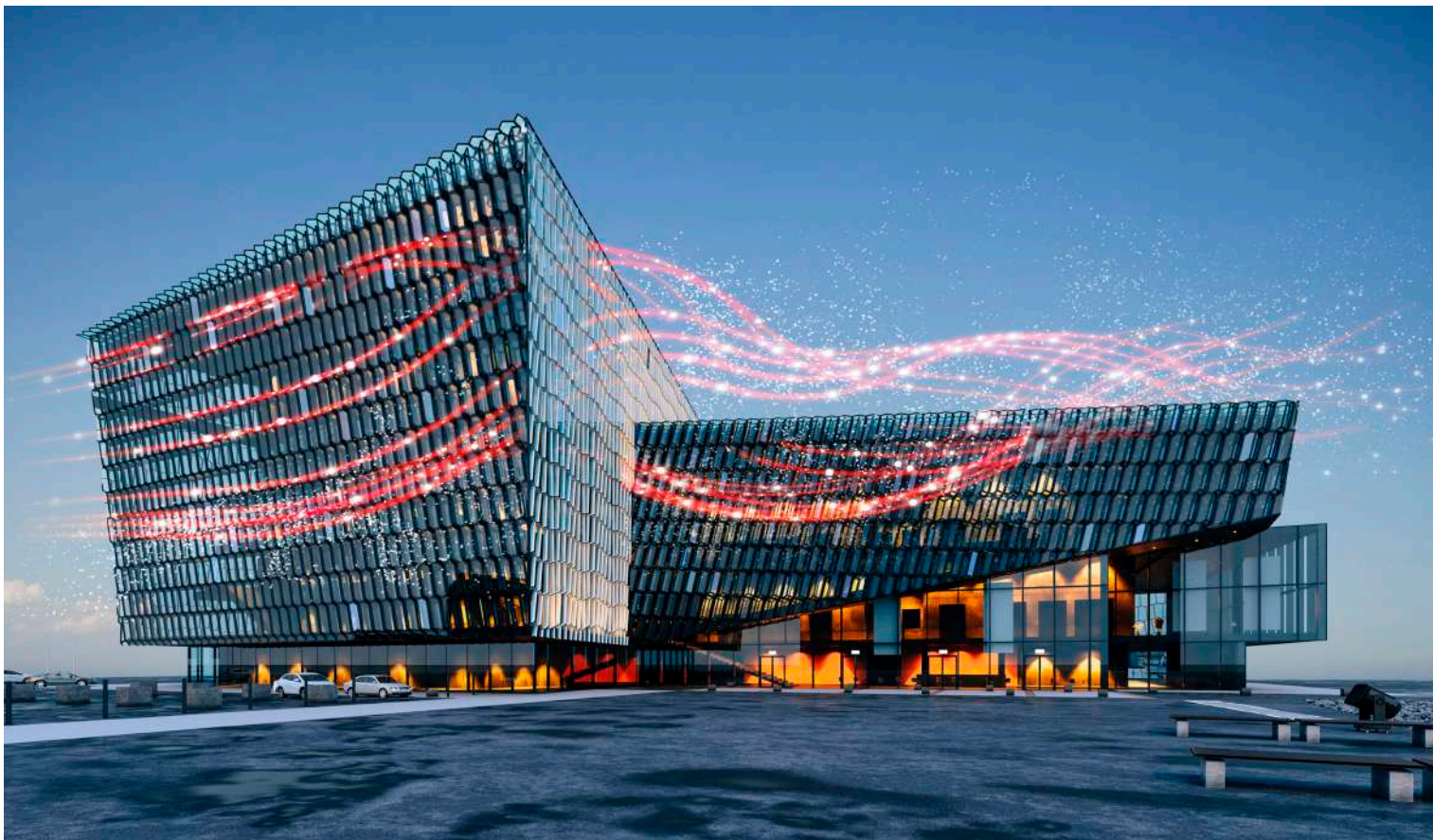

WHITE PAPER

Energy efficiency of smart buildings

Towards zero consumption and beyond



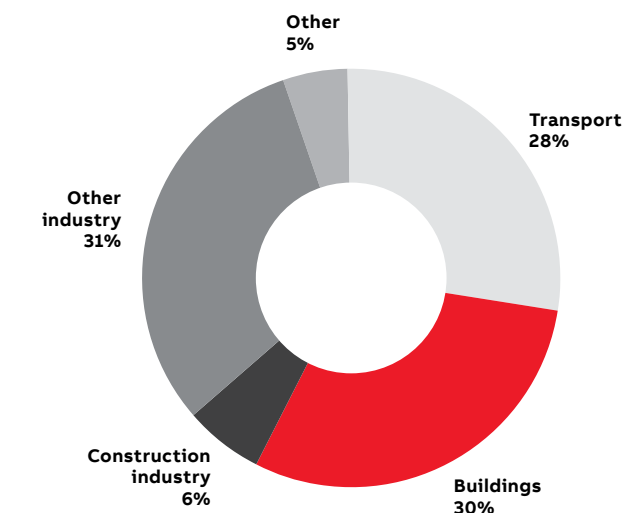
Ready for the sustainability challenges ahead

The rate of urbanization is growing rapidly – 55% of the world's population lives in urban areas nowadays, and the proportion is set to increase to 68% by 2050.¹ This means that infrastructure will continue receiving massive development, and the number of buildings will continue to increase substantially worldwide.

Because of the exponential growth of the global population, and especially the rising population density in urban areas, the energy and water consumption of both new and existing buildings should be optimized to increase energy efficiency and reduce greenhouse gas (GHG) emissions.

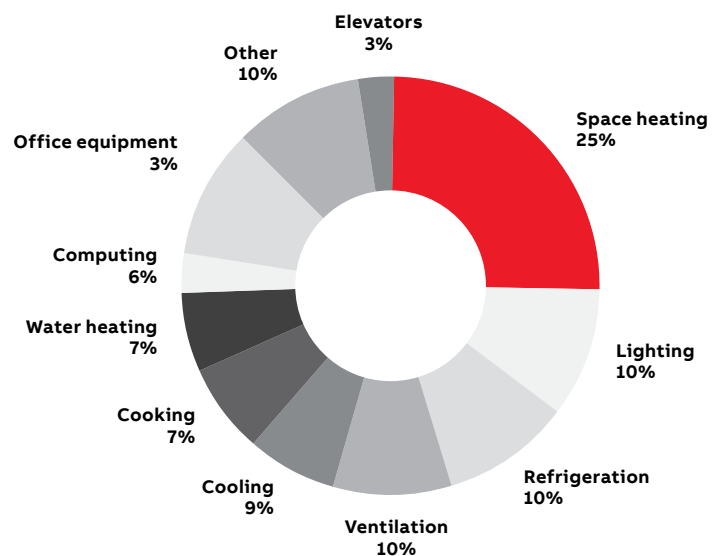
Governments all over the world are legislating to reduce the energy consumption and CO₂ emissions from buildings, and professional organisations are also establishing the relevant certification programs. For example, the U.S. Green Building Council has developed the Leadership in Energy and Environmental Design (LEED) certification scheme. LEED certified buildings resulted in \$1.2 billion in energy savings between 2015 and 2018.⁵ In the European Union, new regulations demand that all new buildings should have an energy consumption level close to zero. The Energy Performance of Buildings Directive (2018/844/EU) aims to decarbonize national building stocks by 2050.

When we aim to minimize energy consumption while still optimizing the living conditions in buildings, we need to rethink the whole system from the ground up. Every possible way to save energy must be considered, and the most energy efficient technologies and techniques must be applied.



Global energy consumption by sector, according to the IEA.²

Buildings are responsible for over 30% of global energy consumption.² To improve our living conditions, we have engineered solutions to control the temperature, humidity, and fresh air flow in buildings. Not surprisingly, heating, ventilation, and air conditioning (HVAC) consume on average about 50% of the energy used in buildings.³ At the same time, in large commercial buildings the equipment used to move people, like escalators and elevators, can account for 2-5% of the building's energy use.⁴ Therefore, improving the energy efficiency of these systems is essential.



A breakdown of the average energy consumption in commercial buildings.⁶

Making buildings smart with smart solutions by ABB

Building energy use is never uniform – the water consumption and need for air conditioning depend on the occupancy, the time of day and the weather. Modern buildings must be flexible and adapt to changes promptly.

The indoor temperature must follow changes in the outdoor weather conditions. Seasonal variation in some areas may be over 50°C, and the daily variation can be over 20°C. Day or night, sunny or overcast – it all affects a building's indoor environment.

Building automation and control solutions

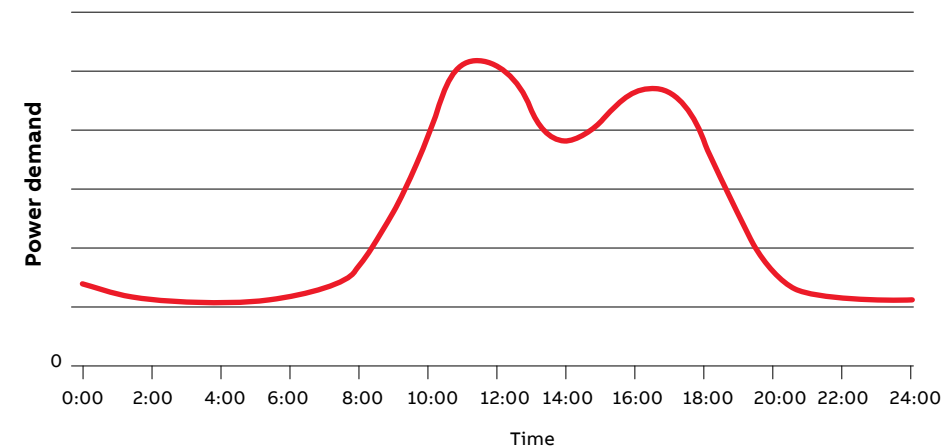
Much of the savings in smart buildings come from the adjustability and controllability of the systems. Sensors all over the building continuously measure indoor and outdoor ambient conditions and help the building management system (BMS) controllers adjust the HVAC accordingly. Movement detectors facilitate optimization of different areas when they are not in use. Water circulation can be optimized depending on the need as well, and tap water pumps can be stopped during silent hours.

Real time information from occupancy sensors can tell when an elevator is needed and how many stops it makes sense to have before it reaches its destination. This can prevent unnecessary stops when the elevator is already full or limit elevator occupancy to avoid the spread of disease in special situations like during a pandemic.

ABB's set of building automation and control solutions ensure advanced, energy-efficient and safe operation of buildings through powerful local or remote monitoring across all levels, for the best occupant comfort and safety.



ABB's AC500 PLC open control platform enables energy efficient management of a whole building via connections to other smart network solutions and protocols.

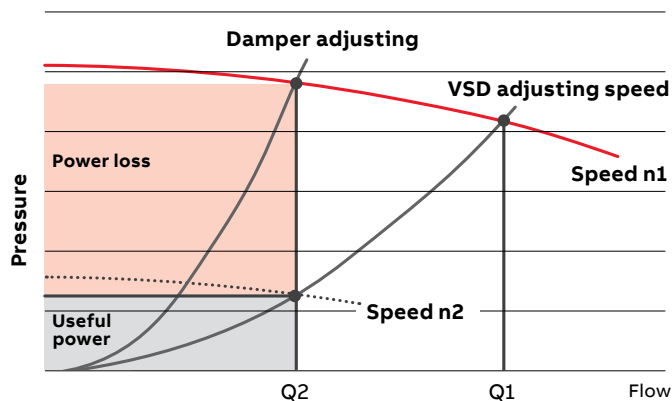


A typical power demand profile for an office space on weekdays.

Variable speed drives

Systems to control different processes inside buildings have existed for decades. However, the energy efficiency of these systems has not been sufficient. The development of variable speed drive (VSD) technology has enabled us to solve many of the energy loss problems in buildings.

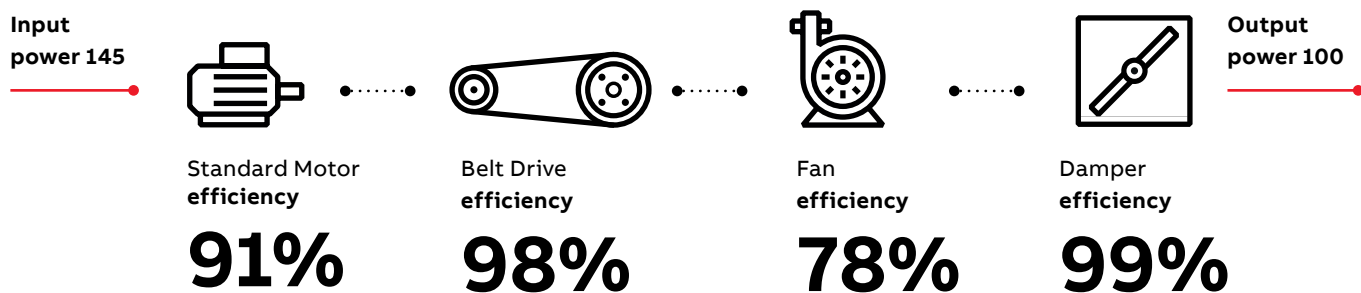
Because building systems like HVAC run at partial loads for most of the time, variable speed drives can save energy by an average of 20 to 60% compared to traditional damper or valve control methods. Such massive energy savings are possible because drives are able to adjust the motor speed of fans, pumps and compressors directly to meet the current building needs. Variable speed control delivers the full benefit of running HVAC applications at partial load, allowing accurate control of ambient CO₂ levels, temperature, and humidity for the best occupant comfort, health and safety, while optimizing the energy use.



The graph shows how power consumption changes with decreasing the flow rate from Q1 to Q2 with a damper and a VSD. The damper doesn't decrease the speed of the application but rather creates the resistance to decrease the flow, so the energy gets wasted (power loss square in the graph). The VSD decreases the application speed as well (from n1 to n2) making it consume less energy, so no energy gets wasted.

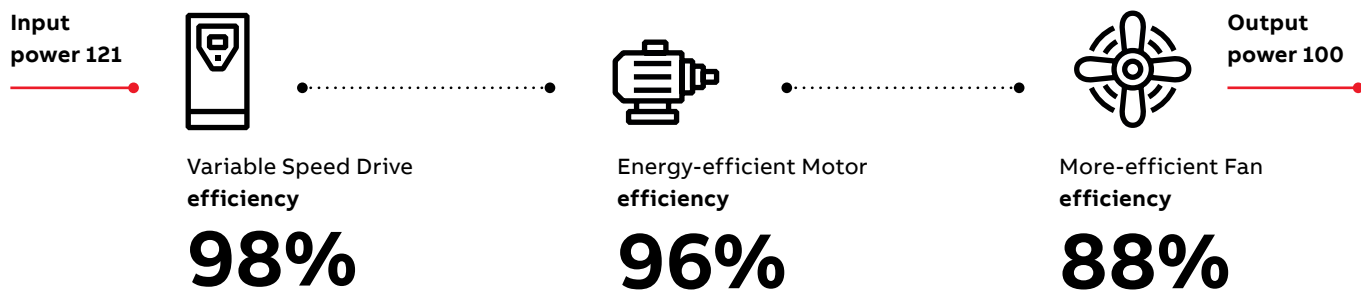
Conventional ventilation system

System efficiency = 69%



Energy-efficient ventilation system

System efficiency = 83%



To achieve the greatest energy savings, it is crucial to ensure that drives are well integrated into the BMS for smarter and more efficient building management. Support for all common building automation protocols, including BACnet, as well as the wireless control capabilities in ABB drives, enables complete and seamless integration.

ABB's ACH580-31 ultra-low harmonic drives for HVAC based on active front end drive technology.



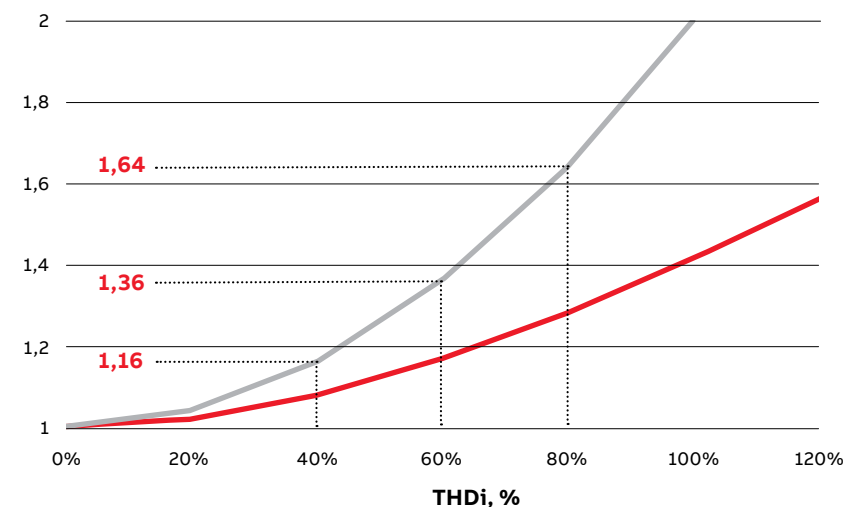
AFE technology offers specific benefits to elevator system efficiency because it enables the braking energy to be recovered when an elevator descends and slows, instead of losing it as heat through braking resistors or mechanical brakes. Drives with a regenerative unit built-in can run elevator motors as generators during braking and feed the energy back to the network or an accumulator for later use, for example, to lift people when the elevator ascends or in other building processes like HVAC.

The ACS880 regenerative drive family brings specific benefits to elevator operation.



Drives help to save a considerable amount of energy through motor speed control. However, they can also generate electromagnetic noise due to the constant switching of elements in their design. This noise is called harmonic distortion and it negatively affects power system efficiency, increasing the total current and generating higher losses as a result. Therefore, variable speed technology for building systems must be selected carefully.

ABB's active front end (AFE) drives limit current harmonics to 3%. In contrast, the current from a conventional 6-pulse drive technology with passive harmonic mitigation components has a harmonic content of about 40%. As a result, a system using a 6-pulse drive has 16% more current losses than a system with no harmonics.



Total line current Irms and relative Joule losses as a function of the THDi harmonic content.

Irms Joule losses



More efficient motor technologies

Variable speed drives help save a lot of energy, but with a small investment savings can be increased further. The optimal companion to a variable speed drive is a high efficiency motor like ABB's IE5 synchronous reluctance motor (SynRM). Compared to an IE3 energy efficiency class induction motor, it offers up to 40% reduced energy losses, delivering ultra-premium energy efficiency – a new level of efficiency defined by the International Electrotechnical Commission. This makes SynRMs the new first choice to meet the growing global demand for improved energy efficiency.

Because buildings operate for most of the time at partial loads, it's important to consider a motor's partial load performance instead of just the nominal performance. A SynRM IE5 motor at partial load offers even greater advantages over other motor technologies.

Synchronous reluctance technology combines the performance of permanent magnet motors with the simplicity and service-friendliness of induction motors. The rotor in a synchronous reluctance motor has no magnets or windings and suffers virtually no power losses. It also requires less material for manufacturing than a traditional motor – a great bonus for sustainability.

IE5 synchronous reluctance motors (SynRM) reduce energy losses by up to 40% compared to IE3 induction motors.



ABB's SynRM IE5 motors can achieve the highest energy savings in buildings, even at partial loads.

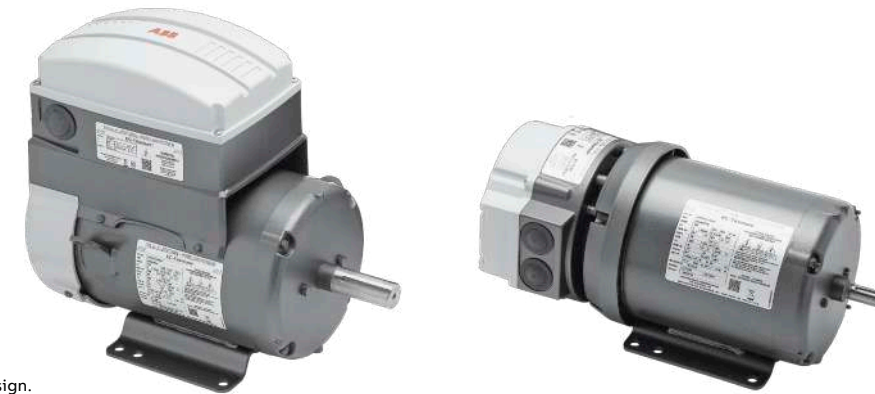


ABB EC Titanium™ integrated motor drives combine the highest available SynRM efficiency with a compact design.

Following the market need for rational building space usage and increased HVAC equipment compactness, ABB has developed a motor with integrated speed controls. The EC Titanium™ motor is highly efficient and has the motor drive built-in. It combines synchronous reluctance and permanent magnet technologies for a sustainable, wirelessly connected solution to improve the customer's bottom line. EC Titanium™ helps to save valuable space in

equipment like air handling units, while also ensuring higher efficiency over the load profile compared to the more established commutated (EC) motor technology currently used in the market.

Since HVAC applications run for most of the time under partial load, SynRM motors offer excellent energy saving potential.

EC Titanium™ speed-load efficiency

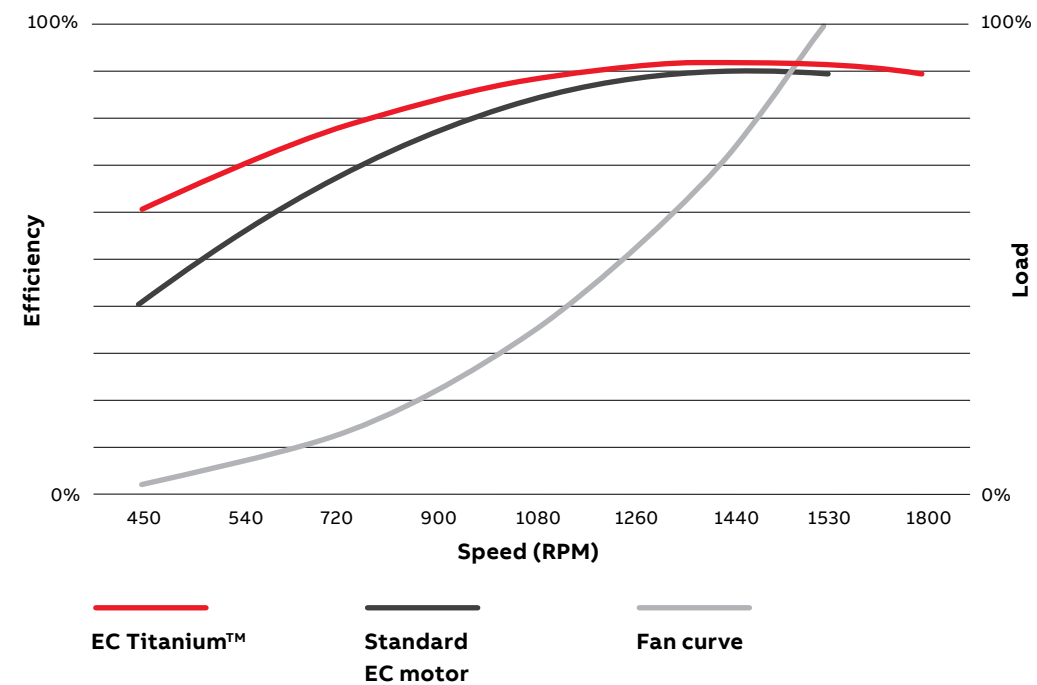


ABB EC Titanium™ vs a conventional EC motor: speed-load efficiency of a 2.2 kW, 1800 rpm motor.

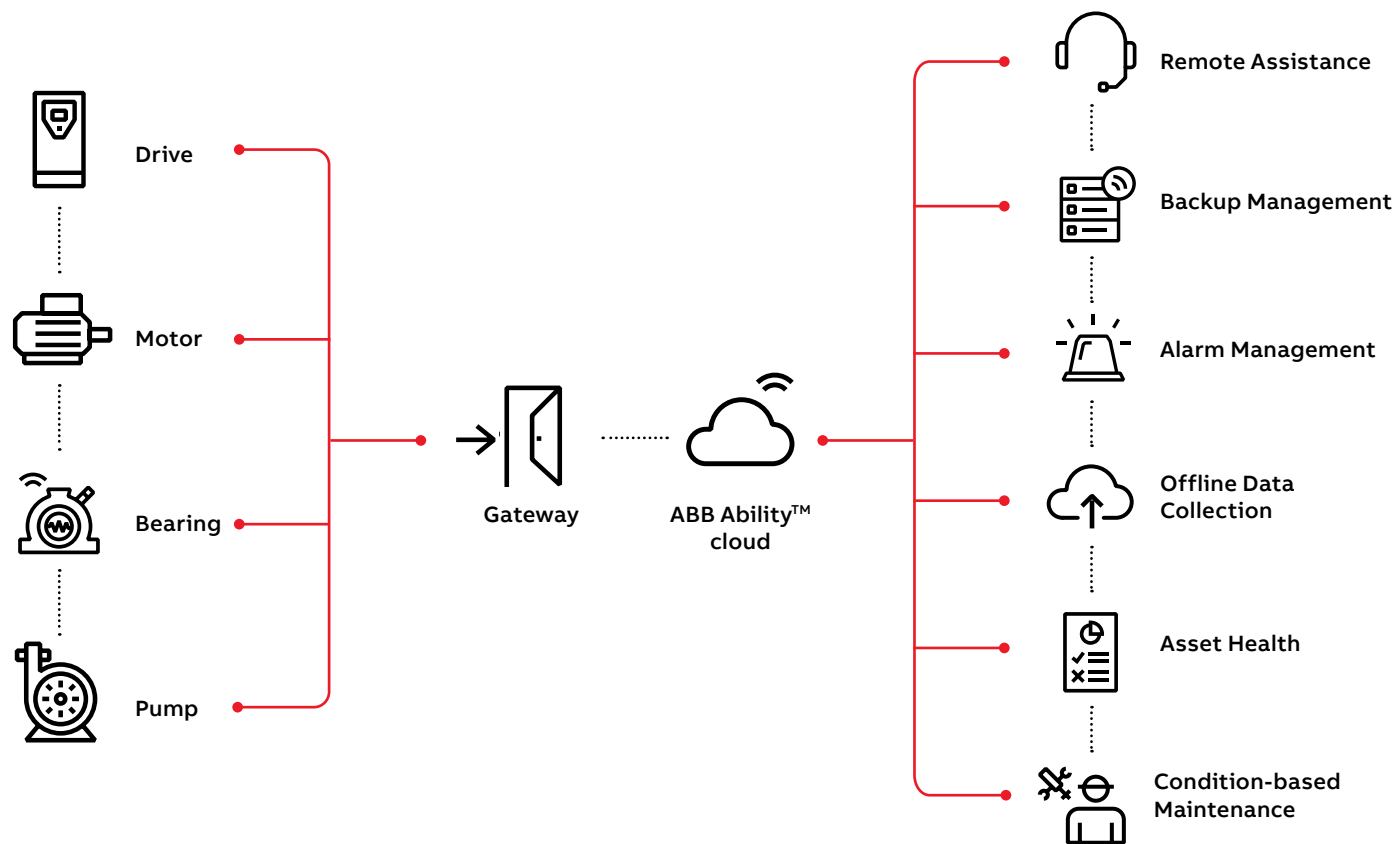
Digital services

The world is going digital and the buildings segment is no exception. Applied to buildings, digital technology can increase overall transparency and help optimize building system performance for better occupant comfort and reduced energy use.

The ABB Ability™ Digital Powertrain concept connects drives, motors, pumps, and bearings through the ABB Ability™ cloud service, taking efficiency to new heights. Condition monitoring services for powertrains deliver real-time reports to facility managers on energy consumption and the performance of equipment used in the HVAC, water supply and other building systems. This data provides deeper insight into building operations and it can be used to identify which parts of a system consume most of the energy so they can be optimized first.

The digital powertrain concept helps make buildings more energy efficient and also more sustainable through smarter maintenance. With continuous condition monitoring, there is no need to run constant manual checkups – all the data about building maintenance is collected in a cloud service and is easily available, relieving the pressure on service teams and reducing the number of service-related trips to a minimum. Spare parts can also be brought to the site by service engineers on the first visit, saving traveling time and eliminating related emissions.

With predictive maintenance it is possible to avoid failures by foreseeing the status of equipment and proactively keep components performing, rather than repairing or replacing them with incident-based reactive maintenance. It is one more step towards improving a building’s sustainability and reducing its carbon footprint.



— The ABB’s condition monitoring services for powertrains – increased efficiency and prolonged lifetime.

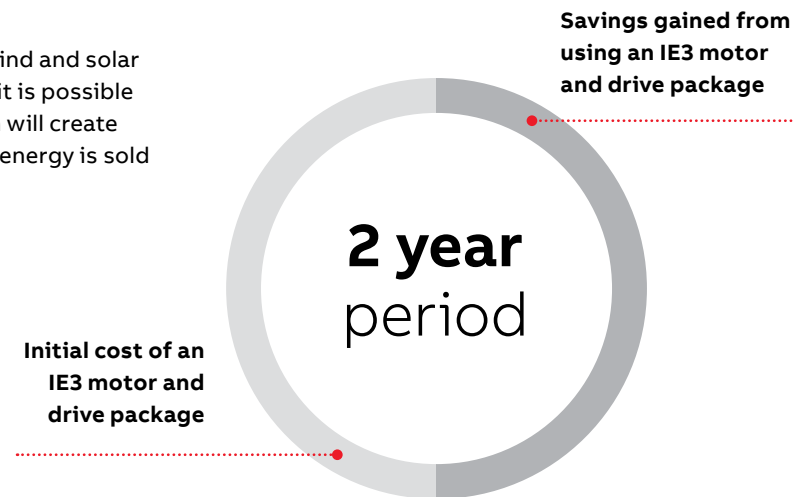
Return on investment and other benefits

Modern energy saving systems are often good investments. For building operators and owners, a basic smart management system can generate annual savings of 25%, with a payback period of less than two years.⁷

A good example is a recent case with ABB HVAC drives and IE3 energy efficient motors used in the renovation of the HVAC and hot water supply systems of the InterContinental hotel in Madrid. Thirteen ABB variable speed drives and sixteen IE3 motors were integrated into the BMS, which resulted in energy savings of around 40%, helping the hotel to meet its sustainability goals. Over a year these savings totaled 445 000 kWh, cutting the hotel’s annual energy bill by \$37 000, which delivered on the projected return on investment in exactly two years.

Together with renewable energy sources like wind and solar power, and energy regeneration technologies, it is possible for buildings to generate surplus energy, which will create extra revenue for the owners when the surplus energy is sold back to the grid.

An energy-efficient building with smart management systems can be a tempting dealmaker on many levels for many different target groups. In the commercial world, investors, developers, buyers and tenants are increasingly aware of how an energy efficient building can boost the positive reputation of their company. It has also been reported that people who work and live in “green” buildings are happier, healthier, and more productive.⁷



(1) United Nations, Department of Economic and Social Affairs, 2018.
 (2) IEA, Energy Technology Perspectives, 2017.
 (3) US Energy Information Administration, Commercial Buildings Energy Consumption Survey: Energy Usage Summary, 2016.
 (4) American Council for an Energy-Efficient Economy, Advancing Elevator Energy Efficiency, 2015.
 (5) HSBC. Smart Buildings Cut Emissions. March 2020.
 (6) Commercial Buildings Energy Consumption Survey, EIA 2016.
 (7) U.S. Green Building Council, 2018.



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