FONDAZIONE ENI ENRICO MATTEI

secure
Security of Energy Considering its Uncertainty, Risks and Economic implications

SEVENTH FRAMEWORK PROGRAMME

Energy efficiency and Energy Security in Europe

SECURE WP 5.8: Energy Demand

SECURE Stakeholder Workshop

ERSE, Milan, 18-19 January 2010

Andrea Bigano and Roberta Pierfederici
with Emauela Menichetti (OME) and
Agnieszka Monika Skowron-Rincon (Ramboll)

Outline

Introduction:

- Motivation
- Energy use in Europe

Energy indicators:

- Energy Intensity
- Energy Efficiency
- Carbon Intensity
- Energy Security

Energy policy and energy efficiency in Europe

Panel analysis of the effects of policies and measures on energy efficiency and energy security

Conclusions

Motivation

Direct observation of energy intensity trends in Europe seem to suggest that EU countries have, overall, converged toward lower energy intensity over the last decades.

On the other hand, since the 90's, the EU and the national governments have been taking steps in terms of energy policy and measures to reduce energy consumptions and carbon emissions.

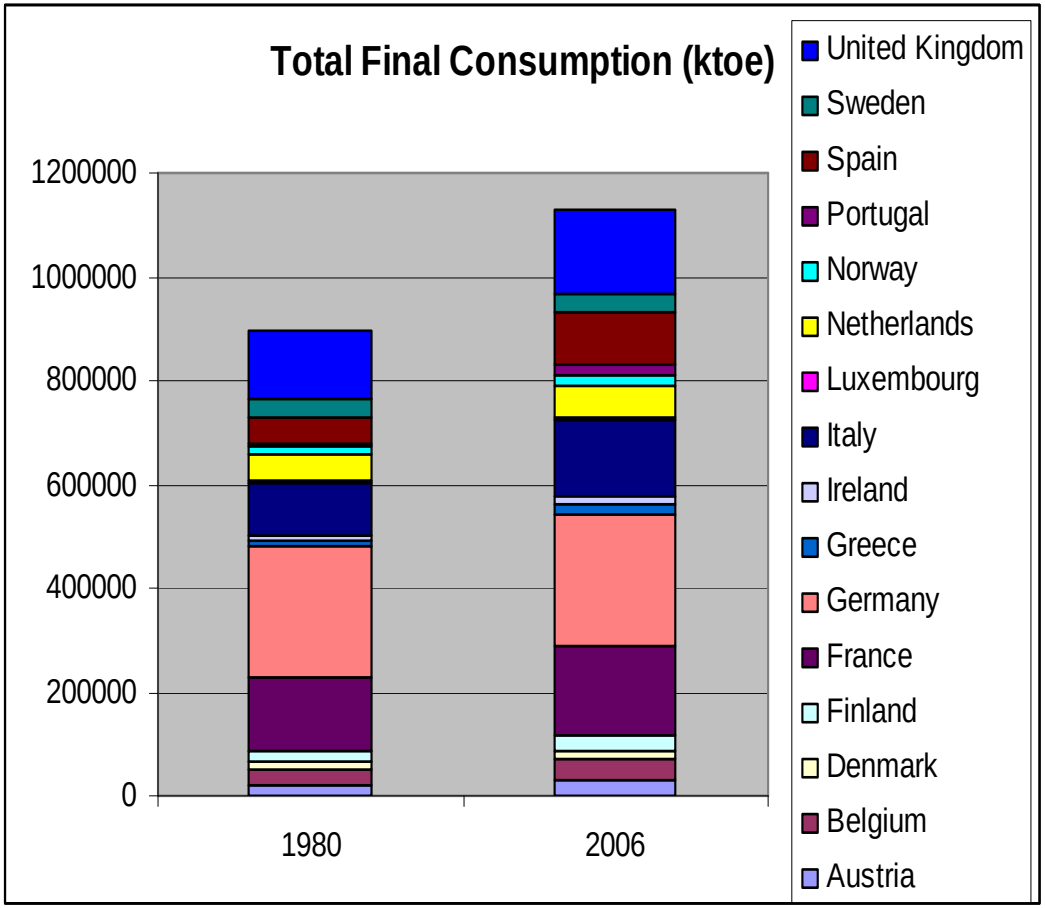
In recent decades, increasing demand for energy, fluctuating oil prices, uncertain energy supplies and global warming made the EU-citizens to realize that secure and safe supplies of energy can no longer be taken for granted.

It can be argued that one way to reduce the dependence from external energy sources, or the exposure to energy prices volatility and increase, is simply to reduce the demand for energy.

Using an innovative econometric approach, we check whether policies and measures that affect indicators of energy efficiency performance have an analogous effect on security of supply indicators, both at the whole economy level and within the main sectors of energy use, in the EU 15 countries, using an updated database.

Energy consumption in Europe : an overview (1/2)

- From 1980 to 2006, energy consumption has increased for the EU as a whole;
- The consumption share of each country has remained rather stable;
- The highest portion of energy consumption is ascribable to Germany, followed by France, United Kingdom and Italy;
- France, Italy and Spain registered the highest increase in energy consumption.



secure
Security of Energy Considering its Uncertainty, Risks and Economic implications

Fondazione Eni Enrico Mattei

Energy consumption in Europe : an overview (2/2)

Energy Consumption by Fuel.

Energy mix mainly composed by oil, gas and electricity;

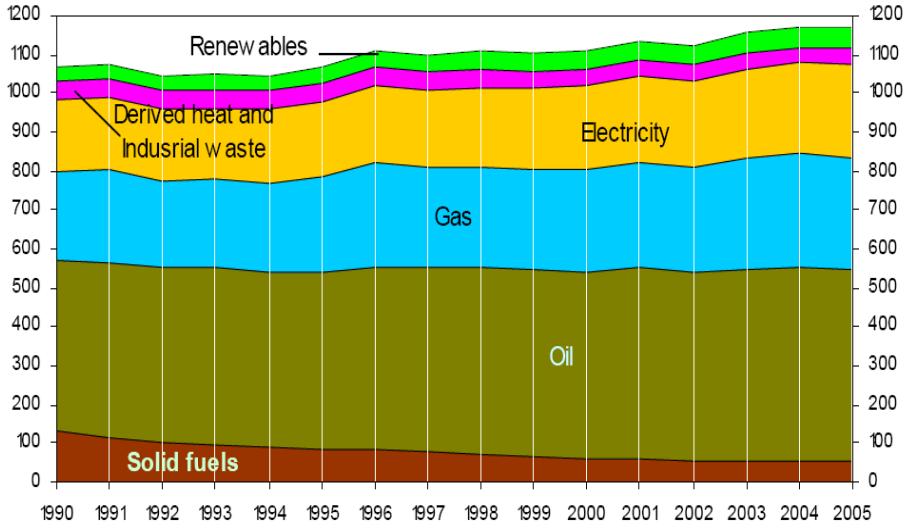
Solid fuels, renewables and industrial waste: limited share of total consumption.

Energy Consumption by Sector.

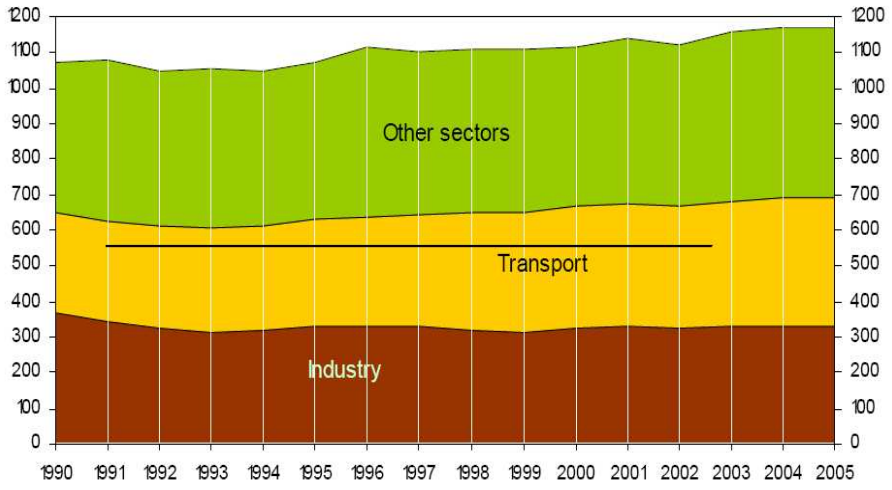
Largest share of total final energy consumption: households and service sectors (“other sectors”).

Final Energy Consumption EU27, Mtoe

a) by Fuel.



b) by Sector.



Energy Intensity

Definition: ratio between final energy consumption and Gross Value Added (GVA). It is an economic measure of the energy requirement that a country, or one of its industries, needs to fulfil for its production;

General trend in the EU 15: The average of the EU-15 shows a smooth decrease over the period 1980-2006;

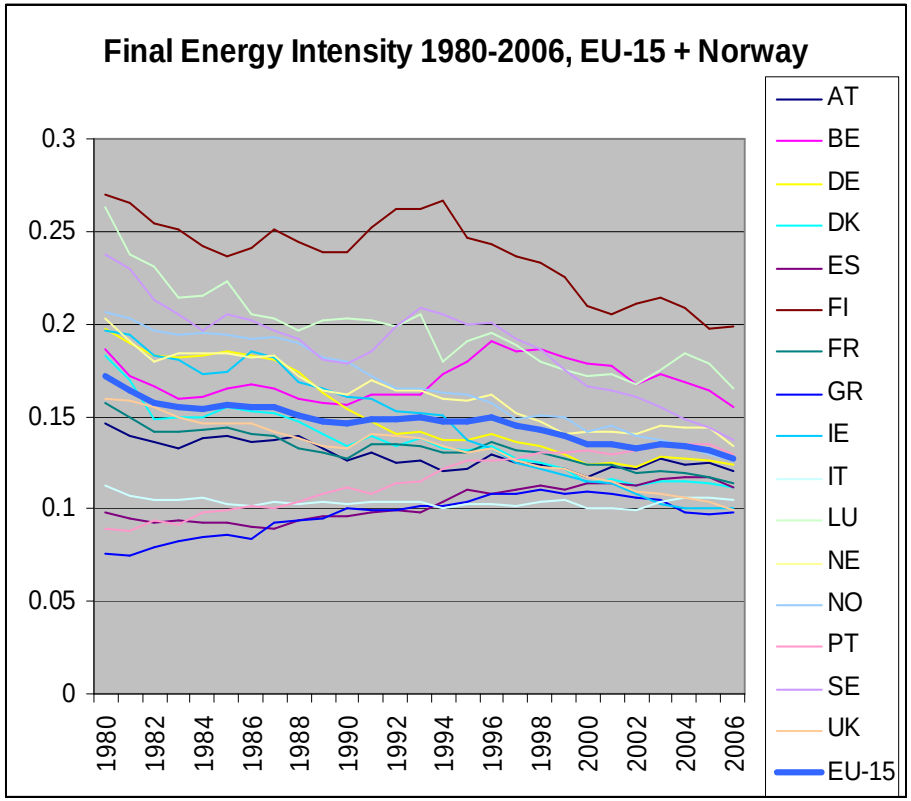
The largest improvements are displayed by Luxembourg and Finland.

Energy Intensity
All Sectors

Portugal shows a stable upward trend, interrupted by a drop starting from 2005;

In Spain after a period of decrease, the index starts to grow up from ‘90s;

Italy exhibits a stable decrease until the mid-‘80s. From this period the index remains nearly constant up to 2002, when it starts to rise. In the latest phase, starting in 2005 the index drops again.



Unit of measure: ktoe/00$ppp

secure
Security of Energy Considering its Uncertainty, Risks and Economic implications

Fondazione Eni Enrico Mattei

Energy Intensity Industry Sector

- **Best performance in Ireland, Denmark & Greece**
- **The average and median values show how energy intensity has improved and converged among all countries.**

Energy Intensity in the Industry Sector, 1980-2006, ktoe/00$ppp.

3-year Average Centered on 1985			3-year Average Centered on 1995			3-year Average Centered on 2005	
IT	0.113		IE	0.110		IE	0.063
ES	0.120		DK	0.113		DK	0.088
UK	0.121		IT	0.120		GR	0.108
DK	0.122		UK	0.123		UK	0.117
GR	0.125		GR	0.125		IT	0.126
AT	0.136		AT	0.130		NO	0.131
PT	0.150		ES	0.137		AT	0.139
FR	0.163		DE	0.137		DE	0.139
DE	0.165		FR	0.167		ES	0.142
IE	0.173		PT	0.184		FR	0.154
BE	0.209		NO	0.195		PT	0.201
NE	0.227		NE	0.215		SE	0.210
NO	0.240		BE	0.278		NE	0.234
SE	0.252		SE	0.285		LU	0.240
FI	0.330		LU	0.315		BE	0.297
LU	0.391		FI	0.370		FI	0.318
Average	0.190			0.188			0.169
Median	0.164			0.152			0.140
Minimum	0.113			0.110			0.063
Maximum	0.391			0.370			0.318

Energy Efficiency
Household Sector

Definition: EE is measured as the variation of energy consumption for unit of product with respect to a base year. A downward trend indicates a progressive improvement of the country's energy efficiency.

In the household sector Norway and Portugal have achieved significant improvements in terms of energy efficiency, due to the policies introduced by these countries in order to boost energy savings and energy conservation.

Large potential for improvement in the EE for the less performing countries such as Italy, where the improvement in EE achieved by this sector has been equal to a tenth of the improvement registered by more efficient countries (namely, Portugal and Denmark).

Energy Efficiency
Household Sector

Percentage Change of Energy Efficiency in the EU-15 Countries and Norway, 1980-2004. Household sector.

HOUSEHOLD (% change in EE Index over period)

1980 - 2004			1980 - 1992		1992 - 2004	
PT	-49.8%		-31.7%	DK	PT	-42.4%
DK	-43.4%		-18.0%	SE	DK	-17.2%
SE	-28.5%		-12.9%	PT	AT	-16.3%
AT	-24.9%		-10.3%	AT	SE	-12.8%
FR	-17.1%		-10.0%	FR	NO	-11.7%
FI	-16.1%	Median	-7.9%	FI	FI	-8.9%
DE	-10.5%		-6.9%	UK	DE	-8.5%
UK	-8.7%		-2.2%	DE	FR	-7.9%
IT	-4.2%		0.5%	IT	IT	-4.7%
NO	2.2%		15.8%	NO	UK	-1.9%
ES	142.7%		40.5%	ES	ES	72.7%
BE	n / a		n / a	BE	BE	n / a
EL	n / a		n / a	EL	EL	n / a
IE	n / a		n / a	IE	IE	n / a
LU	n / a		n / a	LU	LU	n / a
NL	n / a		n / a	NL	NL	n / a
Average =	-5.3%		-3.9%			-5.4%
Median =	-16.1%		-7.9%			-8.9%
St. Dev =	0.516		0.188			0.280
Minimum =	-49.8%		-31.7%			-42.4%
Maximum =	142.7%		40.5%			72.7%

Energy Efficiency
Transport Sector

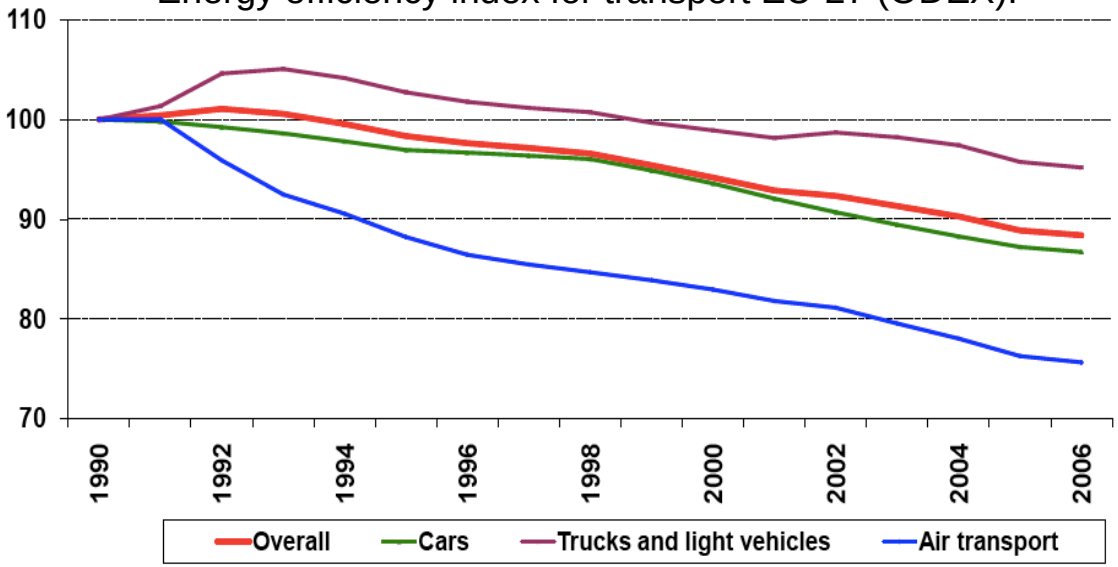
Disaggregating the E.E. index by transport modes, a regular improvement of the energy efficiency of transport (12%) takes place in the EU over the period 1990-2006.

The lower progress can be blamed on the road transport of goods, while the best performance in the index takes place in the air transport.

For the transport sector as a whole, Ireland and Greece reported the best performances in the period 1980-2004.

By contrast, performances in the energy transport sector have worsened in Spain.

Energy efficiency index for transport EU-27 (ODEX).



secure
Security of Energy Considering its Uncertainty, Risks and Economic implications

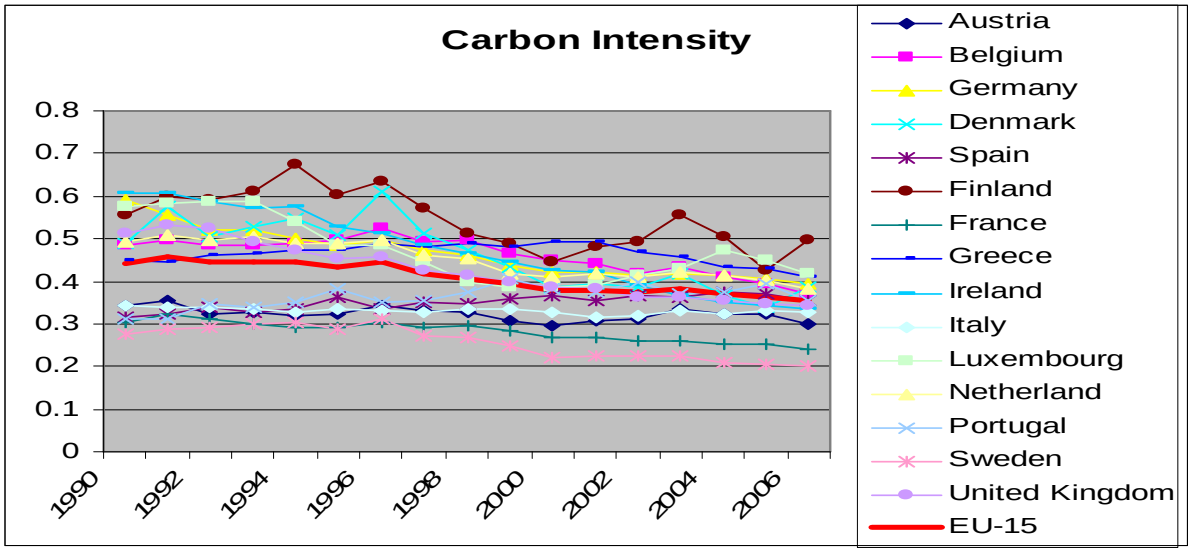
Fondazione Eni Enrico Mattei

Carbon Intensity
All Sectors

Definition: Carbon Intensity is the ratio of CO_2 emission equivalents generated (in terms of Mton of CO2) to the indicator of economic activity, GVA. It measures the degree of carbonisation of an economy or of a given productive sector.

Looking at the average of EU-15 Countries, carbon intensity decreased from 1990 to 2006 of about 20 percent, although in Spain and Portugal, the index increased.

The best performances are attained by Ireland and Germany, which show a variation of about -45 and -33 percent respectively between 1990 and 2006.



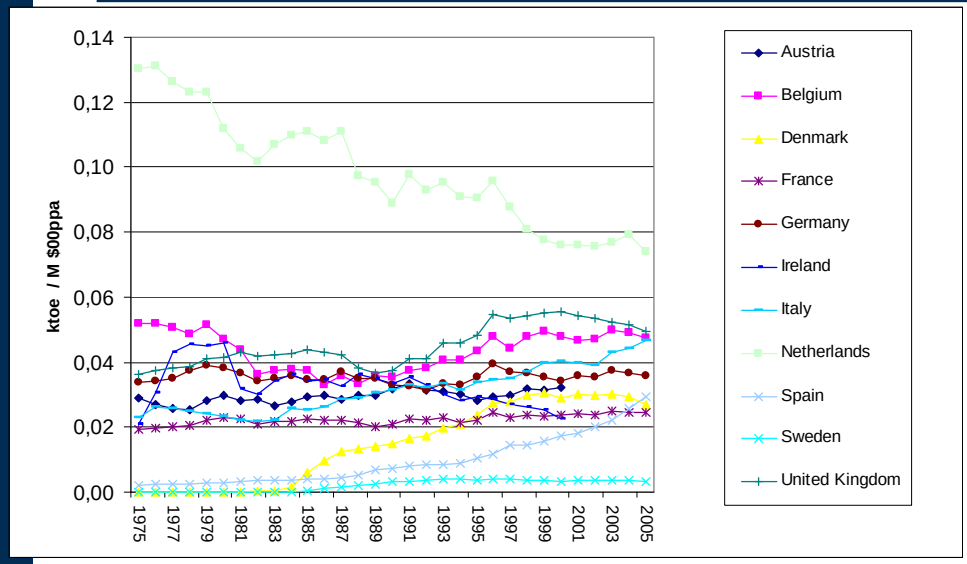
Source: Authors' computation on data from ENERDATA, EUROSTAT, OECD.

Energy Security: many possible indicators

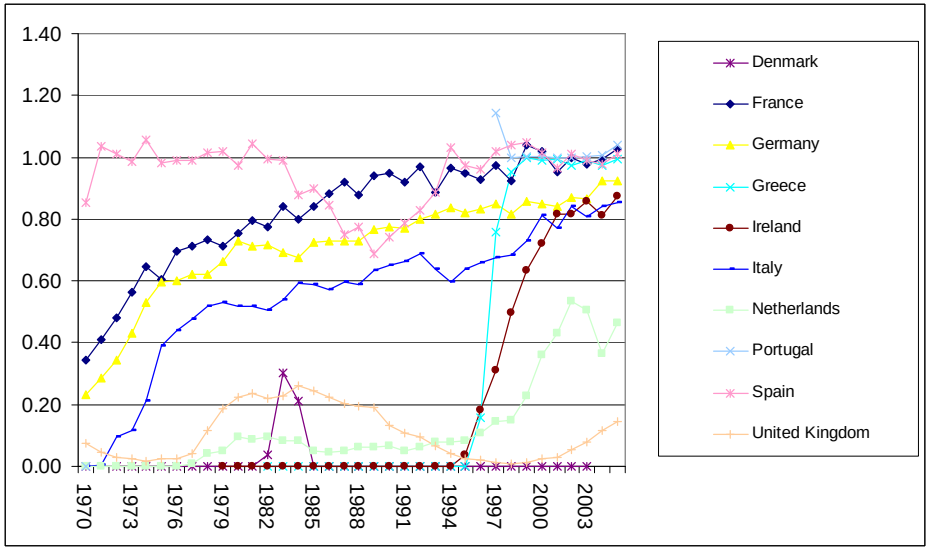
	Vulnerability	Dependence
Physical Dimension	Imported oil used in transportation (Mtoe)/Total energy used in transportation (Mtoe)	Imports of energy/Total primary energy supply
	Imported Oil and Gas–fired electricity generation (gWh)/Total electricity consumed (gWh)	Country's oil imports/Total oil consumption
	Per capita oil consumption (Ktoe)	Country's gas imports/Total gas consumption
	Degree of supply concentration for oil and gas	
	Shannon-Weiner Index for supply	
	Per capita gas consumption (Ktoe)	
Economic Dimension	Value of oil (or gas) imports/Value of total exports	Oil consumption (Toe) per $ of real GDP
		Gas consumption (Toe) per $ of real GDP

Dependence is a measure of how much the domestic economy relies on sources of energy that are not under its control. **Vulnerability** is a measure of the likelihood of domestic disruption in case some external energy source is reduced or cut off.

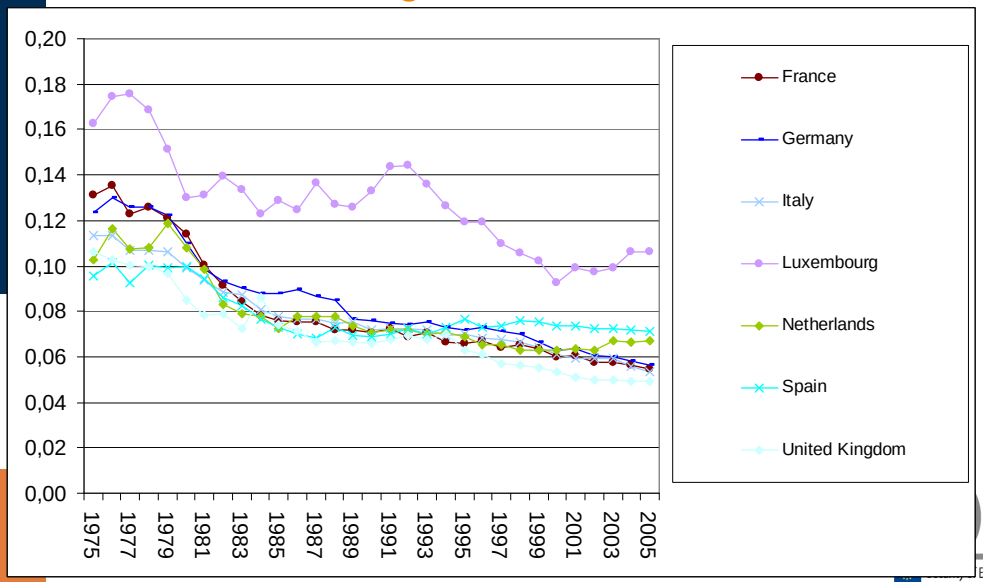
Energy Security Indicators



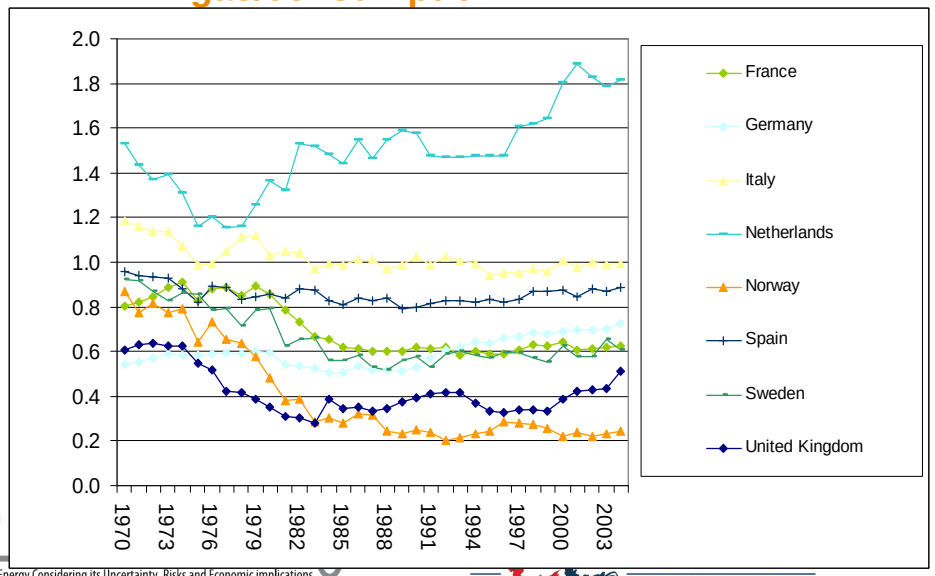
gas/GDP



gas/consumption

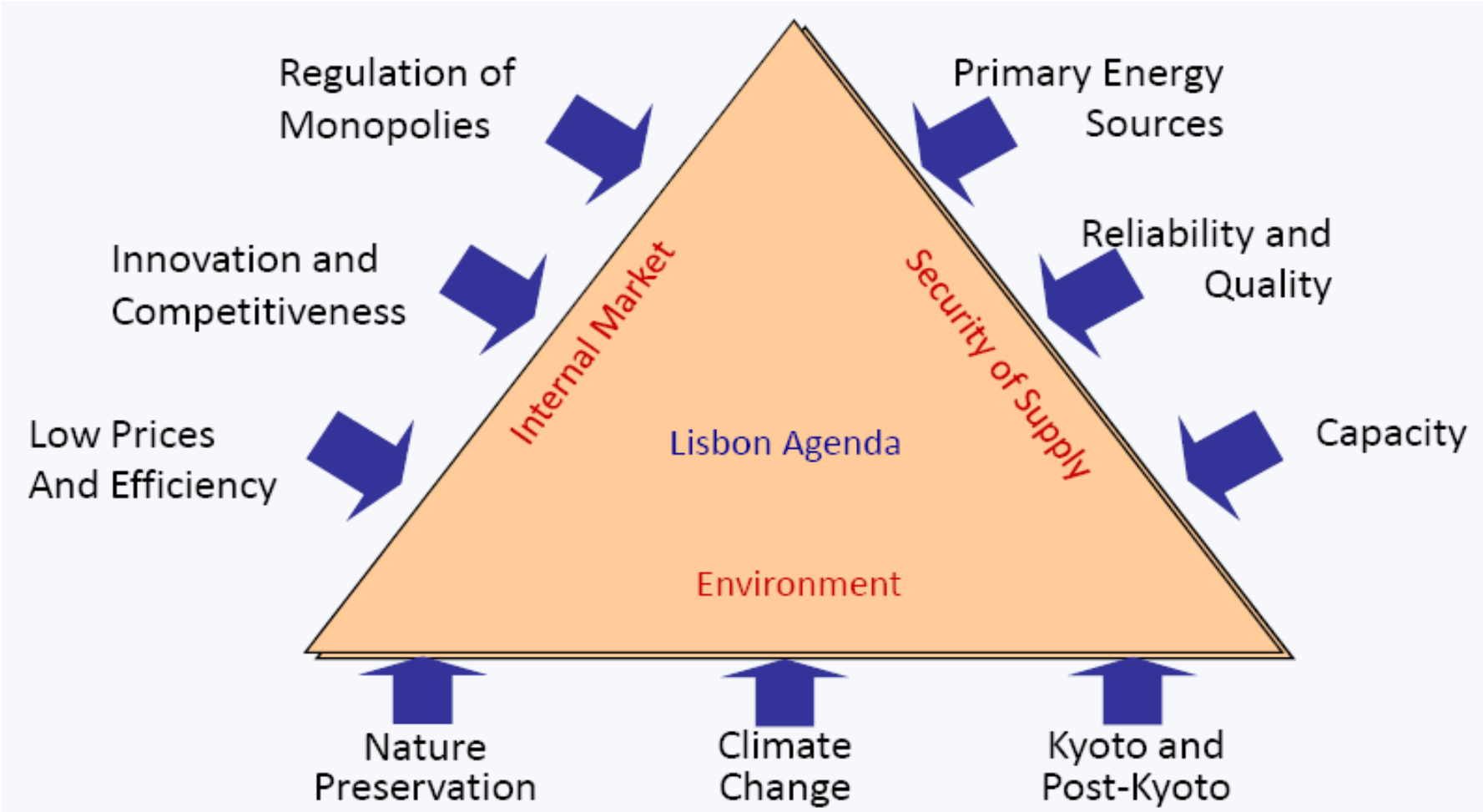


oil/GDP



energy imports/TPES

Energy Policy in the EU (1/2)



Source: Bellmans (2009)

secure
Security of Energy Considering its Uncertainty, Risks and Economic implications

Fondazione Eni Enrico Mattei

Energy Policy in the EU (2/2)

Security of supply, sustainability and competitiveness are not independent objectives;

Need to have a consensus view about the current situation and a (long-run) policy to deal with it.

The Green Paper (2006) “A European strategy for sustainable, competitive and secure energy” [COM(2006) 105 final]:

- Identifies priority areas and lists proposals to meet and fine-tune three core objectives:
  1. Increasing **security** of supply;
  2. ensuring the **competitiveness** of European economies and the availability of affordable energy, and;
  3. promoting environmental **sustainability** and combating climate change.

The “20-20-20” objectives : By 2020

- 20% reduction in CO_2 emissions
- 20% increase in renewable source share in TPES
- 20% increase in energy efficiency

EU policies promoting energy saving and efficiency

- Energy efficiency is identified as a key ingredient to improve self-sufficiency and reducing GHG emissions.

1992	*European Directive on labeling of the energy consumption's household*
2000	*Action Plan for Energy Efficiency 2000-2006*
2002	*European Directive on building's efficiency*
2005	*Eco-Design Directive concerning all new products outside of the transport sector*
2006	*European Action Plan for Energy Efficiency (2007-2013)*
2008	*Climate Action and Renewable Energy Package*

Key energy savings policies in the EU. *Source: ADEME*

GP on "Energy Efficiency or doing more with less" (2005):

- to cut energy consumption by 20% by 2020.
- to reduce the dependency on imported oil and gas
- to reduce the energy bill by an estimated 100 billion euro every year.

The EU has proposed directives and regulations concerned with areas where there is potential for energy savings:

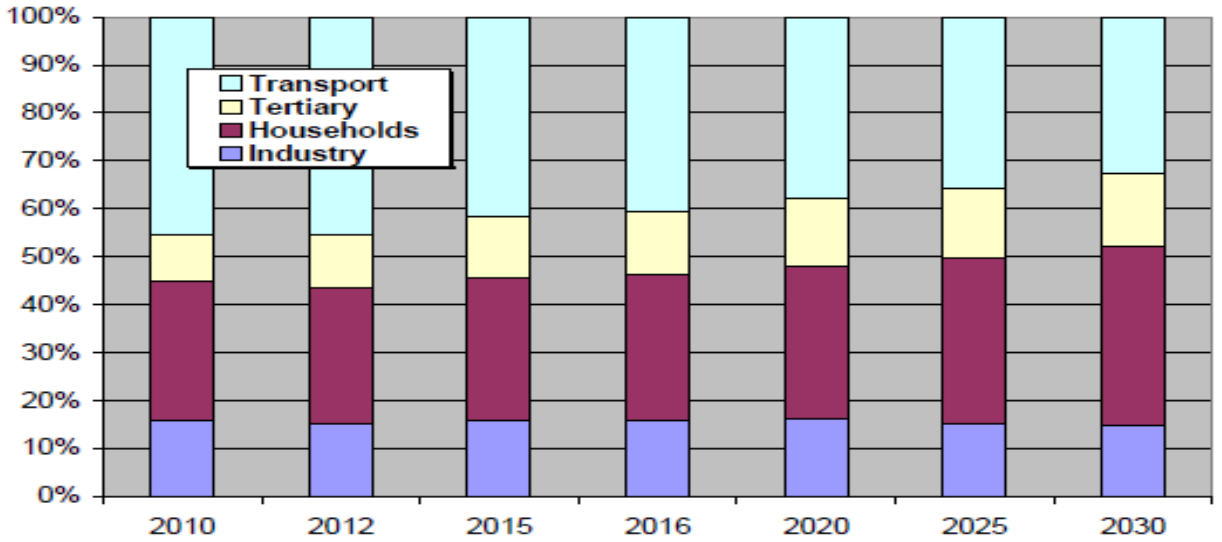
- End-use Efficiency & Energy Services;
- Energy Efficiency in Buildings;
- Eco-design of Energy-Using Products;
- Energy Labeling of Domestic Appliances;
- Combined Heat and Power (Cogeneration).

Energy savings potentials

According to the study of the European Commission (2009) on Energy Savings Potentials, in the short run (2010) transport, non-EU ETS sectors (in particular crosscutting technologies such as electric motor applications) and electric applications in the residential/tertiary sectors may have the largest potentials.

In the medium run (2020) the contribution from the building sector (residential and tertiary) to the potentials grows larger.

Sectoral contributions to the Energy savings potentials over time in relative terms.



secure
Security of Energy Considering its Uncertainty, Risks and Economic implications

Fondazione Eni Enrico Mattei

Panel analysis of policy effectiveness in Europe

Data sources:

The energy indexes (dep.variables) are computed from IEA, Eurostat, Enerdata and OECD data.

The policies were obtained from the MURE database.

The economic time series per country were obtained from Eurostat, the World Development Indicators (WDI) and IEA databases.

Dependent variables:

Energy intensity (EI), energy security (ES) and carbon intensity (CI) indexes calculated for the whole economy, and for Industry, Other (agric.+tert.+hous.) and Transport sectors.

Energy efficiency index (EE) for Households and Transport.

CO_2 emission for Households.

Panel analysis of policy effectiveness in Europe

Countries : EU15+Norway.

Time dimension: 1980 to 2006.

Number of observations: 432

Models: Static fixed effect models (dynamic models did not yield stable results).

Dummies per policy sub-type : the dummy variable equalled 1 if any of the policies of the same sub-type was in place in the country in a given year.

Estimation strategy: include all potential determinants and policies with their lags and excluding from the model those variables with coefficients not statistically significant. The process was repeated until we obtained a set of statistically significant variables and policies with the expected signs.

In the case of P&Ms coefficients we expect a negative sign, that is, when the policy is in place (dummy=1) it implies EE / EI improvements.

Panel analysis: methodology (1/2)

Econometric analyses of energy efficiency determinants focusing on the following factors suggested by the literature.

- Structural changes in the economy: GDP, sectoral GDP shares changes, R&D expenditure
- Policies: national and supranational energy policies (eg. EU directives, presence of national carbon/energy taxes, etc.)
- Measures: fiscal, education/information initiatives, legislation (mandatory standards or labelling), cooperative measures, cross-cutting measures
- Energy: energy prices, energy balance sheet.

Goal: to assess the economic variables which could have a significant effect in improving the energy intensity, energy efficiency, energy security and carbon intensity and to identify the policies and measures (P&M) implemented in European countries which have been effective for the same purpose.

Further goal: to compare the significant drivers resulting from regressions, in order to understand whether there are some factors which affect both energy intensity and energy security and if improvements in carbon intensity match with lower energy intensity.

Panel analysis: methodology (2/2)

The 18 general panel models have the following functional form:

$$EI_{it} = \alpha_i + \lambda X_{it} + \beta_1 PM1_{it} + \ldots + \beta_K PMKi_t + u_{it}$$

$$EE_{it} = \alpha_i + \lambda X_{it} + \beta_1 PM1_{it} + \ldots + \beta_K PMKi_t + u_{it}$$

$$ES_{it} = \alpha_i + \lambda X_{it} + \beta_1 PM1_{it} + \ldots + \beta_K PMKi_t + u_{it}$$

$$CI_{it} = \alpha_i + \lambda X_{it} + \beta_1 PM1_{it} + \ldots + \beta_K PMKi_t + u_{it}$$

$$CC_{it} = \alpha_i + \lambda X_{it} + \beta_1 PM1_{it} + \ldots + \beta_K PMKi_t + u_{it}$$

fixed effects

panel structure: country (i) x time (t)

macro drivers: GDP, prices, etc

Policies & Measures

Panel analysis: results (1/8)

The effect of macro drivers:

The price of energy has a small but significant effect on most indicators in all sectors. It has a relatively larger effect on household energy efficiency. In the transport sector it only influences energy intensity.

The effects of increases in GDP are mixed. In some cases GDP increases result in more efficiency and lower intensity, carbon content and higher security; in other cases the reverse holds. There is a moderate prevalence of beneficial effects (60%).

The effects of R&D expenditure on most indicators are disappointing. We do not generally find improvements when R&D increases. In some cases, it appears to be detrimental.

Panel analysis: results (2/8)

Dependent Variables	Significant Regressors (Economic Variables)				
EI all sectors	Energy Price	GDP/capita	R&D	Share of industry	---
EI industry	---	GDP/capita	R&D	Share of industry	Energy production
EI other	---	GDP/capita	R&D	---	---
EI transport	Energy Price	GDP/capita	R&D	---	---
EE household	Energy Price	GDP/capita	---	---	---
EE transport	---	---	R&D	---	---
ES all sectors	---	GDP/capita	R&D	Share of industry	Energy production
ES industry	---	GDP/capita	---	Share of industry	Energy production
ES other	Energy Price	GDP/capita	---	---	---
ES agriculture+tertiary	Energy Price	GDP/capita	---	---	---
ES household	---	GDP/capita	R&D	---	---
ES transport	---	GDP/capita	---	---	---

Panel analysis: results (3/8)

Dependent Variables	Significant Regressors (Economic Variables)				
CI all sectors	Energy Price	GDP/capita	---	---	Energy production
CI industry	Energy Price	GDP/capita	---	Share of industry	---
CI other	Energy Price	GDP/capita	---	---	---
CI agriculture + tertiary	---	GDP/capita	R&D	---	---
CI transport	---	GDP/capita	R&D	---	Energy production
CO2 emission household	Energy Price	GDP/capita	R&D	---	---

Panel analysis: results (4/8)

Econometric Results for the whole economy and the industry sector

			Dependent variables							
			Unit	Energy intensity		Energy security				Carbon intensity	
				eifin	eiind	esfin1*	esfin2§	esind1+	esind2°	Cifin	ciind
Coefficients	Macro Drivers	Energy Price	US$/unit	-0.0009	-	0.0047	-	-	-	-0.0024	-0.003
		GDPppp	US$	-0.0203	-0.096	0.3333	-22.412	-20.434	3.447	-0.0675	-0.054
		R&D	mio_pps	0.0166	0.0515	-0.1	6.843	-	-	-	-
		Share Industry	%	-0.002	-0.0061	-	-0.473	-0.388	-0.436	-	-0.007
		Energy Production	ktoe	-	-0.012	-0.1781	-11.1977	-12.641	10.049	0.0341	-
	Industry Policy Variables	In03		-	-	-	-	-	-	-0.0602	-
		In06							-8.294		-
		In08		-0.0124	-0.0135	-	-	-	-	-	-
		In09		-	-0.0094	-	-	-	-	-	-0.026
		In10		-	-	-	-	-7.3016	-4.693	-	-
	Household Policy Variables	Hh04		-0.02	-	-	-	-	-	-0.0431	-
		Hh06		-0.011	-	-	-	-	-	-	-
		Hh07		-0.010	-	-	-	-	-	-	-
		Hh11		-	-	-	-	-	-	-0.0304	-
		Hh12		-	-	-	-	-	-	-0.0194	-
	Transport Policy Variables	Tr11		-	-	-	-12.59	-	-	-	-
	Tertiary Policy Variables	Te05		-	-	-	-3.29	-	-	-	-
		Te06		-	-	-	-9.126	-	-	-	-
		Te07		-0.012	-	-	-	-	-	-	-
		Te08		-	-	-0.041	-3.878	-	-	-	-
		Te09		-	-	-	-	-	-	-0.0175	-
	Cross-Cutting Policy Variables	Cc01		-0.0056	-	-	-	-	-	-	-
		Cc02		-	-	-0.0421	-	-	-	-	-
		Cc05		-	-	-0.0754	-	-	-	-	-
		Cc06		-0.007	-	-	-	-	-	-	-0.034
		Cc07		-0.009	-0.0145	-	-5.379	-6.453	-	-0.0196	-0.03
R^2				0.72	0.45	0.64	0.71	0.67	0.44	0.67	0.54

Panel analysis: results (5/8)

Sectors in which P&Ms are implemented	EFFECTIVE P&Ms
CROSS-CUTTING POLICIES	General cross cutting policies EE, promotion of renewables or climate change mitigation Marked based instruments
RESIDENTIAL POLICIES	Mandatory standards for electrical appliances Grants / subsidies Loans / Other
INDUSTRY POLICIES	Information, education and training
TERTIARY POLICIES	Tax exemptions / reduction Soft loans, grants / subsidies and information initiatives
TRANSPORT POLICIES	Cross cutting policies with sector specific characteristics

Legend: **ES only** **EI & ES** **EI only**

Panel analysis: results (6/8)

Sectors in which P&Ms are implemented	EFFECTIVE P&Ms
CROSS-CUTTING POLICIES	General cross cutting policies
RESIDENTIAL POLICIES	Mandatory standards for electrical appliances Cooperative measures Cross cutting policies with sector specific characteristics Loans / Other
INDUSTRY POLICIES	Legislative and informative measures
TERTIARY POLICIES	Cooperative measures Soft loans, grants / subsidies and information initiatives
TRANSPORT POLICIES	Cross cutting policies with sector specific characteristics

Legend: **ES only** **ES & CI** **CI only**

Panel analysis: results (7/8)

In terms of aggregate **energy intensity**, **energy security** (or **both**) the effective measures are:

general cross cutting policies and those about energy efficiency, promotion of renewables or climate change mitigation, (particularly if using marked based instruments)

in the residential sector, mandatory standards for electrical appliances, the deployment of grants, subsidies or loans

measures supporting information, education and training in the industrial sector

tax exemptions, soft loans, grants and information initiatives in the tertiary sector

cross cutting policies with sector specific characteristics in the transport sector.

Panel analysis: results (8/8)

In terms of aggregate carbon intensity, energy security (or both) the effective measures are:

general cross cutting policies

in the residential sector, mandatory standards for electrical appliances, cooperative measures, cross cutting policies with sector specific characteristics, loans

measures supporting information and legislative measures in the industrial sector

cooperative measures, soft loans, grants and information initiatives in the tertiary sector

cross cutting policies with sector specific characteristics in the transport sector.

Panel analysis: discussion (1/2)

Reasonably good fit of the econometric models, (R-square ranging from 0.3 to 0.76); on average lower for sectoral regressions than for those focusing on the overall economy.

A number of policies have a beneficial influence across EU countries on specific policy target indicators. There is however very little overlapping among policies in terms of their effectiveness on both energy efficiency indicators and energy security indicators, bar general cross cutting policies.

Between energy intensity and carbon intensity the overlaps are more widespread, and also some sector specific policies improve the performance of both indicators. This is hardly surprising, given the high correlation between the two indicators, and holds in particular for the household sector, but also cooperative measures in the industry sector affect both carbon and energy intensity at the aggregate level.

Panel analysis: discussion (2/2)

Energy efficiency policies aimed at the residential, tertiary and agricultural sector have very little effectiveness in improving energy security.

For the transport sector, while there are quite a number of cross cutting policies and of policies aimed at the transport sector that improve energy efficiency, energy intensity and carbon efficiency, only cross cutting policies have a significant impact on oil security.

While energy efficiency can be significantly improved in the transport sector by well-designed policies, the sector is still too tightly bound to oil products for any of these policy to result in significant change in its oil security.

Conclusions (1/2)

Quite a number of policies had a beneficial impacts on energy efficiency and carbon efficiency, measured respectively as energy intensity and carbon intensity, at the aggregate level. However only one category of these policies (general cross-cutting policies), have proven also useful to improve the performance of aggregate energy security indicators.

Restricting our focus to the industry sector, sectoral energy efficiency and carbon efficiency have been improved significantly by a number of policies. However, none of these policies had an impact strong enough to improve also energy security.

Also restricting our analysis to the residential sector, the tertiary sector and the agricultural sector, or the transport sector does not lead to sharper or more encouraging conclusions in terms of co-benefits on energy security of energy efficiency policies.

Energy efficiency policies aimed at the specific sub-sectors sector have very little effectiveness in improving energy security.

Conclusions (2/2)

Main conclusion: no silver bullet. Energy efficiency policies in the EU do work, but none can successfully address different policy objectives, unless it is so general that naturally encompasses different sectors and modes of energy use. Thus only broadly defined cross cutting policies seem to have this double effect.

The other seemingly surprising lesson is that there are policies, designed to improve energy efficiency, that are more effective in terms of improving energy security than in terms of their original goal. This may have to do with our choice of energy security indicators: we may have focused on the consumption of fuels that are more sensitive to certain policies, but may have not enough weight to improve the efficiency of the overall or sectoral energy mix.

What seem to work is the policy mix rather this or that policy in insulation: the good news then are that currently in Western Europe a policy menu is in place that has produced significant improvements in energy efficiency, has reduced the amount of carbon emissions generated by the economic system, and has contributed to a more secure energy supply for Europe. But, it can be improved.

Further research directions:

- more countries (too few data for NMCs panel analysis),
- continuous, instead of binary, policy variables and the role of the intensity of energy policy.

Thanks for your attention!

andrea.bigano@feem.it

www.feem.it