Energy efficiency indicators in industry

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Why energy efficiency need to be assessed in industry? Who is concerned by these evaluations?

- Energy efficiency agencies or administrations need to:
  - Monitor sectoral agreements and/or existing regulations
  - Evaluate future potentials
  - Set up new policy measures
  - ➔ They will combine micro and macro data and indicators
- Industrial companies or associations need to:
  - To report about sectoral agreements, in terms of progress achieved or energy savings realized
  - To compare their performance with the companies of the branch ➔ benchmarking
  - ➔ They will rather deal with micro data

Issues to be addressed with respect to energy efficiency in industry

- How to assess energy efficiency progress in an industrial branch ?
- How to compare the energy efficiency performance between companies at national or international level (benchmarking) ?
- How to compare the energy efficiency performance of an industrial branch across countries?
- How to assess the energy efficiency progress at the level of the industry sector?
- How to compare the energy efficiency performance of the industry sector across countries?

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1. Energy efficiency indicators at the level of industrial branch

Content

- Definition
- Indicators of specific energy consumption /energy intensities
  Assessment of energy efficiency progress and energy savings by branch
- Comparison of energy efficiency performance : benchmarking

- Definition

Final energy energy consumption of an industrial branch and energy purchased

- **Energy purchase** in industry **includes** five types of uses:
  - fuel used in industrial process (e.g. kilns, boilers)
  - electricity uses in industrial process (e.g. electrolysis) , in motors , for lighting...
  - diesel consumption of vehicles
  - fuels used for own generation of electricity or for Combined generation of Heat and Power (CHP or cogeneration)
  - uses as a raw materials, mainly in petrochemicals, to produce fertilisers or plastics (also called" non energy uses"

- For industrial consumers, energy consumption is usually assimilated to energy purchased

- For energy efficiency evaluation need to have a more restrictive definition

Energy consumption: definition at macro level (energy balance)

Energy consumption of industry **in energy statistics** (also called final energy consumption of industry) **excludes** :

- ➢ energy transformation industries
  - ✓In section C (mining), energy mining, such as coal mining (Division 10), oil and gas extraction (Division 11);
  - ✓In section D (manufacturing), refineries and coking plants (Division 23);
  - ✓In section E (electricity, gas and water): electricity power plants and gas processing plants (Division 40).

    ➔ in energy transformations
- ➢ diesel consumption of vehicles ➔ in transport
- ➢ fuels used for autoproduction of electricity or cogeneration (own production of electricity on industrial sites) ➔ in energy transformations under production of electricity

There exist a difference between sales to (or purchase by) industrial consumers and final energy consumption of industry

Allocation of fuels for cogeneration between electricity and heat

The fuel input is divided between the electricity and heat in proportion to their shares in the output.

Methodology for Allocating Fuel Use at CHP Plants between the Electricity and Heat Produced

The overall efficiency of the CHP process e is defined as:

$$e = (H + E) / F$$

where: E is the quantity of electricity produced
H is the quantity of heat produced, and
F is the quantity of fuel consumed in the transformation process

The UNIPEDE definition states that "total heat consumption for the production of electric energy in a combined heat and power station is the heat equivalent of the fuel consumed by the plant less the heat supplied for external purposes when related to the fuel input."

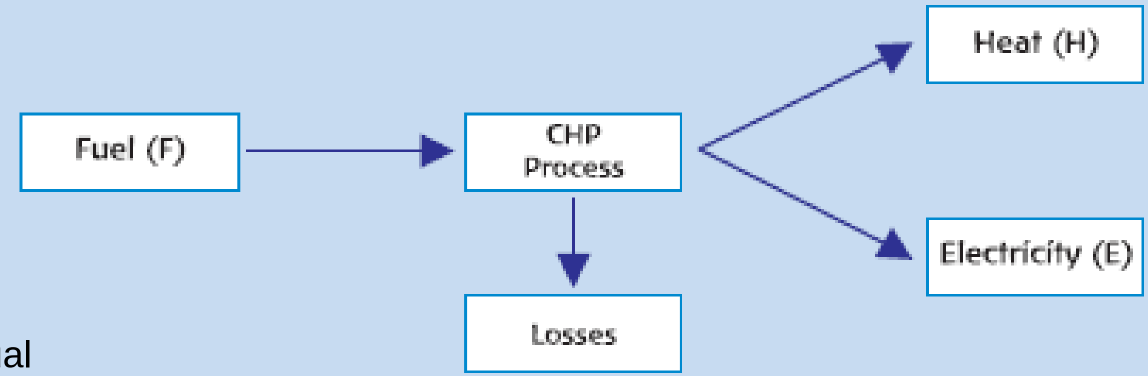
This definition proposes that the imputed fuel used for heat and electricity are:

$F_h = H / e = F [H / (E + H)]$ $F_e = F - H / e = F [E /(E + H)]$

In other words, the fuel input is divided between the electricity and heat in proportion to their shares in the output.

Note: The methodology is based on a UNIPEDE definition and it should be used only if there is no reliable national method for undertaking this allocation.

Figure 2.4 • Simple Diagram Representing the Relationship between the Fuel Input and the Electricity and Heat Produced in a CHP Unit



Source: IEA/Eurostat Energy Statistics Manual

International classification of industrial branches (ISIC or Nace)

➢Industry is broken down into 4 main sectors:

- Section C: Mining
- Section D: Manufacturing
- Section E: Electricity, gas and water
- Section F: Construction

➢Manufacturing is disaggregated into 23 main industrial branches at the two digits levels.

➢By going at a more detailed level (3 or 4 digits level), one can find some key branches from an energy consumption viewpoint, such as cement for instance, which is part of branch 26 (Division 26.5 including lime and plaster and 26.51 for cement alone).

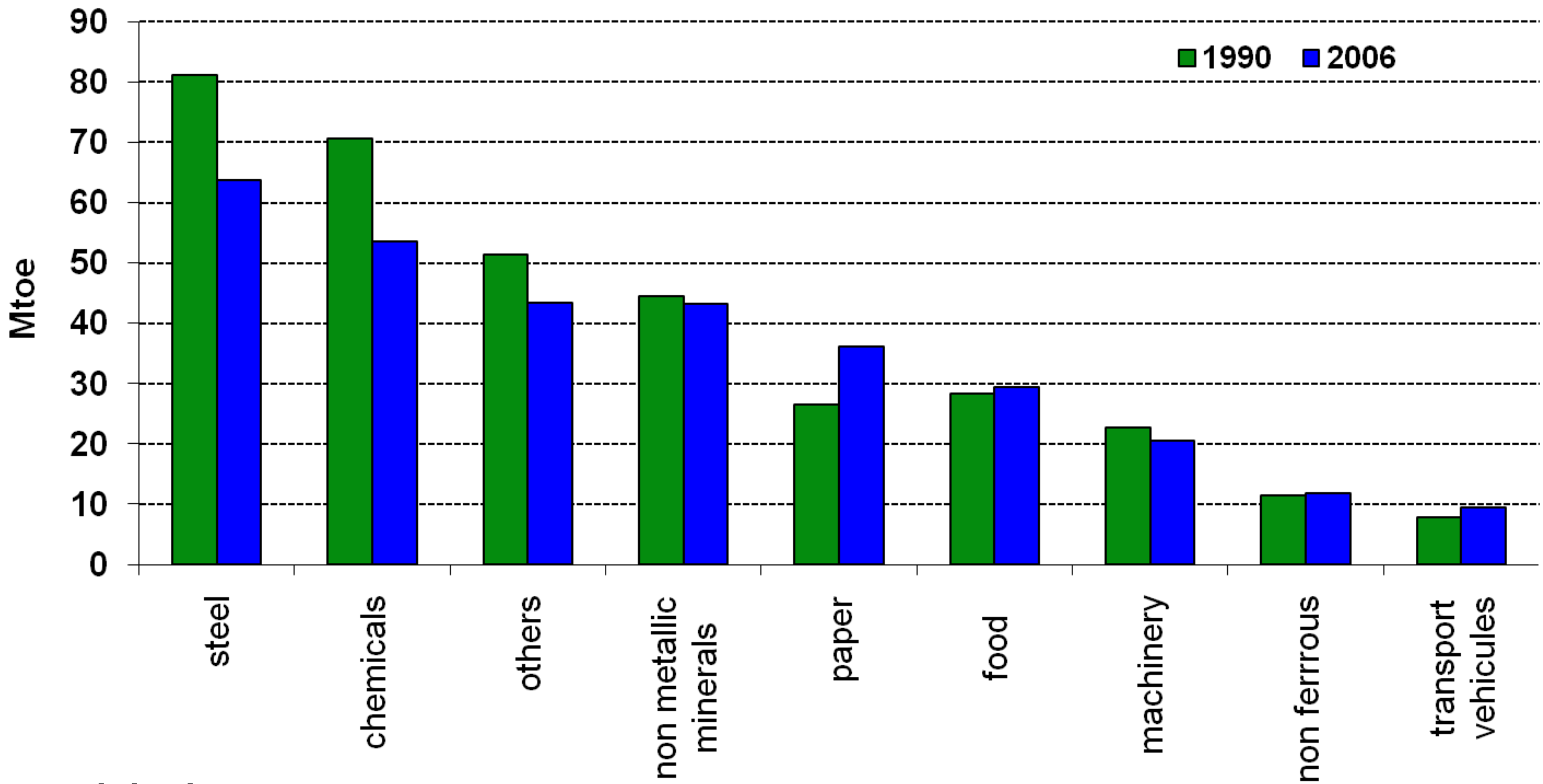
Energy consumption of manufacturing industry by branch: international classification(ISIC / Nace)

	Nace code (2 digits)	
	15-16	Food (15) and tobacco (16)
	17-19	Textile (17), Wearing apparel (18) and Leather (19)
	20	Wood
	21-22	Paper (21) and printing (22)
	24-25	Chemicals (24), Rubber & plastics (25)
	26	Non metallic Minerals
	27	Primary metals (steel, non ferrous)
	28	Fabricated metallic products
	29	Machinery and equipment
	30-33	Office equipment (30), electrical machinery (31), communication equipment (32), optical (33)
	34-35	Motor vehicles (34) and transport equipment (35)
	36-37	Others (furniture,...)

Refineries and coking plants (Division 23) excluded;

Change in energy consumption of industry by branch (EU)

Decrease of the energy consumption for most industrial branches, except for 2 branches (paper, food); others branches quite high (construction included)



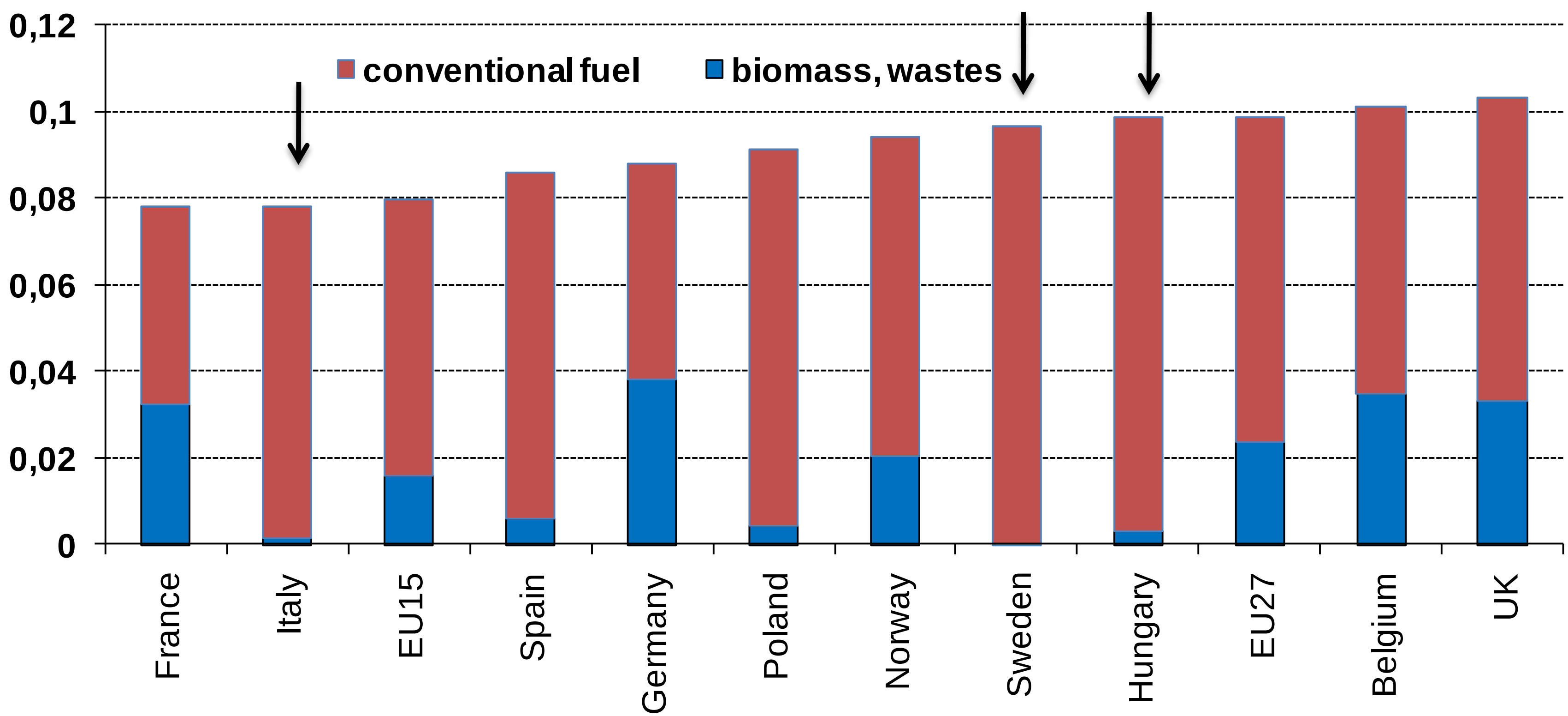
« others » includes also construction

Energy consumption for EU-27 is provided by Eurostat

Non-conventional fuels

- Important in some branches: cement, pulp and paper, food industries
- Contribute to around 25% of consumption of clinker in the EU on average; high contribution for Germany and France (around 40%)
- Not often well covered by conventional statistics, need to be complemented with industry sources (eg cement associations)
- Sometimes included in total and not given by branch

Share of non conventional fuel in the specific consumption per ton of clinker (toe/t)



- Indicators of specific energy consumption /energy intensities

Overall indicators of energy efficiency in industry

- **Specific energy consumption**: ratios relating the energy consumption to the output of the plant measured in physical units → toe/tonne GJ/t, kWh/t;
  - If several products the production of the dominant output (e.g. cement) should be used or the dominant intermediate product (e.g. crude steel);
  - If there is no dominant production (i.e. various types of outputs) ,two indicators can be used:
    - An index of industrial production
    - Or a monetary indicator, can be used
- Specific energy consumption should be as much as possible measured in physical units to enable a more detailed analysis of technical changes

Index of industrial production

✓**M**easure the changes in the volume of physical production in relation to a base year➔ index base 100 in 2000 for instance

✓Measured at a very detailed level (4 to 5 digits) on the basis of physical production in different units (e.g. number of litres of milk processed , of tons of meat produced for the food industry)

✓Are aggregated at the branch level (e.g. food) on the basis of the weight of each sub-branch in the value added of the branch in the base year (2000)

✓Most common indicator used to measure the industrial output (monthly monitoring)

Monetary indicators: production value vs value added

- Value added should be preferred to output value (i.e. turn over) as its variation is closer to the physical output

- Production value may be affected by a change in the price of inputs, which is not the case for value added ;

- Value added should be measured at constant price so as to remove the effect of inflation (using a price deflator or the rate of inflation)

- Monetary indicators are thus ratio relating the energy consumption to the value added (koe/Rs2000)

Price deflator (DEF): price index used to convert a monetary value given in nominal price (PRX) into a value **at constant price** (PRC); it equals 100 for the reference year (e.g. = 100 in 2000 if the values are measured at constant 2000 prices and 120 in 2005 if prices increased by 20% between 2000 and 2005) ; PRC = PRX/DEF x 100

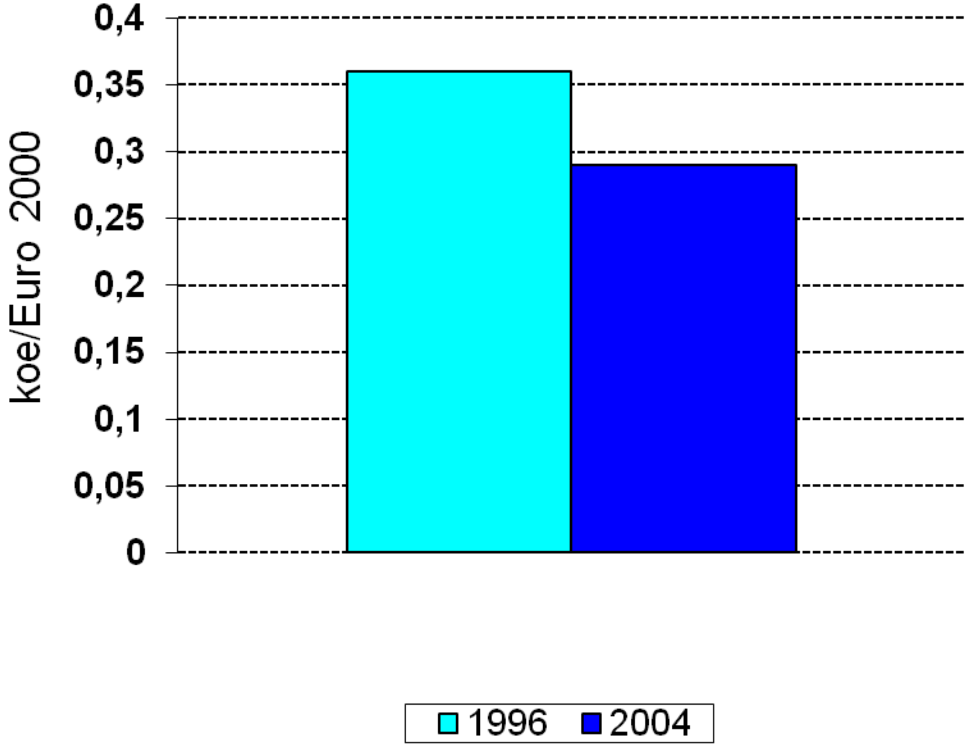
Rate of inflation: annual change in general price level (e.g. 5%)

Basic indicators: specific consumption and sectoral intensities

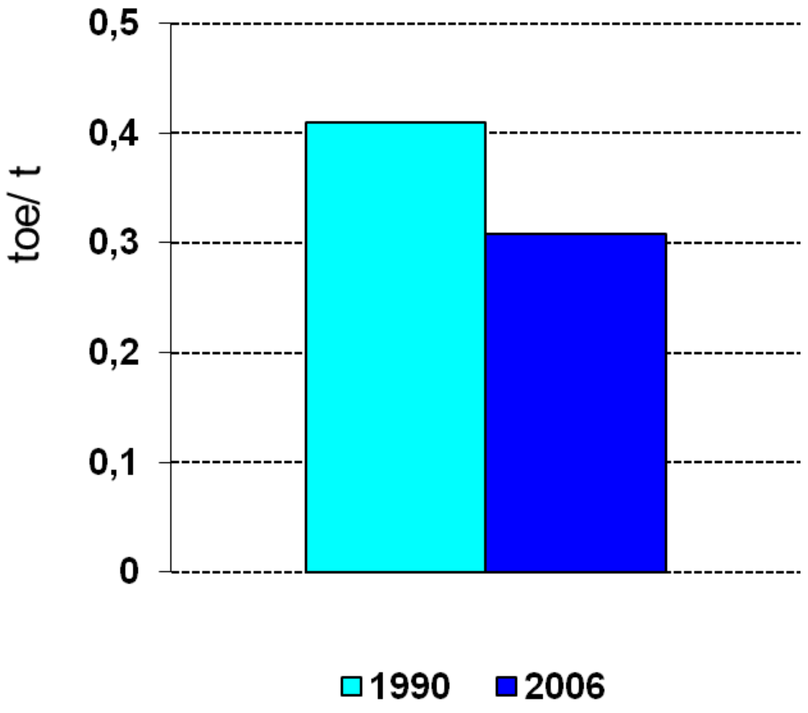
Energy intensity: ratio energy consumption over value added*

Specific energy consumption: ratio energy consumption over physical production

Example of chemicals (EU)



Example of steel (EU)



Value added: turnover minus intermediate consumption (inputs)

How to express changes in specific energy consumption

- Variation of a specific energy consumption can be expressed :
  1. In absolute values (e.g. in toe/ton or kWh/ton)
  2. In terms of index of variation between two years (base year = 100)
  3. In terms of a variation of a period (% reduction)
  4. In terms of an average annual growth rate (%/year over a period) (agr)
- Example : reduction of the specific consumption per ton of cement from150 to 120 kWh/ton between 1990 and 2005
  1. Absolute value : 30 kWh/ton
  2. Index of variation between two 1990 and 2005: 80 in 2005
  3. Variation over the period: 20% reduction
  4. Average annual growth rate (agr): 1.5%/year*

* $120 = 150\,(1+agr)^{15}$ ➔ agr= ((120/150)^(1/15))-1=0.015

Trend in specific energy consumption or energy intensities of industrial branches

➢Variation in the specific energy consumption or amount of energy savings at a plant level can be linked to various factors:

- Energy savings actions of consumers, linked to prices and policies; ↘
- Changes in fuel mix (fuel substitutions) because of difference in end-use efficiencies (e.g. from coal to gas) ↘ ↗
- Fluctuations in industrial activity (« business cycles ») ↘ ↗
- Changes in process mix (e.g. electric steel to oxygen steel) ↘ ↗
- Changes in product mix (e.g. % clinker/additive for cement, type of paper...) ↘ ↗

➢Before drawing any conclusion about the explanatory factors, need to check that there is no change in definition or boundaries (especially with respect to energy consumption)

Impact of changes in fuel mix

- End-use efficiency of various fuels different at the level of industrial equipments (furnaces,boilers)
- End-use efficiency of electricity =100%, gas around 80%, coal or wastes lower(60 to70%)
  - ✓ a substitution from oil or gas to coal and wastes (e.g. cement) increases the final energy consumption ;
  - ✓ a substitution from oil or gas to electricity decreases the final energy consumption (at the consumer level), but increases the primary energy consumption
- To measure the impact of fuel substitution, we can compare trend in the specific energy consumption (or energy intensity) in useful energy consumption (SECU) and in final energy (SEC)
  - ✓the variation of SECU is independent of substitutions
  - ✓for example, if SEC decreases by 3%/year and SECU by 1%/year ➔ fuel substitutions have contributed to reduce the specific energy consumption by 2%/year

Impact of business cycles

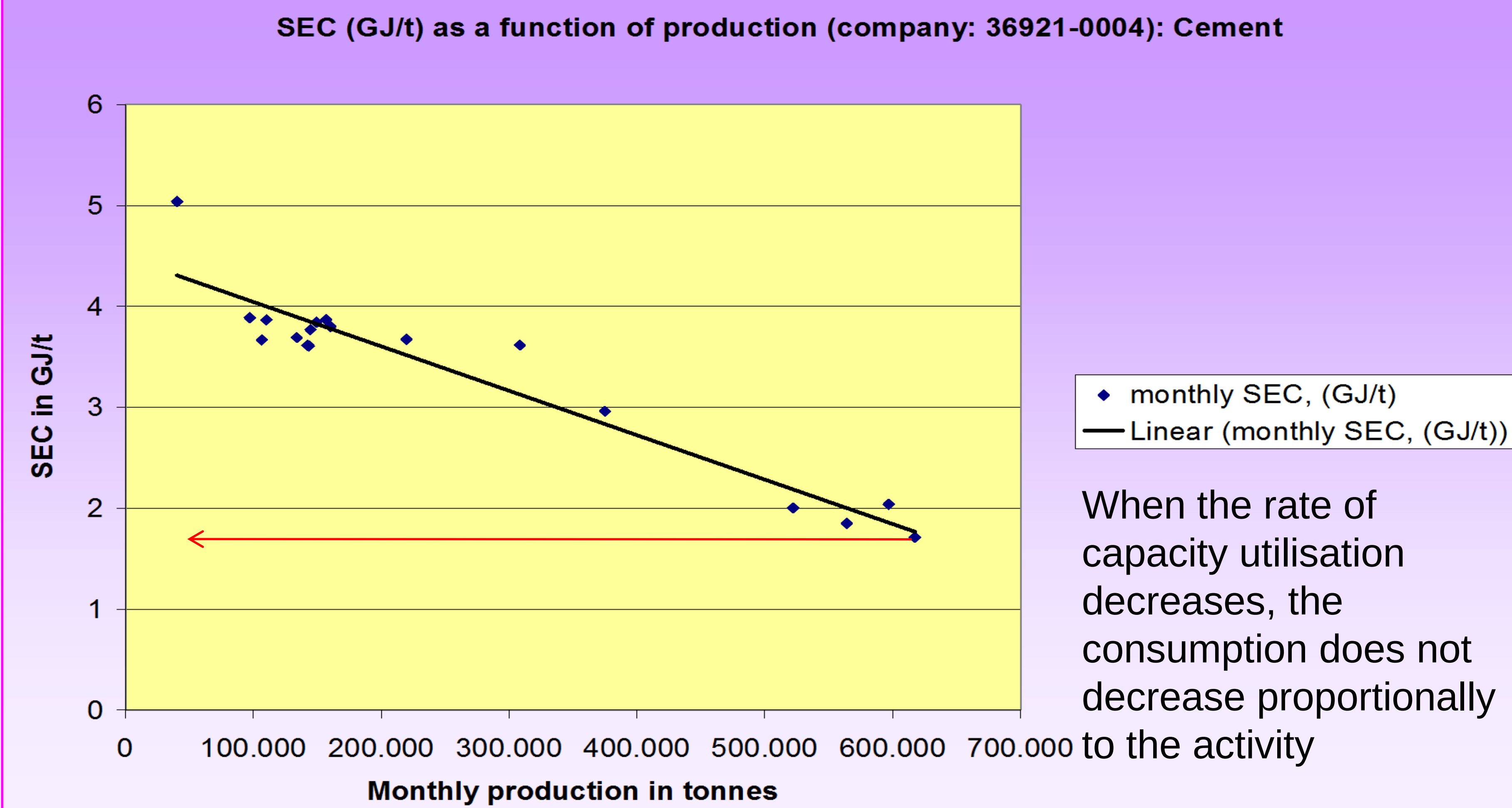
- From one year to the other, variations in specific energy consumption are strongly influenced by business cycles (short term variation in activity)

- A reduction in production => non proportional reduction of energy use as:
  - ✓ part of the consumption is not linked to the level of activity and does not decrease with the production;
  - ✓ the consumption of energy for process does not decrease proportionally to the reduction of production as equipment are less energy efficient with lower rate if utilisation of capacity

    ➔ increase in specific consumption (or energy intensity)

- With strong economic growth, reverse phenomenon ➔ decrease in specific consumption (or energy intensity)

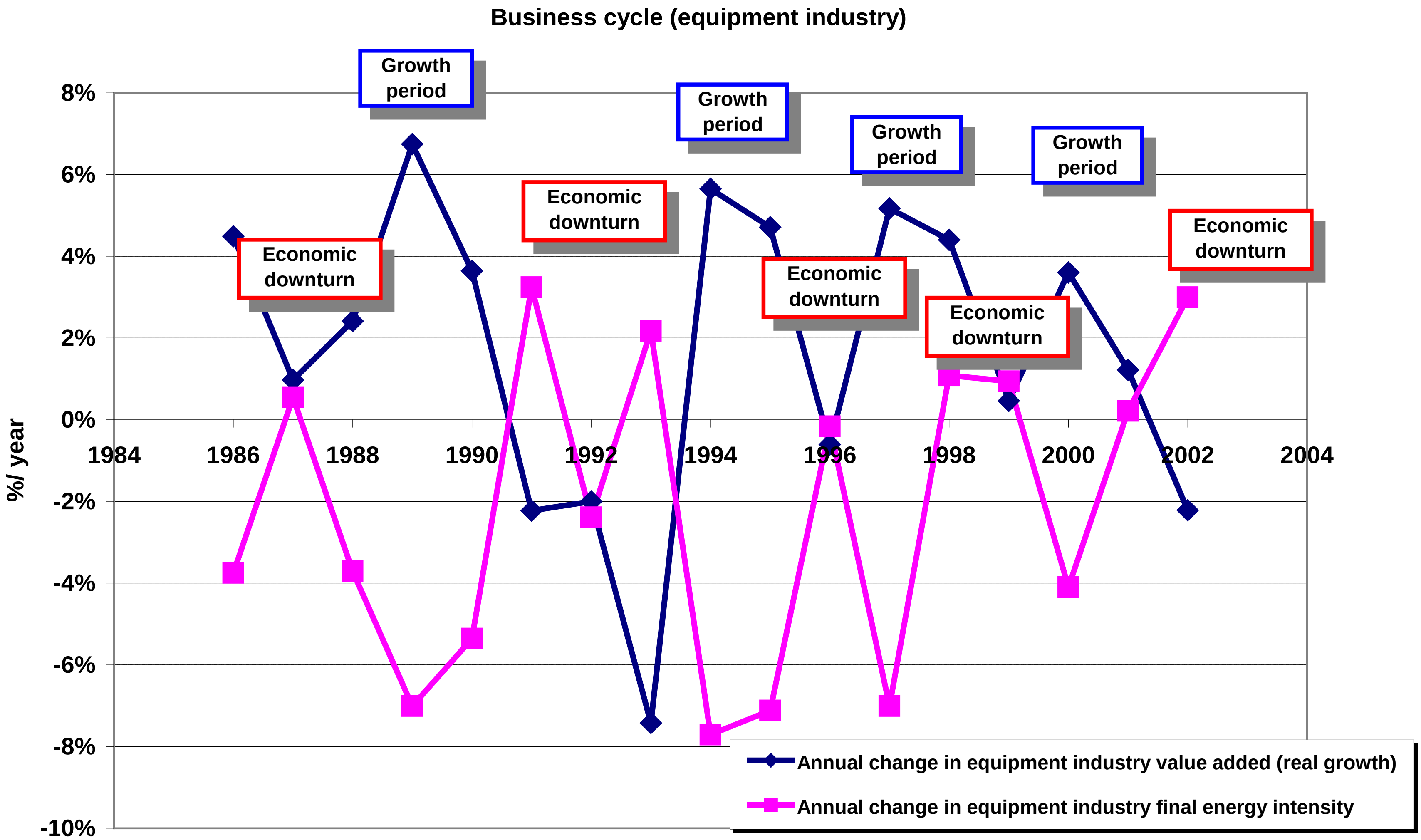
Business cycles: case of a cement factory in Thailand



When the rate of capacity utilisation decreases, the consumption does not decrease proportionally to the activity

Source: W Eichhammer, FhG-ISI

Business cycles :relation value added growth and energy intensity in equipment industry



Impact of changes in process/product mix

➢The specific energy consumption depends on the process or the type of product : in cement industry, to produce one ton of clinker with the wet process requires about 40% more thermal energy than with the dry process

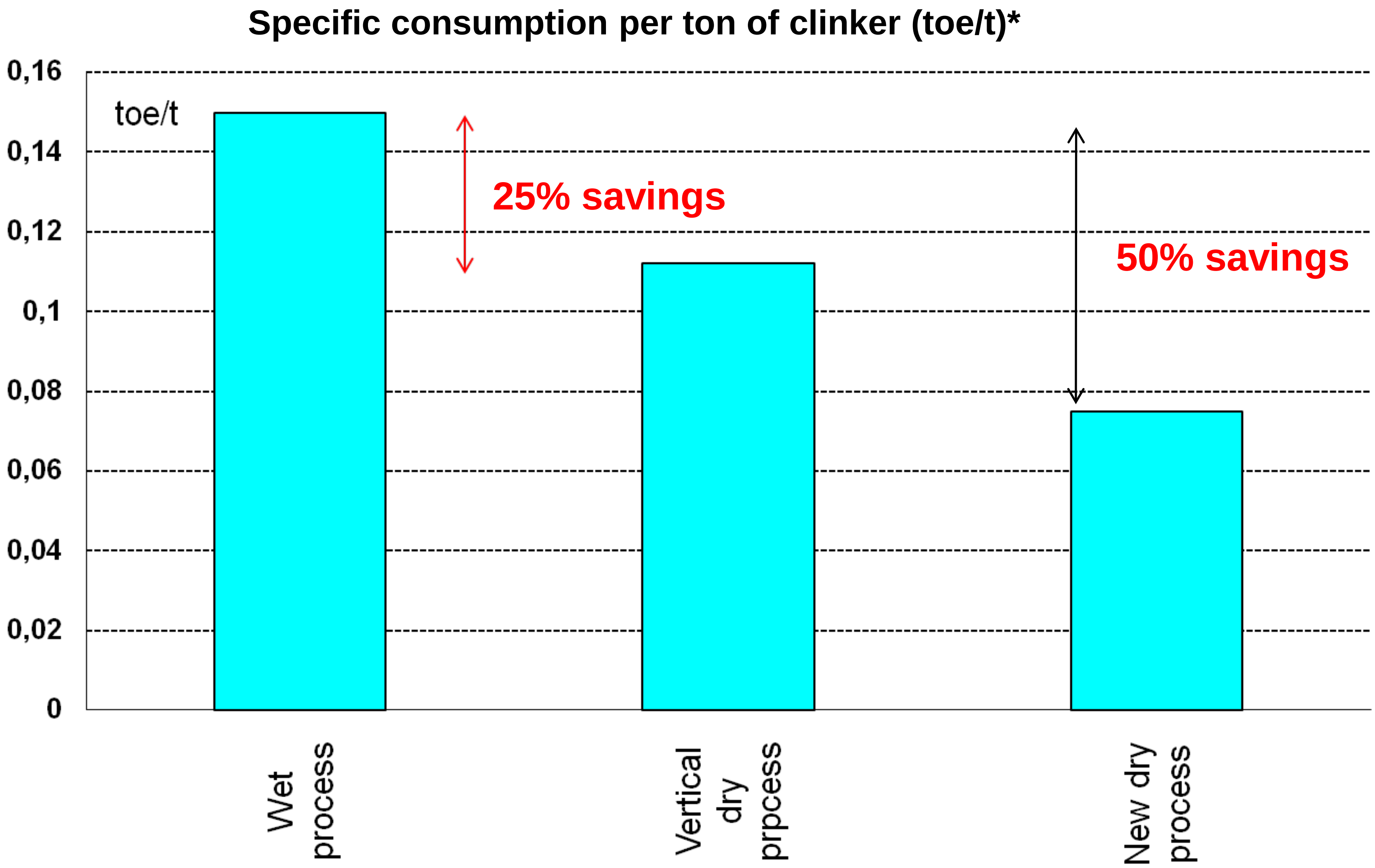
➢To measure the impact of changes in process or product mix between year 0 and year N one can compare the actual average specific consumption in year N with a fictive specific consumption at year N assuming the same process or product mix as at year 0 (i.e. constant product mix)

➢Example if the specific consumption per ton of clinker decreases from 0.09 toe/ton in 1995 to 0.08 toe/ton in 2005 (-1.2%/yr) and the specific consumption at constant process mix decreases from 0.09 toe/ton to 0.086 toe/ton

➔ Energy savings explain a reduction from 0.09 to 0.086, i.e. - 0.5%/yr

➔ Change in process mix contributed to reduce the specific consumption from 0.086 to 0.08 ie - 0.7%/yr

Large differences in the specific energy consumption by process: case of clinker

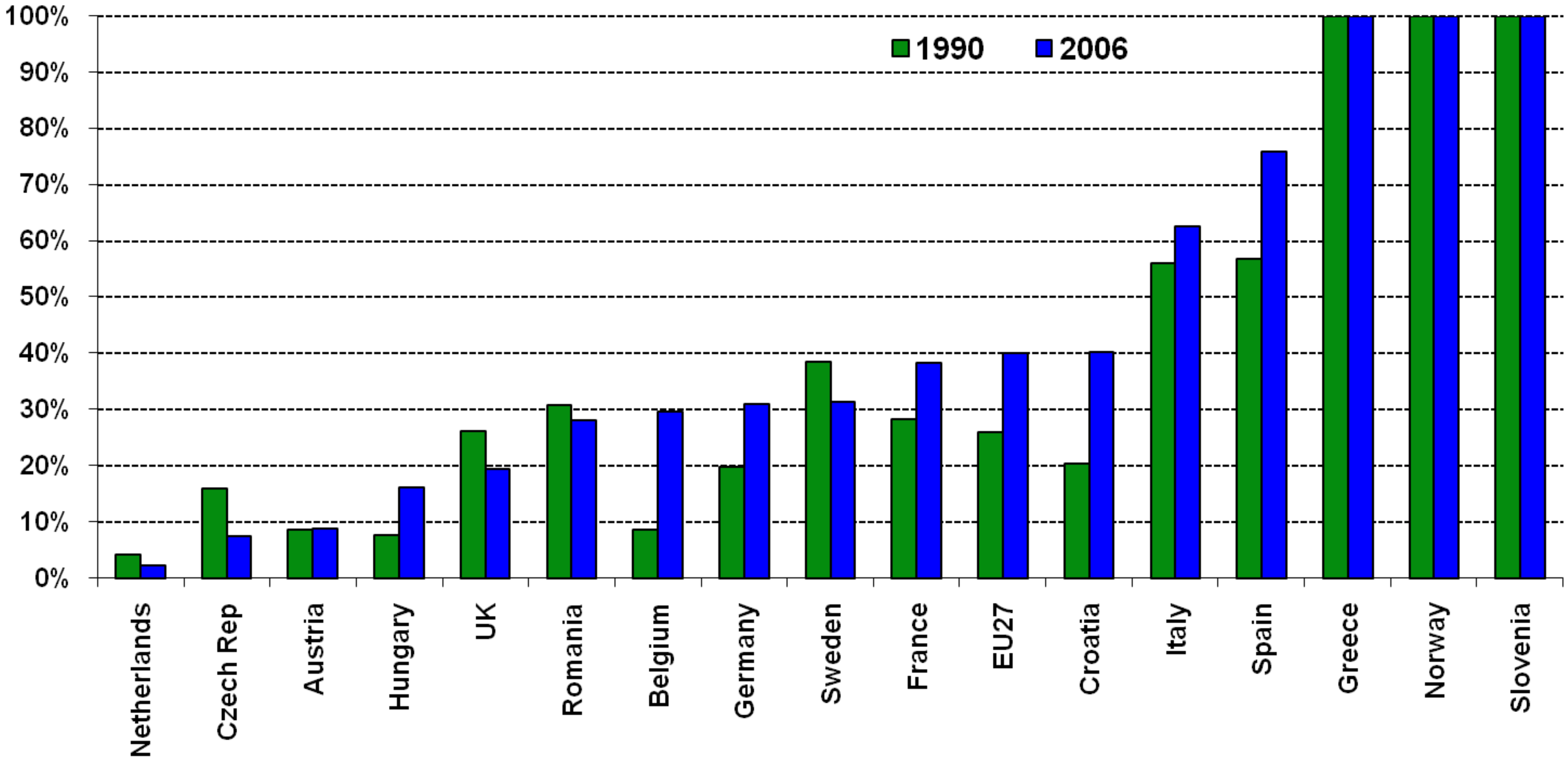


* Data from China

Change in process mix : case of electric/oxygen steel

Increasing share of electric steel in most countries contribute to reduce the average specific consumption per ton of steel as the electric process consumes on average 3 times less than the oxygen process

Share of electric process in steel production in EU countries



- Assessment of energy efficiency progress and energy savings by branch

Evaluation of energy savings and energy effciency progress

- Evaluation of energy efficiency progress or energy savings measured from the variation in specific energy consumption : in %/year, in % over a period, or in energy units (GWh, Mtoe, PJ)

- Evaluation carried out by companies to report about the progress achieved in energy efficiency or the energy savings achieved :
  - ✓ to the shareholders,
  - ✓ to the administration when there are commitments (case of mandatory savings programs)

- Evaluation carried out by industry associations and the administration to monitor **sectoral agreements (**also called “voluntary agreements”)

Calculation of energy savings

- **Definition** : for a company or at a level of an industrial branch i, energy savings are equal to the variation of the consumption Ei due to a reduction in the specific energy consumption Ei/Qi between year t and a base year, as :

  Qt*(Eit/Qit-Eio/Qio) (Qi= output)

- **Example**: case of energy savings in cement production between 1990 and 2005

- 1990 : Consumption : 0.85 Mtoe; production 10 Mt and specific energy consumption 0,085 toe/tonne
- 2005: Consumption : 1.2 Mtoe; production 15 Mt and 0,08 toe/tonne

Energy savings : variation of consumption due to a reduction in specific energy consumption

Ei/Qi = Qit*(Eit/Qit-Eio/Qio) = 15* (0,085- 0,08)=- 0.075Mtoe

- Explanatory effect of the variation in energy consumption

Explanatory effects of the variation of the energy consumption in a branch: energy savings versus activity effect

- Objective: explain the variation of the energy consumption and the respective role of energy savings (-) and industrial growth (+) in this variation ("decomposition method")

- Calculation of a **quantity effect** for each industrial branch i as the variation of the consumption Ei due to a variation of the output Qi measured in physical units (production, index of industrial production) compared to a reference base year 0:

  (Qit-Qio)*(Eio/Qio)

➔Calculation of **energy savings** **(or « unit consumption effect")** for each industrial branch i », as the variation of the consumption Ei due to a variation of the unit consumption Ei/Qi compared to the base year : Qt*(Eit/Qit-Eio/Qio)

Energy savings and quantity effect: example of cement

1990 : Consumption : 0.85 Mtoe; production 10 Mt and unit consumption 0,085 toe/tonne

2002: Consumption : 1.2 Mtoe; production 15 Mt and 0,08 toe/tonne

Consumption variation = 1.2 –0.85 = 0.35 Mtoe

- Consumption variation = quantity + unit consumption effect
- Quantity effect: variation of energy consumption due to increase in production of cement between reference year (1990) and year t (2002) :

(Qit-Qio)*(Eio/Qio)= (15-10)*0,085= 0.425 Mtep

- Unit consumption effet: variation of consumption due to variation in unit consumption Ei/Qi = Qit*(Eit/Qit-Eio/Qio) = 15* (0,085- 0,08)=- 0.075Mtoe (assimilated to energy savings)

Consumption variation = 0.425 –0.075 = 0.35 Mtep

- Comparison of industry performance: benchmarking

Benchmarking of energy efficiency perfomance (1/3)

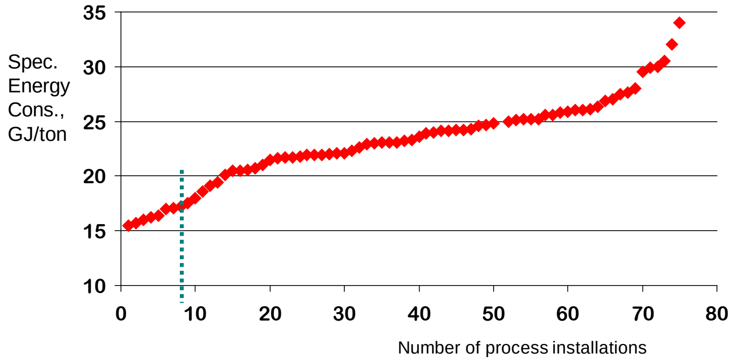
- Benchmarking means comparing to references values

- Benchmarking common in industry:
  - For companies to check how efficient they are compared to the other companies of the sector (in energy intensive industries lower energy input means lower production cost and more profit) (e.g. cement, fertilizer)

  - For energy administrations and energy efficiency agencies :
    - ✓ to evaluate energy savings potential and identify the companies with lower performance that could receive technical and financial assistance
    - ✓ To draw the attention of industrial consumers on implementing energy efficiency programs and to give them incentive to do energy audits and to embark in investments programs in energy efficiency

Benchmarking of energy efficiency perfomance (2/3)

- Benchmarking usually made on a graph showing the specific energy consumption (vertical axis) as a function of the cumulative production (horizontal axis): from the lowest value, i.e. the benchmark, to the highest value (i.e. the less efficient plants)
- The horizontal axis graph represents :
  - The number of plants from 1 to the total number of plants in the country or at world level
  - Or the cumulated production from 0 to total production
  - Or the share of production from 0% to 100%
- The difference between the extreme values give the dispersion of specific consumption and somehow the potential of energy savings



Benchmarking of energy efficiency perfomance (3/3)

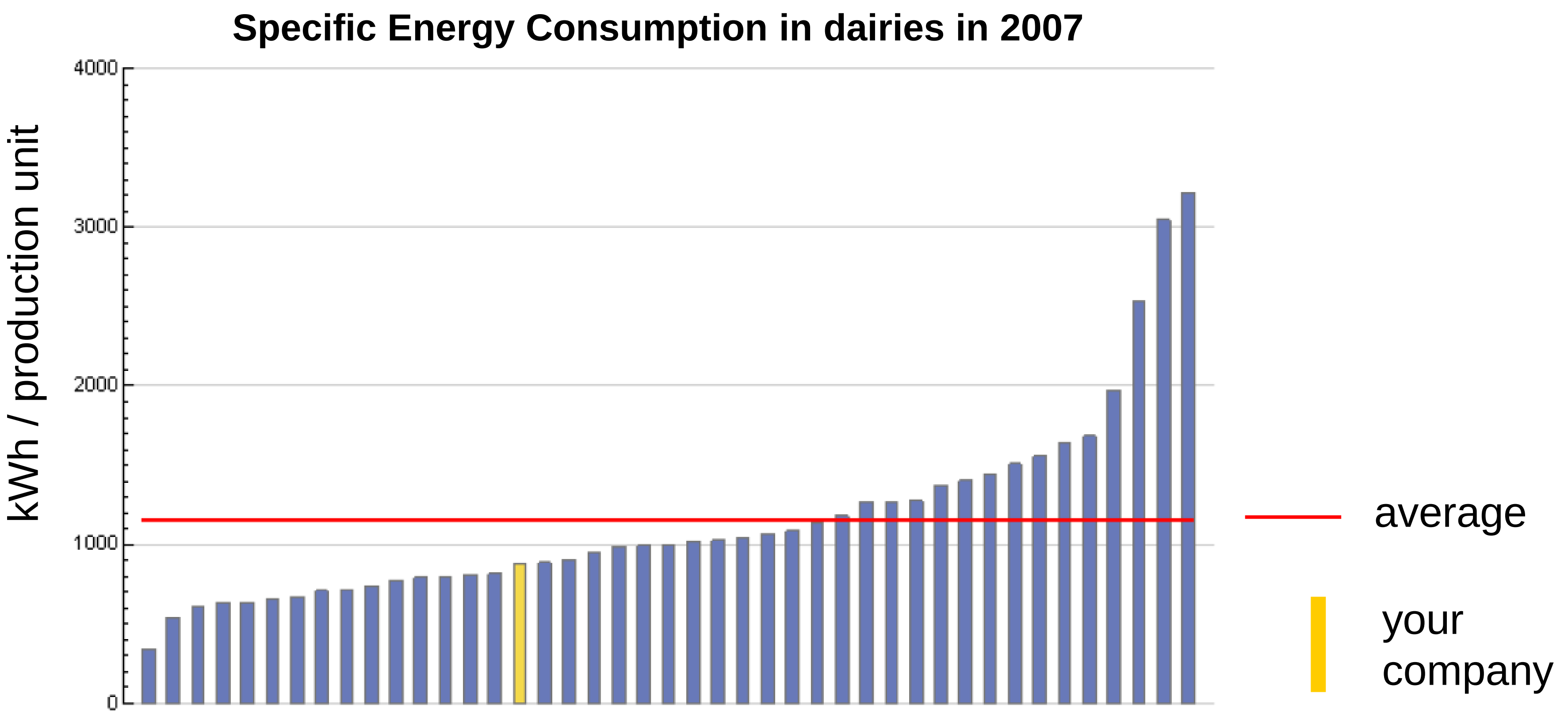
- Benchmarking used for many years in UK within the "Best Practice programs"

- Benchmarking used in the Netherlands to set up target of energy efficiency improvements ("Benchmarking Convenent"): commitment to perform at least as in the 10% best performance in the world by 2012 (dynamic target to catch for improvement at world level : first benchmark cycle established in 1999, second benchmark cycle in 2004)

- Benchmarking used in many countries by administrations, industry associations ; benchmarking service offered on internet for SME's (eg food industry within the "BESS" EU sponsored program) (http://www.bess-project.info)

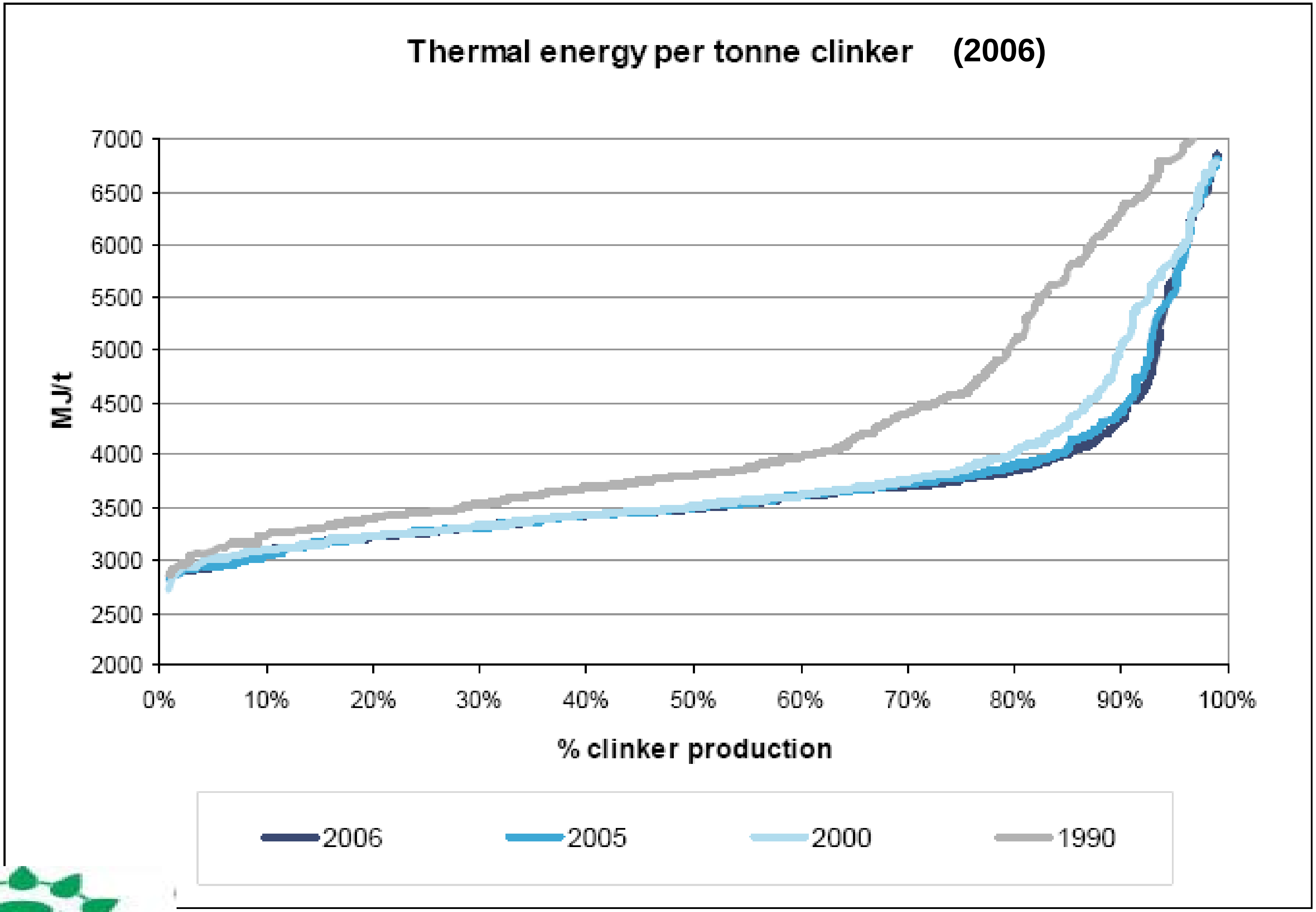
Example of benchmarking: Norwegian dairies

Benchmarking used as a communication tool to raise the awareness of industrial stakeholders



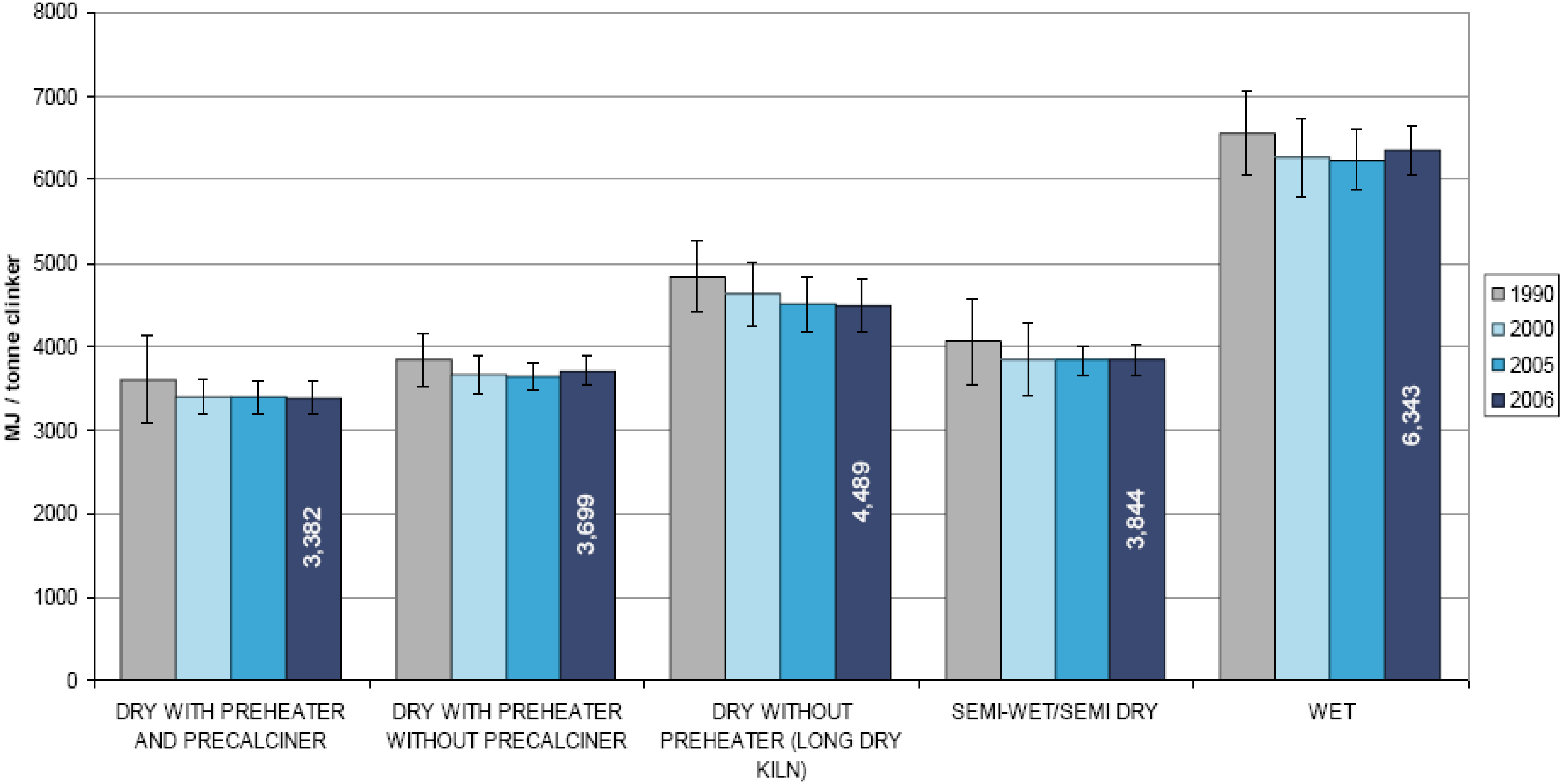
Source: IFE/enova

Benchmarking of cement production at world level: the Cement Sustainability Initiative



Benchmarking of cement production at world level: the Cement Sustainability Initiative

Specific consumption for clinker production (world)



Cement Sustainability Initiative

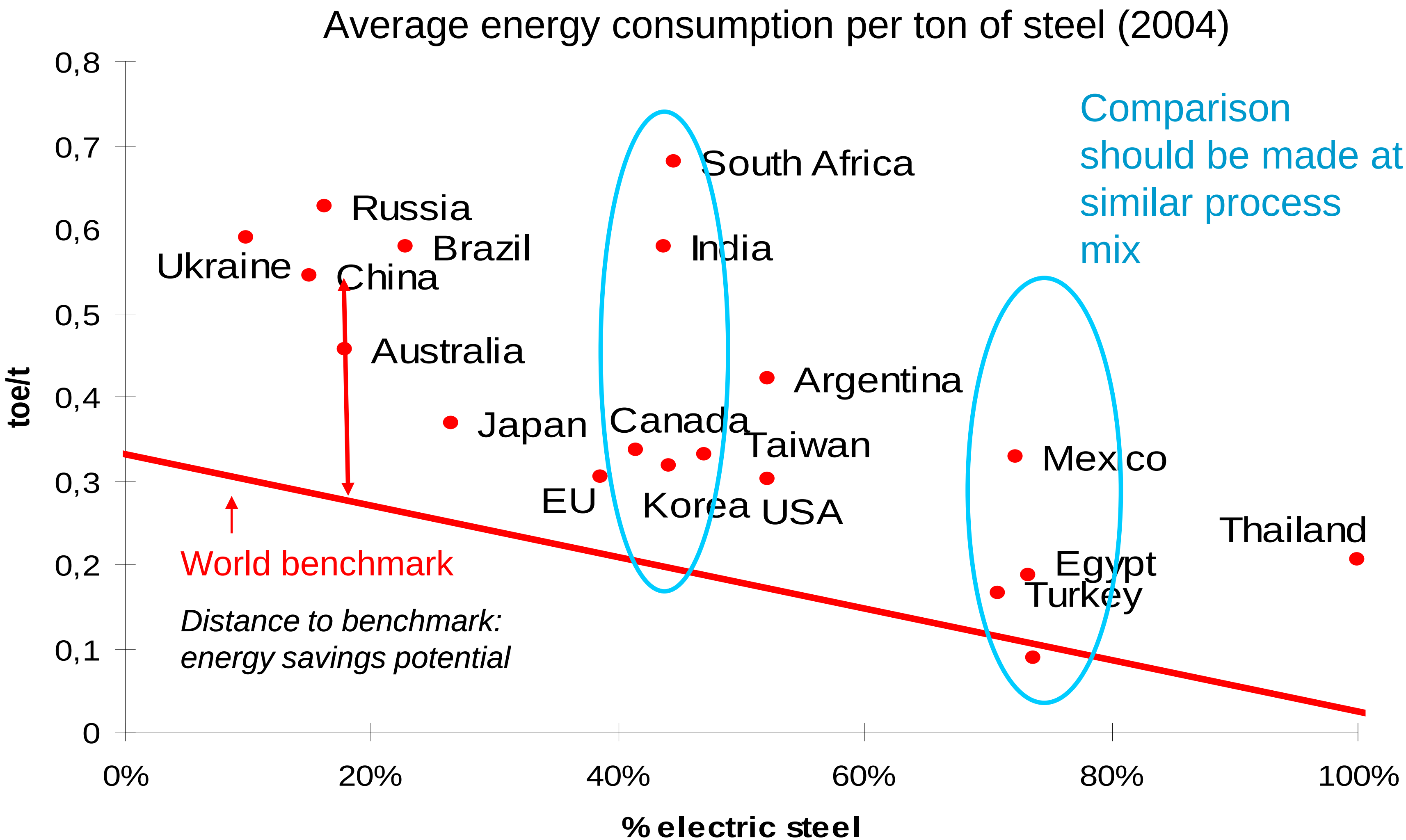
Benchmarking of energy efficiency perfomance among EU countries: case of ODYSSEE

- Need to compare performance with homogeneous product (e.g. clinker, the energy intensive component of cement, or mechanical pulp or oxygen steel)

- If heterogeneous product or if there exist different production process, need of benchmarking on a similar mix of product and process (e.g. steel, cement, paper)

  - ✓ In ODYSSEE graphical benchmarking with the specific consumption in the vertical axe and the process mix in the horizontal axe
  - ✓ Distance to the world benchmark line indicate the potential of improvement

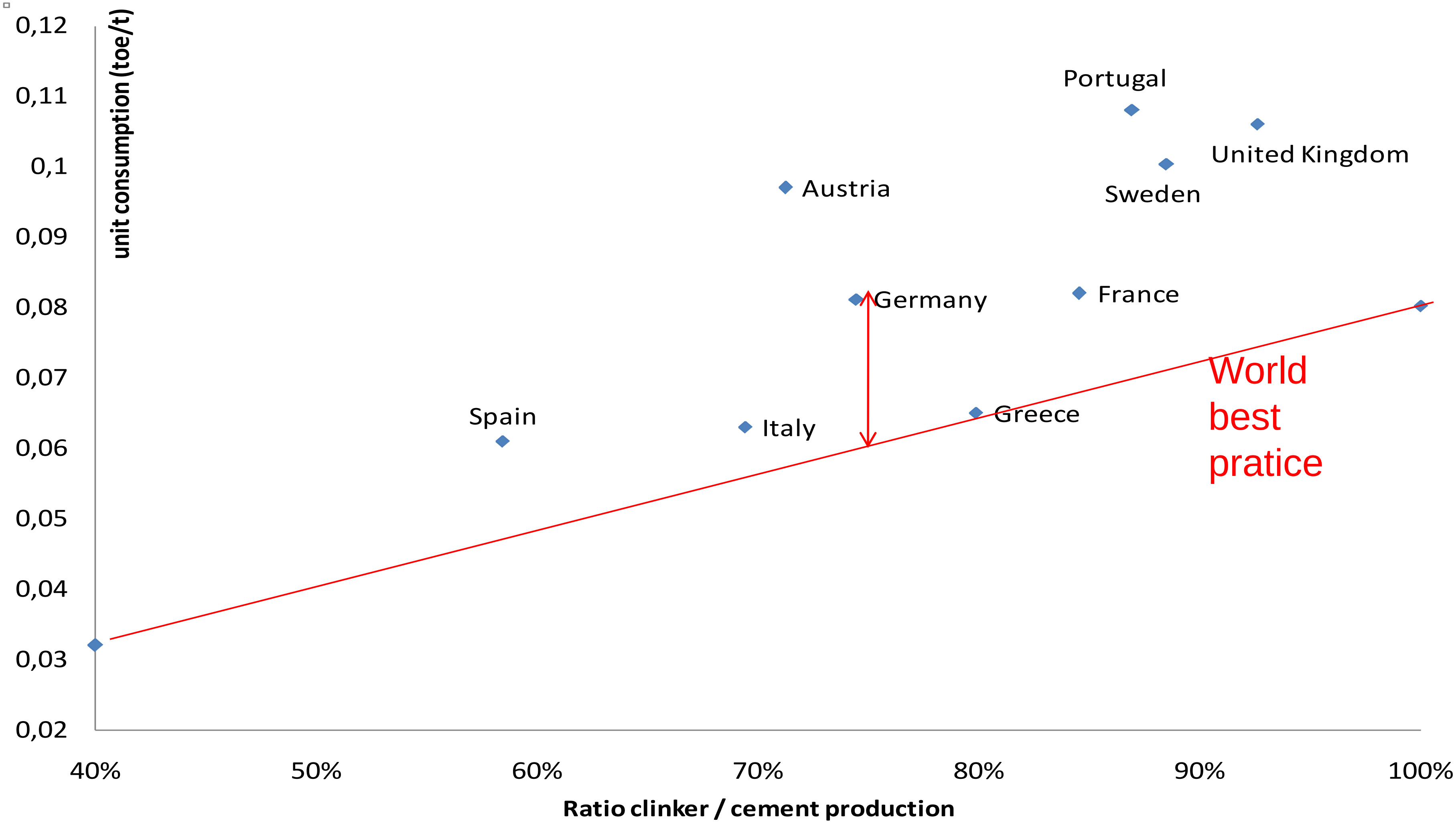
In industry, the best world practices are no longer found in the most developed countries



Source: Enerdata

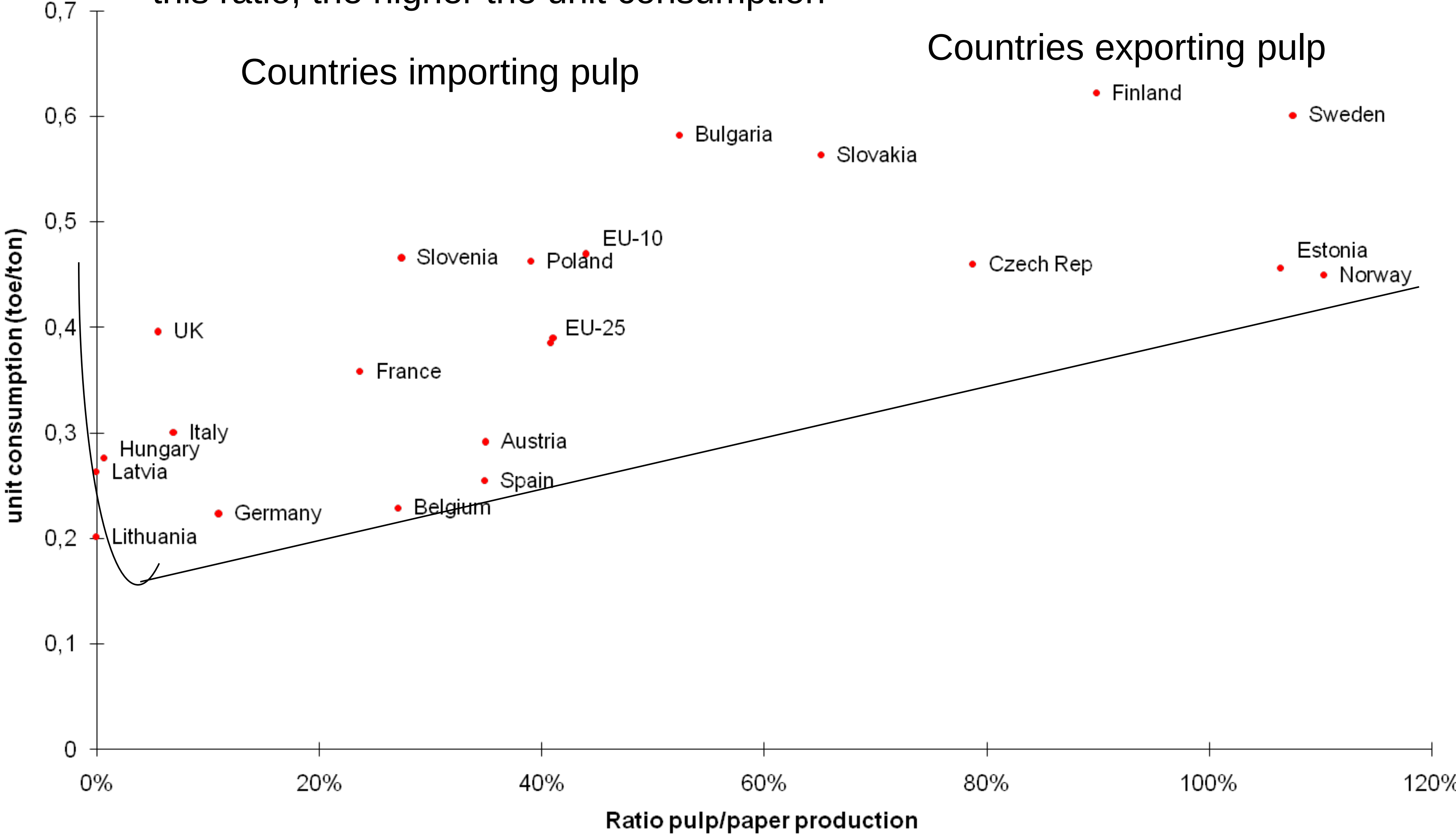
Benchmarking of the specific energy consumption of cement

The energy performance of cement production is linked to the share of clinker produced in the country in relation to the cement production: the higher this ratio, the higher the specific energy consumption. Distance to the red line (best prcatice) indicates the potential of energy saving



Unit consumption per ton of paper

The energy performance of the paper industry is linked to the share of pulp produced in the country in relation to the paper production: the higher this ratio, the higher the unit consumption



2. Energy efficiency indicators at industry sector level

Content

- Indicator of energy efficiency progress at industry level (ODEX)
- Measuring energy savings of the industry sector
- Measuring the impact of structural changes in industry
- Comparison of industry performance among countries
- Decomposition of electricity consumption variation: case of France

2. 1 Measuring energy efficiency progress at industry level (ODEX)

Energy efficiency index

- Aggregation of specific energy consumption indices by branch in one index for the sector on the basis of the weight of each branch in the sector consumption

- Specific consumption by branch can be expressed in different units so as to be a s close as possible to energy efficiency evaluation : toe/ ton, toe/index of production

- Energy efficiency improvement <=> index decreases (e.g 85 in 2000 → 15% energy efficiency improvement)

- Index called ODEX
- ODEX can be expressed in volume of energy saved (ktoe or TJ)

Energy efficiency index: principle of calculation:

1 Calculation of indices by branch and weighting

Energy ratios	1990	1991	1992	1995
Chemicals (toe/100) (index)	8.5 (100)	8.3 (98)	8.2 (96)	8.2 (96)
Steel (toe/tonne) (index)	0.30 (100)	0.29 (97)	0.26 (87)	0.25 (83)
Energy consumption	**(weight)**			
Chemicals (Mtoe) (%)	20 (50)	20 (48)	20 (44)	22 (46)
Steel (Mtoe) (%)	20 (50)	22 (52)	25 (56)	26 (54)

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Energy efficiency index: principle of calculation:

2 Calculation of sector index (year t-1 as reference)

Energy efficiency index	1990	1991	1992	1993
Chemicals	100	98	96	96
Steel	100	97	87	83
Total	100	97,4	90,9	88,6

$IE_{91} = IE_{1990}$ x (98 x 0.48 + 97 x 0.52) = 97,4

$IE_{92} = IE_{1991}$ x (96/98 x 0.44 + 87/97 x 0.56) = 90.9

$IE_{93} = IE_{1990}$ x (96/96 x 0.46 + 83/87 x 0.54) = 88,6

➔ gains of 11.4% in 1993 compared to 1990

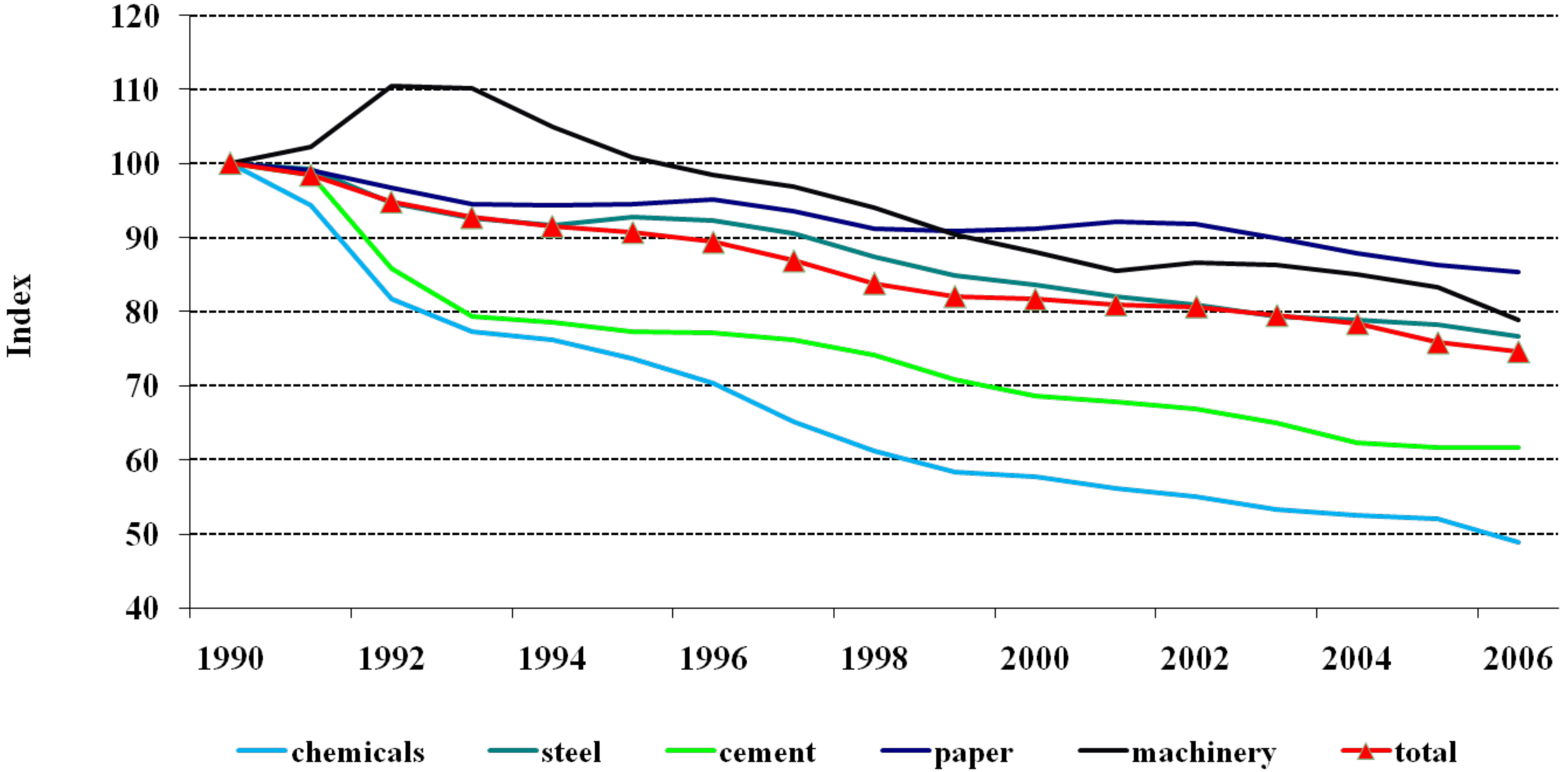
Energy efficiency index for industry in ODYSSEE

- Evaluation carried out at the level of 9 branches:
  - 4 main branches: chemicals, food, textile & leather and equipment goods;
  - 3 energy intensive branches: steel, cement and pulp & paper
  - 2 residual branches: other primary metals (ie primary metals minus steel), other metallic minerals (ie non metallic mineral minus cement)

- Specific energy consumption expressed in terms of energy used
  - per ton produced for energy intensive products (steel, cement, glass and paper)
  - per unit of production index for the other branches

ODEX in industry (EU-27)

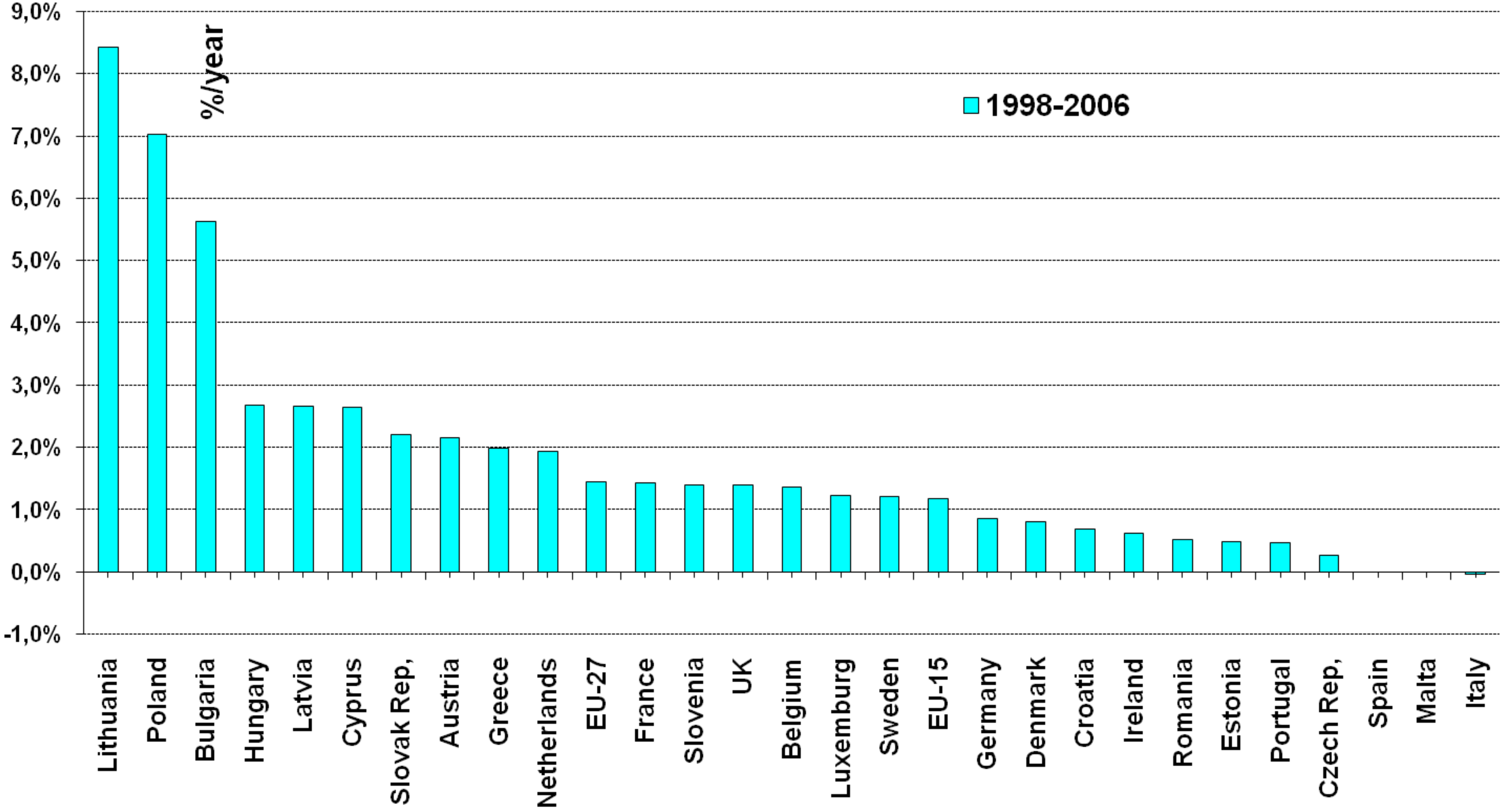
Around 25% progress in energy efficiency in industry in the EU-27 since 1990; slow progression since 1998 (1,4 %/year compared to 2.2%/year from 1990 to 1998)



Not all branches are shown for sake of clarity

Energy efficiency trends in industry in EU-27 countries

Energy efficiency improved on average by 1.4 % per year in industry in EU-27 countries since 1998 , but quite unevenly across the countries; no progress in 5 countries (eg Italy, Spain)



2. 2 Measuring energy savings of the industry sector

How to measure energy savings at the industry sector level

- Two methods that are equivalent:
  - Use the ODEX
  - Sum the energy savings calculated directly for each branch

From energy efficiency index to energy savings

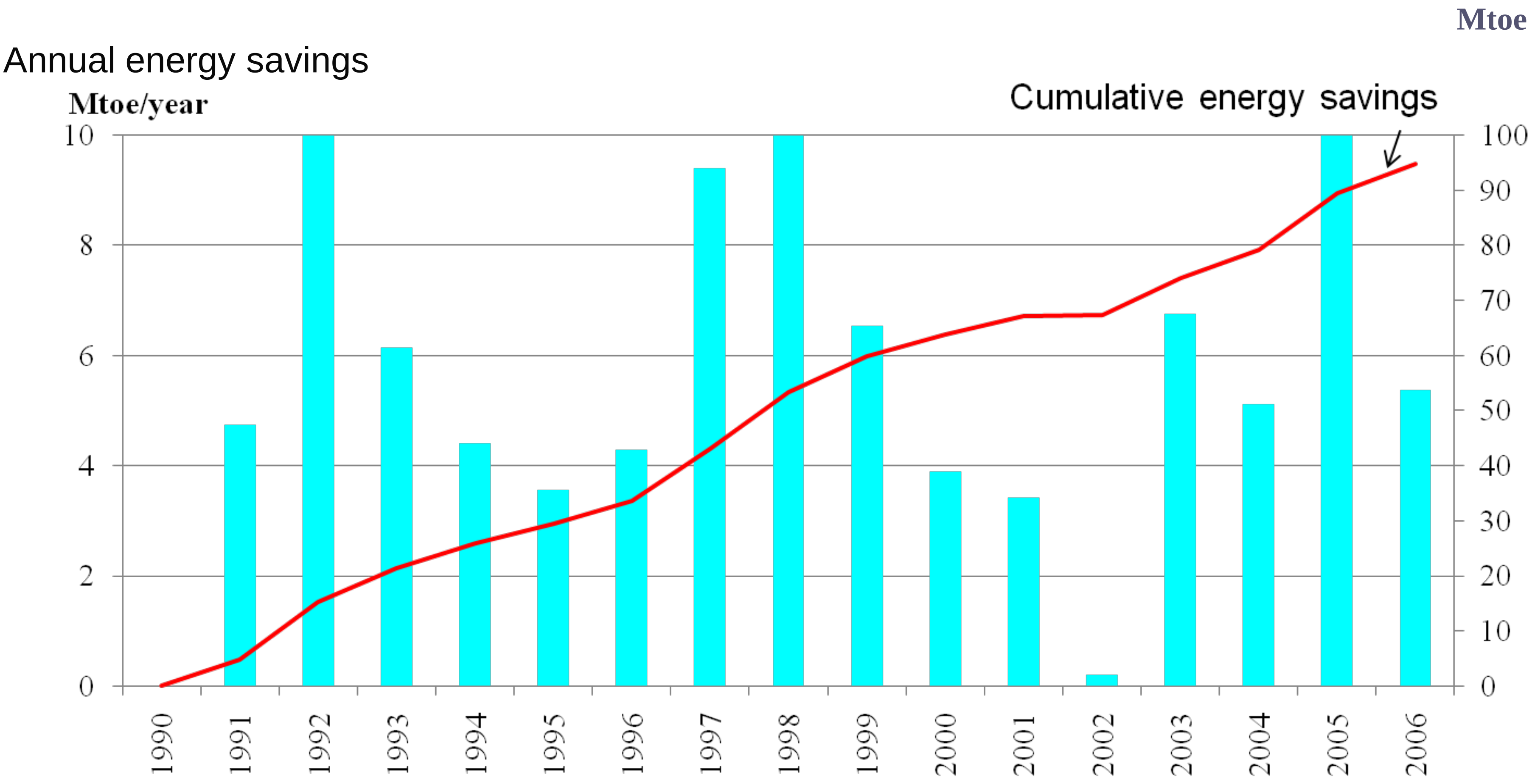
- Energy Savings (ES) can be directly derived from ODEX
- ODEX is defined as the ratio between the energy consumption at year t (E) and a fictive consumption that would have happened without the savings:

  ODEX=E/(E+ES)*100 (ES is >0)

- Energy Savings= ES = E x ((100/ODEX)-1)
- If energy consumption = 50 Mtoe and ODEX =80
  ➔Energy savings =50* ((100/80)-1)=12.5 Mtoe

Energy savings in industry (EU-27)

In 2006, energy savings in industry almost reach 100 Mtoe: without energy efficiency improvement in industrial branches, the energy consumption would have been higher by 100 Mtoe). Slow down in annual energy savings since 1998 (4 Mtoe/ year annual savings on average against 7 Mtoe before)



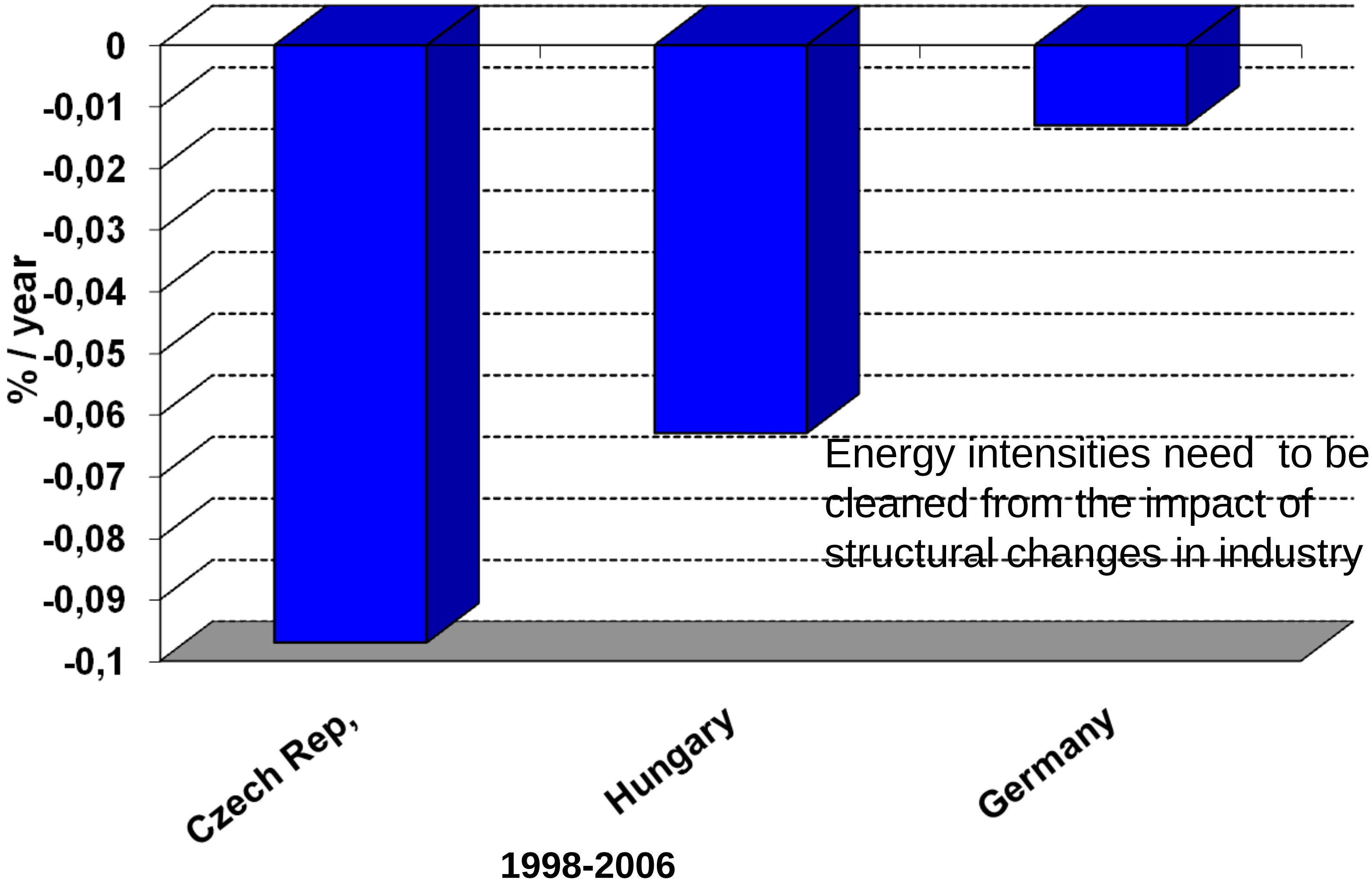
2.3 Measuring the relationship between energy consumption and value added: impact of structural changes on the overall energy intensity of industry sector

Energy intensity of industry

- Energy intensity of industry: ratio relating the energy consumption of industry to the value added of industry (koe/€2000)

- Decrease of the ratio means that industry requires less energy to generate one unit (i.e. one euro) of value added
  - ➔It means that industry use energy more efficiently from an economic viewpoint
  - ➔but not necessarily from a technical viewpoint
  - ➔We will say that industry has improved its energy productivity

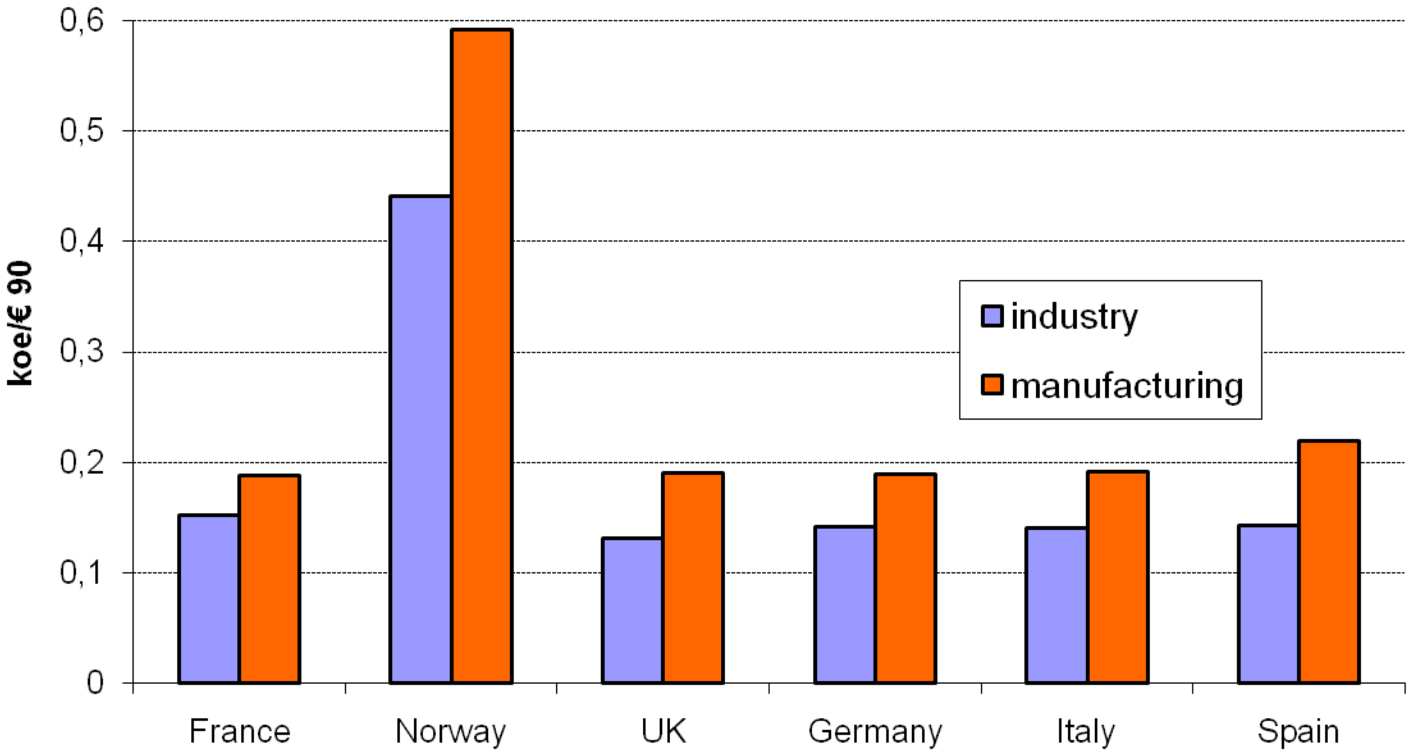
Different trends of energy intensity in industry : does it reflect difference in energy productivity?



Energy intensities need to be cleaned from the impact of structural changes in industry

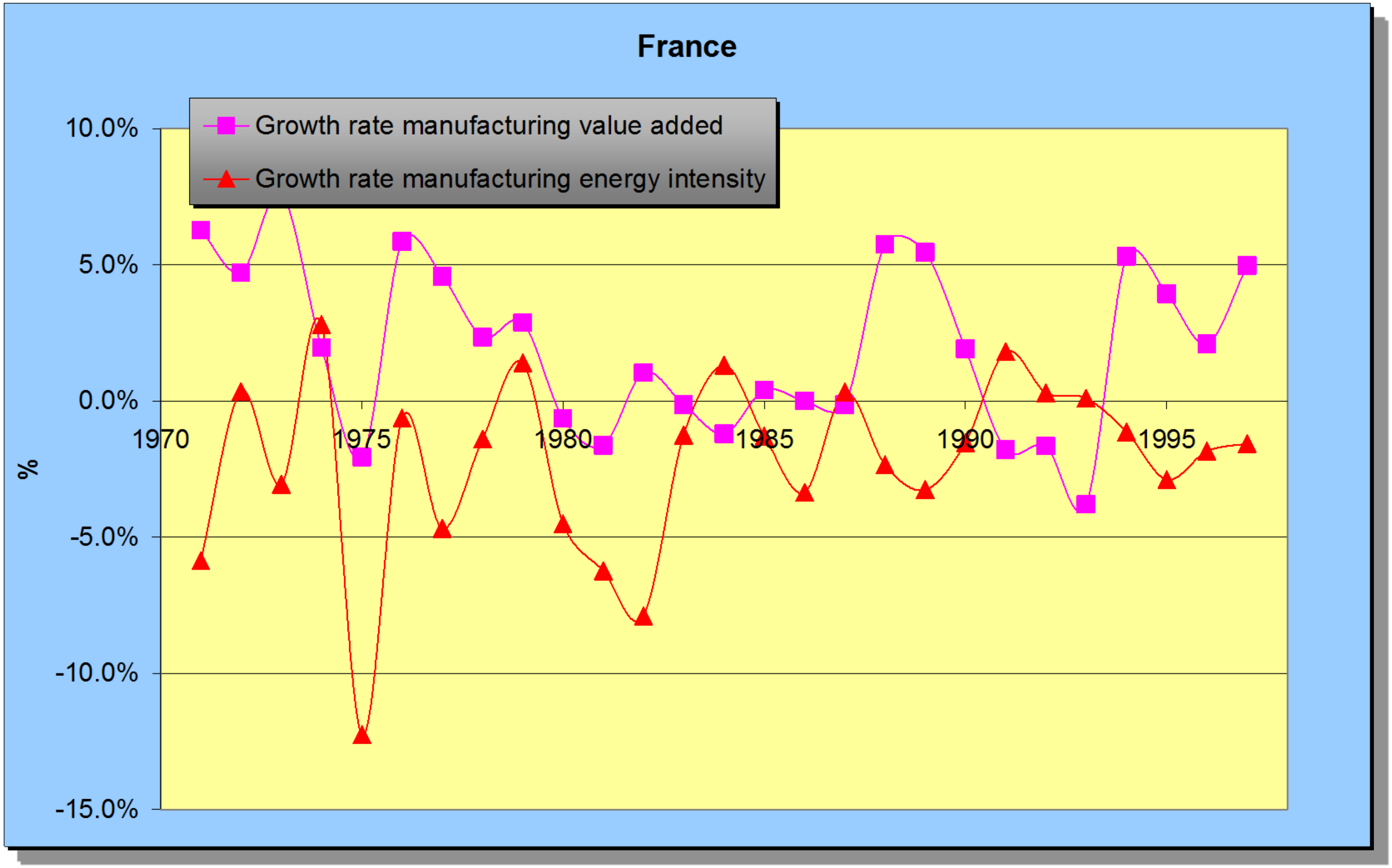
Energy intensity : industry / manufacturing

Industry less intensive than manufacturing because of construction, a sector with a high value added and a low energy intensity, and mining (part of consumption not included in industry)



At the level of the whole industry also, business cycles influence the trends from one year to the other

Relation between value added and energy intensity growth in industry



Diversity of energy intensities by industrial branch

- All industrial branches do not have the same energy intensity ➔ they do not require the same amount of energy inputs to produce 1 € of value added

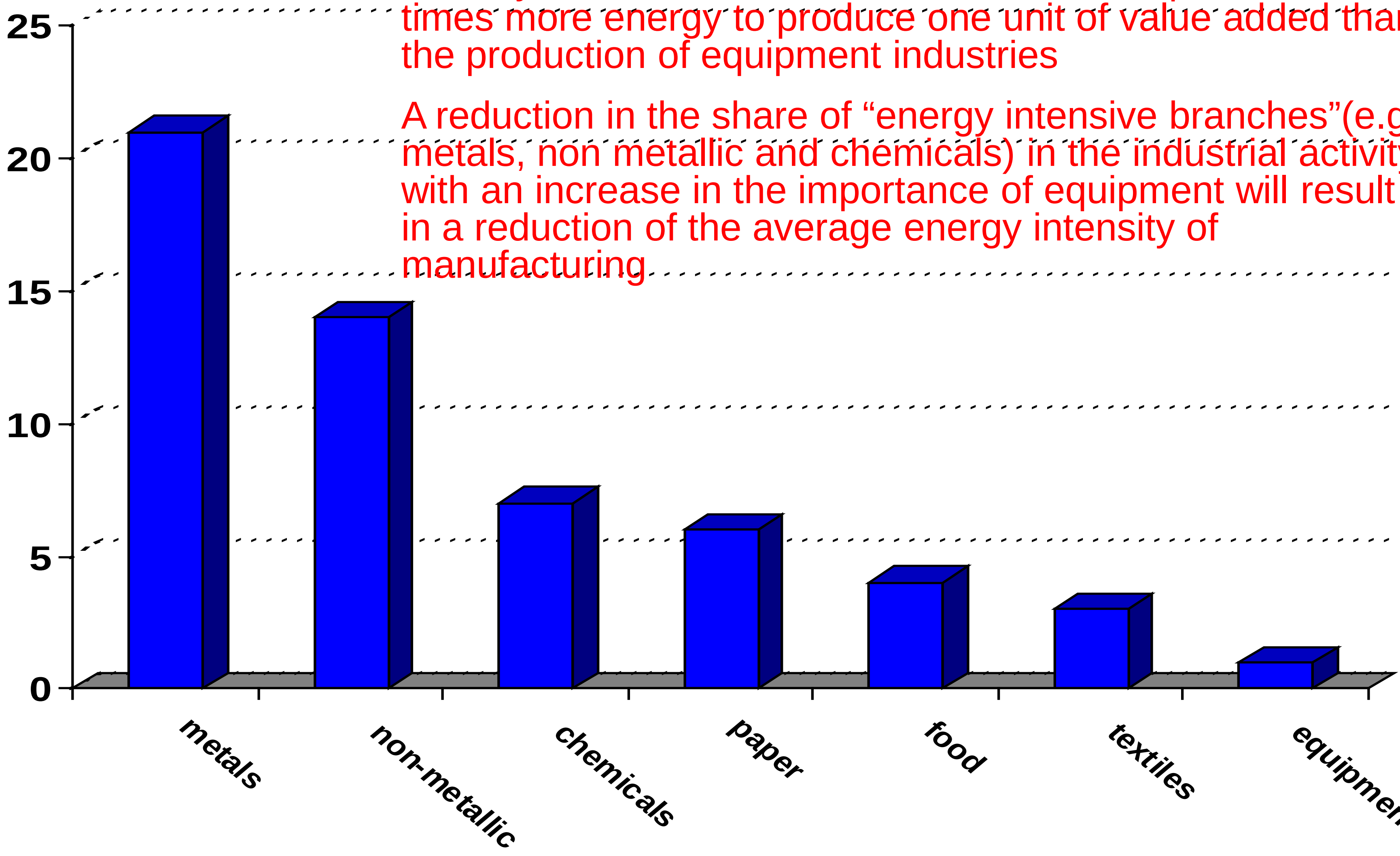
- Some industrial branches are more energy intensive than others (e.g. non metallic minerals (cement, bricks, glass), primary metals, chemicals and paper

- On the other extreme producing equipment goods (computers…) require muck less energy per € of value added (10 times less)

Relative levels of energy intensities by branch in the EU-25 (equipement=1).

Primary metals and non metallic minerals require 21 and 14 times more energy to produce one unit of value added than the production of equipment industries

A reduction in the share of “energy intensive branches”(e.g. metals, non metallic and chemicals) in the industrial activity with an increase in the importance of equipment will result in a reduction of the average energy intensity of manufacturing

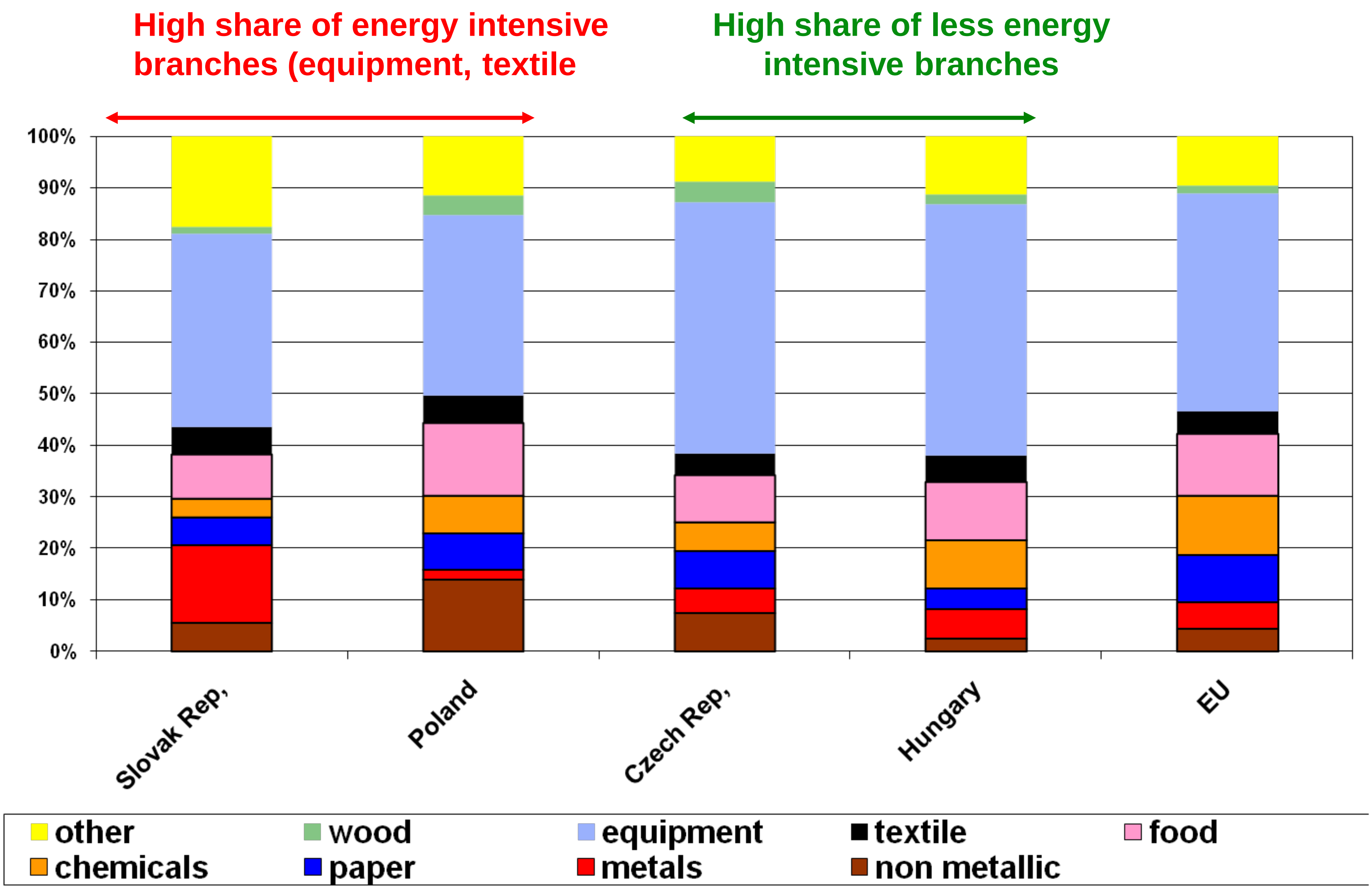


Structural changes in industry

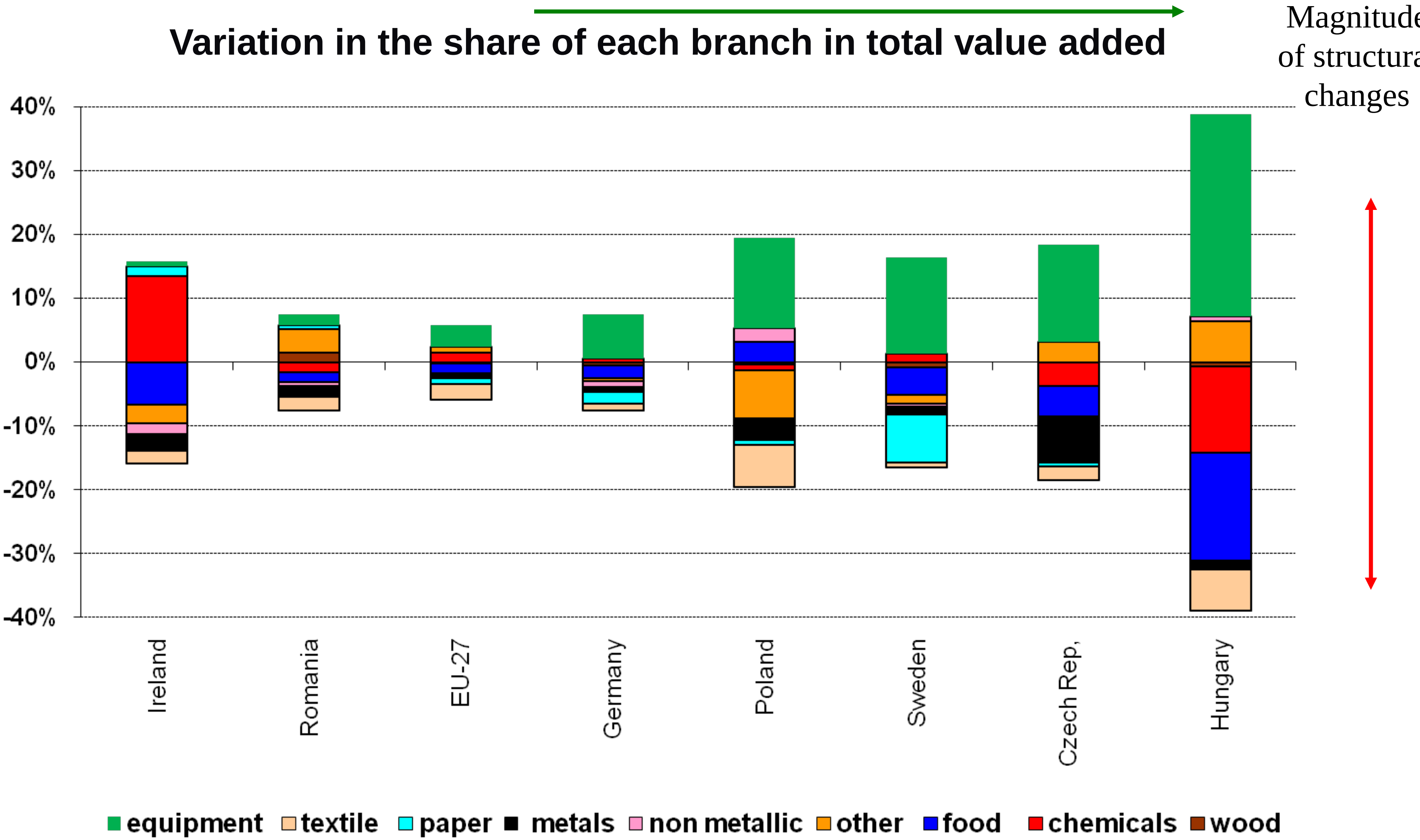
- Industrial development is not uniform among branches: some branches grow faster than others

- The share of each branch in the industrial production, in the industry value added, change over time ➔industrial structural changes

Structure of value added of manufacturing: examples



Changes in industry specialisation in the EU: example of countries with large structural changes towards less energy intensive branch:



Asssesment of the role of structural changes in industry

-If less energy intensive branches grow faster than other branches, this will reduce the overall intensity of industry all things being equal

-To quantify the impact of structural changes on the overall intensity of industry , calculation of a fictive energy intensity at constant structure , ie assuming that the structure did not change

-Two main methods to calculate this intensity at constant structure , depending on what year serves as reference for the constant structure

- -Use of a fix base year
- -Use of a moving reference year

Intensity at constant structure in industry / manufacturing: use of a reference base year

-Fictive value of energy intensity of manufacturing calculated at year t :

- ✓with the sectoral intensities at year t
- ✓with the structure of a base year (e.g. 2000)

$IEs = \Sigma(VAi/VA)o * (Ei/VAi)t$

IEs : intensity at constant structure

VAi: value added of branch i;

Ei: energy consumption of branch i

o :base year t: current year

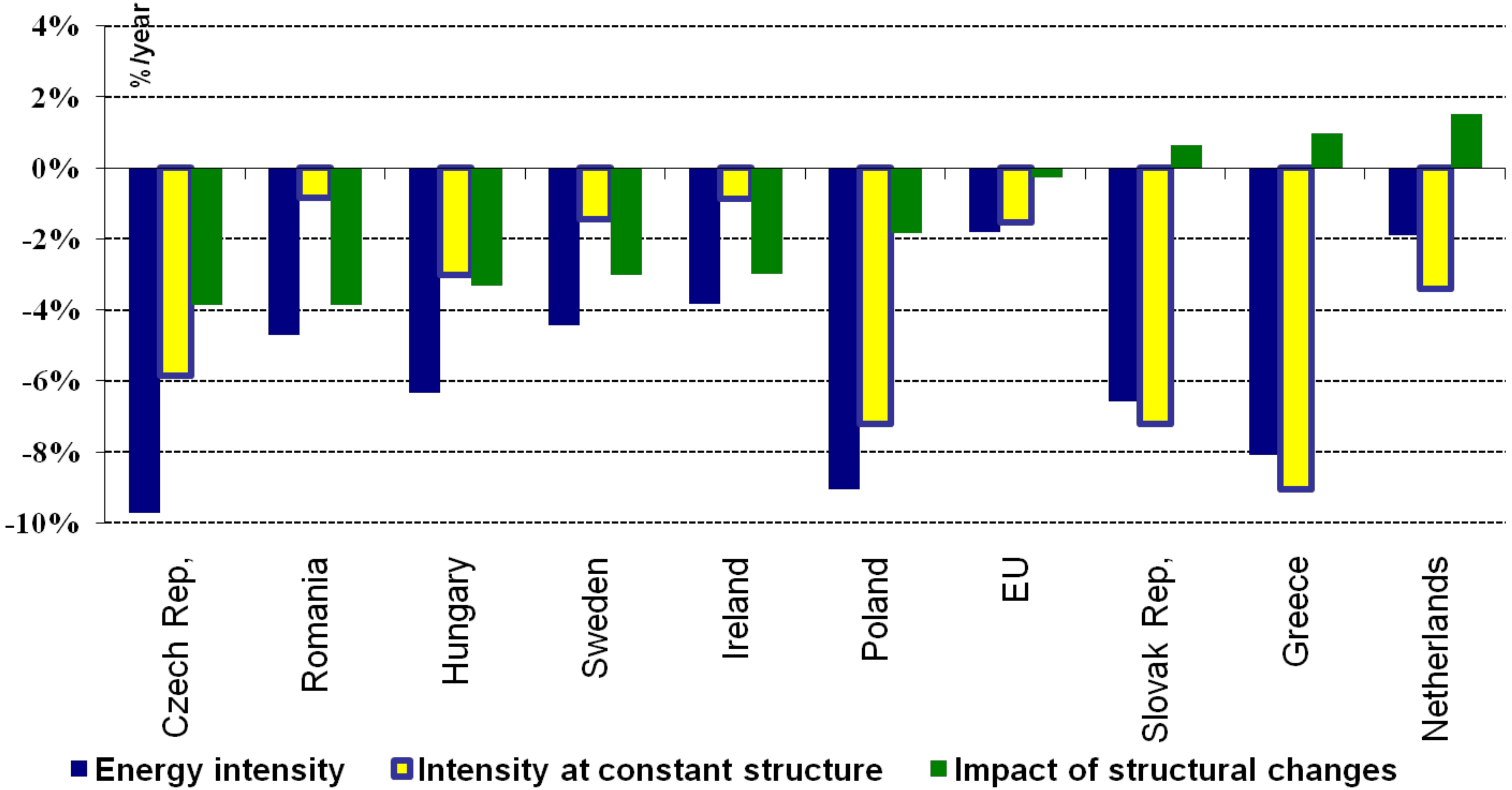
-Advantage simple to understand

- Drawback : results much influenced by the choice of the reference year

A faster growth of less energy intensive branches contributed to reduce significantly the energy intensity t of manufacturing

Structural changes towards more energy intensive branches contribute to lower the energy intensity reduction

Impact of structural changes on the energy intensity of manufacturing (1998-2006)



Enerdata

Use of a moving reference year : the Divisia method

- Yearly variation of energy intensity of manufacturing decomposed into two components:

  - ✓ one representing the impact of changes in the industrial branch intensities
  - ✓ one representing the impact of changes in the mix of branch in the total activity (industrial restructuring)

- No need of a base year; previous year taken as a reference → results more relevant and more stable over time

Decomposition of energy intensity changes : the Divisia method

Decomposition of the annual variation:

$$\ln\left(\frac{ie_t}{ie_{t-1}}\right) = \sum_i w_i \ln\frac{s_{it}}{s_{t-1}} + \sum_i w_i \ln\frac{ie_{it}}{ie_{t-1}}$$

w_i = poids de la consommation d'énergie de la branche i $= E_i / E$

Then calculation of 2 indices:

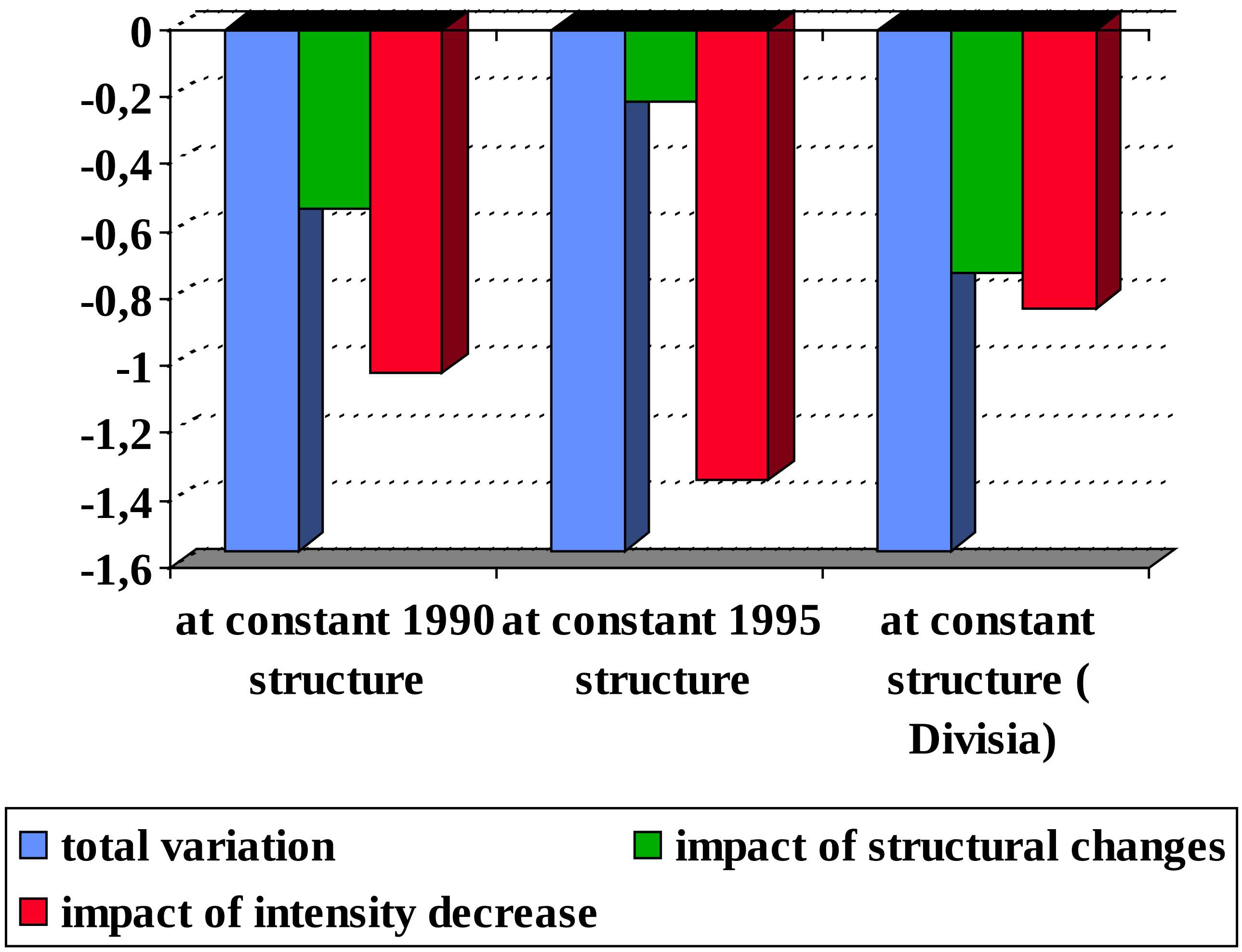
Ie : index of sectoral intensities ➔ represents the intensity variation due to changes in branch intensities (= index of intensity at constant structure) ➔ proxy fro assessing energy efficiency improvement (from an economic viewpoint

Is :index of structural changes ➔ represents the intensity variation due to structural changes

$$Ie = \exp\left(\sum_t \sum_i w_i \ln\frac{ie_{it}}{ie_{it-1}}\right) \times 100$$

$$Is = \exp\left(\sum_t \sum_i w_i \ln\frac{s_{it}}{s_{it-1}}\right) \times 100$$

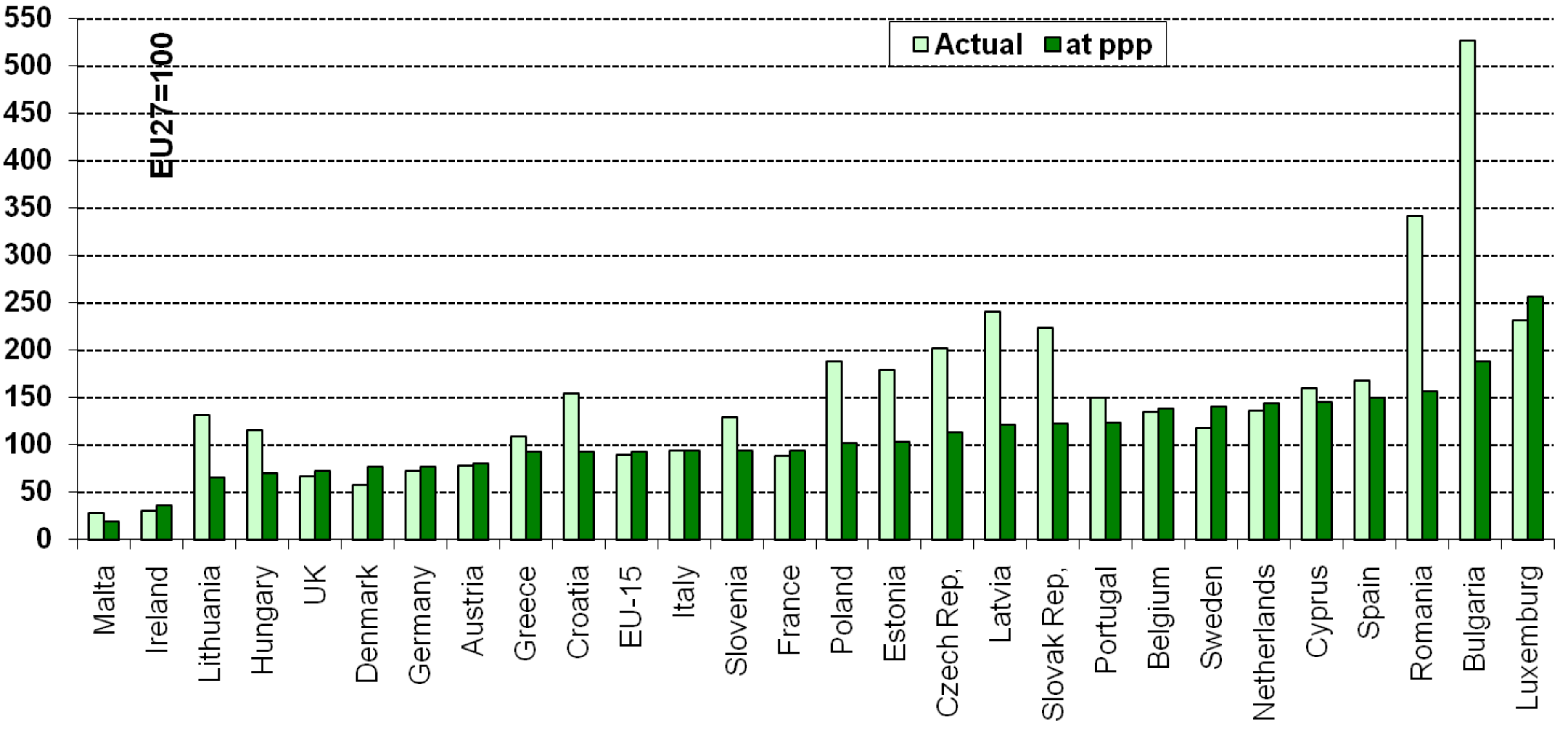
Intensity at constant structure in industry : influence of the method (case of UK) (1990-2002)



2.4 Comparison of industry performance

Very large differences in the energy intensity of manufacturing industry based on market exchange rates; comparison at purchasing power parities more relevant as independent of currency fluctuations and closer to technical energy efficiency (most of value added made of salaries, and thus function of relative values of living costs);

Energy intensity of manufacturing: actual versus at purchasing power parities (ppp) (2006)



Adjustment to same industrial structure

Differences in final energy intensity level for come from:
•different industry structures (% of value added by branch)
•different level of intensities of branches

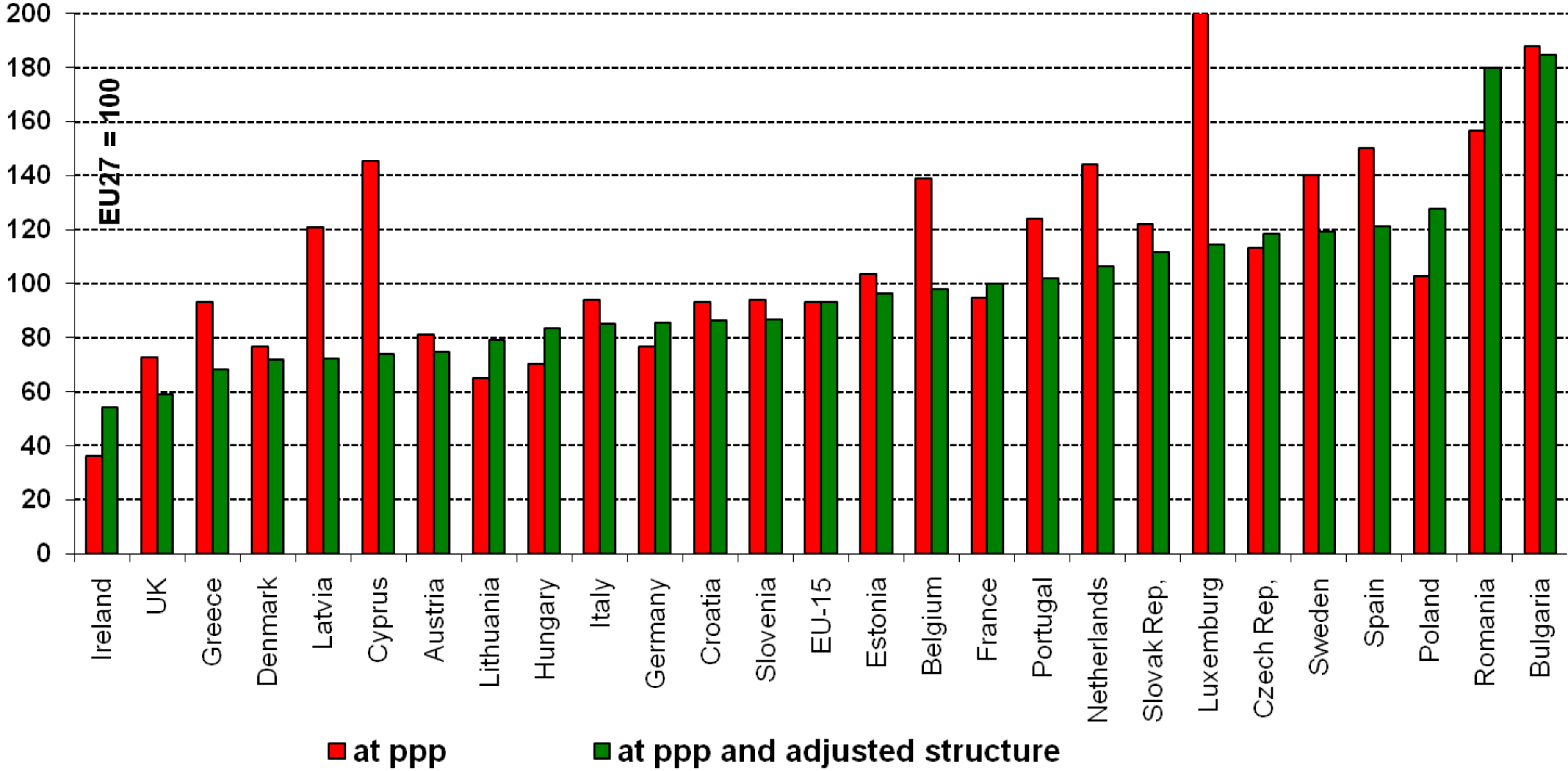
To leave out difference in industry structures calculation of a fictive intensity with the actual sectoral intensities of each country and the same industry structures (eg the EU average)

➔ **Energy intensity of manufacturing at reference value added structure and current purchasing parities (koe/€ppp)**

Energy intensities of manufacturing adjusted to the same structure

Energy intensity : more relevant with purchasing power parities however it is still influenced by differences in industry specialisation (“industry structure”)

➔ need of **adjustment to the same value added structure** (EU average). A higher intensity at adjusted structure means that the country’s share of energy intensive branches is lower than the EU-27 average



2.5 Decomposition of electricity consumption: case of France

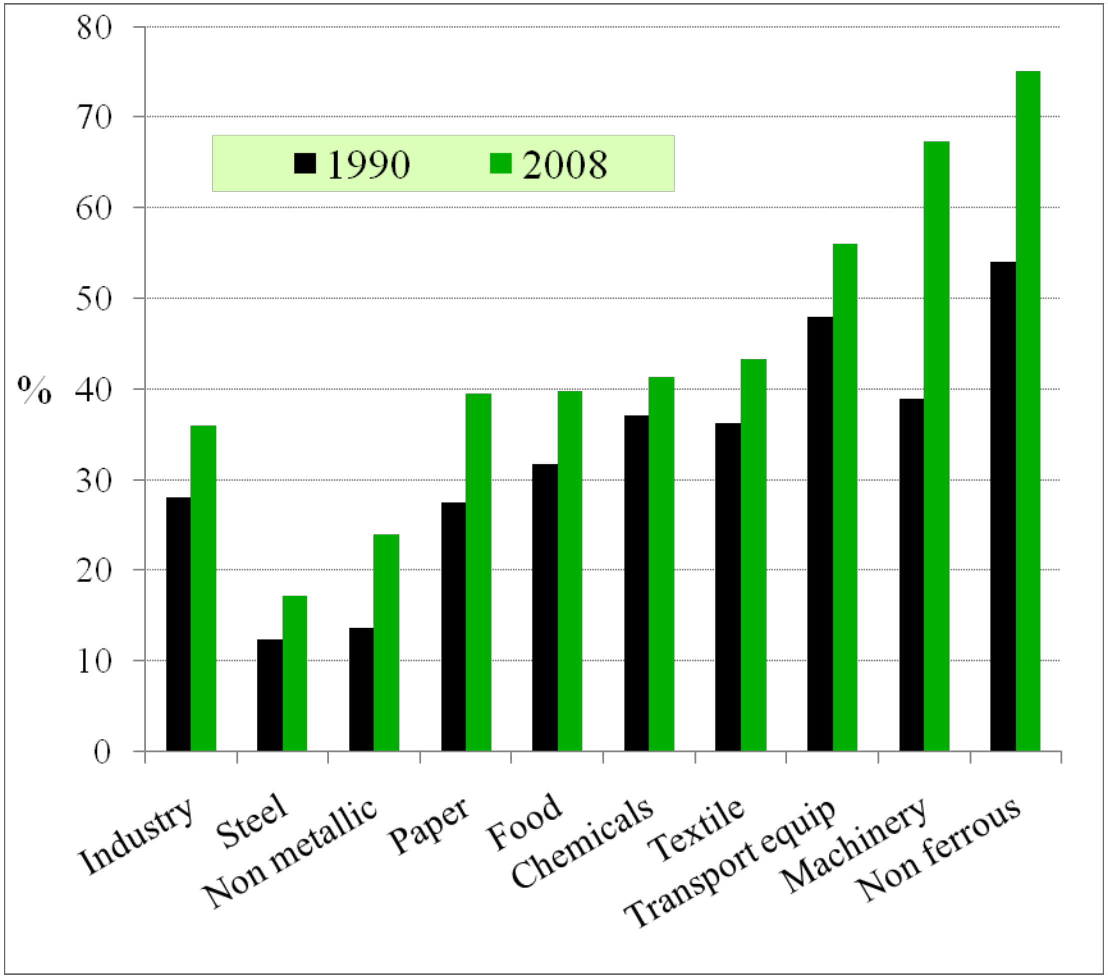
Enerdata

Decomposition of variation in electricity consumption in industry

Industrial electricity consumption is changing under the influence of various factors :

- Change in industrial activity
- Structural changes, i.e. the fact that individual branches with different electricity intensities are not growing at the same rate: if the manufacturing of machinery is growing much faster than the other branches, this will decrease the overall electricity of industry, all things being equal, as machinery is the branch with the lowest intensity
- Change in the branches' electricity intensities, which is driven by two factors:
  - Substitution from fossil fuels to electricity, ie increase in the market share of electricity in industrial branches
  - Technical progress (more efficient motors) as well as automatisation

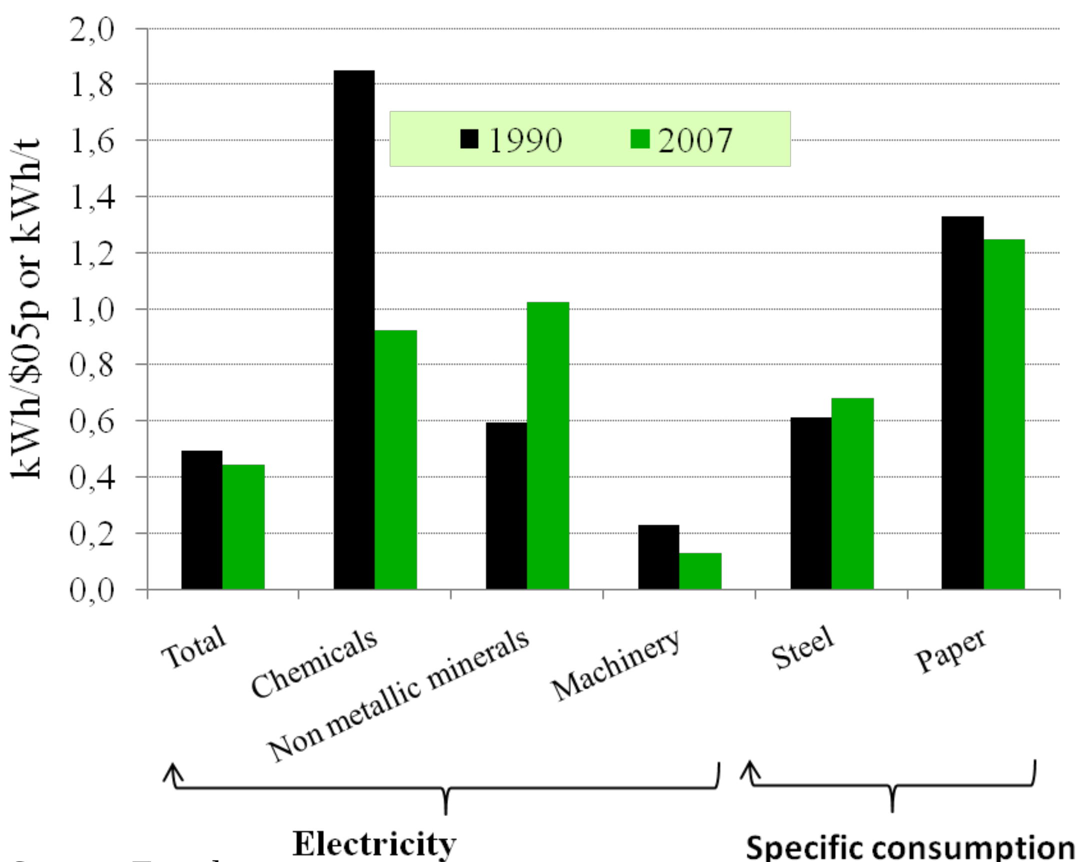
Electricity penetration rate by industrial branch (France)



Source: Enerdata

- Increase of the market share of electricity in all sectors
- Largest progression in machinery by 28 points compared to 8 points for industry as a whole
- Highest electricity penetration with non ferrous

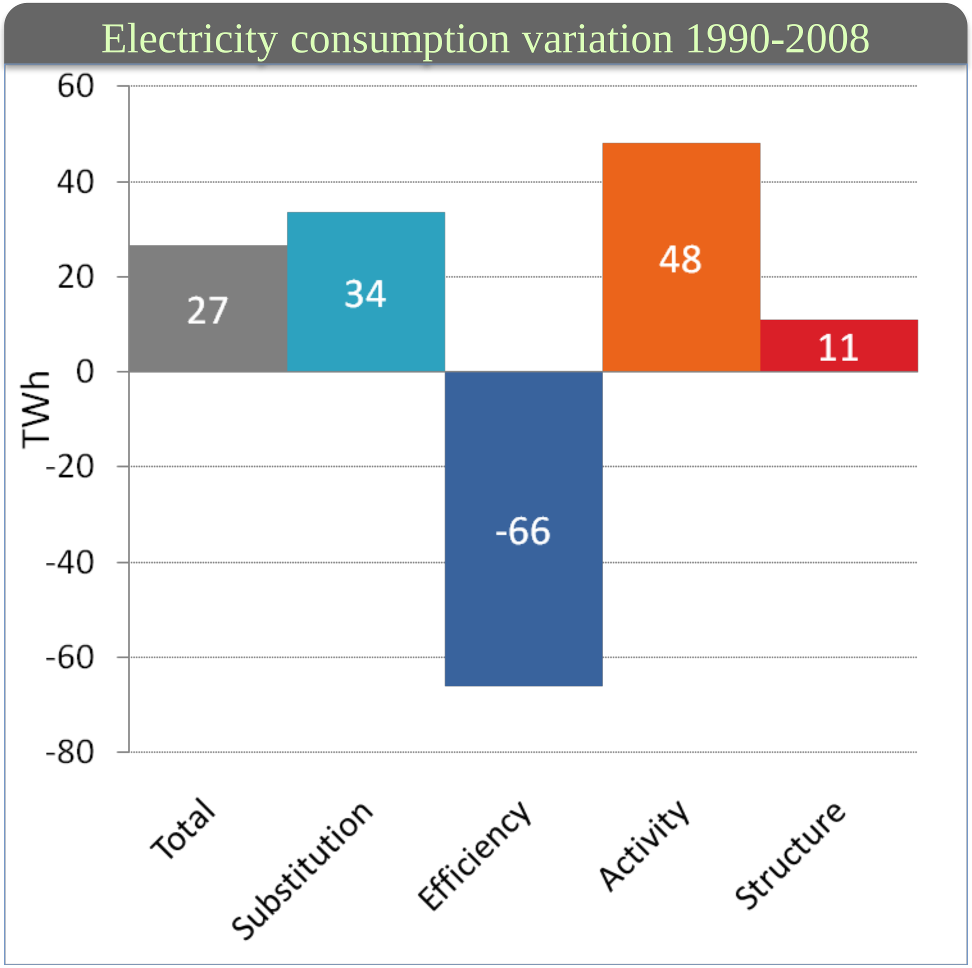
Electricity indicator by industrial branch (France)



Source: Enerdata

- Industrial electricity intensity has decreased by 1.3%/yr since 1990
- Highest decrease in chemicals (4.6%/yr)
- 3.3%/yr drop in machinery
- Specific electricity consumption per ton:
  - Slight reduction for paper (0.1%/yr)
  - 1.8%/yr for steel
  - Non ferrous metals: above 15 MWh/t

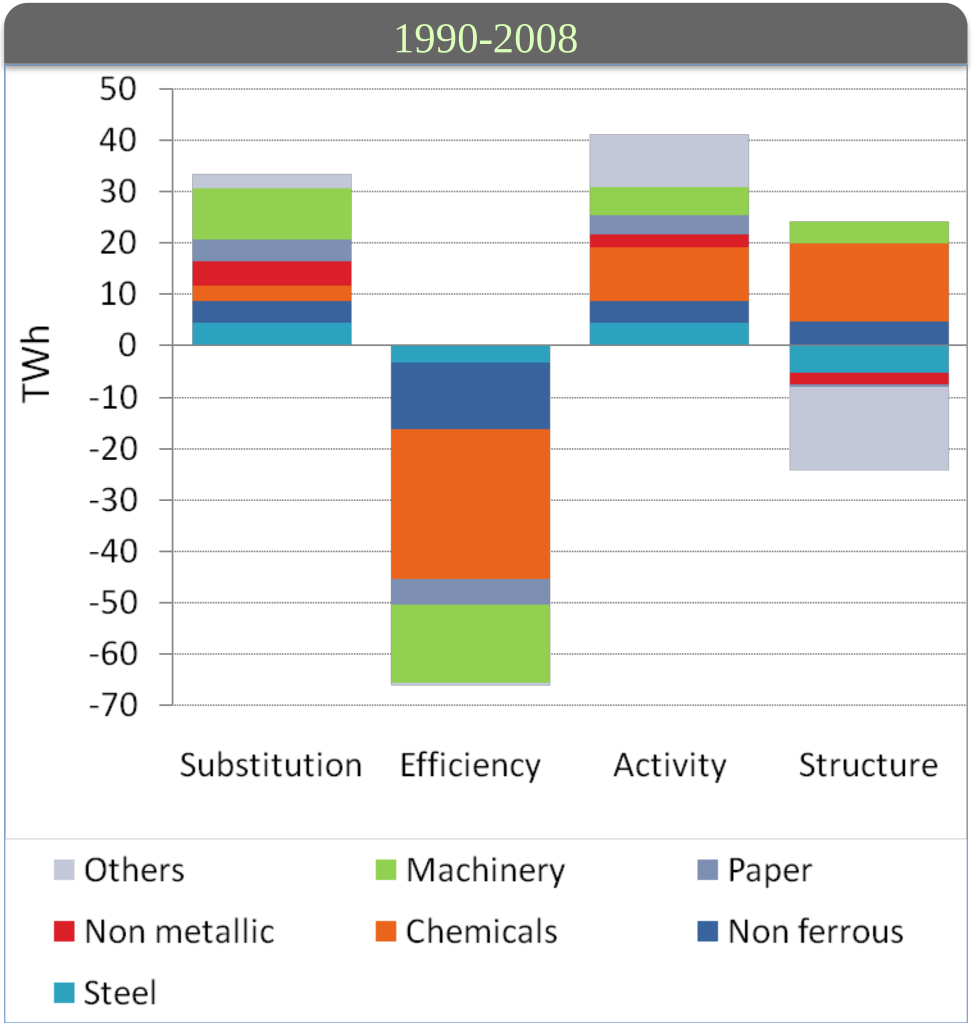
Decomposition of electricity consumption variation in industry (France)



Source: Enerdata

- Industrial electricity consumption increased by 27 TWh between 1990 and 2008
- Three factors contributed to this increase:
  - Growth in the sector's activity (+ 48 TWh)
  - Electricity market share in thermal use (+ 34 TWh)
  - And structural change in industrial activities (+ 11 TWh) (mainly from chemicals)
- Their effect was counterbalanced by energy efficiency improvements (- 66 TWh)

Decomposition of consumption variation: contribution of the various industrial branches (France)



- Structure of industrial value added:
  - Large positive effect in chemicals
  - Negative in steel and others (textiles and food)
- Large substitution effect in machinery, non metallic and paper
- Bulk of efficiency effect from chemicals, machinery and non ferrous metals

Source: Enerdata

Annual energy survey in industry: the French experience (EACEI)

Didier BOSSEBOEUF (ADEME, France)
Bruno LAPILLONNE (Enerdata)

Logo

Contents

- Methodology
- Questionnaire

Methodology (1)
Main characteristics

- Under the law 7 June 1951 on obligation, coordination and confidentiality on statistics.
- Starting in the seventies, refreshing of the methodology in 2005.
- Mailing of 12000 mandatory questionnaire (93% response rate).
- Extrapolation for responses is different according to the size of the site.
- Personalised questionnaire .

Methodology (2)
Field of survey

Statistical unit : industrial site having a process activity. When other activities co-exist, the whole energy consumption is surveyed

- Coverage : industry including the agro food industry
- Sampling size : 12000 sites based on registry of company (Sirene) and yearly company survey
  - Exhaustivity for all important energy consumers with more than 20 employees for selected sectors
  - All sites with more than 10 employees for selected branches (yearly sampling rotation)
  - All sites more than 500 employees
  - By selection,for sites between 20 and 499 employees of less consuming sectors

Questionnaire (1)

AOOO general data for the site

- A2 : Number of employees
- A4 : Description of the main activity

E000 Fuels

- B Electricity
  - B1 : Purchased electricity in value and quantity
  - B2 : Electricity own generation and destination
  - B3 : Breakdown of electricity by end-use (mechanical power; thermal uses; others end-uses i.e. electrolysis
  - B4 : Which tariff
- C Heat
  - C1 Purchased heat in value and quantity and sold
  - C2 : Breakdown of heat by end-use (process; electricity generation; heating and others)

Questionnaire (2)

D Natural gas

- D1 : Purchased natural gas in value and quantity
- D2 : Breakdown of gas consumption by end-use (process; raw material; electricity generation; heating and others)
- D3 : Which tariff

E Network gas and other gas

- E1 Purchased network gas in value and quantity
- E2 : Breakdown of network gas by end uses
  - Process; electricity generation; raw material, heating and others

Questionnaire (3)

F Coal

- F1 : Purchased coal in value and quantity
- F2 : stocks beginning and end of 2007
- F3 : Breakdown of gas by end uses
  - Process; raw material; electricity generation; heating and others

G : Lignite and low coal (idem Coal)

H : Coke (idem coal)

I : Petroleum coke (idem coal)

J : LPG (idem coal)

K :Heavy fuel oil(idem coal)

L : Light fuel oil (excluding diesel) (idem diesel)

Questionnaire (4)

M: Other petroleum products

- M1 : Consumed fuels in quantity
- M2 : Break-down of other petroleum fuels by end uses
  - Process; raw material; electricity generation; heating and others

N : Black liquors (idem other petroleum products)

O : Wood and wood products for energy uses

- O1 : Consumed fuels in quantity
- O2 : Breakdown of wood products by end uses
  - Process; electricity generation; heating and others

X : Renewables special fuels

- X 1 : Consumed special fuels in quantity
- X 2 : Break-down of special fuels by end uses
  - Process; raw material; electricity generation; heating and others

Y : Non renewables special fuels (idem special fuels)

Questionnaire (5)

Z: Other fuels

Z1 : Purchased other fuels in value, quantity and stoked

Z2 : Quantity consumed

Z3 : Break-down of other fuels by end-uses

Process; raw material; electricity generation; heating and others

Main published results

http://www.industrie.gouv.fr/sessi/enquetes/eacei/eacei.htm

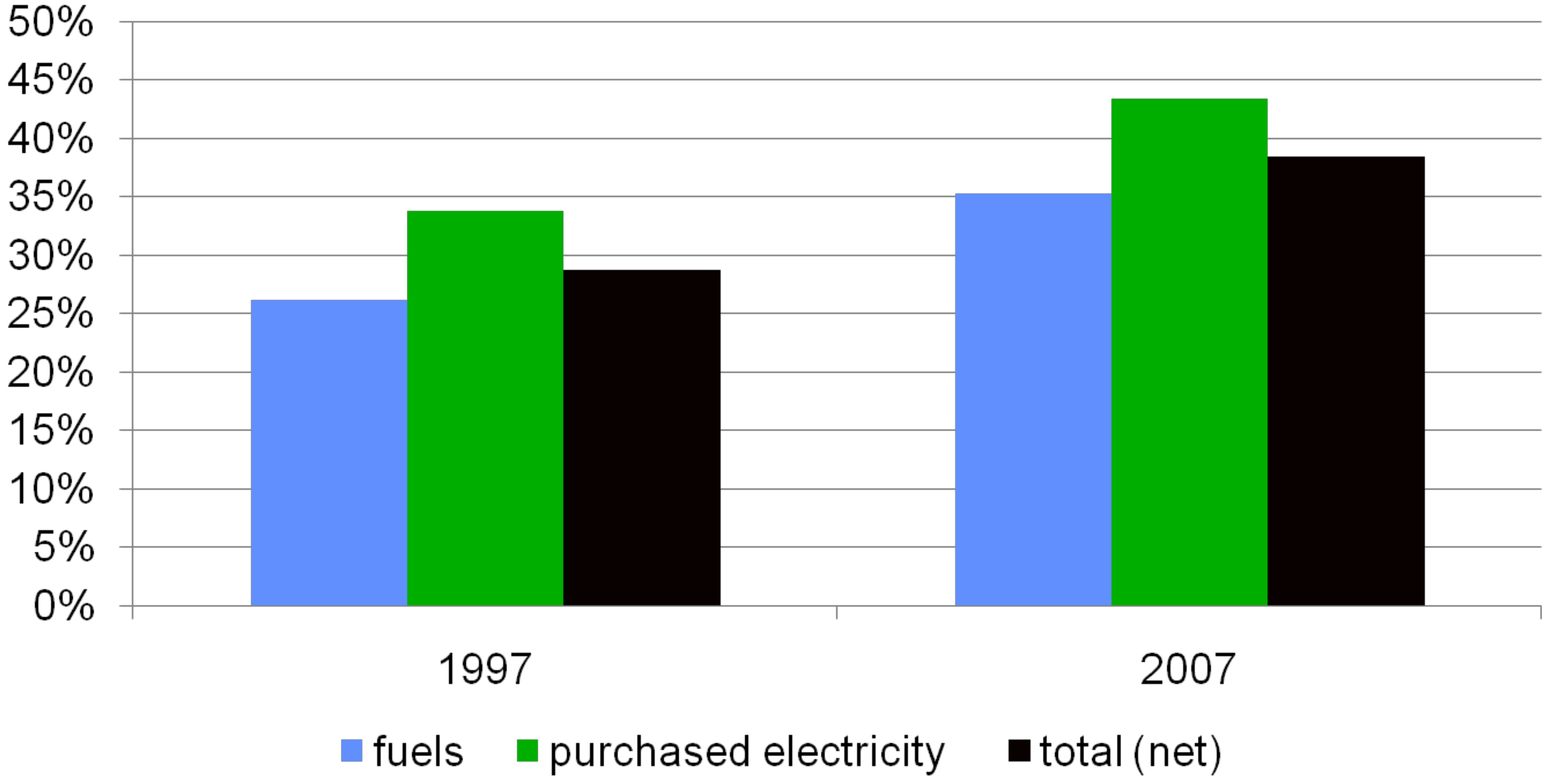
- Energy consumption (cross checked)
  - By energy sources (10 types including renewables and special fuels)
  - By sector (24 sectors)
  - By end use (3-4):
    - Fuels (4): process (kilns, dryers, boilers) , raw materials, electricity generation, heating and other uses
    - Electricity (3) : motors, thermal uses, other uses (e.g. Electrolysis)
  - By company size
  - By region

- Energy expenditures

- Average fuel prices of purchased energy by sector

Example of results: energy consumption by company size (France)

Share of SME’s (<250 employees): increasing role



Remarks

- Results are published on web site with times series but are not always retropolated.
- However, not publicly available when the number of sites is too limited (< 3 companies).
- When a company change its main activity, the related energy consumption shifts to the relevant sector.
- Unit energy consumption are not calculated as such
- Results are used for the national energy balances
- Results are reworked by CEREN for ADEME
- Specific statistical treatments can be ordered

Conclusion

- All European countries have similar annual surveys
- These surveys are used to fulfil reporting requirement to Eurostat/IEA
- Difference may come from the additional question to energy use (e.g. consumption by end-use not always asked)
- Main source of information for energy efficiency indicators by industrial branch