CARBON TRUST

Motors and drives

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[1]. The Carbon Trust manages the list and promotes the ECA scheme on behalf of government.

This leaflet gives an overview of motors and drives specified on the ETL and illustrates the reductions in energy bills that can be realised by investing in qualifying ETL energy saving equipment over non-qualifying equipment.

Further information

For more information please visit www.carbontrust.co.uk/motors or download the Carbon Trust's Motors technology overview (CTV048) or the Variable speed drives technology guide (CTG070).

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; the ETPL is the list of products that have been assessed as being compliant with ETCL criteria.

[1] Eligibility for ECAs is based on a number of factors. Visit https://etl.decc.gov.uk to find out more.

Setting the scene

An electric motor is a device for converting electrical energy to rotary kinetic (movement) energy in order to power a process such as a pump, fan or conveyor.

Motors can be found in the vast majority of equipment, for example:

- The fans that provide combustion air for gas to burn in a heating system.
- The pumps that deliver the hot water to the heating systems radiators.
- The prime mover in an air compressor.
- The device that drives a conveyor belt in a production line.

Electric motive power is likely to form a large part of an organisation's energy consumption. The industrial use of electric motor power accounts for almost two-thirds of the entire industrial electricity consumption in the UK.[2]

The energy consumed by a motor and drive system can be seen in the diagram below. For every unit of energy (kWh) supplied to a system containing a variable speed drive (VSD), motor and gearbox, 5% is lost in the VSD and around 8% in the motor. In this example only around 77% of the energy supplied to the system is converted into useful movement at the load.

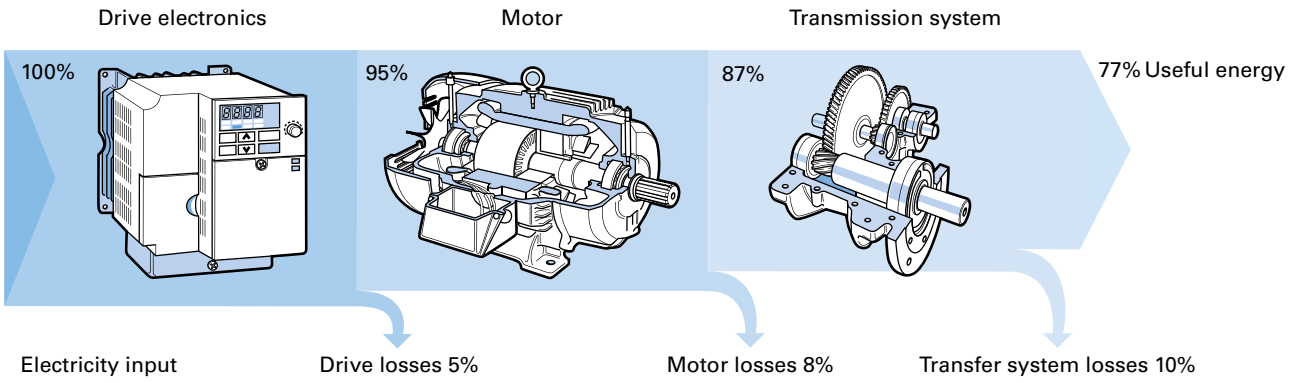
Energy savings can be achieved for motors and drives by purchasing and installing energy efficient ETL listed equipment.

Did you know?

In an average year, a central heating pump can cause 173kg CO_2 to be released into the atmosphere.

(Assume a heating pump consuming 110Watts for 3000 hrs per year = 330kWh = 173kg carbon).

Figure 1 Typical system losses



[2] The CarbonTrust's *Motors and drives* technology overview (CTV048).

Benefits of purchasing ETL listed products

Motor and drive products listed on the ETL are highly energy efficient, particularly when compared to older versions of the same technology.

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.

This leaflet also illustrates the reductions in energy consumption, carbon emissions and energy bills that can be realised by investing in qualifying ETL energy saving equipment over non-qualifying equipment.

Did you know?

An 11kW, 4 pole ETPL listed motor uses almost £76 less energy per year than a non-listed model.[3]

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. Motor and drive 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.

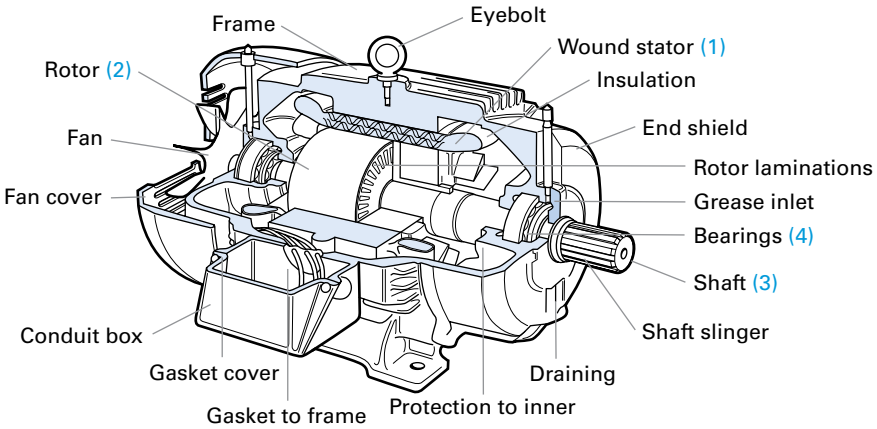
Motor and drive equipment eligible under the ECA scheme[4]

Single speed ac induction motors

Single speed a.c. induction motors (SSIMs) are fixed speed caged induction motors which use conventional alternating electric current (AC) to induce a force (torque) on their rotor, causing it to rotate.

The diagram below shows the components of a fixed speed caged induction motor. As electrical power is applied to the motor, a rotating magnetic field is created around the stator (1). This induces currents and associated magnetic fields in the rotor (2), causing the rotor and shaft (3) to spin. The shaft is mounted on bearings (4) and is able to rotate freely.

Figure 2 Fixed speed caged induction motor



[3] Based on difference in efficiencies between an eligible IE3 motor (91.4%) and a non-eligible IE2 motor (89.8%) operating for 4,000 hours a year at 100% load.

[4] The descriptions of the motors and drives equipment given in this leaflet are examples only. The formal criteria and details governing the ECA scheme can be found at https://etl.decc.gov.uk

SSIMs eligible under the ECA scheme are fixed speed three-phase caged induction motors, which operate from a supply voltage less than or equal to 1,000Volts ac at a frequency of 50Hz. These motors must have a minimum efficiency level which depends on the kW rating and the number of poles the motor has. The number of poles in a motor relates to the rated fixed speed of the motor.

Using the baseline scenario below, the potential financial (£), energy (kWh) and carbon savings (tonnes CO_2) have been calculated for installing an ETL specified SSIM.

Baseline scenario:

- Installation of a new 22kW 4-pole motor which has an efficiency of 93.0%.
- Replacing a 22kW 4-pole single speed induction motor which has previously been rewound and has an efficiency of 80.0%.
- The motor is running continuously for 24 hours per day, 365 days per year at 100% load.
- Electricity unit price is 9p/kWh.
- Carbon emissions for electricity is 0.525 kgCO_2/kWh.

By installing a single 22kW ETL listed SSIM the potential annual savings are calculated as:

- £3,039.
- 33,674kWh.
- 17.7 tonnes CO_2.

Did you know?

Using a VSD to slow down a fan or pump motor from 100% to 80% can save as much as 50% on energy use.[5]

Variable speed drives

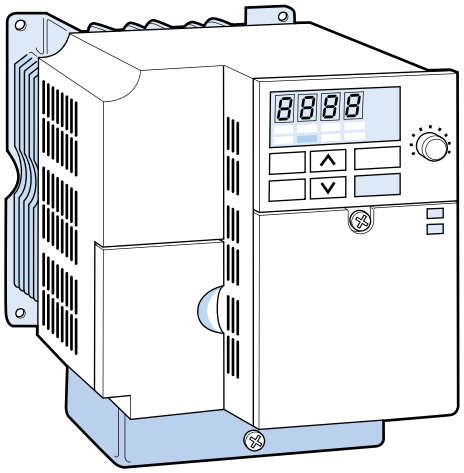
Electric induction motors run at fixed speeds and are ideally suited to applications where a constant motor output speed is required, for example a conveyor.

However, there are some applications where varying motor output speeds are preferable, for example, fans, pumps, winders and precision tools.

A variable speed drive (VSD), (also known as a variable frequency drive, adjustable speed drive or inverter), is an electronic device that controls the characteristics of a motor's electrical supply. Therefore, it is able to control the speed and torque of a motor, achieving a better match with the process requirements of the machine it is driving. For applications where variable control is desirable, slowing down a motor with a VSD can reduce energy use substantially.

A VSD works by converting the incoming electrical supply of fixed frequency into a variable frequency output. This variation in frequency allows the drive to control the way in which the motor operates – a low frequency for a slow speed and a higher frequency for a faster speed. The output can also be changed to enable the motor to generate more or less torque as required. The motor and drive combination can be used for turning a large load at relatively slow speeds, or turning a lighter load at high speeds, thereby maximising efficiency.

***Figure 3** A typical variable speed drive*



[5] Source: The CarbonTrust's *Variable speed drives* technology guide (CTG070).

VSDs listed on the ETPL are able to vary the speed of an SSIM by generating a variable frequency, three-phase power output. This can be matched to the torque-speed characteristics of the driven load, including both loads with a quadratic torque-speed and linear torque-speed characteristics. Put simply, this means that the VSD should be able to drive a motor connected to either a conveyor or one that is connected to a pump.

ETPL listed VSDs are able to vary the frequency of their output between 5% and 100% of their maximum frequency output and this typically enables them to operate the attached motor at between 20% and 100% of its maximum continuous speed rating.

Using the baseline scenario below, the potential financial (£), energy (kWh) and carbon savings (tonnes CO_2) have been calculated for installing ETL specified VSD equipment.

Baseline scenario:

- Installation of a new 22kW 4-pole motor which has an efficiency of 93.0%.
- Replacing a 22kW 4-pole single speed induction motor which has previously been rewound and has an efficiency of 80%.
- The motor is running continuously for 24 hours per day, 365 days per year.
- Electricity unit price is 9p/kWh.
- The 22kW motor drives a centrifugal pump which runs continuously circulating water around a closed loop.
- The VSD is 95% efficient.
- The speed of the pump can be reduced by 20% without any noticeable reduction in the performance of the water system.

By installing a single VSD onto a 22kW pump, the potential annual savings are calculated as:

- £11,865.
- 131,833kWh.
- 69.1 tonnes CO_2.

Integrated motor drives

A fast expanding market is that of a motor and VSD attached piggy-back style in a combined package. These are called integrated motor drives (IMD) but can sometimes be referred to as smart motors. IMDs have several advantages over separate units, including:

- Lower total cost.
- Reduced wiring time.
- No electromagnetic interference from the motor side inverter leads, cables or cabling.
- Optimum matching of the motor to the VSD.

IMDs are typically used in the pump market, where pump manufacturers can utilise the ability to reduce the speed of a pump, and therefore supply one package comprising pump, motor and drive.

Image supplied courtesy of Brook Crompton UK

IMDs eligible under the ECA scheme are able to vary the speed of the attached SSIM by generating a variable frequency, three-phase power output that can be matched to the torque-speed characteristics of the driven load, including both loads with quadratic torque-speed and linear torque-speed characteristics. Put simply, this means that the IMD should be able to drive a motor connected to either a conveyor or one that is connected to a pump.

As a minimum, ETPL listed IMDs are able to vary their speed by between 100% and 50% of their maximum continuous speed rating.

Using the baseline scenario below, the potential financial (£), energy (kWh) and carbon savings (tonnes CO_2) have been calculated for installing ETL specified IMD equipment.

Baseline scenario: Installation of a new 22kW 4-pole motor which has an efficiency of 92%.

- Replacing a 22kW 4-pole single speed induction motor which has previously been rewound and has an efficiency of 80%.
- The motor is running continuously for 24 hours per day, 365 days per year.
- Electricity unit price is 9p/kWh (including climate change levy at full rate).
- The 22kW motor drives a centrifugal pump which runs continuously, circulating water around a closed loop.
- The VSD is 95% efficient.
- The speed of the pump can be reduced by 20% without any noticeable reduction in the performance of the water system.

By installing a single IMD to replace a 22kW pump motor, the potential annual savings are calculated as:

- £11,865.
- 131,833 kWh.
- 69.1 tonnes CO_2.

Permanent magnet synchronous motors

Permanent magnet synchronous motors (PMSMs) offer a higher efficiency and more compact alternative to induction motors controlled by VSDs. PMSMs are easily manufactured, with multi-pole arrangements. These offer the added advantage of direct drive motors (without gearboxes), which minimise the drive chain losses arising from gearbox losses. They can be used for applications varying from 100 to 10,000rpm.

Stator with pole windings

Permanent magnet synchronous motor drives consist of a PMSM, and a matched, electronic, VSD. The VSD is specifically designed to provide the variable frequency, multi-phase electrical power input needed to operate the PMSM, and to vary its speed in a controlled manner in response to an external signal.

The VSD can either be physically mounted on the motor to form a single factory assembled, integrated unit, or the VSD and the motor can be supplied as two separate units that are designed to be connected together during installation. These two parts are frequently supplied as a package, but may also be purchased separately.

PMSMs can be used in most sectors of industry and business to operate fans, pumps and compressors, lifts and conveyors, and on average they realise energy savings of 7 to 8%. These energy savings are realised in addition to the 25-30% savings that can be achieved by using a VSD. The lifetime of a PMSM is around 10 to 20 years depending on its application.

The product market for PMSMs consists of three main areas:

1. Integrated PMSM and VSD units.
The unit is electrically and mechanically integrated. These units are generally only available for motor ratings up to 10kW.

2. IEC frame sized PMSM packaged with a separate matched VSD.
These are typically supplied as direct replacements for standard sized induction motors. The PMSM and matched VSD can also be purchased separately.

3. PMSM non-standard frame sizes with a separate matched VSD.
These are typically designed for 'gearless' (direct) connection to the load. These 'gearless' motors are usually supplied either for low speed, high torque applications or for high speed, low torque applications. The matched VSD may be packaged with the PMSM or purchased separately.

The ETL includes PMSM machines with the highest specifications and efficiencies. The associated VSD will further enhance the energy savings by allowing the operator to reduce power to match the process load requirements.

Using the baseline scenario below, the potential financial (£), energy (kWh) and carbon savings (tonnes CO_2) have been calculated for installing ETL specified PMSM equipment.

Baseline scenario:

- Installation of a 22kW permanent magnet motor with an efficiency of 93.0%.
- Replacement of a 22kW 4-pole single speed induction motor which has previously been rewound and has an efficiency of 80%.
- The motor is running continuously for 24 hours per day, 365 days per year.
- Electricity unit price is 9p/kWh.
- The 22kW motor drives a centrifugal pump which runs continuously, circulating water around a closed loop.
- The VSD is 95% efficient.
- The speed of the pump can be reduced by 20% without any noticeable reduction in the performance of the water system.

By installing a single 22kW ETL listed PMSM with matched variable speed package, the potential savings are calculated as:

- £11,865
- 131,833 kWh.
- 69.1 tonnes CO_2.

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 https://etl.decc.gov.uk or contact the Carbon Trust on +44 (0)300 330 0657 or email ECAQuestions@carbontrust.co.uk.

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.

↘ Empower Savings Calculator

Calculate your organisation's potential carbon savings with our online calculator. Empower has been configured entirely around the employee, to help them see that through simple behavioural changes, their individual efforts add up to make a bigger difference. **www.carbontrust.com/resources/reports/advice/empower-savings-calculator**

↘ Events and Workshops

The Carbon Trust offers a variety of events and workshops ranging from introductions to our services, to technical energy efficiency training. **www.carbontrust.com/about-us/events**

↘ Publications

We have a library of free publications detailing energy saving techniques for a range of sectors and technologies. **www.carbontrust.com/resources**

↘ SME Network

An online community for SMEs with the aim of increasing the sharing of best practice between SMEs looking to reduce carbon emissions from their estate and operations. **http://smenetwork.carbontrust.com**

* Subject to terms and conditions.

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Advice

- We advise businesses, governments and the public sector on their opportunities in a sustainable low carbon world

Footprinting

- We measure and certify the environmental footprint of organisations, products and services

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