Climate change and energy use: the role of energy efficiency

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Adaptation to Climate Change: An essential part of the Climate Change Policy
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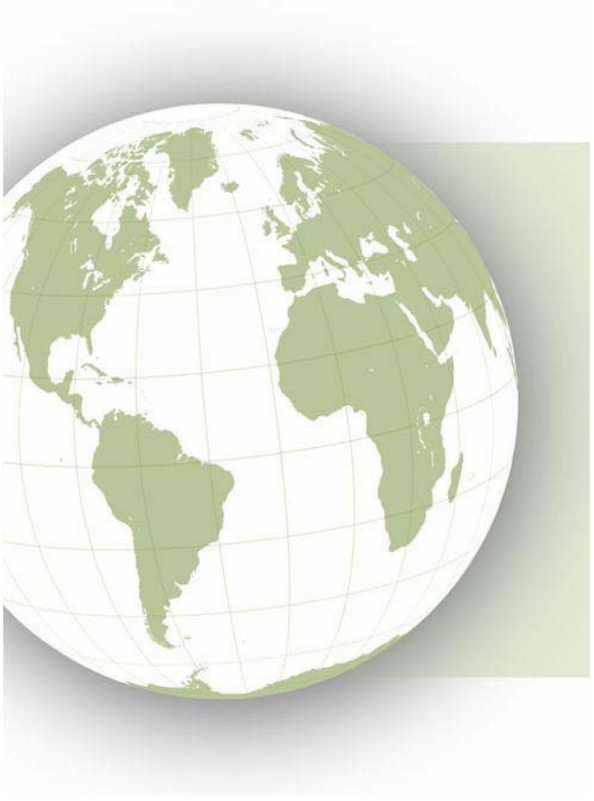

1. Challenges in the current energy model: energy efficiency as part of the solution

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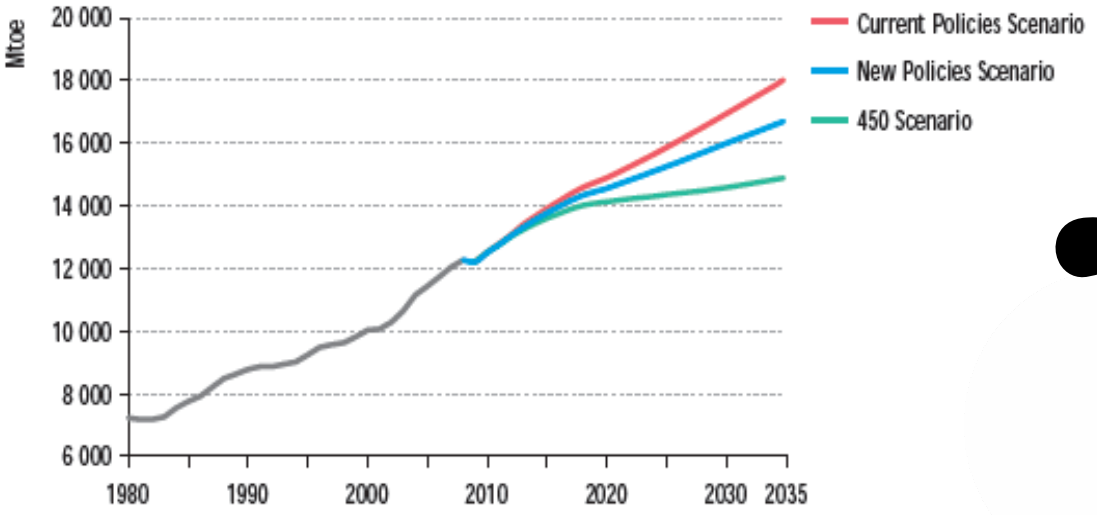
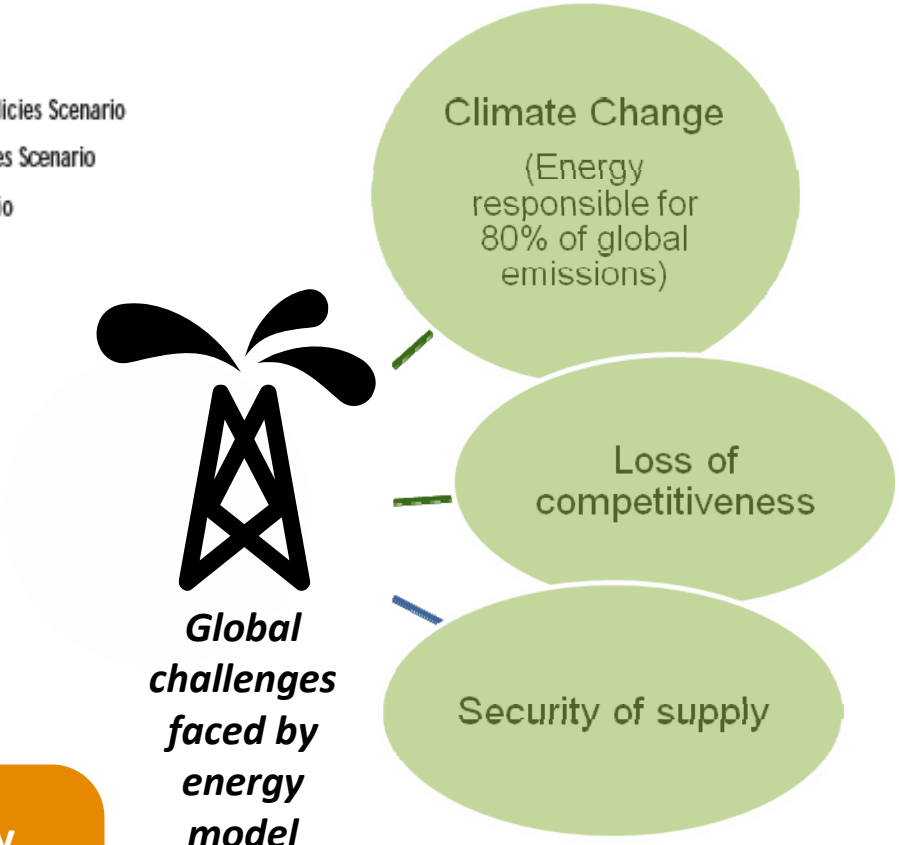
Energy model is unsustainable, based on a continuous path of energy consumption.

World primary energy demand (Mtoe)

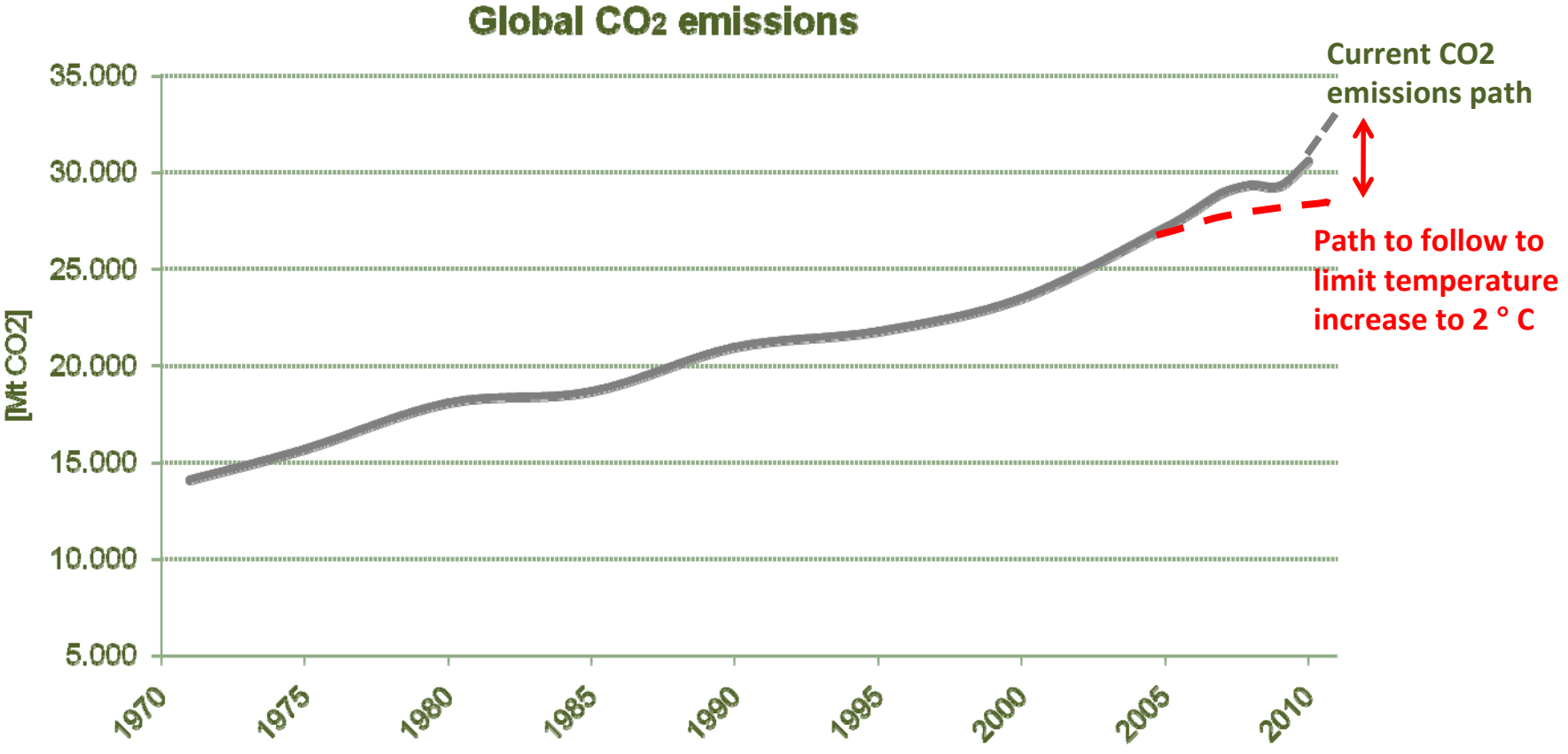


Source: World Energy Outlook. 2010 International Energy Agency.



The energy model is characterized by steady growth in demand, mainly met by fossil fuels. Fossil fuels would constitute 80% of demand in BAU scenario, and 60% in the 450 ppm scenario.

One consequence of the energy model is the growth of CO_2 emissions, which peaked in 2010 and are far from achieving a sustainable path.



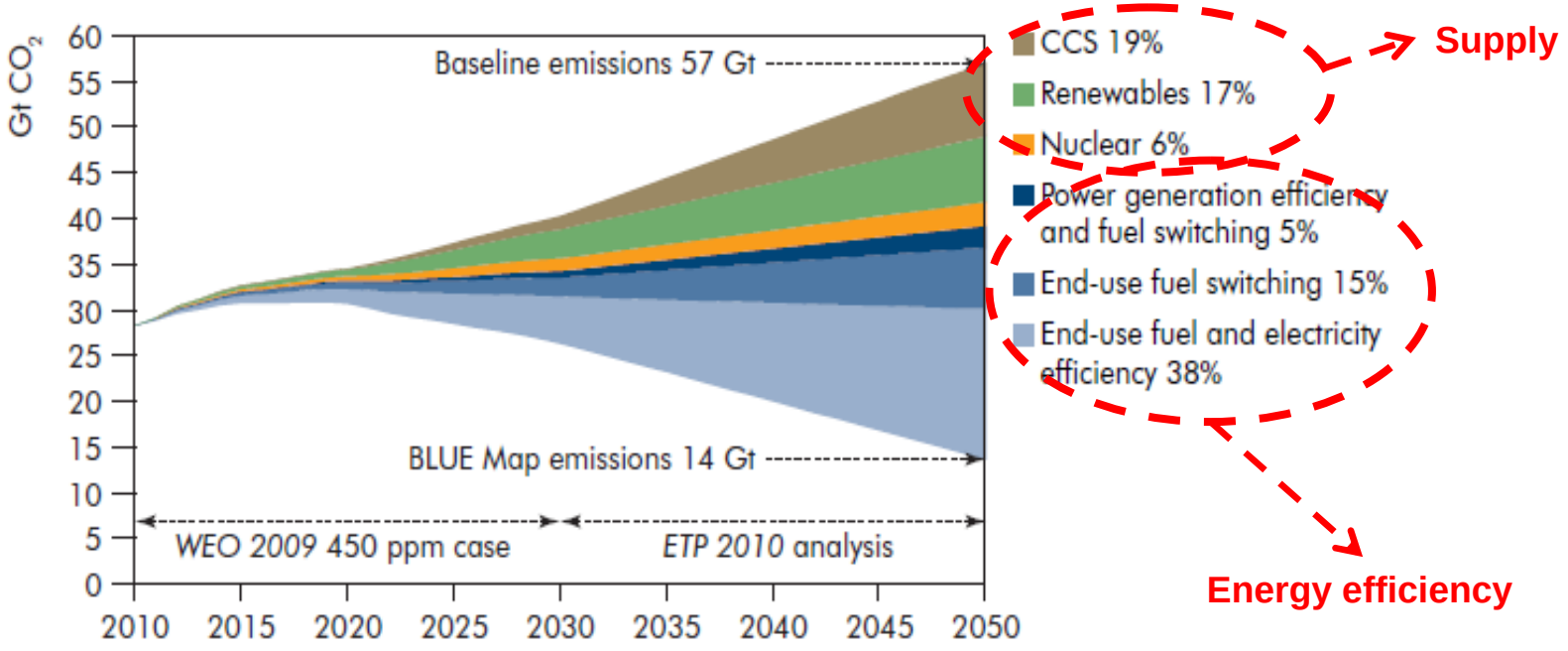
Source: International Energy Agency.

After stabilization in 2009, emissions rose sharply again in 2010.

The IEA considers energy efficiency as the main option to mitigate climate change... Supply technologies will have also an important role.

Energy efficiency (58%), Renewable energy sources (17%) and CCS (19%) are the main options to tackle climate change.

Contribution of each option to global CO2 emissions abatement



Source: Energy Technology Perspectives. 2010. International Energy Agency.

Compliance with the BLUE scenario is not possible without a significant improvement in energy efficiency, which will require technological improvements and regulatory measures.

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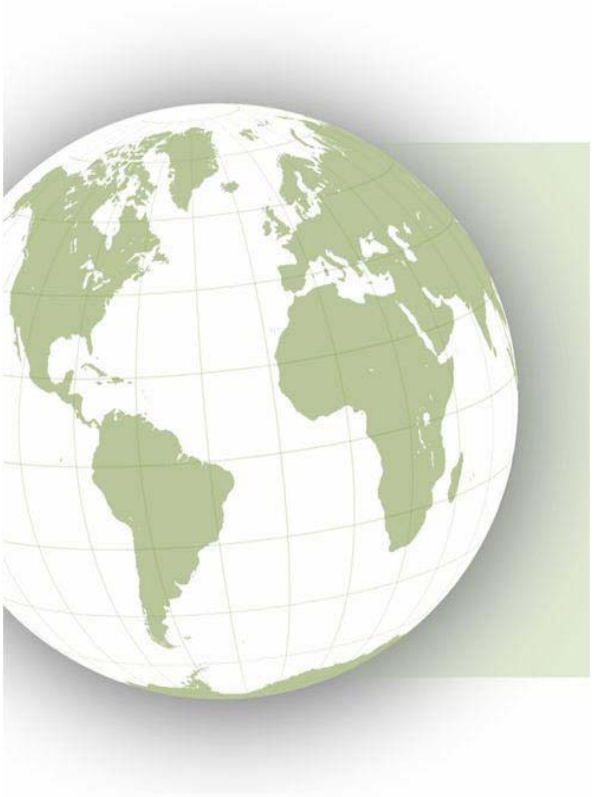

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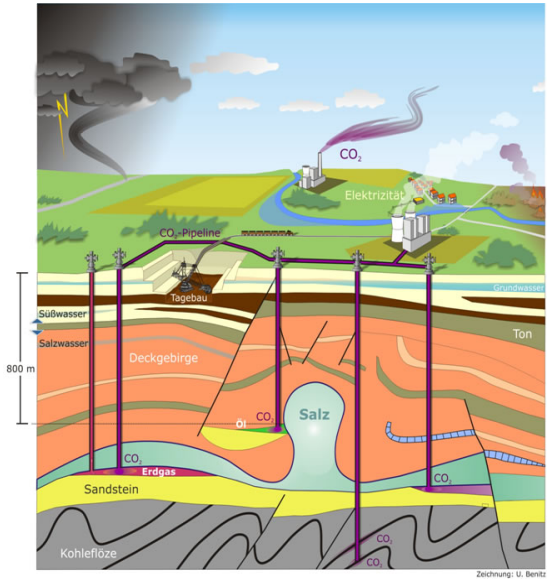
Main supply options for emissions' abatement (1) Conventional options.

	Hydro	CCGTs (gas)	Nuclear
Envi. Sustainability	No CO_2 emissions, NOx or sulfur…	CO_2 emissions (350 gr/kWh) and little quantities of NOx and sulfur…	No CO_2 emissions, NOx or sulfur…
Economic Efficiency	Significant fixed costs to recover in the long run.	Low investment cost. Volatile variable cost and indexed to oil, future price risk.	High uncertainty about their costs. Low variable cost. License extensions presented as the most efficient option.
Security of supply	Manageable and relatively firm due to the storage capacity. Rapid response. Dependent on rainfall.	Production very flexible and manageable. High availability.	Very firm capacity. Base-load capacity.

Main supply options for emissions' abatement (2) Renewable Energy Sources.

	Wind	SFV	CSP
Envi. Sustainability	No CO_2 emissions, NOx or sulfur…	High: no CO_2 emissions, NOx or sulfur…	It is not an emission-free energy. •Renewable 70%. •Use natural gas to keep on working the production process.
Economic Efficiency	Cost of investment has declined, converging with conventional technologies. Total cost of supply increases due to the need of back up investments and networks.	SFV has traditionally been an expensive technology: the cost of SFV was six times the cost of conventional plants in 2008. Significant reduction of cost and manufacturing technology improvements. Convergence with conventional in the medium and long run.	Expensive technology: CSP cost was four times the cost of conventional plants in 2008. Concern: in recent years there has not been any significant reduction in costs.
Security of supply	Neither is firm nor manageable. Back up needed.	Neither is firm nor manageable.	More manageable than SFV or Wind but lower than gas.

Main supply options for emissions' abatement (3) Carbon Capture and Storage.



Currently, neither it is technically nor economically feasible:
Far from ensuring future storage of CO2 under appropriate conditions.

Assessed costs around 50 €/MWh .*

Environmental sustainability

- **Only way to use coal in the future.**
- **Potential environmental risk.**

Economic Efficiency

- **Only pilot projects.**
- **It will not be commercially viable before 2030.**

Security of supply

- **There are huge coal reserves (diversified origins with low risk profile).**

Little potential in Spain.
Scarce suitable locations for storage and high distance to those located in the North Sea.

* Fuel and investment costs should be added to them.

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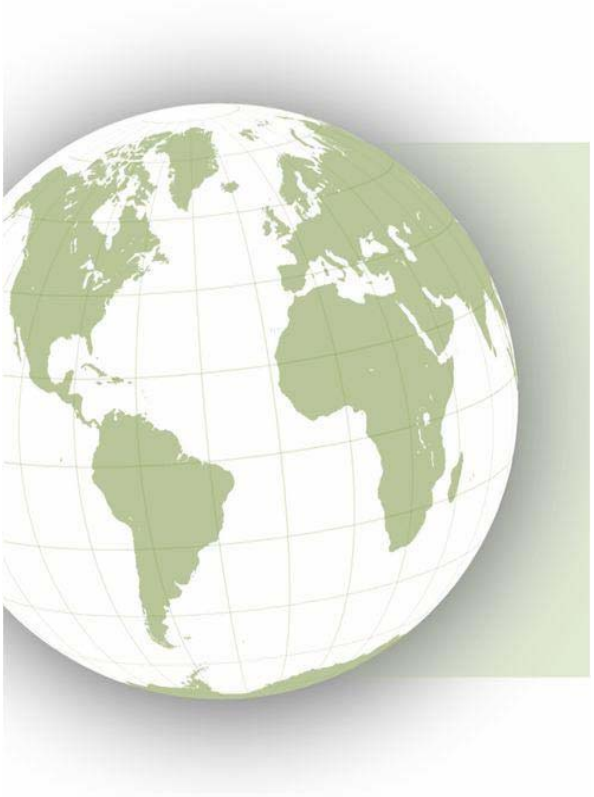

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Energy intensity (EI) is a good indicator for energy efficiency.

ENERGY INTENSITY =

$$\frac{\text{Energy consumption}}{\text{Gross Domestic Product}}$$

An improvement in energy efficiency means a reduction in energy intensity.

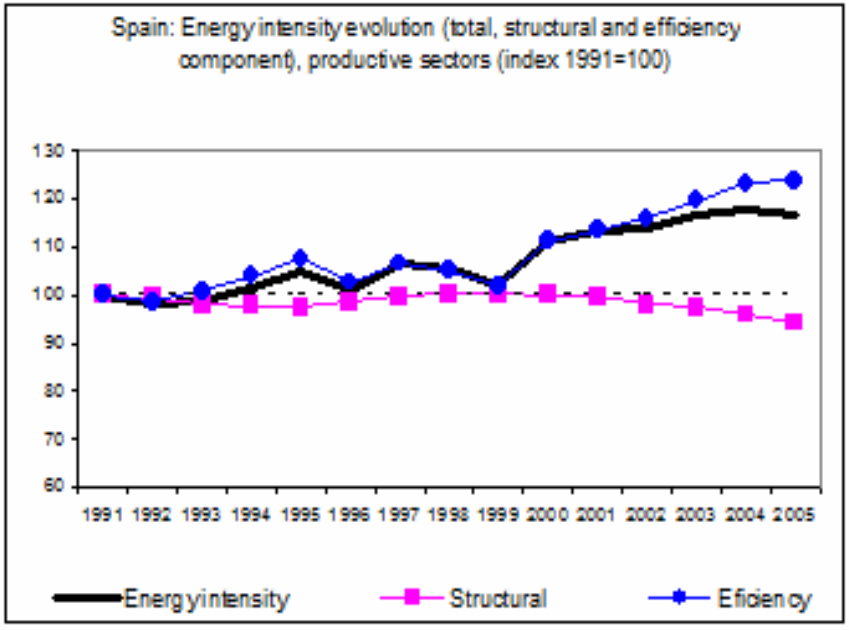
Energy intensity has two components:

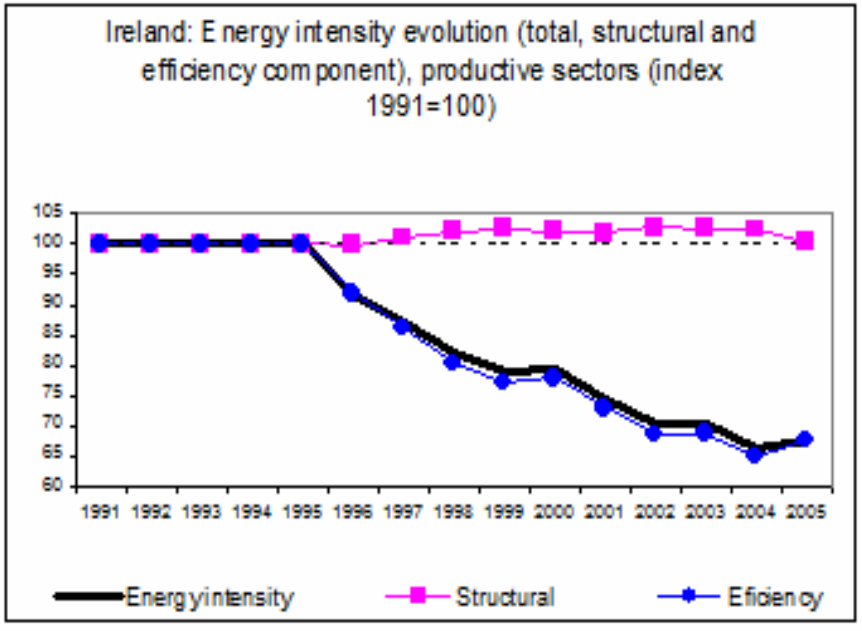
1. Structural: depends on the economic structure (share of energy-intensive sectors in total GDP).
2. Efficiency: Considers internal energy efficiency improvements in each sector.

Reducing energy intensity improves competitiveness, since the same goods and services are produced with less energy.

Differences in the evolution of EI among countries come from different behaviors with respect to their structural and efficiency components.

Two cases: Spain vs. Ireland, the country with the best energy efficiency performance.



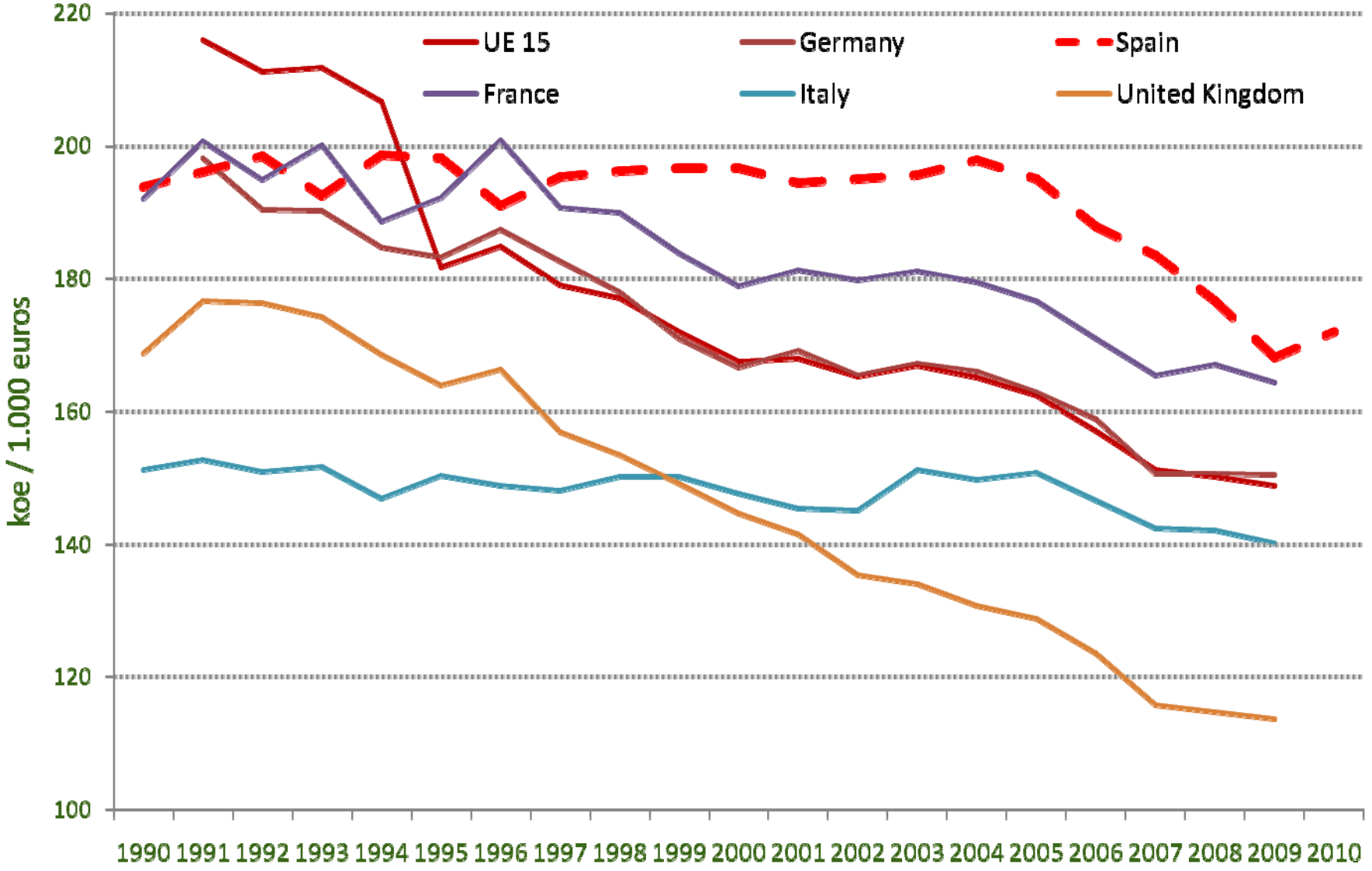


Source: “La intensidad energética en los sectores productivos en la UE-15 durante 1991 y 2005: ¿Es el caso español diferente?” Gustavo A. Marrero and Francisco J. Ramos-Real . 2008. FEDEA.

Although Spain has maintained its economic structure, energy intensity has increased. Whereas Ireland reduced energy intensity by 44%, mainly due to improvements within sectors (efficiency component).

There are important differences among European countries...

Evolution of energy intensity across Europe



Importance of energy efficiency within building sector in Spain: Technical Building Code (TBC).

Buildings account for 27% of final energy consumption in Spain

The TBC can achieve energy savings of 30-40% in each building.

If all buildings constructed in Spain since 2001 had fulfilled the requirements of the TBC, energy savings within this sector would have accounted for 7 to 9 TWh (equivalent to solar FV power generation in 2010).

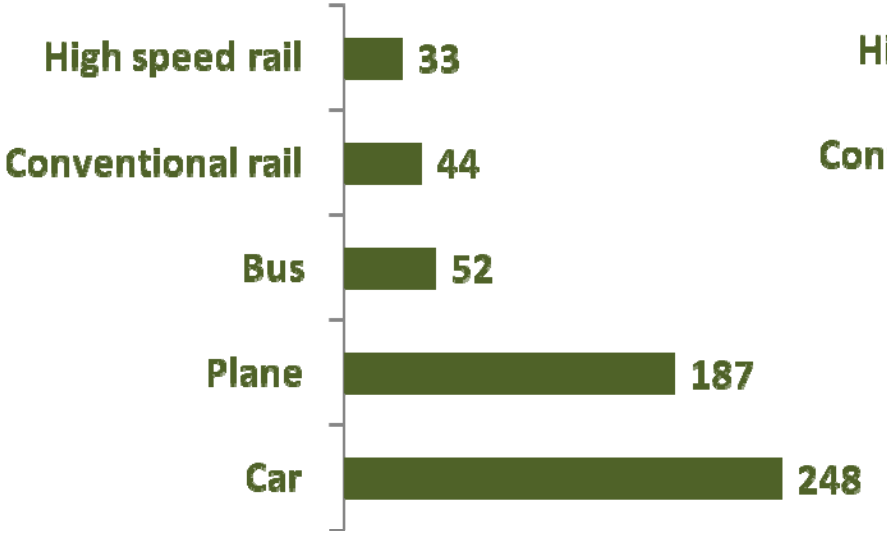
Energy and cost savings of TBC if implemented since 2001 would be equivalent to solar FV power generation in 2010 :

Annual energy savings due to TBC		Investment required to achieve TBC savings		Annual investment TBC		Economic support to SFV power generation in 2010
7 – 9 TWh.	➧	5.200 M€	➧	500 M€	<<<	2.800 M€

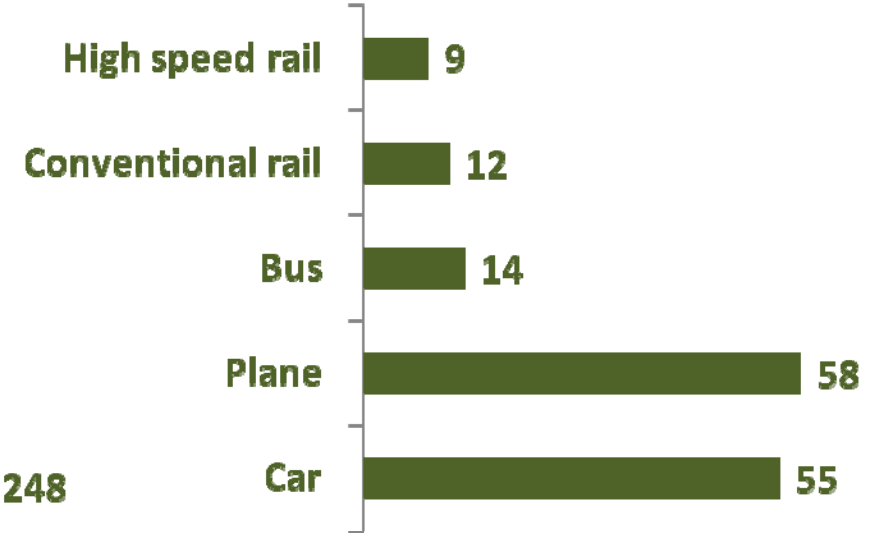
Transport: modal change would involve important energy efficiency gains.

EXAMPLE: Energy consumption by passenger in a Madrid-Málaga trip **

Energy consumption by passenger (kWh)



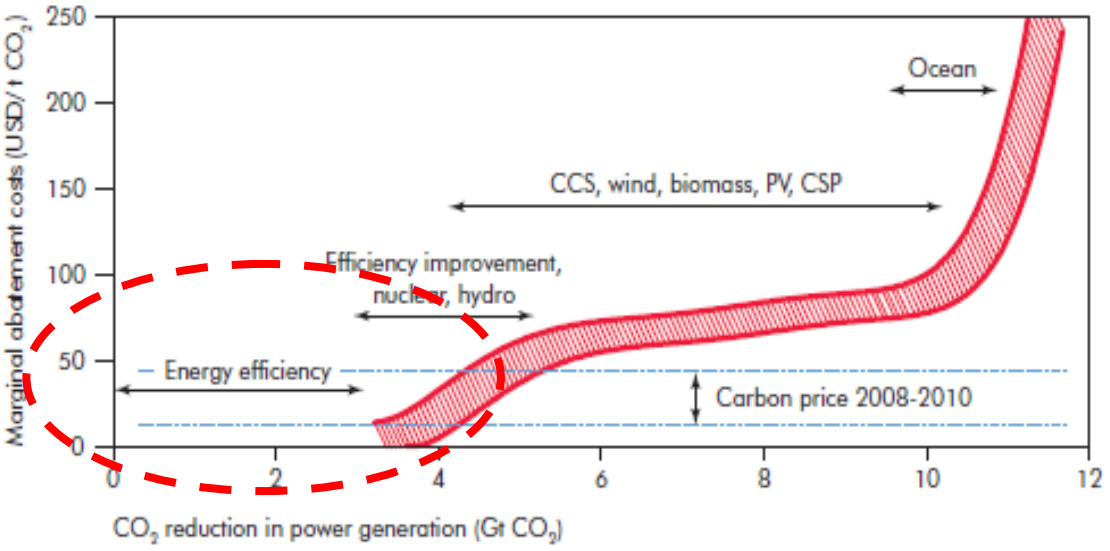
Emissions by passenger (kg de CO2)



** Source: *Consumo de energía y emisiones del tren de alta velocidad en comparación con otros modos*. Alberto García Álvarez. Anales de mecánica y electricidad, sept.-oct. 2007)

Despite the profitability of energy efficiency measures, their full potential has not been developed: "the energy efficiency gap."

Marginal abatement costs within electricity sector (2010-2020)



Source: Energy Technology Perspectives. 2010. International Energy Agency.

Reducing emissions through energy efficiency improvements brings net economic benefits.

However, energy efficiency investment is lower than expected considering its importance to reduce emissions and its economic advantages. This is called the "energy efficiency gap".

Some elements difficult improvements in energy efficiency.

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Market failures

- Energy prices artificially low. Do not reflect real supply costs or are subsidized.
- Principal-Agent problem. Those who will benefit from savings are different from those who make the investment. (tenant-landlord).
- Information failures. Consumers do not have sufficient information about savings and cost.
- Transaction cost.

Barriers

- Uncertainty about future energy prices and difficulties to quantify savings will limit the perception of the profitability of the investment.
- Differences across consumers. Returns of energy efficiency investment depends also on the characterization of energy consumption.
- Financing difficulties, particularly for SME's.

These barriers and market failures explain "energy efficiency gap" (investment in energy efficiency does not correspond with the benefits of energy efficiency improvements) and the need of a regulatory framework to promote energy efficiency.

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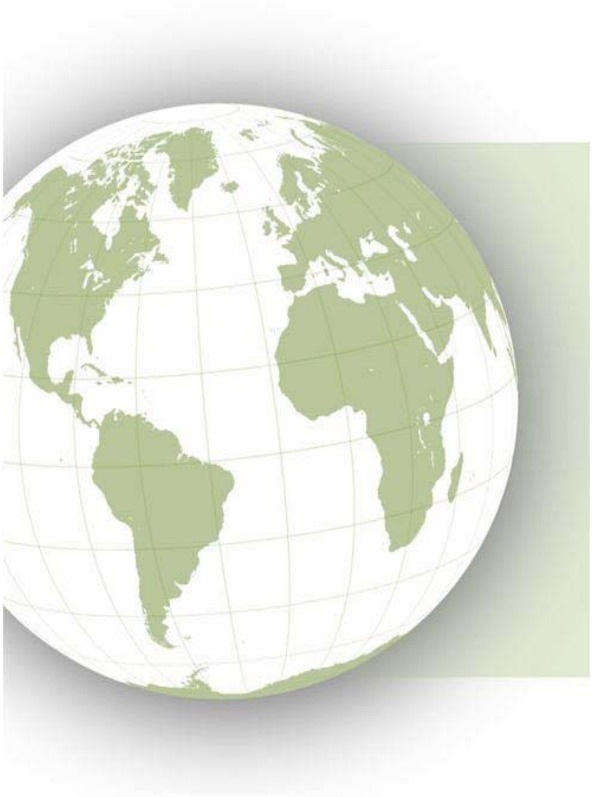

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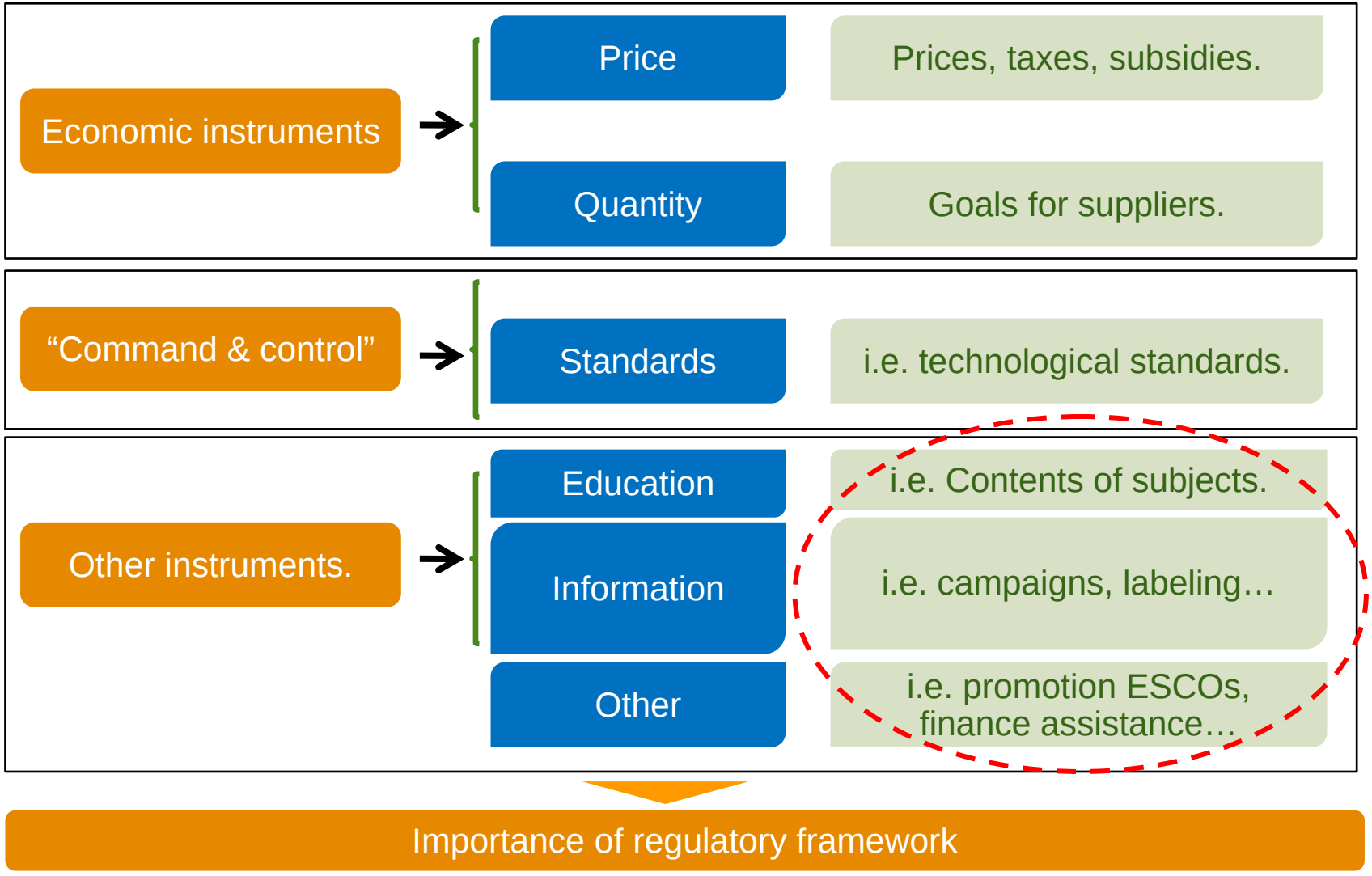
Public policies have different regulatory tools to promote energy efficiency.



Price instruments are the most effective tool to improve energy efficiency.

Internalization of all relevant costs in energy prices (including environmental cost).

Taxes on energy consumption.

Definition of new structures for energy tariffs.

ADVANTAGES

- Transparency.
- Efficiency.
- Induce technological change in the long term.
- No free riding.
- No rebound effect.
- Easy implementation.

DISADVANTAGES

- Low elasticity of demand in the short term.
- Unpopular measure.

Price instruments are the most common tool for energy efficiency improvements. Significant examples are: Germany, Netherlands, Ireland…

In some cases, green tax collection is used to reduce fiscal pressure on salaries. (Germany & Netherlands).

Warning on the renewable option!! Support schemes should not introduce distortions on economy.

Achievement of the RES goal

Electricity sector assumes the biggest effort.

Electricity sector has the greatest technological capacity for the introduction of RES.

Electricity tariffs fund RES support scheme, with an impact on their relative competitiveness against fuel prices, natural gas prices…

The current situation is inefficient (creates distortions between the relative competitiveness of different energies) and has a **negative impact on environmental sustainability.**

Given that the goal is set for global final energy consumption, all energy sources should contribute to fund compliance.

Quantity and "command and control" requires a rigorous design to avoid important disadvantages.

Quantity :
Efficiency Goals to energy suppliers

Italy & France: Energy savings are tradable, through white certificates. These documents certify that a certain reduction of energy consumption has been attained.

ADVANTAGES

Theoretical advantages in terms of efficiency.

DISADVANTAGES

High administrative cost, introduces a risk premium on investment, empirical experience shows low liquidity in white certificates trading, entry barrier to new suppliers…

Empirical analysis of these instruments shows high administrative costs and low achievement of the expected benefits from the exchange of white certificates.

Command and control :
Technological energy efficiency standards

Efficiency standards to appliances, processes....

ADVANTAGES

Politically feasible, low administrative complexity, high effectiveness in the long term.

DISADVANTAGES

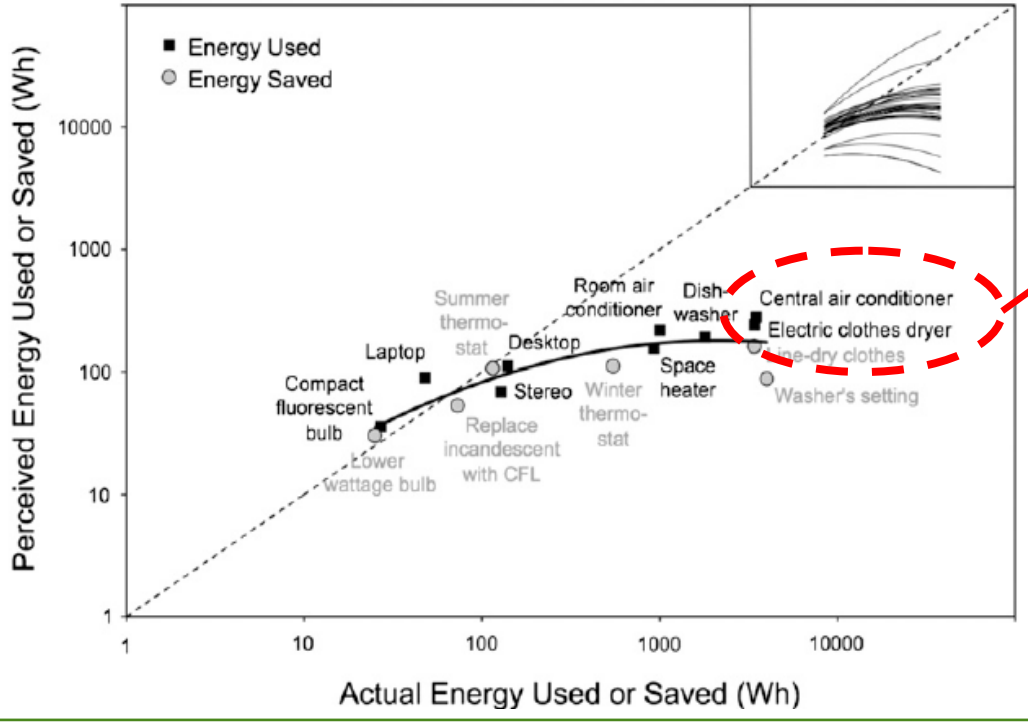
Rebound effect, difficulties to fix optimal goal, regressive impact…

Technological standards have experienced a high growth in EU countries.

Importance of Information: Studies show that consumers have a misperception on their consumption and savings possibilities.

A survey of 505 consumers conducted by Harvard University shows that consumers tend to underestimate their consumption and savings potential.

Errors in the perception of energy consumption and savings *



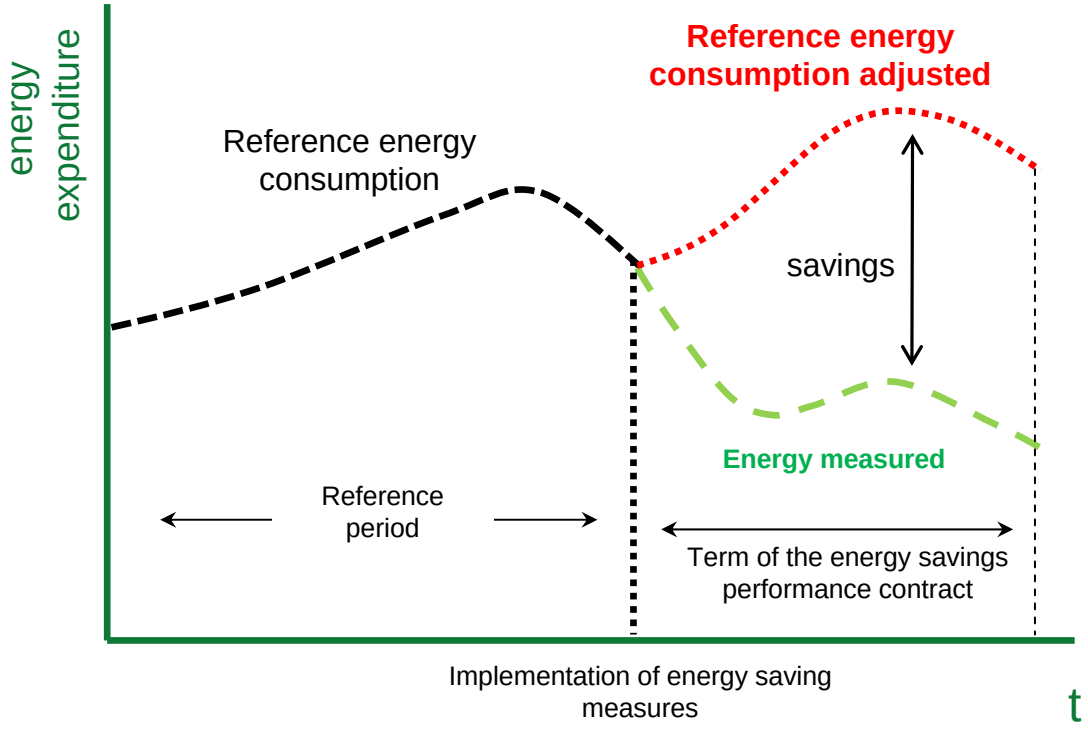
Deviations between actual consumption and perception are especially important in air conditioning and appliances.

The importance of information and awareness to adjust public perceptions to reality.

• Source: *Public perceptions of energy consumption and savings*. Shahzeen Z. Attari Michael L. DeKay, Cliff I. Davidson and Wändi Bruine de Bruin. Edited by William C. Clark, Harvard University, Cambridge, MA, and approved July 12, 2010.

Energy savings present a huge potential.

Diagram of energy services



The Energy Performance Contract between the company and the client guarantees an amount of energy savings, part of which are received by ESCOs as payment for the implementation of measures to improve the EE.

Rebound effect after energy efficiency improvements may not proportionally reduce energy consumption.

Energy Efficiency regulatory instruments may not be sufficient to achieve energy savings due to "rebound effect".

Three elements explain rebound effect:

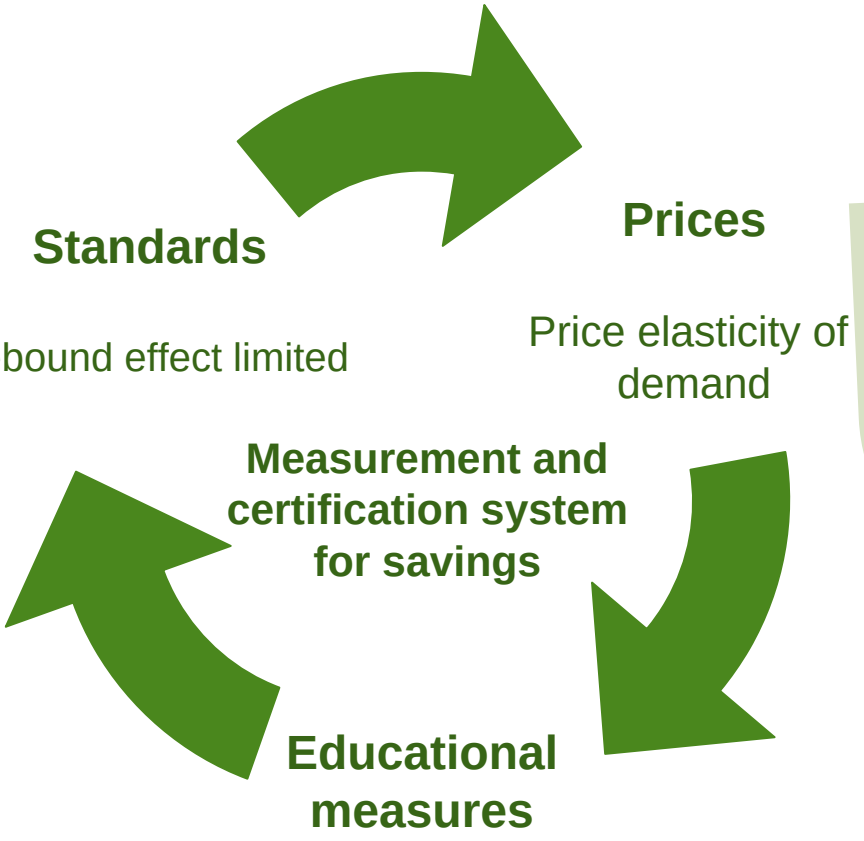
- Price effect. By improving the efficiency of a process or product, its cost is reduced and, accordingly, its effective price.
- Income effect. Lowering the effective price of energy use (for the improvement of EE) increases the budget to consume other goods.
- Macroeconomic effect. When effective energy prices change, there are also changes in relative prices of economic factors, improving the growth of energy intensive sectors.

Example of "rebound effect": Improvement of efficiency in air conditioners

Improvements in air conditioning efficiency are usually compensated partially by an increase in use.

Energy efficiency tends to increase the level of service.

The regulatory framework for energy efficiency should contain three basic elements: price, standards and education.



Whenever the rebound effect is less than 100%, there is reduction in consumption.

Estimations: **5-15%**, (Grubb, 1990) **19% for U.K** (Barker et al 2007)**...**

Price elasticity of **10%** (Linn, 2006)**.**

Induce technological change (Newel et al, 1999)

UK: Green Deal, the leading UK environmental policy, is an instrument to finance reforms in homes and businesses.

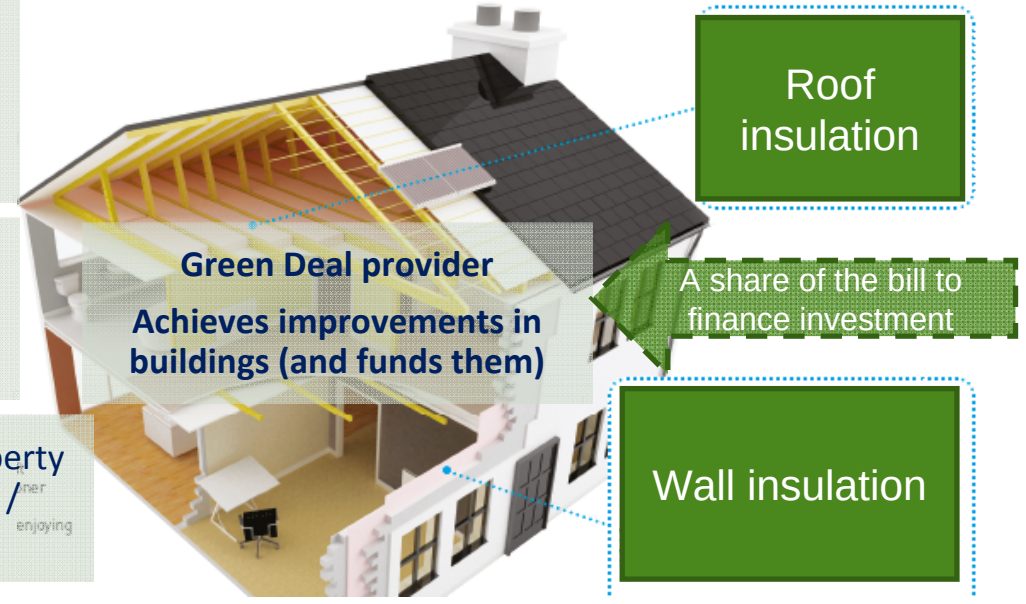
Main elements of the *Geen Deal*.

Golden Rule

Savings in the bill should be higher than investment cost.

Fist step: an audit of the shortcomings of home / business.

Program linked to the property not to the client (owner / tenant)



Customer

They benefit from savings on their bill.

A charge in the bill is used to finance investment.

Green Deal's approach seems appropriate, but there are still many questions regarding the design of regulatory framework: how to ensure that the client will reduce their bill after energy investments, who manages the program (audits / checks), disposability of human resources for program development ...

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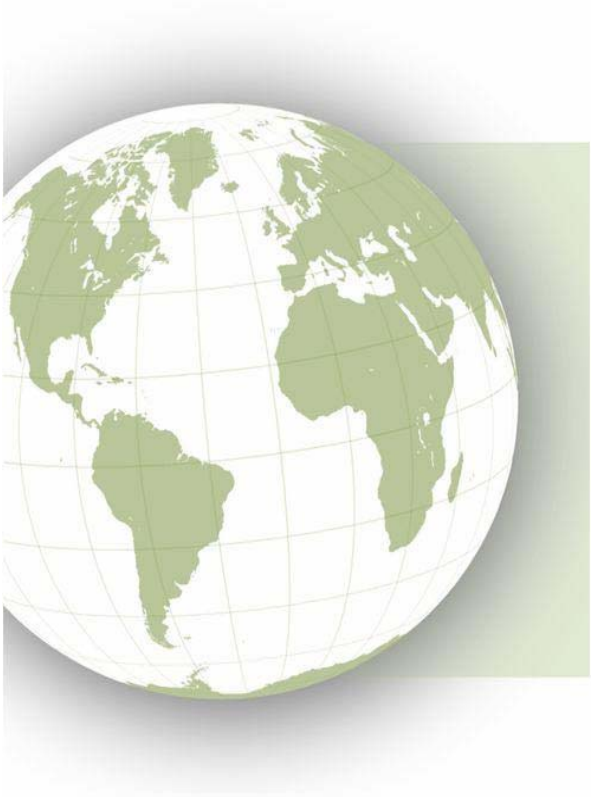

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Conclusions

- **World energy model** is **in crisis** due to its high dependence on fossil fuels and its impact on climate change. **Energy efficiency can play a significant role in solving these problems.**
- Despite the profitability of energy efficiency measures, their full potential has not been developed, resulting in what is known as **"the energy efficiency gap“**. Behind this phenomenon lie some elements: **artificially low energy prices**, **information** problems, principal-agent, transaction costs…
- **Public policies** have different regulatory tools to promote energy efficiency. But in general a successful regulatory framework for energy efficiency should contain three basic elements: **price, standards, and education.**
- **Energy efficiency** has significant **business opportunities**, with a positive impact on economic growth and employment. Experience shows that the energy services sector can be enhanced by public sector demand.