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Turn down the power

A study into current levels of energy inefficiency in industry in ten countries around the globe

SFS Research Study, October 2012

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Contents

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 overheads

- Businesses across the world are therefore keen to invest in energy-efficient equipment and facilities in order to reduce their electricity usage and expenditure

- This research paper seeks to quantify one of many areas in industry where significant energy-efficiency gains can be made – variable speed drives – in order to illustrate the potential sums that the sector could be saving

- Industrial enterprises around the world could save billions of Euros on their electricity bills by implementing variable speed drives (VSDs) on motors in their production environment

- This study's highly conservative estimate of industrial electricity overspend over the next five years, directly attributable to non-implementation of VSDs, is:-
    - USA - € 16,742 million
    - China - € 8,691 million
    - Russia - € 7,217 million
    - Germany - € 6,466 million
    - India - € 5,426 million
    - UK - € 3,128 million
    - Spain - € 2,878 million
    - France - € 2,703 million
    - Turkey - € 1,869 million
    - Poland - € 1,284 million

- 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 and 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 to 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 fulfil this demand, financing methods are coming to market which 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, ready to be spent on market or acquisition opportunities

Introduction

Industrial enterprises around the world are facing challenging markets. Concerns about the Eurozone's stability are affecting both mature and higher growth economies, slightly taking the gilt off formerly meteoric GDP increases in the BRIC counties. 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 organisations to have a sustainable commercial future. In the ten countries studied in this report, industry consumes anywhere between 30% and 60% of all electricity generated. It is natural, then, that board members in the industry sector would be paying increasing attention to ways of making their organisations 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 EU, this need has been enshrined in official targets, with one key European Commission communication[1] stating a goal to improve energy efficiency by 20% by 2020.

Goals and targets are all very well, but business minds need to focus on the key discipline – return on investment. Whilst regulation and legislation do have some effect in forcing change in the business community, a compelling business case - with clear method, reliable return on investment and financial efficiency - is much more powerful and more likely to accelerate that change. In addition, finance directors have to prioritise 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 fulfils all of these criteria.

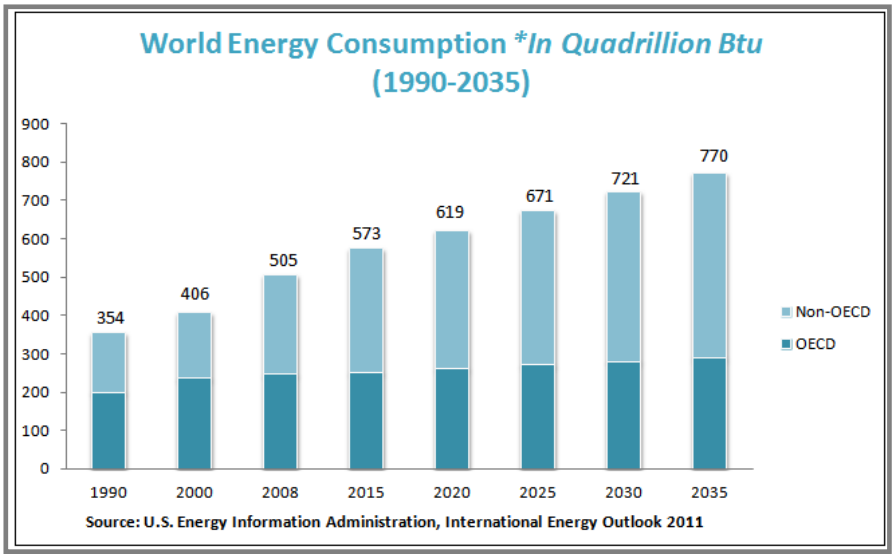
Financially efficient funding methods are needed however to deliver immediate returns from energy-efficiency initiatives. This is especially the case in an environment where companies continue to face restricted access to bank credit, and where finance directors want to conserve cash for initiatives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

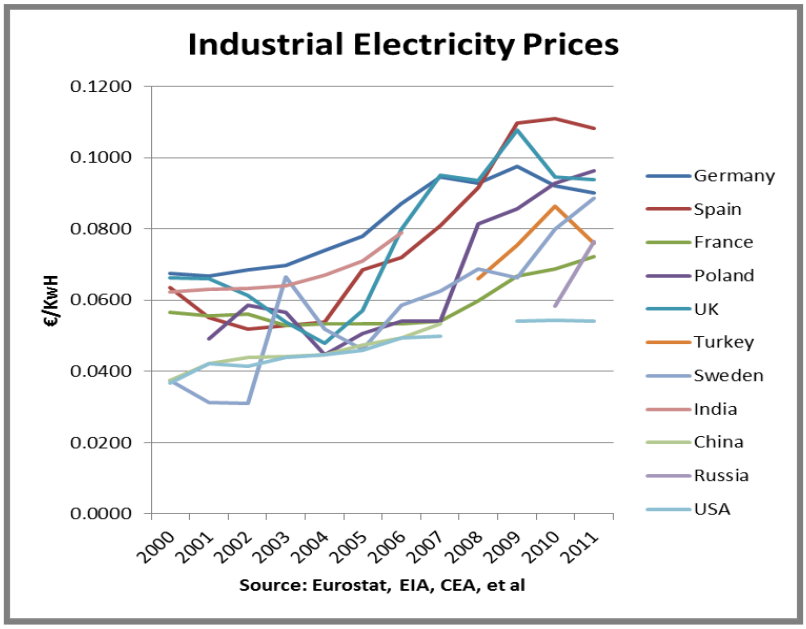
This paper therefore describes the background evidence for rising energy prices and limited access to credit. It then seeks to quantify one of many areas in industry where significant energy-efficiency gains can be made – variable speed drives – in order to give a tangible idea of the potential sums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

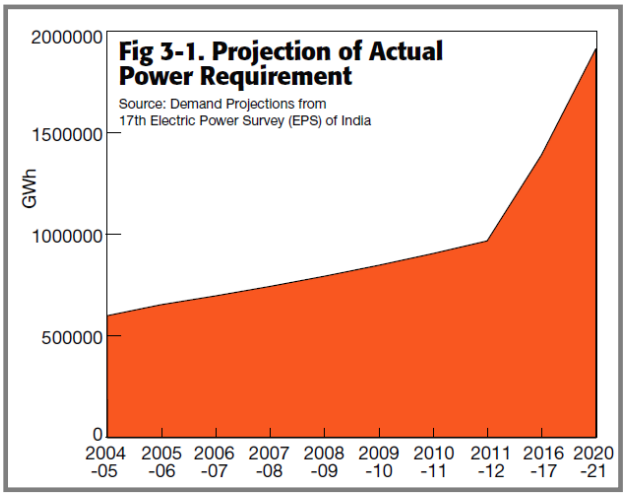
[1] European Commission: Energy, (COM(2007) 1)

Rising energy costs

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.







World 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 2011/12 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 amongst European countries seen in the above chart is replicated in rapidly developing economies. China recently increased the cost of electricity for industrial use in fourteen provinces and its Chongqing municipality[2], and has rationed industrial consumption[3]. In India, industrial electricity prices are high, largely to subsidise low domestic charges, and these prices are set to continue rising[4]. Russia is also seeing major rises in electricity prices, with hydro charge increases being capped at 15% last year[5]. And it is widely argued that rising industrial demand from high growth economies is forcing up electricity prices, and that this will continue in the future.

With electricity prices rising around the globe, 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 Organisation 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 UK, Germany), 96% of participating (large) businesses indicated that they had started implementing energy-saving measures[6]. 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'[7].

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.

[2] AFP, *China hikes industrial electricity prices*, May 30, 2011; CCTV News Channel, 31 May 2011
[3] Financial Times, *China forced to ration electricity*, 17 May 2011
[4] N.Rao,G.S. Sant,S.C. Rajan, *An overview of Indian Energy Trends*, 2009
[5] BBC, *Can foreign firms make Russia's electricity cheaper?*, 31 March 2011; NewsBCM, *Rise in Russia's hydro rates not to exceed 15% in 2011*, 21 March 2011
[6] OECD : *Transition to a Low-Carbon Economy, Public Goals and Corporate Practices*, 2010
[7] ibid

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 keen 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[8]. These rapid growth economies are – sensibly - keen to balance short-term gain against the possible long-term pain of over-indebtedness. They are building industrial infrastructure which has to be financially sustainable long into the future if their current rising star is to remain in the ascendant.

A quick review of the issue across the globe helps to give a wider economic context to energy-efficient investments.

Regular reports from the US Federal Reserve[9], the European Central Bank[10] and the bank of England[11], report no very substantial change in the company credit criteria and largely expect the credit squeeze to continue for a while longer, and overall loan volumes to also remain relatively flat[12].

Poland is inevitably harnessed to the Eurozone's fortunes and, although an economy which 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% (compared with 9% in 2011) has seen a series of bank reserve requirement reductions in a bid to stimulate greater credit availability[13]. Turkey's central bank increased the reserves banks must deposit[14] last year, but has now seen economic contraction and wants to boost credit availability[15]. In India, bad loan rates have soared and threaten to force a tightening of lending criteria[16].

Western banks, in summary, are keeping their corporate criteria tight, and are only gradually easing lending conditions. Stability concerns in the Eurozone may yet reverse this trend. Yet Western corporations are extremely keen to have access to capital in order to invest in

[8] 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.
[9] Federal Reserve, *Senior Loan Officer Opinion Survey on Bank Lending Practices,* July 2012
[10] European Central Bank, *Euro area bank lending survey,* July 2012
[11] Bank of England, *Credit Condition Survey 2012 Q2*
[12] Bank of England, Time Series, *Net Lending, Trends in Lending July 2012*
[13] Peoples Bank of China
[14] Bloomberg, *Turkey's Central Bank Boosts Reserves*, Warns of Inflation, 23 March 2011
[15] Bloomberg, *No apology needed as contraction boosts bonds: Turkey credit*, 5 July 2012
[16] Livemint/Wall St Journal, *Banks and bad loans*, 10 July 2012

energy-efficient equipment. As a result, they are exploring alternative financing methods to standard corporate borrowing[17] 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 that, "in China, small private sector firms still suffer from capital shortages.[18]"

Affording energy-efficient investments

How then, 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 finance 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 longer-term?

Various forms of asset-financing techniques are coming to the fore as effective, alternative methods of funding energy efficient equipment upgrades. These techniques, in brief, aim to offset the monthly cost of the new equipment, against the energy savings that 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 corporates' greatest concern to be lack of confidence over whether energy-efficient investments will deliver the promised savings[19]. Combined financing and equipment solutions overcome this obstacle as the finance providers proficient in this area understand what the solution should deliver and predicate the finance arrangement on projected savings being met.

Financing technique such as leasing and renting is increasingly being used in a number of countries to provide organisations of all sizes with financing for energy-efficient equipment where the energy savings pay for the equipment investment. Where possible, these schemes wrap everything into a single financing package, including energy efficiency assessment, the equipment itself, installation etc., all via a leasing, renting or hire purchase arrangements.

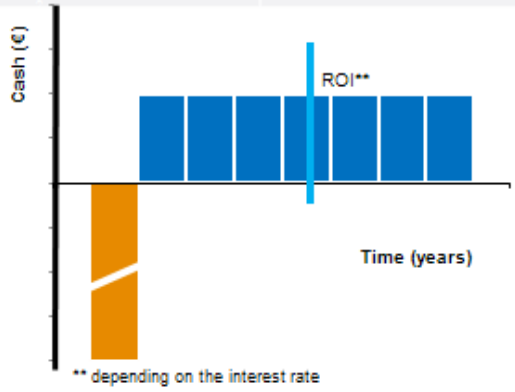
[17] See, for instance: HBS-USC Conference, *Alternative Financing in a Stabilized Economy*, May 2010; Global Corporate Venturing, *Funding Business Growth in an Age of Scarcity,* February 2011; Davos 2010, *Financing Low Carbon Growth.*
[18] China Analytics, *Industrial Policy in China and the 12th Five-year Plan*, 12 October 2011
[19] Green Monday, *Energy Efficiency*, Summer 2011

Payments are at least equal to, or lower 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 nevertheless subsidise the larger 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 scheme has the advantage of tax efficient, fixed payments for the agreement term, which are calculated taking into account the type of equipment, its expected working life and the customer's individual circumstances, so that the customer has the specific reassurance that tailored finance payments can be offset against the expected energy savings.

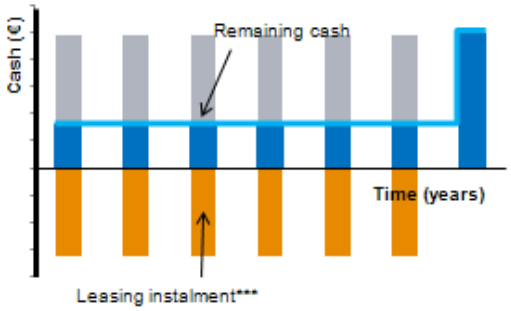
Investment can be financed solely by savings gained in a leasing model

Return on investment	
Investment	155 000 EUR
Gain p.a.	45 000 EUR



** depending on the interest rate

Savings potential & leasing	
Investment per month	2 500 EUR
Gain per month	3 750 EUR



*** ca. 30 000 EUR p.a. with market-typical interest rate in arrears and good credit rating, six-year term, annual payment in arrears. Precise conditions are to be determined for the respective project .

Priority areas for industrial energy-efficiency

Whether making individual energy-efficient equipment investments or engaging in a 'whole facility' performance contracting arrangement, businesses need an awareness of which key areas of their infrastructure are most susceptible to, and 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 comprised:-

- Heating, Ventilation and Air Conditioning
- Biomass Heating
- Onsite Solar and Wind Power
- Supply Voltage Optimisation
- Power Management Solutions
- Increased Factory or Process Automation
- Intelligent Lighting Controls and Low-energy Lighting
- Building Controls
- Monitoring and Targeting Systems
- High Efficiency Motors
- Variable Speed 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 A.

By way of an example, this report has now quantified the advantages, in terms of saved electricity costs, that can be gained from more widespread implementation of Variable Speed Drives (VSDs), 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 variable speed drives, with reference to third party sources. The highly conservative model on which the estimate of wasted electricity costs based is then described in detail.

Variable speed drives and industrial motors

Variable Speed Drives (VSDs) optimise the voltage and frequency supply to 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 VSD systems typically reduce energy consumption by 20% and 70%, depending on the application.[20] 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 VSD benefits include soft start-up of the equipment, reduced current on starting, reduced mechanical stress and high power factor. VSDs 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 tariff management and demand reduction.

VSD lowers energy bills by reducing electricity consumption

Exemplary calculation		
Conversion of a standard fan to an energy-saving fan (VSD) in a paper machine drive		
Machine details		
Device performance: 800 kWh, 690 V	Utilised capacity: 70%	
Operating mode: non-stop operation 24h	Ambient temperature: 24°C	
Calculation of energy costs		
	Standard fan	Energy-saving fan (VSD)
Power consumption/24h (metered value)	60 kWh	10 kWh
Energy costs/kWh	EUR 0,12	EUR 0,12
Annual energy costs for 8,000 operating hours	EUR 2.400,-	EUR 400,-

With an estimated usage period of 8,000 hours and energy costs of 0.12EUR/kWh, the annual savings are 2,000 EUR

The gains to be made from installing VSDs should not be confused with the process of installing motors which themselves are more energy efficient. Both activities – installing VSDs, 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

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

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, EU legislation of July 2009 set out a timetable for the phasing out of less efficient IE1 and IE2 motors; the directive required all motors with an output of 7.5-375 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 0.75-375kW from January 2017.[21]

Operating hours per year	Purchase price	Maintenance and repair	Energy costs
2 000 h	3.80%	1.00%	95.20%
4 000 h	1.90%	1.00%	97.10%
6 000 h	1.30%	1.00%	97.70%

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),[22] and the Energy Independence and Security Act of 2007, which requires all motors manufactured after December 2010 to conform to the same standard.[23] Although motor efficiency levels are slightly lower in China than in the EU and US,[24] the Chinese government is at the forefront of efforts to develop the IE4 motor class[25] and has introduced legislation requiring manufacturers to meet IE2 motor efficiency levels from 2013.[26]

[21] Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for electric motors, July 2009
[22] Control Engineering, *Motor-Driven Systems Efficiency Update*, 19 June 2012
[23] NEMA, *Summary and Analysis of the Energy Independence and Security Act of 2007*, January 2008
[24] 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

Governments have very clear incentives for implementing these policies. Electric motor systems use approximately 40% of total global electricity,[27] and their share in industrial electricity consumption is much higher, standing at 65% according to the International Energy Agency.[28] The U.S. Department of Energy estimates that the 40 million motors used by U.S. industry are responsible for a hefty 70% of its electricity consumption.[29] Similarly, in the EU, electric motor-driven systems account for approximately 70% of total industrial electricity consumption,[30] and are responsible for approximately 60% in China.[31] With the global cost of electricity on the rise,[32] any equipment that results in energy savings constitutes a valuable investment. The case for energy-efficiency becomes all the more compelling in the light of the fact that over 95% of the lifetime costs of an industrial motor is the cost of the electricity it consumes.

Implementing VSDs 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 Variable Speed Drives is a long way from being realised. Globally, the penetration of VSDs (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 US, at nearly 20%.[33] The UK Trade Association for Automation, Instrumentation and Control Laboratory Technology puts market penetration of VSDs at a mere 10%,[34] a statistic thought to be matched in China,[35] and figures suggest that VSD penetration in Europe stands at no higher than 15%.[36] However, some progress is being made, with estimates in Germany showing that 30% of industrial electric motors are currently sold with a VSD.[37]

Case study examples:

a) Glass manufacturing is a highly competitive industry and rising energy prices is a major concern for industry players in the sector. By installing variable speed drive control technology, Allied Glass Containers in Leeds has cut the electricity consumption of its fan coolers by more than 40%. This has saved several hundred thousand pounds, cut annual carbon emissions from the plant by almost 2,000 tonnes – and achieved the forecast 10-month payback on investment.

b) Excessive energy costs, high maintenance requirements, operational problems and potential safety issues persuaded a large European steel plant, to upgrade three 2,7MW high pressure pumps used on the steel strip de-scaling. With a payback period of less than two years, not only has the retrofit reduced carbon emissions and energy costs, it has also increased system reliably, substantially reduced maintenance costs and extended system life.

[27] IEA 4E: *Electric Motor Systems Motor Policy Guide*, January 2011
[28] International Energy Agency, *Energy Efficiency Policy Opportunities for Electric Motor-Driven Systems*, 2011
[29] United Nations Working Paper, *Energy efficiency in electric motor systems: Technical potentials and policy approaches for developing countries,* 2011
[30] International Energy Agency *Energy Efficiency Policy Opportunities for Electric Motor-Driven Systems*, 2011
[31] US Energy Information Administration
[32] Eurostat
[33] Center on Globalization, Governance & Competitiveness, Duke University, *U.S. Adoption of High-Efficiency Motors and Drives: Lessons Learned*, February 2010
[34] Gambica
[35] Center on Globalization, Governance & Competitiveness, Duke University, *U.S. Adoption of High-Efficiency Motors and Drives: Lessons Learned*, February 2010
[36] Gambica
[37] International Energy Agency, *Energy Efficiency Policy Opportunities for Electric Motor-Driven Systems*, 2011

Quantifying savings from greater VSD implementation

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

All aspects of this model are designed to be cautious and conservative[38], 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 ten 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 ten countries is for 2010. This data has therefore 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% of industrial electricity is used to drive electric motors. However, in the countries studied, between 10% and 20% of industrial motors are controlled through a VSD. Therefore, industrial energy consumption has to 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% of industrial processes would benefit from variable speed drives, and that the proportion could well be nearer 70%. The lower of these figures has been used in the Siemens model.

Industrial Electricity Consumption

X

Industrial Electricity Pricing

X

Motors' consumption %

Reduced by

Penetration of motors controlled by a VSD

X

Applications which benefit from VSD control

X

Energy-efficiency gain from VSD implementation

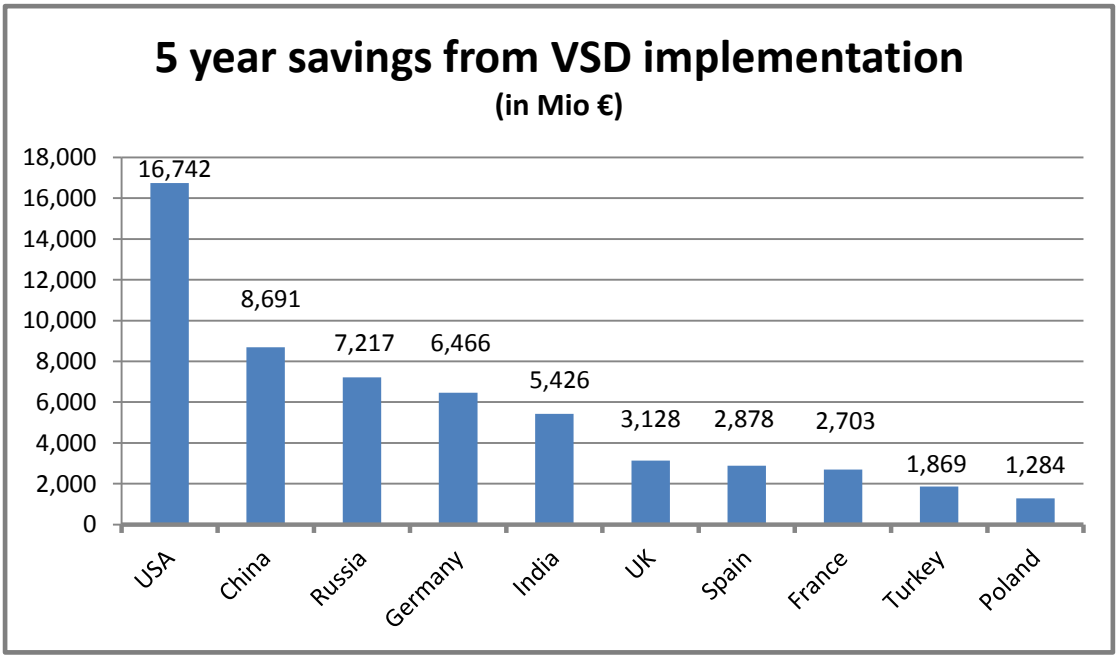
=

Industrial electricity overspend

Finally, what energy-efficiency gains do VSDs typically enable (and therefore how much can electricity consumption/cost be reduced?). Most sources cite a range between 20% and 70%,

[38] 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. 20-30% 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.

depending on the application. In order to make sure the Siemens' model generates, if anything, a conservative estimate, a low average savings level of 25% was used.
When this highly conservative model[39] is applied to industrial electricity consumption in the ten countries studied – USA, UK, France, Germany, Spain, Poland, Turkey, Russia, India and China – the following figures are revealed.



This, then, 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 VSDs on all appropriate industrial processes.

[39] 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 variable speed drives in industrial enterprises in ten 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 can 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, that not only saves on energy costs but also is often more productive than the equipment it replaces, and is 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.

APPENDIX A

Sources for Siemens model – electricity cost savings in industry resulting from full implementation of Variable Speed Drives

Industrial energy cost & consumption

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- Inverter China, Blog
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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 which present great cost savings potential in industry.

Industrial lubrication and water cooling systems

Lubrication oil is a by-product in the distillation of petroleum to produce petrol. It is a transparent, colourless 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 re-use this oil means that industry has to rely on imports of more expensive crude oil.[40]
Every year, the EU uses 4.7 million tonnes of oil lubricants. Almost 1 million tonnes of oil are currently used for conventional cooling and lubrication of machining processes in the machining industry in Germany alone.[41] 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 tonnes of used oil - compared to ten tonnes of crude oil - to produce one tonne 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 life-cycle perspective, waste oil recycling is far superior to combustion.[42]

Globally, about 69% of the finished lubricant demand is converted into used oil. Of the total used oil collected, 78% is consumed as industrial fuel and 16% 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% is collected. The remaining 26% is combusted, reused without appropriate treatment, or simply discarded.[43]
The criticality of oil in industry is matched by that of water. 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.[44] Considerable savings can therefore be made in this department, since the quantities of water used in industrial applications are vast. Probably every

[40] European Commission, *Life and Waste Recycling: Innovative waste management options in Europe*, 2007
[41] Machinery Lubrication, *Sustainable Production Using Minimal Quantity Lubrication*
[42] European Commission, *Life and Waste Recycling: Innovative waste management options in Europe*, 2007
[43] Kline Press Release, 21 September 2010
[44] US Environmental Protection Agency, Climate Protection Partnerships Division and Municipal Support Division, March 2008

manufactured product uses water during some part of the production process;[45] in the US, nearly 5% of all water withdrawn is used for industrial processes.[46] According to the Dow Chemical Company, China's water demand in 2030 is expected to reach 818 billion m3, 32% of which will comprise industrial demand driven by thermal power generation. However, Chinese industry is extremely inefficient in water use, recycling only 25% of its water compared with an average of 85% in developing countries.[47]

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.[48] 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.

[45] US Geological Survey, *Industrial Water Use*, March 2012
[46] US Environmental Protection Agency, Climate Protection Partnerships Division and Municipal Support Division, March 2008
[47] The Dow Chemical Company, *China's thirst for water*, April 2011
[48] US Environmental Protection Agency

APPENDIX C
Industrial Landscape Summaries

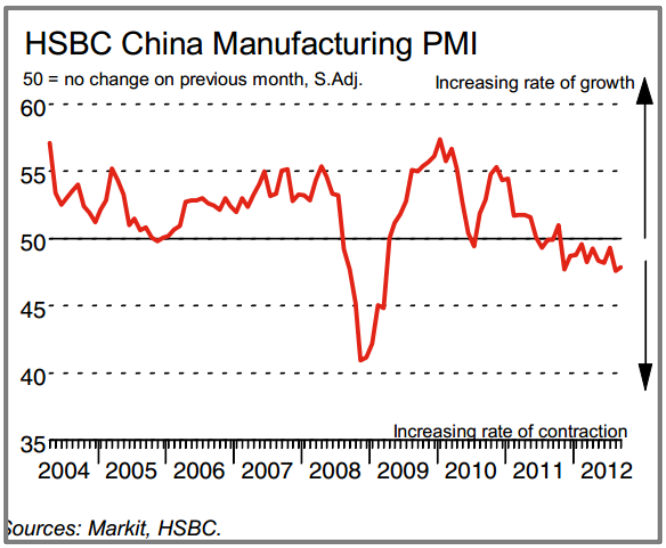
CHINA:

Overview

- Industry's contribution to GDP: 46.8% (CIA Factbook)
- Industry's contribution to the labour force: 28.7% (CIA Factbook)
- Primary industries: mining and ore processing, iron, steel, aluminium, and other metals, coal; machine building; armaments; textiles and apparel; petroleum; cement; chemicals; fertilizers; consumer products, including footwear, toys, and electronics; food processing; transportation equipment, including automobiles, rail cars and locomotives, ships, and aircraft; telecommunications equipment, commercial space launch vehicles, satellites (CIA Factbook)
- Industrial production growth rate: 13.9% (in 2011 – CIA Factbook)
- Value of exports: $1.898 trillion (2011 – CIA)
- Country comparison: in 2010 China became the world's largest exporter (CIA Factbook)
- Primary exports: electrical and other machinery, including data processing equipment, apparel, textiles, iron and steel, optical and medical equipment (CIA Factbook)
- Primary export partners: US 17.7%, Hong Kong 14.1%, Japan 7.8%, South Korea 4.4%, Germany 4% (2009 - CIA)
- As of 2010, China is the world leader in gross value of industrial output, exceeding that of the US (CIA Factbook)

Trends (Markit)

- Manufacturing PMI in September signalled a stronger decline, as the volume of new orders fell for the eleventh consecutive month. New export orders declined at the sharpest rate in 42 months amid reports of weak international demand. The rate of reduction in manufacturing output in China accelerated during September, signalling the strongest contraction since March.
- The rate of reduction in new export orders remained stronger than the decline in overall new orders. Panellists commented on tough trading conditions in a number of key trading markets.
- Staff numbers decreased for the seventh month in a row. However, the rate of job shedding was relatively modest in September asa majority of goods producers (nearly 85%) indicated no change in employment levels.
- Purchasing activity fell in China's manufacturing sector for a fifth successive month during September.
- Input costs faced by manufacturers fell in September for the fifth month running due to lower prices for a variety of raw materials.



GERMANY:

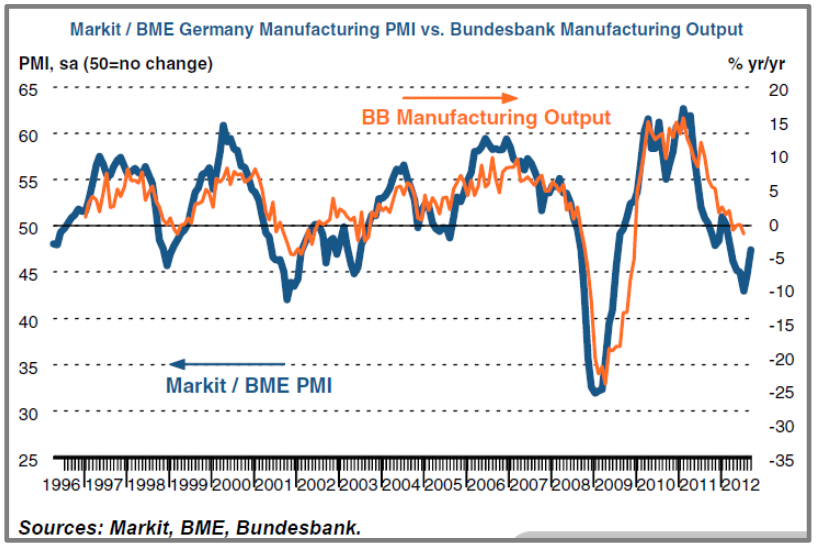
Overview

- Industry's contribution to GDP: 28.6% (CIA Factbook)
- Industry's contribution to the labour force: 24.6% (CIA)
- Primary industries: among the world's largest and most technologically advanced producers of iron, steel, coal, cement, chemicals, machinery, vehicles, machine tools, electronics, food and beverages, shipbuilding, textiles (CIA)
- Industrial production growth rate: 8% (in 2011 - CIA)
- Value of exports: $1.408 trillion (2011- CIA)
- Country comparison: 4th largest exporter in the world (down from 2nd in 2008 – CIA)
- Primary exports: motor vehicles, machinery, chemicals, computer and electronic products, electrical equipment, pharmaceuticals, metals, transport equipment, foodstuffs, textiles, rubber and plastic products (CIA)
- Primary export partners: France 9.4%, US 6.8%, Netherlands 6.6%, UK 6.2%, Italy 6.2%, China 5.7%, Austria 5.5%, Belgium 4.7%, Switzerland 4.4% (2009- CIA)
- Germany's central bank projects that GDP will grow 0.6% in 2012, a reflection of the worsening euro-zone financial crisis and the financial burden it places on Germany as well as falling demand for German exports (CIA Factbook)

Trends (Markit)

- Germany's Manufacturing PMI September data showed a significantly low deterioration in overall operating conditions and the biggest one-month manufacturing gain of the "big four" euro area nations.
- The decline in production volume was only modest, and output was supported by the completion of outstanding work in September, as well as a slower drop in incoming new business.
- Export work continued to fall sharply in September.
- Consumer goods companies have a better intake of new business compared to intermediate and investment goods companies.
- German manufacturers remained cautious in their purchasing activities and inventory levels.

Germany Manufacturing PMI:



FRANCE:

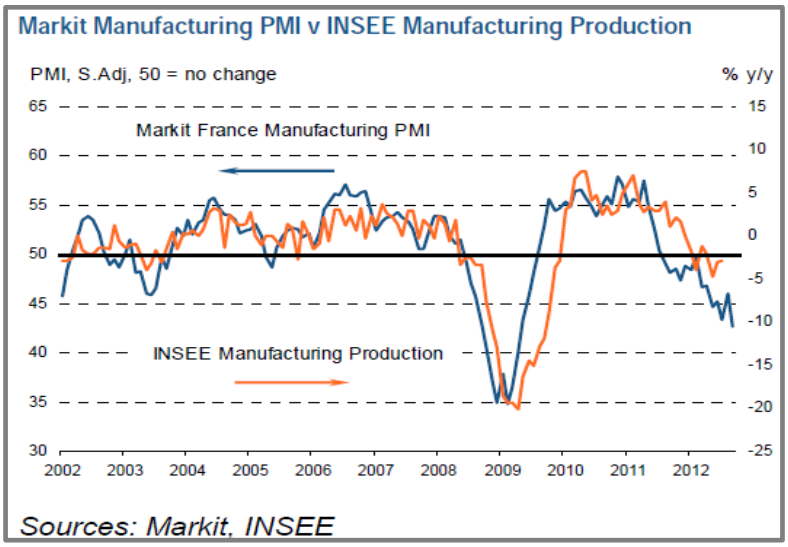
Overview

- Industry's contribution to GDP: 18.8% (2011 – CIA Factbook)
- Industry's contribution to the labour force: 24.3% (CIA Factbook)
- Primary industries: machinery, chemicals, automobiles, metallurgy, aircraft, electronics; textiles, food processing; tourism (CIA)
- Industrial production growth rate: 2.4% (in 2011 – CIA)
- Value of exports: $578.4 billion (2011- CIA)
- Country comparison: 6th largest exporter in the world (CIA)
- Primary exports: machinery and transportation equipment, aircraft, plastics, chemicals, pharmaceutical products, iron and steel, beverages
- Primary export partners: Germany 16.4%, Italy 8.2%, Belgium 7.7%, Spain 7.6%, UK 6.8%, US 5.1%, Netherlands 4.2% (2009)

Trends (Markit)

- Manufacturing PMI drops to 41-month low in September as output and new orders fall sharply
- Business conditions in the French manufacturing sector continued to decline indicating a substantial deterioration in operating conditions.
- PMI data signalled the weakest quarterly output performance since Q1 2009.
- Volumes of new orders fell at a three-and-a-half-years record. Domestic demand, in particular, went down.
- Employment decreased for the seventh successive month.
- Stocks of finished and purchased items declined.

France Manufacturing PMI:



UK:

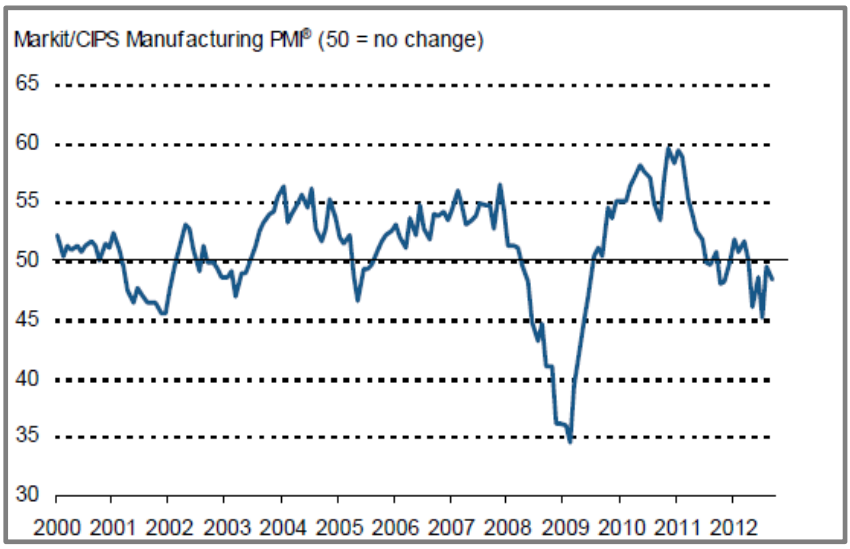
Overview

- Industry's contribution to GDP: 21.4% (CIA Factbook)
- Industry's contribution to the labour force: 18.2%
- Primary industries: machine tools, electric power equipment, automation equipment, railroad equipment, shipbuilding, aircraft, motor vehicles and parts, electronics and communications equipment, metals, chemicals, coal, petroleum, paper and paper products, food processing, textiles, clothing, other consumer goods
- Industrial production growth rate: -1.2% (2011 – CIA)
- Value of exports $495.4 billion (2011 – CIA)
- Country comparison: 11th largest exporter in the world
- Primary exports: manufactured goods, fuels, chemicals; food, beverages, tobacco
- Primary export partners: US 11.4%, Germany 11.2%, Netherlands 8.5%, France 7.7%, Ireland 6.8%, Belgium 5.4% (2009)

Trends (Markit)

- Manufacturing production declined for the third successive month.
- Order inflows were low, but increased at a marginal growth rate at the second successive month.
- Inflows of new export orders continued to decline. Reportedly, demand from Asia and the EU has decreased, but companies saw new work from the US and the Middle East.
- Cost pressures surged amid higher oil, food, and commodity prices.
- Tough market conditions resulted in an increase of job losses in the manufacturing sector.
- Charge inflation reached its lowest point for eight months as pricing power was restricted by economic circumstances.

UK manufacturing PMI:



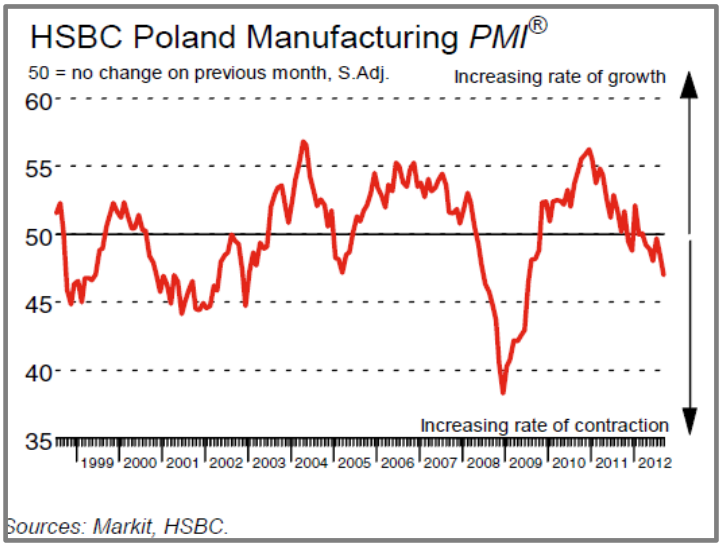
POLAND:

Overview

- Industry's contribution to GDP: 33.6% (2011 – CIA Factbook)
- Industry's contribution to the labour force: 29.2%
- Primary industries: machine building, iron and steel, coal mining, chemicals, shipbuilding, food processing, glass, beverages, textiles (CIA)
- Industrial production growth rate: 6.9% (2011 – CIA)
- Value of exports: $197.1 billion (2011 - CIA)
- Country comparison: 29th largest exporter in the world (CIA)
- Primary exports: machinery and transport equipment 37.8%, intermediate manufactured goods 23.7%, miscellaneous manufactured goods 17.1%, food and live animals 7.6% (CIA)
- Primary export partners: Germany 26.9%, France 7.1%, UK 6.4%, Italy 6.3%, Czech Republic 6.2%, Netherlands 4.3%, Russia 4.1% (2009)
- Poland is the only country in the European Union to avoid a recession through the 2008-09 economic downturn (CIA Factbook)

Trends (Markit)

- Data indicated an intensification of the downturn in the Polish manufacturing sector in September – the worst overall performance of the goods-producing sector in Poland since July 2009.
- The current downturn in business conditions now stretches to six months.
- Goods production has declined at the fastest rate since 2009, Output has fallen steadily since May.
- The volume of new work has declined every months since February. New export business declined for the sixth successive month.
- Employment declined for the first time since March, and at the sharpest rate of the year so far.
- The rate of inflation was only modest, as the strong zloty helped to restrict import prices.



TURKEY:

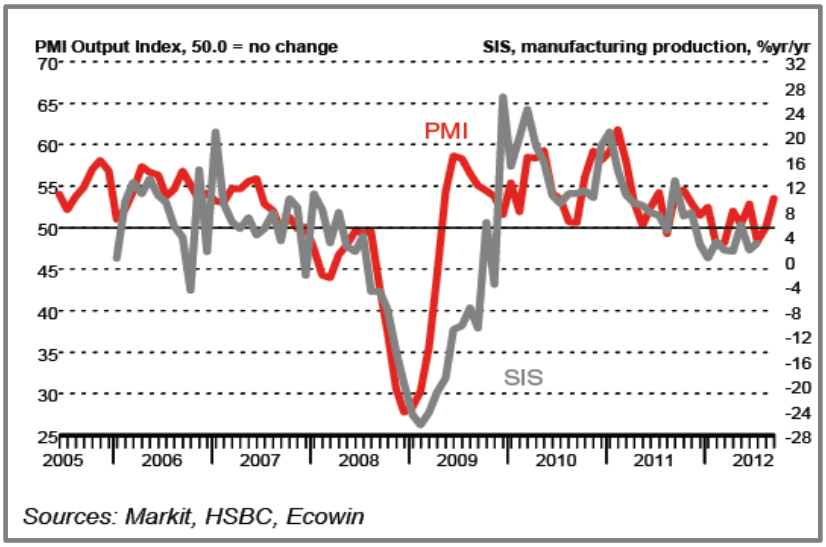
Overview

- Industry's contribution to GDP: 28.1% (CIA Factbook)
- Industry's contribution to the labour force: 26.2%
- Primary industries: textiles, food processing, autos, electronics, mining (coal, chromate, copper, boron), steel, petroleum, construction, lumber, paper
- Industrial production growth rate: 9.2% (2011 – CIA)
- Value of exports: $133 billion (2011 – CIA)
- Country comparison: 33rd largest exporter in the world
- Primary exports: apparel, foodstuffs, textiles, metal manufactures, transport equipment
- Primary export partners: Germany 10.1%, UK 6.4%, Italy 5.7%, France 5.3%, Iraq 5.3%, Russia 4.1% (2009 – CIA)

Trends (Markit)

- Turkey's manufacturing sector growth in September signalled a positive development of business conditions since June.
- New orders increased marginally during September after falling over the summer on account of rising client demand and an expansion of new export orders.
- The rate of growth in production was solid and the fastest for almost a year.
- Input cost inflation accelerated again due to unfavourable exchange rate fluctuations and higher oil and material costs.
- Increased production requirements led to a steep rise in purchasing activity.
- Post-production inventories also increased as output growth outpaced that of new orders.

Turkey Manufacturing PMI:



SPAIN:

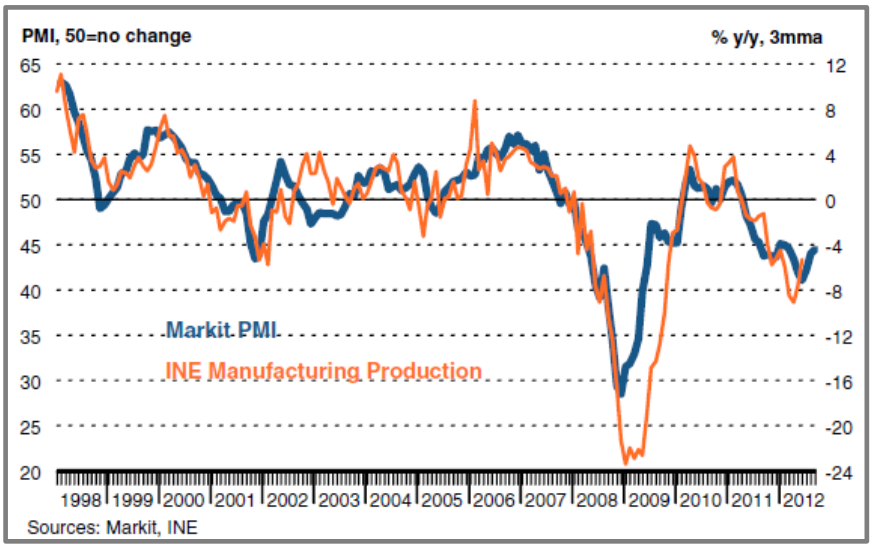
Overview

- Industry's contribution to GDP: 25.8% (CIA Factbook)
- Industry's contribution to the labour force: 24%
- Primary industries: textiles and apparel (including footwear), food and beverages, metals and metal manufactures, chemicals, shipbuilding, automobiles, machine tools, tourism, clay and refractory products, footwear, pharmaceuticals, medical equipment
- Industrial production growth rate: -1.4% (2011 – CIA)
- Value of exports: $330.6 billion (2011 – CIA)
- Country comparison: 18th largest exporter in the world (CIA)
- Primary exports: machinery, motor vehicles, foodstuffs, pharmaceuticals, medicines, other consumer goods
- Primary export partners: France 18.7%, Germany 10.7%, Portugal 9.1%, Italy 9%, UK 6.3% (2009- CIA)

Trends (Markit)

- The Spanish PMI in September marked the seventeenth successive monthly fall in manufacturing output.
- However, the rate of decline in production slowed to the weakest in six months.
- The rate of input cost inflation accelerated sharply over the month amid rising raw material prices.
- Weak client demand amid the on-going Spanish economic crisis resulted in a further reduction in new business.
- The reduction of new exports orders was seen as marginal and linked to falling demands in Europe.
- Falling demand has also led to lowered inventories of purchases and finished goods.
- Re-emergence of cost inflation over the past two months has piled further pressure on profit margins at firms as they are unable to pass on higher costs burdens to clients given the weakness of demand.

Spain Manufacturing PMI:



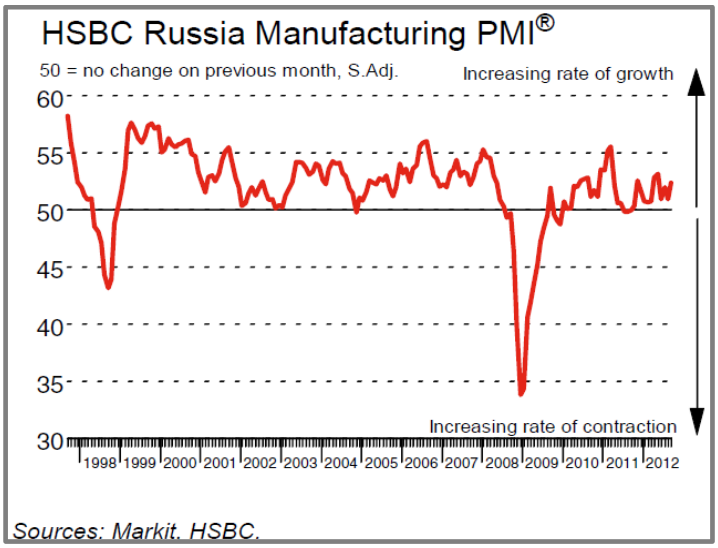
RUSSIA:

Overview

- Industry's contribution to GDP: 36.9% (CIA Factbook)
- Industry's contribution to the labour force: 27.5%
- Primary industries: complete range of mining and extractive industries producing coal, oil, gas, chemicals, and metals; all forms of machine building from rolling mills to high-performance aircraft and space vehicles; defense industries including radar, missile production, and advanced electronic components, shipbuilding; road and rail transportation equipment; communications equipment; agricultural machinery, tractors, and construction equipment; electric power generating and transmitting equipment; medical and scientific instruments; consumer durables, textiles, foodstuffs, handicrafts
- Industrial production growth rate: 4.7% (2011 – CIA Factbook)
- Value of exports: $498.6 billion (2011 – CIA)
- Country comparison: 10th largest exporter in the world
- Primary exports: petroleum and petroleum products, natural gas, metals, wood and wood products, chemicals, and a wide variety of civilian and military manufactures
- Primary export partners: Germany 8.2%, Netherlands 6%, US 5.6%, China 5.4%, Turkey 4.6% (2009 - CIA)

Trends (Markit)

- The Russian manufacturing sector improved to the best overall performance since May.
- Growth rates for output, new orders and employment all accelerated. New export business stabilised.
- The rate of good production expansion was the fastest since April.
- New orders have continuously been rising for a year.
- Employment in the sector rose in September. Workforce numbers have expanded eight times in the past eleven months.
- Firms also increased the volume of purchasing activity, but the level of inputs held in stock continued to fall.



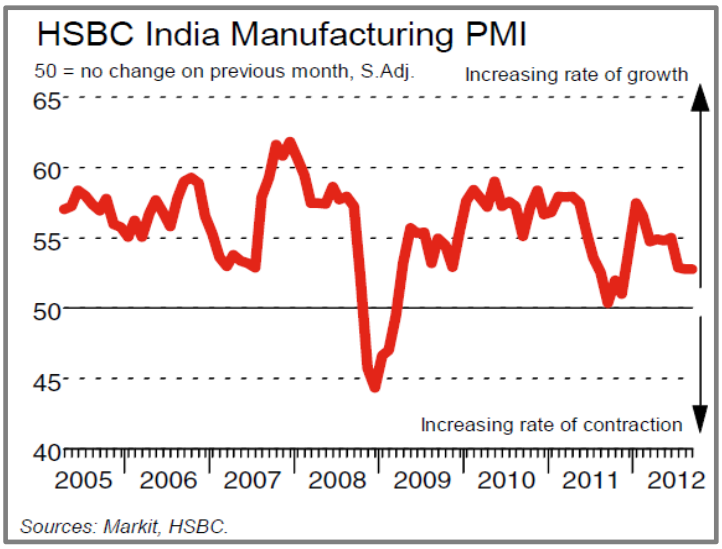
INDIA:

Overview

- Industry's contribution to GDP: 26.4% (CIA Factbook)
- Industry's contribution to the labour force: 14%
- Primary industries: textiles, chemicals, food processing, steel, transportation equipment, cement, mining, petroleum, machinery, software, pharmaceuticals
- Industrial production growth rate: 4.8% (2011 – CIA)
- Value of exports: $298.2 billion (2011 – CIA)
- Country comparison: 21st largest exporter in the world
- Primary exports: petroleum products, precious stones, machinery, iron and steel, chemicals, vehicles, apparelPrimary export partners: US 12.6%, UAE 12.2%, China 8.1%, Hong Kong 4.1% (2009 - CIA)

Trends (Markit)

- Economic activity in the manufacturing sector held steady supported by faster output growth and rising export orders.
- New orders increased for the forty-second successive month. However, new export orders have only this month picked up after three months of decline.
- Manufacturing companies in India signalled an increase in purchasing activity. Consequently, pre-production inventories were accumulated, as have stocks of finished goods.
- Input prices rose again as has been the case since April 2009.
- The rate of inflation was steep and the fastest in three months. Increased prices for raw material and diesel were cited as reasons behind purchase cost inflation.
- Job creation experienced a growth for seven successive months.



US:

Overview

- Industry's contribution to GDP: 19.2% (CIA Factbook)
- Industry's contribution to the labour force: 20.3% (CIA Factbook)
- Primary industries: petroleum, steel, motor vehicles, aerospace, telecommunications, chemicals, electronics, food processing, consumer goods, lumber, mining
- Industrial production growth rate: 4.1% (2011- CIA)
- Value of exports: $1.511 trillion (2011 – CIA)
- Country comparison: 3rd largest exporter in the world
- Primary exports: agricultural products (soybeans, fruit, corn) 9.2%, industrial supplies (organic chemicals) 26.8%, capital goods (transistors, aircraft, motor vehicle parts, computers, telecommunications equipment) 49.0%, consumer goods (automobiles, medicines) 15.0%
- Primary export partners: Canada 19.4%, Mexico 12.8%, China 7.2%, Japan 4.7% (2009 - CIA)
- The USA has the second largest industrial output in the world, behind China

Trends (Markit)

- The US Manufacturing PMI fell to its lowest level for three years in September. Although manufacturing production increased further in September, the rate of growth was only marginal and the weakest since September 2009.
- There was a slight rise in output and new orders grew at the fastest pace for three months in September – nonetheless the expansion rate was weaker than the post-recovery average.
- The increase in total new work intakes was mainly due to greater demand from the domestic market as new export orders fell at the sharpest rate for 11 months..
- Stocks of finished goods were broadly unchanged.
- Reflective of the weaker expansion in output, the quantity of purchases bought by monitored companies rose only marginally in September.
- Employment in the manufacturing sector increased for the 32nd month. Yet, the increase was only marginal and at a 21-month low.