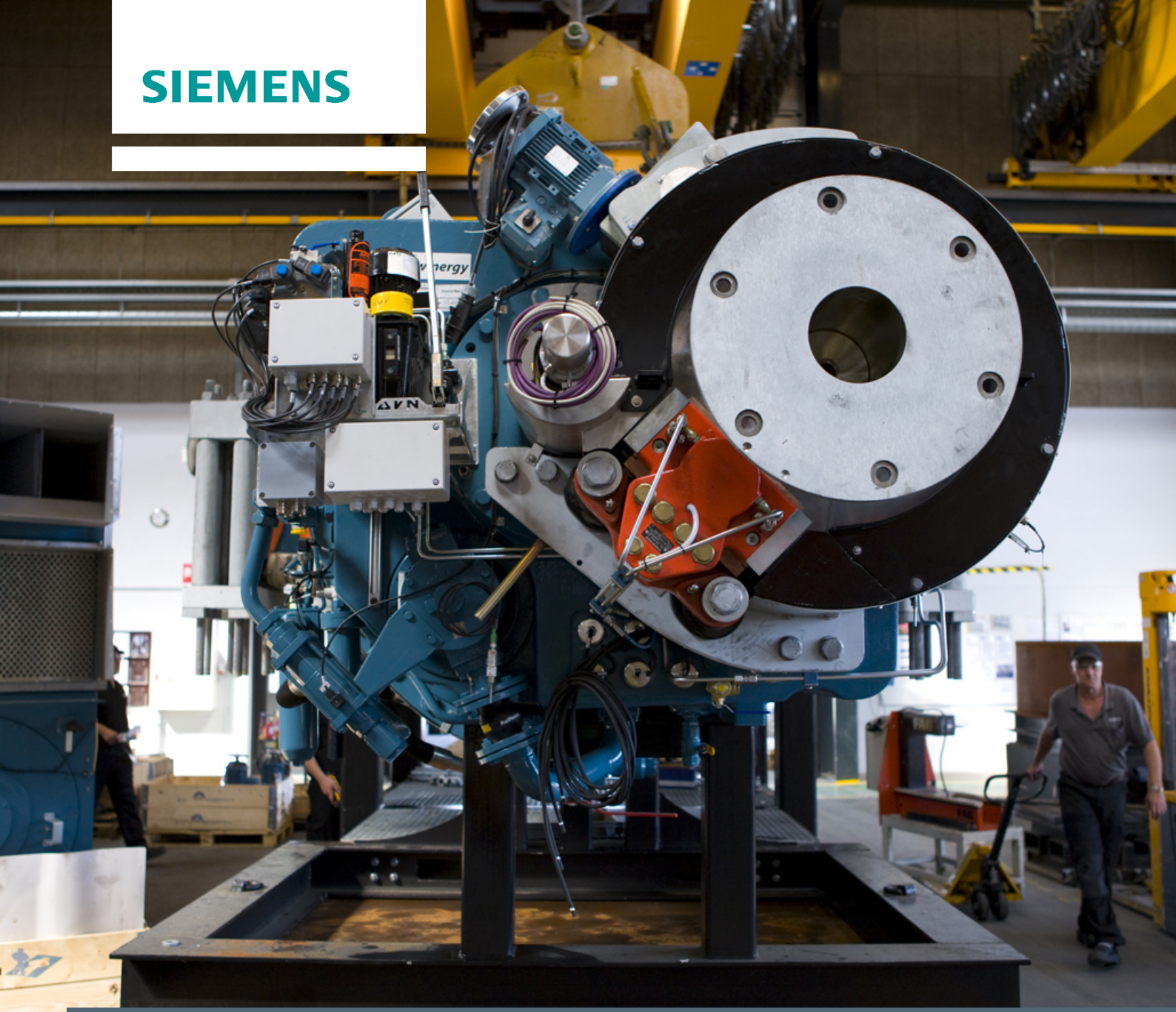
SIEMENS



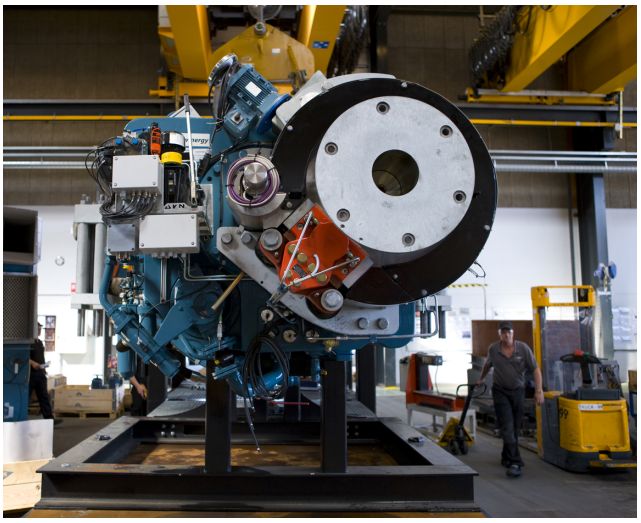
Financial Services

More From Less

A global study into electricity-efficiency potential and how it affects the future of the manufacturing sector

www.siemens.com/finance

Contents



Key Findings

- In order to remain competitive in the future, the manufacturing sector must continually innovate and reinvent itself.
- Development cycles are becoming shorter while product complexity is increasing; resources are becoming scarcer. In particular, electricity consumption and prices have risen substantially over the last decade.
- Electricity usage in manufacturing has undergone huge growth over the last 40 years, rising three times faster than overall energy use, and now represents over a quarter of industrial energy consumption. The manufacturing sector globally is now estimated to account for 42% of total annual electricity consumption.
- Not only has electricity usage soared in the manufacturing sector, but the unit cost of that electricity has also risen dramatically over the last ten years, so resource efficiency, in terms of reducing electricity consumption, is vital to the economic health of manufacturing.
- The impact of the current dip in crude oil prices will undoubtedly be felt in overall manufacturing energy costs, where processes such as heating are driven by fossil fuels on site. However, since few power stations are fuelled by oil (because of cost and adverse environmental impact versus other fuels), hikes in global electricity price may slow, but are unlikely to be significantly reduced in the future.
- The manufacturing sector has therefore become keenly focused on installing more electricity-efficient equipment[1] to reduce the consumption and cost of electricity. As a result, an increasing range of electricity-efficient solutions are now available to manufacturers that help reduce electricity consumption, reduce transmission losses, improve business performance, reduce lifecycle costs and meet environmental regulations.
- Research, conducted by Siemens Financial Services among the global top 20 industrial equipment manufacturers, provides an estimate on the untapped potential for electricity-efficiency (usage and cost-savings, expressed as a proportion of total electricity consumption) in the manufacturing sector, as follows:
  - Russia 19.1%
  - India 17.9%
  - China 17.2%
  - Poland 16.2%
  - Turkey 16.1%
  - Scandinavia[2] 15.6%
  - USA 15.3%
  - France 15.1%
  - Germany 14.5%
  - Spain 14.2%
  - UK 14.2%
- Access to finance with which to fund investments in energy-efficient equipment however remains relatively limited in many countries, especially for smaller and medium-sized manufacturing operations.
- Specialist financiers with a deep understanding of energy-efficiency technology are offering flexible financing arrangements that use the resulting energy savings to offset the cost of acquiring energy-efficient equipment. Tailored financing arrangements will prove fundamental to the expansion and development of the energy-efficiency market in global manufacturing, as the sector globally seeks to address its future performance and competiveness challenges.
- Innovative financial solutions for vital automation and industrial equipment is set to help the manufacturing sector further reduce electricity usage, increase productivity, improve efficiency and reduce time to market.

[1] Electricity-efficiency is defined as the electricity consumption savings that a manufacturing company can save by installing more electricity-efficient technology. A good example is Variable Speed Drives for industrial processes (pumps, fans, production lines) which consume significantly less electricity than single speed drives. Equally, an industrial site might install solar photovoltaic cells on roof spaces or land in order to generate electricity and subsidize its consumption of commercially supplied electricity. Electricity-efficiency does not include the wider range of energy-efficiency possibilities on industrial sites, such as biomass-fuelled heating, heat recovery, condensing boilers, etc.

[2] Norway, Sweden, Finland, Denmark

Introduction: Industrial Energy Consumption and the Energy-Efficiency Issue

According to the Washington D.C. based Energy Information Administration, which monitors and reports statistics on energy matters around the world, the industrial sector is the single largest user of global energy – consuming 51% of energy produced.[3] It is not surprising, therefore, that governments, environmentalists and industrial businesses are all keen to reduce that energy consumption and save costs, while at the same time maintaining or increasing industrial productivity.

The issue is deemed so critical to the economic and environmental health of the globe, that the European Bank for Reconstruction and Development (EBRD) has an initiative dedicated to improving industrial energy-efficiency.[4] The initiative screens existing and potential projects to identify opportunities for energy savings and provides energy audits and energy management training to unlock savings potential. The EBRD notes that "If energy-efficiency investments are assessed and implemented properly, the returns can be high and the technical risks relatively low. Such investments can help reduce energy consumption and may also have other positive implications, such as improved product quality... More than ever, companies are facing increased competitive pressures to produce high quality products at comparable or lower cost... companies are pressured to bring energy costs in line with standards of best practice."[5]

Despite the recent collapse in crude oil prices, it remains a fact that electricity prices have been rising across the world for the last decade and more, driven up by increased demand stemming from the positive economic growth experienced in emerging economies, coupled with uncertainty of electricity supply from areas of the world affected by political insecurity.[6] The industrial sector is responsible for 42.3% of global electricity consumption.[7] Although the dramatic fall in oil prices will certainly deliver overall energy cost savings for manufacturers – especially where processes such as heating are powered by fossil fuels on-site, the impact on manufacturing electricity costs is not likely to be significant, especially when it is borne in mind that the cost of oil per Kilowatt hour (Kwh) was many times greater than that of other fossil fuels before the oil price slump. This long-term picture of electricity prices provides manufacturing industry with a challenge in all countries, but particularly those such as China, India, Turkey and Eastern Europe, where the industrial infrastructure is likely to experience growth in the years to come.

Energy-Efficiency – Key Initiatives

To give an idea of the projected scale of possible energy-efficiency gains in industry across the globe, the Paris-based International Energy Agency (IEA) projects a scenario over the next twenty years in which "The cumulative additional investments in industry reach $1.1 trillion by 2035, giving rise to $3.3 trillion in energy bill savings over the same time frame." Although in many OECD (The Organisation for Economic Co-operation and Development) countries, large energy-intensive industries have already installed efficient technologies, further improvements can be realized by replacing older facilities, optimizing processes or through enhanced energy management practices. Again, the impact of falling oil prices will affect overall industrial energy management practices, but the IEA's principles may continue to be applied to electricity-driven processes as they stand. The IEA makes a specific set of recommendations for achieving energy/electricity-efficiency improvements in industry:

1. *Better equipment and technology*. The IEA has estimated that the accelerated adoption of best available industrial technology could cut global energy use in industry by almost a third.[8] Replacing technologies such as less efficient industrial motors, drives and compressors, as well as installing heat conservation systems, is viewed as making a radical contribution to energy cuts.
2. *Managing energy and optimizing operations*. Systems' optimization leading to energy-efficiency improvements can, in certain examples, deliver additional savings of up to 20%.[9] In this case, the concept of 'optimization' means going beyond simple technology and equipment replacement, towards a review of complete manufacturing processes. Optimization of electric motor systems, such as fans, pumps, compressors and drives has potential for particularly large and cost-effective savings in all industry sectors.[10]

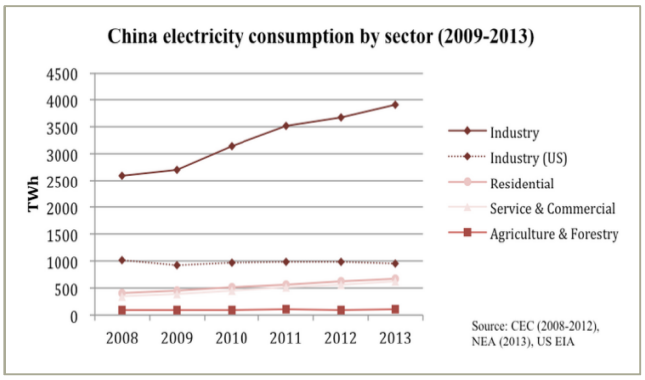
[3] EIA, World Energy Outlook, 2013
[4] EBRD, Improving industrial energy-efficiency, Factsheet
[5] Ibid
[6] See, for instance: CNN, Oil Prices Spark Economic Growth Concerns, 8 July 2014
[7] International Energy Agency, Key World Energy Statistics, 2014

[8] OECD/IEA, Energy Technology Perspectives 2012 – Pathways to a Clean Energy System
[9] United Nations Industrial Development Organization (2011), Industrial Development Report 2011, UNIDO, Vienna
[10] Energy Efficiency Policy Opportunities for Electric Motor-Driven Systems, OECD/IEA, Paris

3. *Holistically transforming production systems*. Even more visionary perspectives on radical reduction in industrial energy involve an integrated approach to managing supplies, resources and waste products over the complete manufacturing process and materials management cycle. This might involve converting waste into energy and reusing that energy back into the process, whether capturing excess heat midway through a process, or converting back-end waste into energy.

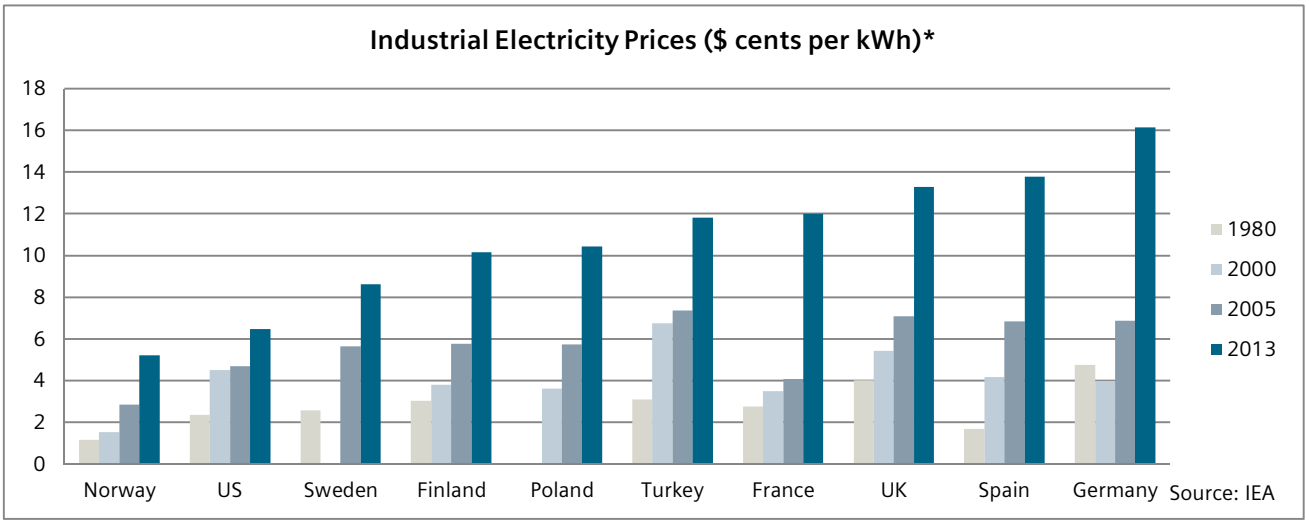
The Industrial Electricity-Efficiency Challenge

The specific challenge of using electricity more efficiently in the manufacturing industry is a particularly important focus for manufacturers, equipment vendors and policymakers alike because electricity is making up an increasingly large proportion of industrial energy use.[11] In other words, global manufacturing is inexorably electrifying its operations, and will continue to do so. Over the last 40 years, industrial energy usage has risen by 65% (1541 Million Tonnes of Oil Equivalent [Mtoe] to 2541 Mtoe); however, industrial electricity usage has risen by a staggering 193% (235 Mtoe to 688 Mtoe) over the same period, now representing over a quarter of industrial energy consumption.[12] Manufacturing activities now account for just over two fifths (42.3%) of the world's total final electricity consumption,[13] although this proportion varies widely around the world. The industrial sector currently accounts for three quarters of China's electricity



consumption,[14] whereas, in the 28 member countries of the European Union, the figure is just 25.6%. In India industrial usage represents 33% of total electricity consumption.[15]

Not only is electricity usage in industry increasing in all the countries studied, but the unit price of that electricity has also risen sharply over the last three decades. Even in countries where electricity has traditionally been subsidized, or capped at levels that do not truly reflect its cost of generation, markets have been liberalized so that prices are now rising in a freer market atmosphere. The recent dip in oil prices may affect this picture, but the since oil-fired electricity generation has been much more expensive than other fossil fuels, and releases large quantities of pollutants into the atmosphere, which have mainly only been used for back-up purposes. Unless there were wholesale conversion of the power-generation estate to oil, the current trends in electricity pricing are likely to continue, and certainly will not be reversed in the same way as has happened to crude oil prices.



*Poland, 1980: no data available; Sweden, 2000: no data available

[11] See, Leonardo Energy, Understanding the Electrification of Industrial Energy Consumption in Europe, 2 July 2012
[12] Ibid, all data
[13] IEA, Key World Energy Statistics, 2014

[14] EIA, China, 4 February 2014
[15] Government of India, Draft report of the 18th Electric Power Survey, 14 March 2013

One final point that escalates the issue of electricity-efficiency still further is that, according to the Energy International Association (EIA), the level of electricity use in manufacturing or other activities has broader implications for total energy usage.[16] It takes three units of primary energy (from fuels such as coal, nuclear and natural gas) to generate one unit of electricity, meaning that increased electricity use has a disproportionate effect on the amount of total primary energy required to support site-level energy use. So, not only do industrial companies want to reduce their electricity consumption to save money, but their achievements in doing so have a disproportionately large positive impact on carbon emission reduction.

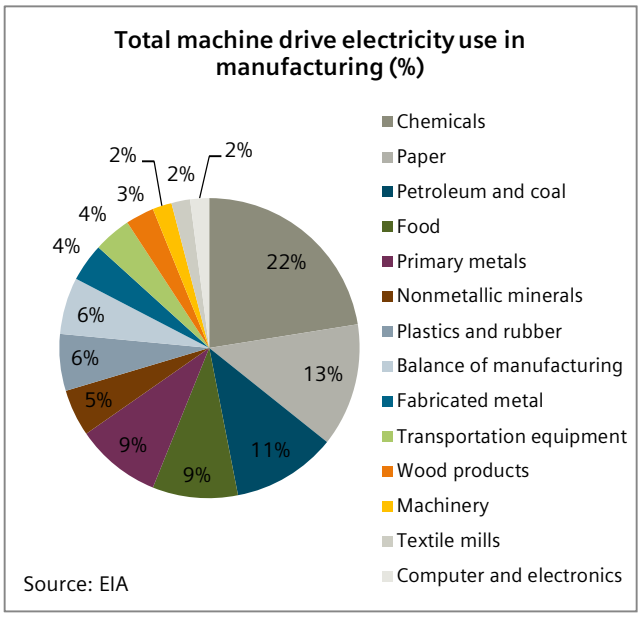
A Focus on Motors and Drives

In terms of key technological areas to address, up to 70% of industrial electricity consumption powers industrial motors and drives.[17] It has been estimated that optimizing motor-driven systems could deliver overall savings of between 30% and 60% on industrial electricity consumption.[18] In a broader sense, automation and drive technologies help manufacturers to increase productivity, efficiency and reduce time to market.

The European Directive 2005/32/EC on the Eco-Design Requirements for Energy-Using Products ("the EuP Directive") and its implementation instrument Commission Regulation 640/2009[19] are, for the first time, making energy-efficiency classes for industrial electric motors mandatory. This is a move further beyond the CEMEP (European Committee of Manufacturers of Electrical Machines and Power Electronics) efficiency classifications, a previous initiative to implement more energy-efficient motors throughout the industrial community, which was voluntary.

Under the EuP Directive, implementation is phased. From June 2011 new motors sold on the market had to be at least IE2 (High Efficiency).[20] From 2015,[21] motors rated from 7.5 to 375kW have to be IE3 (Premium Efficiency) or be IE2 and installed with a variable-speed drive.[22] The same requirement will be extended to motors in the range 0.75 to 7.5 kW from 2017.

Although the exact calculation depends on a motor's specific application, energy-efficient motors often offer a lower total cost of ownership than less efficient alternatives. While the purchase cost of energy-efficient motors may be several times higher, it must be noted that 95% of the lifetime cost of an industrial motor is made up by the electricity it consumes.



Similar measures in the United States include the Energy Policy Act of 2005, mandating that government motor purchases must meet the National Electrical Manufacturers Association premium efficiency levels (equivalent to IE3),[23] and the Energy Independence and Security Act of 2007, which requires all motors manufactured after December 2010 to conform to the same standard.[24] Although motor efficiency levels are slightly lower in China than in the EU and US,[25] the Chinese government is at the forefront of efforts to develop the IE4 motor class[26] and has introduced legislation that required manufacturers to meet IE2 motor efficiency levels from 2013 onwards.[27]

[16] EIA, Electricity use by machine drives varies significantly by manufacturing industry, 8 October 2013
[17] Ibid
[18] Engineer Live, Energy-efficient motors – new standard supports market, 21 February 2013
[19] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32009R0640
[19] The IE classification system applies internationally and is used to measure the efficiency of devices including electric motors. Products covered by the system must conform to a certain energy and resource efficiency to be used in the EU by defined dates. There are four defined classes, and power consumption is reduced by approximately 15% between the different IE-classes
[21] See, for instance: Controls Drives & Automation, BEAMA secures clarification on motors regulation, 12 March 2014

[22] For a specific study on energy-efficiency savings from VSDs, see SFS, Turn Down the Power, 2012
[23] Control Engineering, Motor-Driven Systems Efficiency Update, 19 June 2012
[24] NEMA, Summary and Analysis of the Energy Independence and Security Act of 2007, January 2008
[25] IMS Research, China: The World's Largest and Fastest Growing AC Induction Motor Market, October 2011
[25] Ibid
[26] IMS Research, Efficiency Legislation Pushes Low Voltage Motors Market into Double-digit Growth Despite Eurozone Economic Woes, March 2012

Above and beyond the motor/drive unit itself, there are other ways in which systems intelligence can help deliver major energy savings. For example, a sensor can be used to detect when a conveyor is empty, thereby enabling the conveyor to be automatically switched off. Many of the current generation of drives have built-in processing capability, which means they can be connected directly to inputs and outputs without any need for a separate programmable logic controller. In dynamic applications, fine-tuning of the speed profile can yield energy saving benefits, as employing the maximum acceleration available may be unnecessary and wasteful of energy.

With lighting being a significant part of electricity consumption, savings can also be made by deploying efficient lamp technologies, such as light-emitting diodes, compact fluorescent lamps and also energy saving halogen lighting. Savings of up to 80% are possible compared with traditional incandescent lamps.[28] Further savings can be enabled through intelligent lighting controls, which can reduce over 40% of energy used in lighting. Applied in conjunction with light level sensors and presence detection, controls can be optimized to take full advantage of daylight savings and maximum off periods.[29]

In addition, Building Energy Management Systems (BEMS) can also help cut down on energy usage by improving plant control, monitoring energy usage and optimizing plant operating times. The installation of an effective BEMS can often yield energy savings of up to 30%.[30]

Additional energy savings initiatives from manufacturing industry around the world encompass techniques such as:

- optimized automation systems;
- transforming waste products into fuels;
- the recovery of heat from production processes for electricity generation or space heating;
- lubricant and coolant recovery systems;
- product lifecycle management;
- power transmission efficiency systems.

[27] Siemens, Top Ten Energy Savings Tips
[28] Ibid
[29] Ibid

The Financing Challenge

Next comes the issue of affording alternative, more efficient technologies, either for power generation or to reduce electricity consumption. Investments in clean and efficiently produced power, as well as electricity-efficiency initiatives for consumers of power require appropriate and available financing techniques.

At the energy generation level (i.e. power plants), according to the IEA, new types of investors in the energy sector are emerging, but the supply of long-term finance on suitable terms is still far from guaranteed.[31] In North America private sector longer-term financing arrangements are more readily available, but less so in other parts of the world. As a result the IEA notes that "there is a need to unlock new sources of finance.... This would help to diminish undue reliance on the relatively short maturity of loans available from the banking sector, which may be constrained by new capital adequacy requirements (the Basel III accord) in the wake of the financial crisis."[32]

The same need for an extended range of financing arrangements is also true for end-user investments in electricity-efficiency equipment, an equally important way of reducing electricity consumption, reducing carbon emissions and – most importantly for a commercial organization – reducing the costs of production.

Traditional lenders might also be more reluctant to finance energy-efficient and renewable energy equipment due to an insufficient understanding of the assets and a lack of technical expertise in assessing the expected cost: a benefit of its adoption in practice.

Electricity-Efficiency in the Manufacturing Sector – New Research

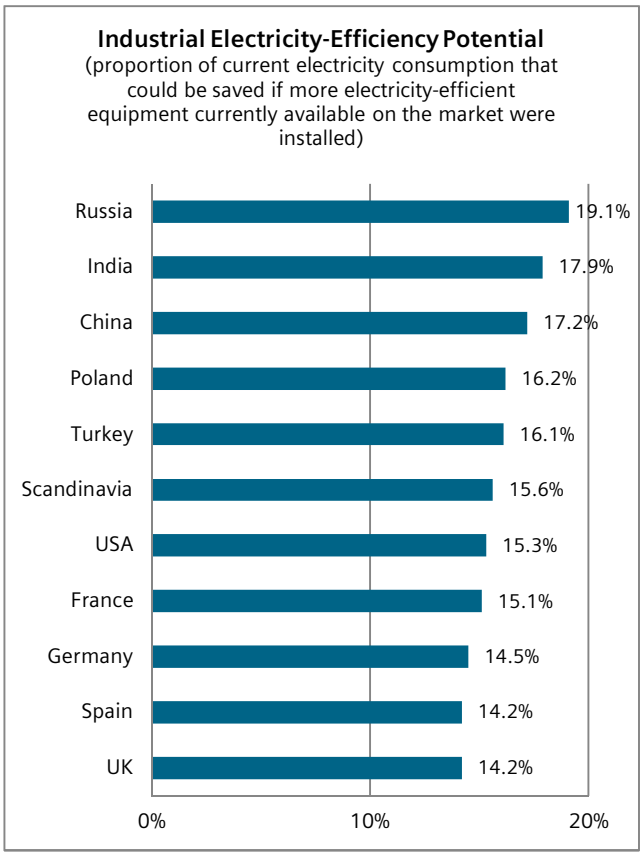
In the light of all these trends in industrial electricity consumption, Siemens Financial Services (SFS) commissioned independent research to estimate the minimum levels of electricity-efficiency potential in manufacturing industry across the globe. The countries studied were: China, France, Germany, India, Poland, Russia, Scandinavia (viewed as a region), Spain, Turkey, the UK and the USA.

The research, conducted among the global top 20 industrial equipment manufacturers, asked respondents to

[31] IEA, World Energy Investment Outlook 2014
[31] Ibid

estimate the base-level potential for electricity-efficiency in each country's manufacturing sector. "Efficiency potential" was defined as the proportion of current electricity consumption that could be saved if more electricity-efficient equipment currently available on the market were installed, and if more rigorous energy management policies and procedures were introduced and implemented. An average of respondents' estimates was then calculated for each country studied.

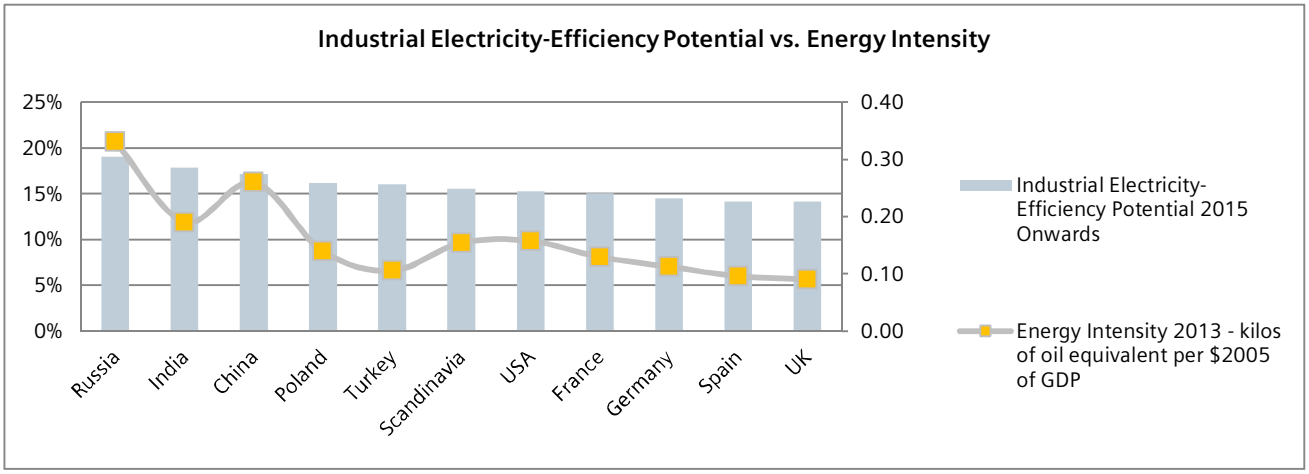
The resulting average industrial electricity-efficiency estimates were:



A number of consensus interpretative views were expressed by respondents when giving their estimates. In China and Turkey a high proportion of manufacturing sites are brand new, and therefore tend to be equipped with more energy-efficient equipment. This reduces somewhat the opportunity for electricity-efficiency gains. Russia has a mature industrial sector, but this segment is often characterized by older equipment that is less energy-efficient. This amplifies the opportunity for electricity-efficiency gains in Russia's manufacturing sector. Spain may appear at the low end of the table less because of equipment energy-efficiency, but more because Spanish manufacturers have been particularly active generating solar power onsite to subsidize their electricity requirements. Germany's position in the table is felt to be directly as a result of enthusiastic and effective energy-efficiency initiatives – investment and implementation – and the country is felt by respondents to be leading other European countries in this respect. Further work is still to be done, however, given that Germany's manufacturing industry segment is more balanced towards heavy engineering (high electricity consumption) than for example UK manufacturing.

It is also interesting to look at these electricity-efficiency potential figures in relation to each country's industrial energy intensity (electricity consumed per unit of GDP). While a direct relation is not consistently seen from country to country, a broad correlation is observable in most of the countries studied, where energy intensity ranking is broadly equivalent to electricity-efficiency potential ranking.

In summary, the research results carry a clear and consistent message. There remains very significant financial savings for manufacturers through electricity-efficiency investments, which at the same time deliver important environmental benefits around the globe. The key issue however is how this potential can be tapped in practice. How can manufacturing firms best finance their investments in energy-efficiency?



Affording Electricity-Efficient Investments

Investment in the necessary technologies to achieve electricity-efficiency brings a number of benefits to manufacturing firms. By reducing electricity consumption, a manufacturer improves competitive position and cost to manufacture. Often the new equipment acquired to enable energy-efficiency also brings production productivity and capacity improvements as an added bonus. And right across the world, the long-term commercial, environmental and social benefits of more sustainable use of energy are being enabled through regulatory requirements, and are increasingly being presented as tender requirements. It follows therefore, that manufacturing firms need a range of flexible and appropriate financing techniques in order to make further investments in growth, competitive positioning, productivity and sustainability, including their electricity-efficiency initiatives. Whether or not standard borrowing is accessible, all companies in the sector want to make sure that their investment in electricity-efficiency is financially sustainable.

Various forms of asset financing techniques are increasingly available as effective, alternative methods of funding energy-efficient equipment investments and upgrades. These techniques, in one way or another, are designed to offset the monthly cost of the new equipment against the energy savings that the equipment delivers – a form of 'pay-as-you-save' financing. In some special and tailored agreements, finance payments may even flex with the energy saving or energy generation outputs resulting from the new equipment.

These financing arrangements – which are distinct from lines of standard borrowing – are becoming increasingly important. Research has shown that companies' greatest concern in such cases is lack of confidence over whether energy-efficient investments will deliver the promised savings.[33] Combined financing and equipment solutions overcome this obstacle. Specialist finance providers who are proficient in the electricity-efficiency market are able to access specialists capable of determining what any given solution should deliver and arrange the finance solution based on projected savings being met. For end customers who feel uncertain about buying leading edge equipment due to their inability to properly assess return on investment, pay-as-you-save financing mechanisms can provide the necessary reassurance.

Where possible, electricity-efficiency finance schemes wrap everything into a single financing package, including electricity-efficiency assessment, the equipment itself, installation and ongoing maintenance, all via a leasing, renting or hire purchase arrangement. Payments are at least equal to, or lower than, the energy savings and in many cases, deliver savings and net positive cash flow immediately after installation has been completed. In some instances, businesses can also benefit from additional earnings from available government incentives for green investments and/or performance guarantees from the technology supplier. Where a project does not completely offset the equipment upgrade with electricity-efficiency cost savings, the financing arrangement can nevertheless subsidize the larger part of the investment. In the manufacturing sector, this is often highly attractive as up-to-date equipment may not only lower energy costs, but also boost productivity and extend manufacturing capability, generating more revenue and margin.

In summary, manufacturers are attracted to a finance agreement under this kind of integrated scheme, on account of a number of advantages over simply borrowing the capital sum required to buy a piece of energy-efficient equipment:

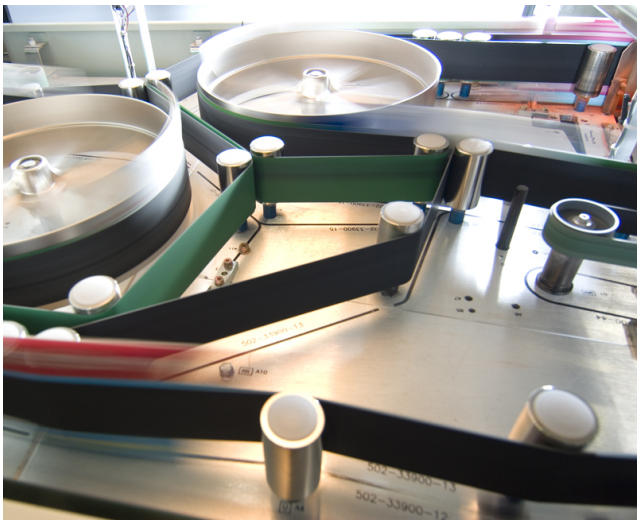
- Financing period flexed to ensure regular periodic payments covered (often in full) by energy savings.
- Fixed payments mean that borrowing terms are not subject to any changes in interest rates, volatility of shorter-term economics and market dynamics, ensuring easier budgeting.
- Financing arrangement cannot be foreclosed as long as payments are maintained.
- Separate from standard borrowing sources, reducing customers' reliance on one source of funds and allows them to maintain their bank facilities.
- Options to 'bundle' total cost of ownership (equipment, regular servicing and maintenance) into one single, fixed price agreement.

[33] Green Monday, Energy Efficiency, Summer 2011

Conclusion

The manufacturing sector across the globe is inexorably electrifying, allowing it to introduce greater levels of automation and digitalization of the manufacturing process. The original research contained in this short paper, along with the many third party references cited in its narrative, serve to underline the exciting potential for electricity savings still available to the manufacturing sector companies across the globe. While that potential varies from country to country, it is of a significant level across all countries.

Access to finance with which to fund investments in energy-efficient equipment remains relatively restricted in many countries, especially for smaller and medium-sized manufacturing operations. Specialist financiers, who understand in great detail the payback that can be obtained from electricity-efficiency technologies, are stepping into the gap to provide financing arrangements that use the resulting energy savings to offset the cost of acquiring energy-efficient equipment. Such tailored financing arrangements will prove fundamental to the expansion and development of the energy-efficiency market in global manufacturing through to the end of the decade and beyond.



Methodology

Phone research was conducted in 2014-15 with respondents from the top 20 global manufacturing equipment companies (ranked by turnover) who were qualified as senior personnel managing energy-efficiency product and/or service offerings, including managed services and performance contracting. Respondents were asked to give their conservative estimate of the potential still remaining in the countries studied for electricity-efficiency gains, based on today's available electricity-efficient technology.

Siemens Financial Services GmbH
Otto-Hahn-Ring 6
81739 Munich, Germany

www.siemens.com/finance