ENERGY EFFICIENCY GUIDE

The impact of synchronous reluctance motor and variable speed drive technology to improve sustainability ratings

Even small upgrades can have a big impact when it comes to reducing HVAC energy consumption in commercial buildings

State of the industry in Australia

There is no question as to the benefits of reducing energy consumption on our global environment. Businesses investing in high efficiency technology upgrades across industry and commercial sectors benefit from favourable returns by lowering energy consumption and associated lower energy cost and may also gain reductions in other operating costs such as reduced maintenance requirements, longer equipment life, and lower operating temperatures.

Context

In July 2022, the Australian Government confirmed its commitment to reducing greenhouse gas emissions with the 'Climate Change Bill 2022'. This legislates the nation's commitment to reducing emissions by at least 43% below 2005 levels by 2030, and net zero by 2050.

This is no small task and to meet these commitments will require a coordinated effort across all sectors without delay, particularly given Australia's climate policies have been ranked last out of 64 countries in 2021, when it came to emissions, renewables, and energy use.

The Australian Government Department of Climate Change, Energy, the Environment and Water (DCCEEW), September, Canberra, recently released a report titled 'Australian Energy Update 2022'. It identified the Manufacturing, Mining, Residential and Commercial sectors as significant contributors (>46%) of Australian energy consumption in the 2020-21 period.

The report noted that the 'Commercial and services sector energy consumption fell 3% in 2020–21 after a 4% decline the year before. This was influenced by ongoing reduced workplace activity as a result of COVID-19 rules and changes to business practice from March 2020.'

However, as we now return to our offices and pre-COVID-19 business practices, we can expect this energy consumption to increase again, and a renewed pressure on energy reduction will occur.

One such pressure in the commercial building segment comes in the form of the 'Building Energy Efficiency Disclosure Act 2010'.

This legislation, also known as the Commercial Building Disclosure (CBD) act, requires energy efficiency information to be provided when most commercial office space of 1000 square metres or more is offered for sale or lease.

This is achieved via a NABERS Energy rating, which is a national independent system that provides a comparable sustainability measurement across various building segments and gives energy transparency to all interested parties.

The NABERS ratings programs have been in operation for over 20 years now and the current system yields up to a 6-star rating.

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Figure 1: NABERS is a simple, reliable sustainability rating for the built environment. This rating provides a rating from one to six stars for buildings efficiency. This helps building owners to understand their building's performance versus other similar buildings, providing a benchmark for progress. The NABERS rating is valid for 12 months.

In Australia, heating ventilation and air conditioning (HVAC) systems account for up to 50% of a commercial building's energy use and dominate peak electricity demand. Capital and maintenance costs for these systems also comprise a high portion of overall building costs.

The cost of energy is a significant concern for businesses – it affects their sustainability, profitability and growth strategies. Data on 2,300 business leaders from the ABB Energy Insights Report shows that three in five businesses reported that high energy costs might delay their progress toward sustainability targets.

At the same time, the report shows that the rising price of energy is cutting into profit margins and forcing businesses to reallocate funds away from areas that are key to growth, such as R&D, technology, infrastructure and marketing.

Improving HVAC efficiency can therefore have a big impact on operational costs, by reducing energy consumption, maintenance costs and peak demand charges, along with additional reputational benefits through higher NABERS energy efficiency ratings.

What can be done?

While there is no one size fits all in the quest to optimise energy use, there are common strategies to consider. Can building loads be reduced? Can existing systems be optimised? What are the benefits of upgrading to more efficient systems?

Methods to reduce demand for HVAC services include, improved building insulation, high performance window glazing, natural ventilation, external window shading, colour and reflectivity of external materials, and living green roofs.

Humidity, air movement and temperature all influence the comfort of building occupants, and all can be measured and optimised. Optimisation can also involve adding strategies like 'night purge' that reduces mechanical cooling by automatically flushing a building with cooler night air using ambient ventilation.

Upgrading or enhancing existing HVAC system components can deliver significant savings

An efficiency assessment (or Energy Appraisal) connects domain experts with consumers to identify potential energy savings and CO_2 emission reductions on existing sites, with consideration of customer needs, like reducing risks while enabling them to take full advantage of plant potential.

An Energy Appraisal requires collection of plant, utility and operation data, and for best results includes a site inspection to evaluate implementation and logistical aspects of any technology upgrade recommendations that might be relevant.

In older commercial buildings or buildings with low NABERS ratings, there are typically significant opportunities to improve building energy performance utilising a combination of high efficiency motors and system upgrades utilising variable speed drives.

Energy efficiency: The first fuel for sustainability and improvement is motors and drives

Many HVAC systems utilising pumps and fans, as well as variable torque compressor systems, are bound by the physics of the affinity laws. Simply put, the affinity laws express the mathematical relationships between flow, pressure and power when all other variables are fixed.

Flow (Q) $\frac{Q1}{Q2} = \frac{n1}{n2}$

Pressure (H) $\frac{H1}{H2} = \left(\frac{n1}{n2}\right)^2$

Power (P) $\frac{P1}{P2} = \left(\frac{n1}{n2}\right)^3$

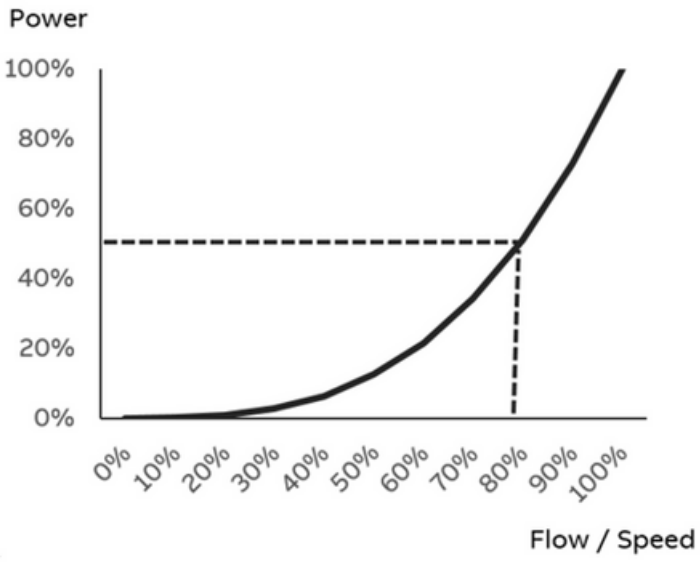

Figure 2: The affinity laws state: a) Flow is directly proportional to (fan/pump/compressor) impeller speed; b) Total Dynamic Head (or pressure) is proportional to the square of the impeller speed; and c) Power is proportional to the cube of the impeller speed.

As an example, reducing the motor speed in a system by 20%, results in a reduction of flow by 20% but yields a 48.8% reduction in power consumption. Or conversely, if a motor is running 20% faster than required, the additional power is 72.8% higher than needed.

Those working in HVAC for commercial buildings should take note of this. It's salient because when it comes to HVAC for commercial buildings almost all plant operation is variable and occurs below the design operating point.

In older buildings, designers utilised other strategies to control variable loads on a fixed speed motor. This included throttling and bypass valves and dampers, inlet guide vanes on fans, or buffer tank systems and plant cycling. All these older strategies are less efficient than variable speed solutions, and the most common energy efficient technology today for controlling the speed of an electric motor is a variable speed drive (VSD). They're a sure-fire way to improve the HVAC system efficiency.

The best method to achieve optimal system efficiency is to control the load in a manner to match the performance system curve. VSD's offer the most energy efficient solution of load control for all motor variants: standard induction motors, permanent magnet motors, and high efficiency synchronous reluctance motors. There is a 10-70% potential energy saving when compared to other control mechanisms.

Selection of high efficiency motors operating at their best efficiency point will also improve efficiency and reduce utility costs. Motors are rated under IEC/EN 60034-30-1 (single speed) or -2 (variable speed) with an efficiency class ranging from IE1 to IE5 (highest efficiency). Each change in class represents a 20% improvement in energy losses.

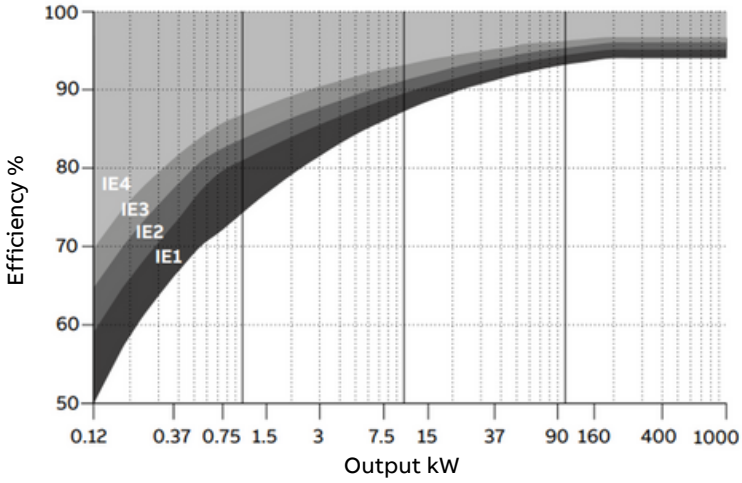

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Figure 3: IE efficiency classes for 4-pole motors at 50Hz

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Photo credit: University of Queensland's (UQ) Andrew N. Liveris Building, which was recently prefabricated with ABB's HVAC drives. Read the full story here.

Under Australian MEPS, the minimum requirement is IE2 however as noted in the most recent government advisory report (Equipment Energy Efficiency (E3) Prioritisation Plan Stage 2 Report – June 2022), pumps, air compressors, boilers, fan units, electric motors, and cool rooms were all highlighted to improve efficiency.

Specifically for electric motors, it was noted that "Given that most developed countries have now adopted IE3 levels for a broader range of motors than are currently regulated in Australia, and the EU will adopt IE4 levels in 2023, the potential exists for Australia to investigate following a similar pathway. Preliminary data from New Zealand suggests that an upgrade would deliver substantial energy and greenhouse gas savings."

Looking to the future

The legislative and financial drivers to improve commercial building energy efficiency are strengthening.

HVAC consumes up to 50% of commercial building energy. There are many technical options readily available from ABB to improve energy efficiency of motors which reduces energy consumption and improves NABERS energy ratings of commercial buildings. In new buildings, designers today should be embracing highest efficiency motors coupled with variable speed drives to deliver optimum performance. In existing buildings, owner/operators can engage ABB experts to deliver Energy Appraisals to identify best opportunities to optimise motor systems through appropriate technology upgrades to reduce energy and maximise ROI's.

The news that businesses in the commercial sector are having to cut important investments and delay sustainability efforts is concerning. Fortunately, the technology is available today to enact meaningful change and overcome both the financial challenges of high energy prices and doing the right thing by achieving sustainability targets.

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Reports and guides referenced in this document:

Climate Change Bill 2022
The Australian Government Department of Climate Change, Energy, the Environment and Water
Released 28 July 2022

Australian Energy Update 2022
Department of Climate Change, Energy, the Environment and Water
Released September 2022

Department of Climate Change, Energy, the Environment and Water sector and equipment guide for HVAC
As at August 28th 2023

ABB Energy Insights Survey Report 2023
Research reveals energy concerns impacting business competitiveness, the workforce and decarbonisation.

ABB Energy Appraisal Tool

Article: Construction prefabrication – how it's reducing time to installation by half and lowering costs.
Published August 20th 2021

Equipment Energy Efficiency (E3) Prioritisation Plan Stage 2 Report
Energy Rating, a joint initiative of Australian, State and Territory and New Zealand Governments
Published June 10th 2023

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ABB Pty Limited
597 Blackburn Rd, Notting Hill, VIC. 3168
P: 1800 222 435
E: contact.centre@au.abb.com