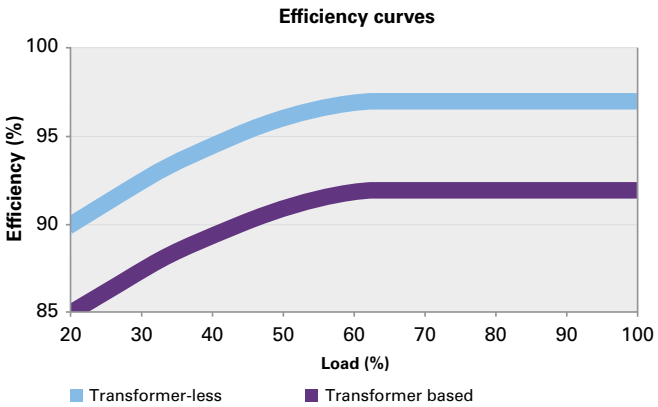


Parallel operation of UPS

In large business environments where reliability is of great importance, a single UPS can also be a single point of failure that can disrupt many other systems. To provide greater reliability, multiple smaller UPS modules and batteries can be integrated together to provide redundant power protection equivalent to one very large UPS. Operating in this way is called an 'N+1' system, where if the load can be supplied by N modules, the installation will contain N+1 modules and failure of one module will not impact on system operation. When operating in this way, each individual UPS module operates at 50% load or less. *Figure 4* shows the efficiency of UPS compared to the electrical load. It is possible to see that the efficiency drops off at lower loads, leading to increased energy loss. Higher-efficiency UPS, such as those specified on the ETL, are designed to minimise the energy losses at all load levels.

In its simplest form, an example would be two 200kVA UPS modules connected in parallel supplying a 200kVA load. Under normal operation they share the load equally at 100kVA each. However, if there is a problem with one UPS module, the other is quite capable of supplying the load on its own, and the UPS that has a problem can be taken out of service for repair or maintenance.

Figure 4 *Typical efficiency/load curves for transformer and transformer-less UPS systems*[5]



[5] Source data: The Handbook Uninterruptible Power Supplies, Peter Bentley

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 period[6].

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%.

[6] 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 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.

Annual energy consumption (kWh/y)	=	Equipment consumption (kW)	x	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.

Carbon emissions	=	Annual energy consumption (kW)	x	Emission factor (kg CO_2/kWh)

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

ARC	=	Annual energy consumption (kW)	x	Pence/kWh	+	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.

Annual saving	=	ARC of new equipment	-	ARC of existing equipment

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.

CA tax allowance = Capital expenditure x 20%* x Rate of corporation tax

ECA tax allowance = Capital expenditure x 100% x 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.

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

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

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%.

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**

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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.

* Subject to terms and conditions.

The Carbon Trust is a not-for-profit company with the mission to accelerate the move to a low carbon economy. We provide specialist support to business and the public sector to help cut carbon emissions, save energy and commercialise low carbon technologies. By stimulating low carbon action we contribute to key UK goals of lower carbon emissions, the development of low carbon businesses, increased energy security and associated jobs.

We help to cut carbon emissions now by:

- Providing specialist advice and finance to help organisations cut carbon
- Setting standards for carbon reduction.

We reduce potential future carbon emissions by:

- Opening markets for low carbon technologies
- Leading industry collaborations to commercialise technologies
- Investing in early-stage low carbon companies.

www.carbontrust.co.uk
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ACT ON CO_2 is the Government's initiative to help individuals understand and reduce their carbon footprint. Visit http://actonco2.direct.gov.uk for more information.

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