WHITE PAPER

Concrete steps for an energy efficient future
with the top industrial efficiency option

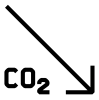
Should energy efficiency policy consist of minimum efficiency performance levels that all suppliers need to reach? Or should the industry in addition strive for the most sustainable solutions possible, thereby promoting faster deployment of the most efficient available technology as well as pushing technical boundaries even further?

In other words, should we drive sustainability because we are obliged to or because we want to make a difference?

This white paper discusses the role of efficiency in reducing energy consumption and related CO_2 emissions and considers the shortcomings of current international energy efficiency standards. It also shows the implications of adopting an approach where the focus is not only on a minimum efficiency performance but also on achieving a top industrial efficiency level that goes above and beyond current regulations.

Industrial motors consume **45% of the world's electricity**

By 2040 the number of motors **will have doubled**



Improving motor efficiency could cut energy-related **CO_2 emissions by 40%**

Changing just one motor can make a difference

The vital role of efficiency in reducing energy consumption

Electric motor driven systems such as compressors, refrigerator systems, conveyors and pumps account for 45% of the world's energy usage. Although only 0.03% of electric motors are classed as large motors drawing more than 375kW of power, they account for 23% of all the electricity consumed by motors globally, or 10.4% of all electric power usage.[1]

These large industrial motors are primarily used in the chemical, air separation, oil and gas and energy industries, as well as water and waste water, metal and mining and pulp and paper segments. Their main applications are compressors 32%, mechanical movement 30%, pumps 19%, and fans 19%.[1]

A step in the right direction

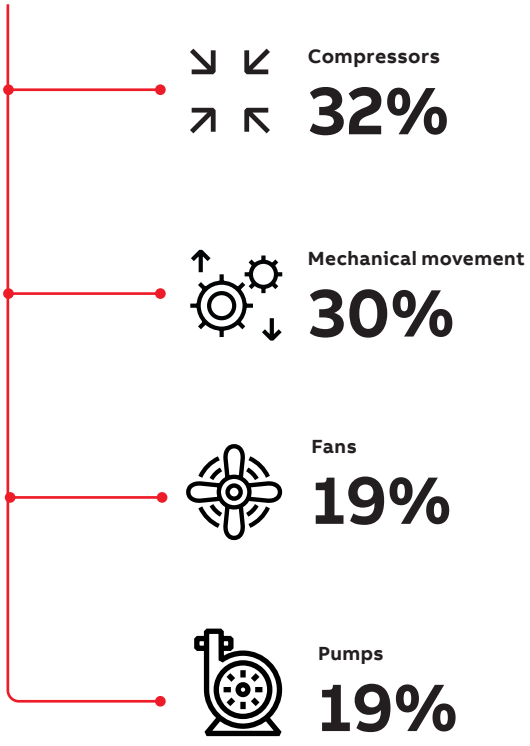
As the world searches for more sustainable and environmentally-considerate ways of providing power, increasing the energy efficiency of electric motors is one vital step in the right direction. However, current international energy efficiency standards only cover motors up to 1000kW. And although new regulations are due to be introduced they will only cover motors up to 2000kW, despite motors larger than this accounting for a significant portion of global motor energy use.

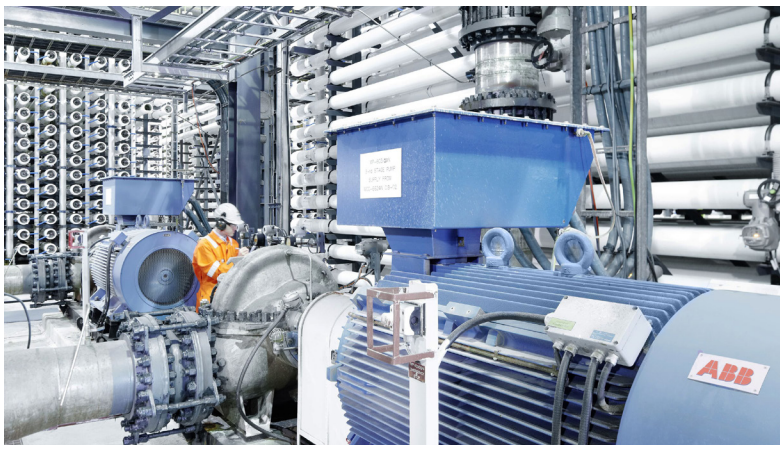
Even though the standard correctly describes these large motors as efficient there is still room for improving their performance by 1 to 3 efficiency classes by selecting the most efficient solution. The corresponding reductions to be achieved in energy consumption and CO_2 footprints are dramatic, to say the least.

There are many ways to reduce the amount of energy consumed when a motor is in use. For example, operators should be able to accurately measure energy usage through all their motors and processes, choose appropriately between fixed-speed and variable-speed motors, and optimize the entire system.

Increasing the energy efficiency of industrial motors is one of the single most beneficial steps that can be taken to reduce energy consumption. Luckily, the technology that the world needs to dramatically improve energy efficiency is at hand. Much of it, such as high-efficiency motors and drives, is well established and time-tested. Accelerating the adoption of these existing technologies would achieve significant energy savings around the world.[2]

Large industrial motor applications





Sustainability through energy efficiency
The International Energy Agency (IEA) has stated that increasing energy efficiency could provide more than 37% of the reduction in greenhouse gas emissions required by 2050 to reach climate goals and be in line with the Paris Agreement.

In the industrial sector, the largest potential for a reduction in electricity consumption and corresponding emissions lies in improving the efficiency of electric motors and end-use devices such as pumps and fans, as well as the use of better system and process control strategies.[4]

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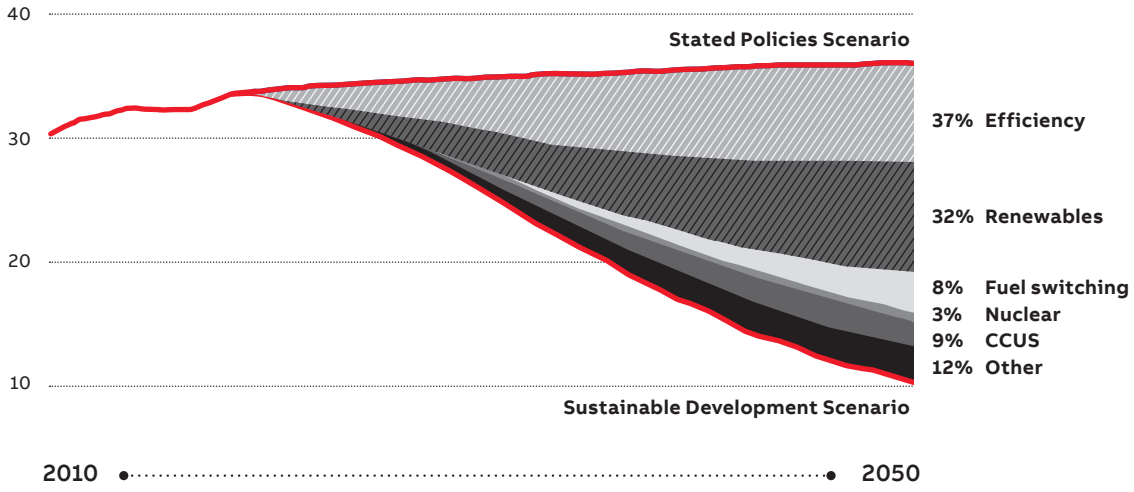
The percentage of greenhouse gas reductions achievable by sector in meeting the Paris Agreement goals. Source: IEA Energy Outlook 2019[3]



The use phase and energy efficiency
From a sustainability perspective it is important to consider the the total CO_2 footprint from manufacturing, use phase as well as end of life phase.

An academic study in Sweden has established that when using a 20MW motor drive package the use phase corresponds to ~99% of the total CO_2 emissions. With a large motor lifespan of some 20 to 25 years, increasing efficiency in this stage is clearly vital. The larger the motor, the more energy consumption the use phase will be responsible for.

In countries where the electricity production has a higher CO_2 footprint, the use phase has a much higher impact. As a comparison, in Australia the use phase accounts for 25 times as much CO_2 emissions than in Sweden or 99.95% of the total emissions. This suggests that the dominant factor when assessing sustainability for electric motors and drives will always be efficiency.[5]

Further studies under the Mistra-REES initiative lead to similar conclusions. When considering sustainable manufacturing and circular business models, too much emphasis is normally placed on the end of life phase. In the case of active products the use phase should be focused on. Through ensuring high efficiency and prolonging the lifetime through design and maintenance, incentives to adopt these products can be more easily formulated and resource consumption reduced.

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CO2 emissions in tonnes over the lifecycle of a 20MW motor drive package[5]

Use phase	Motor manufacturing	Drive manufacturing	Re-used materials
4320	41	39	-30

Global efficiency standards and their limitations

Economies around the world are trying to find ways to meet their climate and sustainability targets, including acknowledging the potential contribution of improved energy efficiency. As a result, regulations known as minimum energy performance standards (MEPS) have been introduced in many countries and regions for low voltage electric motors. In some countries and regions energy efficiency requirements for end-use equipment such as fans and pumps have also been set.

Recognition of the energy savings potential of motor driven systems has also led to the development of energy efficiency standards in testing (IEC) and classification for motors and frequency converters (VSD) and Power Drive Systems (PDS). Today there are no mandatory regulations or requirement set for PDS nor for the application as a whole.

The first European ecodesign regulation was implemented in 2011. A new regulation was published in 2019 which extended the scope further and mandates higher efficiency levels. Figure 2 outlines the current minimum energy performance standards for electric motors, 10 years after the first implementation.

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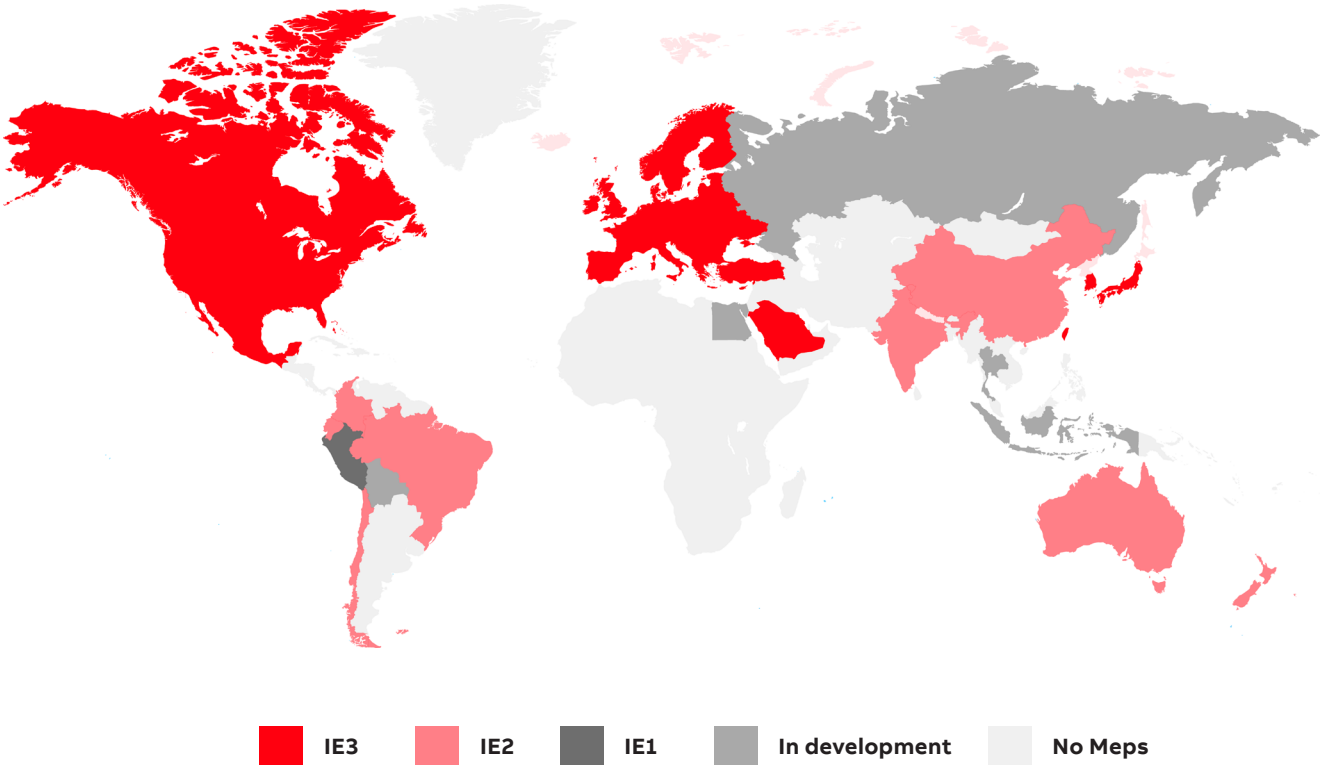
Figure 2
Minimum energy performance standards worldwide for electric motors



Global MEPS

To serve as a basis for MEPS standards, the International Electrotechnical Commission (IEC) has introduced standards which define efficiency classes for specific motors. So far, the standards only cover low voltage induction motors up to 1000 kW. Authorities around the world have used these IEC standards as the basis for their own MEPS. Figure 2 shows the current regulatory status of MEPS. It can also be noted that some countries or regions use local MEPS classifications in preference to the IEC classification, such as in North America where the NEMA standard is in use. These standards are broadly similar, although NEMA standards only reach the equivalent of IE3.

The IEC standard for low voltage DOL motors, IEC 60034-30-1, currently specifies four International Efficiency (IE) classes from IE1 (least efficient) to IE4 (most efficient). Each class of efficiency equates to roughly 18% lower energy loss, so IE4 motors have 18% lower energy losses than IE3 motors, and so on. In addition, a separate technical specification, IEC TS 60034-30-2, for VSD motors also includes an IE5 class.

Limited standards

A third IEC standard is under implementation, although no fixed date is set when any country or region will enforce it as mandatory legislation. This standard will initially cover MV motors up to 2000 kW. However, motors with higher power ratings will not be included. This is in part because of the relatively low numbers of such motors produced, and in part because efficiency is already an important aspect of design and manufacturing of such motors. Thus, according to the IEC, no significant energy saving would result from a new classification.

Therefore, the highest upcoming common efficiency level for medium-voltage motors, IE4, requires only up to 97% efficiency, even though significantly higher levels of efficiency have been achieved in large motors. Of equal importance is the fact that the standard is limited in scope. As an example, it does not mention generators, only motors. Research further suggests that the standards and regulations have been limited in their application to individual components, to a large extent disregarding the interaction between them.

The energy savings achievable by addressing and improving entire systems are potentially much higher than those achievable when considering individual components. Setting a minimum efficiency level and measuring it on systems with high variance has been, and still is, a challenge. Furthermore, because larger motors tend to have design lifetimes of at least 20 years, the full impact of any new MEPS legislation would not be seen for decades. Importantly, the IEC has, however, proposed that manufacturers around the world can apply an additional efficiency classification on a trial basis for motors that fall outside the scope of the current standards.

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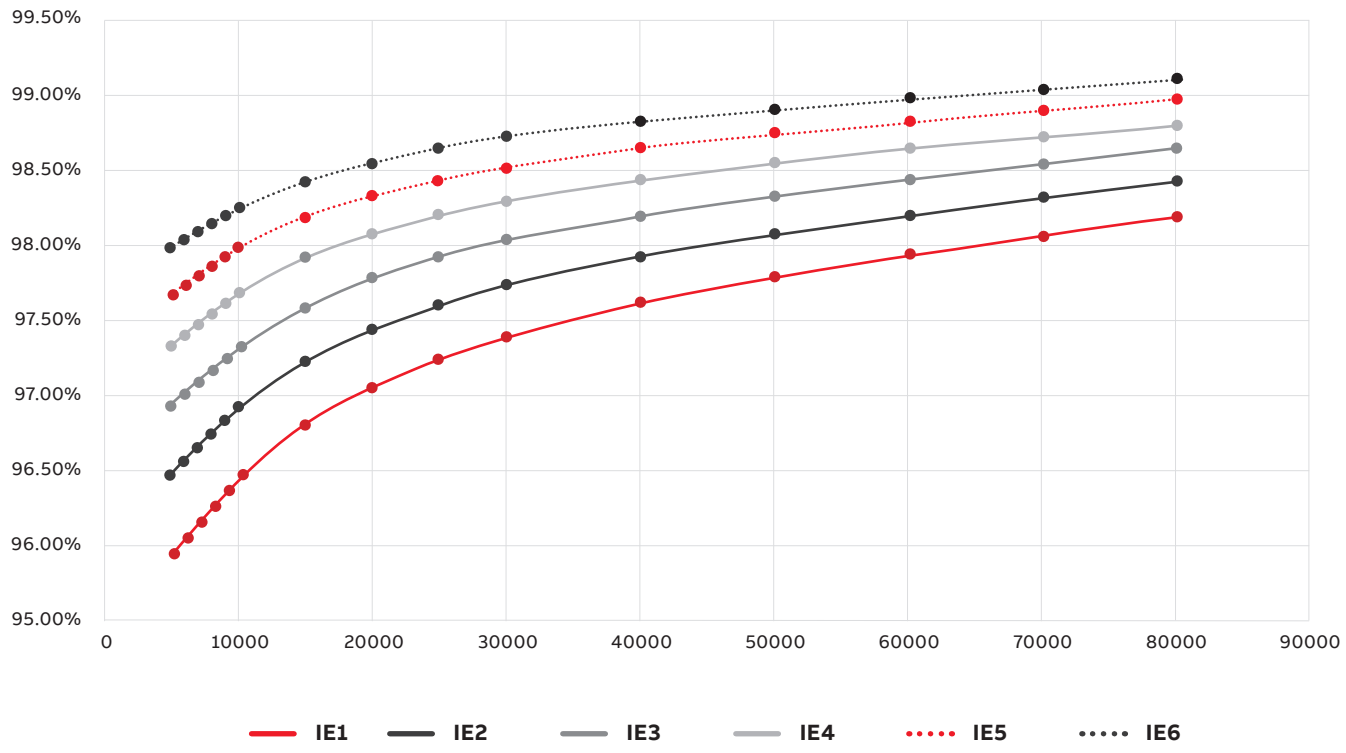
We feel the need to take concrete steps today to ensure a sustainable tomorrow

Efficiency vs Output (kW) extrapolation for efficiency classes IE1 to IE6.



Potential efficiency gains

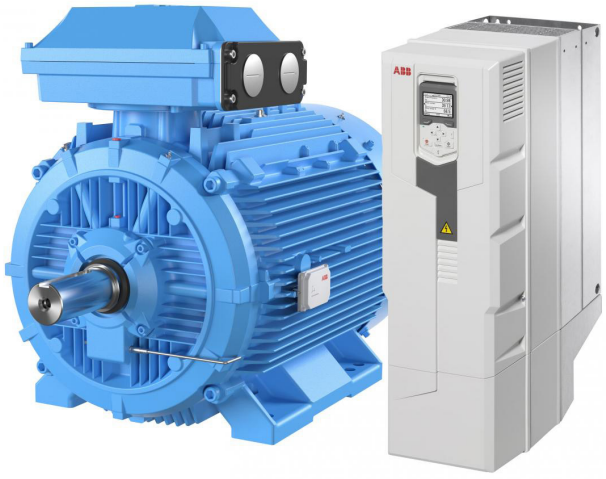
Using the current IEC standards and data, ABB has extrapolated the potential energy efficiency for large motors up to a possible IE6 level (figure 3), removing the correction factors used in the IEC standard for outputs above 10000kW to create a more suitable and demanding classification. We can see that despite the lack of recognized standards above IE4, large motors have the potential to improve their efficiency.

In fact, on a delivered synchronous motor rated at 44MW ABB achieved an energy efficiency of 99.05%, which would be in line with an IE7 standard. Also, the chart indicates that for large motors the efficiency standards of IE1 and IE2 are irrelevant, as their typical out of the box efficiency is closer to IE3 or IE4 level even without efficiency optimization.

At ABB we feel the need to take concrete steps today to ensure a sustainable tomorrow. Therefore we have decided to introduce a top industrial efficiency (TIE) option for the products and systems where we perceive the prevailing efficiency standard is lagging.

The first focus for the TIE option will be synchronous motors and generators above 10MW. This focus has been chosen partly because we see a clear gap between the available technology and what customers are buying. This in turn indicates a large untapped potential for significant CO_2 savings.

We also observe that these products are so far above current MEPS in terms of their efficiency that it will take a long time for standards to develop and mandate higher energy efficiency requirements.



The top industrial efficiency option
We make the promise. You make the choice.

The top industrial efficiency option outlines an alternative that provides the highest possible energy efficiency without compromising on reliability, complexity or specification compliance. It will give end users an easy and clear way to take a major step in reducing CO_2 emissions while also significantly reducing total cost of ownership.

Instead of focusing on minimum energy performance the top industrial efficiency is a contractual commitment to supply the most energy efficient solution that we can offer while maintaining the reliability of our products.

With the TIE option the suppliers, as experts on their respective products/solutions, commit to providing their most efficient solution available.

Our aim is to help our customers live up to their sustainability commitments while benefitting from an improved total cost of ownership.

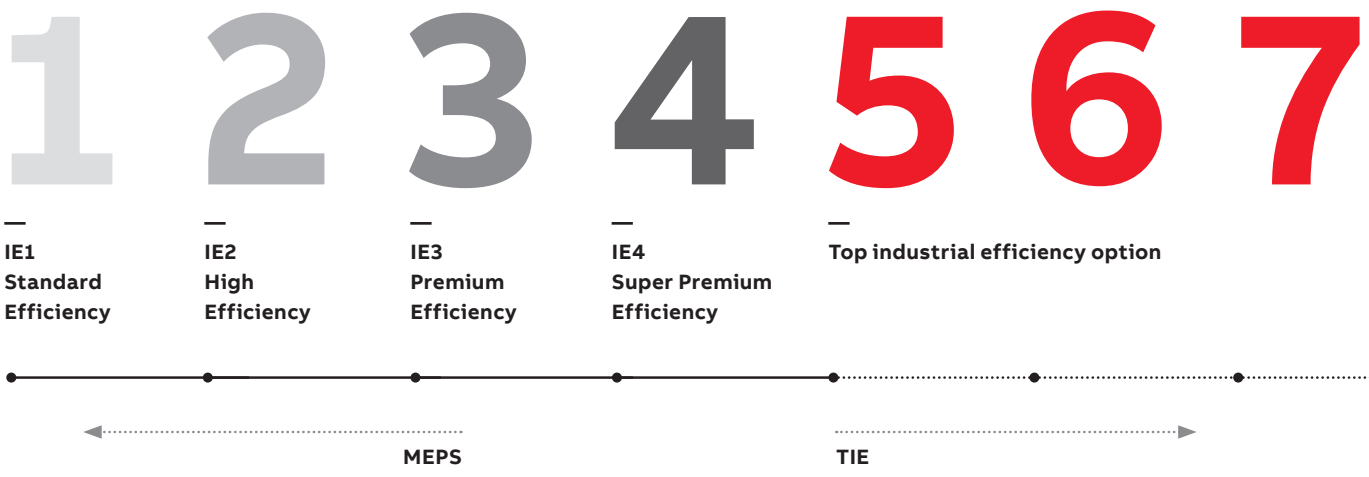
Raising awareness and encouraging action
The TIE option is not intended to compete with the development of new, more demanding standards. In fact, its purpose is to raise awareness and actively support the fast-track introduction of such official standards for large electrical equipment while recognizing the need to act immediately to reduce CO_2 emissions.

We believe that if we provide cost-effective alternatives to the current, insufficient standards we can effect change that will ultimately benefit not only our customers but all stakeholders.

The maximum forthcoming MEPS energy efficiency class requires 97% for a 2MW IE4 solution. The top industrial efficiency option will result in greater efficiencies for large synchronous motors and generators, corresponding to IE6 or even higher efficiency levels.

Working together for sustainability
Ultimately, the target of the TIE option is not only to improve the energy efficiency of motors and generators alone but rather for a wider range of products and solutions. As a concept it is free and open for everyone. We need to reduce CO_2 emissions and contribute to a more sustainable world together.

Relative Illustration of top industrial efficiency option in comparison with current IE levels.



Key benefits of the TIE option

- **Secure the future by using the most energy-efficient technology**
- **A concrete way to live up to company values**
- **Lower operational and life cycle costs and increased bottom line**
- **A legally binding contract**

All barriers removed:

- **Same performance, no added deviations to specs**
- **No extra complexity, same ease of use**
- **No compromise on reliability, same proven technology**
- **A practical measure open to all**

CASE STUDY: SUBSTANTIATING THE EFFECT OF THE TIE OPTION

ABB Large Motor and Generator factory in Västerås

The TIE option in number

- Average payback time of just 0,5-3 years
- Up to 827 kilotons of CO_2 savings every year
- An increase in efficiency of up to three IE classes

The Large Motor and Generator factory in Västerås has for a long time been at the forefront of pushing the boundaries of efficiency and sustainability. It now produces the most energy efficient motors and generators within ABB and is the first adoptor of the TIE concept to expand the limits of energy efficiency.

In Västerås a large motor efficiency level of 99.05% has been reached, which is currently the highest known commercial efficiency achieved and equivalent to an IE7 rating. Each individual motor or generator is tested before delivery, allowing us to monitor efficiency increases over time.

Notwithstanding the efficiency levels so far achieved, we see a large potential for improvement.ABB have calculated that there is a potential to further increase the energy efficiency of the products they deliver by one to three IE classes in general.

This despite our existing large motor and generator products already having an energy efficiency level of 98.3% (IE4) on average. The technology to do this is available and well proven. Its uptake relies on customers more highly prioritizing efficiency and the total cost of ownership..

Should our existing customers consistently opt to buy the top industrial efficiency option from ABB it would correspond to a 1,6TWh electricity saving during the product life time due to the increase in energy efficiency. Using the global energy production average of 525,000 ton CO_2/TWh this corresponds to a CO_2 saving of 827,000 tonnes per year, just from this single factory. For comparison, 827 kton CO_2 is equivalent to 6% of Sweden's total CO_2 emissions from electricity generation.

Conclusion

Creating a sustainable future requires significantly improving the energy efficiency of the millions of motors and drives that power our everyday lives. But the problem is not only one of technology. Advances have been and are constantly being made that genuinely push the boundaries of what is possible in this regard. As we have seen, ABB have delivered large motors that noticeably surpass any international standards – if there were any such standards that actually applied to large motors.

While there are improved international energy efficiency standards on the way, we cannot wait to take action for them to be formulated, approved and complied with. Given that we have the technology available, the next step must be to increase its uptake.

The goal of the top industrial efficiency option is to provide stakeholders with a cost-effective option that offers significant energy and economic savings over the product lifecycle, helping to incentivize the transition to more sustainable energy usage. Ultimately, we expect that legislation will follow that mandates equivalent or, preferably, more stringent energy efficiency standards.

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(2) ABB white paper. 2021. The vital role of high-efficiency motors and drives in reducing energy consumption. https://www.energyefficiencymovement.com/wp-content/uploads/2021/03/ABB_MotionEnergyEfficiency_WhitePaper.pdf

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(4) J. Fong , F. J. T. E. Ferreira, A. Silva and A. de Almeida. 2020. IEC61800-9 System Standards as a Tool to Boost the Efficiency of Electric Motor Driven Systems Worldwide. https://res.mdpi.com/d_attachment/inventions/inventions-05-00020/article_deploy/inventions-05-00020.pdf

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(6) IEC. 2014. International standard IEC 60034-30-1. https://webstore.iec.ch/preview/info_iec60034-30-1%7Bed1.0%7Db.pdf

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