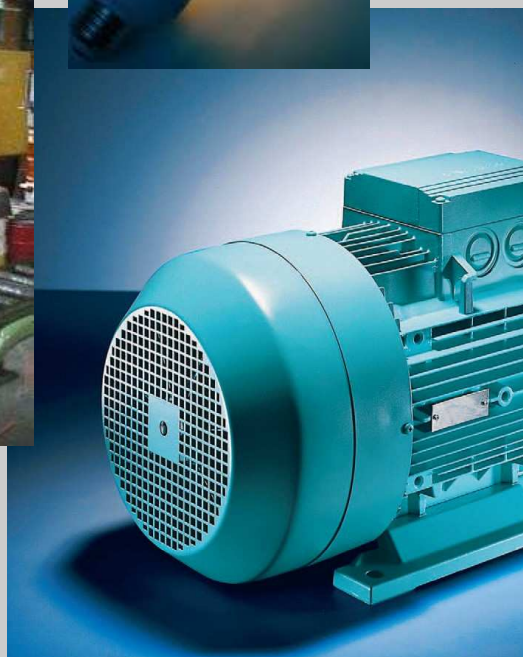


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Energy Efficiency

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Introduction

Electricity is a high quality energy carrier, and its inefficient use needs to be avoided by all means. But more important than the question 'can we save electricity?' may be to ask ourselves whether electricity can save energy.

The use of electricity is growing fast, and it's growing faster than the consumption of primary energy. Paradoxically, this may be an opportunity rather than a problem, since electricity's high efficiency at the point of use in combination with increasing options for low-carbon generation can be one of the main roads towards a sustainable energy system.

We are evolving towards a digital society, offering unprecedented opportunities to rethink transport and healthcare, increase productivity, develop knowledge. In OECD countries, the reliability of the electricity systems is consistently above 99.95% but this may not be sufficient for an increasing number of high end technological applications.

While requirements imposed on the electricity system increase, the growing amount of decentralized generation risks reducing reliability, and requires us to rethink system operation. Fortunately, many of the technical solutions needed are already within sight, and some even available today.

High oil prices and mainly the instability of the price and supply will make the sector turn even more to indigenous or renewable energy sources, and to improve the efficiency of generation and distribution. This carries significant consequences for the electricity sector for two reasons: the need to incorporate more decentralized solutions and a more efficient use. But on the other hand, it may carry a big overall benefit, as the precision and efficiency of electricity may be the key to reduce our environmental impact without compromising economic and productivity growth.

Some scenarios

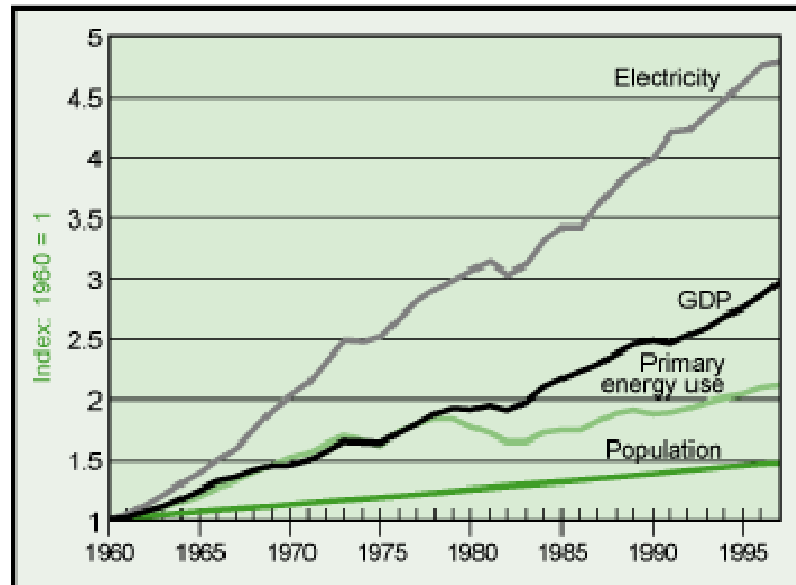
Nations worldwide are making efforts to reduce their energy consumption and they are succeeding. At the same time, energy use is becoming cleaner in terms of CO₂ or other emissions due to the implementation of numerous techniques to improve its generation, distribution and use.

On the contrary, a number of studies support that electricity consumption has been growing and will continue to grow despite the reduction of primary energy use - electricity generation and use has become more efficient.

The growing importance of electricity is the result of following trends (according to the WBCSD, that forecasts the electricity share in total energy consumption to double by 2050):

- Improvements in electrical applications and substitution of fossil fuels
- Increasing number of electrical appliances
- Information technology and the internet
- Urbanisation

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Source: IEA, 1999.

Figure 1 – evolution of population, energy, electricity and GDP (WEA)

The International Energy Agency (IEA) has analysed the evolution of primary energy and electricity consumptions and GDP (see Figure 1) over a period of nearly 30 years. Electricity has been growing faster than the primary energy consumption due to continuous efficiency improvements. Also, forecasts for the next 3 decades point that total energy use per unit of GDP is likely to fall by 1.8%, at the same time that electricity use almost doubles, rising its share from 17 to 22% of the final energy consumption (IEA 2007).

The European situation was thoroughly studied in the “Role of Electricity” study developed by Eurelectric. Figure 2 shows some results obtained were the world trend is confirmed. The overall energy intensity of GDP declines 1.7% per year and electricity demand grows about 1.3% per year raising its market share from 17% in 1990 to 25% in 2030.

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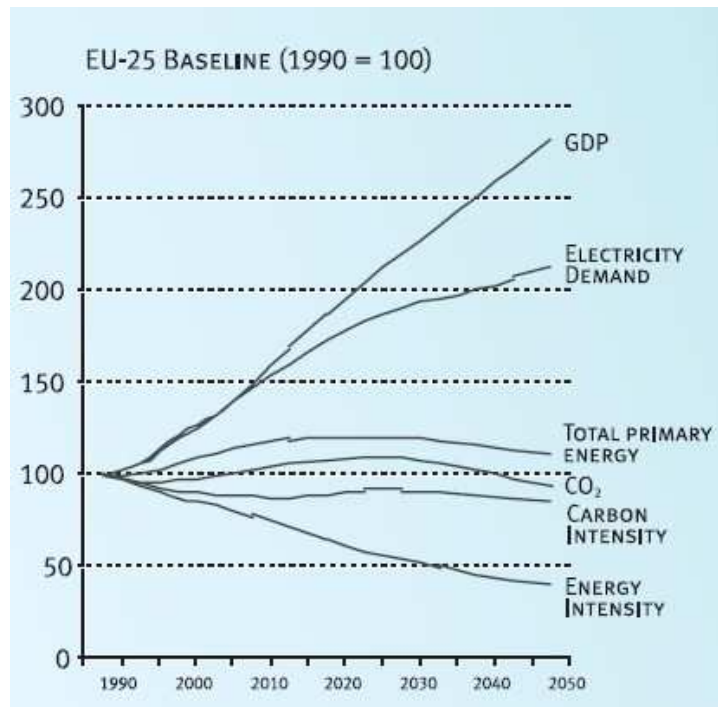


Figure 2 – Baseline energy and economy indicators (Source: *The Role of Electricity*, Eurelectric, 2007)

Moreover, the Electric Power Research Institute (EPRI) has made a study and forecast for the same variables over the next 5 decades for the US situation (see Figure 3). The evolution is quite similar to what has happened in the past, but with a more noticeable decoupling of electricity and primary energy demand. While primary energy consumption is declining, electricity consumption will continue to grow and GDP will grow even faster.

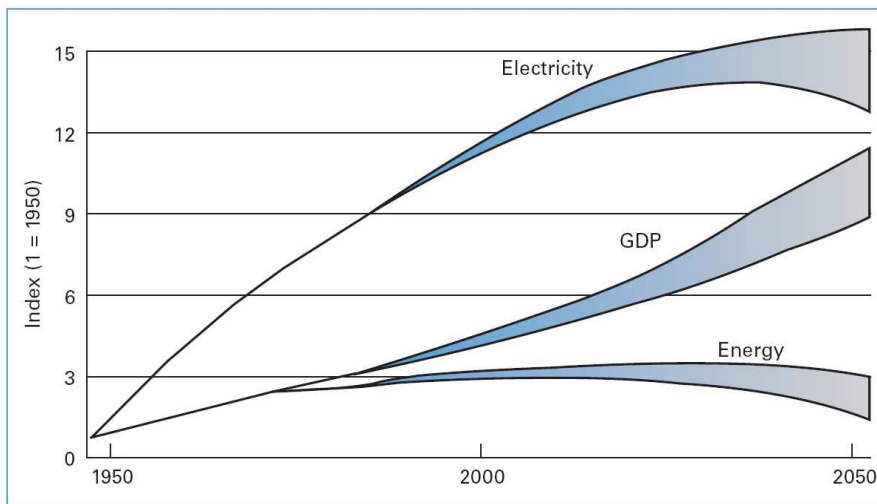


Figure 3 – Trends for energy, GDP and electricity growth in the US (Source: EPRI, 2003)

These trends constitute very strong evidence of the value of electricity as an energy carrier fuelling GDP growth, driving technological progress, comfort and new economic growth.

New technology

The most important characteristic of electricity is its high quality, and its capability to serve practically any energy service (light, appliances, motion, electronics, heat) from a single system.

Technology innovation in electricity use is a cornerstone of global economic progress. Extremely reliable delivery of high quality “digital-grade” power is needed by a growing number of critical end-uses. Even though electricity is “transparent” to most users – at least until there is an outage – technology improvements are quite visible in day life. The domain of electronics has experienced great breakthroughs allowing for many energy efficiency improvements in other equipment due to an increased management of the resource electricity.

In the EU-15, electric motors in industry and manufacturing used about 24% of total electricity consumption in the year 2000 (European Copper Institute 2004). Significant energy savings can be achieved by applying more energy efficiency electric motors or variable speed drives – an electronic mechanism to regulate rotors speed and torque increasing their efficiency. Economical electricity savings can be as high as 29%, with further savings in primary energy upstream at the power plant – 1% savings on the overall electricity consumption. (WBCSD)

Distribution transformers are highly efficient machines but losses can still be reduced by a factor 3 or 4 through the use of amorphous iron. Due to the high and constant load these equipment are subject, the final energy savings are considerable. (Targosz, 2005)

The installation of efficient heat pump-based air conditioning units instead of average air-conditioning units in Chinese households would result in a saving of more than 15 EJ (including transmission and distribution losses) until 2030. This would translate into an energy saving of 0.5 EJ in 2010, which would equal about 1.1% of total energy consumption that year or, about 20% of Germany’s electricity consumption in the year 2002. (WBCSD)

Lighting consumes 5 to 15% of total electricity in industrialized countries and up to 86% in developing countries. Between 30 and 50% of this could be saved by investing in energy-efficient lighting systems. Compact fluorescents are on average 80% more efficient than incandescent lamps and have 8 to 12 times longer lifetime. (EURELECTRIC) Light Emission Diodes (LEDs) are also experiencing a very fast development and demonstrating high efficiency and reliability for a number of applications.

An electric vehicle can be about twice as efficient in converting primary energy into transport services, compared to an internal combustion engine (see table 1), and still with the added value of limited noise and particle emissions.

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ICE	η	EV	η
Oil refinery	85 - 90%	Gas transport	95%
Distribution	95 - 99%	Generation	55%
Engine	15 - 20%	T&D	90 - 96%
Transmission	95 - 98%	Battery	60 - 70%
		Motor	80 - 85%
		Transmission	95 - 98%
Well-to-wheel	12 - 17%	Gas-to-wheel	21 - 29%

Table 1 –Comparison of system efficiency for Internal Combustion Engine (ICE) and electrical vehicles (EV) (Husain)

The energy intensity of freight trains is less than half that of trucks. High-speed long-distance passenger rail transport is 40% less energy intensive.

The energy consumption of most domestic electrical appliances has been reduced considerably between 1995 and 2000 - 13% for freezers and refrigerators, 14% for dishwashers - and 37% for washing machines between 1982 and 1998. Induction heaters for cooking transfer 90% of the final energy is transferred to the pan, compared to 55% for gas-fired cooking.

High temperature electroheat solutions for industry can achieve very high efficiencies and save up to 80% primary energy and up to 60% CO₂ emissions (see table 2). Due to the possibility of precise control of electroheat installations there is also less material wasted and a better product quality.

All the mentioned solutions are currently available in the market. Their energy saving potential is however far from being fully explored, even if their technical feasibility and cost-effectiveness is thoroughly proven.

Many more examples could be observed supporting that the use of electricity in our society and our daily life can easily and economically be improved with the subsequent considerable environmental benefits.

	Gas-fired melting furnace	Induction Oven
Combustion loss	1 - 5%	0.3 - 1%
Final Energy	310 - 1550 kWh/t	93 - 310 kWh/t
Primary Energy	1700 - 8500 MJ/t	510 - 1700 MJ/t
CO ₂ emissions	91 - 455 kg/t	27 - 91 kg/t

Table 2 –Comparison of characteristics for gas-fired melting furnace and induction oven for Aluminium (Böhmer, 2001)

Obstacles

Power stations transform primary energy from a variety of sources into heat and then into electricity. The primary energy necessary to generate 1 kWh varies from a factor 1 to 4, depending on the source and the installation, therefore the grid mix (energy sources and different technologies implemented) in a country is greatly responsible for the primary energy consumption and emissions profile from electricity generation.

Alongside with the substantial increase of the efficiency and the use of low carbon sources over the last decades, the CO₂ emissions of these power plants have also been reduced significantly. Current trends point to further improvements in efficiency and CO₂ emissions due to technologies like Carbon Capture and Storage (CCS) and improvements in the combustion cycle or the turbines in power plants. This carries an amazing added value as one of the hurdles of electricity is the “quite low” efficiency of generation.

The availability of a wide range of electricity related consumer and business services, including low-cost, high value energy services, stimulates the economy and offers greater control of energy usage and expenses to the consumer and more efficient demand management and supply from the utilities. In this sense, the efficiency increase in a product must not be seen as an isolated event but in a wider perspective as an integrating part of a very complex system.

This represents a great challenge but also a great opportunity. The overall improvement of the electricity system is largely dependant on concerted actions at several levels of abstraction.

The networks of the future will need to have deeply integrated management systems that are able to more easily match generation response to demand. But the consumer will also have a very important role becoming a “prosumer” (producer + consumer). More and more consumers will integrate electricity production at their premises, as well as storage technologies. Well managed, these can become active solutions for managing and balancing the grid and offering both a more reliable electricity supply but also a bigger hosting capacity for the integration of renewables intermittency.

Concepts like plug-in hybrid vehicles or passive houses may well be active players in the “smart grids” of the future. Passive houses, because of their high capacity to retain and manage heat, can postpone demand for electricity for several hours and reduce demand at peak times. Plug-in hybrids can store electricity during the night and “deliver” it back to the network at peak times. The Smart Grids research project from the European Commission illustrates well this concept. Figure 4 is one of the illustrations used to for the systems integration.

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Figure 4 – Vision of Future Electricity Networks (Source: EC, 2006)

Electricity is consumed at the time it is being produced - the margin for mistakes is minimal, without possibility for quality improvement. In reality the electricity users have as much influence over its quality as its suppliers. Nevertheless, the reliability of the system is most times above the 99.9%. Interruptions on the supply typically vary from 30 to 100 minutes per year in OECD countries [CEER, 2005]. 100 minutes of non-availability per year correspond to about 99.98% availability and even this level may not be sufficient to an increasing number of high end technological applications. Internet Data Centres are among these applications, requiring electricity availability above 99.9999%.

But reliability is not the only quality parameter for electricity. The perfect sinusoidal curve of current and voltage is sometimes distorted by disturbances such as interruptions, dips or surges, harmonic pollution and interference, degrading the quality of the electricity delivered. A recent survey by Leonardo ENERGY Power Quality Initiative concluded that poor power quality costs European Business more than €150 billion a year, and that the majority of the causes identified are avoidable using technologies available in the market. Following the survey, a number of sector specific information sheets are being produced.

The added value of distributed generation.

The electricity sector as it currently operates is at the mercy of natural disasters, price fluctuations, terrorist attacks and blackouts or several origins. Coupled with other, more long-standing problem such as increasing levels of pollution, growing vulnerability and inefficiency of transmission and distribution networks, and rising electricity prices related to disruptions and interruptions in fuel supply, these challenges add to the need for an evaluation of alternative technologies. (Springer)

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As for the use of other energy carriers, some appear to have advantages, even if their associated efficiency is quite low. On the other hand, the development of delivery mechanisms for these carriers would mean a great deal of research, capital investment and likely a huge environmental and societal impact.

Environmental and societal impact are minimised by improving the use of the existing infrastructure, promoting the development and use of energy efficient equipment and systems, and stimulating the development and use of clean distributed energy resources.

Conclusion

If we are to build a sustainable energy future for Europe, a key role will be reserved for electricity. Its simplicity and cleanliness at the point of use, combined with the feasibility of clean power generation, make it a preferred energy carrier.

Emissions from electricity generation are diminishing at a higher rate than the emissions from other energy carriers. The generation, use and management of electricity are highly mastered and it can be used for almost every application with an impressive safety and availability record. It is even the only energy carrier that is able to power the increasingly digital economy we live in, opening ground for even more efficient actions as videoconferencing or teleworking, reducing the need for travel, and an infinity of automated highly controlled processes in industry and households.

The question that was asked is actually not correct. It should have been: Why are we wasting this high quality good - electricity?

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