

# Training Workshop: Electricity Efficiency in generation, transmission, and distribution of electricity systems



## “Energy Management and Energy Efficiency Improvement in Industry”

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# Structure of the presentation

Introduction to Energy Efficiency in Industry

Developing EE policies for industry

– from support schemes to mandatory regulations

Examples of EE policies for industry

Examples of EE measures in industry

Conclusions



# Introduction to Energy Efficiency in Industry with focus on the case of EU

*Energy efficiency (EE) is defined as "the ratio of output of performance, service, goods or energy, to input of energy"*  
*Directive 2012/27/EU*



# EE from industry's point of view

EE investments are **defensive investments, not offensive:**

- Do not increase production capacity, sales, direct (visible) profits
- They reduce energy consumption and energy costs
- Increase the lending exposure (loans / own capital, loans / sales volume)

EE was not (and to a large extent is still not) priority for industry:

- Luck of awareness, know how, limited availability of energy services in the market
- Relatively small share of energy cost in the total production cost, etc.

EE efficiency in industry was driven either form mandatory regulations (safety, environmental regulations, etc.), or by incentive schemes – State supported

Today the picture changes in EU:

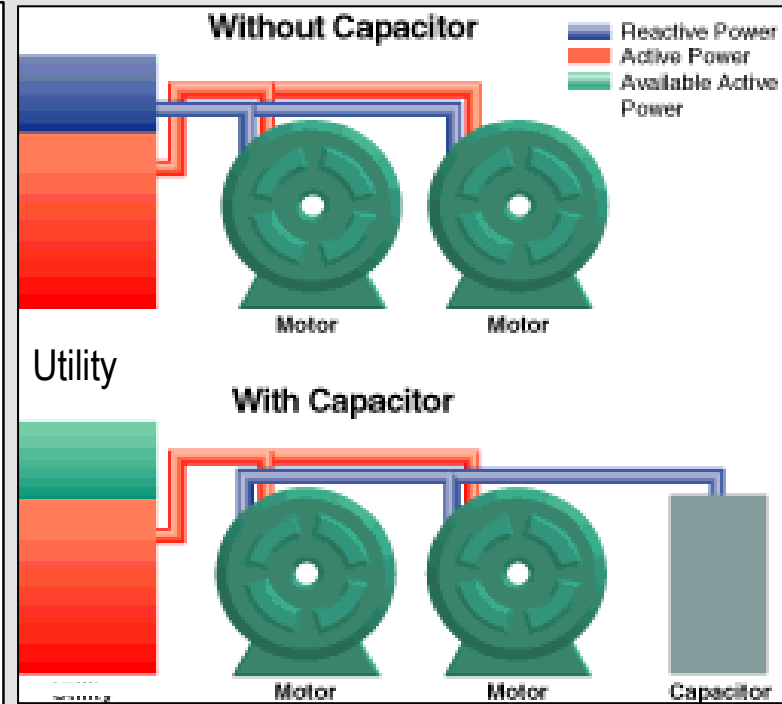
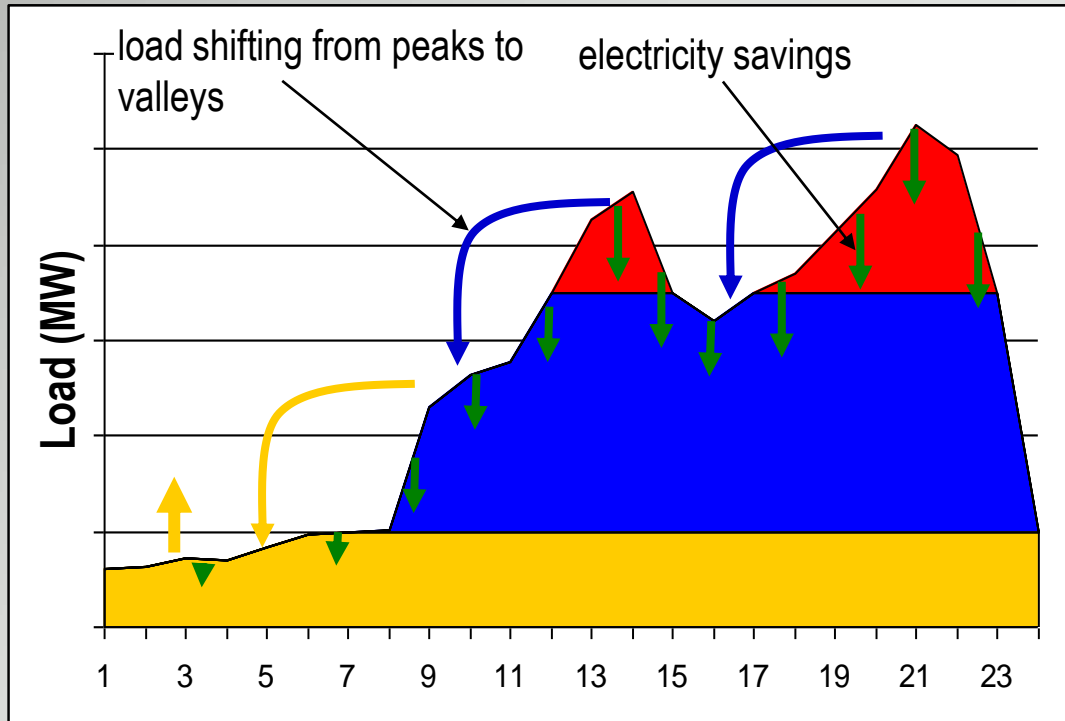
- EE services, EE equipment, etc. are widely available
- EE policies for industry are more mature; compulsory EE requirements have been introduced.

In **mature markets with production overcapacity, or in economies under recession** EE and the associated cost reduction, offer an opportunity for price cutting, that is necessary **to retain market share**. EE becomes marketing advantage for industry.

EE (linked with environmental improvement plans) is a means to demonstrate **“corporate social responsibility”** and improve the company's image among the clients.



# EE from power utility's point of view -1



- Utilities are interested to **normalise their load curve and reduce reactive power** (reserve more capacity for active power); tariffs should be designed in a way to motivate consumers to take appropriate measures.
- **Saving electricity (EE) is normally against the utility's interest** (reduction of volume of electricity sales).



# EE from power utility's point of view -2

Why power utilities are engaged in EE programmes?

- Because they are obliged to do so through **regulatory measures** such as White Certificates, EE obligations schemes.
- In liberalised markets utilities compete to keep their clients by offering a package (power supply + energy services) instead of selling electricity only; industry is their best client
- They expand their businesses though investing for the establishment of energy service companies (ESCOs).



# EE from EU's / States point of view

To serve the public interest:

- **Security of energy supply** (uninterrupted availability of energy sources at affordable prices)
- Reduction of **dependency from energy imports (and the associated geopolitical implications)**
- Reduction of **effects to the economy** from sharp increases of fuel prices
- **Improved competitiveness** of the economy and businesses; employment, etc.
- Concern for the **climate change**.

**Industry is an ideal target** for State EE policies, as:

- It can achieve massive savings at few sites (reducing thus the complication and administrative costs to achieve the same savings by a large number of small consumers)
- It has better access to financing (disincentive for State support)
- It has some in-house technical capacity (disincentive for State support).



# The EU climate policy targets at a glance

## 2020 Package

**GHG Emissions Reduction**  
20% compared to 1990

**Increase of Renewable Energy Use**  
20% of total energy consumption

**Increase of Energy Efficiency**  
20% compared to baseline scenario

## 2030 Framework

**GHG Emissions Reduction**  
40% compared to 1990

**Increase of Renewable Energy Use**  
27% of total energy consumption

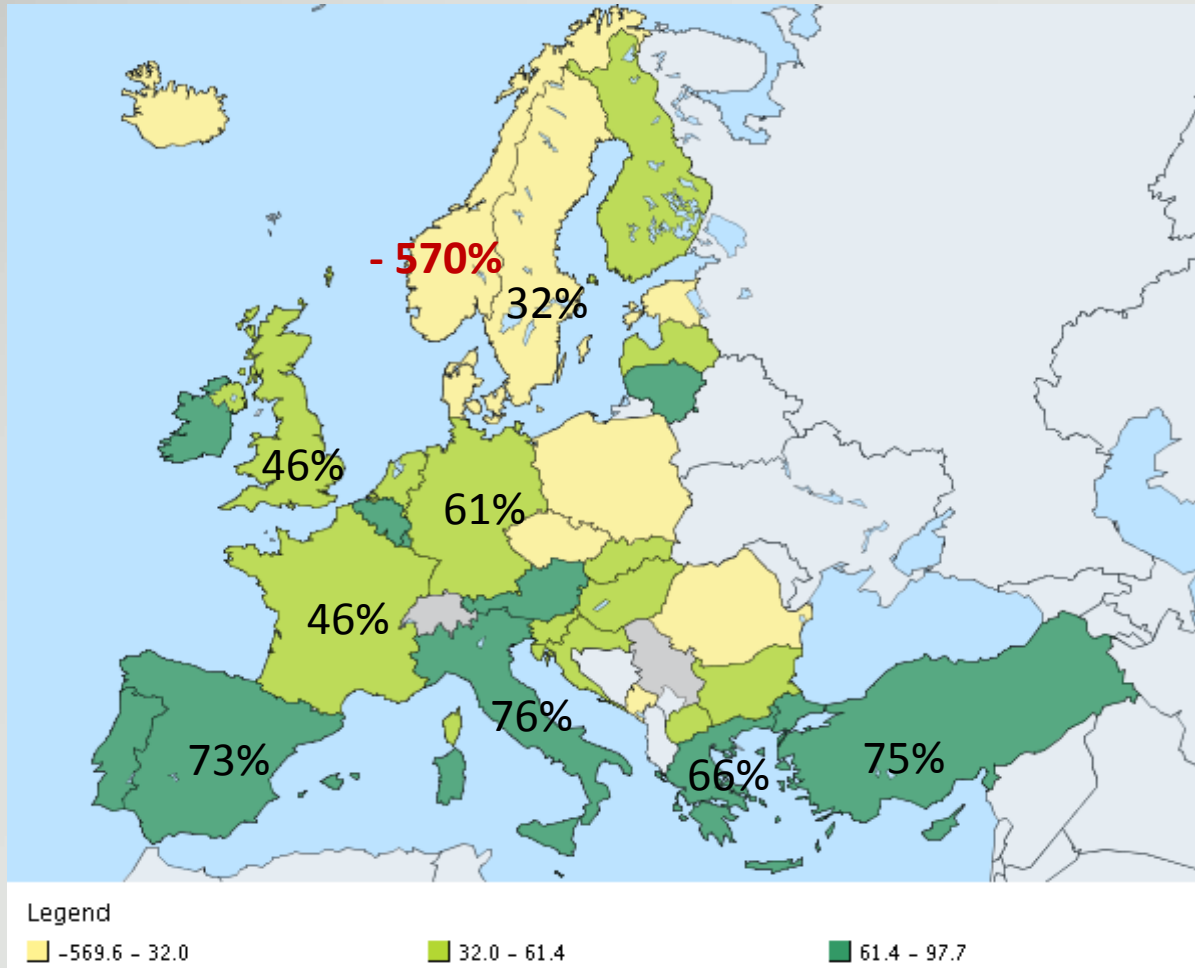
**Increase of Energy Efficiency**  
27% compared to baseline scenario





# Energy dependence - the key challenge for EU

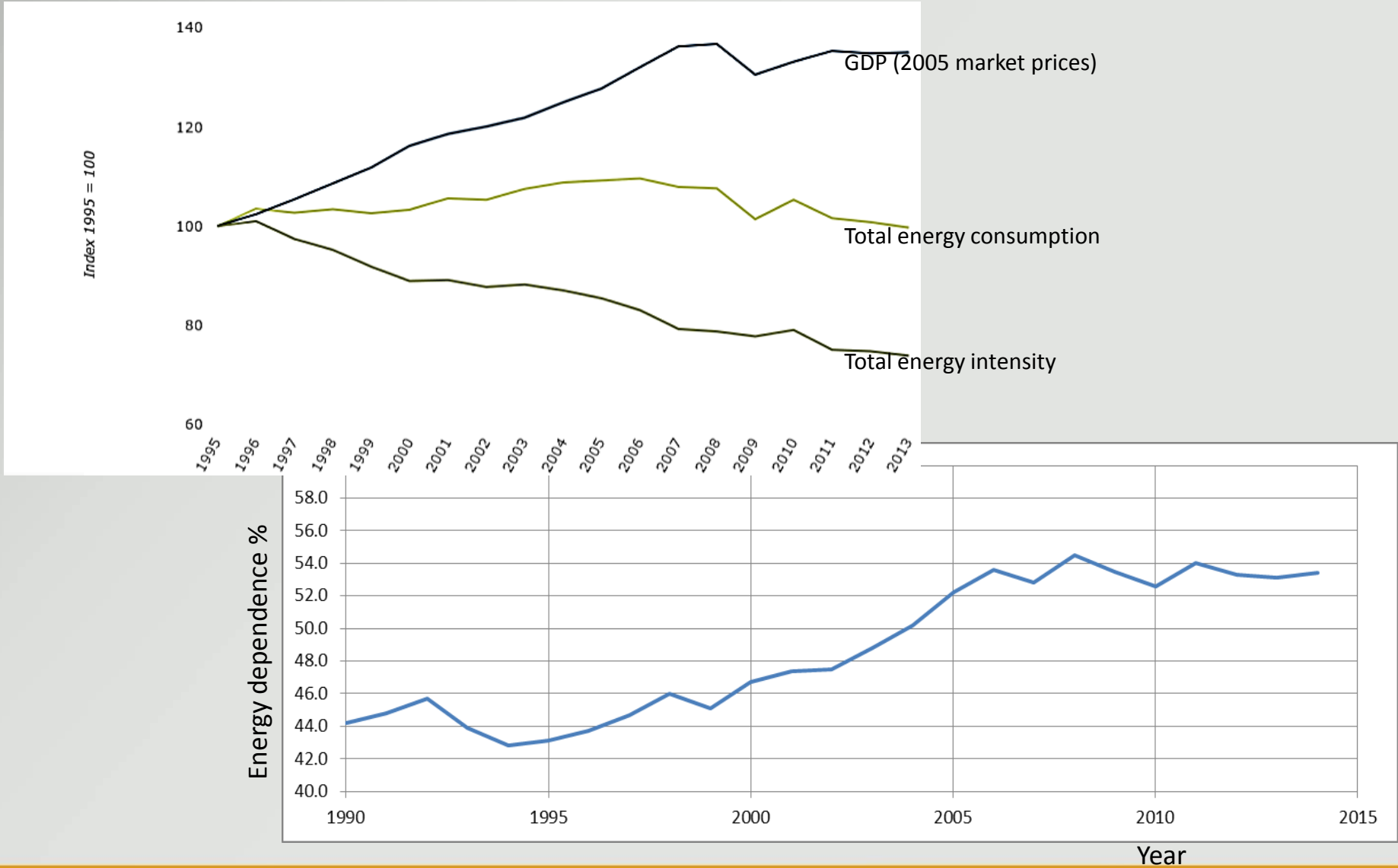
Level of energy dependence by country - 2014



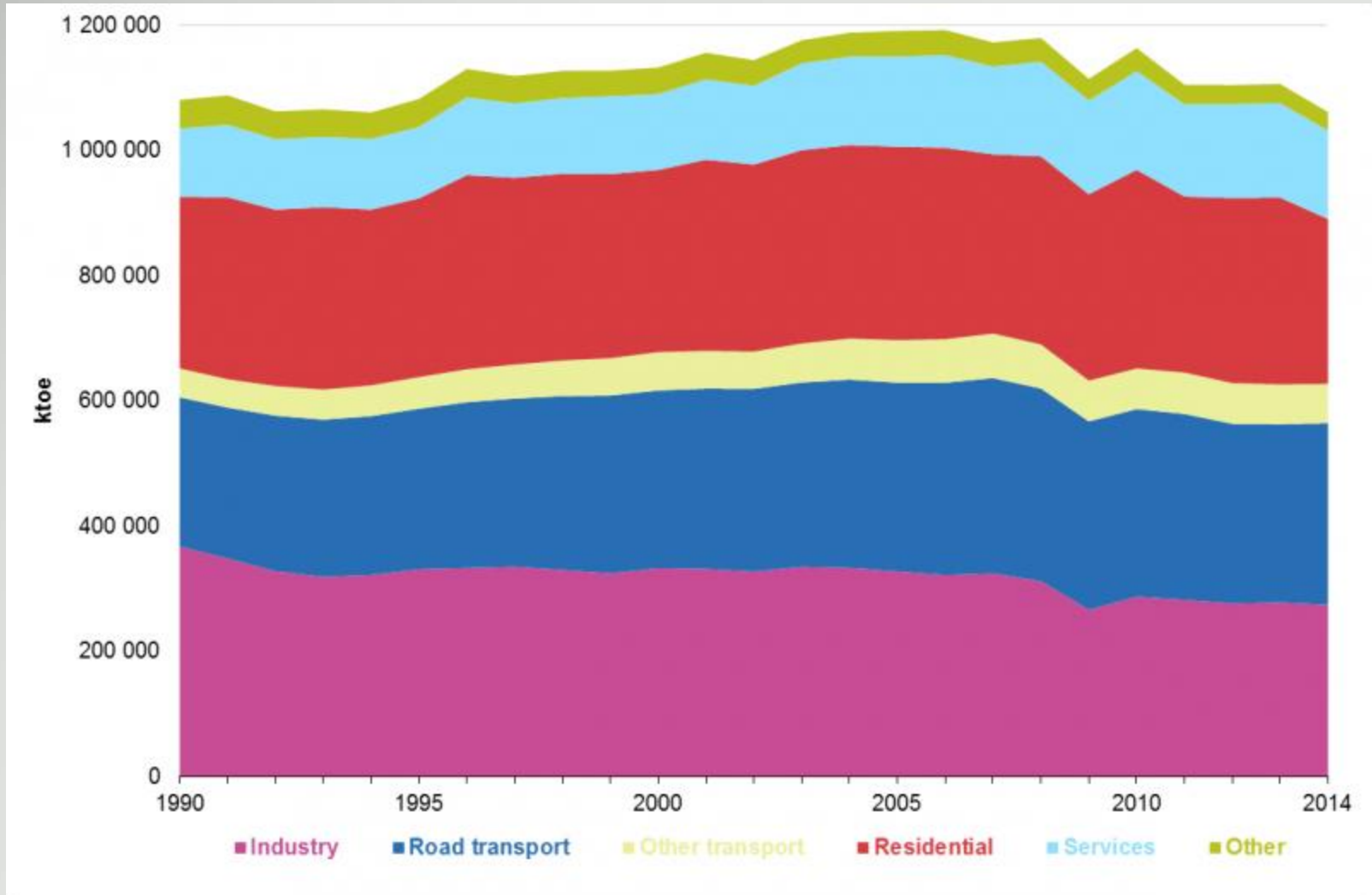
Year



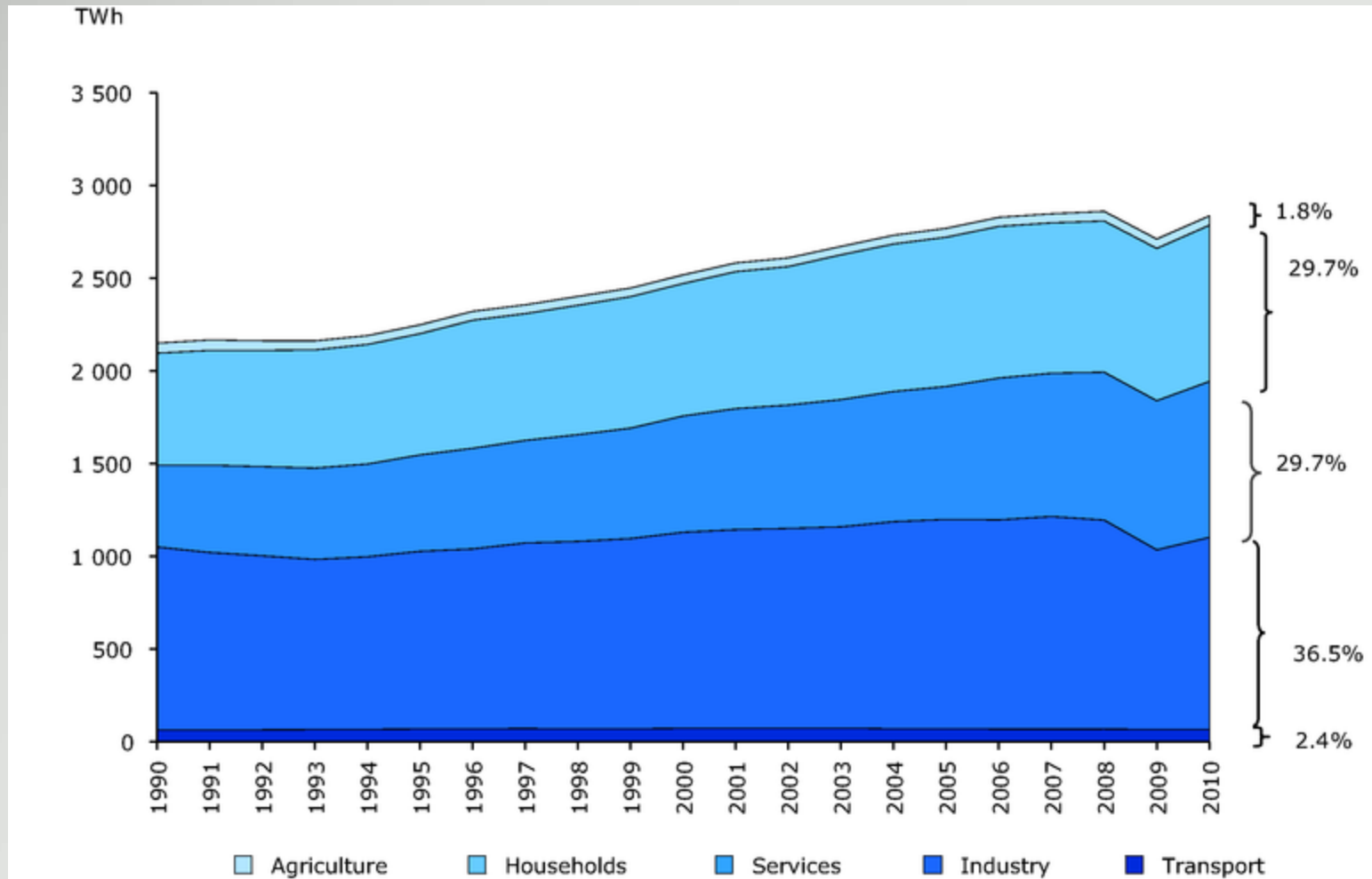
# Energy intensity decreases but dependence increases - EU



# Final energy consumption by sector, EU



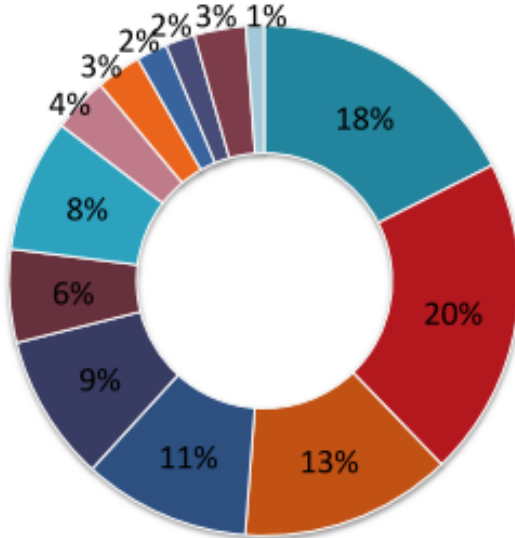
# Final electricity consumption by sector, EU



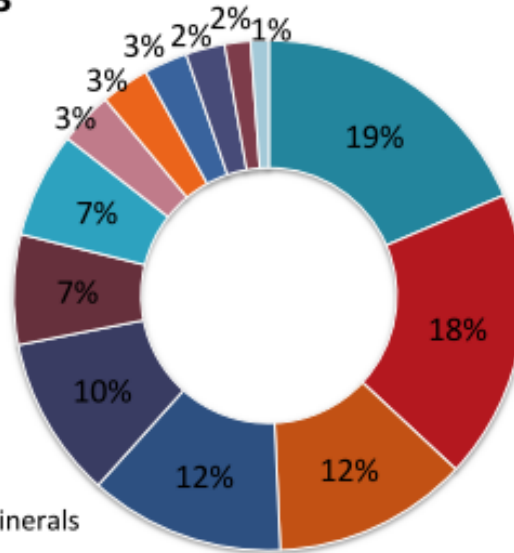
# Energy consumption in industrial sectors - EU

The **chemical industry** is the main energy consuming branch with 19% of total energy consumption in 2013. **Steel** is in second position with 18%, followed by **non-metallic minerals and paper** (12% each), and **food** (10%).

2000



2013



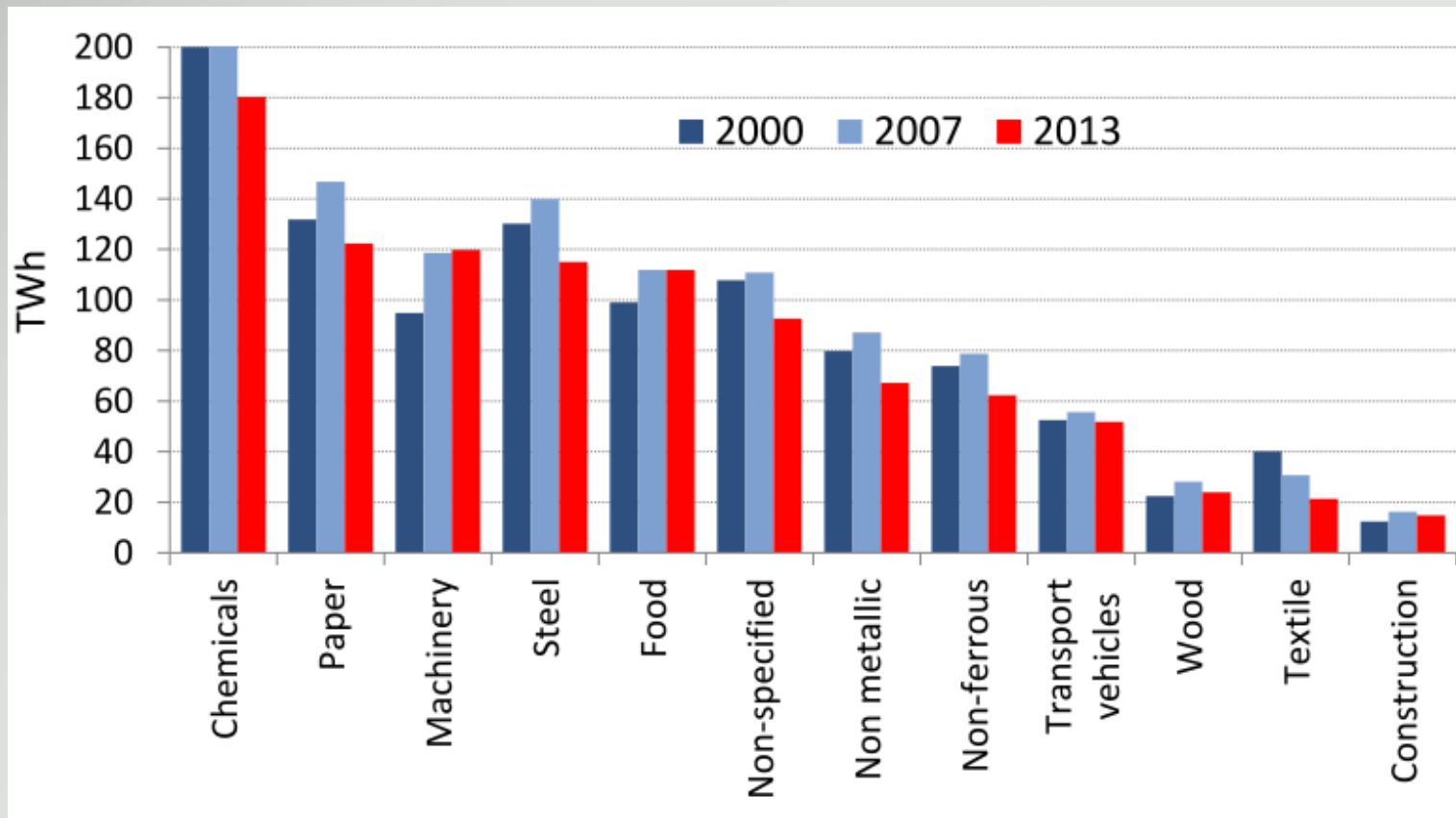
The share of all **energy-intensive branches (steel, chemicals, non-metallic minerals, non-ferrous and paper)** represents two thirds of the industrial consumption.

Source: ODYSSEE from Eurostat

Distribution of energy consumption by industrial branch in the EU



# Electricity consumption in industrial sectors - EU



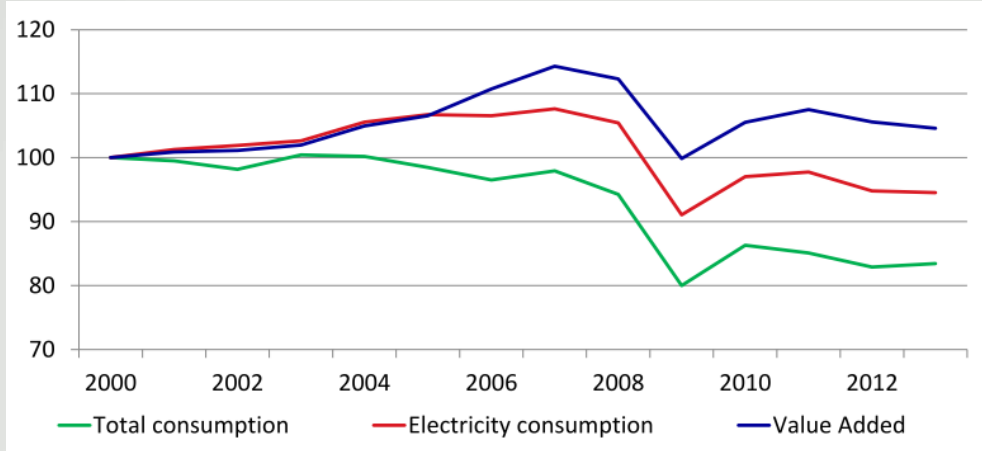
Source: ODYSSEE from Eurostat

## Electricity consumption trends by industrial branch in EU

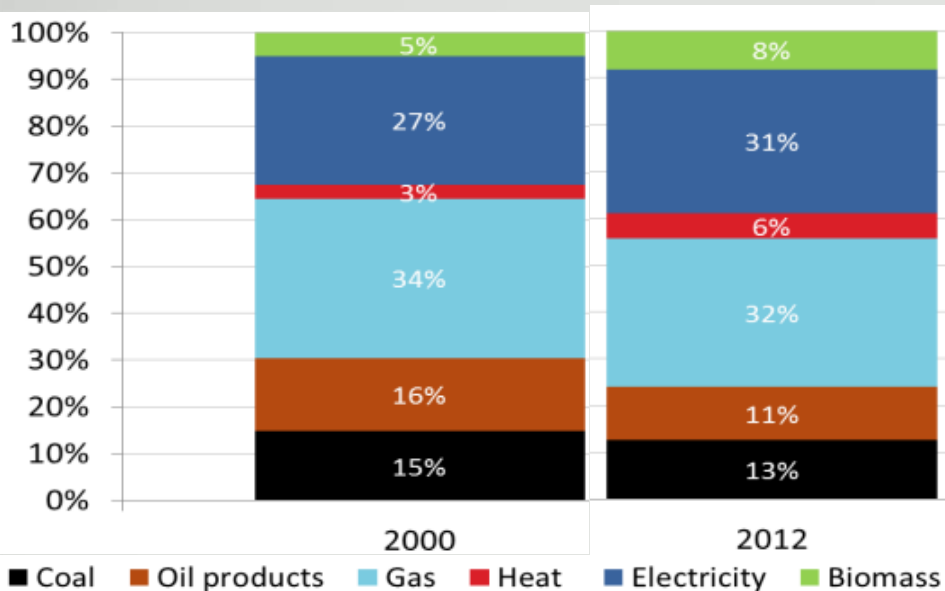


# Energy consumption trends – EU industry

The industrial sector accounts for around 26% of total final energy consumption in the EU-28 in 2012, some 17% below its 2000 level.



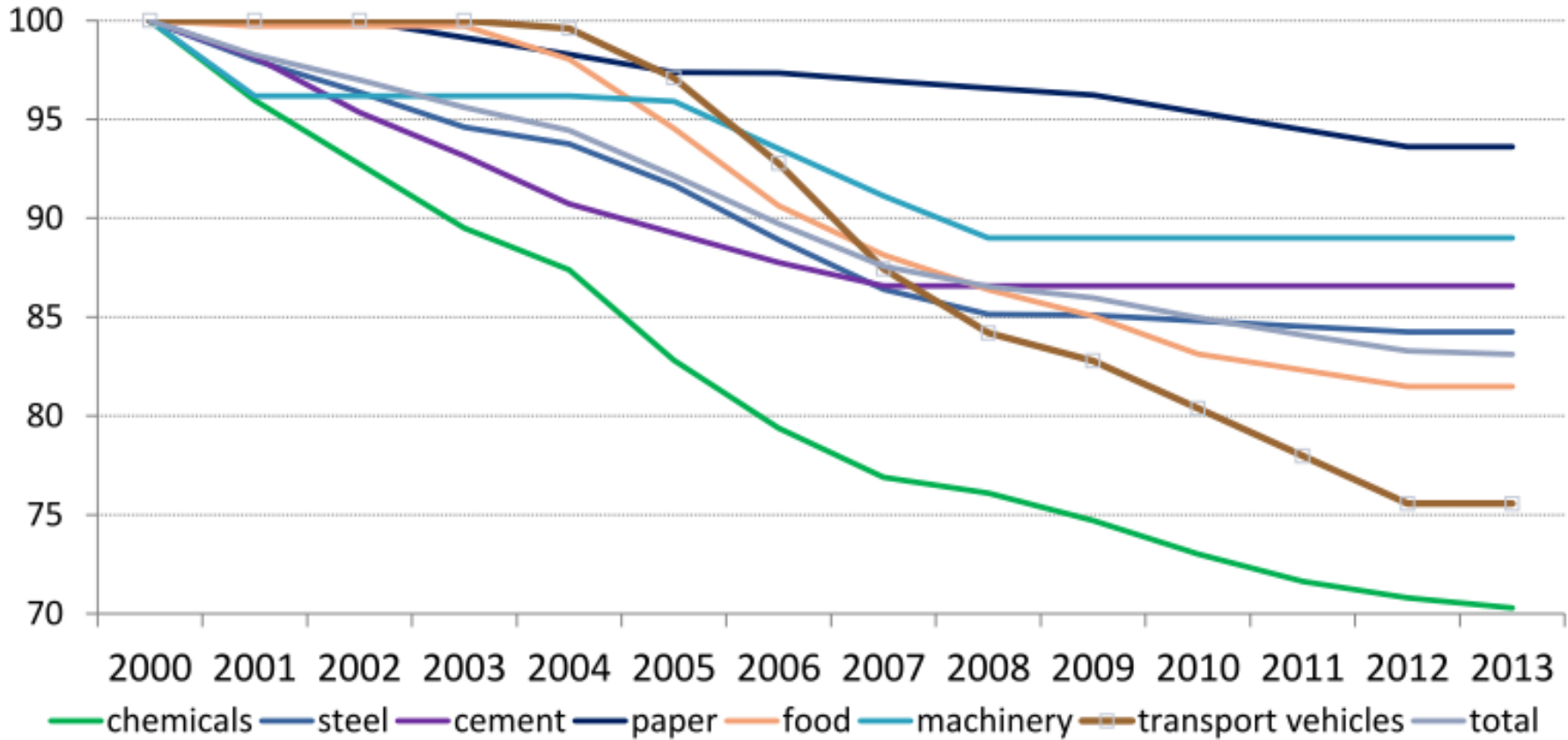
Index: Energy consumption trends and activity in industry in the EU



Natural gas and electricity are the dominant sources of energy for industry with respectively 32 % and 31% of the market in 2012



# Energy efficiency index in industry (EU)

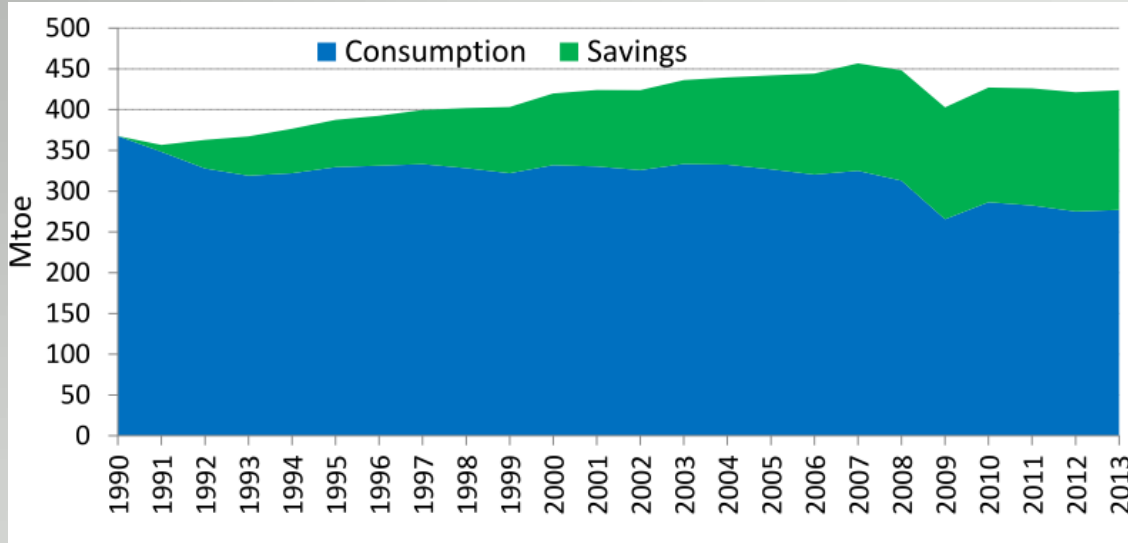


Source: ODYSSEE



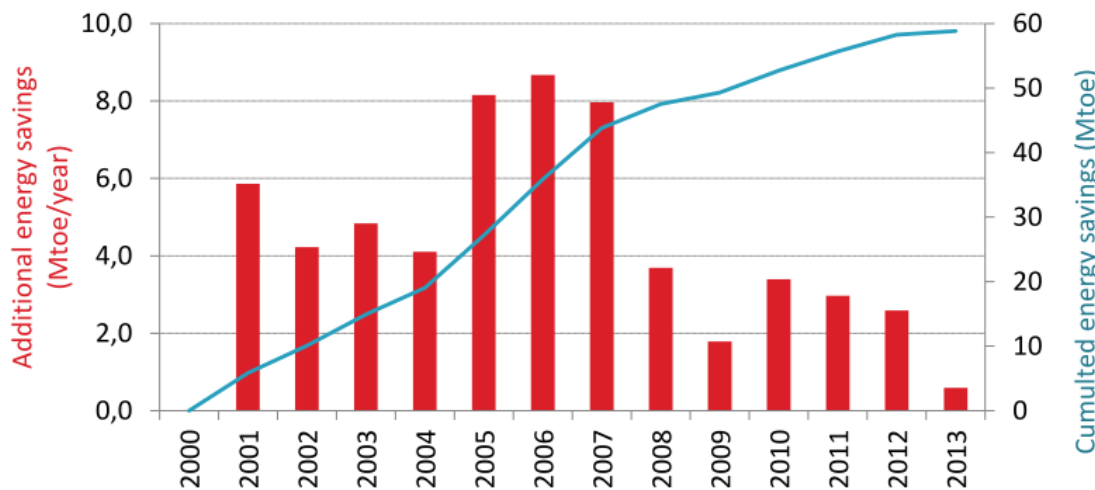


# Energy consumption and energy savings in industry



In 2013, energy savings in industry reached around 150 Mtoe.

**The average energy efficiency progress in industry has been 1.4%/year on average since 2000 (0.9%/year since 2007 compared to 1.9%/year before; slower progress mainly due to recession).**



Source: ODYSSEE



# Developing EE policies for industry (from support schemes to mandatory regulations)



# EU policy for EE: Phases of development

## The EU policy concept:

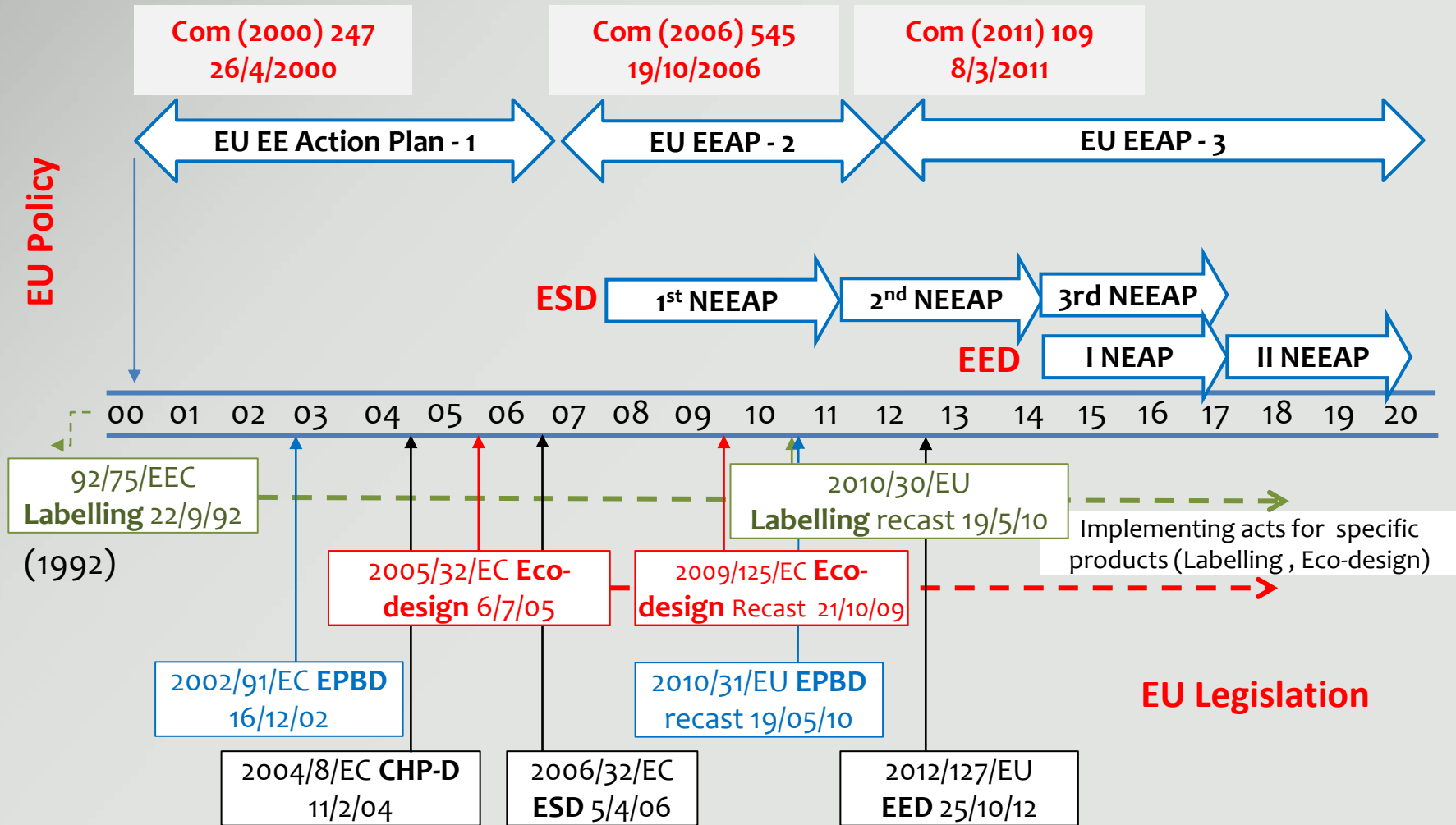
The State supports and regulates. The market implements.

### The well-informed energy consumer is the key

1. The early years (mid 70ties- 2000): Policies supporting the EE market opening (incentives, awareness, support to Research and Development, development of technical standards, etc.)
2. From 2000-onwards: Comprehensive EE policies and plans; **legislative, regulatory and institutional development** (energy labelling, eco design, energy performance of buildings, high efficiency CHP, Energy Services Directive, etc.)
3. From about 2005 –onwards: the market gradually undertakes by itself “enforcement of regulations” i.e. **the regulatory obligations gradually become standard engineering and energy management practices**; shift from financial incentives to market based mechanisms
4. From 2010 – onwards: The EE market becomes more mature; **more stringent regulations**; (e.g. Energy Efficiency Directive)

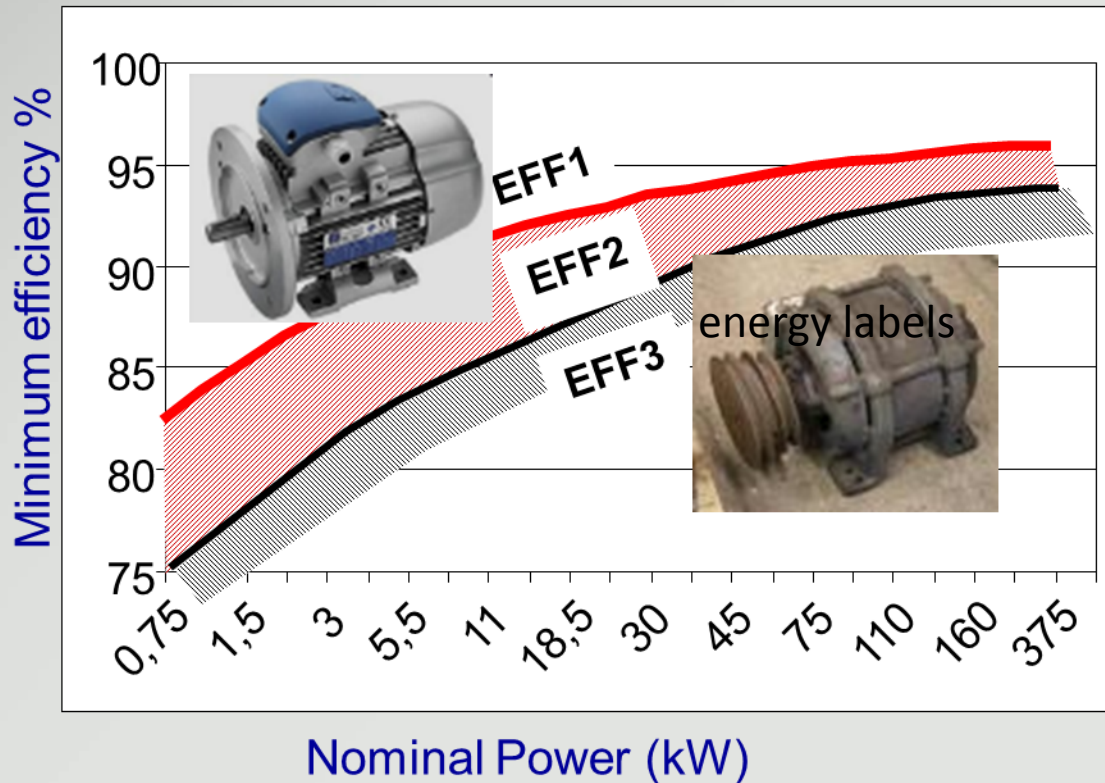


# EU policy for EE: 2000 – 2020



# High efficiency motors – Example of policy development -1

1998 – The International Electrotechnical Commission (IEC) introduced a voluntary “motor efficiency labelling system” (similar to “energy labelling system for energy related products”).



Energy label for energy related products



### Regulation or voluntary agreement?

The European Commission (EC) examined two options:

- a) **To impose a regulation** for mandatory use of EE motors (at that time very expensive and produced by few manufacturers)
- b) To collaborate with manufacturers and **agree with them (voluntary agreement) to increase the number of high efficiency motors sold in EU**

**1997** – The “voluntary agreement” was signed between the EC and 38 major manufacturers:

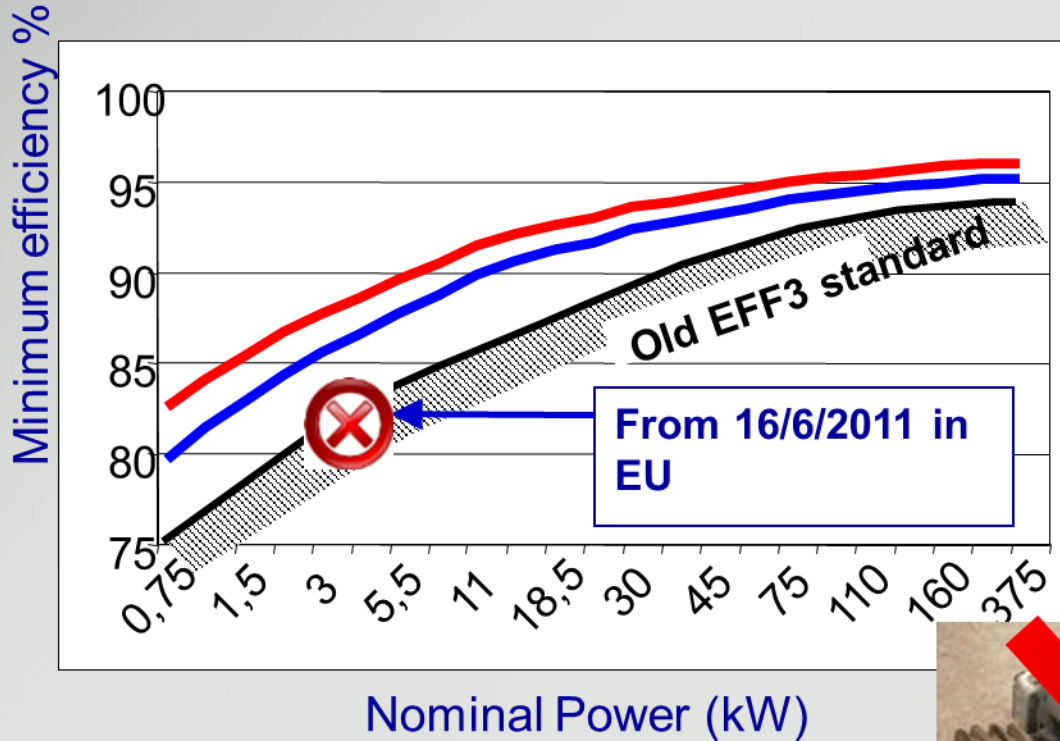
- The agreement gave to manufacturers the time to adapt before strict regulations are imposed. The market of high EE motors enlarged and their prices dropped.
- The EC supported Research and Development, actions to increase of awareness; EC and States subsidized relevant programmes and investments to help market opening.



## From voluntary agreement to Regulation



**2008** - Adoption of new, internationally recognized EE standards

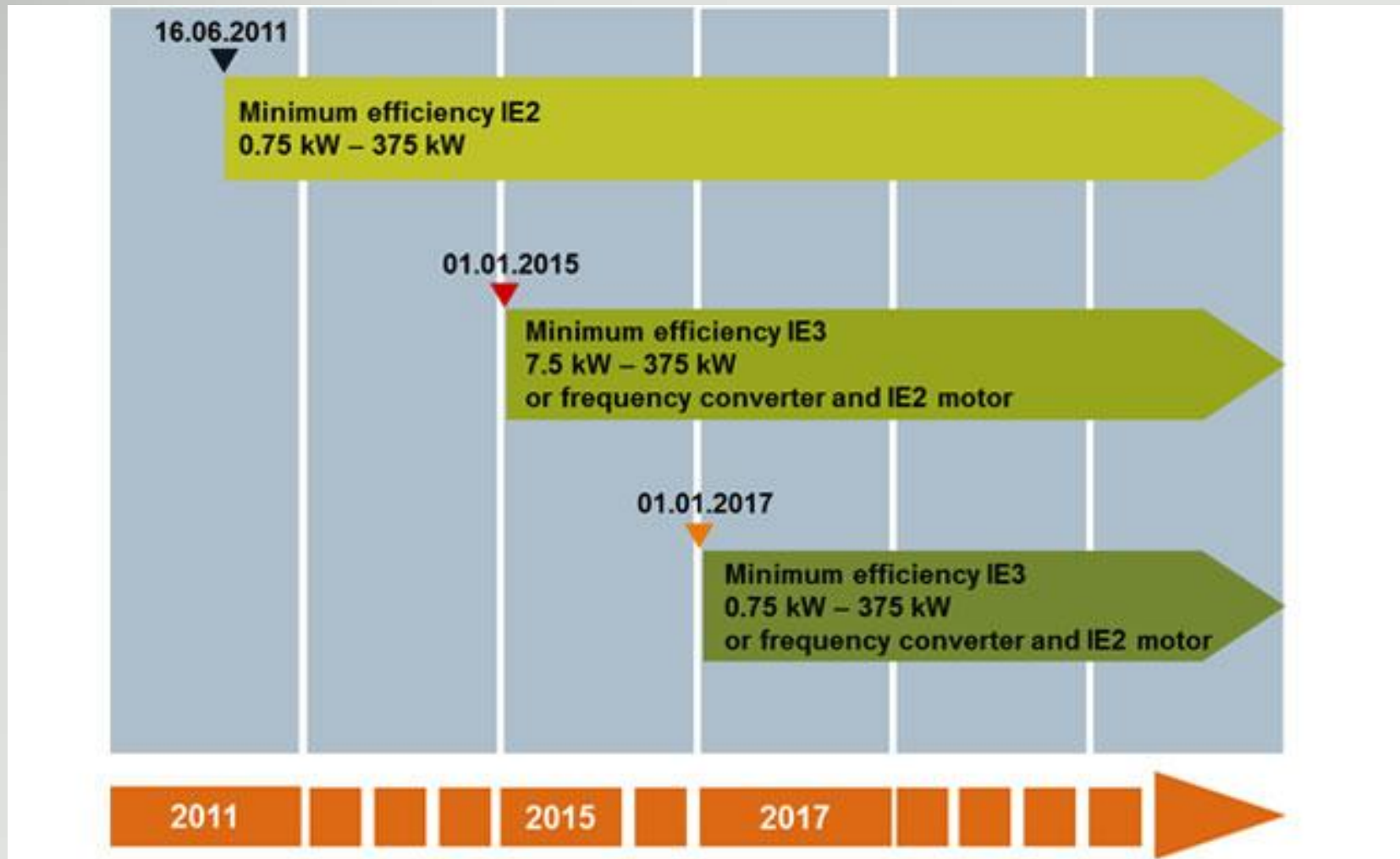


**2009** - Eco-design regulation: new low efficiency motors are gradually banned from the EU market.



# High efficiency motors – Example of policy development -4

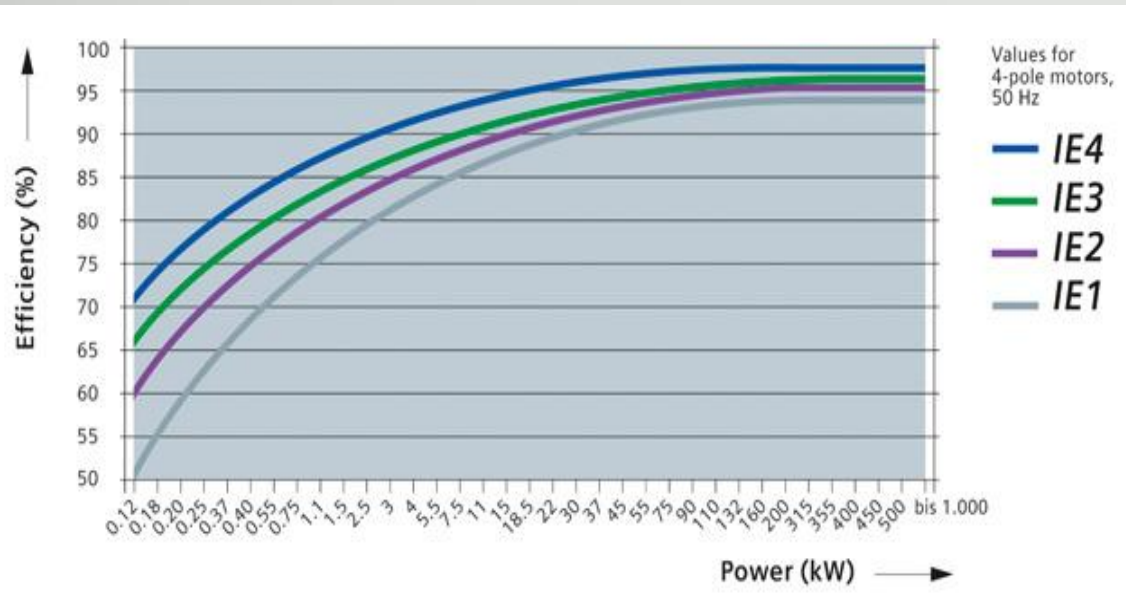
... timeline for the introduction of minimum efficiency





# The most recent standards for EE motors

➔ **2014** - the **standard IEC 60034-30-1** has been published. It replaces the standard IEC 60034-30:2008. The updated standard IEC 60034-30-1 now includes the fourth efficiency level IE4 (see below).



1. IE1 (Standard Efficiency)
2. IE2 (High Efficiency)
3. IE3 (Premium Efficiency)
4. IE4 (Super Premium Efficiency)



# The EE Directive (EED) 2012/27/EU -1

- The EED has been adopted as the central EU framework legislation in the field of EE.
- It repeals Directives 2004/8/EC (CHP Directive) and 2006/32/EC (Energy Services Directive).
- It consolidates and promotes implementation of all EE related legislation (energy labelling, eco-design, energy performance of buildings)
- It provides for **compulsory measures of particular interest for power utilities and other energy suppliers and for the industry**
- Unlike the previous legislation that focused on the demand side only, **the EED addresses for first time energy efficiency in the supply side as well.**



# The EE Directive (EED) 2012/27/EU -2

## Key provisions of interest for industry and utilities

### Energy Efficiency Obligation Schemes (Article 7)

- The State designates as “obligated parties” certain energy distributors and/or retail energy sales companies.
- The “obligated parties” must achieve each year at least new savings, equivalent to **1,5 % of the total annual energy sales** in the country (transport fuels may be excluded).
- The savings must be achieved through EE measures addressed to final customers (not necessarily to the customers of the “obligated parties”)
- The “obligated party” may transfer part or all of its obligation to a national EE Fund by financing investments that will produce the expected savings (Art. 20)
- Alternatively the State must implement EE programmes of equivalent effect.

Each EU Member State applies its own system. Full scale EE obligation schemes have been implemented so far by few countries. Some countries had already established Energy Efficiency Obligations through the so-called “white certificates”.



# The EE Directive (EED) 2012/27/EU -3

## Key provisions of interest for industry

### Energy Audits to Industry (Article 7)

- The State must ensure availability to all final customers of high quality energy audits carried out by **qualified and/or accredited experts (auditors)**
- The State shall develop **programmes to encourage SMEs to undergo energy audits** and the subsequent implementation of the recommendations from these audits.
- **Energy audits are obligatory for large enterprises** (as stand-alone activity or as part of a certified Energy Management or Environmental Management system) every 4 years.
- The State shall set **minimum quality criteria for energy audits**
- The State must put in place a **scheme to assure and check quality of audits** and audit reports.



# The EE Directive (EED) 2012/27/EU -4

## Key provisions of interest for industry

### Availability of qualification, accreditation and certification schemes (Article 16)

- The State must ensure (if not already in place sufficient capacities) availability of qualification, accreditation and certification schemes for providers of energy services (e.g. ESCOs), energy audits, energy managers and installers of energy related building elements.

The EED promotes *i.a.*:

- **Certification of energy management systems** according to ISO 50001 ( and ISO 50002, ISO 50003, ..4, ..6 and ..15) – not explicitly mentioned in the EED
- **Implementation of EN 16247-1 to-5 on energy auditing** (series of EN Standards) - not explicitly mentioned in the EED
- Establishment of **Measurement and Verification schemes to verify savings.**



# The EE Directive (EED) 2012/27/EU -5

## Key provisions of interest for utilities

### Energy transformation, transmission and distribution (Article 15)

- National energy regulatory authorities, through the development of network tariffs and regulations, **provide incentives for grid operators permitting them to implement (cost effective) energy efficiency improvement measures** in the context of the continuing deployment of smart grids.
- The State shall ensure that **an assessment is undertaken of the energy efficiency potentials of their gas and electricity infrastructure.....** (by 30/6/2015)
- .... to **encourage high-efficiency cogeneration** ....

### Energy services (Article 17)

- The State shall ensure that **energy distributors etc. refrain from any activities** that may impede the demand for and delivery of energy services or other energy efficiency improvement measures .... **including foreclosing the market for competitors or abusing dominant positions.**



# Examples of EE policies for industry



# Overview of EE policies for industry

- Financial measures (e.g. subsidies for energy audits and efficiency investments); by far dominating type of measures in industry in almost all EU Member States.
- Co-operative measures (e.g. agreements among enterprises on energy efficiency)
- Cross-cutting measures with sector-specific characteristics (e.g. eco-tax with reduced rates for the industry)
- Fiscal/Tariffs (for e.g. tax deduction for energy saving investments in businesses)
- Information/Education/Training (for e.g. advice programs for industry, energy management systems)
- Legislative/Informative (for e.g. mandatory energy audits in large enterprises)
- Legislative/Normative (for e.g. CO2 emission fee for large emitters)
- New Market-based Instruments (for e.g. Emission trading scheme, white certificates)

Certain examples are presented in the following slides





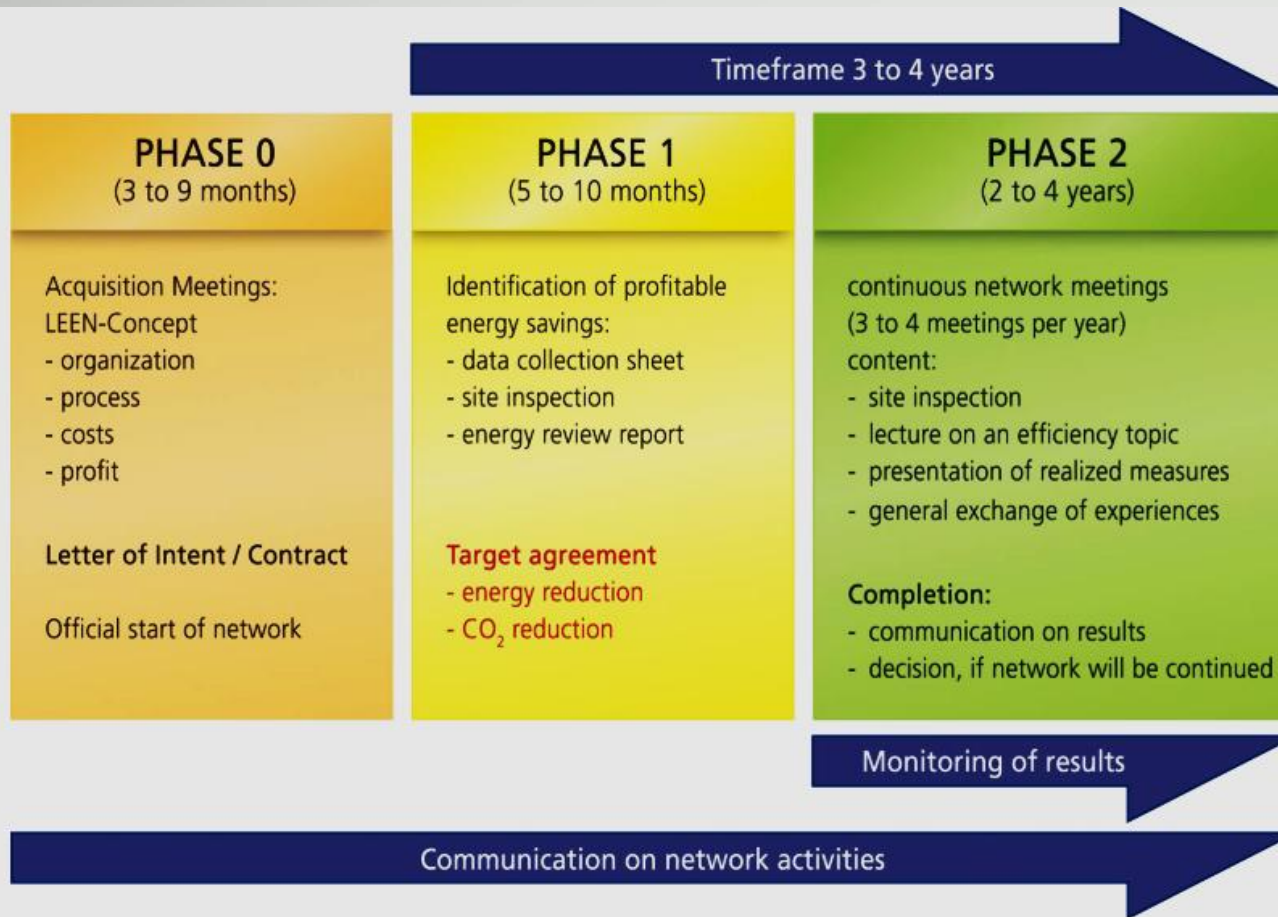
# White Certificates – a market mechanism for EE

- Started in Italy in 2005 followed by France and Denmark in 2006.
- Producers, suppliers or distributors of electricity, gas and oil are required to achieve pre-defined energy savings by undertaking energy efficiency measures for the final users.
- If the obligated parties do not meet the mandated target for energy savings they are required to pay a penalty.
- White certificates are given to the obligated parties whenever an amount of energy is saved and verified.
- White certificates are usually tradable.
- The EE Directive did not adopt the white certificates due to their large administrative costs and complexity; Instead it adopted the more flexible scheme of “Energy Efficiency Obligations” that can be implemented by Member States in different ways (presented previously).



# Learning Energy Efficiency Networks - Germany

A LEEN is usually formed with 10-15 companies operating in different sectors, which are recruited by the network operator (e.g. utilities, industrial associations and platforms, Chamber of Commerce and Industry, city governments, or consulting engineers).



Around 4.000 measures were identified in 30 networks in Germany, with an average IRR ~30% and an average PBP ~3yr.

The companies participating increased their EE about 2x as quickly as the German industrial average.

Source: [www.leen.de](http://www.leen.de)



## Companies in a Network get:

- A complete assessment of the saving potentials in cross-cutting technologies and several process-technologies
- An economic evaluation of the saving potentials (IRR, Payback Period and Net Present Value)
- Exchange of experiences (network acts as a know-how-pool)
- Up to date information on new technologies (presented by engineering experts)
- Evaluation of realized measures by a yearly monitoring
- A four year employee training
- LEEN components are compliant to ISO 50001 and 16247 standards.



# Learning Energy Efficiency Networks - 3

## Energy savings in LEEN networks

- Hohenlohe: -20.1% (after 5 years)
- Ravensburg: -12.7% (after 5 years)
- Franken-Oberpfalz: -8.7% (after 4 years)
- Süd-West: -7.6% (after 3 years)
- Hanse: -7.5% (after 3 years)
- Donau-Alb: -7.0% (after 3 years)
- Heilbronn-Franken: -6.9% (after 3 years)

A voluntary agreement was signed by the German Government and 18 associations of industry to generate 500 energy efficiency networks until 2020.

## Participating companies (indicatively)

- Barilla (Food)
- Bayer Health Care (Pharma)
- Evobus part of Daimler Group (Auto)
- Evonik (Pharma & Plastics)
- Hilti (Tools & Machinery)
- Liebherr (Engineering)
- L'oreal (Cosmetics)
- Michelin (Auto)
- Procter & Gamble (Food)
- Stora Enso (Paper)
- Fiducia (IT)



# Voluntary agreements in energy intensive industry



Belgium

- **Audit covenants**

The companies undertake to carry out an energy audit and draw up an energy plan to improve energy efficiency.

1<sup>st</sup> phase: implement measures with IRR  $\geq$  15%.

2<sup>nd</sup> phase: measures with IRR  $\geq$  13.5%.

- **Benchmark covenants (large consumers)**

The companies involved are bound to achieve and maintain a benchmark performance. They are inspected/advised once every four years.



Hungary

The state concludes agreements with groups, such as:

- Energy-intensive industries,
- Manufacturers of appliances.

The companies undertake:

- Achieve energy savings
- Application of more EE technologies,
- Development of products with better EE performance (for manufacturers of appliances)

“Remuneration” is provided through

- favorable publicity
- exemption from applying “mandatory” rules
- financial support.



# Examples of EE measures in industry



# Setting up an energy and load management system

## Project identity

**Client:** A SME wood processing factory (Greece)

**Consultant:** EXERGIA S.A.

### **Purposes:**

- To monitor electricity consumption by department/process line/large motors, produce **energy performance indicators**, take corrective actions and identify EE investments
- To **monitor on-line electricity loads** in order to reduce peaks (and benefit from electricity tariffs)
- To **monitor on-line electricity loads for identifying “unusual behaviours”** and taking immediate actions.

**Energy management methodology:** Monitoring and Targeting.

## Results

**Annual electricity cost:** 3,4 million Euro

**Investment cost:** 285.000 Euro (including design, installation of infrastructure and monitoring and training by the consultant for 8 months)

**Cost savings during the monitoring period:** 6,5% (only by avoiding wastage of electricity and reduction of peak loads, without any additional EE investment)

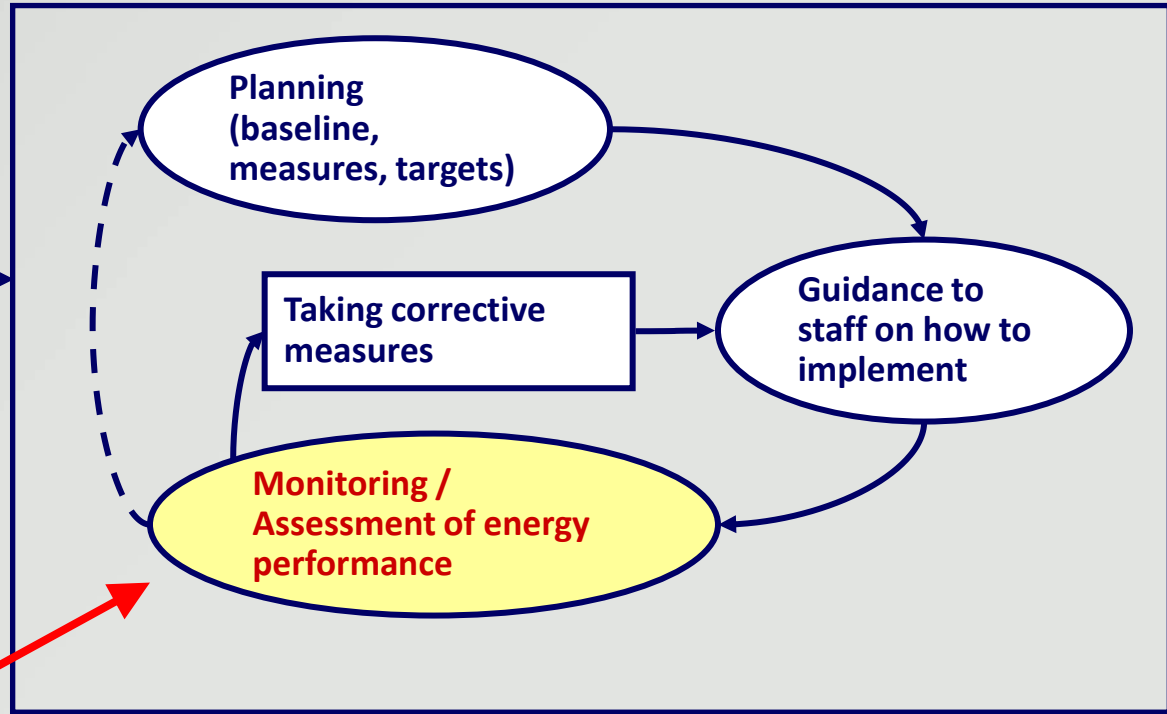
**Payback period:** 1,3 years

Additional savings were achieved from implementation of EE investments identified through the EM system functions and implemented later

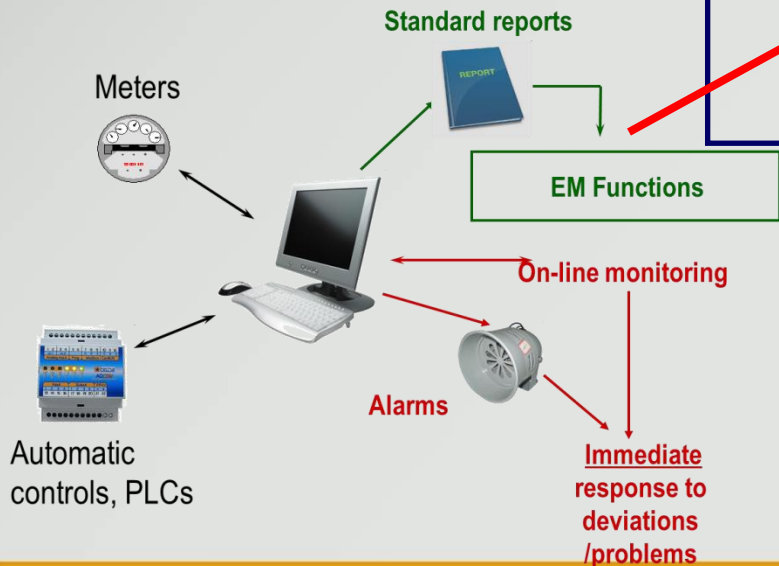


# Concept of energy management system

Energy audit  
 Inventory of motors and other electricity loads  
 Design of the metering and control system  
 Installation / calibration of software  
 Setting up of the **EM Organization**

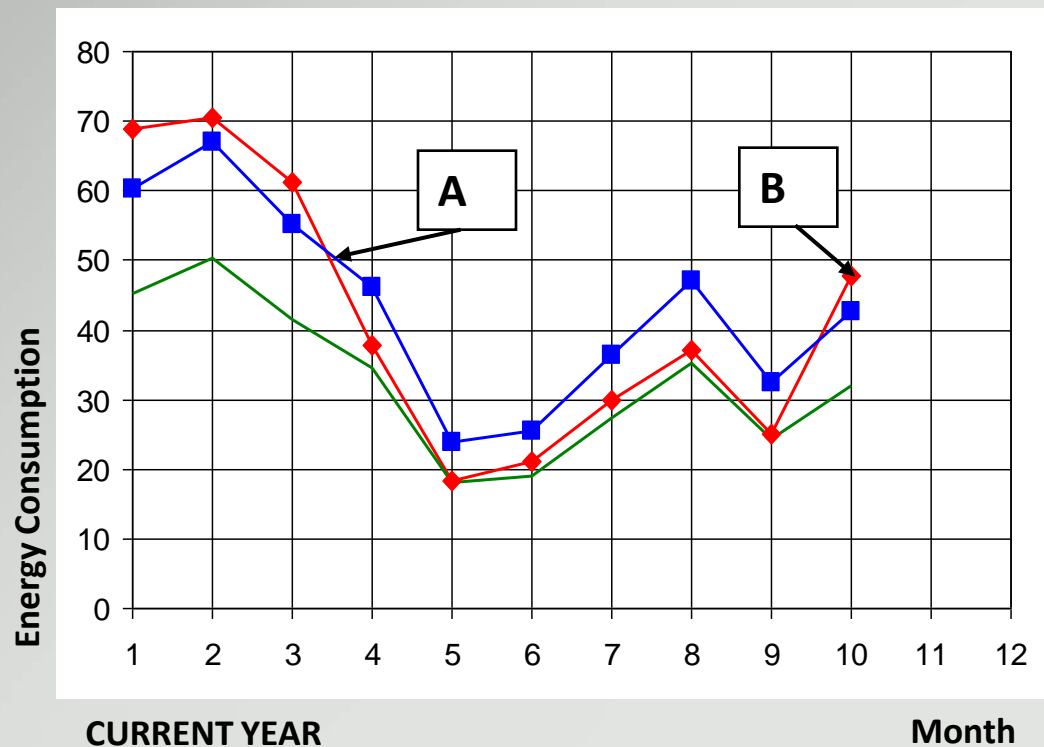


**Reporting system**  
 Awareness raising / Training of personnel





# Monitoring against Baseline - Planned Targets



—■— Baseline (calculated)

—◆— Actual consumption

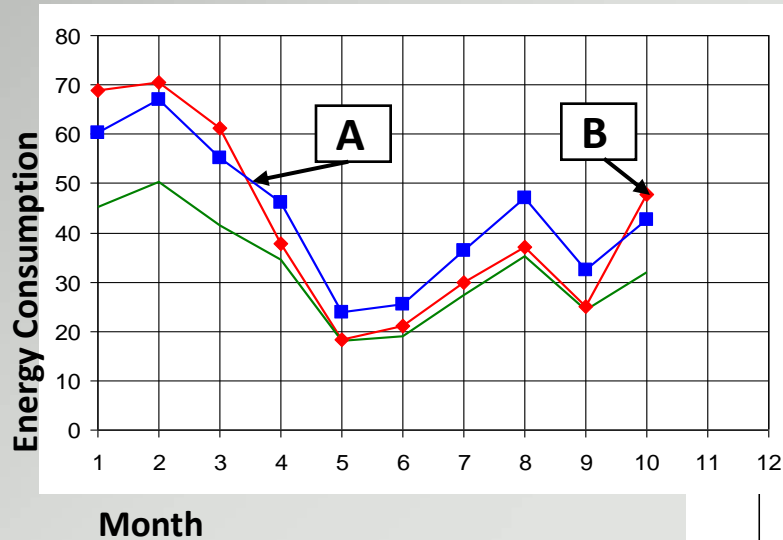
— Target (calculated)

A: effects from implementation of the energy management system

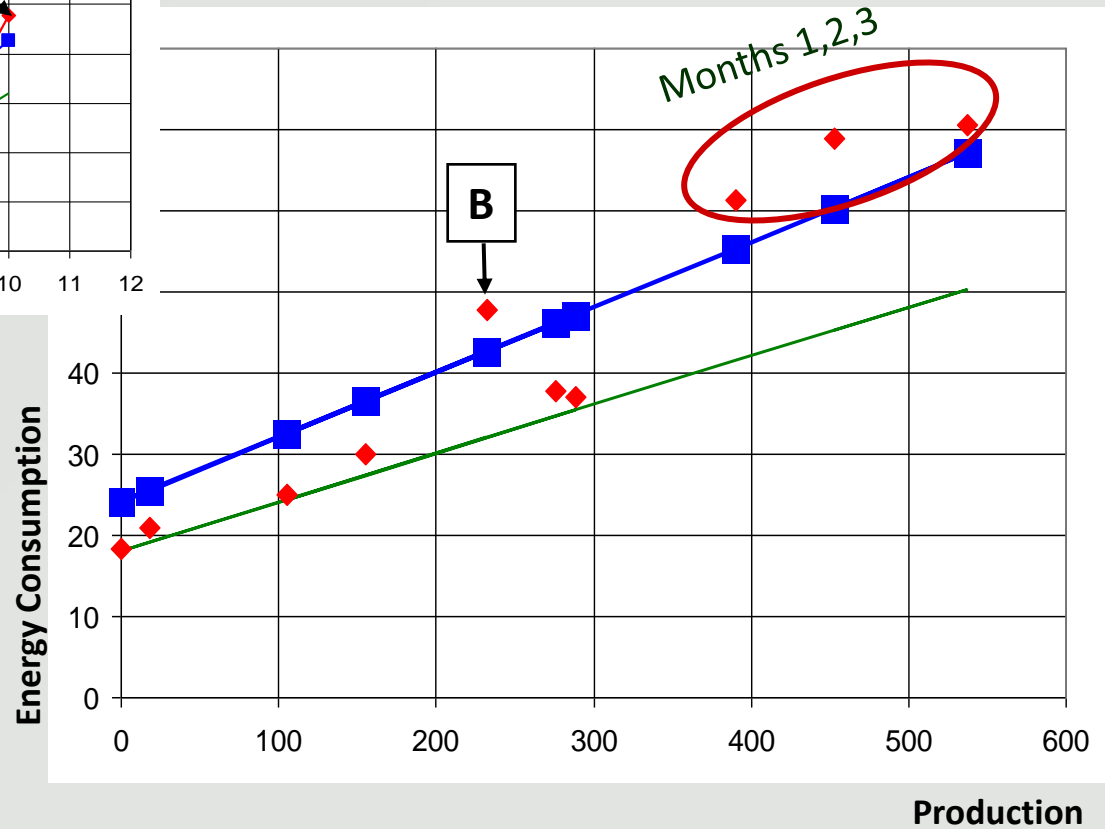
B: Last month: the reasons for the increase in consumption must be investigated / measures may be taken



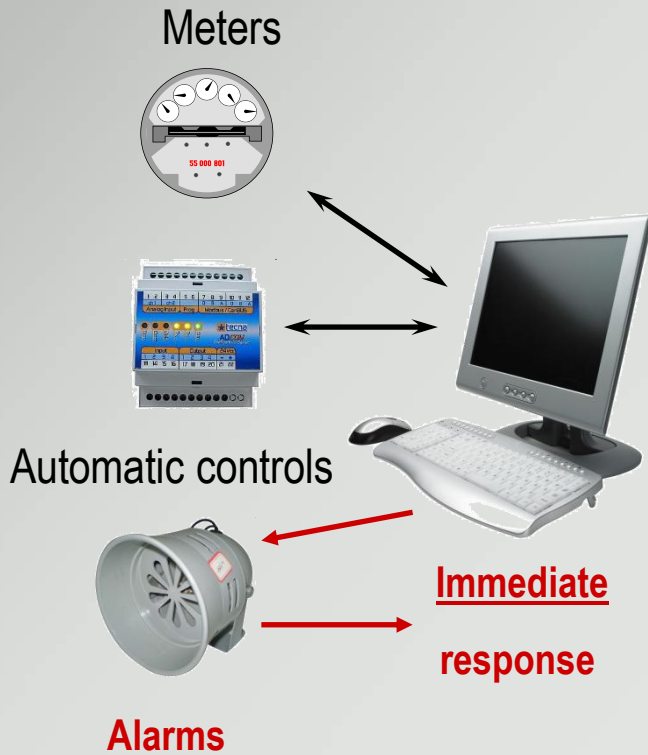
# Monitoring against Baseline - Planned Targets



- Baseline
- ◆ Actual consumption
- Target



# Load management



- Analysis of loads and tariffs – cost/benefit calculations for permanent load shifting (changes in production programme) – Rationalisation of programme
- Classification of electricity loads into 3 categories:
  - A) inelastic (can not be switched off)
  - B) semi-elastic (decision to switch off is with the operator)
  - C) elastic (in case that load is approaching high peaks they are switched off)
- Training of personnel on how to react to peak alarms.



# The case of Variable Speed Drives -1

Variable-speed drive (VSD) is an equipment used to control the speed of machinery.

They are usually electronic equipment that regulate the speed and rotational force, or torque output of an electric motor through frequency regulation (most common type), voltage regulation, etc.

There are different types suitable for different applications.

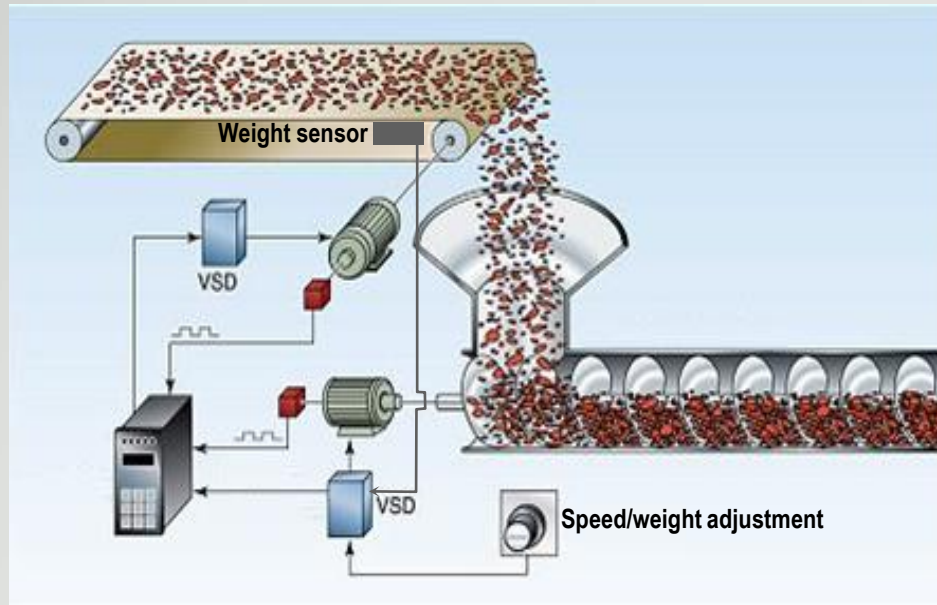


A VSD adjusts the motor's output on the basis of a programmable settings and (normally) from signals by one or more sensors (temperature, pressure, level, weight, flow, etc.). Some examples of use:

- **pumps:** to maintain pre-set pressure levels, discharge flows, etc
- **fans:** similar as above
- **boilers:** to maintain optimal combustion e.g by adjusting the quantity of inlet combustion air
- **air compressors:** to meet varying demand and maintain the required pressure/flow
- **conveyors:** with speed control, weight control
- **refrigeration systems:** to maintain the pre-set temperatures,
- **HVAC:** to maintain the required in-door conditions at low energy consumption, ... and all these and many more, with significant energy and cost savings.



# Example of VSD use



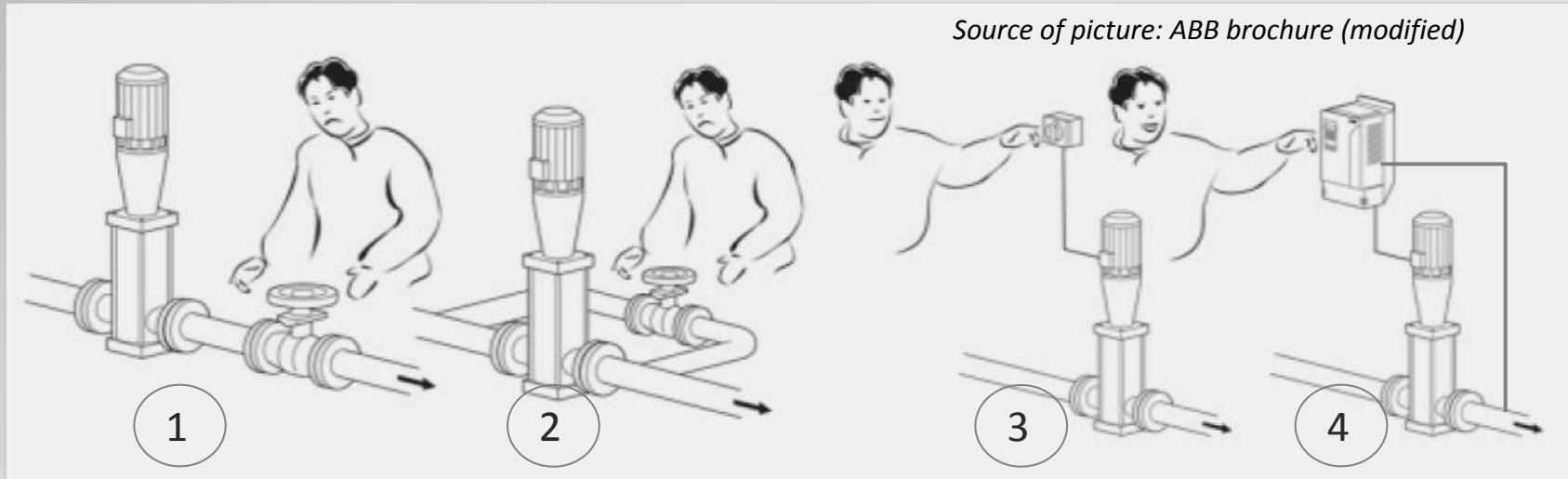
## Conveyors' system controlled by VSD:

- for synchronisation between the two conveyors,
- for conveying the required quantity of material by changing their speeds

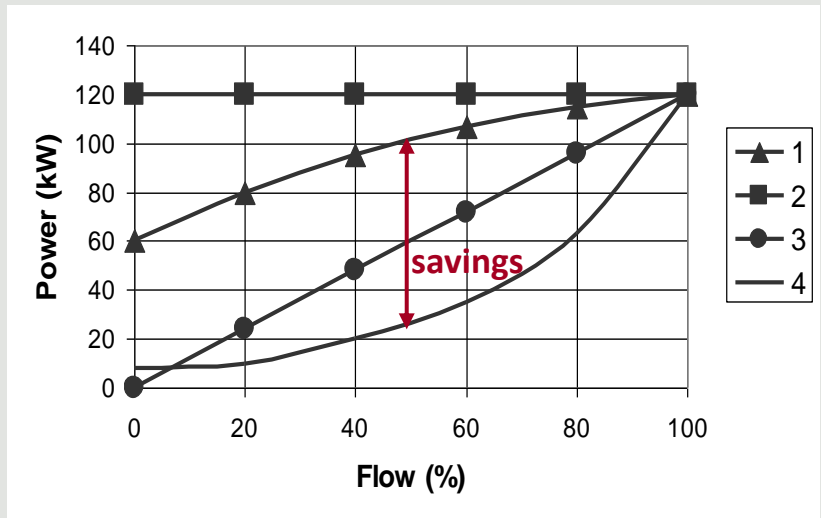
Electricity savings are achieved when motors run at fluctuating loads. Most savings are achieved when motors operate <50% of load



# VSD in a pumping system -1

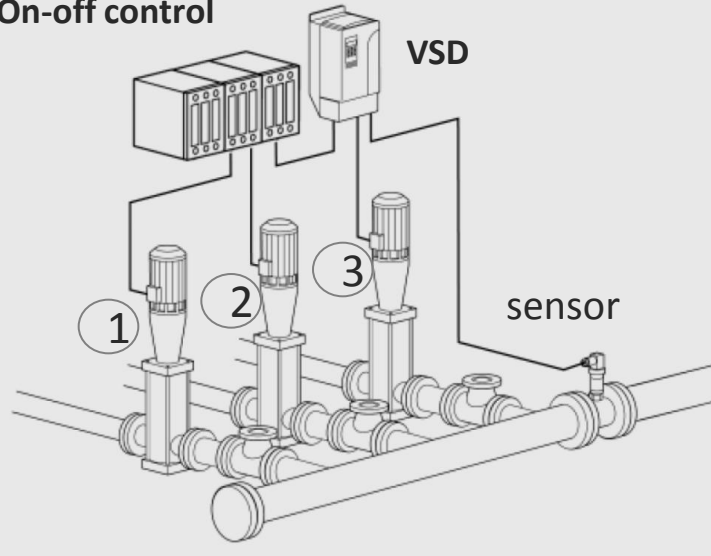


1. **Throttle valve** (manual or automatic)
2. **By-pass valve** (manual or automatic)
3. **On-Off** (manual or on-off activated by pressure sensor)
4. **VSD** (programmable - driven by pressure sensor)



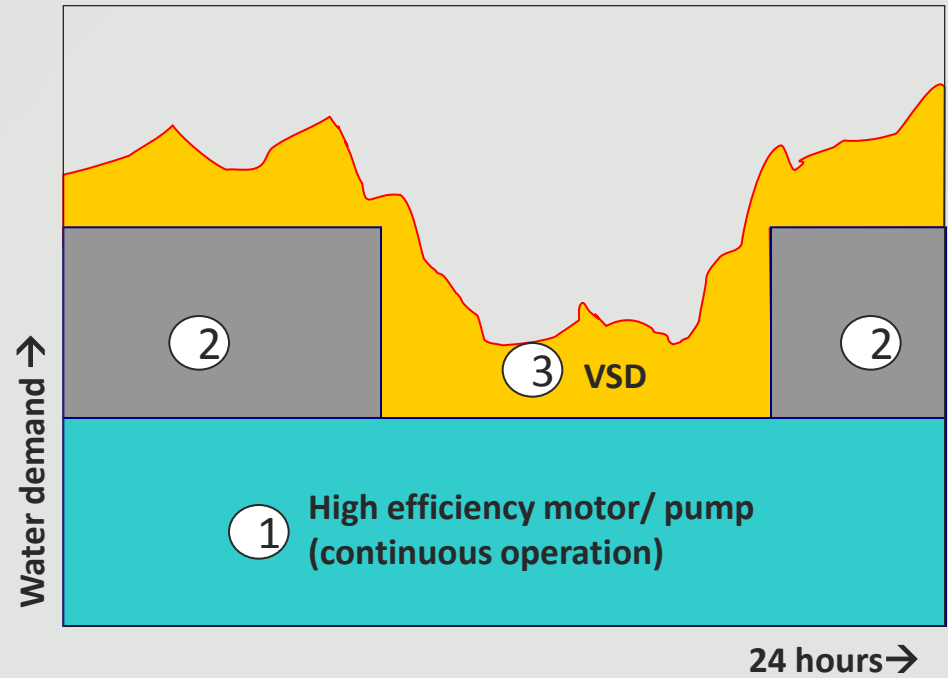
# VSD in a pumping system -2

On-off control



Source of picture: ABB brochure (modified)

Concept of pumping station operation schedule



# Case study - VSD

## Variable Speed Drives

Company	###, UK
Project Actions	Use of Variable Speed Drives
Contract Type	Conventional + Grant
Finance Source	Internal
Total Project Cost	€ 9.400
Grant	€ 2.000
Simple	4 months
	<b>Annual Energy(MWh)</b>
Before	258
After	67
Savings	75 %

### Summary

Electric motors account for approximately **60% of the total energy** used in the workplace and the majority of these motors are on fans and pumps. Most industrial applications simply **switch on and off** these motors.

Only way to control the speed of an AC motor is to **alter the frequency** and this is achieved with the addition of a Variable Speed Drive.

### Scope of intervention

Addition of VSDs

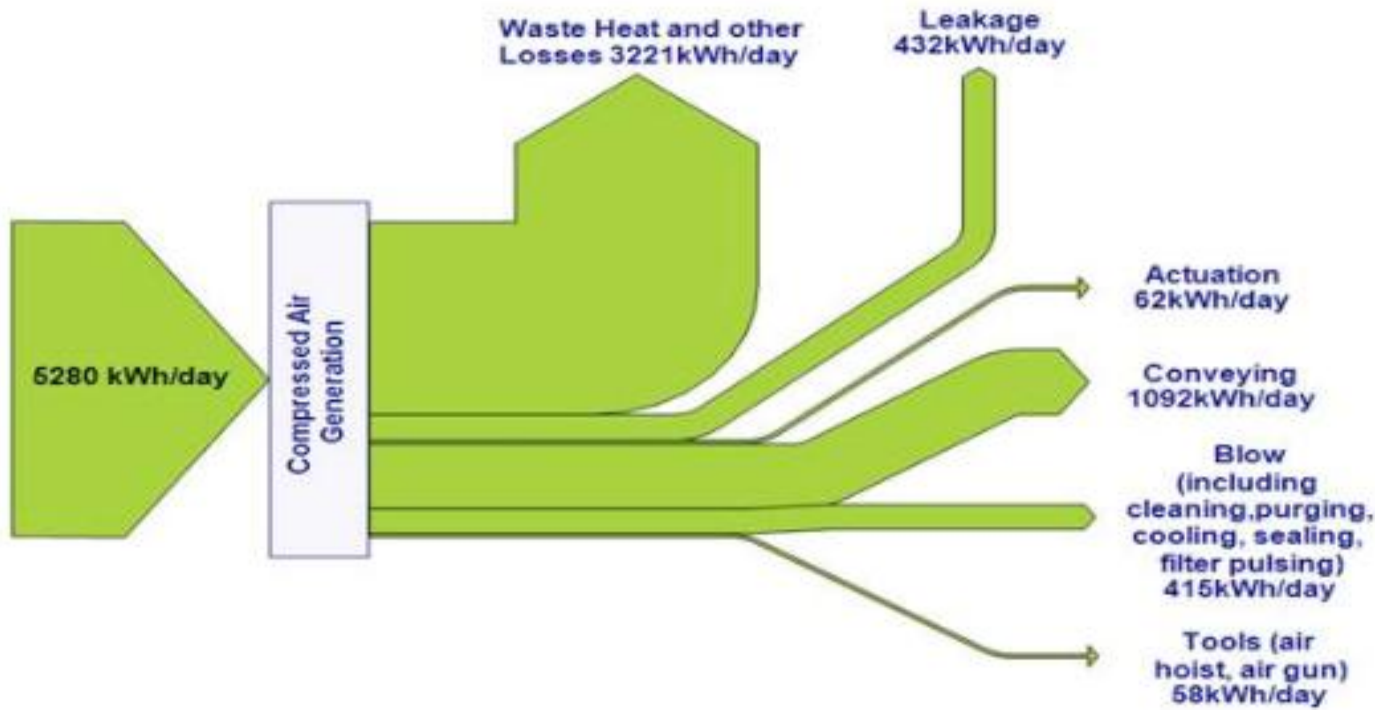
### Major effects.

- Better control of the process
- Reduction in motor speed, thus less energy consumption and reduced costs

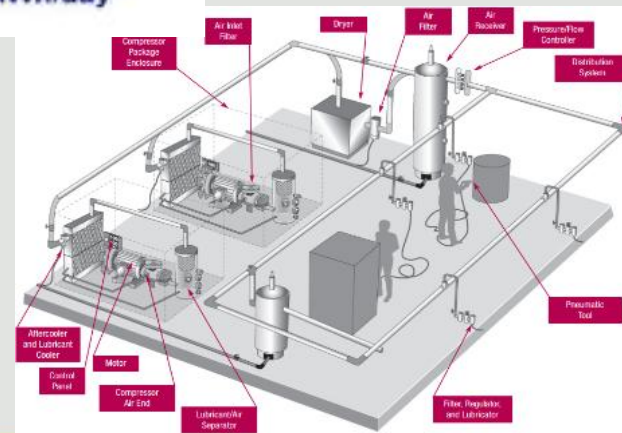




# The case of Compressed air system



Uses include powering pneumatic tools, packaging and automation equipment, conveyors, etc.



# EE measures in a Compressed air system

Energy savings measure	% applicability	% annual savings	Comments
Improvement of drives (high efficiency motors)	25	2	Most cost effective in small (<10kW) systems
Improvement of drives (speed control)	25	15	Applicable to variable load systems. The estimated gain is for overall improvement of systems.
Upgrading of Compressor	30	7	
Use of sophisticated control systems	20	12	
Recovering waste heat for use in other functions	20	20-80	The gain is in terms of energy, not of electricity consumption
Improved cooling, drying and filtering	10	5	
Overall system design, including multi-pressure systems	50	9	
Reducing frictional pressure losses (for example by increasing pipe diameter)	50	3	
Optimising certain end use devices	5	40	
Reducing air leaks	80	20	Largest potential gain
More frequent filter replacement	40	2	

Source: JRC/EC



# Case study – Compressed air system

## Replacement for parts of compressed air system

Company	Manufacturer of polyolefin foam , North America
Project Actions	Replacement for Compressed Air System
Contract Type	Conventional + Grant
Finance Source	Internal
Grant	\$ 78.900 (Mass Save Sponsor Inventive)
Total Project Cost	\$ 197.500
Simple payback	≈ 4 years

Annual Energy Savings (MWh)	Annual Cost Savings (USD)
274	34.000

### Summary

### is the leading manufacturer of crosslinked polyolefin foam in North America. Their Massachusetts manufacturing facilities were in need of a **energy-efficient replacement for their compressed air system.**

### Scope of intervention

- Replacement of old, inefficient air compressors with a new high efficiency air compressor using a **variable-speed drive motor**
- Replacement of inefficient non-cycling air dryer with a high efficiency **cycling air dryer**

### Major effects.

- Saving on annual energy costs.
- Reduction of impact on the environment (2,215 tons less)
- Improvement of the efficiency of the facility



# Some conclusions



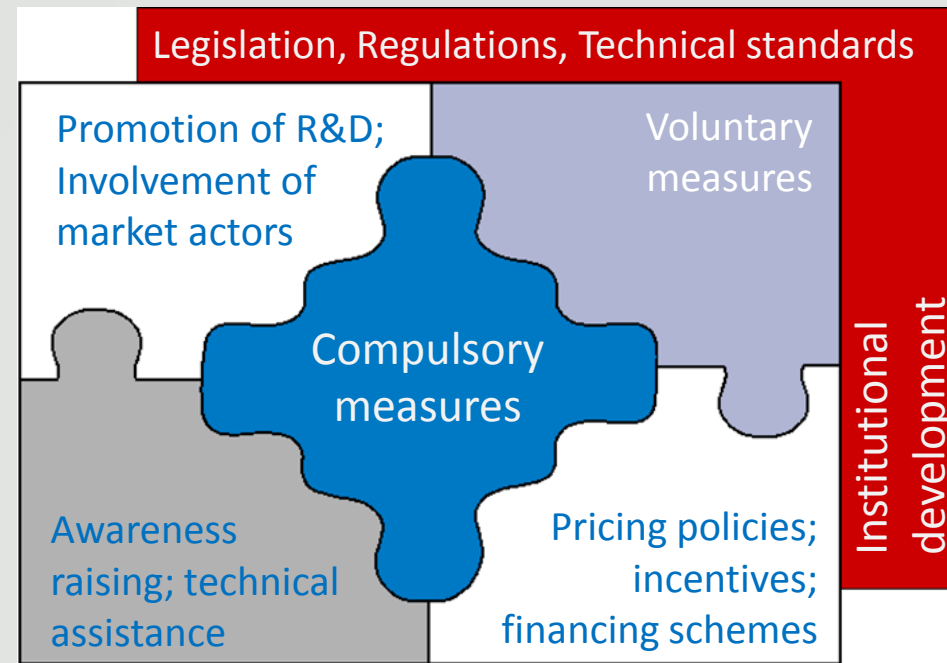
# The challenges to develop policies for industry

Promotion of EE in industry is a complicated issue. Legislation/ regulations alone, can not solve it.

Key policy challenges:

- **A large number of relatively small EE projects** must be promoted in different sectors
- Many market actors need to be involved
- **Mentalities must change**
- **Financing EE cannot rely on state support only**
- **Premature obligatory regulations may harm businesses** (manufactures of equipment, industry, utilities, etc.)
- **A background job must be done before implementation of a policy** (e.g. standards, training/ certification of auditors, certification schemes for Energy Management, verification schemes to verify savings, etc.)

*A proper policy mix should be found to address barriers*



# Exploiting the EU experience

- The EU and individual Member States have tested a wide variety of measures for promotion of EE in Industry over the past 40 years. This experience can be analysed, adapted and implemented in the specific conditions of the country.  
**It is not necessary to reinvent the wheel.**
- Although some financial measures are included in most programmes in EU the trend is to move towards market based mechanisms, cooperative measures, compulsory measures (e.g. obligatory energy audits, EM systems with annual reporting, etc.).
- “Successful policies” tools must not be “new” in order to be successful (e.g. voluntary agreements)
- Awareness raising (alone) has limited effects
- Additional taxation on energy (alone) may not have the expected effects; elasticity is limited in industry; any revenues from energy price increase must be directed to energy efficiency measures.



Thank you!

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