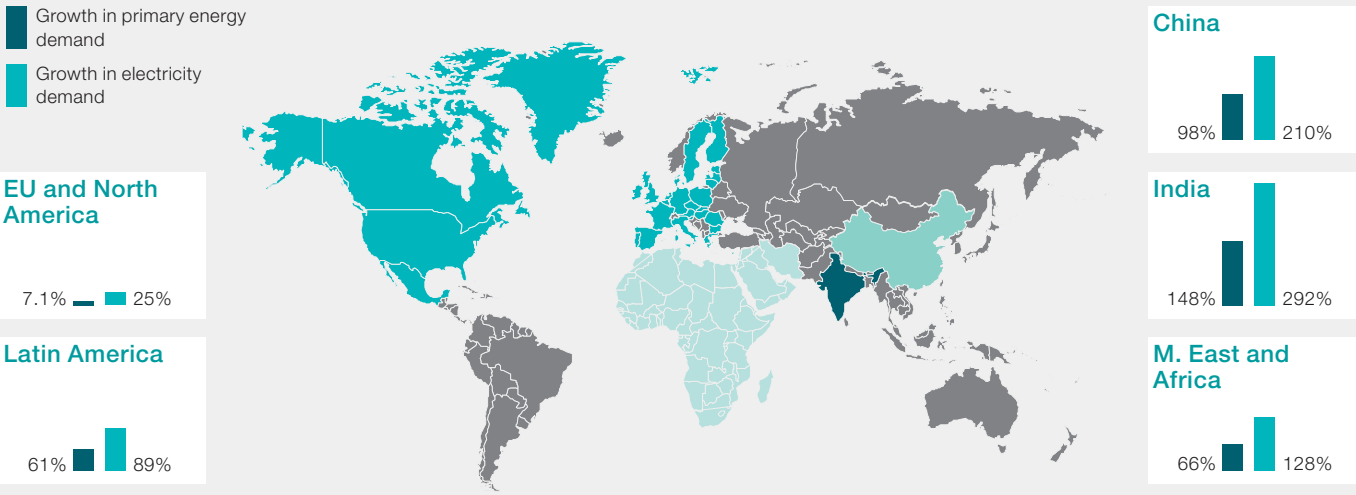
Background information

Energy efficiency and renewables
Managing the energy and climate challenge



Source: Values calculated by ABB from data in Current Policies Scenario in IEA's World Energy Outlook 2010

The world is facing a serious energy challenge; how to provide reliable and affordable supplies in the face of fast-growing demand and rising concerns for the environment.

Under current policies, energy demand is set to rise 47 percent between 2008 and 2035, according to the International Energy Agency (IEA), reflecting global economic growth and rising living standards. Electricity demand is expected to grow almost twice as fast, with most of the increase occurring in emerging markets. Power consumption in China is likely to triple.

However, such growth under current policies would also result in a 45 percent surge in CO_2 emissions and block efforts to slow climate change.[1]

Global leaders have agreed in principle to limit global warming to less than 2°C above pre-industrial levels. Climate scientists say that reaching this limit requires annual emissions of green-house gases to be cut to half what they were in 2000 by 2050.

New policies and technologies are therefore needed to enable the growth in demand for energy to occur without generating emissions.

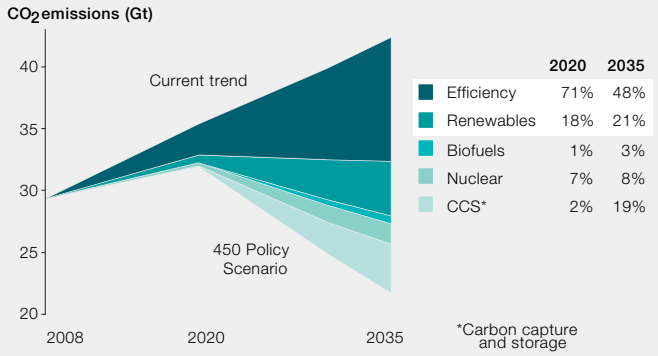
Energy efficiency and renewables
Managing the energy and climate challenge

Where the savings can be achieved

The IEA has mapped out a scenario that would enable the world to achieve the 2°C goal. It is called the 450 Policy Scenario, because it sets out to limit greenhouse gas concentrations in the atmosphere to around 450 parts per million of CO_2 equivalent (ppm CO_2-eq).

The IEA says energy efficiency will contribute most to achieving these aims (see chart) and together with renewables could abate 69 percent of CO_2 emissions by 2035.

World energy-related CO_2 savings potential by policy measure under 450 Policy Scenario relative to Current Policies Scenario



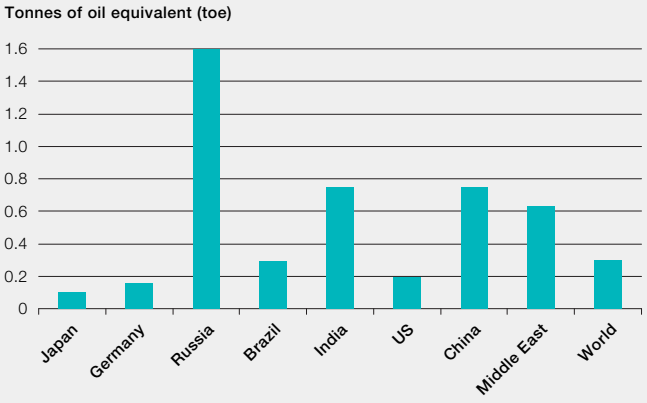
Source: IEA, World Energy Outlook 2010

Energy efficiency – the low-hanging fruit

Using energy more efficiently will not only contribute the lion's share of the emissions reductions needed, it is arguably the fastest, most sustainable and cheapest way to reduce emissions and enhance global energy security.[2]

Variations in energy efficiency across the world give a sense of what can be achieved with today's technologies. The most efficient economies generate almost 16 times more GDP with the same amount of energy than the least efficient (see chart).

Primary energy used per $1,000 of GDP



Source: International Energy Agency, Key World Energy Statistics 2010

The key advantages of existing energy-efficient technologies are that they are tried and tested, and investment payback times are short. They provide the opportunity to save energy and reduce environmental impact, without compromising economic development.

Renewable energy

Global investment in renewable energy has expanded rapidly in recent years, even if the global financial crisis postponed some projects.

Today, most renewables investment goes into wind power, followed by solar. Global investment in wind power reached $67.3 billion in 2009, a 14 percent increase over 2008 and nearly 60 percent of the total investment in renewables.[3] According to Ernst and Young's country attractiveness indices, China is now the clear leader in renewable investment with one in every two wind turbines commissioned globally in 2010 being in China.[4] Despite shifts in regional investment levels, 80 percent of the world's renewables can be attributed to investments made in recent years by Europe, China and the United States added together.

Renewable energy technologies are maturing and becoming more competitive, and as concern grows about the cost and the security of fossil-fuel supplies, policy support for renewable energy schemes continues to strengthen.

The ABB contribution

Energy efficiency and renewable energy are the two areas in which ABB technology can contribute most, and are the focus of this information pack.

1 IEA's World Energy Outlook 2010
2 Closing statement of G8 summit, June 2007
3 IEA's World Energy Outlook 2010
4 Renewable energy country attractiveness indices. Ernst & Young 2010

Energy efficiency and renewables
ABB and energy efficiency

Energy efficiency is the fastest and cheapest way to reduce energy consumption and emissions. The example of Japan, which generates more GDP per unit of energy than any other economy, shows just how much can already be done today, with existing technology.

Energy efficient systems can pay for themselves in energy savings, sometimes within months, and further reduce operation and maintenance costs in the long-term. Seizing such opportunities helps industries in mature markets to remain competitive and also gives fast-growing emerging markets the chance to minimize environmental impact, without compromising their economic development.

The IEA identifies three main areas in which the end-use of energy can be made more efficient: industry (including the power industry), transportation and buildings.

The sections below outline how ABB technologies and solutions help to improve the efficient use of energy in each of these sectors.

Industry and utilities

Energy efficiency in power utilities

For electrical generation, ABB systems improve the efficiency of fuel combustion, boiler operations and energy consumption in support operations.

Coal is still the main fuel of power generation. Since 1970, the average efficiency of coal-fired power plants has improved by about 20 percent. On average, the process that turns coal into electricity is now 40 percent efficient, while a modern combined heat and power plant (cogeneration plant or CHP) that uses heat produced during power generation to warm nearby buildings can achieve an efficiency of as much as 85 percent.

Enel's Torrevaldaliga clean-coal power plant in Italy. The plant is equipped with ABB control systems and electrical equipment, which help to increase efficiency from 39 to 45 percent

ABB has designed and commissioned CHP projects around the world. One is at the heart of a district heating system in China that takes heat normally wasted in a cooling tower and uses it to heat homes for about one million people, reducing CO_2 emissions by 500,000 metric tons and SO_2 emissions by 2,200 metric tons annually.

ABB supplies all the electric and automation equipment for power plants except for turbines and boilers. ABB's power combustion software and precise boiler control systems are helping to minimize losses and better use primary fuel sources by operating the process very close to its limits.

The new, highly efficient 750 megawatt (MW) coal-fired CHP plant in Walsum, near Duisburg, Germany uses optimized ABB equipment and monitoring systems, which will help ensure more electricity is fed into the grid than other generating units that use the same amount of fuel.

At the Grosskraftwerk Mannheim AG's (GKM's) 1,675 MW coal-fired power plant at Mannheim, in Germany, two ABB medium-voltage drives and a Resibloc dry-type transformer to control two boiler-feed pumps were installed, cutting pump energy consumption by 25 percent. This increased revenue by $800,000 a year and reduced emissions of CO_2 by 10,200 metric tons annually.

From the power station, electricity is sent through transmission and distribution systems, to end users who are often hundreds or even thousands of kilometers away. Losses typically range from 6 to 8 percent, but can be as high as 10 percent.

Current technology can save substantial amounts of electricity and increase the capacity of transmission and distribution networks by 16 percent, so more power can reach consumers over existing networks, instead of building new transmission lines and power plants. China increased capacity of a transmission corridor into Beijing by 40 percent using one of these transmission technologies.

Similarly the installation of ABB's Flexible AC Transmission Systems (FACTS) in eight substations owned by the Power Grid Company of Bangladesh has reduced electrical losses by 34 MW. The cost of achieving those savings was less than 15 percent of the investment needed to build a conventional fossil-fuel power plant with a similar power capacity, producing a payback time of just 18 months.

Using currently available technology the EU commission estimates that network losses in the European Union could be cut by up to 48 million megawatt-hours (MWh) annually, an amount equal to the power consumption of 13 million EU households.

Energy efficiency and renewables
ABB and energy efficiency

Paper machine at Stora Enso Kvarnsveden in Sweden. The machine is equipped with 45 ABB drives, frequency converters and motors.

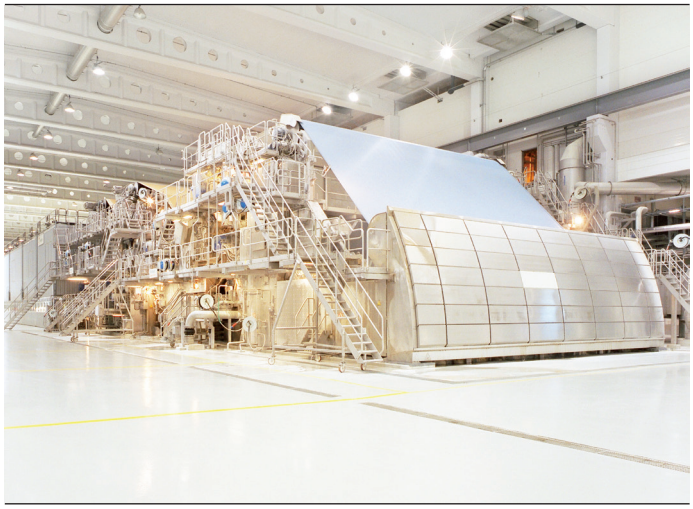


ABB is the recognized global leader in sophisticated power transmission and distribution technologies, such as high-voltage direct current (HVDC) electrical transmission and high-efficiency power and distribution transformers, which significantly reduce power losses.

In China, ABB's HVDC technology will help cut consumption of raw coal by 40 to 50 million metric tons per year, and eliminate 100 million metric tons of CO_2 emissions. Power for Shanghai generated more than 1,000 kilometers away at the Three Gorges hydropower station is sent to the city over two HVDC transmission lines, which save enough electricity per line to power more than 150,000 households.

ABB's ultrahigh-voltage direct current (UHVDC) technology can save about 30 percent of transmission losses on very long power transmission distances above 1,500 kilometers compared with conventional technology.

Energy efficiency in industry

Overall industry consumes about 42 percent of all electricity generated, according to the International Energy Agency. The most energy-intensive industries are cement, chemical, iron and steel.

The vast majority of ABB's industrial product range improves energy savings by helping factories run more productively with state-of-the-art control systems, automation products and electrical equipment. Our key technologies include controls, enterprise software, instrumentation, low-voltage products, drives, motors, robots and turbochargers.

The energy saving potential in industry is enormous in motor systems alone: hundreds of millions of electric motors driving machines, compressors, fans, pumps or conveyors in virtually all sectors account for about 67 percent of all the electricity industry uses.

More than 90 percent of these motors either cannot adjust their power consumption, or use only crude and grossly inefficient ways to do so. Many are constantly running at full speed regardless of actual output requirement. In many applications, energy use can be cut to one-eighth just by adjusting motor speed to one-half.

ABB has delivered more than 2.5 million energy-efficient motor control devices. The installed base of ABB low-voltage drives alone (just one type of motor control device) saved more than 220 million MWh of electricity in 2009, equal to the annual electricity consumption of 54 million households in the 27 member states of European Union. In CO_2 terms, the savings were about 180 million metric tons, equal to the yearly emissions of 45 million cars.

Robots are mainly used in industry to increase productivity, improve quality and reduce safety risks to employees. Increasing productivity typically leads to lower scrap rates and therefore lower energy consumption per manufactured unit. Roland Murten AG, a Swiss maker of bakery products, reduced its scrap rate on a pretzel packaging line by 80 percent with ABB robots, cutting energy consumption by 12 percent in the process.

Energy efficiency in transportation

The transport sector represents 23 percent of overall global CO_2 emissions generated by fossil fuel combustion and is expected to grow by approximately 40 percent from 2007 to 2030.[1]

ABB technology can help lower energy losses and reduce CO_2 emissions in transportation on both land and sea.

The efficiency of trains is mainly determined by the combination and design of traction chain components (generators, circuit breakers, transformers, traction converters and motors). ABB supplies energy efficient equipment for trains either as individual components or as complete traction packages to rolling stock manufacturers, along with modern turbochargers for diesel locomotives.

The shipping industry, although more efficient per ton-kilometer than trucking, accounts for 4 percent of global CO_2 emissions, but more significantly 10 to 15 percent of all nitrogen oxides (NO_X) and 4 to 6 percent of sulphur oxides (SO_X).

Energy efficiency and renewables
ABB and energy efficiency

ABB Azipod ship propulsion systems reduce fuel consumption by up to 15 percent. ABB also supplies connections so that vessels in port can get electricity from shore rather than generate their own power on board, helping reduce CO_2 and other emissions.

In addition, tankers, container ships and mining vehicles fitted with high-performance ABB diesel engine turbochargers can increase power output four-fold.

Energy efficiency in commercial and residential buildings

Commercial and residential buildings account for about 38 percent of global end-user energy demand, mainly for heating, cooling and powering electric appliances.

Adjusting the heating temperature, lighting and the energy consumption of electric appliances to the actual requirements offers a substantial energy-saving potential without compromising comfort or quality of life. A study by the Association of the German Electrical Industry (ZVEI) found that energy consumption and costs for lighting in buildings of all kinds can be reduced by up to 80 percent using intelligent building systems.

Every day, ABB ships one million products for the commercial and residential building sector and is a leading producer of low-voltage devices and automated control and building automation systems that can help to achieve savings mainly in three areas:

- Temperature control can save up to 30 percent
- Lighting control can save up to 50 percent
- Building automation can save up to 60 percent

ABB i-bus KNX technology installed in one of Italy's most important contemporary art museums, the Museo d'Arte Moderna, in Rovereto, produced annual energy savings of about 28 percent with advanced lighting control systems. The installation has reduced electricity consumption by more than 450,000 kilowatt-hours (kWh) per year and cut costs by $112,000 in its first year of operation.

Similarly, ABB provided building system technology for the Singapore National Library, which now consumes 17 percent less energy than it was designed for, saving around $370,000 a year, using about 32 percent less energy than the national average for a building of its kind in Singapore.

Further reading:
www.abb.com/energyefficiency
www.abb.com/powergeneration
www.abb.com/powerT&D
www.abb.com/processautomation
www.abb.com/pulpandpaper
www.abb.com/robots
www.abb.com/railways
www.abb.com/automotive

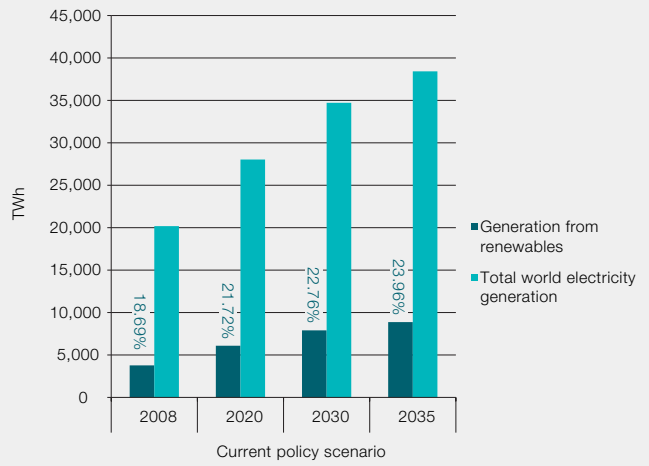
[1] Reducing Transport Greenhouse Gas Emissions: Trends and Data (ITF) 2010

Energy efficiency and renewables
ABB and renewable energy

Electricity generation from renewable sources is set to more than double by 2035 under current policies (see graphic), and rise even faster if governments take further measures to promote low-emission power generation, according to the IEA.

Most of the increase will come from hydro and onshore wind power, followed by offshore wind and solar power.

World electricity generation from renewables



Source: IEA World Energy Outlook 2010

Global wind generation capacity is projected to reach 2,300 GW by 2030.[1] At the end of 2009 global wind power capacity had reached 159 GW, and by the end of 2010 it had reached about 200 GW.

About 340 terawatt-hours (TWh) of wind power was generated globally in 2009, equivalent to the total electricity demand of Italy, the world's seventh-largest economy, and 2 percent of global electricity consumption.[1]

ABB provides both power and automation technologies for the renewable power industry. These are used to generate the electricity from renewable sources, to control the power plants, and to feed the electricity into the grid in such a way that the stability of the network is maintained or improved even when changeable weather conditions lead to irregular power generation.

Many of these technologies are also used in other segments of the renewable energy industry, to help generate heat or produce biofuels, but power generation and transmission remains the main renewables market.

Renewable portfolio

ABB is one of the world's leading suppliers of electrical components, systems and services to the wind power industry, designing and making everything from transformers and generators to grid connections and the power electronics needed to maintain grid stability while accommodating the erratic nature of renewable power.

Wind farms in coastal waters or onshore can be connected to the grid using alternating current (AC) technology that can regulate the voltage and avoid instability (eg, Flexible AC Transmission System technologies), as well as with high-voltage direct current (HVDC) technology.

ABB innovations in HVDC transmission technology mean wind farms can also be located far out at sea, where average wind speeds can be 20 percent higher than on land, and yield as much as 70 percent more energy.

Electric power can be fully controlled with HVDC, so that the intermittent electricity supply from a wind farm cannot disrupt the grid. Using a form of the technology that ABB calls HVDC Light, the transmission system can be started from a powerless state, for example if the wind hasn't been blowing at all. Very little electricity is lost during transmission, even over long distances.

The use of oil-free cables running underwater to the coast, where underground transmission can begin, are further ways that HVDC Light transmission technology minimizes environmental impacts.

In addition to a deep involvement in wind generation projects, ABB has been a leading force in the solar power industry since the early 1990s, when it developed an automation platform for the world's first test facility for concentrating solar power technologies at the Plataforma Solar de Almería (PSA) in Spain.

Since then ABB has been involved at a pioneering stage in just about every type of photovoltaic (PV) and concentrating solar power (CSP) technology developed, in Europe, North America, Australia, North Africa and the Middle East.

In addition to providing products, systems and services for large-scale wind, solar and hydro power plants, ABB produce custom-built generators that are the key components of wave energy projects.

ABB is a partner in an award-winning pilot project in Germany, which is designed to reduce energy consumption and minimize CO_2 emissions by integrating an entire power grid system – generation, distribution and consumption - into a single, inter-

active, real-time network.

This solution will integrate clean energy generated by solar panels, wind turbines, fuel cells and other sources of distributed generation and provide the grid operator with real-time information about the entire power network in terms of supply and consumer demand.

ABB references

– ABB has delivered the power transmission link for the 400 MW Borkum 2 wind farm, situated in the North Sea 125 kilometers (km) from the German coast. It is the world's most remote wind farm and is expected to save 1.5 million metric tons of CO_2 emissions per year by removing the need for additional fossil-fuel generation. The HVDC Light trans mission link will send power harvested at sea underwater to the coast, and then 78 km underground, where it will join the German power grid with minimal impact on the environment.

– Totana is a high-efficiency, ABB-designed 1 MW turnkey photovoltaic power plant in Spain. Pre-assembled and factory-tested equipment modules can be installed and commissioned very quickly on site, and include patented technologies to increase plant performance. Totana pro duces 2.2 gigawatt-hours of grid-quality electricity, displacing about 1,350 tons of tons of CO_2.

– Custom-built ABB generators are key components in the world's first commercial wave farm, a 2.25 MW installation off the coast of northern Portugal set up to convert the motion of water into power. That is done with three wave energy converters, which generate enough power for 1,500 Portuguese homes, and displace 6,000 tons of CO_2 annually.

Further reading:

www.abb.com/solar
www.abb.com/windpower
www.abb.com/powergeneration
www.abb.com/powerT&D

1 "World Wind Energy Report 2009," World Wind Energy Association, March 2010.

Energy efficiency and renewables
Focus on technology: high-voltage direct current transmission

The world average transmission and distribution losses are about 8 percent, but in some countries it may be as high as 35 percent.

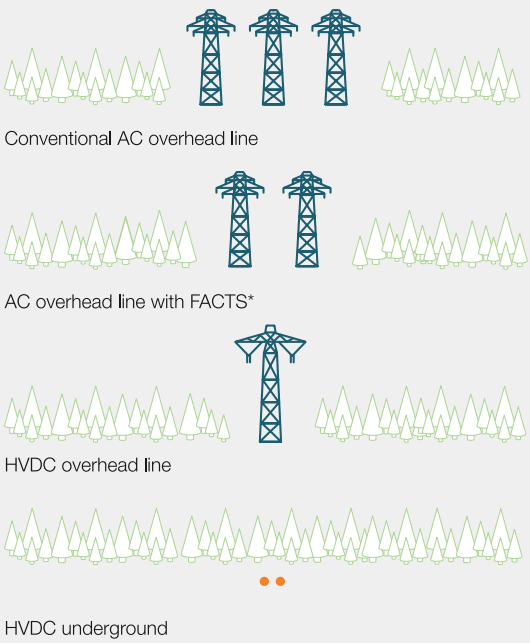
Losses are created by resistance[1] in the metal cables used to conduct the electricity. Resistance converts some of the electrical energy into heat, which then simply dissipates from the power lines into the surrounding atmosphere. The further electricity has to go, the more energy is converted into heat, and ultimately lost.

It's an increasingly common challenge, as electricity has become a long-distance traveler. Offshore wind farms, hydroelectric dams in remote mountainous areas and international power trading systems moving electricity from country to country all demand efficient long-distance transmission systems that can conduct large amounts of electricity across long distances with low losses.

The simplest way to reduce losses is to increase the transmission voltage. But the greatest transmission efficiency is obtained by using high voltages and direct current. High-voltage direct current (HVDC) was developed by ABB more than 50 years ago, and one of its central features is that it achieves lower energy losses during transmission than conventional alternating current (AC) transmission.

HVDC systems need technology to switch electricity from AC (the form in which it is generated) to DC, and then back to AC again at the other end of the transmission. Since the switching process also causes power losses, HVDC is economically viable only for transmission distances greater than 600 km (kilometers) for overhead lines and 100 km for underwater cables.

An ABB engineer tests HVDC Light during installation



*FACTS: Flexible AC Transmission System, a series of ABB technologies that enhance the capacity of exsting transmission infrastructure

Over very long distances, however, the potential to save power and money is considerable. Losses amount to about 7.5 percent in a 500 kV (kilovolt) AC system transmitting 3,000 megawatts (MW) over a distance of 1,000 km. This energy loss shrinks to 6 percent when HVDC technology is used at 500 kV.

Environmental benefits

HVDC transmission is environmentally friendly for a number of reasons. A single HVDC line can provide the same capacity as multiple lines using alternative transmission systems. This means that DC high-voltage transmission corridors can be significantly narrower, reducing the land area and the construction materials required. Furthermore, in some applications, transmission cables can be buried underground, avoiding the need for steel pylons across the countryside.

Energy efficiency and renewables
Focus on technology: high-voltage direct current transmission

As the electricity in DC transmissions can flow in both directions, its use can provide further environmental benefits. The 580 km link that ABB has built between Norway and the Netherlands allows the Netherlands to import “green” hydropower from Norway during the day, when demand is high, and export excess capacity from its thermal power stations during the night, when demand is low.

The ability to efficiently trade power back and forth like this maximizes the use of renewable power and allows thermal generating plants in the Netherlands to reduce their output, yielding a reduction in CO_2 emissions of almost 1.7 million tons per year.

The vision of harvesting solar power in deserts and transmitting it to population centers within a range of 2,000 to 3,000 km with low losses is virtually dependent on HVDC transmission technology.

ABB references

ABB is the world leader in power transmission and distribution technology and has delivered more than 50 percent of HVDC projects in operation or under construction around the world, including:

- Cross Sound, a 300 MW, 40 km HVDC Light underwater link between Connecticut and Long Island, New York, that improves power reliability and enables regional power trading.

- Troll A, a North Sea oil and gas platform is powered from the Norwegian mainland 70 km away with a breakthrough HVDC Light underwater link that provides reliable power and lower emissions.

- Three Gorges-Shanghai, long-distance HVDC links (one 850 km, the other 1,060 km) that deliver a total of 7,200 MW of clean hydropower from central China to the coastal city of Shanghai.

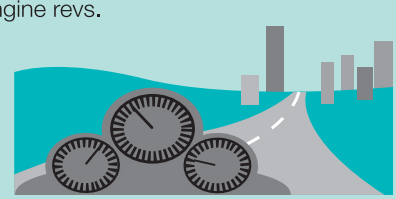
Further reading:
www.abb.com/powerT&D

Energy efficiency and renewables
Focus on technology: motors and drives

Electric motors are the workhorses of industry, so commonplace they are estimated to consume about two-thirds of all the electricity used by industry. Since industry accounts for about 42 percent of the world's electrical consumption[1], it follows there are enormous opportunities to save energy, simply by improving the way electric motors are used.

Name virtually any industrial activity, and the chances are it uses an electric motor. Motors operate all kinds of machines, fans, pumps, conveyors and compressors in applications as varied as pharmaceuticals and chemical processing, pulp and paper and cement manufacturing, mining and electronics, to name only a few.

The importance of speed control has always been clear in cars. You can imagine how difficult it would be to manage a car by keeping your foot on the accelerator and controlling your speed with the brake. It is much easier to change to a lower gear and reduce engine revs.



The problem is that many of these motors are bigger than they need to be, and most are running constantly at full speed, even when they don't have to. While the motor keeps on running at full speed, the output of the process is controlled by "throttling," which is like trying to control your car's speed by braking with one foot while continuing to accelerate with the other.

This not only wastes a vast amount of energy, but also causes excessive wear and tear on equipment. But there is another way. The speed of a motor can be controlled by gently raising or lowering the amount of power it receives, using a variable-speed drive. This simple approach can significantly reduce the amount of electricity a motor uses, and also lengthens the life of equipment that is no longer subjected to the jolting, on/off braking that results from throttling.

By connecting the motor to a variable-speed drive (VSD), the motor's speed can be matched exactly to the job in hand, ensuring that no more power than necessary is used. Typical applications can achieve energy savings of about 30 percent, meaning an investment in variable-speed drives can often pay for itself in less than a year.

Using high-efficiency motors in combination with drives is even more effective. The energy savings quickly add up because the energy used to run a motor over its lifetime costs 100 times more than the motor itself.

Electrical energy efficiency has long been recognized by the International Electrotechnical Commission (IEC) as one of the priority areas. Standardization initiatives have resulted in the harmonization of energy efficiency requirements, testing methods, and certification schemes for the electric motors market.

These standards have introduced more accurate measurements of motor efficiency, which benefit manufacturers, who can compete on equal terms with competitors, and benefit consumers, who can more easily compare the efficiency of different motors.

By implementing standards, emissions will be reduced significantly over time, since they encourage most motor manufacturers to improve the efficiency of the motors they sell. ABB manufactures a full range of motors in the IE2 class, premium efficiency motors in the IE3 class, and super premium efficiency motors in the IE4 class (within the output range of 75 to 355 kW).

ABB is the world's largest maker of electric motors and variable-speed drives. The installed base of ABB drives saved more than 220 million MWh of electricity in 2009, equal to the annual electricity consumption of 54 million households in the European Union.

If that 200 million MWh of power had been generated by electric plants burning fossil fuel, the resulting CO_2 emissions would have been about 180 million metric tons, equivalent to the annual emissions of more than 45 million cars.

Bigger is not always better

In addition to issues of speed and inefficiency, the vast majority of the world's industrial motors are oversized. That is because companies commonly buy more powerful motors than are actually needed as a "buffer" to protect them from power spikes and uncontrolled overload.

An intelligent, or software-based, motor control system allows businesses to manage the status, condition and energy consumption of all the motors in a plant, which means they can install smaller motors that consume far less energy, knowing their investment is monitored and protected. Smaller, energy-efficient motors that are correctly dimensioned consume less energy and reduce greenhouse gas emissions.

Energy efficiency and renewables
Focus on technology: motors and drives

Replacing an oversized, 37 kW (kilowatt) motor with a 30 kW motor would save a typical medium-sized site with 200 motors about 180,000 kWh (kilowatt-hours) a year, and avoid the generation of 90 metric tons of CO_2 emissions. For a paper mill, which might contain 1,500 motors, the savings are even more striking.

A new ABB low-voltage drive features an innovative built-in energy counter that shows the amount of energy saved (in kilowatt-hours or local currencies) and even the quantity of CO_2 emissions avoided by using the drive to regulate the speed of the motor. The ACS310 drive specifically targets millions of small electric motors that are used in common pump and fan applications, most of which have no speed control at all.

ABB references

– Drives controlling the speed of kitchen fans have cut energy consumption in half at 50 McDonald's restaurants in the United Kingdom, with the added benefits of reduced fan noise and improved equipment efficiency in the kitchens.

– Fitting a drive to a cooling fan at Pena Colorada, Mexico's largest iron mining operation, reduced energy consumption of the installation by 23 percent, and boosted productivity by increasing the availability of the system.

– Equipping the motor of a mixer at the Daqing Petrochemical Plastic Factory in China, improved production quality and resulted in energy savings of 30 percent.

Further reading:

www.abb.com/motors
www.abb.com/drives

[1] International Energy Agency, Key World Energy Statistics, 2010 (data from 2008)