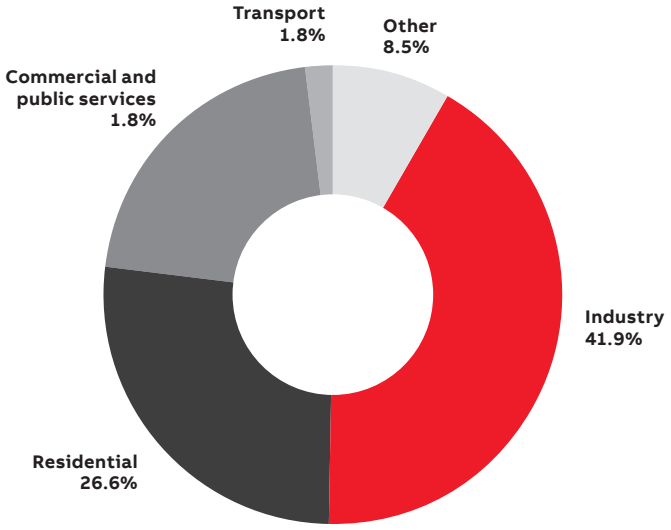
WHITE PAPER

Energy efficiency opportunities in chemical manufacturing

Introduction
Necessity breeds efficiency

The chemical industry is an integral part of our daily lives, producing chemicals that many other industries and processes rely on. According to International Energy Agency (IEA) data, the sector is the second-largest industrial energy consumer and the third-largest direct emitter of CO_2.[1] Improving the energy efficiency of chemical production applications is a vital step in the continuing push towards a sustainable future for all.

Share of electricity final consumption by sector 2019[3]



Energy use in the chemicals industry

As ever more advanced modes of production are developed, and the demand for products continues to grow, a key global emphasis must be placed on improving the efficiency of industrial manufacturing. Industrial manufacturing consumes about 42% of global electric energy.[2] Around 70% of the electricity consumed by industry is converted into motion by motors that power equipment.[3] Therefore, we should develop technologies that can reduce energy consumption across many industries, and identify those industries where most energy is used. The chemical industry is the largest energy user of all manufacturing industries and in the top two highest electricity consuming industrial sectors along with iron and steel production.

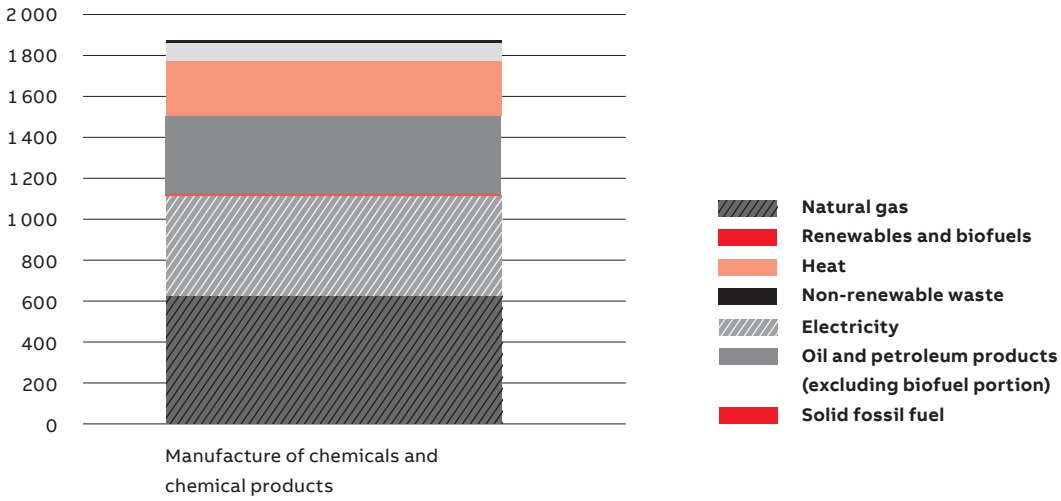
Natural gas, liquefied petroleum gases (LPG), and natural gas liquids (NGL) are the major energy sources used in the chemicals industry. Including fuel and feedstock use, the chemical industries account for about 30% of the total energy consumed in the manufacturing sector and is one of the top GHG emissions-intensive industries, being responsible for 20% of industrial and 7% of all emissions.[4] Most of the electricity consumed by the chemicals industry is used for drive and motor systems and is set to grow by 30% by 2030.[1] However, the technology exists to implement improvements that could significantly reduce energy use and help reach net zero carbon targets.

Saving energy in the chemicals industry

The chemical industry concerns the conversion of raw materials such as oil, natural gas, air, water, metals, and minerals into thousands of various products. Chemicals are key materials for producing an extensive assortment of consumer goods. The industry is responsible for creating many resources that are essential inputs to numerous other industrial segments.

From those thousands of chemical products, just four product groups account for 50% of the energy use. These especially energy intensive groups are based chemically on olefins, ammonia, aromatics and methanol. Also, ammonia and methanol are notable areas of increased demand. Demand for methanol, used for formaldehyde, fuel applications, and intermediaries, has shown growth in demand of 7.2% annually over the last decade.[1] Carbon capture and green hydrogen technologies can help to manufacture the majority of these chemicals in a much more environmentally friendly manner.

Final energy consumption in the chemical and petrochemical industry by energy product, EU, 2020 (PJ)[5]



Savings through pump efficiency

There are dozens of ways in which energy efficient technology can be used in the chemicals industry. For example, upgrading motors and drives in chemical plants could significantly reduce electricity use in pumping systems while improving safety, reliability, and profitability.

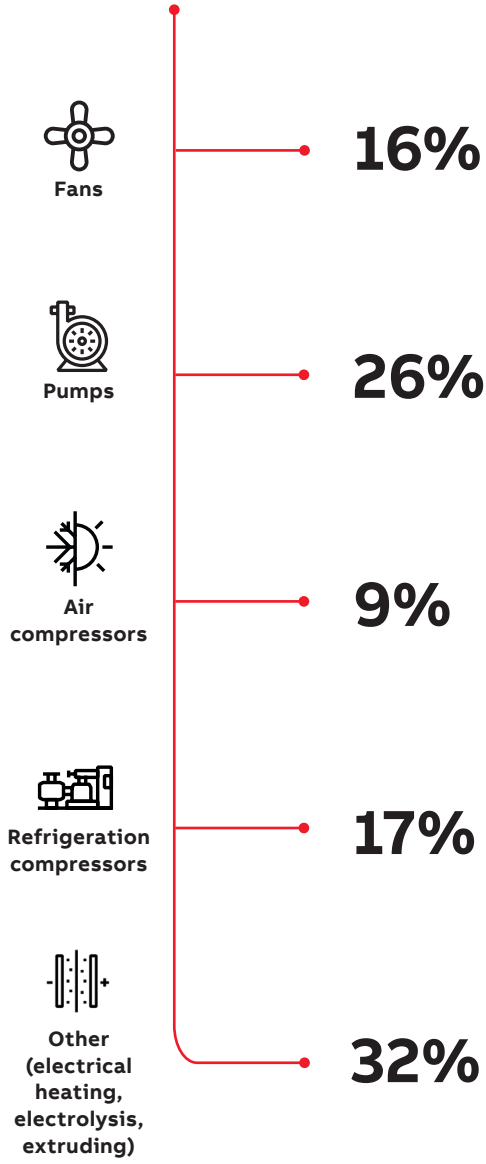
Chemical plants can have hundreds of pumping systems working in applications that consume enormous amounts of electricity, representing over 90% of the pump life cycle cost.[6] Given the huge electricity needs, motors and drives that improve the efficiency of these systems can quickly make a big difference.

Pumps account for 10% of the world's total electrical energy consumption, and pump systems are responsible for around 20% of industrial electricity use. Further, the chemicals sector is one of the biggest pump system users, with the application accounting for 26% of total electricity consumption in that industry.[7]

However, pumping efficiency in manufacturing and processing plants can be improved. Process intensive sectors, such as the chemical industry, have a high base production flow that is generally managed by pumps – usually centrifugal pumps – operating at constant speed. There is always a need to control the process flow over time.

Operating pumps at a constant speed and using traditional methods of flow control, such as throttling (forcing a bottleneck), wastes a lot of energy. Modern drive and motor technologies offer far more efficient control and monitoring of pump operations.

Electricity use per main chemical application[7]



Better flow control improves process reliability and efficiency

Traditionally, controlling fluid flow rates in chemical plant pumping systems was a bit like driving a car with the accelerator pedal pushed flat on the floor, while simultaneously using the brake pedal to vary the speed.

A control valve is put on the outlet side of a centrifugal pump, which is powered by an electrical direct-on-line (DOL) motor running at full speed. The valve is used to throttle or choke the liquid to achieve the desired flow. To be on the safe side, oversized pumps and DOL motors are often chosen in the engineering phase, but in practice the maximum conceivable flow rates are rarely reached.

Simply put, the fluid comes out of an oversized pump run by an oversized motor working at full speed and hits a partially closed flow valve. The flow rate is controlled but in a very crude manner, causing severe wear and tear on the system components and wasting energy.

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Applications in explosive atmospheres can now benefit from SynRM motor technology.

Motors, drives and digitalization

Identifying energy efficiency savings
The next question is how potential improvements can be best identified. Thanks to customized, flexible business models, ABB solutions and services enable better energy efficiency and reduction of CO_2 emissions and waste to meet global and local environmental regulations while maximizing the value from motors and drives.

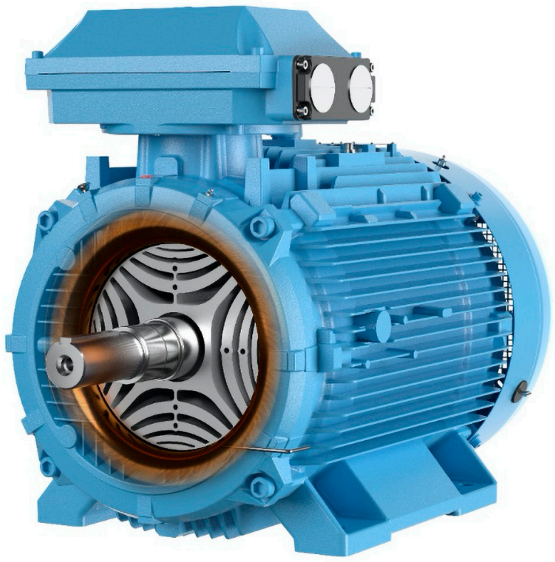
ABB Energy Appraisals allow the assessment of the energy improvement potential of electrical motor-driven systems with the help of data insights and expertise, giving detailed understanding into how motor-driven applications perform and thereby helping to make better decisions on ways to save energy, lower CO_2 emissions and boost a company's overall sustainability. Appraisals can be conducted on-site, remotely, or as a combination of the two.

Post-assessment, ABB Motion Services supports customers implementing the key solutions and services to deliver substantial energy efficiency gains and CO_2 emissions reductions, with attractive ROI and payback time.

Advantages of Variable Speed Drives
A far better alternative for adjusting flow rates and pumping capacity is to use a variable speed drive (VSD) on the motor. Flow control can be more precise and energy savings very large due to the 'Cube Law', which describes the relationship between flow output and energy input for centrifugal pumps or fans.

This matters for motors because running them without a VSD means that they are frequently operating at a higher capacity than needed. Having too high or too low torque or speed wastes materials and energy – the motor's speed should exactly match the process requirements. For instance, a 20% drop in motor speed can result in up to 50% reduction in energy consumption, especially when used with highly efficient motors.[8] Drives designed for use in hazardous environments such as ABBs ACS880 industrial drives and ACS580 general purpose drives have been designed to meet the requirements set by the chemical industry.

For applications in explosive atmospheres, which are common in chemical production, motor-drive packages are available with ATEX certification. The introduction of SynRM Increased Safety motors to the market finally allows



chemical manufacturers to take advantage of the most energy efficient motor and drive technology available.

SynRM (Synchronous reluctance motors)
Increased Safety motors for explosive atmospheres
We have seen that the technology already exists to make significant inroads towards our goals of achieving carbon neutrality within just a few decades. One important way of utilizing this new technology is to replace older, obsolete equipment with newer, more energy efficient variants. When we think about the motors and drives used throughout the chemical industry, we know that the industry is highly energy-intensive, and related demands will only continue to grow. Therefore, increasing the efficiency of motors and drives cannot but help to improve overall energy efficiency. Synchronous reluctance (SynRM) motors deliver a new standard of IE5 premium efficiency that provide up to 40% lower energy losses compared to IE3 certified motors.[9]

Of equal importance in the chemical industry is ensuring that processes and applications run safely. Motors used in explosive atmospheres must meet strict criteria to ensure their use is suitable in such environments. ABB is the first manufacturer in the world to provide SynRM motors suitable for use in explosive atmospheres and certified to ATEX and IECEx requirements.

In addition to meeting explosive atmosphere regulations, SynRM Increased Safety motors provide all the class benefits such as higher efficiency, increased reliability and reduced maintenance thanks to lower running temperatures, longer lifetime and fast ROI. The motors produce minimal CO_2 emissions and are sustainably manufactured, containing no rare earth elements.

Additionally, the motors can help specify a more cost-effective installation. For example, in Zone 1, the cooler running design could allow the use of an increased safety motor where a flameproof motor with a special enclosure would be the traditional choice. While in Zone 2, the improved loadability of SynRM motors, that enables more power to be delivered from the same size as an induction motor, is important. This could enable a smaller, and therefore lower-cost, motor to fulfill the same duty.

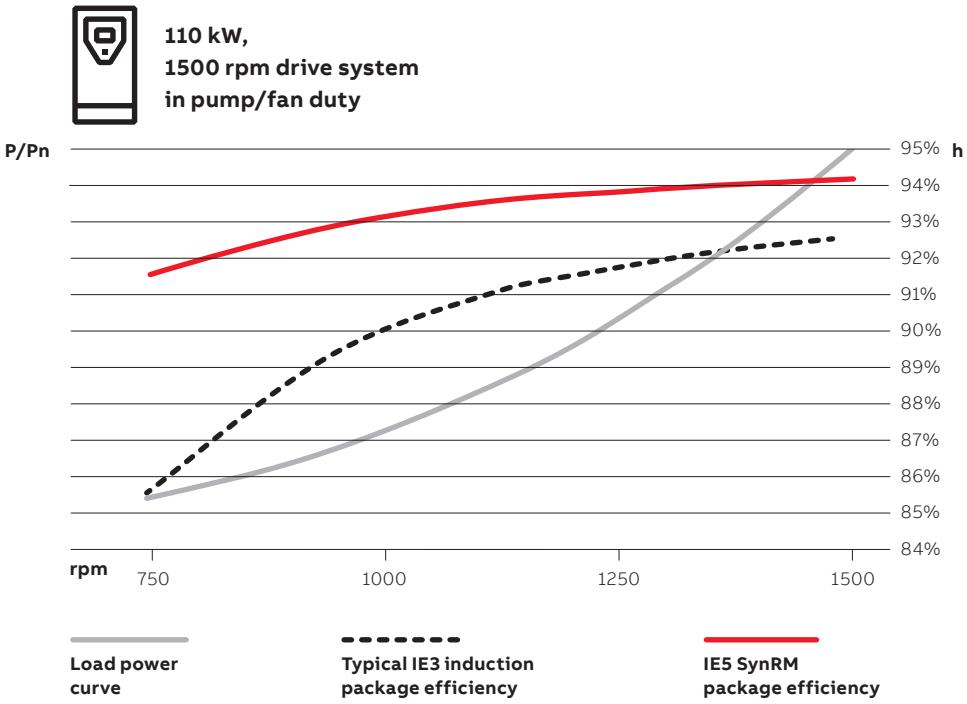
SynRM motors are also ideal for companies looking to upgrade and modernize their assets. Because they are the same size as induction motors, replacement is straightforward and requires minimal process disruption. The motors are also compatible with ABB Ability™ Digital Powertrain, allowing remote monitoring of electrical motor driven processes, as well as being certified for use with drives.

Long-term energy efficiency

Digitalization enables new smart and secure ways to prevent unexpected downtime while optimizing the energy efficiency of chemicals applications. For example, ABB Motion Services' digital portfolio and industry knowledge help identify potential energy savings and CO_2 emissions reductions. Motors, drives, or the entire powertrain is connected to a cloud service for equipment monitoring that enables efficient operations, waste reduction and improved uptime.

Practical benefits of digitalization also include easy access to condition data from equipment in locations that might be difficult or dangerous to reach. ABB Ability™ Condition Monitoring for powertrains allows the monitoring of critical assets in every part of the process, including pumps, fans, compressors, and centrifuges. Remote capture of reliable condition monitoring data provides insights into an asset's health and energy efficiency and helps to increase uptime and reduce costs.

It is often possible to retrofit and upgrade aging motors and drives with the latest technology. These processes extend their lifetime and enhances their performance while increasing production capacity and lowering energy consumption. Retrofits and upgrades also avoid premature scrapping and reduce waste, thereby contributing to the circular economy.



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Example: For a 110 kW 1500 rpm drive system in pump/fan duty, with an IE3 induction motor the package efficiency is 92.5%, while for an IE5 SynRM motor the package efficiency is 94.2%.

Decarbonization in the chemicals industry

Quickly reducing the amount of CO_2 produced by the chemicals industry is required to meet Net Zero targets by 2050. In order to decarbonize the chemical industry, we need to reduce carbon dioxide emissions by closing and moving beyond the current carbon cycle. In this context, decarbonization refers to the reduction of atmospheric carbon dioxide emissions. One route to decarbonization is avoiding the generation of carbon dioxide altogether. For example, this could be achieved by sourcing hydrogen exclusively from splitting water instead of from steam methane reforming and water gas shift reactions.

Another strategy could involve converting otherwise emitted carbon dioxide into valuable commodity chemicals through carbon capture. What both of these routes have in common is that they are likely to involve transforming elements and compounds at the bottom of the free energy landscape, such as carbon dioxide, nitrogen, and water, to desirable commodity chemicals higher up, such as ammonia and methanol. In this case. The required energy would ideally come from renewable sources such as solar and wind.

Electrification is also a major trend in the chemical industry where cracking as well as other heat intensive processes are being electrified. Steam turbines, for example, are being replaced by electric driven compressors, and traditional fuels and feedstock like oil and gas are being replaced with new bio-based feeds, recycled plastics and electricity-based e-fuels.

We must close and move beyond the current carbon cycle.

Customer **success stories**

CUSTOMER CASE

3,500 motors for huge energy savings

Norwegian company Yara – the world's largest producer of nitrogen-based complex fertilizers – turned to ABB to boost the energy efficiency of their main production facility in Porsgrunn, Norway. The upgrade project will ultimately yield annual energy savings of 32-40 gigawatt hours (GWh) and cut CO_2 emissions by 12-19 kilotons (kt) – equivalent to the emissions produced by nearly 14,000 standard cars.

The first project phase involved the replacement of around 1,000 old low-voltage electric motors with IE3 motors, 75 percent of which also had drives added to them. The second, ongoing phase will replace an additional 2,500 motors with SynRM ultra-premium efficiency IE5 motors. Nearly 70 percent of these motors are fitted to pump and fan applications which offer significant energy saving opportunities. As well as energy savings and reduced carbon emissions, Yara further expects significant savings in maintenance costs due to lower wear and tear, attributable to the longer lifetime of motors and drives-driven machinery due to lower mechanical stress.

Conclusion

It has become abundantly clear that significant changes in the way we supply and use energy are required in order to prevent the worst outcomes of climate change. Modern technologies give us the means to do this. Within the chemical industry, demand for products is constantly increasing, which, considering the industry is generally highly energy-intensive, requires us to implement energy-efficiency solutions as quickly as possible. Fortunately, solutions such as high efficient motors and variable speed drives exist and are available on the market. Proving the efficiency and cost-effectiveness of these solutions and identifying where they can make the most difference - not only within the chemical industry but in all sectors – encourages their uptake and paves the way for potentially huge savings in energy, costs and carbon emissions.

(1) Sanchez et al., IEA Chemicals subsector report, 2022.
https://www.iea.org/reports/chemicals

(2) ABB white paper, “Achieving the Paris Agreement: the vital role of high efficiency motors and drives in reducing energy consumption”, 2021.
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(3) Key World Energy Statistics, IEA, 2021.
https://www.iea.org/reports/key-world-energy-statistics-2021/final-consumption

(4) IEA (2022), Chemicals, IEA, Paris
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(5) Eurostat, “Final Energy consumption in industry - detailed statistics, 2023.
https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Final_energy_consumption_in_industry_-_detailed_statistics#Chemical_and_petrochemical_industry

(6) https://search.abb.com/library/Download.aspx?DocumentID=3AUA0000182864&DocumentPartId=

(7) Malinowski et al. “DOE Motor and Drive Assessment Leads to Energy Savings for Power Drive Systems”, 2022.
https://ieeepcic.com/2022conference/wp-content/uploads/sites/7/2022/09/2022-PCIC-0553.pdf

(8) https://new.abb.com/drives/what-is-a-variable-speed-drive
According to IEC 60034-30-1 and IEC TS 60034-30-2.

(9) ABB white paper, “Reaching IE5 efficiency with magnet-free motors”, 2021.
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