# The state of global energy efficiency

1. Global and sectoral energy efficiency trends

1.1 Global trends

In 2010, total energy consumption per unit of GDP (primary energy intensity[1]), measured at purchasing power parity and where 1 is the world average, ranged from 1.8 in the CIS[2] to 0.6 in Europe **(Figure 1)**: energy use per unit of GDP in the CIS is three times higher than in European countries. Levels in OECD Asia and Latin America exceed the European level by about 20 percent, while North America stands 50 percent higher but remains below the world average. India and Other Asia are on a par with the world average, with energy intensity levels 55 percent higher than in Europe. The high energy intensity in the CIS, China and the Middle East is explained by various factors, including the predominance of energy-intensive industries and low energy prices.

Figure 1: Primary energy intensities by world region (2010)
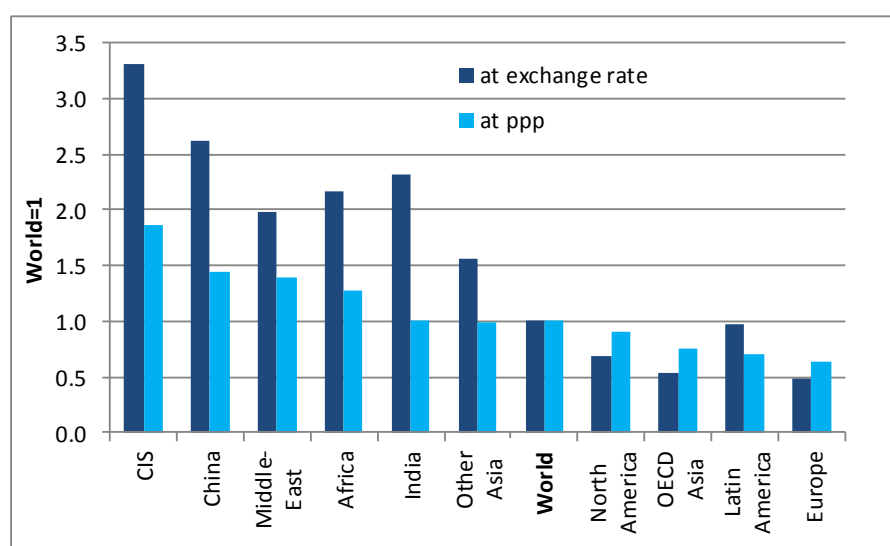
Source: Enerdata

Global energy intensity – or the energy required per unit of GDP – decreased by 1.2 percent/year between 1990 and 2010 **(Figure 2)**, and fell in all regions except the Middle East. The trend is explained by the combined effect of high energy prices, energy efficiency programs and, more recently, CO_2 abatement policies in OECD countries, as well as other economic factors, such as the move by economies towards tertiary activities.

The largest reductions were seen in countries or regions with the highest intensity in 1990 (China, CIS, India). The largest drop in energy intensity since 1990 was achieved in China (-4.6 percent/year), while in the CIS countries and India the reduction was twice as slow. The sharp reduction seen in China was mainly driven by the rapid growth in machinery and transport equipment, ie, the branch with the lowest energy intensity, in the industrial value added. It can also be attributed to a more efficient use of coal and higher energy prices. Above-average reductions were also achieved in North America and Europe (-1.5 percent/year each). Compared with

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[1] Primary energy intensity measures the total amount of energy required to generate one unit of GDP. GDP is expressed at constant exchange rate or purchasing power parity (ppp) to remove the impact of inflation and changes in currency rates. Using purchasing power parity rates instead of exchange rates to convert GDP in the same currency (ie, $) makes it possible to account for differences in general price levels: it increases the value of GDP in regions with a low cost of living (case of developing countries) and, therefore, decreases their energy intensities (Figure 1). Definitions of indicators are available in "Sources and methodology" at the end of the report.

[2] Definitions of regions are available in "Sources and methodology" at the end of the report.

the world average, energy productivity[3] in other world regions improved to a lesser extent over the period. In the Middle East, energy consumption has been growing at a faster pace than GDP; consequently, energy intensity has increased by 1.1 percent/year since 1990.

The surge in oil prices over the 2004-2008 period accelerated reductions in energy intensity in all regions except China. The global economic crisis in 2008-2009 induced a net slowdown in the energy intensity reduction in almost all regions except China and Africa. This poor performance was mainly caused by industry, a sector in which energy consumption did not decrease at the same pace as the value added due to lower efficiency.

Figure 2: Trends in primary energy intensity to GDP
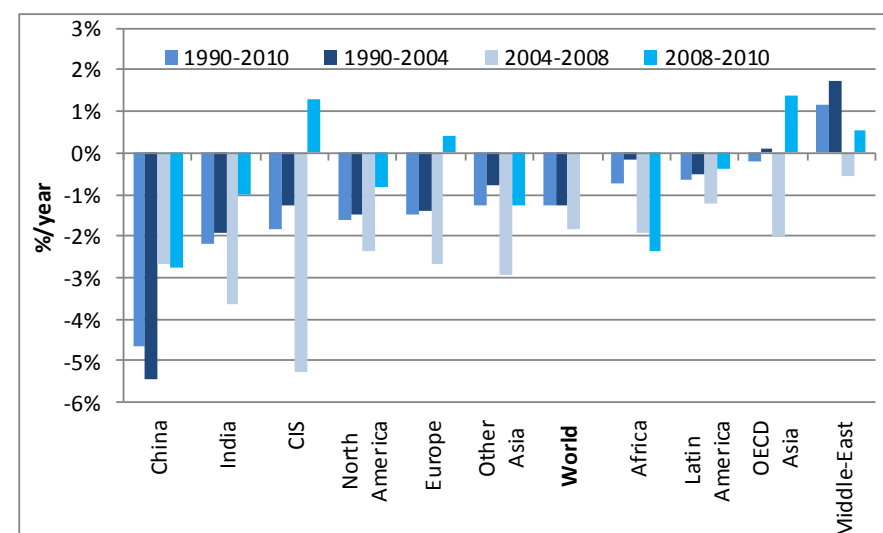
Source: Enerdata

About 80 percent of countries in the world have decreased their energy intensity since 1990 **(Figure 3)**. Productivity gains in about 30 percent of countries were moderate, since their energy intensity decreased by less than 1 percent/year, whereas the reduction in about 15 percent of countries (mainly Asian and East European) took place at the rapid pace of over 3 percent/year. In more than 20 percent of countries, on the other hand, energy productivity is decreasing (mainly in the Middle East, Africa and Latin America).

**Figure 3: Trends in primary energy intensity by country (1990-2010)**

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[3] Energy productivity increase is another way to refer to energy intensity decrease by analogy with labor productivity increase.

1.2 Sectoral trends

At world level, the household-services[4] and industry[5] sectors led the fall in energy intensity between 1990 and 2010, accounting for 40 percent and 30 percent of the overall decrease, respectively **(Figure 4)**. In developed countries, industry is the driving force behind the fall in primary energy intensity; in OECD Asia it accounted for the entire reduction. In the Middle East the increase in primary energy intensity is mainly due to the surge in the consumption of the transformation sector, which is linked to the rapid development of electricity use, which is almost entirely generated from thermal sources, ie, with conversion losses.

Figure 4: Primary energy intensity by sector (1990/2010)
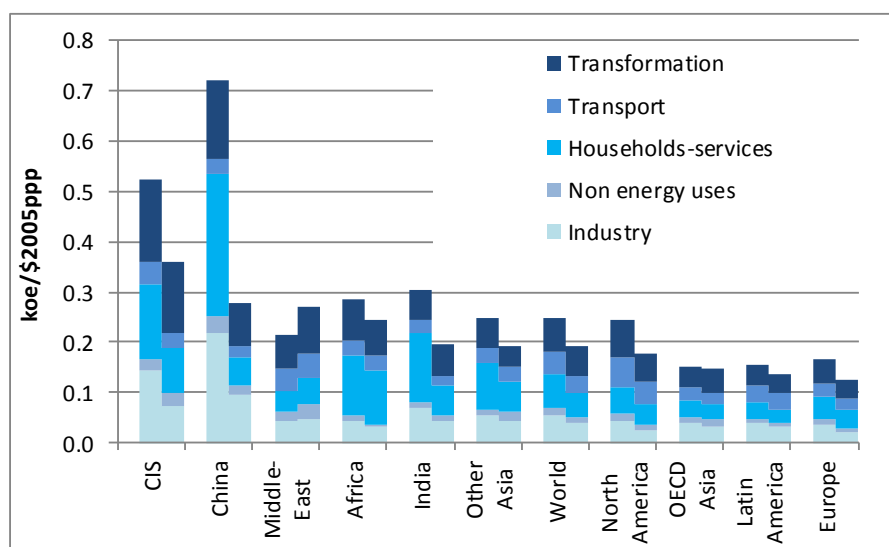
Source: Enerdata

Final energy intensity is a better indicator for the assessment of energy efficiency at end-use level, since it corresponds to the energy consumed per unit of GDP by final consumers for energy uses, excluding consumption and losses in energy conversion (power plants, refineries, etc.) and non-energy uses.

At world level, primary energy intensity has decreased more slowly than final energy intensity since 1990 (-1.2 percent/year vs. -1.6 percent/year) **(Figure 5)**. Africa is the only region where this is not the case. This trend is explained by a rise in energy conversion losses, mainly in the power sector. Globally, the share of losses in energy conversion in primary energy intensity increased from 27 percent in 1990 to 31 percent in 2010. In India, conversion losses represented 33 percent of energy intensity in 2010, compared with 20 percent in 1990.

On the one hand, the growth in conversion losses can be explained by the rapid development of electricity end uses and, on the other hand, by the fact that electricity is mainly generated from thermal sources, with 60-70 percent of losses. At world level, around 20 percent of energy productivity gains are counterbalanced by increasing losses in energy conversion. In India and China that percentage is even higher: soaring electricity demand led to a sharp rise in conversion losses since most power is generated from coal. In North America and Europe, primary energy intensity decreased at the same rhythm as final intensity due to the fact that energy conversion losses decreased over the period. This drop is related to the reduction in thermal power generation, led by the development of renewables in the power mix (primarily wind energy), the growing efficiency of thermal power plants (boosted by the spread of gas combined-cycle technologies) and the increasing use of cogeneration facilities.

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[4] Including agriculture.

[5] Including non-energy uses.

**Figure 5: Energy intensity trends (1990-2010) (%/year)[6]**
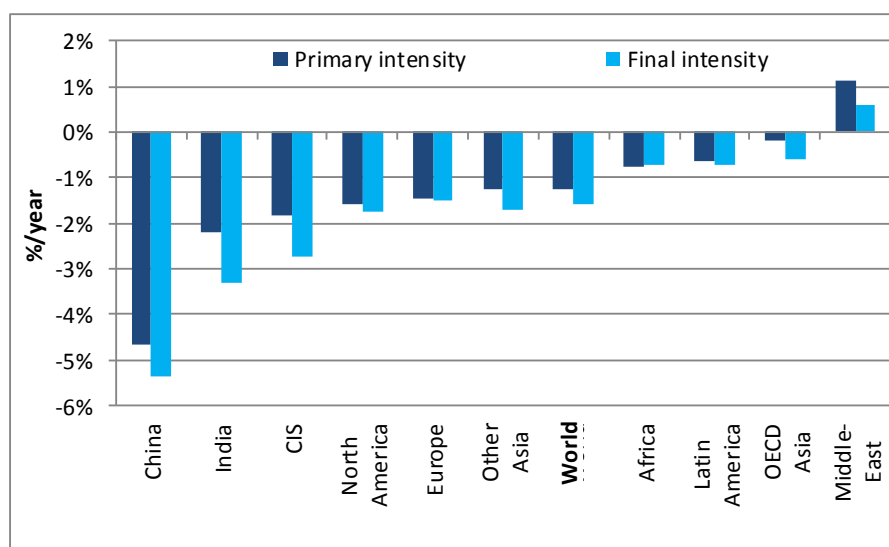
Source: Enerdata

Electricity consumption per capita varies greatly among the different regions **(Figure 6)**. In North America, it is five times higher than the world average (and 20 times higher than in India).

Globally, electricity consumption per capita has increased by 40 percent since 1990. With the exception of the CIS, it rose in all world regions or countries between 1990 and 2010. It increased sharply in most developing countries and regions. In China, electricity consumption per capita has increased fivefold since 1990, while in the Middle East and India it was twice as high in 2010 as in 1990. In developed countries, which already had very high levels, electricity consumption per capita increased to a lesser extent: by just over 10 percent in North America and around 20 percent in Europe.

At world level, industry's share of electricity consumption reached 40 percent in 2010. The largest share was in China, where industry accounts for more than 60 percent of total electricity consumption. In developing countries that share is generally higher than the world average (>40-60 percent), with the exception of the Middle East where it is just 20 percent. In OECD Asia and Europe, industry accounted for 35 percent of electricity consumption in 2010, while it accounted for just 23 percent in North America.

Figure 6: Variation of per capita electricity consumption by sector (1990/2010)
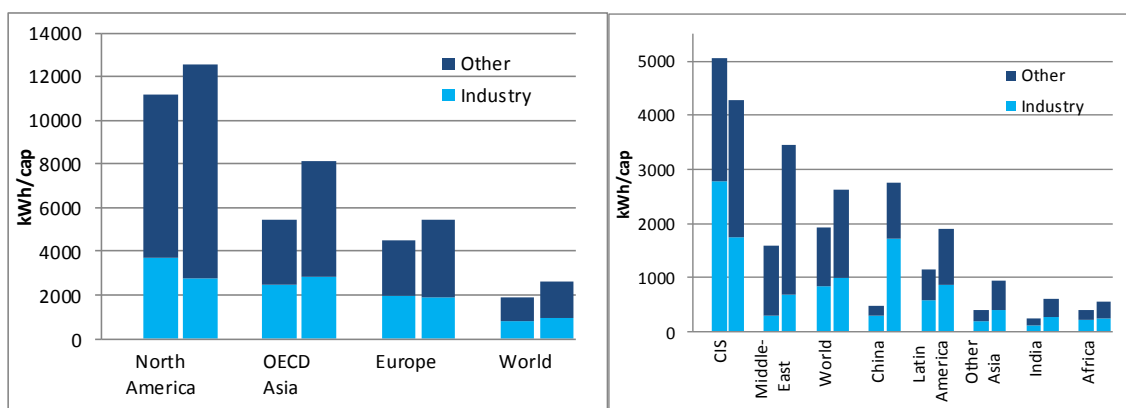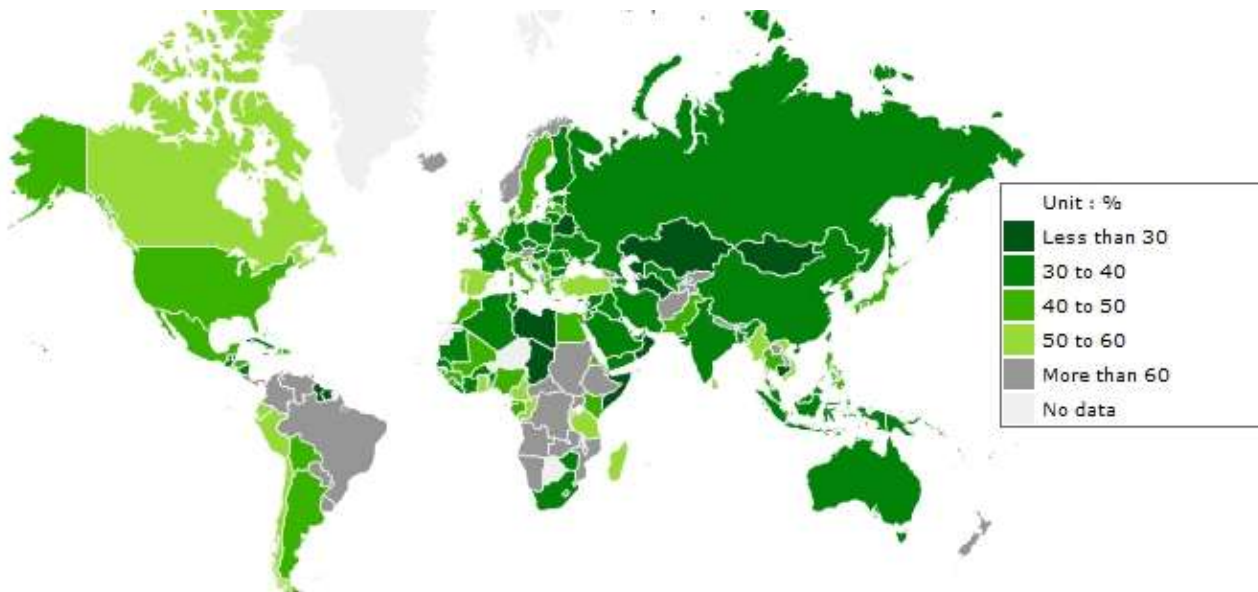

Source: Enerdata

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[6] Non-energy uses are not included in the final energy intensity.

2. Energy efficiency performance in power generation

2.1 Global power generation efficiency

In over half of the countries in the world, the energy efficiency of electricity generation is above 40 percent (world average), while in about 30 percent of countries energy efficiency is above 50 percent **(Figure 7)**. In countries with a large share of hydroelectricity in their power generation mix (Canada, Brazil and Norway) the energy efficiency of electricity generation exceeds 60 percent.

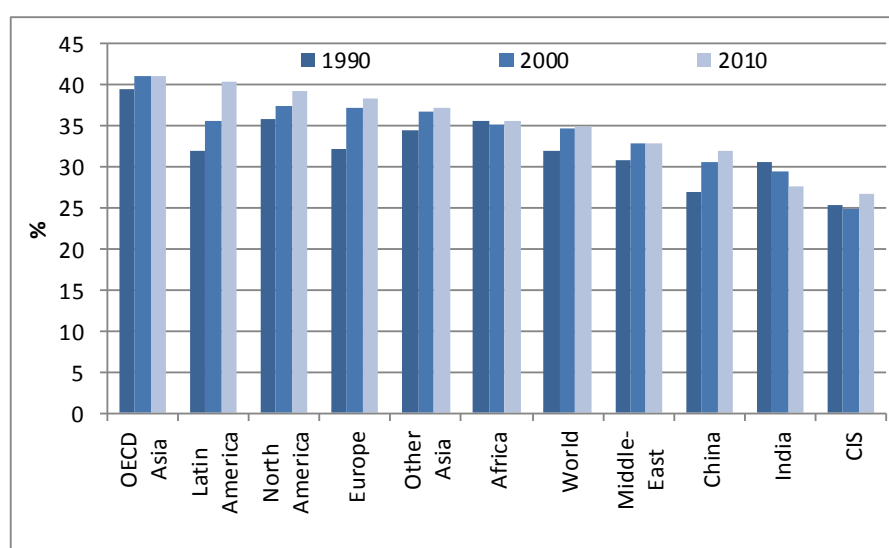**Figure 7: Energy efficiency of total electricity generation (2010) (%)**

Source: Enerdata

2.2 Thermal power generation efficiency

At world level, the energy efficiency of thermal power plants has improved by 3 percentage points since 1990, from 32 percent in 1990 to 35 percent in 2010 **(Figure 8)**. This level is far lower than the average in North America or Europe (around 40 percent), or the level of the world's best performer (Spain, with 48 percent). High energy efficiency levels are also seen in OECD Asia -especially in Japan- and Latin America, mainly thanks to new gas combined-cycle power plants. On the contrary, the efficiency level in most developing countries stands below the world average. In China the large share of coal in thermal generation led to a low efficiency level, despite the improvements that have been achieved since 1990 (5 percentage points). In India the decline in efficiency is explained by aging coal power plants, although it is counterbalanced by a rise in gas combined-cycle capacities (around 15 percent in 2010). In the CIS, the efficiency of thermal power plants was 20 percent lower than the world average in 2010.

The energy savings potential is high: if all regions had an efficiency of 45 percent (average of the top 10 countries), fossil fuel consumption for power generation would be reduced by about 30 percent (ie, 700 Mtoe).
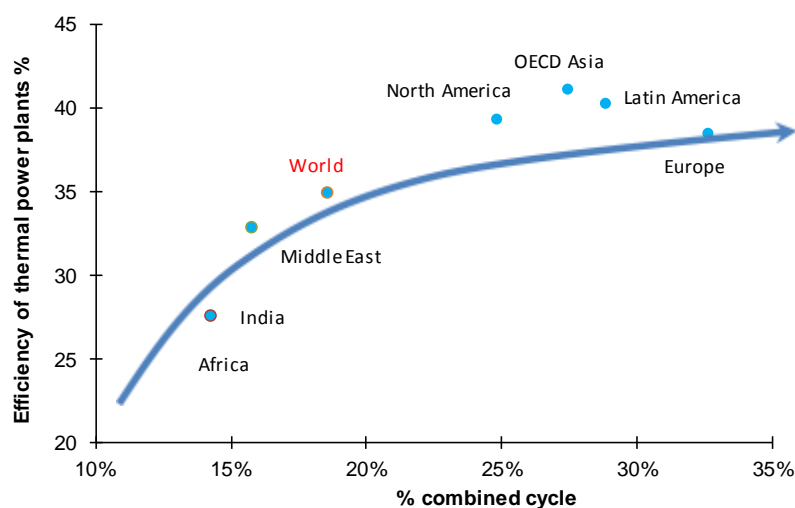
Figure 8: Efficiency of thermal power plants

Source: Enerdata

The energy efficiency improvement in thermal power generation is closely linked to the spread of gas combined cycle plants since the 2000s[7] **(Figure 9)**. In fact, Europe, North America, OECD Asia and Latin America, whose energy efficiency of thermal power plants is among the highest in the world, are also the regions with the largest penetration of combined cycle technologies (about 30 percent of the thermal capacity). Moreover, those regions also showed the largest increase in the energy efficiency of thermal power generation over the period 1990-2010. At world level, in 2010 gas combined-cycle plants made up , on average, 19 percent of the thermal installed capacities ie, a rise of 10 percentage point compared with 2000.

Figure 9: Penetration of gas combined-cycle technology and efficiency of thermal power generation[8] (2010)

Source: Enerdata

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[7] The efficiency of gas combined-cycle plants lies within a range of 50-60 percent, compared with 30-40 percent for conventional steam thermal power plants.

[8] Penetration of gas combined-cycle plants in terms of their share in the thermal power capacity.

2.3 Power grid efficiency

At world level, the rate of transmission and distribution losses (T&D) was around 9 percent of the distributed volumes in 2010 **(Figure 10)**. The regions with the most efficient grids are developed regions and Asia, excluding India, since their losses are below or close to the world level. Other regions suffer losses of more than 10 percent and, in the case of Latin America and India, over 15 percent and close to 20 percent, respectively. However, in those regions a substantial part of the losses are in fact non-technical losses due to unpaid electricity (in India electricity theft and unpaid bills represent up to 20 percent of losses). If all grids were to perform as well as OECD Asia's grid, 4 percent of electricity consumption would be saved (ie, 800 TWh).

Globally, the rates of losses are almost stable, but that stability is the result of two opposite trends. On the one hand, they have been decreasing since 1990 in developed countries due to power grid efficiency improvements achieved in several ways: the use of low-loss conductors and transformers, the standardization and upgrading of transmission and distribution voltages, and reactive power control. In North America, the losses amounted to 6 percent of the distributed volumes in 2010, compared with 10 percent in 1990. In OECD Asia and the EU, the reduction in T&D losses was smaller. On the other hand, losses have been increasing in developing countries. In the CIS and the Middle East, they rose from 9 percent to 12 percent in 2010, while they reached 20 percent in India. Latin America also faces a high and growing rate of T&D losses (17 percent in 2010).

Figure 10: Evolution of T&D losses
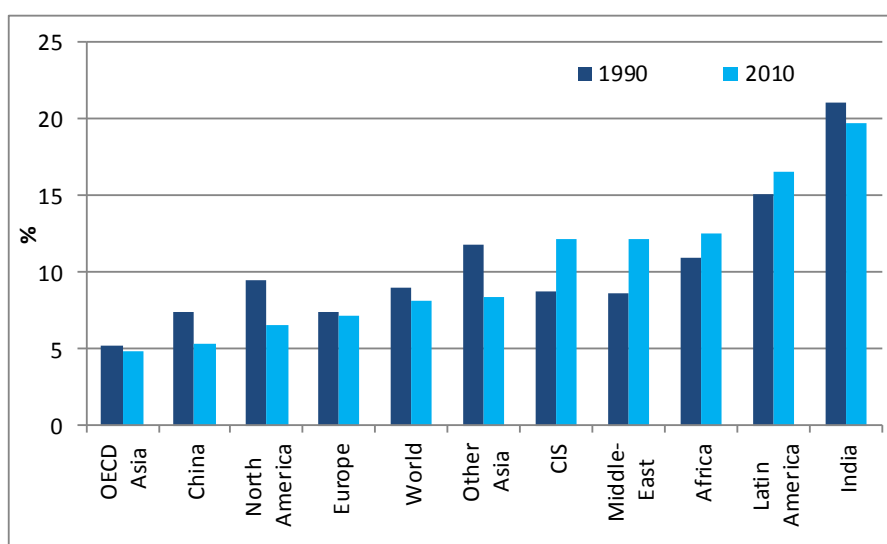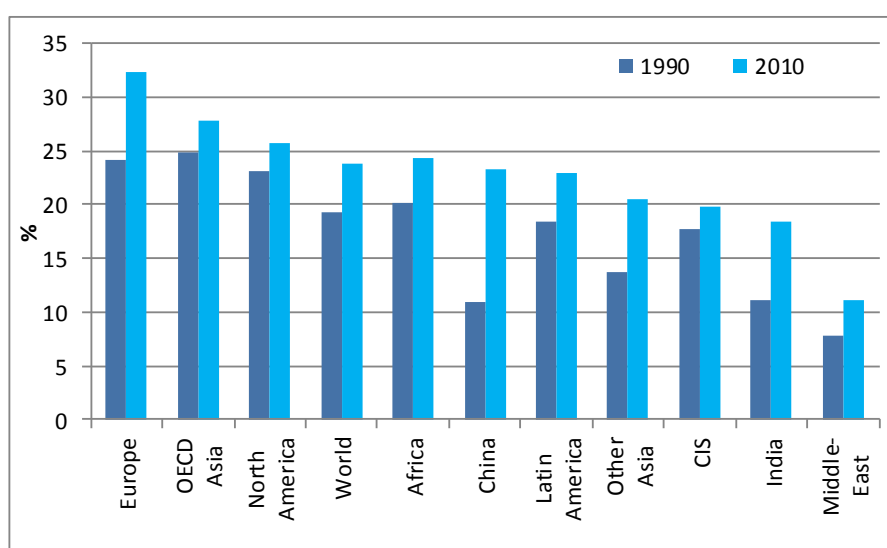

Source: Enerdata

3. Industry

3.1 Global trends

At world level, the share of electricity in industrial energy consumption increased from 19 percent in 1990 to 24 percent in 2010 **(Figure 11)**. That share is higher in developed countries: in 2010 it was above 30 percent in Europe and above 25 percent in North America and OECD Asia. In the Middle East, electricity represented just 11 percent of industrial energy consumption in 2010, showing a slight increase since 1990.

Industrial electricity use is on the rise in all world regions. The largest increases were seen in emerging Asian countries, and primarily in China, where the share of electricity in industrial energy consumption soared from 11 percent in 1990 to 23 percent in 2010. Over the period that share also grew substantially in Europe (+8 points), while in North America and OECD Asia it has remained relatively stable since 1990. At the world level, the share of electricity in industrial consumption has increased by 5 points since 1990.

**Figure 11: Share of electricity in industrial consumption**

Source: Enerdata

The energy required per unit of value added (industrial intensity) has decreased in all regions except the Middle East since 1990. As a result of the globalization of industrial activities, energy intensity levels are converging. At world level, it fell by 1.4 percent/year between 1990 and 2010 (0.5 percent/year between 2000 and 2010).

Industrial energy intensity is lowest in Europe, OECD Asia and Africa, where it stands 40 percent below the world average **(Figure 12)**. Energy intensity is relatively higher in North America than in Europe and OECD Asia: it stands just 5 percent below the world average and 65 percent above the European average.

Figure 12: Industrial energy intensity
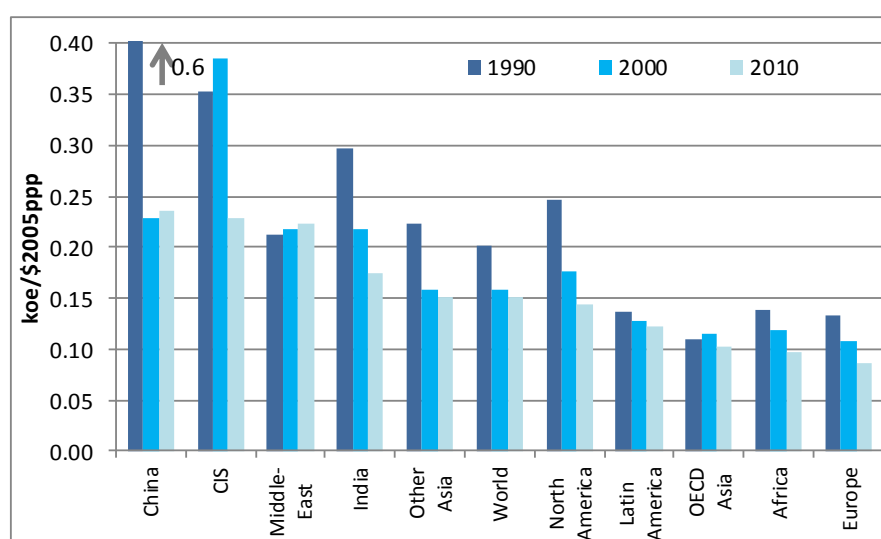
Source: Enerdata

The sharpest decreases over the period 1990-2010 were seen in countries with the highest levels of industrial energy intensity (**Figure 13**). In China, India, the CIS and the United States industrial energy intensity was reduced by more than 2 percent/year between 1990 and 2010. However, despite large reductions over the period, China and India still have above-average industrial energy intensity levels: 15 percent higher in the case of India and 50 percent in the case of China. In the Middle East, industrial energy intensity remains among the lowest in the world and has decreased moderately since 1990 (0.3 percent/year).

The slowdown caused by the global economic crisis in 2009 had a strong impact on industrial energy intensity trends. In almost all regions, the reduction in industrial energy intensity slowed down significantly: the drop in energy consumption was lower than the reduction in industrial production. In Europe, for instance, it fell by 2.1 percent/year between 1990 and 2008, compared with 1.1 percent/year over 2008-2010. OECD Asia, North America and India even posted a reverse trend (for instance, -0.3 percent/year between 1990 and 2008 for OECD Asia, compared with 4.1 percent/year over 2008-2010). This phenomenon is due to the fact that part of the industrial energy consumption is not correlated with GDP and remains stable despite the drop in production.
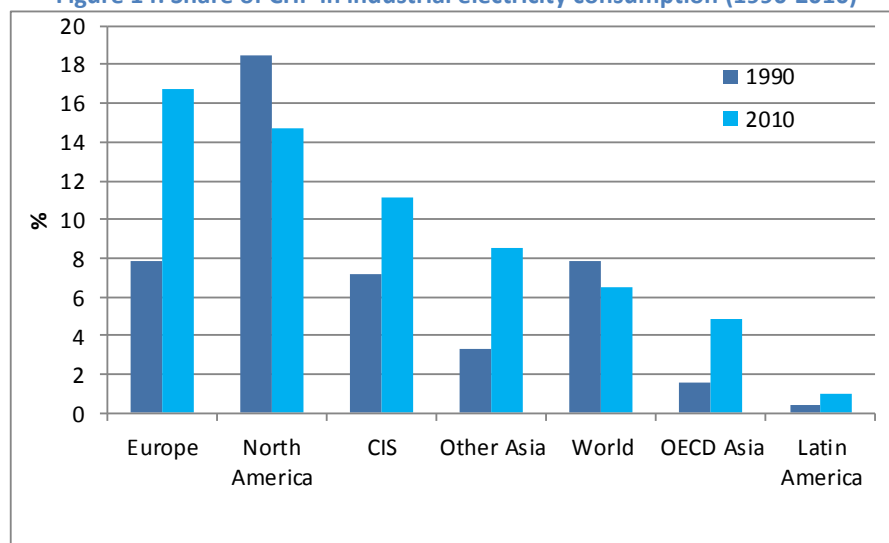
Figure 13: Industrial energy intensity trends

Source: Enerdata

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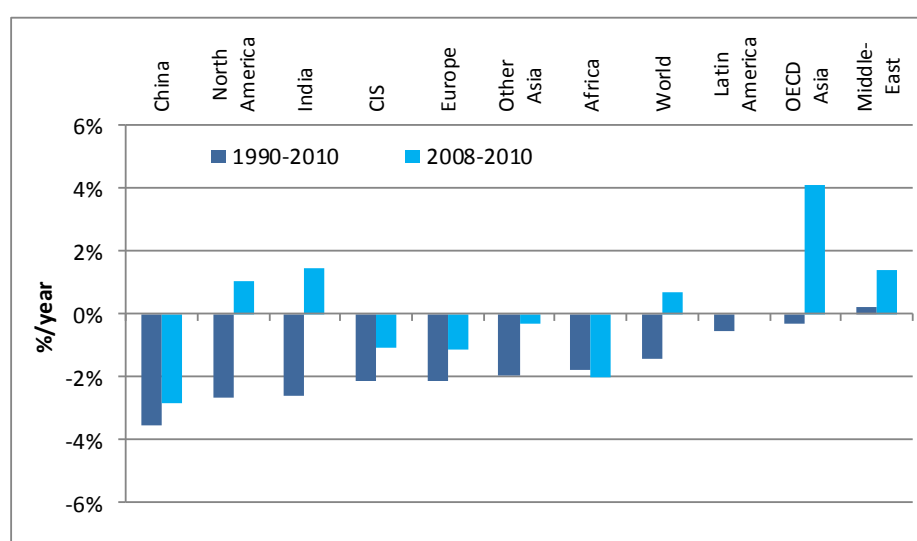
Industrial cogeneration (CHP) covered around 6.5 percent of industrial electricity consumption in 2010, compared with around 8 percent in 1990 **(Figure 14)**. This decreasing trend is strongly influenced by the trend in North America, since in 1990 that region represented more than half of the worldwide electricity production from industrial CHP and in 2010 one third. A reverse trend was seen in all other regions. In Europe, the share of cogeneration increased by 9 points between 1990 and 2010, when it reached 17 percent. Following this increase, the share in Europe is now larger than in North America, where CHP accounted for 15 percent of industrial consumption in 2010, compared with 18.5 percent in 1990. In OECD Asia, CHP represents just 5 percent, approximately, of industrial consumption, up slightly since 1990. In turn, a sharp rise was seen in Other Asia, where the share of CHP in industrial consumption increased from 3 percent to 9 percent between 1990 and 2010. In the CIS, the share of CHP is higher (11 percent in 2010) but has developed at a slower pace since 1990 (by 4 points).

**Figure 14: Share of CHP in industrial electricity consumption (1990-2010)**

Source: Enerdata

At world level, energy-intensive industries accounted for 55 percent of industrial consumption in 2009, up from 50 percent in 1990 **(Figure 15)**. Steel absorbs about 20 percent of industrial consumption while the non-metallic minerals (cement, glass, ceramics, etc.) and chemical industries consume around 15 percent each and the paper industry 5 percent.

The share of energy-intensive industries in industrial consumption is highest in OECD countries, the CIS and China, and stands below the world average in other developing countries. The large share of energy-intensive industries in China and the CIS partly explains the previously observed high industrial energy intensity. However, thanks to the use of more efficient technologies that is not the case in developed regions, which include the countries with the lowest industrial energy intensity.

Industrial energy intensity trends are influenced by energy productivity improvements in each individual branch (ie, steel, chemicals, non-metallic minerals), but also by changes in the structure of the industrial value added. Industrial activities have moved toward less energy-intensive branches (equipment, textiles, etc.), which lowers energy intensity. In India, a decrease in the share of energy-intensive industries (from over 38 percent in 1990 to 33 percent in 2009) contributed to the increase in the country's industrial energy productivity, in addition to energy efficiency improvements. In turn, an increasing share of energy-intensive industries in the CIS between 1990 and 2009 played its part in limiting the improvements in energy productivity over the period.

Figure 15: Share of energy-intensive industries in industrial consumption (1990/2009)
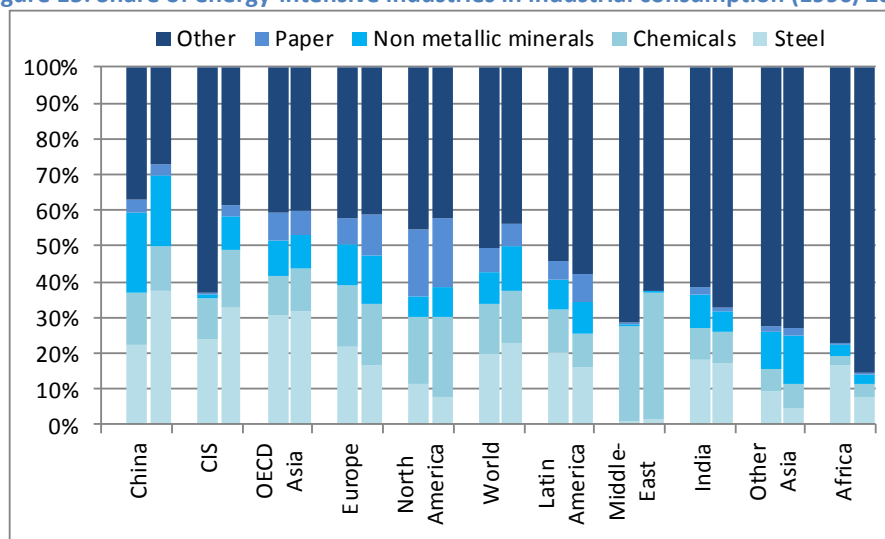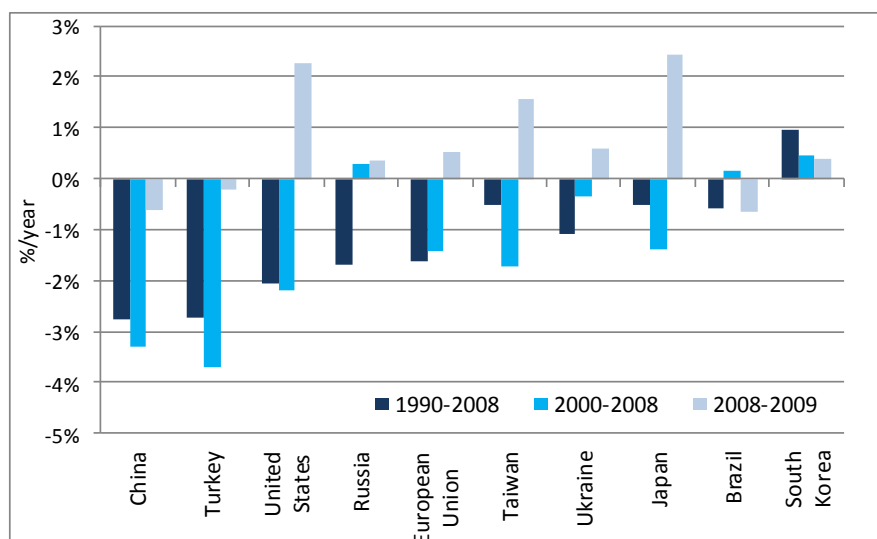

Source: Enerdata

3.2 Steel industry

The steel industry is the main industrial energy consumer and the largest source of industrial CO_2 emissions: it represents about 20 percent of global industrial energy consumption and 15 percent of industrial CO_2 emissions from fuel combustion. More than half of the world's crude steel production is supplied by China, Japan and the United States.

The countries that showed the greatest reductions in their specific consumption between 1990 and 2009 were also the countries that made the greatest use of the electric process, since on average this process uses only half the energy required by the most widespread process, ie, the oxygen/blast furnace process[9] **(Figure 16)**.

Figure 16: Trends in the specific energy consumption of the steel industry[10]
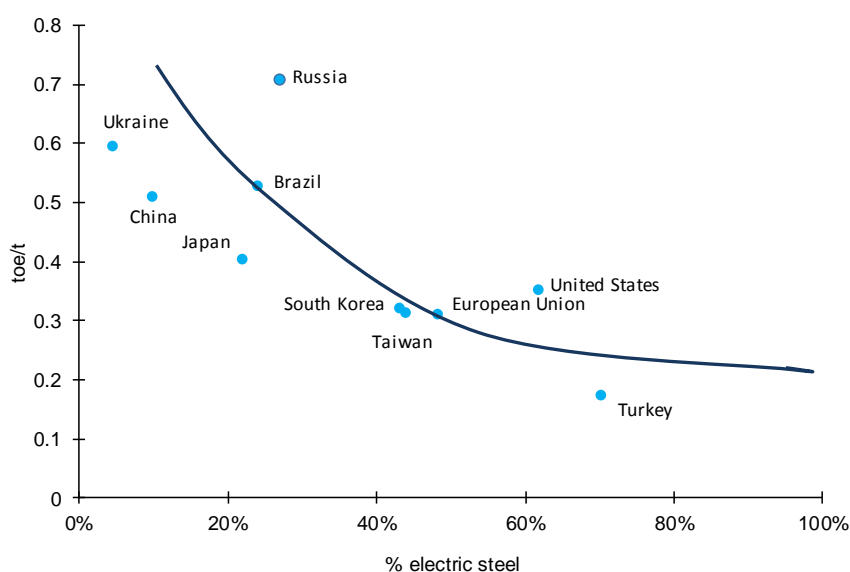

Source: Enerdata

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[9] According to the International Steel Industry Institute, two times less energy is required to produce one ton of steel using the electric process than when using the oxygen/blast furnace process (0.2-0.3 tep/t compared with 0.5-0.7 tep/t).
[10] 1992-2009 for Ukraine. No data for India.

The countries with the largest share of electric steel (Europe, US, South Korea, Taiwan, Turkey) have the lowest energy consumption per ton of steel produced **(Figure 17)**.

However, the spread of the electric process is not the only factor impacting energy efficiency in the steel industry. For the same share of steel produced using the electric process, specific consumption is 1.5 to 2 times higher in Russia, China, Ukraine and Brazil than in Japan. This lower energy performance can be explained by several factors, such as the use of outdated processes like open-hearth furnaces in Russia and Ukraine, or the use of small-sized plants and low quality ore in China. Accordingly, the potential for further energy and CO_2 savings is still high. The energy consumption of the steel industry could be reduced by 40 percent if the main producing countries were to have the same energy efficiency as that achieved by the world's best performer through its current mix of processes; about 60 percent of those energy savings would take place in China.

Figure 17: Specific energy consumption of the steel industry
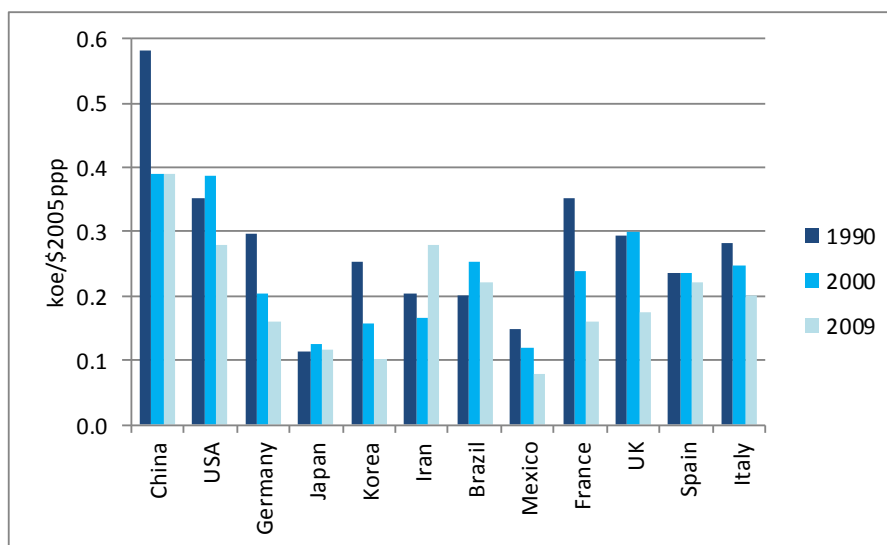

Source: Enerdata

3.3 Chemical industry

The chemical industry is the second largest industrial energy consumer, accounting for just over 14 percent of total industrial energy consumption[11]. In the United States the chemical industry is even the largest energy-intensive branch, with 25 percent of industrial consumption in 2009.

In 2009 China had, by far, the highest energy consumption per unit of value added among the world's main producers of chemical products **(Figure 18)**. Its energy intensity is high, since coal-based production in China requires much more energy than natural gas-based production in other countries.

The largest decrease in the energy intensity of chemicals since 1990 (-6.8 percent/year) was seen in Mexico. Other countries such as South Korea, Germany, France and the UK also saw substantial decreases in their energy intensity, whereas Iran and Brazil posted a growth. Since the chemical industry is highly diverse it is difficult to link these energy intensity reductions to the spread of more efficient processes, in particular, and to genuine energy efficiency improvements; indeed, part of the energy intensity reduction may be explained by a change in the product mix, for instance from heavy chemicals to light chemicals.

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[11] Excluding chemical feedstocks

koe/$2005ppp axis, years 1990, 2000, 2009 for China, USA, Germany, Japan, Korea, Iran, Brazil, Mexico, France, UK, Spain, Italy

Source: Enerdata

3.4 Cement industry

The non-metallic minerals industry (cement, glass, ceramics, etc.) is the third largest industrial energy user, accounting for just about 13 percent of industrial energy consumption. The cement industry absorbs most of the energy consumption of the non-metallic minerals industry and, on average, represents around 70-80 percent of the branch's consumption. China alone accounts for half of the energy consumption for cement production.

The energy efficiency of cement production strongly depends on the process used to produce the clinker, the main component in cement manufacturing[13] (dry or wet), and the type of kiln. Indeed, the dry process avoids the need for water evaporation and is much less energy intensive than the wet process; whereas vertical shaft kilns are the most energy intensive, dry kilns with pre-heaters and pre-calciners are the most efficient **(Figure 19)**.

Figure 19: Unit consumption of clinker by technology/process used

| Technology/process	Unit consumption
Vertical shaft kilns	5 GJ/t (0.119 toe/t)
Wet kilns	5.8-6.7 GJ/t (0.139-0.160 toe/t)
Long dry process	4.5 GJ/t (0.107 toe/t)
Dry kiln (four stages pre-heater)	3.2 GJ/t (0.076 toe/t)
Dry kiln (six stages pre-heater and pre-calciner)	2.8 GJ/t (0.067 toe/t)

Source: International Energy Agency

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[12] 2008 data for China and Iran

[13] Cement is produced by grinding clinker and additives such as ashes; on average, cement is made of between 80-90 percent of clinker.

The most efficient technologies used to produce cement are found in Japan, Mexico and in European countries, whereas the technologies used in Asian and North American countries are less efficient. Vertical shaft kilns are used for almost half of the cement production in China since, while being more energy intensive, that technology is better suited to the smaller factories found in the country.

Between 1990 and 2008, the average energy consumption per ton of cement produced decreased in the main producing countries, except in France, the US, Turkey, Russia and Mexico **(Figure 20)**. This can mainly be explained by the shift from wet- to dry-process cement kilns and the replacement of older dry kilns by new ones using pre-heaters and pre-calciners. The largest drop in the specific energy consumption of the cement industry was seen in China, where the replacement of small cement plants by larger facilities has led to a 5 percent/year decrease since 1990. Although significant progress has been recorded in China, the country continues to have the highest energy savings potential. Indeed, if the main producing countries were to have the same energy efficiency as the world's best performer through the same clinker-to-cement ratio, the specific energy consumption of the cement industry would drop by 20 percent, with China accounting for about 80 percent of those savings. For almost all countries, energy consumption per ton of cement produced increased strongly in 2009 since part of the energy is consumed independently of the quantity of cement produced (ie, fixed size of boilers).

Figure 20: Unit consumption trends in the cement industry for the main producers[14]
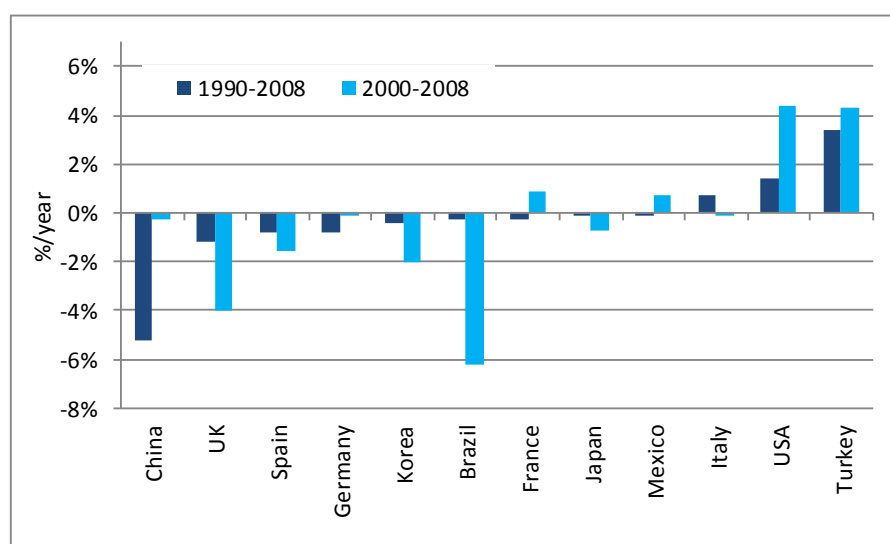
Source: Enerdata

3.5 Paper industry

The paper industry accounts for about 5 percent of global industrial energy consumption. The consumption is mainly used to produce steam. The world's largest producers are the United States, with more than 30 percent of the branch's consumption, Japan, the European Union, China and Canada.

The efficiency of the paper industry is primarily related to the technical age of production facilities. In the United States, aging pulp and paper mills lead to a high specific consumption that exceeds the average level of the main producers. Other factors are the share of imported pulp, the process used to manufacture the pulp and the share of recycled paper. The specific energy consumption is higher in pulp exporting countries. In Canada, the widespread use of mechanical pulping, ie, the process with the highest specific energy consumption per ton produced, combined with aging facilities, leads to a high ratio. The mechanical process is

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[14] Energy intensity trends for the United States, Japan, South Korea and Mexico. No data for India. 2008-2009 trends not provided on the graph due to scale issues.

used for less than 10 percent of the world's pulp production. A high use of recycled paper can also improve the industry's specific consumption. South Korea and Turkey are among the main producers with the lowest energy consumption per ton of paper.

Between 1990 and 2009, the energy consumption per ton of paper decreased in all the world's main producing countries except Brazil and Canada **(Figure 21)**. The largest reductions were seen in China and Mexico, where specific consumption has decreased by about 4 percent/year since 1990. In countries with lower unit consumptions, smaller reductions took place: 1.9 percent/year for Turkey and less than 1 percent/year for other countries. The reduction in the Unites States, which is the largest producer and has a high unit consumption, was just 0.8 percent/year.

Figure 21: Trends in energy consumption per ton of paper
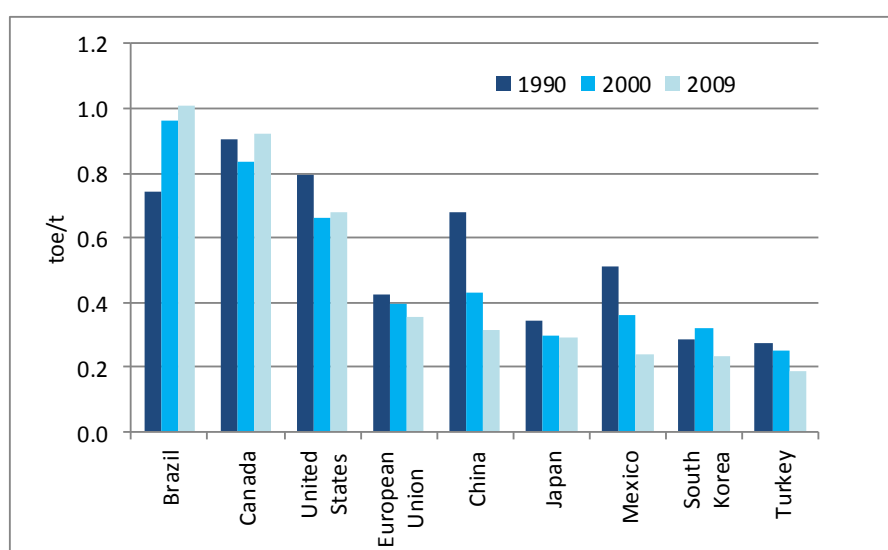
Source: Enerdata

3.6 Aluminum industry

Aluminum production is made up of primary aluminum production and recycling. Primary aluminum production is 20 times more energy intensive than recycling. The world's main producers are China, Russia, North America, Australia and Brazil, which together account for about 60 percent of global production.

The primary production of aluminum requires large amounts of electricity for aluminum smelting, while alumina plants use steam energy, with combined heat and power production in modern facilities. Two main types of smelters are used: the Hall-Héroult system with pre-baked anodes (10 percent of the market), with a relatively high energy efficiency (electricity consumption ranging between 13–16.5 MWh/t); and the older Søderberg cell with in-situ baked electrodes (70 percent of the market), with an electricity consumption ranging from 15 MWh/t to 18 MWh/t.

The specific electricity consumption for primary aluminum production varies on a narrow range among world regions, from 14.5 MWh/t to 16 MWh/t in 2010 **(Figure 22)**. In Africa, where new facilities have been implemented, it is lower, at 6 percent below the world average. The highest rates are seen in Europe and South America. Accordingly, the electricity savings potential in primary aluminum production is limited.

At world level, specific electricity consumption for primary aluminum production has decreased by 4 percent since 1990. That downward trend was seen in all world regions except Europe, with sharp drops in North America and Africa.

Figure 22: Specific electricity consumption for primary aluminum
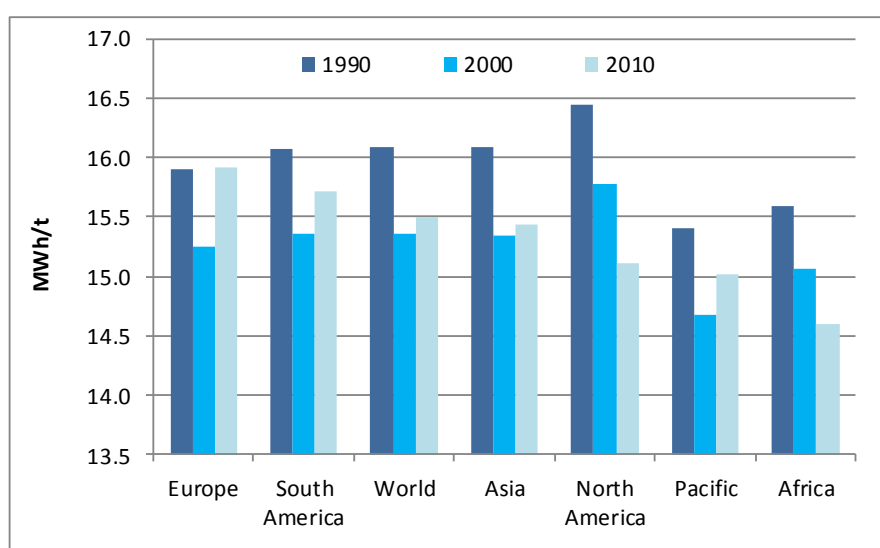
Source: International Aluminium Institute (2010)

According to the International Energy Agency, since the current best practice, ie, that of Hall-Héroult electrolysis cells, is estimated at 12.9–13 MWh/t of aluminum, the global potential for electricity efficiency improvements using the current technology is estimated at around 15 percent. Over time, electrolysis process designs using aluminum chloride or carbothermic processes could become the most energy-efficient way to produce primary aluminum.

4. Conclusion

Over the last 20 years significant progress has been recorded in terms of energy efficiency. At world level, the energy required per unit of GDP (the energy intensity) has been decreasing by 1.2 percent per year since 1990. Improvements were achieved in all regions, with the largest reductions found in the regions with the highest energy intensities (China, CIS and India). Industry and power generation accounted for almost half of that reduction (about 30 percent and 15 percent, respectively).

At world level, the energy efficiency of thermal power plants has improved by 3 percentage points since 1990 thanks to a widespread switch to gas combined-cycle technology. However, strong disparities still exist between developed countries, where thermal power plants are very efficient (up to 48 percent for Spain, the best performer), and developing countries, where efficiency is low due to aging plants and the large share of coal in thermal generation (particularly in China and India). Power grid efficiency improvements led to a reduction in the rate of transmission and distribution losses in developed countries thanks to the use of low-loss conductors and transformers, the standardization and upgrading of transmission and distribution voltages, and reactive power control. However, those technologies are still poorly implemented in developing countries.

The energy required per unit of industrial value added has been decreasing in all regions; as a result of the globalization of industrial activities, energy intensity levels are converging. The global economic crisis in 2009 had a strong impact on industrial energy intensity trends, especially in developed countries, since energy-intensive industries were severely hit.

In the steel industry, which is the main industrial energy consumer, significant progress has been made over the last 20 years thanks to the spread of the electric process. However, the main producers still use outdated processes like open-hearth furnaces (Russia and Ukraine) or small-sized plants and low quality ore (China).

In the chemical industry, the energy consumption per unit of value added decreased in all main producing countries. However, since the chemical industry is highly diverse, it is difficult to link these energy intensity reductions to the spread of more efficient processes, in particular, and to genuine energy efficiency improvements.

The spread of dry processes and kilns using pre-heaters and pre-calciners led to reductions in the average energy consumption per ton of cement (specific energy consumption) in several large producing countries. The sharpest drop in specific energy consumption was achieved in China, thanks to the replacement of small cement plants by larger facilities.

Nevertheless, a great deal still remains to be done, as shown by the significant energy savings potentials identified in this study. In the power sector, the improvement of power generation efficiency could reduce fossil fuel consumption for power generation by 30 percent, and power grid efficiency improvements could reduce global electricity consumption by 4 percent. In industry, the energy efficiency improvement potential is 40 percent in the case of steel, 20 percent for cement and 15 percent for aluminum; potentials in the chemical and paper industries are also high.