
ENERGY INTENSITY IN THE EUROPEAN UNION: THE SPANISH CASE

Cycle de formation "énergie et environnement"

María Mendiluce

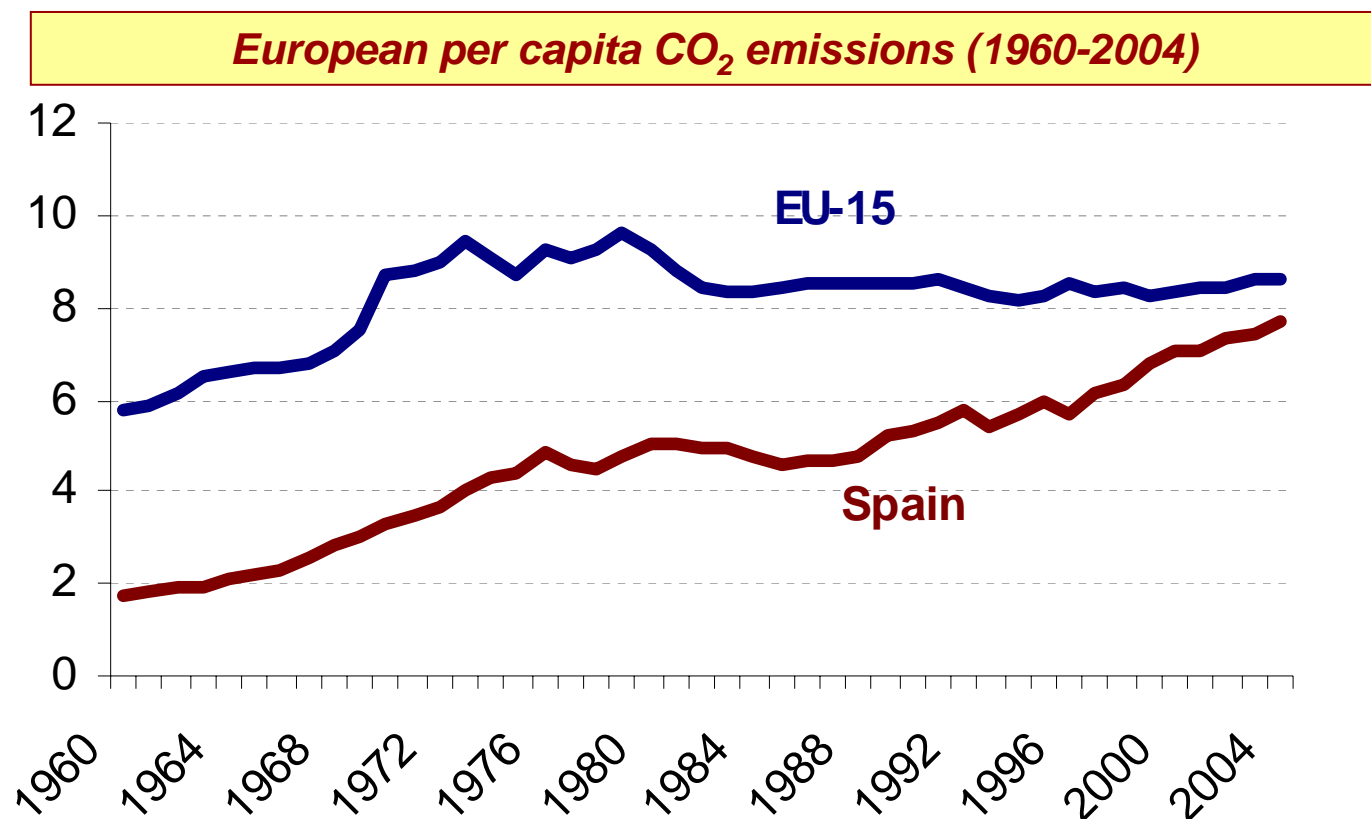
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GENEVA, 5 APRIL 2007

- **Energy intensity & CO₂ intensity**
- **Dematerialization Theories**
- **Disaggregated Analysis of CO₂ intensity**
- **Potential to reduce intensities**
- **Conclusions**

International comparisons of per capita emissions

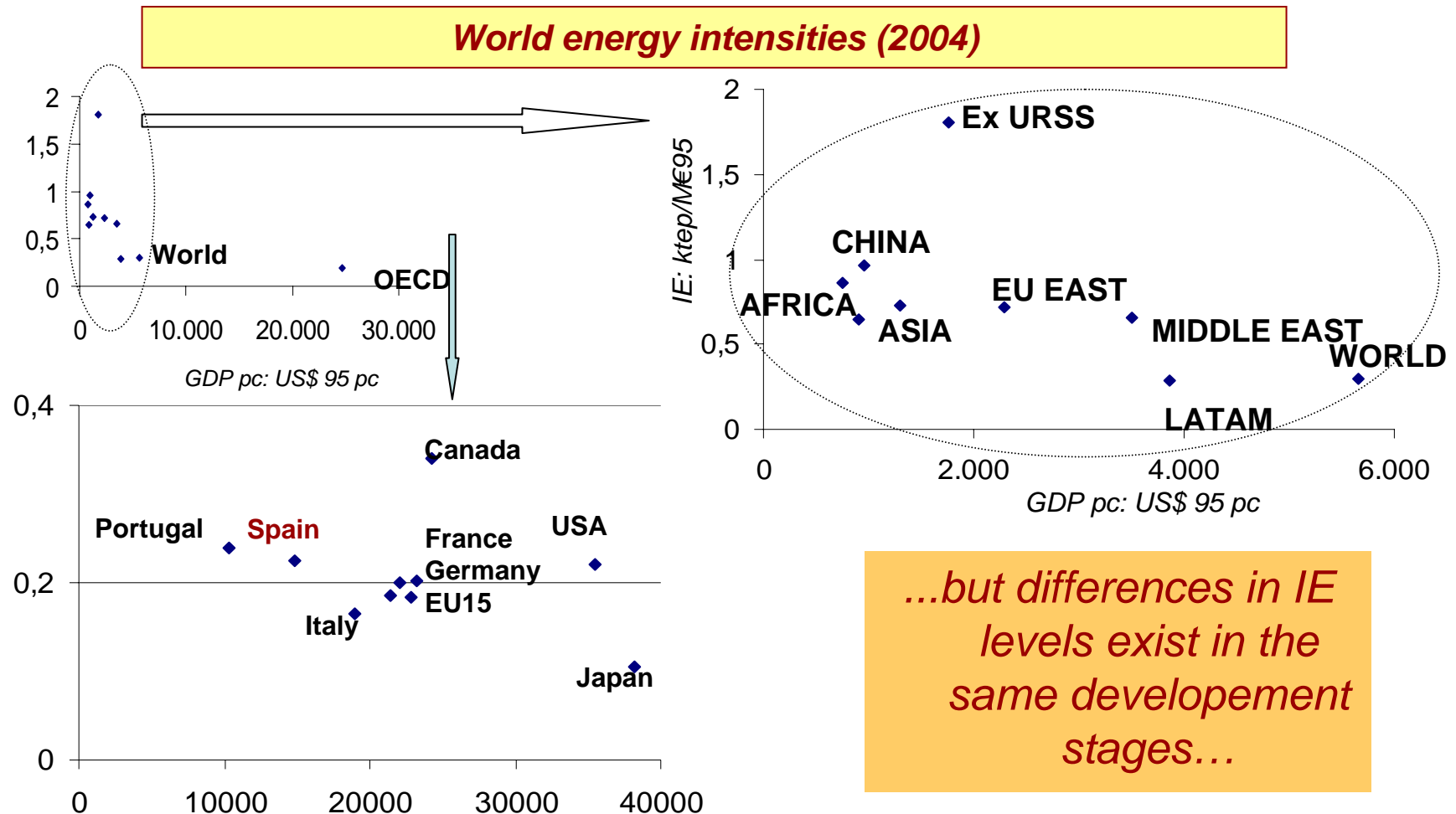
*Spanish per capita emissions are 10% below EU15.
80% of emissions come from energy consumption*



*Energy consumption is closely linked to the country's economic structure,
so energy intensity (IE) & CO₂ intensity (IC) analysis is necessary for its
understanding*

World energy intensities

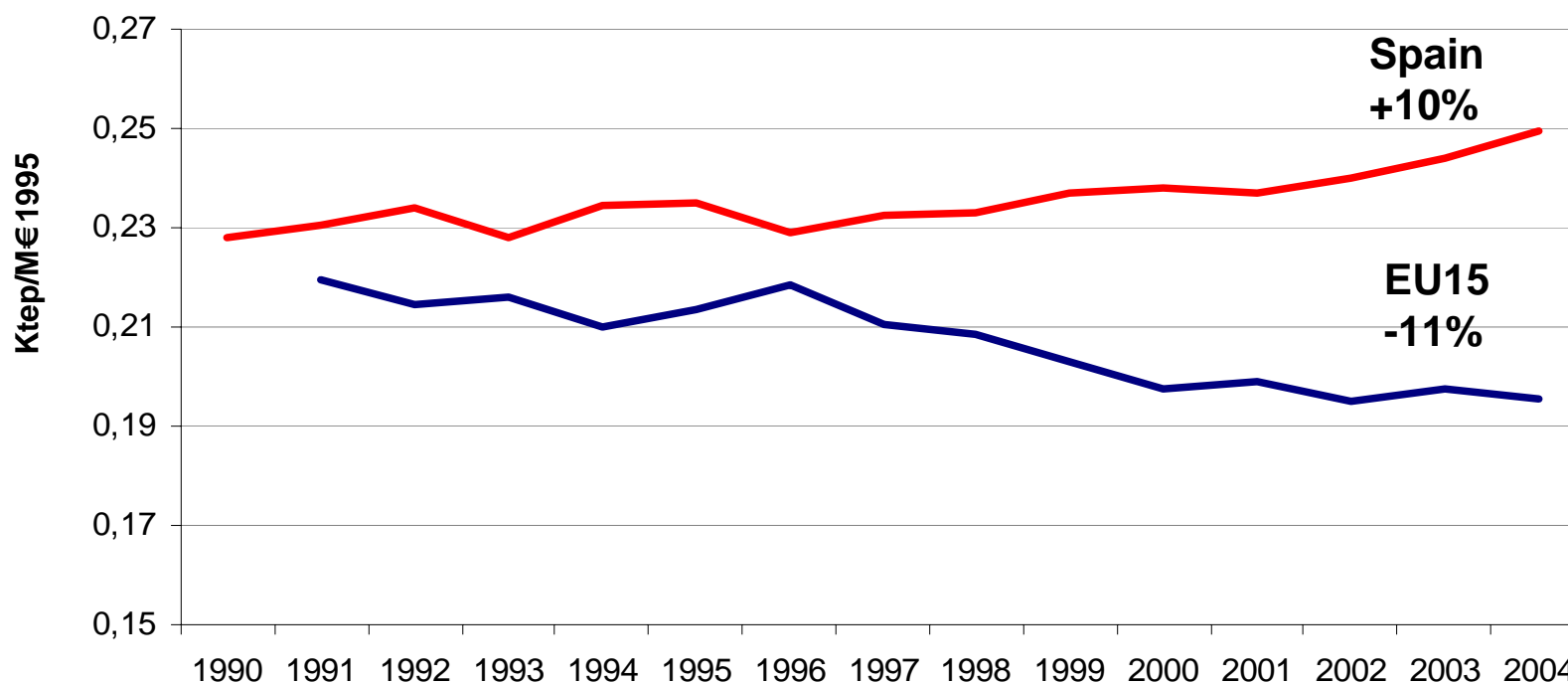
While economies develop energy intensity ratios improve (measured as energy consumption per GDP at 1995 constant prices)...



Europe energy intensities

Energy intensity between 1990 & 2004 grew in Spain, while decreased in Europe...

European energy intensity 1990-2004

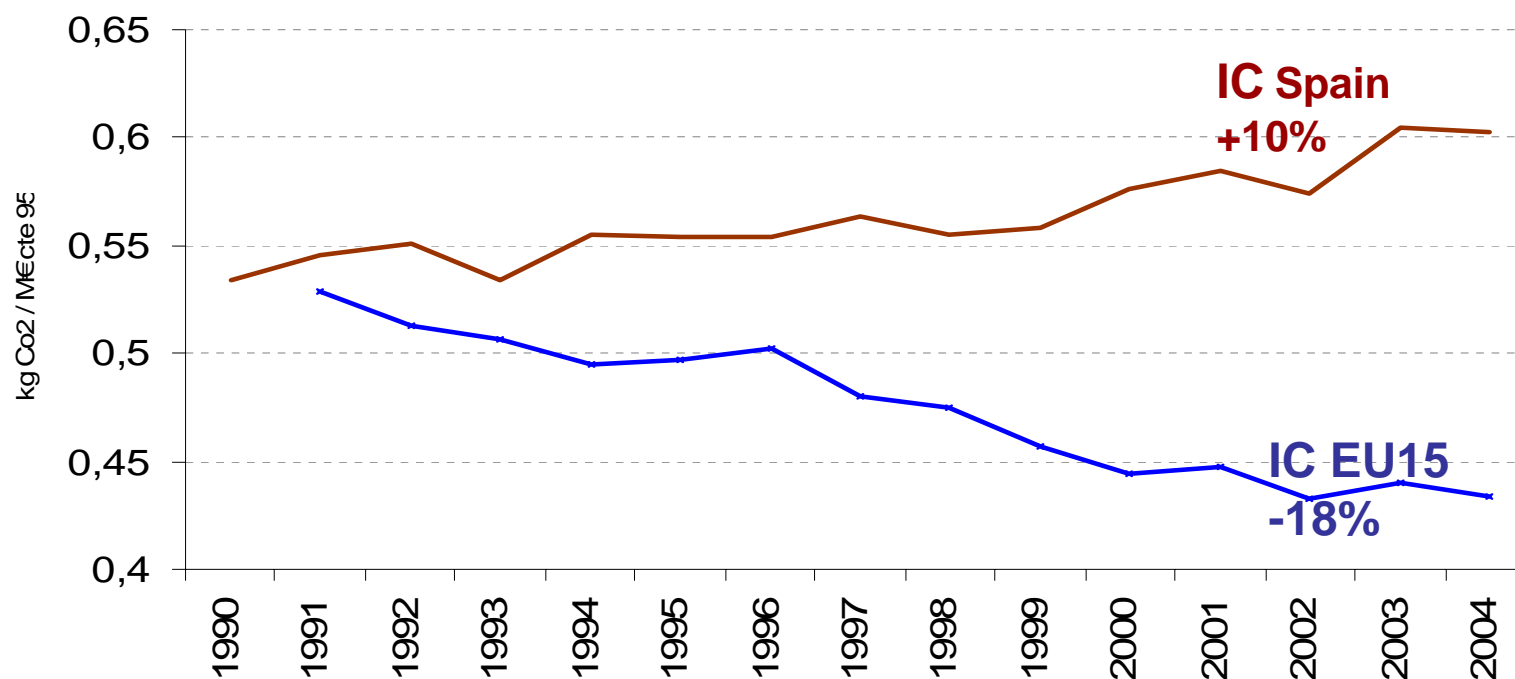


...but CO₂ intensity is more appropriate for measuring progress towards Kyoto Protocol objectives ...

Europe CO₂ intensities

...and it seems that economic growth leads to a certain degree of relative decoupling in Europe...

CO₂ intensity in Europe 1990-2004 (CO₂/GDP 95)

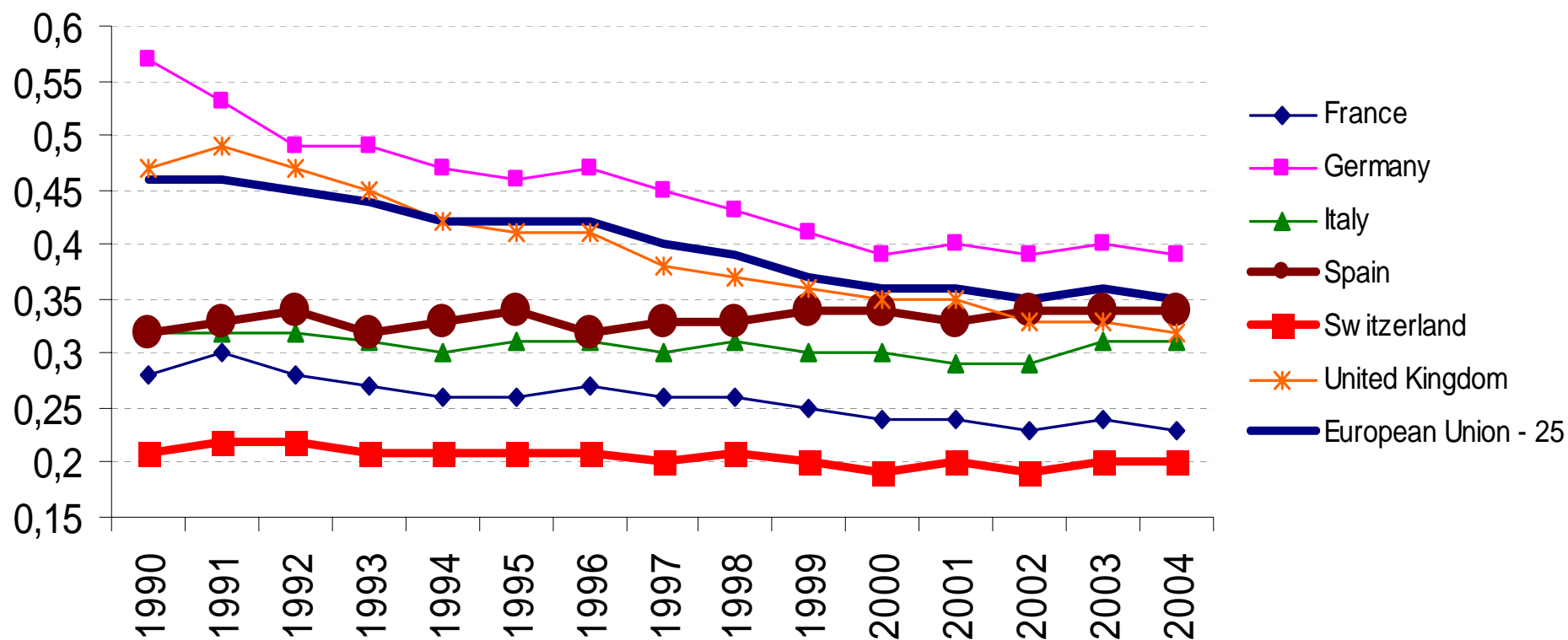


...but not in Spain, although when adjusted to purchasing power parities ...

Europe CO₂ intensities

...the Spanish IC grows, but stays bellow EU levels

Europe CO₂ intensities 1990-2004 (CO₂/GDP 2000 PPP)



Energy intensity vs CO₂ intensity

IC analysis should be complemented by IE analysis because:

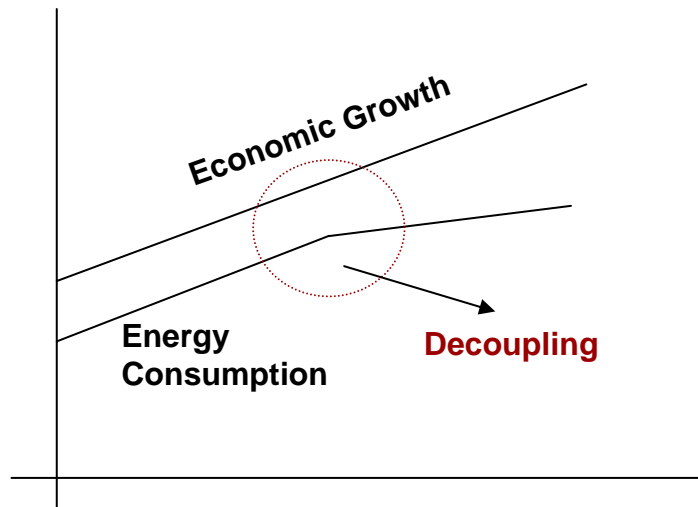
1. Energy balances provide more information than national inventories
2. National Accounts have similar information than energy balances
3. IE analysis enables the understanding of other issues such as security of supply and other environmental problems
4. IE analysis identifies key sectors where energy consumption can be reduced (& emissions) without constraining economic growth and identifies sectors where energy efficiency improvements should be made
5. Conversion from IE to IC is simple, whereas one could not translate IC to IE at sectoral level

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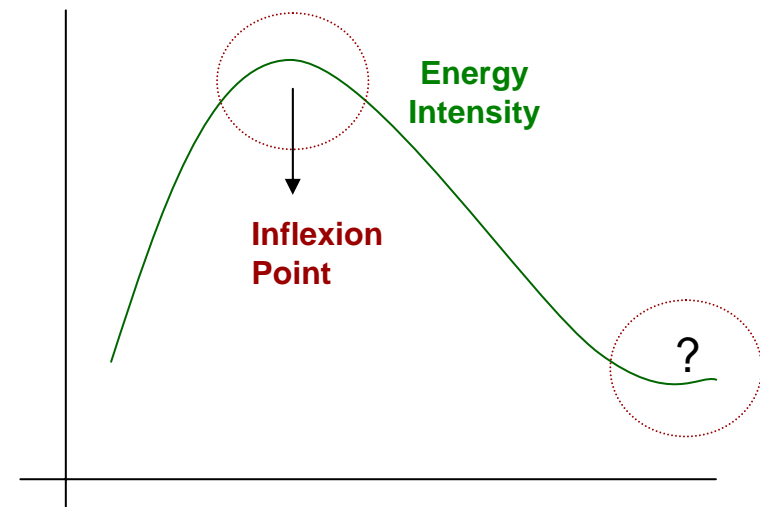
Theories of “dematerialization”

Theories of “dematerialization” (also called delinking or decoupling) state that nations that achieve a certain level of development need less resources and energy...

Energy consumption & economic growth



Energy intensity

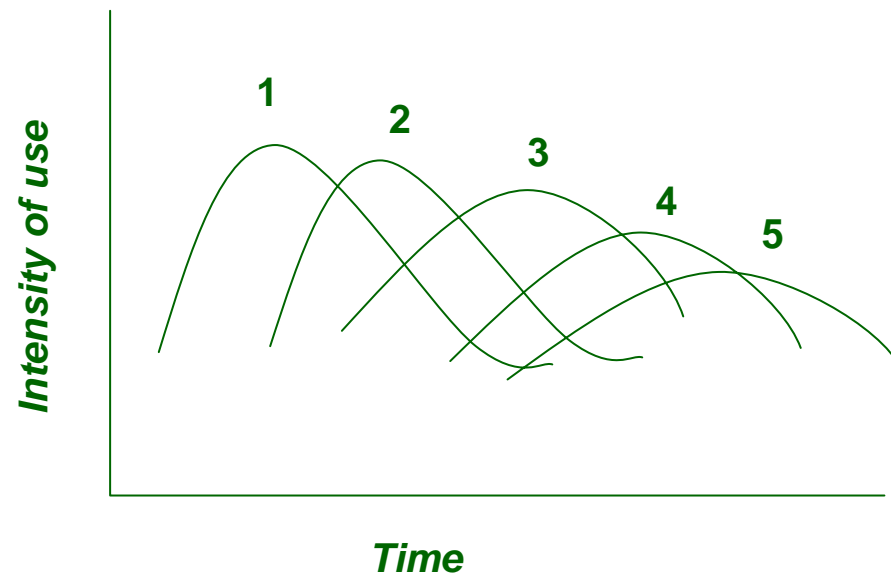


...and therefore economic growth is a “solution” to environmental problems

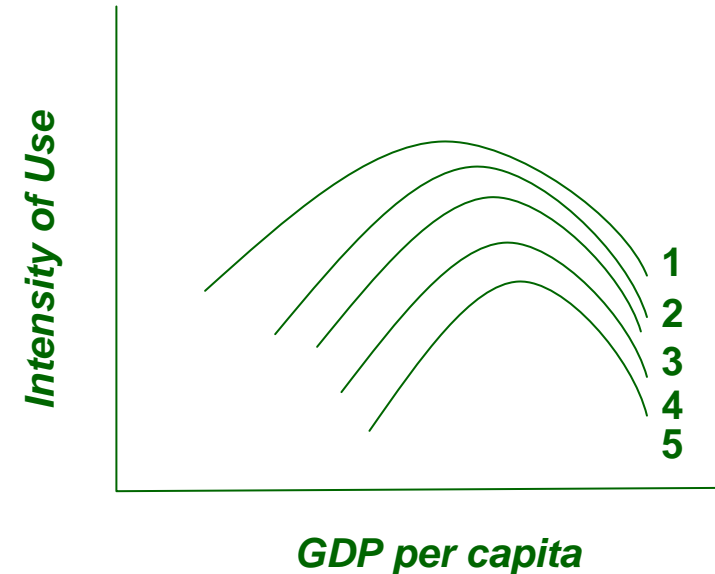
Theories of “dematerialization”

Some researchers state that all countries at initial levels of development need more resources...

Energy consumption & economic growth



Energy intensity

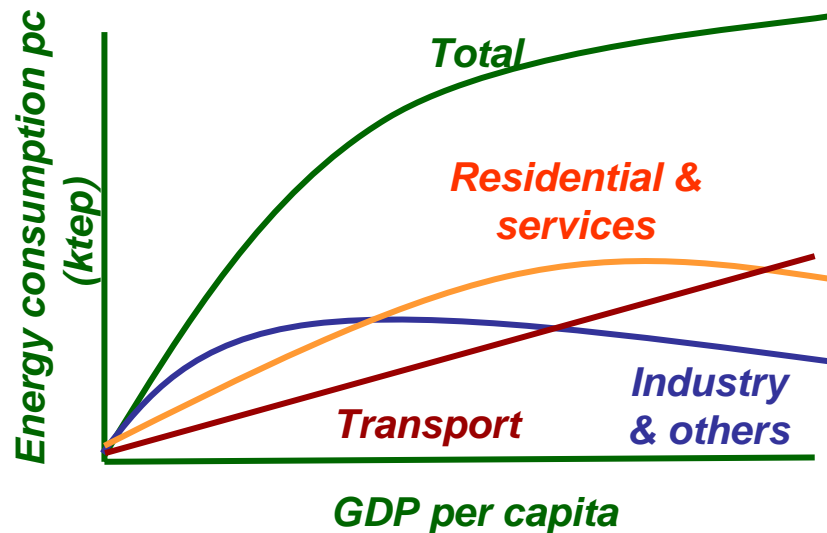


... but when they get to a certain GDP pc level (inflexion point) more economic growth means less resources needed and therefore less contamination (in relative terms)...

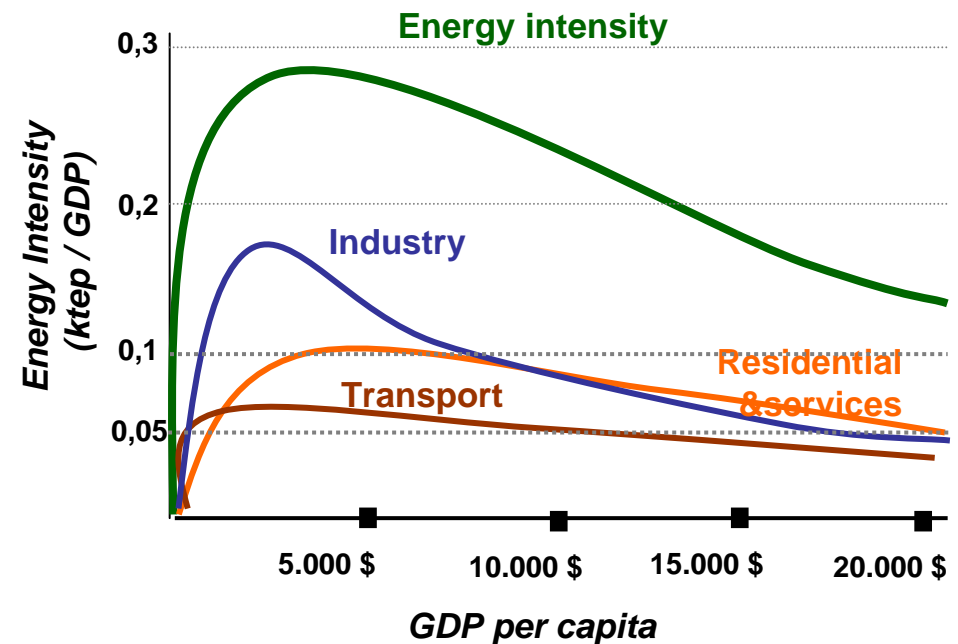
Theories of “dematerialization”

... because at first stages of development countries need more energy for their industrial activities...

Energy consumption



Sectorial energy intensity



... but as soon as economies grow in the services sector, the aggregated IE decreases as those activities need less energy

Key factors in energy intensity

Factors that mostly influence IC & IE are:

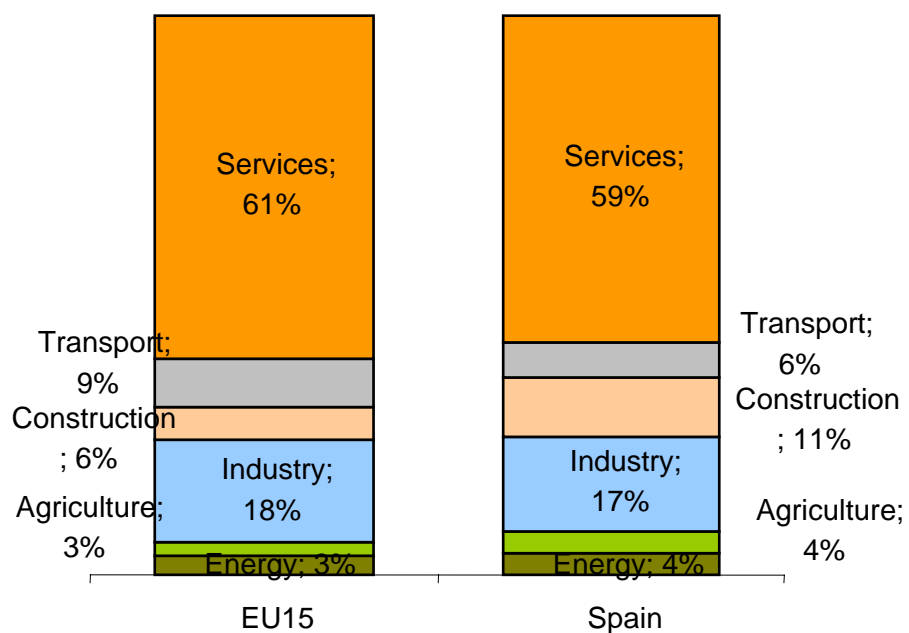
- ✓ ➤ Structural change
 - ✓ ➤ Industrial delocalization
- ✓ ➤ Technological change
 - ✓ ➤ **Rebound effect**
 - ~ ➤ **“Transmaterialization”**
- ✓ ➤ Primary energy resources
- ✓ ➤ Energy prices
- ~ ➤ Substitution of inputs in the production function
- ~ ➤ Saturation effect
- ~ ➤ Changes in consumer behaviour and preferences

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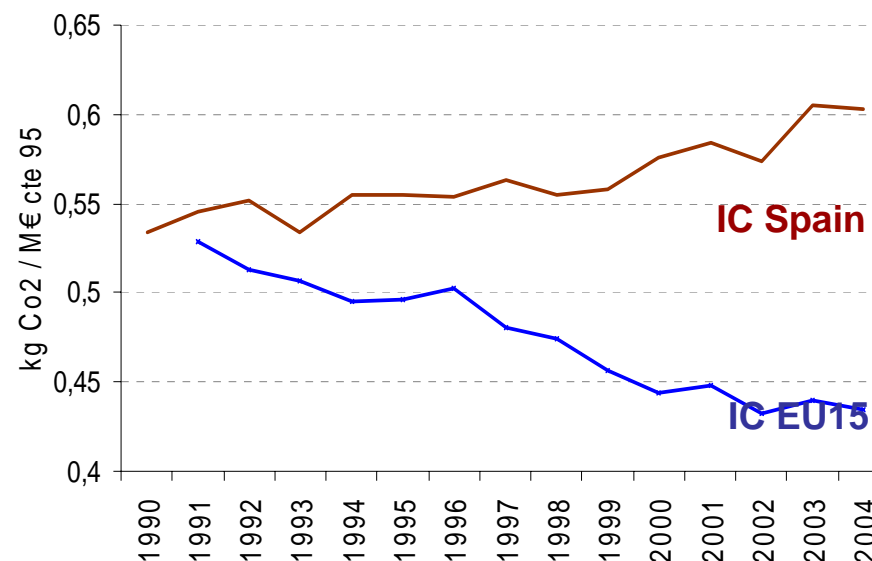
CO₂ intensity evolution

Economic structure plays a key role in IC

Economic Structure



IC in Europe 1990-2004 (CO₂/GDP 95)



International comparisons need to disaggregate the indicator & quantify sectorial effects

Sector IC evolution

In Spain, in absolute terms, IC of energy , agriculture & industry grow & are superior to EU15 levels...

IC SPAIN (kg CO ₂ /M€ CTE 95)				IC EU15 (kg CO ₂ /M€ CTE 95)			
	1990	2004	Var		1990	2004	Var
Energy	5,188	5,951	15%		5,935	5,250	-12%
AGRICULTURE	0,219	0,404	84%		0,362	0,289	-20%
INDUSTRY	0,378	0,381	1%		0,387	0,319	-18%
Primary metals	1,175	0,818	-30%		0,858	0,610	-29%
Chemistry	0,650	0,609	-6%		0,511	0,330	-35%
Non met. minerals	2,325	2,115	-9%		1,676	1,412	-16%
Equipment	0,125	0,153	22%		0,339	0,241	-29%
Mining	0,422	0,520	23%		0,504	0,409	-19%
Food & beverages	0,269	0,344	28%		0,310	0,309	0%
Paper	0,328	0,318	-3%		0,270	0,247	-9%
Wood	0,053	0,306	472%		0,088	0,071	-19%
Construction	0,005	0,013	195%		0,026	0,036	39%
Textile	0,214	0,265	24%		0,206	0,189	-8%
Other	0,074	0,757	930%		0,667	0,777	16%
TRANSPORT	2,180	2,191	1%				
SERVICES	0,018	0,025	41%		0,232	0,192	-17%
Households	0,034	0,038	13%		0,079	0,062	-22%
Tpt Households	0,059	0,063	7%				
IC total	0,543	0,598	10%		0,560	0,456	-18%

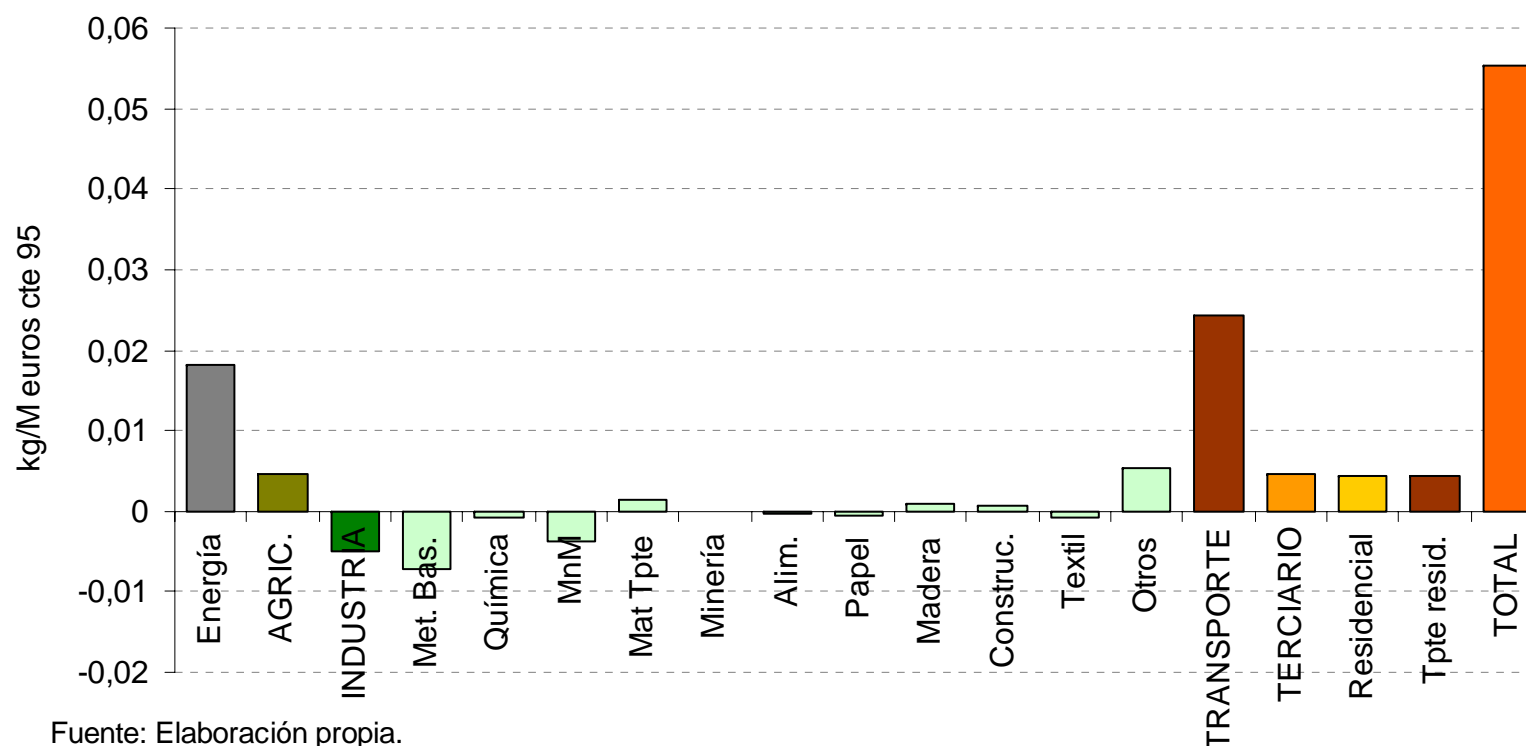
Note: Households intensities are calculated with total GDP

...while services and residential are converging to EU15 levels

Disaggregation of IC in Spain

Sectors that have mostly influenced growth in IC are transport & energy, followed by services & residential

Additive decomposition of IC growth in Spain (1990-2004)

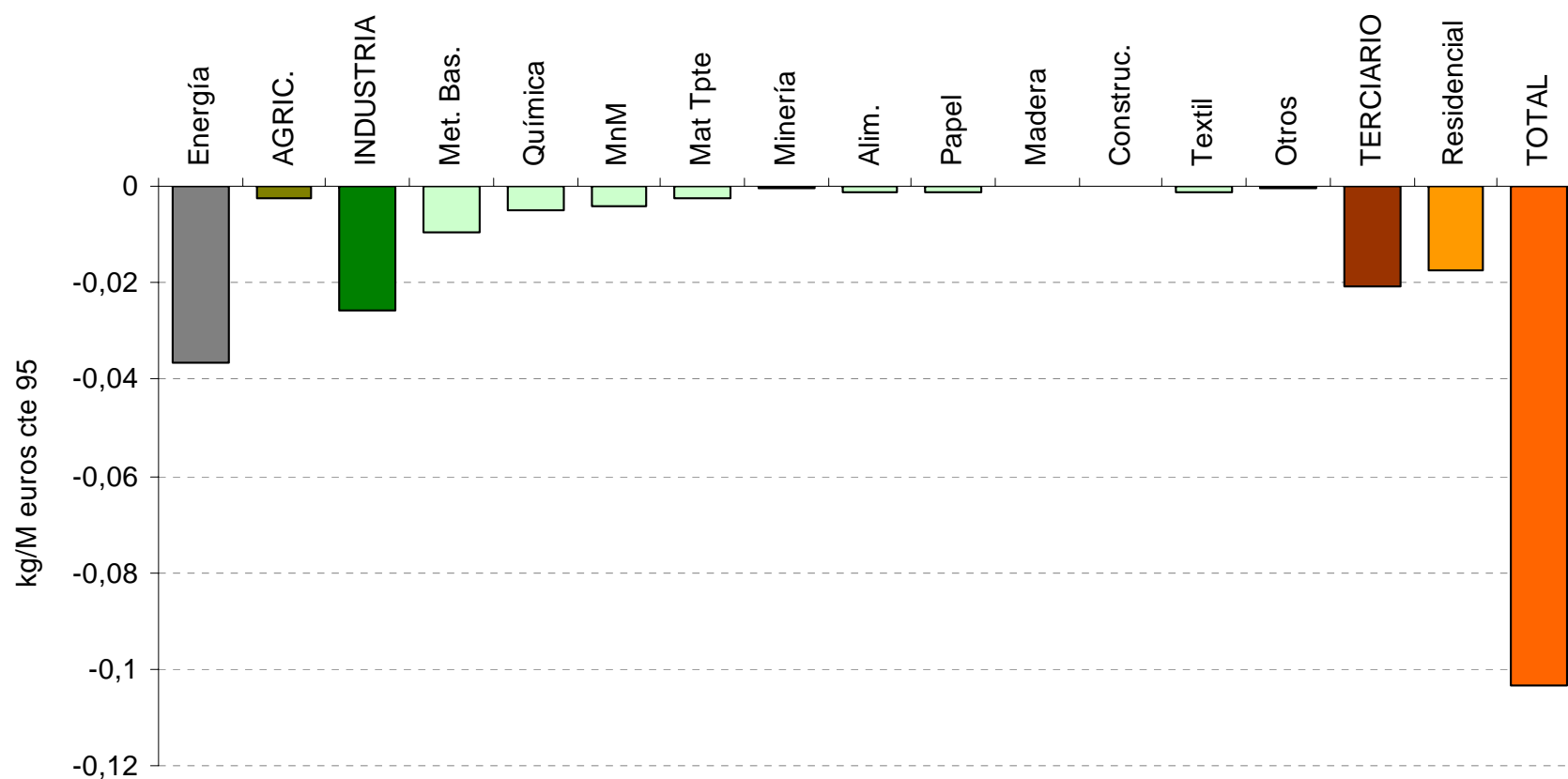


*...while industry compensates partially,
but not as much as in the EU-15...*

Disaggregation of IC in Europe

...where all sectors have contributed to a 18% reduction of IC, particularly energy & industry

Additive decomposition of IC growth in Europe (1990-2004)

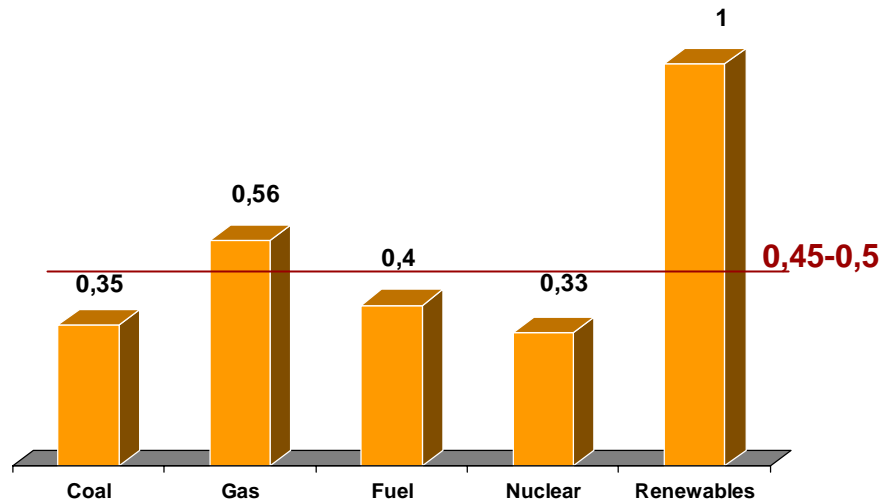


Fuente: Elaboración propia.

Energy

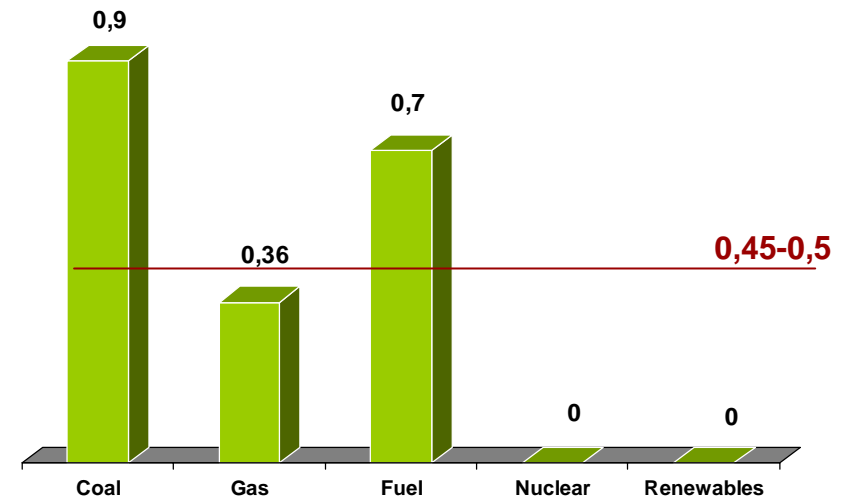
Generation mix determines primary energy needs & emissions

Thermal Efficiency*



To produce 1 kWh of electricity, 2,5 kWh of primary energy are needed & consumed

Emission factors (kg CO₂ / kWh)



1 kWh of electricity produced in Spain generates 450-500 g CO₂

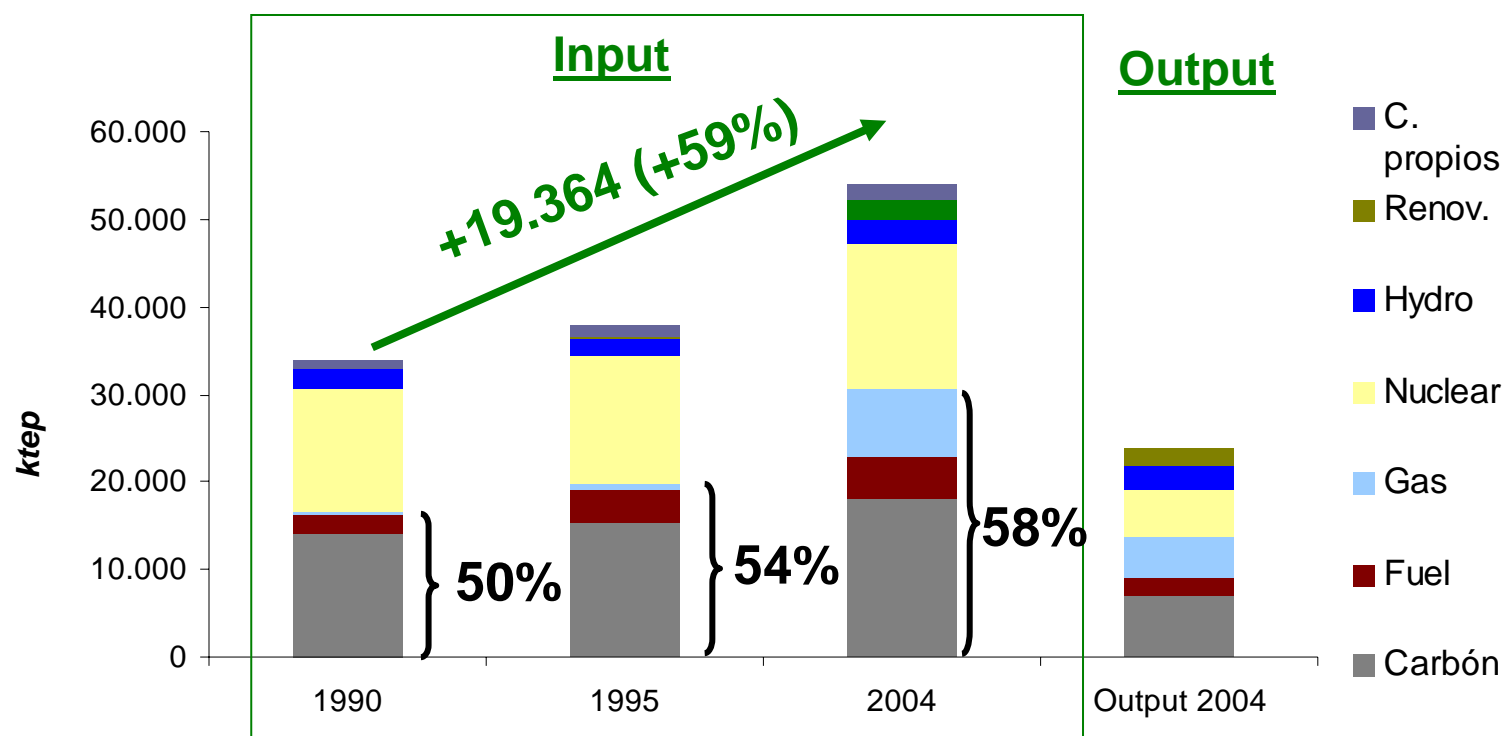
- *A country with renewable generation is more efficient in IC & IE, ex. Austria*
- *A country with more nuclear energy will have a lower IC and a higher IE, ex. France*
- *A country that uses more coal will have a higher IE & IC, ex. USA*
- *Substitution of coal by renewables and gas reduces IE & IC*

** Aproximative values with IEA methodology (2007)*

Spanish Electricity sector

Spanish electricity demand increased by 83% between 1990 & 2004 (30% in EU15) & 59% more primary energy were needed ...

Electricity generation in Spain 1990-2004



...which were covered by fossil fuels (coal & gas) that produce emissions that have grown by 64% in the period

Electricity demand and implications

When a sector replaces primary energy by electricity, it improves efficiency and translates energy consumption & emissions to the electricity sector

Theoretically electricity sector emissions should be translated into higher energy prices. In practice, electricity tariffs do not encourage CO₂ cost internalization

Therefore, electricity consumers do not find economic incentives to consume more efficiently. Furthermore they have incentives to switch demand to electricity instead of other energy sources

In industry, lower energy costs increase competitiveness, which leads to higher demand of their products & further energy consumption for additional production

Households do not have incentives for efficient use of energy due to inappropriate price signals, which do not include environmental cost

Transport

Transport is responsible for 60% of IC increase between 1990 & 2004, mainly freight transport (44%)

Diesel consumption increased by 135% between 1990 & 2004

Spanish taxes are well below EU15 level and favor Diesel

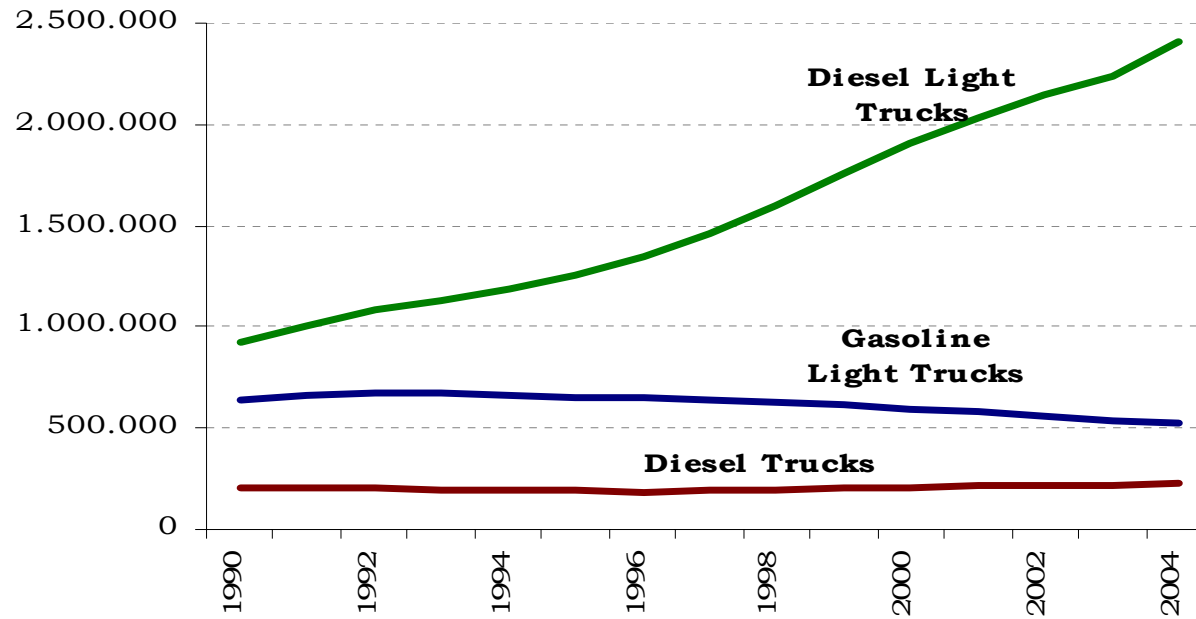
	90-95	95-00	00-04	90-04
Gasoline	9%	-7%	-11%	-10%
Diesel	17%	44%	40%	135%
Total	13%	20%	21%	64%

Country	Gasoline	Diesel	TVA
UK	738	782	18
Netherlands	668	365	19
Germany	655	470	19
Belgium	592	327	21
France	589	417	20
Finland	588	346	22
Portugal	558	339	21
Italy	542	413	20
Sweden	536	394	25
Denmark	507	404	25
Ireland	443	368	21
Luxemburg	442	278	15
Austria	407	297	20
Spain	396	302	16
Greece	313	260	19
EU-15	533	381,5	19

Diesel covers most of the demand, mainly in freight transport, which surpasses efficiency gains

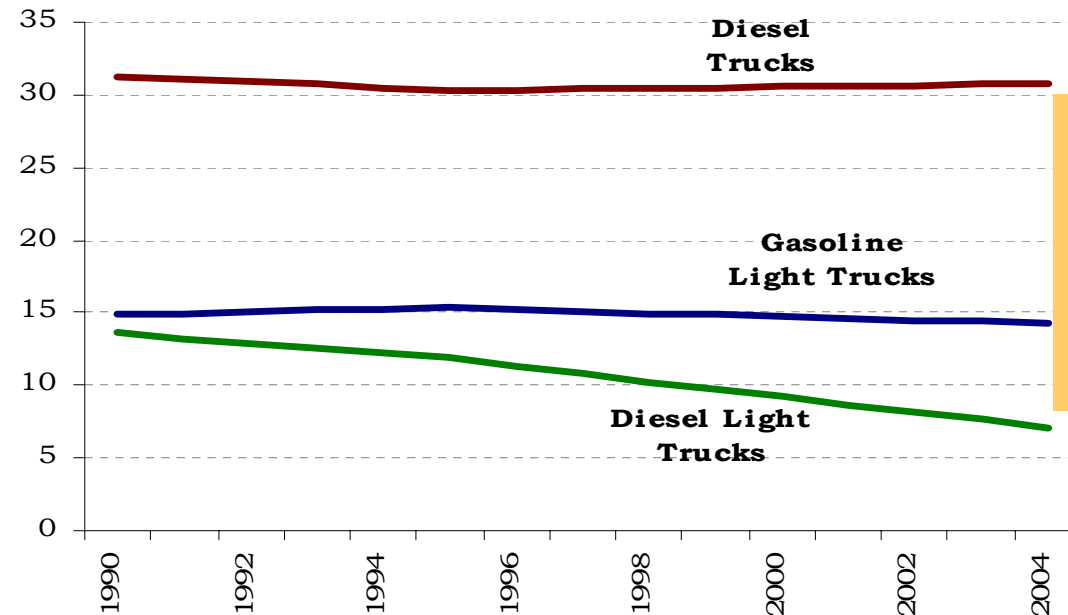
Freight transport

Number
of
vehicules



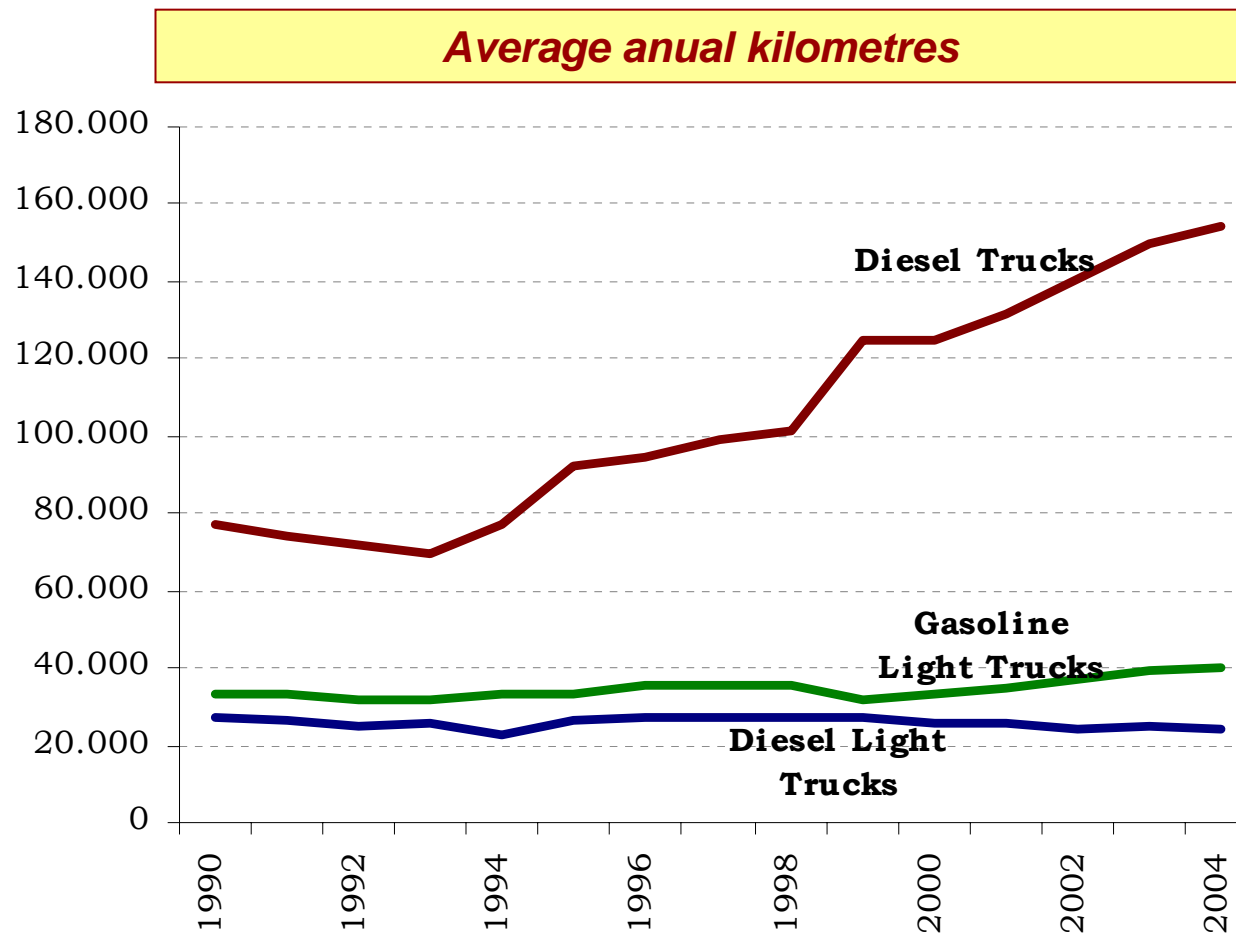
*Growth in
diesel &
small
trucks*

Consumption
(l/km)



*Efficiency
improvements,
mainly diesel*

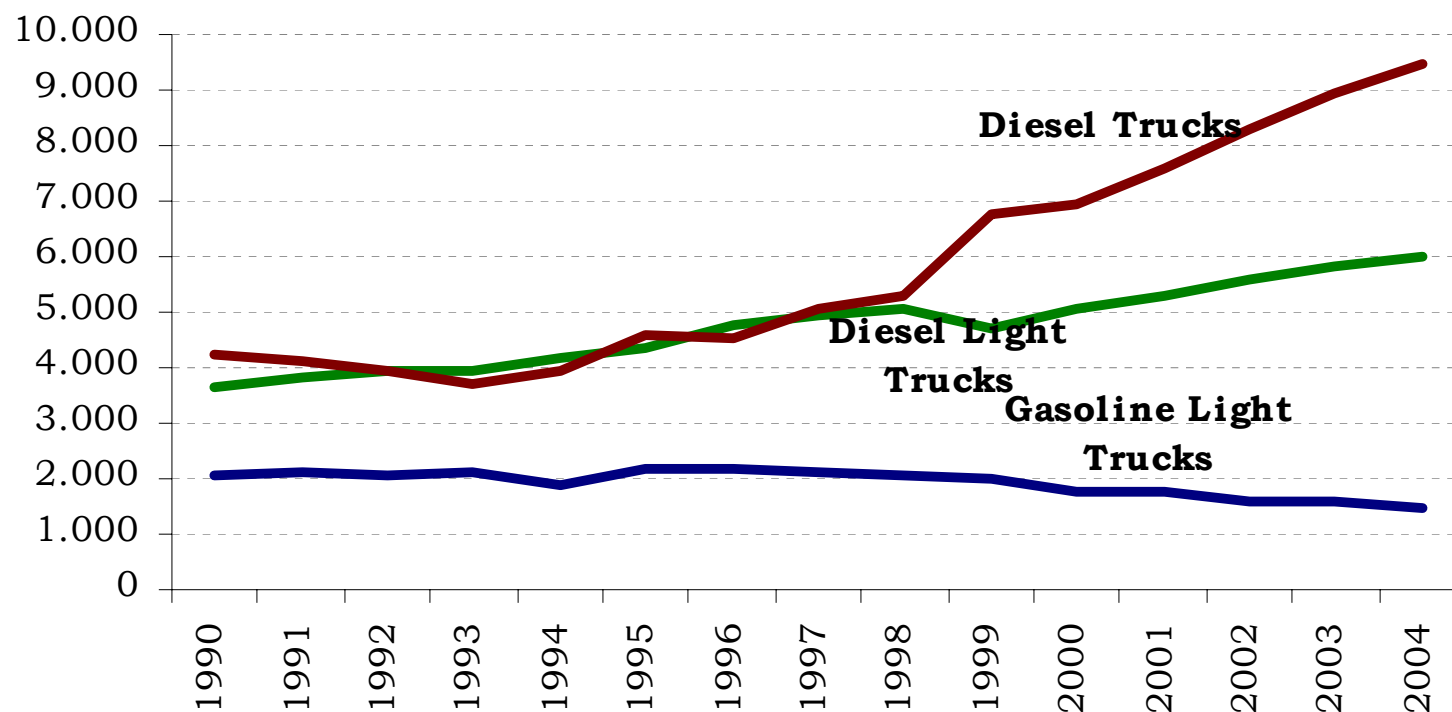
Freight transport



*Global increase in international trade and convergence with EU levels
Long distance to travel to international markets and placement in
north-south axis.*

Freight transport

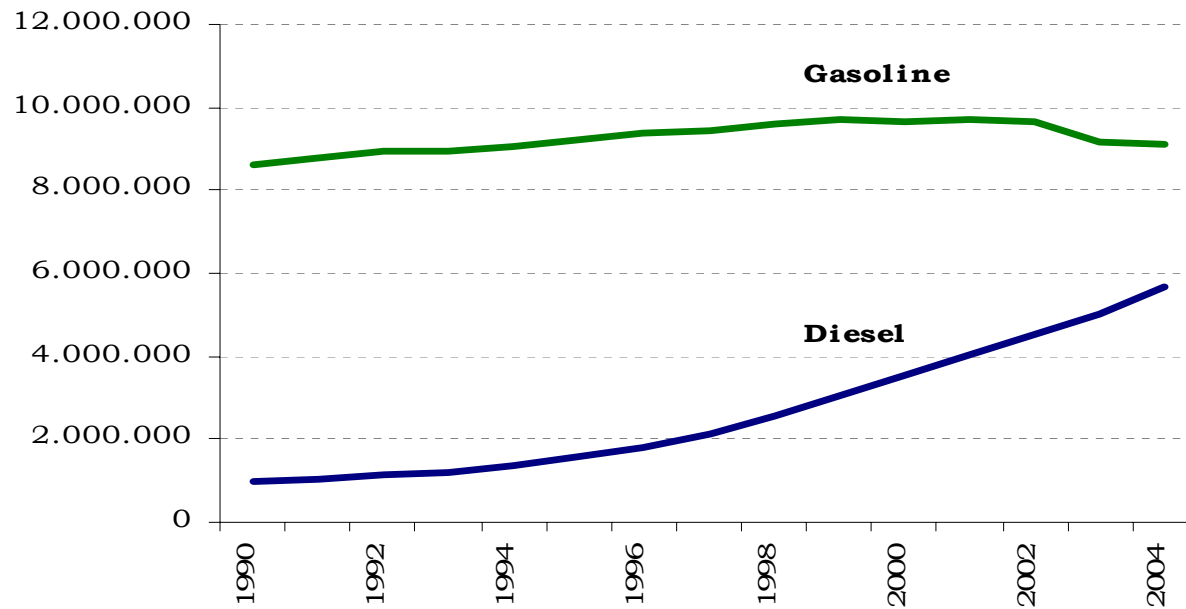
Energy consumption of freight transport (ktep)



Strong increase in diesel consumption in light & heavy trucks due to increase in travelled distance, even if efficiency improves.

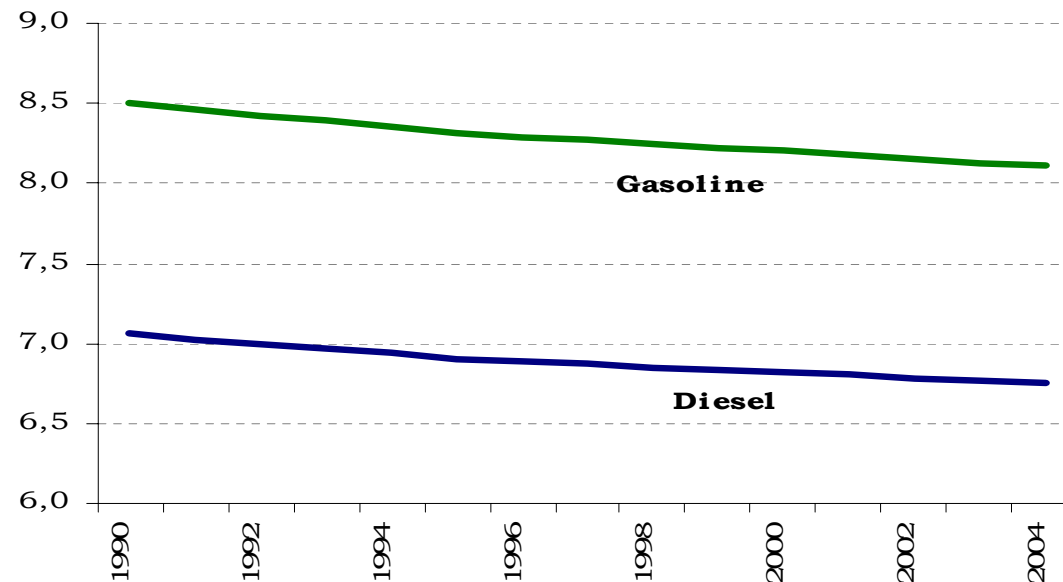
Household transport

Number
of
vehicles



↑ GDP pc
↑ purchase
of cars
Taxes
↓ Diesel
↑ Gasoline

Consumption
(l/km)

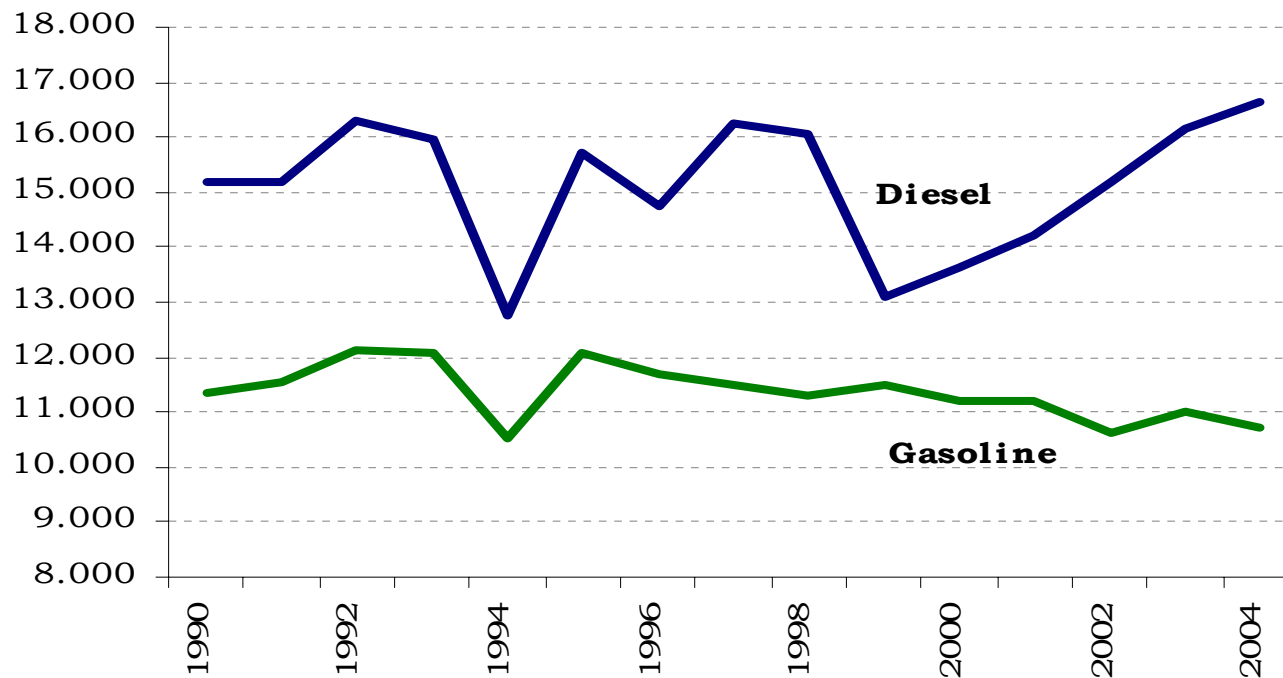


Efficiency
gains,
diesel &
gasoline,
cause
rebound
effect

Source: IDAE (2007)

Hosehold transport

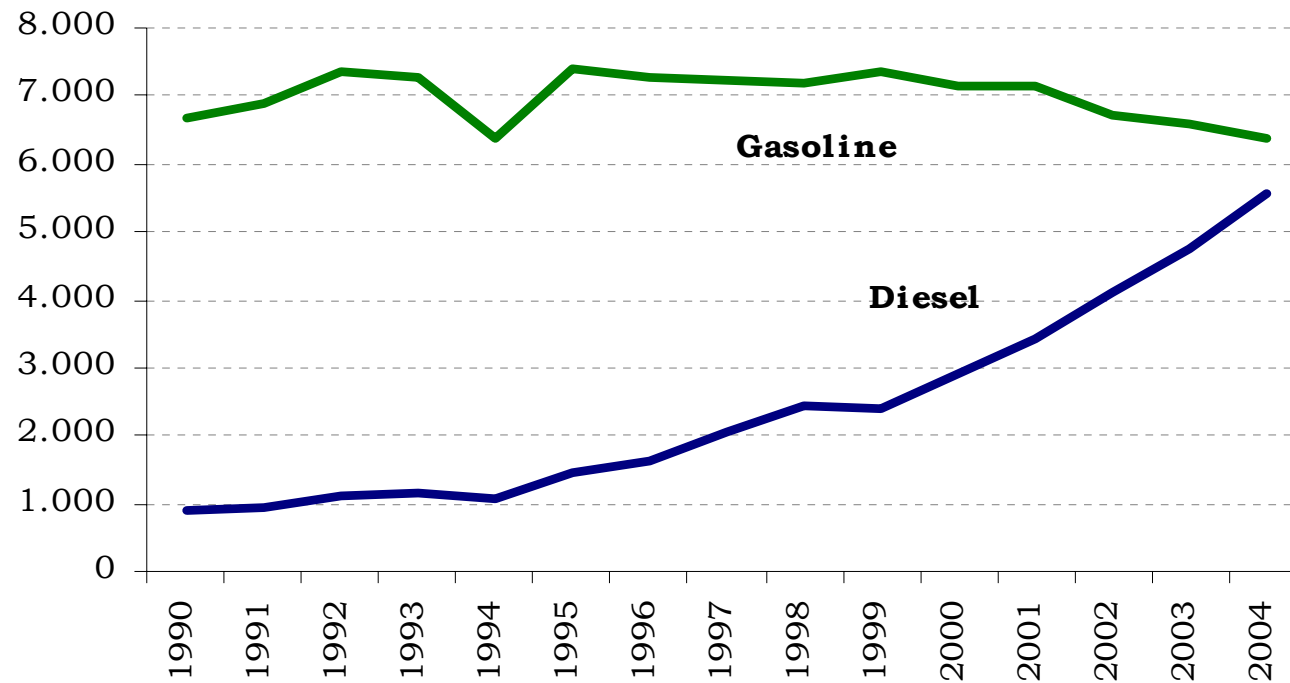
Average anual kilometres



- *Travelled distance depends on economic cycle*
- *Increase in movility & low occupation rate of vehicles*
- *Convergence with EU levels & increase of vacation transport*
- *Strong tourism influence: 50 million in 2004, which equals to an increase of population of 1,5 million*

Hosehold transport

Energy consumption of household transport (ktep)

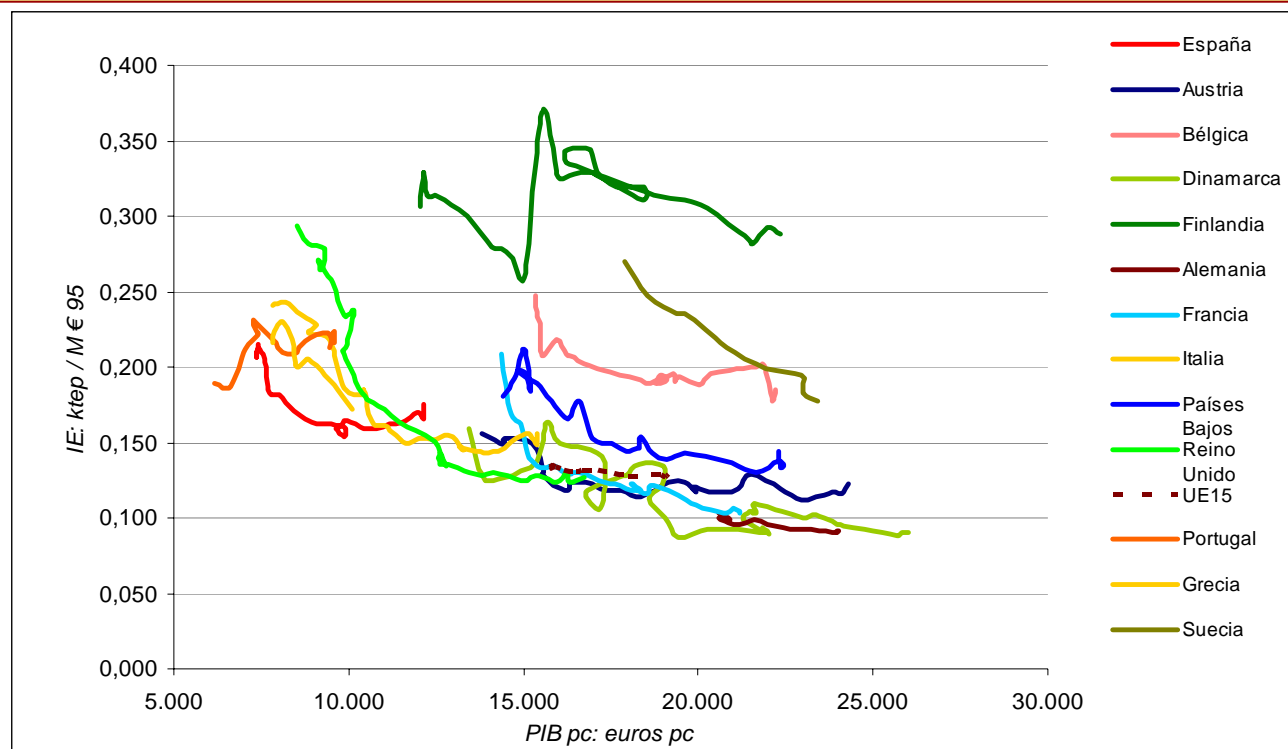


GDP pc growth & rebound effect drive IE & IC, without signs of saturation in the short term

Industry

European industry has decoupled growth from energy consumption, although it could be due to delocalization

Dematerialization in the European Industry (1980-2004)



In Spain, delinking in the industry sector only happens in the 80s, from 1990 onwards rematerialization occurs. Part of the improvement is due to the substitution of coal & fuel by electricity & gas

Industries

All industrial activities have higher IC than EU15 and do not reduce it as much, the most intensive are:

	IC (CO ₂ /VAB) Spain			IC (CO ₂ /VAB) Europe		
	1990	2004	Var.	1990	2004	Var.
Basic metals	1,175	0,818	-30%	0,858	0,610	-29%
Non mineral metals	2,325	2,115	-9%	1,676	1,412	-16%
Construction	0,005	0,013	195%	0,026	0,036	39%
Chemical	0,650	0,609	-6%	0,511	0,330	-35%
INDUSTRY	0,378	0,381	1%	0,387	0,319	-18%

Aggregation of several activities per sector do not allow distinction between efficiency gains or structural changes

Energy intensive activities should not penalise a country, because this will encourage delocalization to countries with fewer environmental constraints

Post-Kyoto commitments should be assigned taking into account economic structure and efficiency benchmarks

Construction

Spanish construction sector contributes more to GDP than EU15 (11% vs 6%) and so has a stronger influence in IE & IC...

Non metallic minerals energy intensities

	EC (ktep)	VAB (M€)	IE (ktep/M€)
Cement	2.962	1.460	2,029
Glass	479	1.181	0,406
Ceramics	2.547	2.508	1,016
Others	959	2.568	0,373
Non Metallic Minerals	6.947	7.717	0,900

Source: Elaboración propia a partir de E4 (2003) y INE (2005).

Driving factors

Spanish per capita consumption doubles EU15: 1.126 kgpc vs. 527 kgpc*
Infrastructures & dwelling construction are bigger than EU due to:

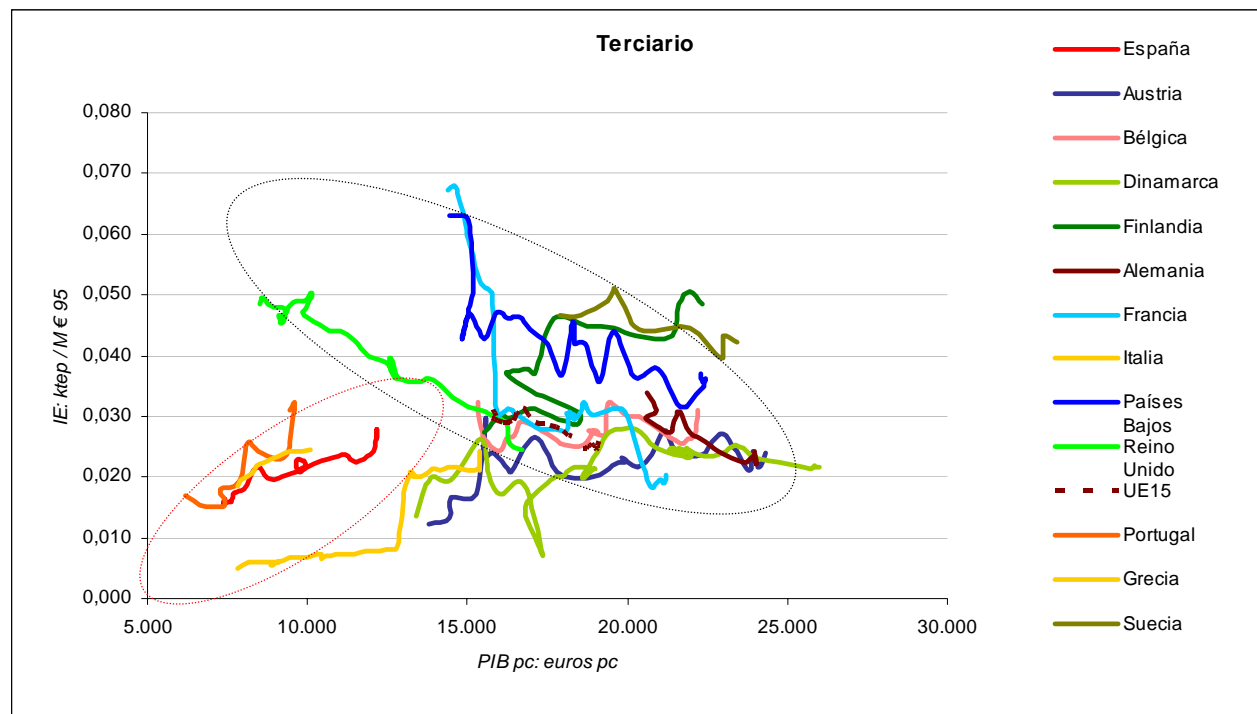
- Convergence to EU infrastructures level
- GDP pc growth & real estate “boom”
- ... could be cyclical, but second residence construction is a structural characteristic of mediterranean countries

Even if construction slows down, second residences & Infrastructure program (PEIT) will keep construction levels above EU

Dematerialization in the service sector

Services IE has grown (+41%) due to the increase of energy needs linked to tourism & air conditioning (as well as in other mediterranean countries)...

Dematerialization in the European services sector (1980-2004)

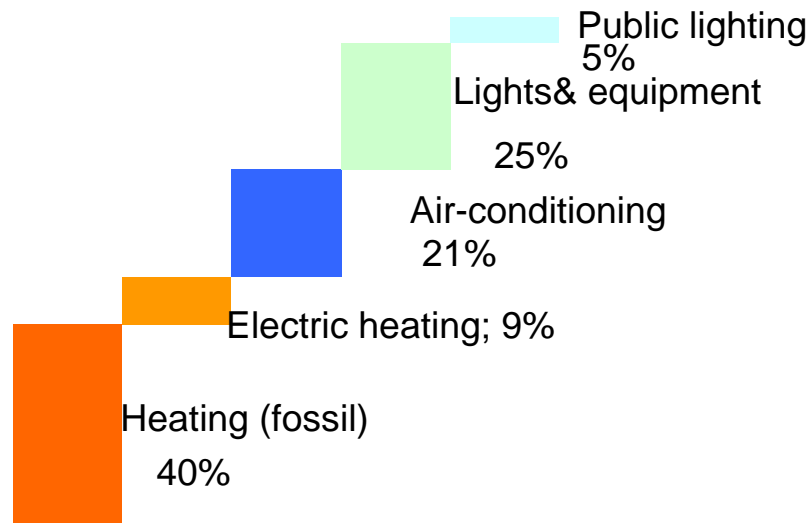


...while central & north European countries have decreasing ratios due to efficiency improvements in heating

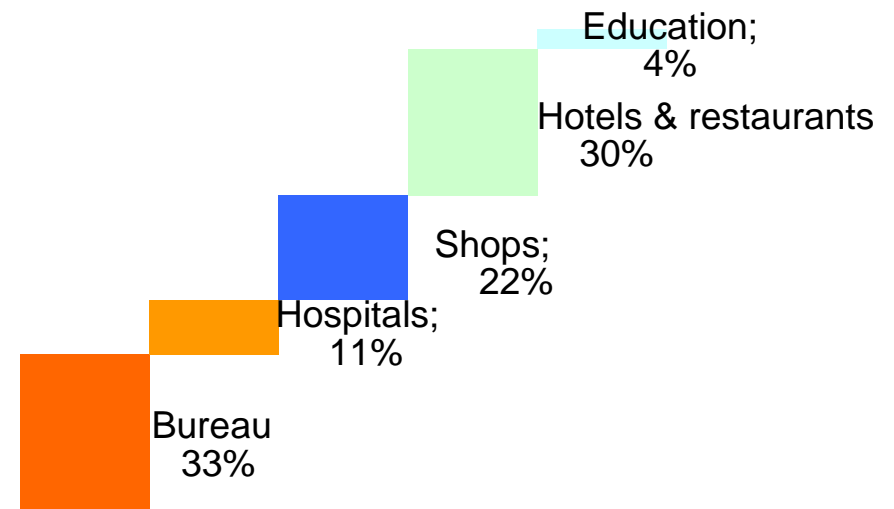
Delocalization of leisure

Mediterranean countries have specialized in tourism activities that generate higher energy consumption than other service activities...

Consumption Breakdown by use



Consumption Breakdown by activities

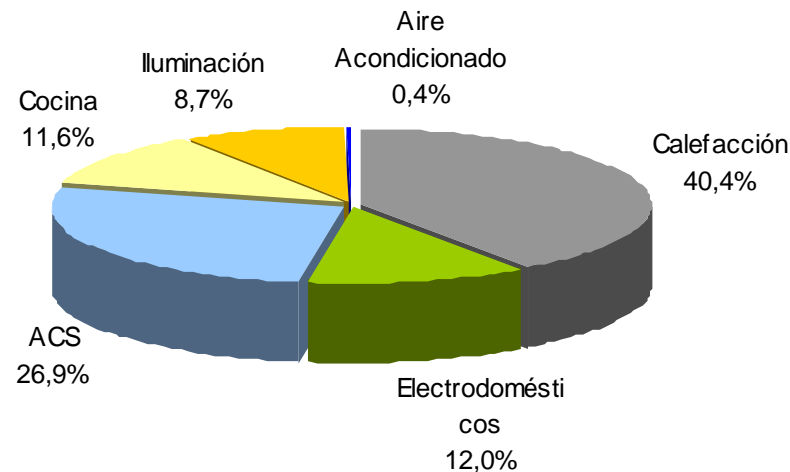


...when compared to central & northern european countries that “delocalize” these activities

Huseholds

Energy consumption in Spanish dwellings is much lower than in EU15, due to mild winters...

Households Consumption Breakdown



European households energy consumption accounts for 25-30% of total consumption, while only accounts to 15% in Spain

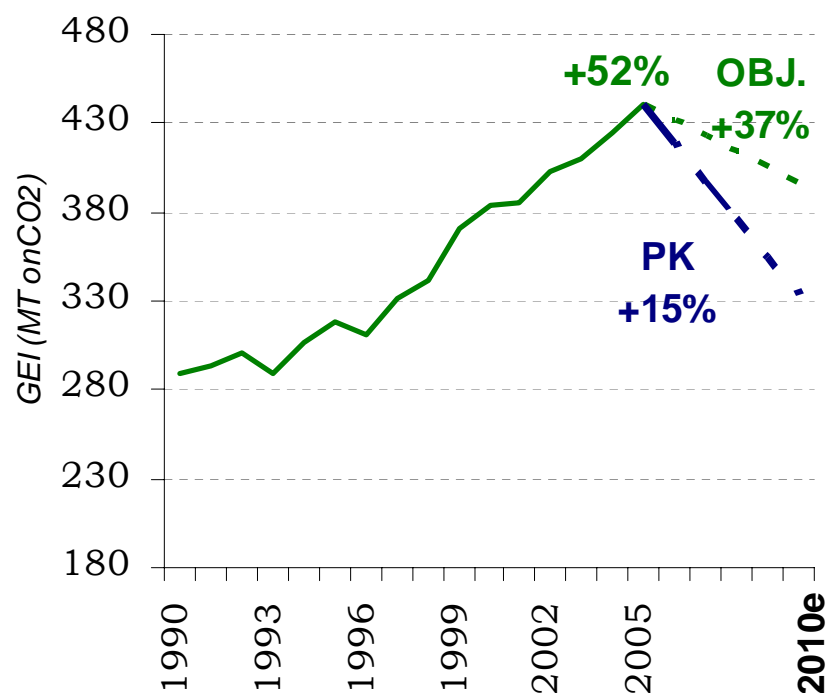
Heating accounts to 70% of European households energy consumption

... but hot summers have increased air-conditioning which adds up with the convergence to EU consumption levels & reduces differences

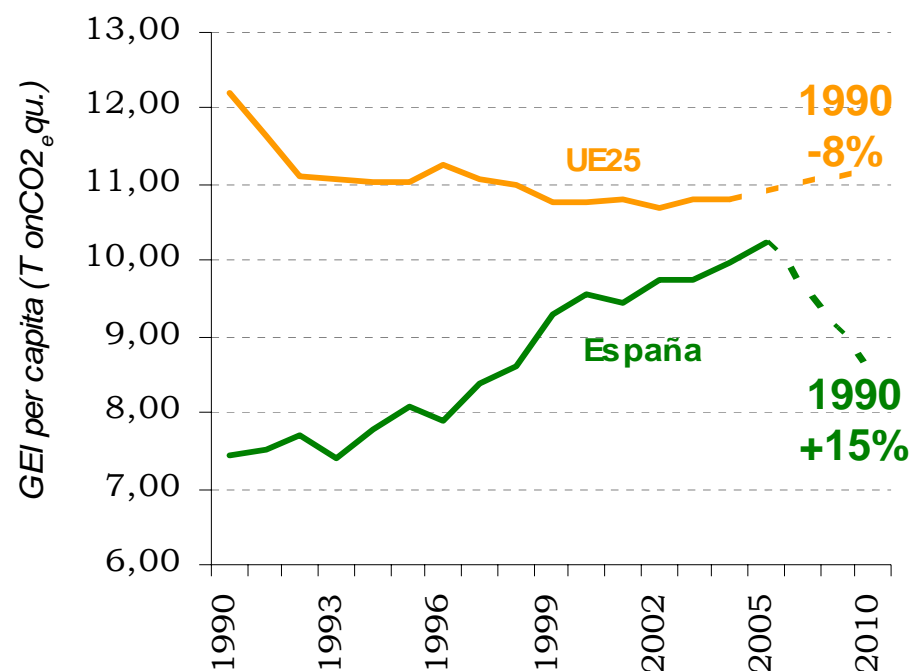
Kyoto Protocol commitments

Kyoto objectives for Spain where very hard & demanding & do not follow the equity principle: in 2010 emissions should be 24% below EU15

Spanish Kyoto objectives



Spanish per capita emissions (1990-2010)

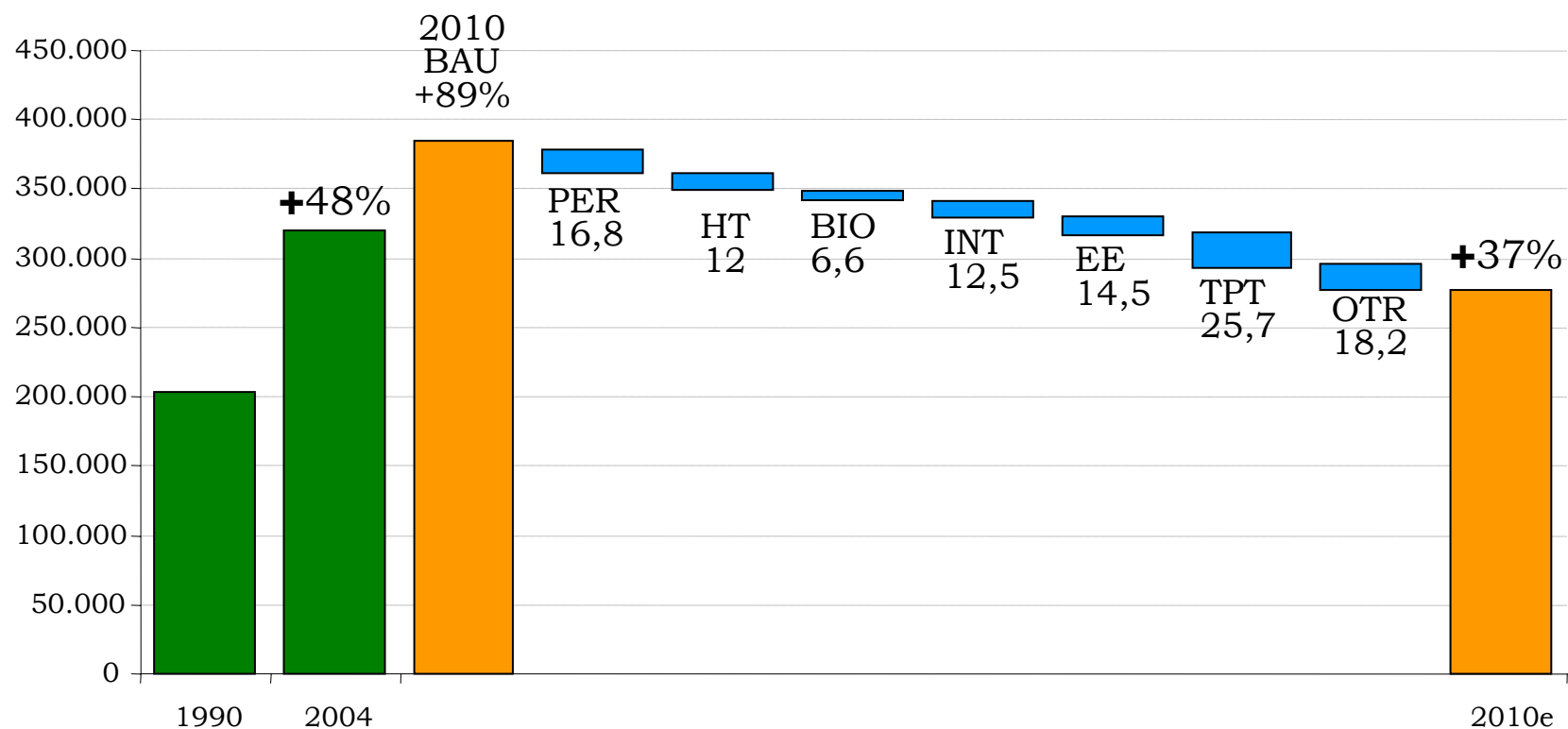


Nevertheless Spanish Government ratified Kyoto & has set measures to delink emissions growth

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Scenarios of emissions reductions

Scenarios of emissions reductions 2004-2010



PER: Renewable Energy Plan; HT: higher CCGT production; BIO: Biofuels; INT: increase in interconexions; EE: efficiency measures in intensive sectors; TPT: eficiencia measurtes in transport; OTR: Other efficiency measures

Efficiency measures

Efficiency measures in the electricity sector have a strong influence in IE & IC

Incentives to efficient technologies with low emissions

	<u>Efficiency</u>	<u>CO₂/kWh</u>
• Renewables:	100%	0
• Gas:	56%	365
• Coal:	38%	900
• Nuclear:	33%	0
• Other:		
– Interconnection	---	0

Improvements in efficiency in more intensive sectors (non met. minerals, primary metals), could come through price signals, that have also a high potential for emission reduction in households & services

Instruments

Renewables Energy Plan with feed in tariffs so that generation with these sources has a stable & predictable framework:

Renewables Energy Plan 2005-2010 (MW)

	<u>1998</u>	<u>2006</u>	<u>2010</u>
Biomass & Biogas	69	527	2.274
Wind	884	11.100	20.155
Solar PV	1	77	371
Solar Thermal	0	0	500
Hydro < 50 MW	1.249	1.740	2.200
Urban Waste	104	261	261
Cogeneration	3.674	5.869	7.500

CO₂ cost should give appropriate market signals for efficient energy use

Future reduction objectives should be fair & sectorial so there are no distortions to competition

Efficiency standards in AA & equipment to complement the New Building Code

There is room for tax signals to favour less polluting fuels

Transport

Transport has the strongest influence in IE & IC & it does not seem that this will change in the near future

EU has set a 2012 objective so that average emissions per car are below 130 g/CO₂/km

*Actions should be made to encourage transportation modal switch:
Increase public transport & train*

*Increase biofuel consumption
(5,8% of 2010 road consumption)*

Transport management

Information & social awareness

Fiscal reform in hydrocarbon taxes, ownwrrship tax and circulation tax offer wide possibilities to incentive efficient behaviours

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Conclusions

Kyoto Protocol objectives for Spain were very demanding: 2010 per capita emissions would be 24% below EU15

IC increases by 10% in Spain & decreases by 18% in Europe

Economic structure influences IC level & evolution

Generation technologies have strong influence in IE & IC

Fuel switching to electricity in final consumption transfers transformation & conversion losses to the electricity sector

Energy intensity increased due to higher energy needs in all the sectors, specially in transport & services

The biggest challenge that countries face is to reduce transport growth

Thank you

María Mendiluce
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