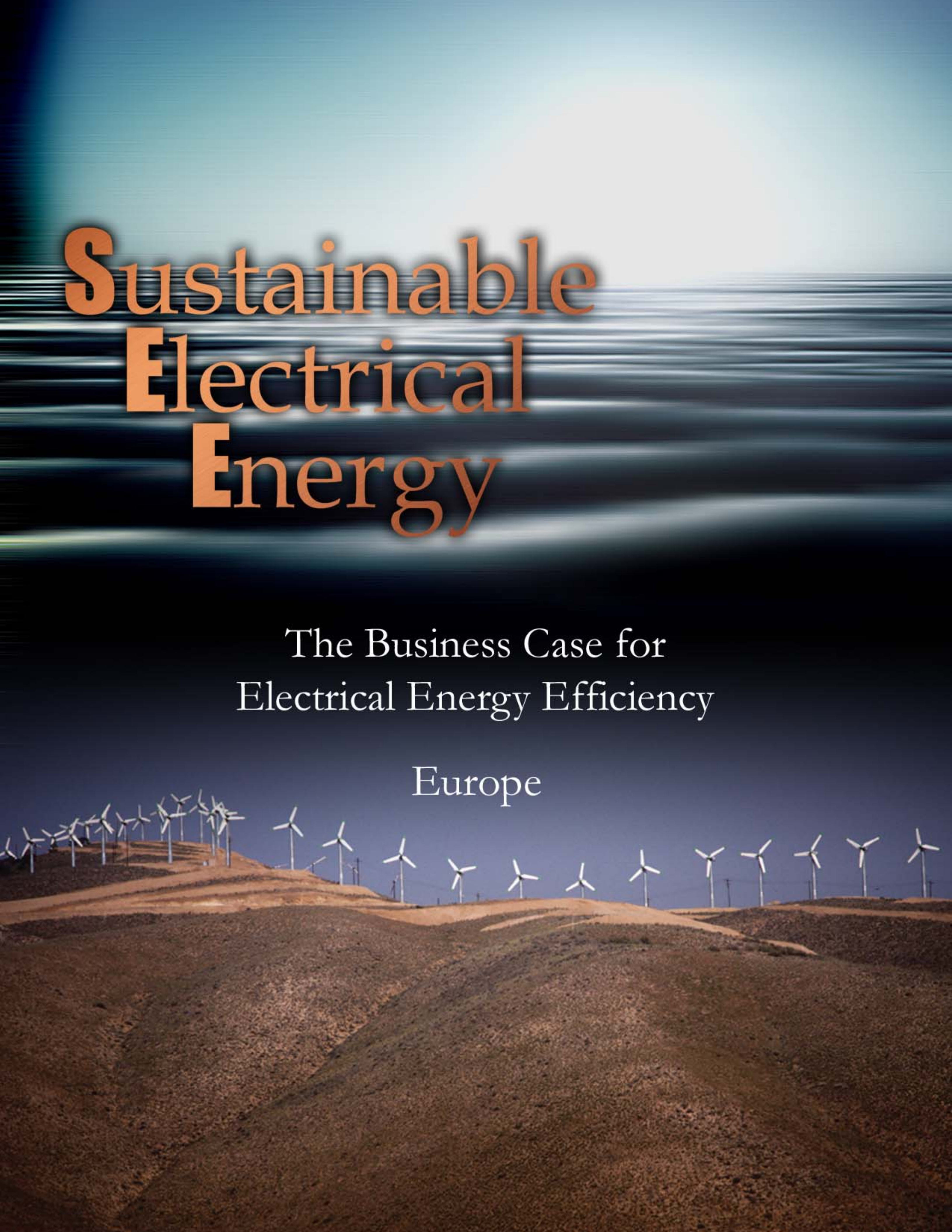


Sustainable Electrical Energy

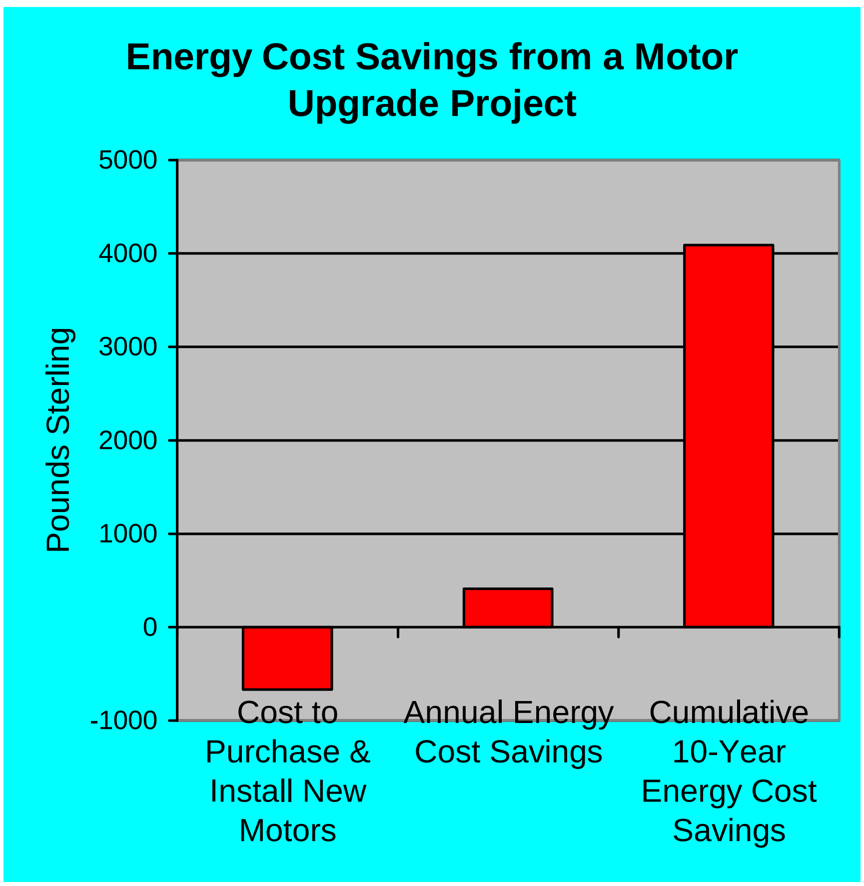
The Business Case for Electrical Energy Efficiency

Europe

The Case for Electrical Energy Efficiency in the European Union

Executive Summary

There is a strong, profit-based business case for investing in more energy-efficient products and designs. Energy efficiency, however, often is viewed as something that businesses and individuals "should" do to as good citizens. The reality is that using energy ***inefficiently*** is like walking past money on the ground - - - money that could be put to far better use than paying electricity bills. Investing in energy efficiency creates economic value.



Source: *Energy Efficient Motor Driven Systems*, European Copper Institute, April 2004 http://www.cda.org.uk/megab2/elecapps/casestud/index.htm

For example, investing in industrial motor systems upgrades could save more than 7 percent of all the electricity used in the EU through projects that pay for themselves in three years or less, with all of the energy savings beyond the breakeven point representing pure profit. The resulting energy savings would help protect the environment, human health and; increase the profitability, competitiveness and growth of energy-intensive industries; create jobs; and benefit the wider economy.

If the business case for energy efficiency is so strong, one would expect market forces to ensure that companies and households operate at optimal levels of energy use. But the market is imperfect. Purchasing decisions are often made on the basis of first cost (the up front price of an appliance or piece of equipment) rather than lifetime operating and maintenance costs. Consumers and corporate purchasing departments may lack information to make wise energy decisions, and company managers may be focused on other priorities.

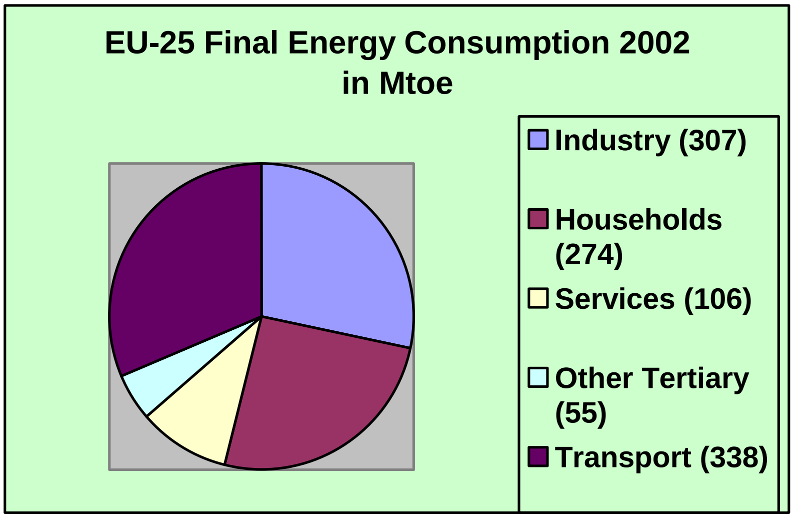
These and other barriers can be corrected or compensated for with the right mix of public policies and programmes. This paper presents an array of proven policies that are available for governments interested in promoting the development and adoption of energy-efficient technologies. The policy options range from standards and codes to labels, voluntary programs, informational campaigns and financial support programs. A carefully crafted suite of policies, phased and targeted to overcome the particular hurdles that each technology faces at different stages, can help promote energy efficiency and improve both the economy and the environment.

Report prepared by ICF Consulting for the International Copper Association, Ltd.
9 November 2005

1 Introduction

Electrical energy efficiency offers valuable benefits for the environment, the economy, individual businesses and households. This paper describes those benefits, and suggests policies and technologies that could be used to help capture them as the EU moves towards more economically optimal levels of electricity consumption.

The International Copper Association sponsored this paper in recognition of the important role that copper plays in improving energy efficiency and thus promoting economic and environmental sustainability more broadly.[1] While the paper discusses the role of copper, a variety of other contributors to energy efficiency are also considered.



Source: European Union Energy & Transport in Figures, European Commission DG TREN, 2004. (Note: to convert Mtoe (millions of tonnes of oil equivalent) to TWh multiply by 11.6)

2 What Are The Benefits of Electrical Energy Efficiency?

2.1 Energy efficiency can improve the environment and human health

Improved electrical energy efficiency reduces the risk of damage to the environment and human health from the burning of fossil fuels to produce electricity. The combustion of fossil fuels creates carbon dioxide (CO_2), oxides of nitrogen (NO_x) and particulate matter (PM). When fuels contain sulphur, burning them leads to emissions of sulphur dioxide (SO_2).

The energy producing sector is a major source of these pollutants, and electricity generation accounts for the majority of the sector's emissions. The production of energy accounts for 37% of the EU-25s' CO_2 emissions, 21% of the NO_x, and 65% of the SO_2.

[1] Appendix B describes how copper makes products more energy-efficient.

In 2002, energy production in the EU-25 released 1.46 billion tonnes of CO_2, 5.8 million tonnes of SO_2 and 2.3 million tonnes of NO_x into the atmosphere.[2]
The adverse impact on the environment and health from these emissions are described briefly below.

2.2 Carbon dioxide

The major goal of energy efficiency policies in the EU is achieving reductions in emissions of climate change ("greenhouse") gases, most notably carbon dioxide (CO_2), which is released whenever a hydrocarbon-based fuel (a "fossil fuel") is burnt. In other words, reducing fossil fuel consumption will reduce CO_2 emissions.
CO_2 concentrations in the air are now almost a third again as high as they were 200 years ago. Like other greenhouse gases, CO_2 traps heat that would otherwise radiate out to space. Many scientists are concerned that the rise in concentrations of CO_2 and other greenhouse gases may affect climate globally. The Earth's average temperature has risen by almost 1°C over the past century, and the United Nations Intergovernmental Panel on Climate Change has concluded that most of the warming observed over the last 50 years is attributable to human activities.[3] Current evidence suggests that unchecked increases in greenhouse gas emissions could lead to further warming of several degrees in this century.[4,5] Over the long term, a warmer climate may lead to rising sea levels, increases in the frequency and severity of extreme weather events, risks to human health, and a range of adverse ecological impacts.
Under the Kyoto Protocol, the EU-15 Member States have to reduce emissions of a basket of 6 greenhouse gases (of which by far the most significant is CO_2) by 8% in 2008-2012 compared with levels in 1990. This equates to a reduction of **336 million tonnes of CO_2 equivalent**. The 10 New Entrant Member States have individual reduction targets of between 6 and 8%. Progress is variable – some Member States have made significant reductions already (e.g. UK) whilst others have much work to do (e.g. Spain). Without concerted effort by all the EU-25 countries the 2008-2012 target may not be met.

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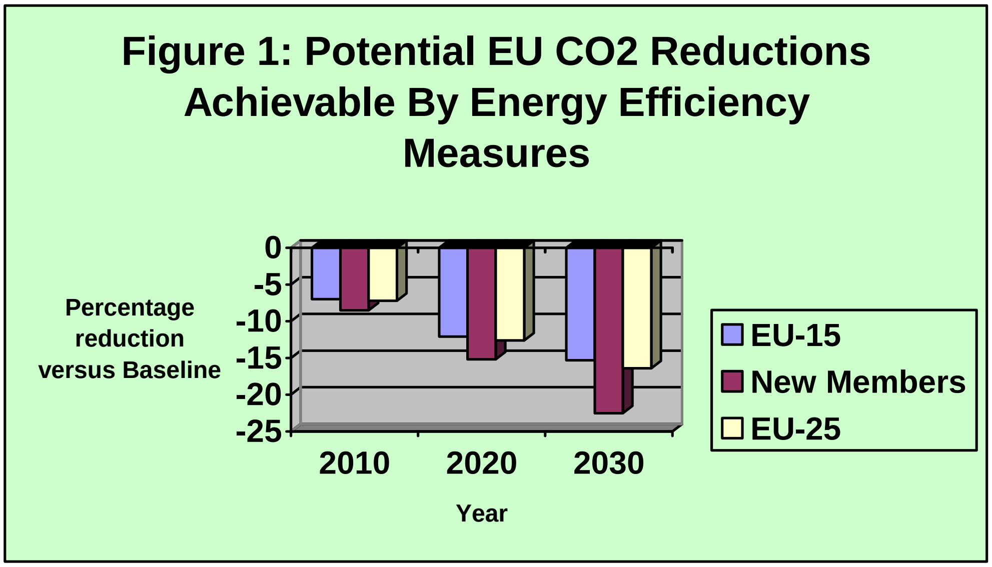
[2] Eurostat Statistical Service Hhttp://europa.eu.int/comm/eurostatH

[3] *Climate Change 2001: Synthesis Report, Summary for Policy Makers*, Intergovernmental Panel on Climate Change (IPCC)'s Third Assessment, Hhttp://www.ipcc.ch/pub/un/syreng/spm.pdfH, September 2001

[4] *Climate Change 2001* (IPCC) concludes that the globe's average temperature is expected to increase by 1.4 to 5.8 degrees Celsius by the year 2100.

[5] "Global Warning: Bulletins from a Warmer World," *National Geographic*, September 2004. http://magma.nationalgeographic.com/ngm/0409/feature1/index.html



Source: European Energy and Transport Scenarios on Key Drivers, DG TREN, September 2004

In 2000, the European Commission published an Action Plan for Energy Efficiency in which it estimated that reductions of over **18%** of EU-15 energy consumption could be made cost effectively. [6] More recently, the Commission's 2004 paper on Key Energy Drivers estimated that if specific energy efficiency policies along the lines of those suggested in the Action Plan were implemented, then CO_2 emissions for the EU-25 would be reduced from a business-as-usual projection by **7.2% in 2010**, **12.6% in 2020** and **16.4% in 2030**.[7] Similarly, a paper produced for the EU Motor Challenge Programme has calculated that a switch to energy efficient motor-driven systems would reduce EU-15 CO_2 emissions by **79 Mt CO_2 equivalent**, about a quarter of the Kyoto requirement. For the EU-25, this reduction potential is **100 Mt**.[8]

2.3 Regulated Pollutants

The combustion of fossil fuels to produce electricity in power plants results in, amongst other things, emissions of SO_2, NO_x and particulate matter (PM), and increases the creation of ground-level ozone. The EU sets permissible levels of these pollutants in the atmosphere through various Directives and national regulations which are based on the adverse health effects and/or potential to cause acidification and eutrophication of ecosystems.

Health effects are primarily respiratory in nature, such as the exacerbation of asthma and bronchitis. The World Health Organisation (WHO) has set guidelines for levels of certain pollutants in the atmosphere and the EU targets have been based on these. Studies have shown that these effects may be serious enough in some cases to lead to hospitalization or

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[6] Action Plan to Improve Energy Efficiency in the European Community, COM(2000) 247 final, 26 April 2000

[7] *European Energy and Transport Scenarios on Key Drivers*, European Commission (DG TREN), September 2004, p88

[8] *Energy Efficient Motor Driven Systems*, European Copper Institute, April 2004

even death. Children are especially vulnerable to air pollutants, in part because they breathe more air relative to their body size than adults do. A study in 2004 looked at the health benefits of the policies restricting pollutant emissions in the electricity supply industry in the UK. These were estimated to be the avoidance of 3725 deaths brought forward and 3047 respiratory hospital emissions annually in the UK alone.[9]

Acidification effects result from sulphate and nitrate droplets and particles formed in the atmosphere from SO_2 and NO_x emissions which lead to reduced visibility in scenic areas and cause acidic deposition ("acid rain"), which eats into paint and stone, damages foliage and stunts plant growth, and can harm some species of fish.

Eutrophication results from the deposition of nitrogen from the atmosphere on land or water, changing the balance of nitrogen required for plant growth. For example, excess nitrogen in lakes can promote algal growth, depleting oxygen from the water and reducing its ability to sustain other forms of life.

2.4 Economic benefits

Investing in electrical energy efficiency is a **low-risk, high-payback strategy** to promote economic growth and competitiveness. The inefficient use of energy acts like a tax on the economy, creating drag on business profits and household savings. The value of electrical energy consumed in the EU 15 alone in 2001 amounted to €181 billion[10] Even a small percentage improvement in energy efficiency nationwide could thus free substantial amounts of money for more productive purposes. Increasing energy efficiency can also improve cash flow, increase asset value, and decrease maintenance expenses.

Enhancing energy efficiency typically (though not always) requires an investment in improved equipment, but the savings in electricity costs can quickly pay for both the initial investment and the costs of tying up the capital (or borrowing it) for a few years. Beyond that point, net savings will continue to flow.

> *Energy Efficiency in Action:* Energy Efficiency Upgrades Make Business Sense
>
> Stadtwerke Strausberg runs the district heating scheme in Strausberg, 30 km east of Berlin. Its 86-MW power plant produces 190,000 MWh of heating energy for most official buildings and 50 percent of households. The company upgraded its flow control system from throttling valves to variable speed drives.
>
> The annual pumping energy consumption reduced from about 550 MWh to 230 MWh. The payback period of the variable-speed control system was 12 months. (Data courtesy of ABB)

For consumers, these savings may lead to increased financial security, reduced debt, and/or more money available for other purposes. For businesses the effects are even more dynamic, as higher profits can build on themselves. Higher margins allow for lower prices and/or increased investments in plant, equipment, and marketing, all of which promote sales growth. More rapid growth, in combination with higher profits, will tend to increase shareholder value. Higher shareholder value is likely to attract greater attention

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[9] *An Evaluation of the Air Quality Strategy*, AEA Technology, December 2004 http://www.defra.gov.uk/environment/airquality/strategy/evaluation/pdf/exec-summary.pdf

[10] Statistics and Prospects for the European Electricity Sector, 1980-90, 2000-2020 (Eurprog 2003), 2003 Eurelectric

from the investment community, making it possible to raise additional capital at lower cost.

Electrical energy efficiency—viewed as an investment—compares very favorably with conventional investments, and is more cost-effective than increasing power generating capacity to meet demand. Consider the following:

- Investments in energy efficiency often carry **low risk**.
- Energy efficiency can **enhance the reliability of electric systems** by reducing peak demand;
- Energy-efficient equipment is **often better designed and hence more reliable** than the standard equipment it replaces;
- Energy efficiency improvements are typically **fast and easy to implement** compared with other energy supply options, such as building new power plants.

2.4.1 Electricity savings improve the bottom line for industries and households

Electricity savings by businesses and households are of vital importance to legislators keen to reduce greenhouse gas emissions. Taking the example of the EU 15 for 2000:

- Household electricity accounted for 27.6% of total consumption.[11]
- Industrial electricity accounted for 44.6% of total consumption.[12]

Electricity costs can have an important impact on profitability in electricity-intensive industries and in businesses with thin profit margins. In many other sectors, electricity costs do not have a large impact on the bottom line and are therefore sometimes ignored at the point of use and wastage. But even in these businesses, while the savings may be small, they provide a good return on investment, and may be associated with significant cash savings in other areas. Energy-efficient equipment is often also more efficient in general, saving industry money on raw materials and reject costs for example.

Energy Efficiency in Action: Reducing the size of a pump impeller saves energy

A manufacturer used a centrifugal pump for returning process condensate to a boiler. Operational analysis showed the pump generated too high a pressure, necessitating throttling at the pump discharge. This led to system instability and high maintenance costs as a result of cavitation.

It was decided to reduce the impeller size to remove the need to throttle the pump, which also allowed the selection of a smaller motor. The power consumption of the pump motor fell by 30%, and maintenance costs were reduced. The total investment of €3,971 resulted in annual savings of €18,070, giving a payback of 11.4 weeks.

Source: *Energy Efficient Motor Driven Systems*, European Copper Institute, April 2004

In addition, where low financial margin industries under competitive pressure are continually striving for further savings, power consumption may be an important area

[11] Statistics and Prospects for the European Electricity Sector, Eurelectric op. cit.
[12] Digest of UK Energy Statistics 2004, op cit.

where easy savings can be made. The Carbon Trust, an independent UK-based carbon management body funded by government, considers that a 20 per cent saving in energy consumption can have the same effect as a 5 per cent increase in sales.[13]

2.4.2 Electricity savings enhance economic competitiveness and security

Improving electrical energy efficiency enhances the long-run competitiveness of the economy, by reducing the cost structure of businesses and freeing up funds for re-investment. Lower production costs tend to reduce inflationary pressures, reductions in fuel imports reduce balance of payments deficits, while the increased tax revenues stemming from higher profits assist fiscal policy.[14, 15]

In addition, energy efficiency contributes to the economy through reductions in peak demand for power. To the extent that capital is not needed for investments in new generation or transmission capacity, it will be freed up to flow to other productive uses. Reducing electricity use through energy efficiency can lead to a number of indirect economic benefits as well, including economic feedbacks from environmental improvements (such as better working conditions for workers leading to lower absenteeism, higher productivity, and lower health care costs).

> *Energy Efficiency in Action:* Mining company LKAB removes unnecessary electric motors
>
> LKAB uses powerful electric motors to drive conveyor belts in its Kiruna, Sweden dressing plant. Process measurements on one conveyor showed that energy consumption was 370 kW, whilst installed capacity was 2 x 450 kW motors.
>
> One of the two motors, with its transmission, was removed, and the operation was repeated across all 8 conveyors. Reduced energy costs of €105,000 per year were achieved, together with reduced maintenance costs. The payback period was only 0.3 years.

In the past, energy consumption in Europe tended to increase in step with economic growth. This pattern has changed during the past 15 years and become more complex. Primary energy use as a function of Gross Domestic Product (GDP) in the EU-25 countries fell from 245.6 tonnes of oil equivalent (toe) per million euros (M€) in 1990 to 208.8 toe/M€ in 2002, a reduction of 15 percent.[16] The equivalent figures for the EU-15 countries were 216.4 toe/M€ in 1990 and 190.8 toe/M€ in 2002, a 12% reduction. Yet while primary energy intensity was falling, electricity consumption per unit of GDP did not change significantly. This results from both changes in industrial structures as well as the versatility of electrical power for industrial and domestic use in high technology processes and products.

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[13] http://www.thecarbontrust.co.uk/energy/pages/page_28.asp

[14] *Energy Efficiency: Key to Sustainable Energy Use* (1998) Congressional Research Service. Hhttp://www.ncseonline.org/nle/crsreports/energy/eng-16.cfm?&CFID=18420657&CFTOKEN=85058158H.

[15] Energy Efficiency: Budget, Oil Conservation, and Electricity Conservation Issues (2004). Congressional Research Service. Hhttp://www.ncseonline.org/NLE/CRSreports/04Sep/IB10020.pdfH.

[16] *EU Energy & Transport in Figures*, European Commission (DG TREN), 2004 http://www.epomm.org/downloads/facts_pb2004_complete.pdf

Energy imports must also be considered. About 33% of the coal, 51% of the gas and 77% of the petroleum consumed by the EU-25 are imported. These three fuels accounted for 54% of electricity generated in 2002, demonstrating that Europe's power supply is dependent upon imported primary fuels[17]. Consequently any action which leads to a decrease in consumption of electricity is bound to have a positive effect on the Community's trade position, and reduce its economic dependence on other countries, some of which might not be completely reliable suppliers.

2.4.3 Cost savings are demonstrated in the real world

Dozens of case studies show that investing in energy-saving technologies can provide substantial energy savings, which pay for themselves within a few years. The EU Energy Star® programme estimates that annual EU-15 residential energy consumption from office equipment alone will rise from 2 TWh in 1990 to 64 TWh in 2010. Average electricity expenditure per household for powering office equipment will approach €40/year. The potential to reduce consumption simply by purchasing products labelled as high-efficiency is as much as 50%; saving approximately €4 billion across the EU-15. The potential for the EU-25 is even greater.[18]

> *Energy Efficiency in Action:* International Exhibition Centre reduces energy use
>
> The London International Exhibition Centre (ExCeL) is the largest open exhibition space in Northern Europe, and is a venue for some of the world's most prestigious exhibitions.
>
> When it first approached the Carbon Trust in 2001 to evaluate its energy use and efficiency, its annual energy bill was £1.1 million, primarily for lighting and air conditioning. Following a site survey, the Carbon Trust identified a number of potential savings. Many of the recommendations were concerned with the understanding of energy requirements, utilising the installed equipment efficiently and making employees aware of the need to conserve energy. However, an investment of £60,000 was made, initially in the provision of a stand-alone air conditioning system for the contractors' accommodation.
>
> ExCeL has achieved a cut in its yearly fuel bill by approximately a third; a saving of £350,000 every year. It anticipates that additional actions will save a further £100,000 per year.
>
> Source: The Carbon Trust, London, UK http://www.thecarbontrust.co.uk/energy/pages/page_83.asp

2.4.4 Energy efficiency helps contribute to job creation and retention

Improving electrical energy efficiency on a large scale can create and retain jobs. The EU SAVE programme funded a major study of the impact of energy efficiency on job creation in the EU[19], which found three main positive effects:

- The manufacture and installation of energy efficient measures is relatively labour-intensive. Employment gains are estimated to be 8 to 14 person-years per €1 million spent.
- Consumers divert expenditure from energy into the more labour-intensive general consumption sector. This is estimated to be worth an additional 50 person-years per €1 million spent.

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[17] *EU Energy & Transport in Figures,* European Commission (DG TREN), 2004 http://www.epomm.org/downloads/facts_pb2004_complete.pdf
[18] *EU Energy Star Programme*, 2004 http://www.eu-energystar.org/en/
[19] *National and Local Employment Impacts of Energy Efficiency Investment Programmes,* Association for the Conservation of Energy, SAVE contract XVII/4.1031/D/97-032 2000.

- Some of the work in installing energy efficiency measures is accessible to much of the workforce (given its manual nature and wide disposition around the country) with consequent potential employment gains.

The reduced operating costs associated with energy efficiency may also help businesses maintain competitive prices, in turn helping EU job retention.

2.4.5 Energy efficiency can enhance industrial productivity

Policies to promote energy efficiency within individual businesses can boost productivity significantly. In the USA, more than 70 industrial case studies demonstrated benefits such as increased product output, shorter process cycle times, increased reliability in production, improved product quality, improved working environments, and better morale among workers. For 54 of these case studies, in which the monetary value of improved productivity and other non-energy benefits was included in the analysis, the **savings from energy efficiency investments more than doubled** (from $12.9 [€10.6] million to $28.6 [€23.5] million) and the **average payback period was cut by more than half** (from 4.2 to 1.9 years, based on mostly state-of-the-art energy efficiency upgrades with payback periods ranging from days to decades).[20]

3 Promoting Electrical Energy Efficiency

Despite ample evidence that energy efficiency, as well as benefiting the environment, actually saves money, market forces alone have been slow to lead the EU economy to reach optimal levels of energy efficiency. Energy efficiency faces a number of barriers, and to help overcome these, changes in tax policy or government purchasing would be appropriate and desirable.

Governments can use the general policy approaches described here to encourage improvements in electrical energy efficiency. Section 3 describes more specific policies that governments should use to promote particular energy-efficient technologies.

3.1 Barriers to Improving Energy Efficiency

A range of real and apparent barriers get in the way of improving energy efficiency. These include:

- A lack of information about the costs and benefits of energy-efficient products
- The tendency of consumers and commercial purchasers to base purchases on first cost (the purchase price) rather than the total cost of ownership
- Low organisational priority
- A split between the company function which decides what equipment to buy and the cost centre which owns the equipment's lifetime energy consumption
- Lack of skilled personnel able to install or maintain high efficiency equipment
- A disconnection between energy use and its environmental consequences
- Economic distortions from tax breaks and other subsidies.

[20] Worrell, E; J. Laitner; M. Ruth; H. Finman (2003). Productivity benefits of industrial energy efficiency measures. *Energy*, vol. 28, pp. 1081-1098

These barriers can operate individually or in concert and are responsible for low rates of uptake of many economically feasible energy savings activities. In fact anecdotal evidence from the EU indicates that professional and credible advice on energy saving measures with payback of less than 2 years have an average implementation rate of under 25%, notwithstanding the fact that the advice was delivered with significant supporting materials designed specifically to overcome these barriers. This illustrates how difficult it is to overcome these barriers.

3.2 Can Electricity Save Energy?

It is usually more energy efficient to burn a fuel at the point of use (e.g., in an automobile or boiler) rather than convert the fuel to electricity, transport the electricity through the grid, and then convert the electricity back to heat or work again at the point of use. However, certain electrical product applications have an inherently high efficiency compared with direct combustion of fuels – for example, electrically-propelled public transport, electric fryers, industrial electro-technologies and electric heat pumps. Improving the market penetration of these applications and increasing their electrical efficiency still further will reduce the amount of primary energy consumption.

3.3 General policy approaches for encouraging energy efficiency

3.3.1 Public Purchasing Policy

Governments and Public Administrations should promote energy efficiency and support energy-efficient technologies through their own purchasing policies and practices. Administrations are large consumers of energy and any reduction in an administration's energy use will save public money – potentially reducing the tax burden on individuals and organizations. Because government purchasing is of such a large magnitude, it can also create economies of scale for new energy-efficient technologies, and can influence private-sector manufacturing and design decisions.

The proposed EU Directive on End Use Efficiency and Services (see below) sets out clear mandatory targets for the share of energy efficient public procurement for the period 2006-2012.

A visible green purchasing policy would be a strong asset for institutions accredited under EMAS or ISO 14000 environmental management systems.

Several initiatives are underway throughout the EU to ensure that public procurement is green, for example several European Governments now have green procurement policies in places. In Germany, the "Blue Angel" eco label is a major element in public procurement decisions for IT equipment [21]. The Financial Times [22] displayed a front page headline warning suppliers that within two years all government suppliers would require accreditation to ISO 14001. While ISO 14001 relates only to continuous improvement of internal processes and environmental performance, the sister standard for

[21] Eco-Labelling and Green Procurement Schemes for IT Products: The German /European Approach, S. Thomas, http://www.iges.or.jp/en/ltp/pdf/Paper%208.pdf

[22] Financial Times Tuesday May 24th

product in-service performance, ISO18001, is likely to be adopted as part of the evolution of government procurement.

3.3.2 Tax Incentives and Rebates

Governments should support energy efficient technologies directly by subsidising investments in high-efficiency products and equipment.
Direct subsidy has been used in Denmark under the Sparemotor programme, which offered subsidies to industrial purchasers of high efficiency motors between 1996 and 1998, with almost 100,000 additional motors having been sold up to 1999.[23] Also in the UK, the Energy Saving Trust (EST) ran a series of programmes offering domestic consumers grants, funded by government and electricity suppliers, to improve household energy efficiency by installing more efficient boilers, insulation etc.[24]

3.3.3 Energy Efficiency Standards

Companies should incorporate legislative efficiency drivers into their core product strategies. A significant number of directives are being designed and entering into force to improve the efficiency of products within the EU. These controls all stem from the directive on Integrated Product Policy (IPP) which seeks to improve the life cycle environmental impacts of goods. While some policy instruments target manufacturing and end-of-life impacts, emerging elements are starting to deal with operational consumption of resources, especially energy.

3.3.3.1 Issues Related to Eco-Design

In the European Union some products are subject to requirements for minimum energy performance standards and energy labeling while others are not. The European Commission has recently adopted a Framework Directive (The Energy-using Products Directive) which intends to reduce environmental impact of electrical equipment through measures in the design phase, such as for example improving energy efficiency. Other impacts in the product life cycle, such as those in the manufacture and end of life phases, are being addressed by other directives such as WEEE (Waste Electronic and Electrical Equipment). These separate instruments will be followed by later measures which will establish specific all-encompassing eco-design requirements and which will consolidate these measures and existing laws. This unified approach will help ensure that natural turnover and new construction will result in the spread of energy-efficient technologies.

3.3.3.2 Minimum Efficiency Standards

Minimum EU efficiency standards have already been set for:

- Fluorescent Lighting: Directive 2000/55/EC on energy efficiency requirements for ballasts for fluorescent lighting.

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[23] http://www.sparemotor.dk/uk/velkommen.html

[24] A summary of the EST's current domestic grant funding programmes may be found at http://www.est.org.uk/myhome/gid/

- Household electric refrigerators and freezers: Directive 96/57/EC.
- Hot-Water Boilers: Directive 92/42/EEC on efficiency requirements for new hot-water boilers fired with liquid or gaseous fuels.

3.3.3.3 Energy Labelling

Energy labelling aims to increase consumer awareness of energy consumption in, typically, appliances, to enable an informed purchase choice to be made which takes energy usage into account. Energy labelling is already required for many domestic appliances under the following Directives:

- Electric refrigerators and freezers: Directive 2003/66/EC.
- Electric ovens: Directive 2002/40/EC.
- Air-conditioners: Directive 2002/31/EC.
- Lamps: Directive 98/11/EC.
- Dishwashers: Directive 97/17/EC.
- Washer-Driers: Directive 96/60/EC.
- Electric Tumble Driers: Directive 95/13/EC.
- Washing Machines: Directive 95/12/EC.
- General Household Appliances: Directive 92/75/EEC.

In addition to the mandatory labeling requirements described above, the EU Energy Star® programme for electrical office equipment labels the most energy efficient office equipment in both household and business sectors

As in other energy labeling systems, the EU sets standards for testing and most importantly for progressive tightening of efficiency levels over time, placing strong incentives on manufacturers to continually improve equipment energy performance.

3.3.3.4 End-Use Efficiency

In 2003 the European Commission proposed a Directive on the promotion of end-use efficiency and energy services to enhance the cost-effective and efficient end-use of energy in Member States.[25] The Commission estimated that energy consumption in the EU is approximately 20% higher than can be justified on economic grounds, and that there is a large potential for energy savings. The Directive would provide the targets, mechanisms, incentives and institutional, financial and legal frameworks to remove existing market barriers and imperfections for the efficient end use of energy.

The proposal sets out clear mandatory targets for annual energy savings at Member States' level and for the share of energy efficient public procurement for the period 2006-2012. For the same period, strong incentives are given by the Directive for Member States to ensure that suppliers of energy offer a certain level of energy services.

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[25] http://europa.eu.int/comm/energy/demand/legislation/end_use_en.htm

EU Members of the European Parliament recently voted on the draft Directive - the Parliament's Energy Committee insisted that EU Member States take on binding national targets to improve the energy efficiency of their economies by committing to a reduction in energy consumption of 11.5% by 2015 in three 3-year stages.[26]

3.3.4 Education and training

Imperfect information can be a major cause of the market's failure to invest in energy efficiency: end-users often are not aware of all the benefits of energy-efficient alternatives. **Governments should provide information and training to raise awareness, create alternatives, overcome "business as usual" procurement and operational practices, and create a culture of energy efficiency.** Several well-known examples exist in the EU, such as the energy label affixed to most household appliances and the EU Energy Star® label on electrical office equipment. There are many energy efficiency applications, however, where a simple point-of-purchase decision is not possible, such as the control system for an industrial plant. In these situations, government can provide expert advice, software, and support training and certification by professional societies and states.

3.3.5 Research and Development

EU funding for R&D is concentrated mainly in the **Framework Programmes** which are open to all public and private entities, large or small. The main focus of 6th Framework Programme is the creation of a European Research Area (ERA) as a vision for the future of research in Europe. The overall budget covering the four-year period 2003 to 2006 is €17.5 billion, representing an increase of 17% from the Fifth Framework Programme and making up 3.9% of the EU's total budget (2001), and 6% of the Union's public (civilian) research budget. There are no national quotas for FP6 funds.

Intelligent Energy - Europe (EIE) is the EU support programme for non-technological actions in the fields of energy efficiency and renewable energy sources. It entered into force in August 2003 and runs from 2003 to 2006. It is intended to support the EU's policies in the field of energy as laid down in the Green Paper on Security of Energy Supply, the White Paper on Transport and other related Community legislation (including the Directives on renewable electricity, energy performance of buildings and biofuels). Its aim is to support sustainable development in the energy context, making a balanced contribution to achieving the general objectives of security of energy supply, competitiveness, and environmental protection.

Although at the European level a significant framework and funding are in place, national governments should increase support to the private and public sectors for research and development of energy-efficient technologies.

3.3.6 Systems Benefits Charges to Support Energy Efficiency

Transforming the energy efficiency of the EU economy takes long-term commitment and sustained funding; **governments should consider organizing and funding their energy**

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[26] Hhttp://www2.europarl.eu.int/omk/sipade2?PUBREF=-//EP//TEXT%2BPRESS%2BNR-20050421-1%2B0%2BDOC%2BXML%2BV0//EN&L=EN&LEVEL=2&NAV=X&LSTDOC=N#SECTION4H, 28 April 2005

efficiency efforts for the long term. The Systems Benefit Charge (SBC) has been developed in the USA, where more than 20 states have created dedicated funding sources to support energy efficiency and renewable energy by imposing an SBC on every electricity customer's bill.[27] The funds for energy efficiency collected through these SBCs total more than $873 (€718) million annually. This dedicated, long-term revenue source gives states the ability to implement long-term market transformation programs that are changing the way professionals specify products, installers install them, and retailers stock them. If a consistent EU-wide energy efficiency investment scheme were implemented at similar levels to the United States SBC schemes, it would generate a fund of between €2.5bn and €13bn.

3.3.7 Voluntary Agreements

The European Commission welcomes industry voluntary agreements where such actions are likely to deliver policy objectives faster or more cost-effectively than mandatory requirements.[28] In the recent past, two agreements - covering stand-by losses in televisions and VCRs, and domestic refrigerators and washing machines – have been implemented successfully by industry.

3.3.8 Energy Efficiency Obligations/White Certificates

Increased take-up of energy efficiency measures can be achieved by placing obligations on energy suppliers to provide funding to promote appropriate programmes. A range of programmes have been put in place by countries including Belgium, Denmark, UK, Netherlands, Germany (Hannover), Greece, Ireland, Norway and Spain[29]. In these programmes gas and electricity suppliers are often required to achieve targets for the promotion of energy efficiency through energy savings by domestic and commercial consumers. The aims may not only be to help reduce CO_2 emissions but also to help reduce consumers' fuel bills with particular emphasis on helping the fuel-poor.

3.3.9 Emissions Trading

Emissions trading is an important policy measure to reduce environmentally harmful emissions. Industrial sectors and/or individual companies are allocated a fixed number of emissions allowances by government for a specified period for a specific pollutant – such as CO_2, or SO_2. If a particular participant's actual emissions exceed these allowances, another participant's surplus allowances may be purchased to ensure a balance of emissions and allowances. This gives participants the choice of reducing emissions in actuality (e.g. by investing in abatement equipment, or by changing operations) or by purchasing an appropriate number of allowances to match actual emissions. Because the total number of allowances is capped, emissions reductions will be made, but for global or trans-boundary air pollutants the place where these reductions are made is not

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[27] System Benefit Charges, U.S. Department of Energy, http://www.eere.energy.gov/state_energy/policy_content.cfm?policyid=64.

[28] *European Commission (DG TREN)*, 2004 http://www.europa.eu.int/comm/energy/demand/agreements/index_en.htm

[29] Energy Efficiency Programmes and Policies in the Liberalised EU Energy Markets: Good Practice and Supporting Policies, http://www.wupperinst.org/energieeffizienz/pdf/BEST_background_document.pdf

important. This measure allows emissions reductions to be made at a lower cost than if individual participants each had absolute caps.

The EU concluded that achieving Kyoto targets might cost €2.9 to €3.7 billion annually; but that without CO_2 emissions trading in place the annual cost might reach €6.8 billion.[30] Undoubtedly the effect of CO_2 emissions trading will mean an increase in electricity prices as the generators pass on their costs to consumers. This will, of course, make the return from electrical energy efficiency projects even more attractive. It may also be possible for energy consumers to share in the value of emission credits that have been "liberated" by their investments in energy efficiency. This may be accomplished by contracts between electricity generators and the end-user, or by a "set-aside" of allowances that can be claimed by end-users that implement efficiency projects.

3.3.10 Environmental Permitting

Energy efficiency techniques can be mandated in industrial applications by environmental permitting. For example, certain EU industrial activities (power generation, oil refining, papermaking, iron & steel production etc.) are regulated by the Integrated Pollution Prevention and Control system under Directive 96/61/EC, and in the UK this Directive has been implemented in the Pollution Prevention and Control Regulations 2000. Energy efficiency requirements for installations in these sectors are written into the PPC Regulations and include the requirements for provision to the regulators of energy consumption and emission data, energy management plans and information on proposed energy efficiency improvements.

4 Promoting Specific Energy-Efficient Technologies

A number of technologies show great promise for cost-effectively improving the efficiency of electricity use in the European Union. For each technology, we describe the potential benefits of improving efficiency and discuss policies to encourage technology development and dissemination.

4.1 Energy Efficient Motors

Industrial electric motor-driven systems in the EU-15 consumed 614 TWh in 2000, accounting for 24 percent of all electricity consumed.[31] These systems are used for materials processing and (to a lesser extent) for space heating, cooling, and ventilation. The systems consist of a motor to convert electricity into mechanical energy, end-use equipment such as pumps, fans, mixers or compressed air systems, a coupling or transmission to connect these components, and a control system. Each part of the system can be made more efficient, and the system as a whole can be optimized so that the parts work together with less wasted energy.

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[30] Hhttp://europa.eu.int/rapid/pressReleasesAction.do?reference=MEMO/04/44H, March 2004

[31] *European Energy and Transport Trends to 2030*, European Commission (DG TREN), January 2003

4.1.1 Technical approaches to making motors more efficient

Energy losses can be reduced by increasing the cross-sectional area of the copper wires used for the windings to reduce resistance, using better magnetic steel for the rotor, improving motor aerodynamics, and using higher-precision manufacturing to improve manufacturing tolerances. When applied together, these changes can cut energy losses substantially (e.g., raising efficiency by 2 to 8 percent compared with standard motors). These motors are known as High Efficiency Motors or HEMs.

In the near future, the incorporation of motors with cast copper rotors could reduce motor energy losses by an additional 15 to 20 percent, creating an ultra high efficiency motor or allowing the creation of lower cost and smaller frame sized motors for an equal load.[32]

Motors typically are most efficient at full or nearly-full loading. However, in many applications, the motor can be subjected to a range of loads, which results in significant periods of operation under suboptimal conditions. Variable-speed drives (VSDs) use electronic components to vary the frequency and voltage of the electricity fed to the motor, reducing the efficiency loss that typically occurs when motors are operated at suboptimal loads or low voltages. VSDs can yield impressive results: a UK brick manufacturer reduced its electricity use per brick produced by 8.7% through the use of VSDs; the project payback was 1.4 years.[33]

Additional sources of energy savings can be found in the coupling between the motor and the end-use equipment, and in proper motor sizing. Where v-belts are used, for example, the frictional losses from the flexing of the belt and the rubbing of the belt against its pulleys can be avoided by switching to a direct drive system.

4.1.2 Benefits of making motors more efficient

Since motor systems account for 65% of all industrial electricity use in the EU, they are an important area in which to cut energy use. The energy used by motor driven systems in the EU-15 countries could be cut by 29 per cent using proven technologies and practices, and choosing only improvements that could pay for themselves in three years or less.[34] Estimates for the EU-25 countries show these kinds of improvements would translate into savings of 202 million MWh per year, and would avoid 100 Mt of CO_2 emissions per year.[35]

In many cases, replacing a perfectly functioning but inefficient motor with a more efficient new one makes economic sense, as outlined in the case studies in section 1.2 above. The EU's Motor Challenge Programme (see below) can help companies reduce energy related operating expenses whilst maintaining or improving reliability and quality of service.

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[32] *Casting Copper Motor Rotors: Mold Materials and Processing for Cost-Effective Manufacturing,* Drs. Dale T. Peters and John G. Cowie, Copper Development Association Inc.; and Dr. Edwin F. Brush, Jr., Consultant to International Copper Association Ltd

[33] *The Use of Variable Speed Drives in the Ceramics Industry*, Hanson Brick Ltd, Energy Efficiency Best Practice Programme, December 2000.

[34] *Energy Efficient Motor Driven Systems*, a report for the EU Motor Challenge Programme by the European Copper Institute, April 2004. An economic savings potential of 181 million MWh annually was estimated in various EU SAVE studies carried out in 2000-2002.

[35] Energy Efficient Motor Driven Systems report, op cit.

4.1.3 Policy approaches to encourage efficient motors

4.1.3.1 Existing Policies

An agreement between the major motor manufacturers (through their European body CEMEP) and the European Commission aimed to reduce by 50% the number of low efficiency (EFF3) motors coming into the European marketplace by 2003. An additional result of this agreement was an efficiency labelling scheme for 2 and 4 pole motors of between 1.1kW and 90kW according to the IEC 60034-2 standard. Machines labeled as "EFF1" offer efficiencies some 3 or 4 percentage points higher than lower efficiency (EFF2 and EFF3) machines.

4.1.4 Future Policies and Policy Improvements

4.1.4.1 Make efficiency standards mandatory for 3-phase motors

The continued availability of low efficiency motors incorporated into equipment systems is a continued source of economic. Over time, the retirement of low efficiency motors and their replacement by EFF1 level machines would transform the EU's motor energy footprint. **The EU should immediately act on low efficiency motors as its current regulatory regime leaves it exposed in this area. The setting of MEPS should be accompanied by the immediate adoption of an accurate test methodology, to replace the currently used and inadequate IEC 60034-2 method.**

4.1.4.2 Regulate minimum efficiency of fractional horsepower motors

Fractional horsepower motors are small motors with a power rating of less than 1 horsepower. They are used widely in pumps; refrigerators; heating, ventilation, and air conditioning equipment; computers; and many other industrial and commercial applications. Despite the fact that they are more numerous than larger motors, they are not currently subject to minimum efficiency standards. These motors vary widely in their efficiency, and initial studies suggest that more efficient models can provide significant energy savings, especially in applications with high operating hours.[36] Establishing MEPS for fractional horsepower motors would result in substantial energy savings and spur innovation among motor manufacturers. **The success and benefits with the adoption of EFF standards are an example to be followed and the European Commission could analyze if developing minimum energy performance standards for fractional horsepower motors should be considered.**

4.1.4.3 Encourage accelerated replacement of old motors

There are millions of standard efficiency motors (category EFF3) still in use throughout the EU. These motors have much lower efficiencies than those of modern motors and may not even be running at their rated efficiencies due to loading, age, poor rewinding practices, or lack of maintenance. **Governments could offer tax credits, rebates, accelerated depreciation, or other incentives to encourage faster replacement of inefficient motors.**

4.2 Energy Efficient Distribution Transformers

Electrical transmission losses are reduced at high voltages. Therefore to transmit electricity efficiently, it must be "stepped up" to high voltages. After transmission, it must then be "stepped down" to lower voltages for use in factories, buildings, and homes. These voltage changes are made by transformers, which contain two coils of wire wound around a laminated core of magnetically permeable material. The last transformation step into the end-user voltage is carried out by distribution transformers.

The efficiency of transformers depends on many factors, including the materials used in the core and the conductivity of the wires. Amongst the EU-25, annual efficiency losses in distribution transformers account for an estimated 55 million MWh of the annual energy lost in the generation and delivery of electricity[37], with associated emissions of at least 20 million tonnes of CO_2.

> Transformer technology has advanced significantly in recent years, with adoption of heavy copper windings and advanced amorphous steel alloys to reduce losses. Replacing a relatively modern transformer with a new high efficiency example can reduce losses by up to 75%, while replacing a 30 year old example cuts the losses by as much as 90%.
>
> The rates of return for this type of investment vary between 11 and 70%, clearly offering significant financial gains in certain cases. For on example in Poland, environmental savings were shown to be extremely significant. A 630 kW system was replaced, saving energy to avoid power station emissions of 150 tonnes CO2, 1 tonne SOx, 0.3 tonne NOx, and 15 tonnes of coal ash every year. (Energy-efficient distribution transformers: a hidden opportunity for large scale energy savings, Lebot, De Keulenaer, Hurens, ECEEE Summer workshop 2005)

4.2.1 Technical approaches to making transformers more efficient

More efficient distribution transformers, which use better steel

[36] *Evaluation of the Efficiency of Fractional Polyphase Motors*. (2001) American Council for an Energy-Efficient Economy. Hhttp://www.aceee.org/motors/frmtrs.htmH.

[37] The Potential for Global Energy Savings from High Efficiency Distribution Transformers, Leonardo Energy, European Copper Institute, February 2005

cores and copper windings, for example, can be more costly to buy but can save money over their life cycle. Improving the design, materials, and manufacturing of transformers can reduce energy losses by as much as a third, saving close to one percent of the electricity transformed in a typical case. The savings depend on the size of the transformer and the way it is used. For lightly used transformers, improving the materials used in the core (e.g., using thinner laminations or amorphous materials) is particularly important. Transformers with amorphous steel in their cores lose 70-80 percent less energy in their core than do silicon-core transformers. In transformers that are more heavily used, it is more important to ensure that the windings have low resistance (e.g., by using high-conductivity copper wire, which also allows for less core steel, thus helping to lower no-load loss). Further, for a given electrical capacity, appropriate choice of winding material can actually reduce the amount of steel in the core, thus reducing the core loss simultaneously with the coil loss. Efficiency is also helped by appropriate sizing of transformers to correspond to expected loads.

4.2.2 Benefits of making transformers more efficient

Because distribution transformers are so widely used and have long life spans (30 years on average), even small improvements in their efficiency can result in large energy savings. A recent study estimated that there are 4 million distribution transformers in the EU-15 countries, with an annual market for new transformers of 125,000 new units (worth €580 million).[38] The energy saving potential from distribution transformers in the EU-25 countries was estimated to be 22 million MWh per year, which avoid about 9 Mt of CO_2 emissions annually. Although higher efficiency transformers cost more to purchase, the study found that typically the electricity savings would pay for this extra cost within one to three years.[39]

4.2.3 Policy approaches to improve transformer efficiency

Although power distribution companies have purchased efficient transformers in the past, often as part of a “gold plating” policy for their systems, this behavior may change under restructured utility markets in which first cost plays a more important role.[40] Because ratepayers often end up paying for distribution transformer losses, utilities do not have a strong incentive to purchase the most efficient equipment available. Furthermore, energy efficiency is not normally a primary decision factor in the purchase of the smaller dry-type transformers widely used in industrial, commercial, and institutional buildings. Most of these transformers are bought by contractors, who are attracted to low first costs because they don’t have to pay for the energy costs associated with transformer losses.[41] To address these market imperfections, which lead to large cumulative energy losses and associated costs over the long lifetimes of transformers, **government should consider**

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[38] Leonardo Energy report, p 14, op cit.
[39] Leonardo Energy report, pp 27-30, op cit.
[40] ICF Consulting, private communication.
[41] Supplement to the “Determination Analysis” (ORNL-6847) and Analysis of the NEMA Efficiency Standard for Distribution Transformers. Oak Ridge National Laboratory, 1997. Hhttp://www.eere.energy.gov/buildings/appliance_standards/commercial/disttrans_support.htmlH

setting high efficiency standards for manufactured and imported distribution transformers.

4.2.4 Existing policies

There is no formal policy addressing transformer efficiency yet in place in the EU. However policy could usefully follow the US lead, where in 2004 a test standard for measuring the energy efficiency of distribution transformers was issued.[42]

Cross-over of the ENERGY STAR program concepts into the EU is likely to accelerate the process of minimum standards for transformers, as labels for ENERGY STAR Distribution Transformers and ENERGY STAR Commercial and Industrial Transformers encourage manufacturers and utilities to produce and purchase relatively high-efficiency distribution transformers.

4.2.5 Future policies and policy approaches

While the US leads on setting standards for energy efficient transformers, the US standards are set lower than is financially optimal. Given the possibility that more efficient transmission and distribution of power could significantly assist in delivering the EU's Kyoto obligations, **it is important that the EU take a vigorous approach to setting minimum standards for all new transformer systems.**

An important element of this is likely to be assisting transmission system regulators in setting up charging rules which eliminate perverse incentives and encourage investment in efficient plant.

4.3 More Efficient Local Distribution with Reduced Resistance Wiring

Energy is transferred in electric circuits by the movement of electrons through a metal conductor. However, as the electrons move through the conductor, they strike the atoms along their path; these collisions reduce the flow of electricity, with the difference being converted to heat. Except for superconductors, where the electron flow is very different in nature, every conducting material consequently displays a characteristic 'resistance' to the flow of electrons. Increasing the electron flow through a wire of a given size increases the likelihood that electrons will hit atoms and lose energy. Conversely, for a given flow of electrons, increasing the cross-sectional area of the conductor will reduce its resistance and the associated losses. It makes good business sense to choose a higher gauge wire when cost-effective, especially in industrial and commercial settings where heavy duty equipment pulls high currents through the wires. Further, larger-than-minimum wire size often contributes to equipment reliability, as the over heating from losses is minimized. Government agencies should consider incorporating wiring conductivity efficiencies into existing energy efficiency training materials and programs.

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42 Hhttp://www.eere.energy.gov/buildings/appliance_standards/commercial/distribution_transformers.htmlH.

4.4 Improved Efficiency Appliances

25 per cent of all energy consumed in the EU-25 is used in homes[43], and a significant amount of this is electrical energy. Data for the EU-15 shows that total domestic energy consumption in 1998 was 2878 TWh; of which electrical energy accounted for 613 TWh,[44] or 21% of the total. 520 TWh was accounted for by appliances, water heating and lights, and the remaining 93 TWh was used in heating. Of the 520 TWh, 17% was used for lighting but most was used in electronic equipment and the appliances used for heating, cooling, and washing. Appliances also contribute to the electrical energy consumption in the commercial and public sectors, which for 1997 was 497 TWh.[45]

Almost all of these end uses show substantial potential for increased energy efficiency, in part through the development of new technologies but also through the steady replacement of existing systems with more modern equipment. Policy approaches for improving energy efficiency in appliances mostly involve the use of efficiency standards, including mandatory standards set by Directives and voluntary labelling programmes such as EU Energy Star®.

Savings and benefits arising from these initiatives can be increased by regular and timely reviews of the standards and by strengthening them as cost-effective new technologies become commercially available.

4.5 High Efficiency Boilers

Minimum efficiency standards have been set for domestic central heating and hot water boilers in Directive 92/42/EEC. However, the requirements only cover boilers fired with liquid or gaseous fuels and the Directive specifically excludes instantaneous electric water heaters (which accounted for 87 TWh of consumption in 1998).[46] These heaters are a significant convenience for their users and, by replacing the parasitic heat losses of boiler-fed systems for small consumption points, could be a significant source of carbon savings. **A study of the design, efficiency and use patterns for these heater systems should be launched to identify areas for improvement.**

4.6 Energy Efficient Air Conditioning

Space cooling accounts for less than 6 per cent of domestic energy consumption in the EU-15,47, but a much higher percentage in commercial buildings. Air conditioning is a rapidly growing sector within final energy demand, and is projected to consume about 123TWh/year in the EU-15 by 2010. High-efficiency air conditioners can reduce peak electricity demand, an important consideration in areas where electricity shortages are a risk. Air conditioners have realized substantial gains in efficiency, in the range of 50 percent in recent decades, although there is scope for additional improvement.

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[43] EU Energy & Transport in Figures, op cit

[44] *Consumption and the Environment in Europe*, Danish Environmental Protection Agency, 2004, (referencing a study by Fawcett et al in 2000)
http://www.mst.dk/udgiv/publications/2004/87-7614-193-4/html/kap05_eng.htm

[45] *Energy in Europe*, European Commission, January 2000 p.51

[46] Consumption and the Environment in Europe, op cit.

[47] Consumption and the Environment in Europe, op cit.

Energy labelling requirements for household air-conditioners have been set by Directive 2002/31/EC of 22 March 2002.
The Commission should continue to develop stronger standards for commercial and residential air conditioning to keep pace with technological development.

4.7 High Efficiency Refrigeration

Refrigerators and freezers account for 21 per cent of domestic energy use in the EU-15, and commercial refrigeration can approach 50 percent of total energy use in some buildings (such as supermarkets).[48] Refrigerators use compressors and fans driven by electric motors, so they have benefited from improvements in motor-driven systems. Higher efficiency motors, dual speed or variable speed drives, and better equipment for using the output of the motors (e.g., improved compressors and heat exchangers) can be used to improve the efficiency of refrigerators and freezers as well as related industrial processes.
Minimum efficiency requirements for household electric refrigerators and freezers were set by Directive 96/57/EC of 3 September 1996. Energy labelling requirements have been set by Directive 2003/66/EC of 3 July 2003.
The Commission should continue to look for opportunities to set standards for commercial refrigeration and to strengthen standards for residential refrigeration to keep pace with technological development.

4.8 Heat Pumps

Heat pumps are up to twice as efficient as they were 30 years ago, as a result of more precise control of the flow of refrigerant, variable speed blowers, improved motors, two-speed compressors, and improved copper heat exchangers. In addition to improvements in the heat pumps themselves, more energy can be saved in many cases by substituting heat pumps for less efficient resistance heaters.
The Commission should publish guidelines on the economic case for heat pump technology and assist market developers.

4.9 Efficient Clothes and Dish Washing Machines

Washing machines and dishwashers account for 12 per cent of domestic energy use in the EU-15.[49] Improved washing machines save energy by using less hot water, by spinning clothes faster (thereby removing more water and saving some of the energy needed to dry them), and by using horizontal- instead of vertical-axis designs to take advantage of gravity for agitating the wash despite extremely low water content.
Energy labelling requirements for household washing appliances have been set as follows:

- Washing machines: Directive 95/12/EC of 23 May 1995.
- Washer-driers: Directive 96/60/EC of 19 September 1996.
- Dishwashers: Directive 97/17/EC of 16 April 1997.

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[48] R&D on Heating, Cooling, and Commercial Refrigeration. US Department of Energy. Hhttp://www.eere.energy.gov/buildings/tech/hvac/H
[49] Consumption and the Environment in Europe, op cit.

- Electric Tumble Driers: Directive 95/13/EC of 23 May 1995.

The Commission should ensure that ecolabelling and market support programmes continue to drive improvements in control and operation of these appliances.

4.10 High Efficiency Lighting

4 – 5 per cent of electricity consumption in the EU-15 is used for lighting, and the figure for industry and offices is about 12 - 14 per cent[50] [51]. Substantial reductions in this energy use are possible by changing to higher efficiency types of lighting, incremental improvements in the efficiency of each type, and more effective use of existing equipment. One of the largest sources of improved lighting efficiency is the shift from incandescent bulbs to gas discharge lighting systems, such as fluorescent, compact fluorescent, mercury-vapor, and sodium lamps.

The implementation of Directive EU 2000/55/EC will gradually prohibit the operation of low wattage fluorescent lighting employing high loss types of magnetic ballasts and is expected to save over 4 TWh of energy every year by 2020. The first milestone to be met is the denial of a CE mark for low efficiency magnetic ballasts used in six of the seven power consumption categories. Denial of this certification mark will render sale of such ballasts illegal from 21st November 2005.

Among the voluntary policy options for promoting energy-efficient lighting is the GreenLight Programme, a voluntary pollution prevention initiative encouraging non-residential electricity consumers (public and private) to commit to install energy-efficient lighting technologies in their facilities when it is profitable and when lighting quality is maintained or improved. The programme was launched in 2000 by the European Commission Directorate General for Energy & Transport (DG TREN). The Commission does not provide funding to assist partners with their investments as by definition the work pays for itself, but does provide support in terms of information and marketing.

The EU should increase the rate at which energy efficiency thresholds come forward for eliminating the most inefficient lighting systems more quickly.

4.11 Distributed Generation for Reduced Transmission Losses

To minimize the risk of costly disruptions in electricity supply, many businesses install small-scale or “distributed” power generators. Distributed generation can help businesses save money by providing an alternative to the grid during periods of peak demand, when electricity is most expensive. Distributed generation also can strengthen the transmission and distribution grid by reducing congestion in “load pockets,” areas where physical constraints on transmission make it difficult for utilities to meet electricity demand.

Although some distributed power technologies, such as backup diesel generators, may exacerbate air pollution, others can benefit the environment. Solar panels and wind turbines, for example, are far cleaner than conventional fuel sources and can reduce greenhouse gases and criteria air pollutants significantly. Combined Heat and Power (CHP) systems that use waste heat from electricity production for space heating, cooling, or industrial processes are another environmentally preferable source of distributed power, reaching overall fuel efficiencies of 50 to 70 percent.

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[50] Consumption and the Environment in Europe, op cit.

[51] Sustainable Energy Ireland, 2003, Energy Saving Trust Market Transformation Programme, 2004.

To promote distributed generation, governments should remove barriers to the interconnection of distributed generators to the power grid, offer financial incentives to help offset the cost of clean distributed power units, and establish transparent and barrier-free net metering laws, which allow individuals and businesses to get credit from their utility for excess power that they generate and supply back to the grid.

4.12 Energy Efficient Transportation

Hybrid-electric and all-electric vehicles can reduce local air pollution and greenhouse gas emissions, especially in regions where coal and oil provide a relatively low share of the electricity generation mix. The fuel economy of hybrid-electric vehicles is substantially greater than most conventional vehicles on the market, although their higher purchase price is a barrier for many consumers. Governments can encourage the wider use of hybrid and electric vehicles through tax credits, special parking privileges and access to high-occupancy vehicle lanes, fleet purchases, and consumer education.

5 Appendix: The role of copper in energy efficiency

Introduction

Copper is the first metal to have been used by the human race. Copper's unique properties make it an important contributor to enhancing the energy efficiency of appliances, motors, and hundreds of other commercial, industrial and residential devices.

How copper's fundamental characteristics make it a contributor to greater efficiency

Heat transfer vs. other materials: Copper has an exceptionally high coefficient of heat transfer. For a given shape of material with a given temperature difference across it, copper will transfer over twice as much heat as aluminum, seven times as much heat as cast iron, eight to nine times as much as steel and over 20 times as much as stainless steel. In fact the only metal with a higher ability to transfer heat is silver, which is about 5% better, but costs around 60 times as much (2004 prices).

Electrical resistance vs. other materials: Copper has an exceptionally high electrical conductivity, which is a property closely-related to thermal conductivity. Copper conducts electricity at a rate around 60% better than that of aluminum, 5 times the rate of iron, 10 times that of steel and 18 times that of titanium. As with thermal conductivity, the only metal which can beat it is silver, by about 5%. Copper is therefore the preferred choice where high electrical conductivity is needed, and especially where this must be combined with compactness and affordability.

Substituting copper for other materials yields lower losses in some applications: In many applications, space can be extremely limited. Here copper can be a very useful metal due to its volume-efficient thermal and electrical conductivity. Although some other metals may deliver better performance per unit of weight, copper has tremendous advantages when space is limited. This can include applications in electric motors, electronic circuits and vehicle power transmission components.

Using more copper (without reducing use of other materials) yields lower losses in other applications: Increasing the amount of copper in some applications can improve efficiency, even if the amount of other materials is not changed. A good example of this is in high efficiency motors (HEMs). A low-efficiency motor will use the minimum amount of copper to keep costs down. The motor will still function well, but will lose some energy as the copper conductors are not at the optimum size to minimize resistive current losses. Increasing the thickness of the conductors will cost effectively save energy for the motor user. HEMs cost more to purchase up front than old designs, but motor buyers can recoup the incremental cost many times over through reduced electricity bills.

The Business Case for Electrical Energy Efficiency:

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A Publication of
The International Copper Association

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International Copper Association, Ltd.

260 Madison Avenue
New York, NY 10016 USA
Tel: 212.251.7240 Fax: 212.251.7245
www.copperinfo.com

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