SIEMENS

White Paper—SFS Research Study, March 2014

Turn down the power

A study into current levels of energy inefficiency found in 10 countries around the globe within industry

Management summary

- Electricity costs are rising as global demand continues to follow its long-term growth trajectory, making it imperative for industrial companies to contain electricity usage if they do not want to face escalating overhead costs.
- Therefore, businesses across the world are eager to invest in energy-efficient equipment and facilities in order to reduce their electricity usage and expenditures.
- This white paper seeks to quantify one of many areas in industry where significant energy efficiency gains can be made (implementing variable frequency drives) in order to illustrate the potential sums that the sector could be saving.
- Industrial enterprises around the world could save billions of dollars on their electricity bills by implementing variable frequency drives (VFDs) on motors in their production environments.
- This study's highly conservative estimates* of industrial electricity overspending over the next five years, directly attributable to non-implementation of VFDs, are as follows:

USA	— $20,928 million	U.K.	— $3,910 million
China	— $10,864 million	Spain	— $3,598 million
Russia	— $9,021 million	France	— $3,379 million
Germany	— $8,083 million	Turkey	— $2,336 million
India	— $6,783 million	Poland	— $1,605 million

* Assumes €1 = $1.25 USD

- Access to funding remains a major barrier for businesses to invest in energy efficiency. Bank credit remains tight in mature economies and is expected to remain so in the near term in an atmosphere of faltering economic growth along with concerns about stability in the eurozone. Increased capital adequacy requirements as a result of Basel III also imply that bank credit will get more expensive in the future.
- Governments in higher growth markets such as China are closely monitoring credit availability in order to guard against inflation and ensure that business growth is sustainable and not over-leveraged.
- Businesses are therefore seeking alternatives to standard bank credit with which to finance energy-efficient investments.
- To fulfill this demand, financing methods are coming to market that offset the energy-efficient investment cost against energy savings across the financing term, effectively providing a zero-net-cost investment technique.
- Businesses are using asset-financing techniques to conserve scarce cash that is ready to be spent.

A white paper issued by: Siemens.

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Introduction

Industrial enterprises around the world are facing challenging markets. Concerns about the eurozone's stability are affecting both mature and higher-growth economies. This is also slowing some of the large GDP increases that BRIC counties have enjoyed in previous years. As major global economies continue to feel the aftershocks of the last few years' economic upheavals, the management boards of industrial companies are increasingly positioning their organizations to have a sustainable commercial future.

In the 10 countries studied in this report, industry consumes anywhere between 30 percent and 60 percent of all electricity generated. It is natural, then, that board members in the industrial sector are paying greater attention to ways of making their organizations more energy efficient. Given that electricity prices also present a long-term upward trend, the imperative for greater energy efficiency is becoming more urgent. In the European Union, this need has been enshrined in official targets. Many of the United States' largest companies have publicly declared energy reduction goals as well.

Goals and targets sound good to the public, but business minds need to focus on the key financial metric — return on investment. While regulation and legislation do have some effect in forcing change in the business community, a compelling business case — with clear methodology, reliable return on investment and financial efficiency — is much more powerful and more likely to accelerate that change.

In addition, finance directors have to prioritize their efforts, focusing investment on projects that offer significant savings, that do not tie up large amounts of scarce capital, and that deliver annual efficiencies in the long term. Investing in more energy-efficient industrial technology fulfills all of these criteria.

Financially efficient funding methods are needed, however, to deliver immediate returns from energy efficiency initiatives. This is especially the case in an environment where companies continue to face restricted access to bank credit, and where finance directors want to conserve cash for initiatives such as sales and marketing, new product development and acquisition opportunities.

This white paper describes the background evidence for rising energy prices and limited access to credit. It then seeks to quantify one of many areas in industry where significant energy efficiency gains can be made (implementing variable frequency drives) in order to give a tangible idea of the potential sums that the sector could be saving. Finally, the paper describes the financing techniques that make sense — in terms of return on investment and cash flow management — for industrial finance directors.

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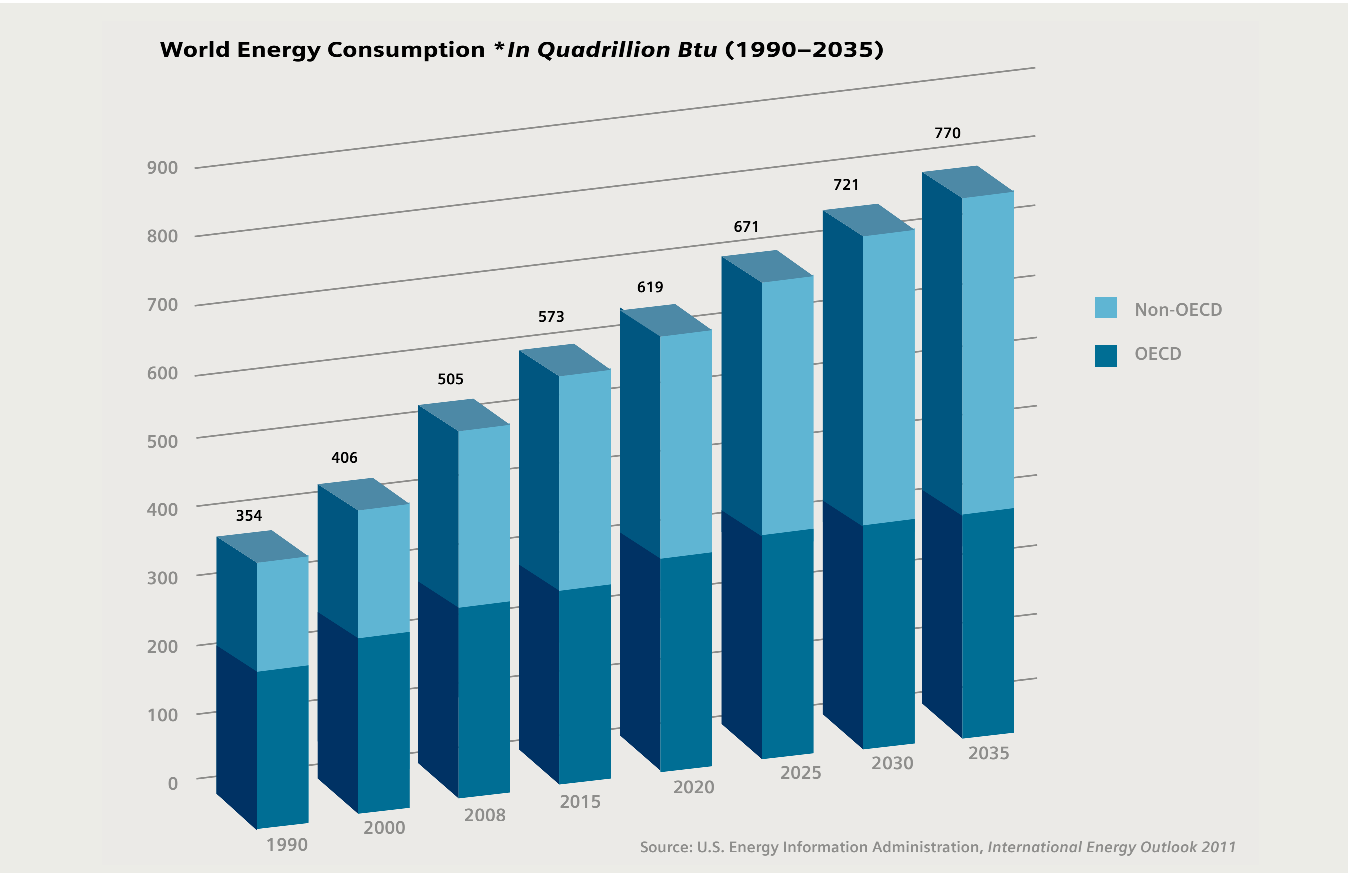
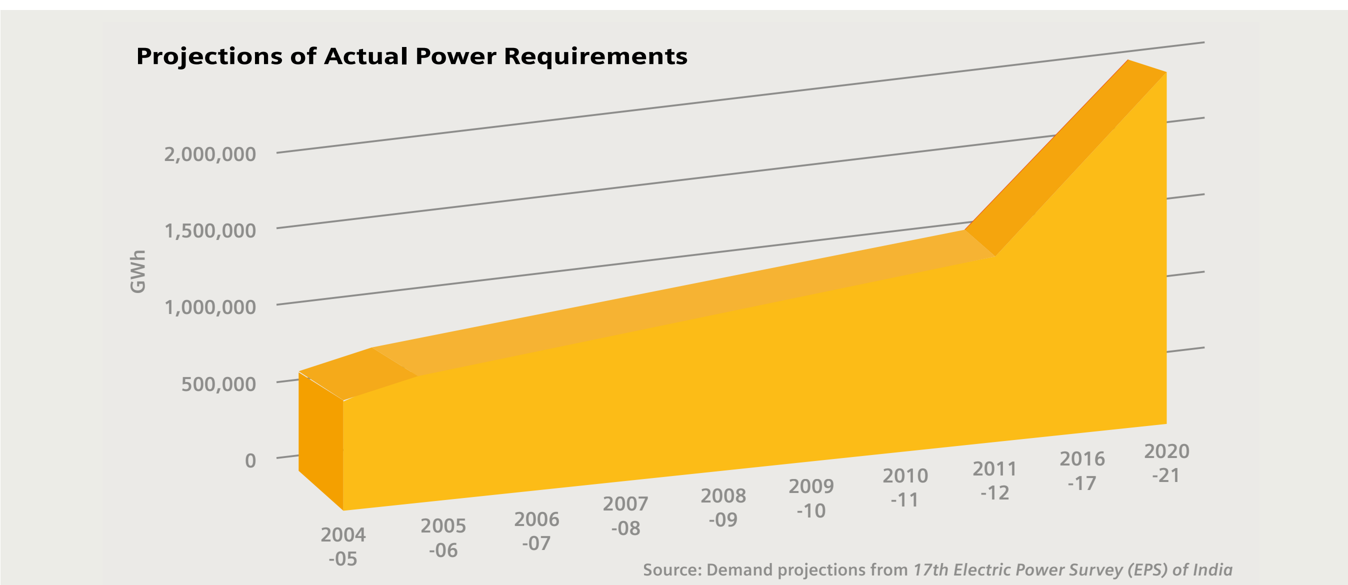
Rising energy costs around the world

The cost of energy for business is an increasingly significant issue. Certainly, energy prices and consumption seem to be on a steady upward trajectory, as evidenced in the following charts.





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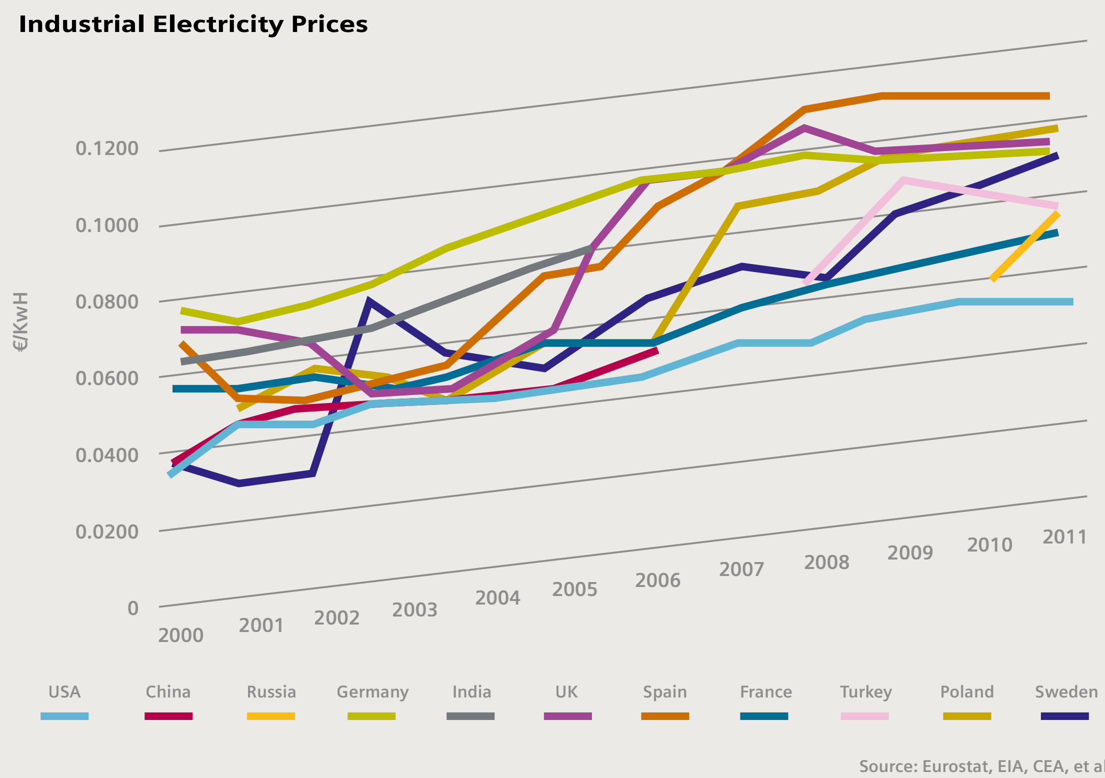

Global energy consumption is predicted to rise dramatically, with power requirements in high growth economies such as India set to enter a radically new phase from 2011 to 2012 and onwards. With the rise in consumption comes a long-term upward trend in prices, exacerbating the penalties for industrial companies that fail to invest in the effective management of energy efficiency.

The pattern among European countries seen in the previous chart is replicated in rapidly developing economies. China recently increased the cost of electricity for industrial use in 14 provinces and its Chongqing municipality[1] and has rationed industrial consumption.[2] In India, industrial electricity prices are high, largely to subsidize low domestic charges, and these prices are set to continue rising.[3] Russia is also seeing major rises in electricity prices, with hydro charge increases being capped at 15 percent last year.[4] And it is widely argued that rising industrial demand from high-growth economies is forcing electricity prices upwards, and that this will continue in the future.

With electricity prices rising around the world, industrial enterprises are increasingly motivated to reduce the cost of electricity as it becomes greater with every month that passes. In a survey conducted by the Organization for Economic Co-operation and Development (OECD) on business energy consumption in its member countries (among which are France, Spain, India, USA, Russia, Poland, the U.K. and Germany), 96 percent of participating (large) businesses indicated that they had started implementing energy saving measures.[5] Moreover, when asked about their motivations to reduce energy consumption, respondents cited "reduce energy costs" as their most important driver, followed by "improve image" and "expected regulation."[6]

Reducing energy costs, therefore, is the major motivator for industrial companies to upgrade to more energy efficient technologies and practices. However, constrained access to capital across the world continues to put a barrier in the way of investing in energy efficient equipment.

[1] AFP, *China Hikes Industrial Electricity Prices*, 30 May 2011; CCTV News Channel, 31 May 2011

[2] Financial Times, *China Forced to Ration Electricity*, 17 May 2011

[3] N.Rao,G.S. Sant,S.C. Rajan, *An Overview of Indian Energy Trends*, 2009

[4] BBC, *Can Foreign Firms Make Russia's Electricity Cheaper?*, 31 March 2011; NewsBCM, *Rise in Russia's Hydro Rates Not to Exceed 15 percent in 2011*, 21 March 2011

[5] OECD : *Transition to a Low-Carbon Economy, Public Goals and Corporate*

[6] Ibid

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A continued credit squeeze

In mature western economies, access to capital for companies has been highly restricted for the last two to three years, and the squeeze continues because of factors such as slow economic growth and concerns about stability in the eurozone. In rapidly developing economies, pressures on capital availability are rather more subtle; governments are eager to restrict soaring rates of corporate debt in the fear that these borrowings will be unsustainable in the long term. Small-and medium-sized firms are often relatively neglected, with restricted access to credit.[7] These rapid-growth economies are also looking to balance short-term gain against the possible long-term pain of over-indebtedness. They are building industrial infrastructure that must be financially sustainable long into the future.

A quick review of the issue around the world provides a wider economic context to energy-efficient investments.

Regular reports from the U.S. Federal Reserve,[8] the European Central Bank[9] and the Bank of England[10] report no substantial change in the company credit criteria and largely expect the credit squeeze to continue for a while longer. They also expect overall loan volumes to remain relatively flat.[11]

Poland is inevitably harnessed to the eurozone's fortunes and, although an economy that continues to develop, has felt the impact of tightened credit availability. Turkey, China, India and Russia are economies in higher growth mode. In most, monetary policy has been deployed in 2011 to stop growth running out of control, but has been followed this year by a relaxation in credit conditions. This is witnessed by the example of China; lower predicted growth of 8 percent (compared with 9 percent in 2011) has seen a series of bank reserve requirement reductions in a bid to stimulate greater credit availability.[12] Turkey's central bank increased the reserves banks must deposit[13] last year, but has now seen economic contraction and wants to boost credit availability.[14] In India, bad loan rates have soared and threaten to force a tightening of lending criteria.[15]

In summary, western banks are keeping their corporate criteria tight and are only gradually easing lending conditions. Stability concerns in the eurozone may reverse this trend, yet western corporations are extremely keen to have access to capital in order to invest in energy-efficient equipment. As a result, they are exploring alternative financing methods to standard corporate borrowing[16] in order to meet the challenge of a tight credit market.

In more rapidly developing economies, such as China and Turkey, the authorities are in many cases concerned about ensuring controlled and sustainable growth and are applying pressure on the availability and cost of funds to counter possible racing inflation and inappropriate borrowing. At the same time, smaller firms are finding obstacles in their attempts to access credit across the globe. For instance, one analyst notes, "in China, small private sector firms still suffer from capital shortages."[17]

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[7] See for instance: World Bank, *Small and Medium Enterprises,* January 2011; Regus, *Small Is Beautiful but Tough*, November 2010; Economist Intelligence Unit, *Surviving the Drought*, 2009

[8] Federal Reserve, *Senior Loan Officer Opinion Survey on Bank Lending Practices*, July 2012

[9] European Central Bank, *Euro Area Bank Lending Survey*, July 2012

[10] Bank of England, *Credit Condition Survey 2012 Q2*

[11] Bank of England, Time Series, *Net Lending, Trends in Lending July 2012*

[12] Peoples Bank of China

[13] Bloomberg, *Turkey's Central Bank Boosts Reserves, Warns of Inflation*, 23 March 2011

[14] Bloomberg, *No Apology Needed as Contraction Boosts Bonds: Turkey Credit*, 5 July 2012

[15] Livemint / Wall Street Journal, *Banks and Bad Loans*, 10 July 2012

[16] See for instance: HBS-USC Conference, *Alternative Financing in a Stabilized Economy*, May 2010; Global Corporate Venturing, *Funding Business Growth in an Age of Scarcity*, February 2011; Davos 2010, *Financing Low Carbon Growth.*

[17] China Analytics, *Industrial Policy in China and the 12th Five-year Plan*,12 October 2011

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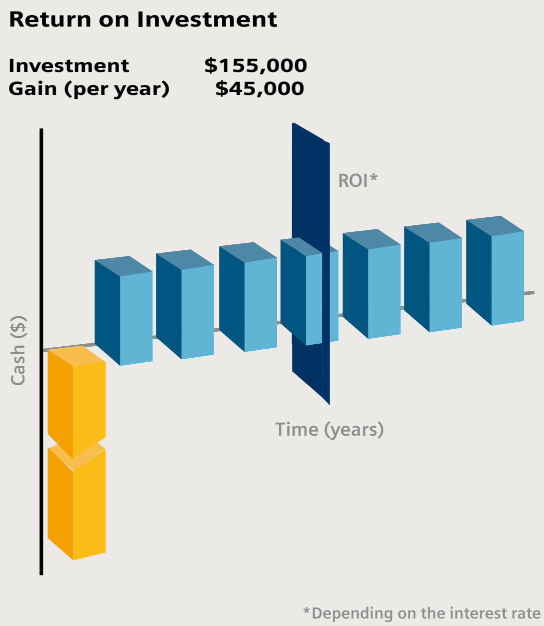

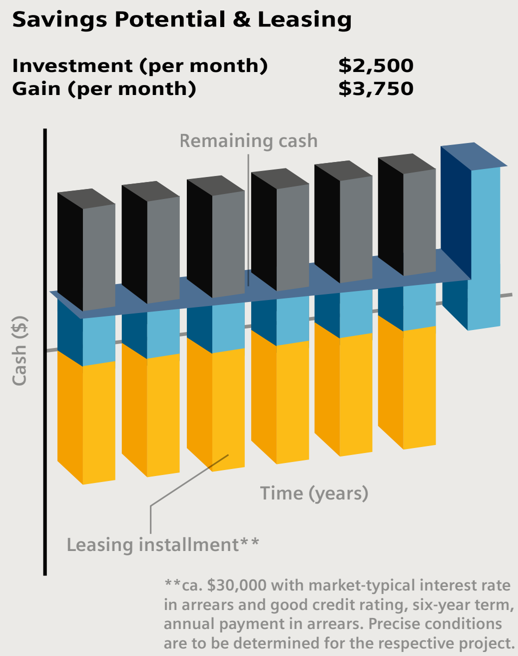

Affording energy-efficient investments

So how can firms across the world access capital to make energy-efficient equipment investments? Even in rapid-growth economies, companies that have seen meteoric growth may well have reached their borrowing ceiling and yet continue to need financing in order to make further investments in growth, including energy efficiency initiatives. Moreover, emerging market companies want to ensure that their energy-efficient investments are financially sustainable in the long term?

Various forms of asset financing techniques are coming to the fore as effective alternative methods of funding energy-efficient equipment upgrades. These techniques aim to offset the monthly cost of the new equipment against the energy savings it enables. In some cases, finance payments even flex with the energy-saving or energy-generation outputs from the new equipment. These forms of financing—which are separate from standard bank lending—are increasingly important, given that recent research has shown that the greatest concern of corporations is the lack of confidence over whether energy-efficient investments will deliver the promised savings.[18] Combined financing and equipment solutions overcome this obstacle since the finance providers in this area understand what the solution should deliver and design the financial vehicle around projected savings being met.

Financing techniques, such as leasing and renting, are increasingly being used in a number of countries to provide organizations of all sizes with financing for energy-efficient equipment where the energy savings pay for the equipment investment. Where possible, these techniques wrap everything into a single finance package, including energy efficiency assessment, the equipment itself, installation, etc., all through leasing, renting or hiring purchase arrangements. Payments are at least equal to, or less than, the energy savings, and in many early cases, deliver savings and net positive cash flow immediately after installation has been completed. Where a project cannot completely offset the equipment upgrade with energy efficiency cost savings, the financing arrangement can still subsidize a large part of the upgrade cost. 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.

A finance agreement under this kind of integrated strategy has the advantage of being tax efficient and offering fixed payments for the agreement term. These are calculated taking the type of equipment, its expected working life and the customer's individual circumstances into account, so that the customer is assured that tailored payments can be offset against the expected energy savings.

[18] Green Monday, *Energy Efficiency*, Summer 2011

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Priority areas for industrial energy efficiency

Whether making individual energy efficient equipment investments or engaging in a facility-wide performance contracting arrangement, businesses need an awareness of which key areas of their infrastructure can offer the greatest payback on energy efficiency initiatives. Businesses should systematically evaluate their own facilities in order to identify the highest priority areas for their sites as a one-size-fits-all approach does not exist. Earlier this year, Siemens published a guide to the most common investment areas, each of which provides substantial and rapid return on investment. Those key areas include:

- Heating, ventilation and air conditioning
- Biomass heating
- On-site solar and wind power
- Supply voltage optimization
- Power management solutions
- Increased factory or process automation
- Intelligent lighting controls and low-energy lighting
- Building controls
- Monitoring and targeting systems
- High-efficiency motors
- Medium voltage variable frequency drives

There are two further areas where major industrial efficiency cost savings can be made, while also reducing environmental impact — lubrication and water-cooling. These are covered in Appendix B.

As an example, this report has now quantified the advantages, in terms of saved electricity costs, that can be gained from more widespread implementation of VFDs, in order to give management teams in industry an idea of the scale of savings to be made.

The following section describes the background to energy-efficient motors, controlled by VFDs, with references to third-party sources. The highly conservative model, upon which the estimate of wasted electricity costs is based, is then described in detail.

VFDs and industrial motors

VFDs optimize the voltage and frequency input into an industrial motor to change its speed of operation, rather than the traditional method of "choking" constant speed motors. This greatly reduces consumption of electricity. Correctly designed VFD systems typically reduce energy consumption by up to 70 percent, depending on the application. The most receptive applications tend to be pumps, fans and centrifugal compressors, although worthwhile savings may even be achieved on more demanding applications such as mixers, centrifuges, reciprocating compressors and extruders.

In addition to providing substantial energy reduction, other VFD benefits include soft startup of the equipment, reduced current on starting, reduced mechanical stress and high power factor. VFDs are intelligent devices that can easily be integrated into energy management systems and may also be a key component in dynamic power management by helping with rate management and demand reduction.

VFD lowers energy bills by reducing electricity consumption

Example calculation: Conversion of a standard fan to an energy-savings fan (with VFD) in a paper machine drive

	Standard fan	Energy-saving fan (VFD)
Power consumption / 24h	60 kWh	15 kWh
Energy costs / kWh	\$0.10	\$0.10
Annual energy costs for 8,000 operating hours	**\$2,000**	**\$500**

With an estimated usage period of 8,000 hours and energy costs of \$0.10 / kWh, the annual savings are \$1,500

The gains to be made from installing VFDs should not be confused with the process of installing motors that themselves are more energy efficient. Both activities — installing VFDs and replacing inefficient motors with more energy-efficient models — will yield energy cost savings.

As far as industrial electric motors are concerned, legislative efforts have been underway in several countries for over a decade to encourage the transition to more efficient electric motor–driven systems. These include the implementation of Minimum Energy Performance Standards (MEPS) requiring that electric motors meet a certain efficiency level in order to enter the national market. For example, July 2009 EU legislation set out a timetable for the phasing out of less efficient IE1 and IE2 motors; the directive required all motors with an output of 7.5 to 375 kW to meet the IE3 efficiency level from January 2015 (or else the IE2 efficiency level in conjunction with a variable speed drive), and for the same stipulations to be in place for all motors with an output of 0.75 to 375 kW from January 2017.

[19] Green Monday, *Energy Efficiency*, Summer 2011

[20] Directive 2005 / 32 / EC of the European Parliament and of the Council with Regard to Ecodesign Requirements for Electric Motors, July 2009

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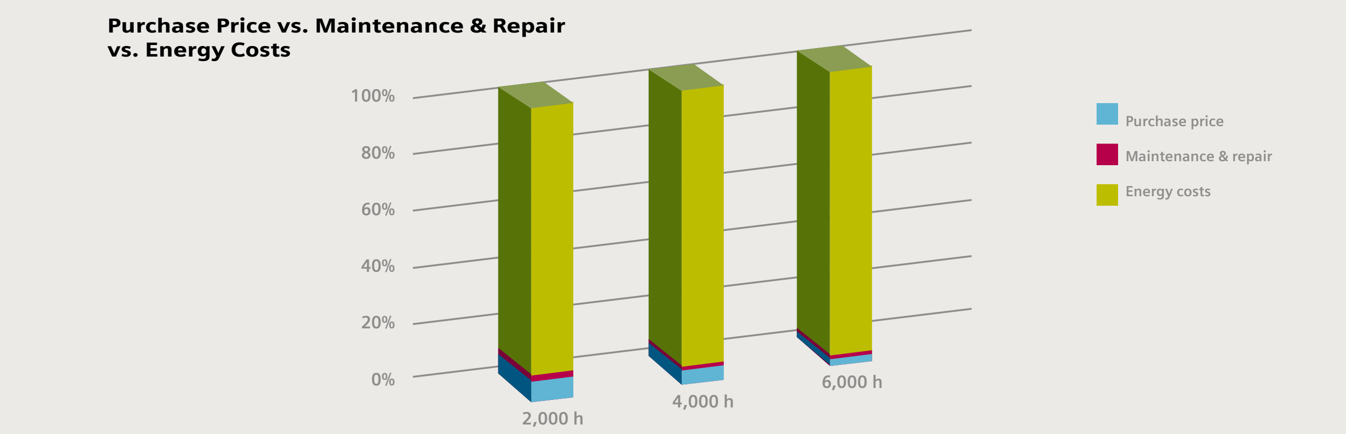

Operating hours per year	Purchase price	Maintenance & repair	Energy costs
2,000	3.8%	1.0%	95.2%
4,000	1.9%	1.0%	97.1%
6,000	1.3%	1.0%	97.7%

Similar measures in the United States include the Energy Policy Act of 2005, mandating that government motor purchases must meet the NEMA premium efficiency levels (equivalent to IE3),[21] and the Energy Independence and Security Act of 2007, which requires all motors manufactured after December 2010 to conform to the same standard.[22] Although motor efficiency levels are slightly lower in China than in the EU and U.S.,[23] the Chinese government is at the forefront of efforts to develop the IE4 motor class[24] and has introduced legislation requiring manufacturers to meet IE2 motor efficiency levels from 2013.[25]

Governments have very clear incentives for implementing these policies. Electric motor systems use approximately 40 percent of total global electricity,[26] and their share in industrial electricity consumption is much higher, standing at 65 percent according to the International Energy Agency.[27] The U.S. Department of Energy estimates that the 40 million motors used by U.S. industry are responsible for a hefty 70 percent of its electricity consumption.[28] Similarly, in the EU, electric motor–driven systems account for approximately 70 percent of total industrial electricity consumption,[29] and are responsible for approximately 60 percent in China.[30] With the global cost of electricity on the rise,[31] any equipment that results in energy savings constitutes a valuable investment. The case for energy efficiency becomes all the more compelling in light of the fact that over 95 percent of the lifetime costs of an industrial motor is the cost of the electricity it consumes.

Implementing VFDs in appropriate processes, however, offers greater energy savings than simply upgrading to more energy-efficient motors. Moreover, the full energy and cost-saving potential of VFDs is a long way from being realized. Globally, the penetration of VFDs (as a proportion of installed motors) is still low. Information in this area is limited, but evidence indicates that the highest levels have been achieved in the U.S., at nearly 20 percent.[32] The U.K. Trade Association for Automation, Instrumentation and Control Laboratory Technology puts market penetration of VFDs at a mere 10 percent,[33] a statistic thought to be matched in China,[34] and figures suggest that VFD penetration in Europe stands at no higher than 15 percent.[35] However, some progress is being made, with estimates in Germany showing that 30 percent of industrial electric motors are currently sold with a VFD.[36]

[21] Control Engineering, *Motor-driven Systems Efficiency Update*, 19 June 2012

[22] NEMA, *Summary and Analysis of the Energy Independence and Security Act of 2007*, January 2008

[23] IMS Research, *China: The World's Largest and Fastest Growing AC Induction Motor Market*, October 2011

[24] Ibid

[25] IMS Research, *Efficiency Legislation Pushes Low Voltage Motors Market into Double-digit Growth Despite Eurozone Economic Woes*, March 2012

[26] IEA 4E: *Electric Motor Systems Motor Policy Guide*, January 2011

[27] International Energy Agency, *Energy Efficiency Policy Opportunities for Electric Motor-driven Systems*, 2011

[28] United Nations Working Paper, *Energy Efficiency in Electric Motor Systems: Technical Potentials and Policy Approaches for Developing Countries*, 2011

[29] International Energy Agency, *Energy Efficiency Policy Opportunities for Electric Motor-driven Systems*, 2011

[30] U.S. Energy Information Administration

[31] Eurostat

[32] Center on Globalization, Governance & Competitiveness, Duke University, *U.S. Adoption of High-efficiency Motors and Drives: Lessons Learned*, February 2010

[33] Gambica

[34] Center on Globalization, Governance & Competitiveness, Duke University, *U.S. Adoption of High-efficiency Motors and Drives: Lessons Learned*, February 2010

[35] Gambica

[36] International Energy Agency, *Energy Efficiency Policy Opportunities for Electric Motor-driven Systems*, 2011

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Industry case study:
Reducing energy use with VFDs

Given the desert climate in Las Vegas, power conservation is a top concern for its mainstay gaming industry. To cut down on energy waste and its related costs, MGM Resorts International sought new ways to reduce HVAC power usage at its flagship Las Vegas hotel, The Mirage.

Built in 1989, the Mirage has 9,600 tons of air-conditioning capacity. Its central plant contains six 1,350-ton chillers operating at 4,160 volts, and its auxiliary plant has three 500-ton chillers operating at 480 volts. The chillers were wasting a lot of power because they ran at full throttle even if inside temperature demands did not require them to do so.

The Mirage deployed a Siemens SINAMICS PERFECT HARMONY 4,160-volt, zero harmonic VFD to each of three 1,350-ton chillers in the central plant. In the auxiliary plant, a SINAMICS Perfect Harmony VFD was connected to each of two 500-ton chillers. In both plants the chillers without VFDs continued to operate at full power, while the VFD-equipped chillers became the buffers that provided the variable capacity needed to accommodate varying demands of time of day and season, thereby saving energy.

As a result of the Siemens-based solution, The Mirage now saves $20,000 a month in operating costs and qualifies for utility rebates of about $70,000. Additionally, the hotel's increased efficiency prevents 4.8 million pounds of CO_2 emissions per year.

Quantifying savings from greater VFD implementation

In order to give an idea, country by country, of the level to which greater implementation of VFDs could offer cost savings to industry, Siemens has drawn on its data sources and customer experiences to create a financial model.

All aspects of this model are designed to be cautious and conservative,[37] at each stage choosing the lower end of reported experiences to ensure that the resulting estimates are likely to understate the situation rather than exaggerate it. In the following paragraphs, we describe how the model works.

The starting point is industrial energy consumption for the 10 countries studied. This figure is published by a number of official sources, as is pricing for industrial electricity. The most complete, verified dataset for industrial electricity prices and consumption across these 10 countries is for 2010. Therefore, this data has been used for the model, factoring out escalating factors such as increased consumption and rising prices. This is the first point at which the model introduces a note of careful conservatism.

Next, a number of sources testify that, throughout the world, over 60 percent of industrial electricity is used to drive electric motors. However, in the countries studied, between 10 percent and 20 percent of industrial motors are controlled through a VFD. Therefore, industrial energy consumption must be reduced by this proportion, which is already energy efficient.

In addition, not all motors are applied to variable speed processes (i.e. where the motors do not run at constant speed all the time). Sources testify that at least 50 percent of industrial processes would benefit from VFDs, and that the proportion could be closer to 70 percent. The lower of these figures has been used in the Siemens model.

Finally, what level of energy efficiency gains do VFDs typically enable, and how much can electricity costs be reduced? Most sources cite a range between 20 percent and 70 percent, depending upon the application. In order to make sure the Siemens model generates a conservative estimate, a low average savings level of 25 percent was used.

[37] Validation of the model's cautious outlook may be found in a comparison with The International Energy Agency: Energy Efficiency Policy Opportunities for Electric Motor-driven Systems, 2011, in which the IEA estimates that it is cost-effective to save approx. Twenty to 30 percent of global electric motor demand, through the use of more efficient electric motors and drives. The results of the Siemens model are somewhere between one third and one half of this IEA estimate.

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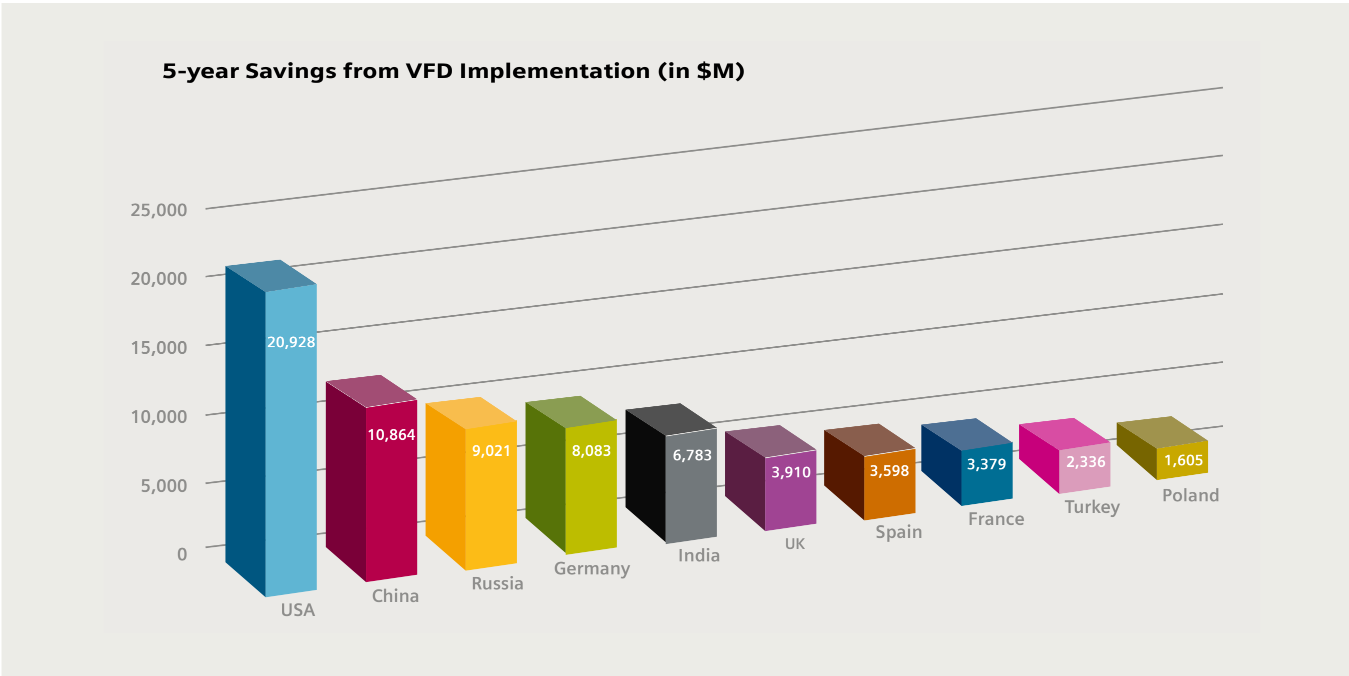
When this highly conservative model[38] is applied to industrial electricity consumption in the 10 countries studied — USA, U.K., France, Germany, Spain, Poland, Turkey, Russia, India and China — the following figures are revealed.

This is a careful estimate of the amount of money that industrial enterprises are potentially spending unnecessarily (wasting) over the next five years, as a direct result of not implementing VFDs on all appropriate industrial processes.



Industrial Electricity Consumption

X

Industrial Electricity Pricing

X

Motor Consumption percent

Reduced by

Penetration of motors controlled by a VFD

X

Applications which benefit from VFD control

X

Energy efficiency gain from VFD implementation

=

Industrial electricity overspend

[38] All sources for model listed in Appendix A

Conclusion

This research paper has quantified the potential energy cost savings to be gained from full implementation of VFDs in industrial enterprises in 10 countries across the world. These projected sums, which are significant even though based on a highly conservative model, serve to illustrate what could be gained from just one of many possible energy efficiency initiatives that industrial enterprises adopt. Readers should view the estimates in this report as just the starting point for a strong business case for energy efficiency investments.

The paper also emphasizes the availability of appropriate financing arrangements that industrial companies can employ — especially in times of scarce credit in mature economies, and concern in rapid growth countries that equipment and infrastructure investment is being made in ways that will be sustainable long into the future. These financing tools provide an alternative to standard bank borrowing, offset equipment investment costs against energy cost savings, and effectively offer businesses a zero-net-cost method of acquiring energy-efficient equipment. This not only saves on energy costs, but also is often more productive than the equipment it replaces and less expensive to maintain and service than previous generation technology.

It appears that, with innovative financing methods now widely available, the outlook for energy efficiency investment is positive.

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APPENDIX A

Sources for Siemens model — electricity cost savings in industry resulting from full implementation of variable frequency drives (VFDs).

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APPENDIX B

In addition to the most common investment areas for industrial efficiency cost savings introduced in the earlier part of the report, lubrication and water cooling are two further areas that present great cost savings potential in industry.

Industrial lubrication and water-cooling systems

Lubrication oil is a byproduct in the distillation of petroleum to produce gasoline. It is colorless oil, which is of low value but produced in high quantities to meet the growing needs of industry and motor vehicles. It is used to lubricate moving parts and for cooling, cleaning and corrosion control. Used mineral lubricating oils represent the largest component of liquid, non-aqueous hazardous waste in the world. Burning or uncontrolled dumping represented inadequate disposal methods and pose significant environmental threats, including the pollution of soil, surface water and groundwater. Furthermore, failure to reuse this oil means that industry has to rely on imports of more expensive crude oil.[39]

Every year, the EU uses 4.7 million tons of oil lubricants. Almost 1 million tons of oil are currently used for conventional cooling and lubrication of machining processes in the machining industry in Germany alone.[40] And recycling rates have been very low. However, the potential savings that could be made by doing so are considerable. It only takes 1.3 tons of used oil — compared to 10 tons of crude oil — to produce one ton of high-grade base oil for the lubricant market. Furthermore, even the leftover fraction of the recycling process can be recovered for use in industrial heating. From a lifecycle perspective, waste oil recycling is far superior to combustion.[41]

Globally, about 69 percent of the finished lubricant demand is converted into used oil. Of the total used oil collected, 78 percent is consumed as industrial fuel and 16 percent is re-refined, according to Kline's study, *Global Used Oil 2009: Market Analysis and Opportunities*. Awareness of the quality of re-refined lubricants is spreading among a growing band of end-users; however, this perception is not nearly universal and customer hesitance due to perceptions of poor quality and inconsistent supply still prevents a larger-scale industry growth. Although used oil collection regulations exist in most countries, varying levels of enforcement and incentives mean that, globally, of the total used oil generated, only about 74 percent is collected. The remaining 26 percent is combusted, reused without appropriate treatment or simply discarded. The criticality of oil in industry is matched by that of water.[42] Water is a critical input for oil refining, where it is used primarily as part of cooling processes. Ironically, more water is used in refineries than crude oil.[43] Considerable savings can, therefore, be made in this department, since the quantities of water used in industrial applications are vast. Probably every manufactured product uses water during some part of the production process;[44] in the U.S., nearly 5 percent of all water withdrawn is used for industrial processes.[45]

According to the Dow Chemical Company, China's water demand in 2030 is expected to reach 818 billion m3, 32 percent of which will comprise industrial demand driven by thermal power generation. However, Chinese industry is extremely inefficient in water use, recycling only 25 percent of its water compared with an average of 85 percent in developing countries.[46]

Water cooling is commonly used for cooling automobile internal combustion engines and large industrial facilities such as steam electric power plants, hydroelectric generators, petroleum refineries and chemical plants.[47] Other uses include cooling the barrels of machine guns, cooling of lubricant oil in pumps, for cooling purposes in heat exchangers, cooling products from tanks or columns, and cooling of various major components inside high-end personal computers.

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39 European Commission, *Life and Waste Recycling: Innovative Waste Management Options in Europe*, 2007

40 *Machinery Lubrication, Sustainable Production Using Minimal Quantity Lubrication*

41 European Commission, *Life and Waste Recycling: Innovative Waste Management Options in Europe*, 2007

42 Kline Press Release, 21 September 2010

43 U.S. Environmental Protection Agency, *Climate Protection Partnerships Division and Municipal Support Division*, March 2008

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