

ENERGY INDICATORS FOR SUSTAINABLE DEVELOPMENT

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Indicators for Sustainable Development

- The 1992 Earth Summit recognized the important role that indicators can play in helping countries to make informed decisions concerning sustainable development (Vera & Langlois, 2007).
- Since human activities are closely linked to energy use, the energy system is a good candidate for providing a small, manageable list of interlinked indicators, able to track sustainability (Kemmler & Spreng, 2007).

Energy Indicators

- The list of energy indicators in use is inexhaustible, e.g. (IAEA, UNDESA, IEA, EUROSTAT and EEA, 2005; EEA, 2006; DTI, 2006).
- However, these sets are:
 - complex
 - difficult to interpret and
 - unable to provide a concise general overview of system behavior.
- Therefore, they are not useful for decision-making purposes, because without any aggregation, such sets do not provide a measure of progress (Hardi & Barg, 1997).

Proposed Set of Indicators (1/2)

- The proposed set is formulated in such a way as to :
 - Satisfy the following criteria (Patlitzianas et al, 2008):
 - Appropriateness (Transparency, Simplicity, Ability of comparison)
 - Completeness (Technical and scientific adequacy, International Acknowledgment)
 - Flexibility (Easy calculation, availability of reliable data, Ability of mapping changes)
 - Reflect all aspects of sustainable development (economic, environmental, social)
 - Express the objectives of both EU and Greek energy policy

Proposed Set of Indicators (2/2)

Abbr.	Name	Description
Social Indicators		
SOC1	Accessibility	Share of households with access to electricity or commercial energy
SOC2	Affordability	Share of household income spent on fuel and electricity
SOC3	Disparities	Share of household expenditure on energy for each income group
Economic Indicators		
ECN1	Overall Use	Final and residential energy consumption per capita
ECN2	Energy Intensity	Total primary energy supply per unit of GDP
ECN3	Security	Energy imports per total amount of primary energy supply
Environmental Indicators		
ENV1	Climate Change	GHG emissions per capita or per unit of GDP
ENV2	RES in FEC	Share of RES in final energy consumption
ENV3	RES in Electricity	Share of RES in electricity generation

Case Study: Greece

Application of the proposed set of indicators to the Greek Energy System for the period 1960-2007

Milestones

- Greece
 - 1967-1974: Dictatorship
 - 1974-Today: Restoration of Democracy
 - 1981: Entry in the European Economic Community
 - 1997: Assignment of the Olympic Games
 - 2001: Acceptance in the Eurozone
 - 2004: Host of the Olympic Games
- The rest of the World
 - 1973 & 1979: Oil Crisis
 - 1986: Chernobyl Accident

GDP & Population

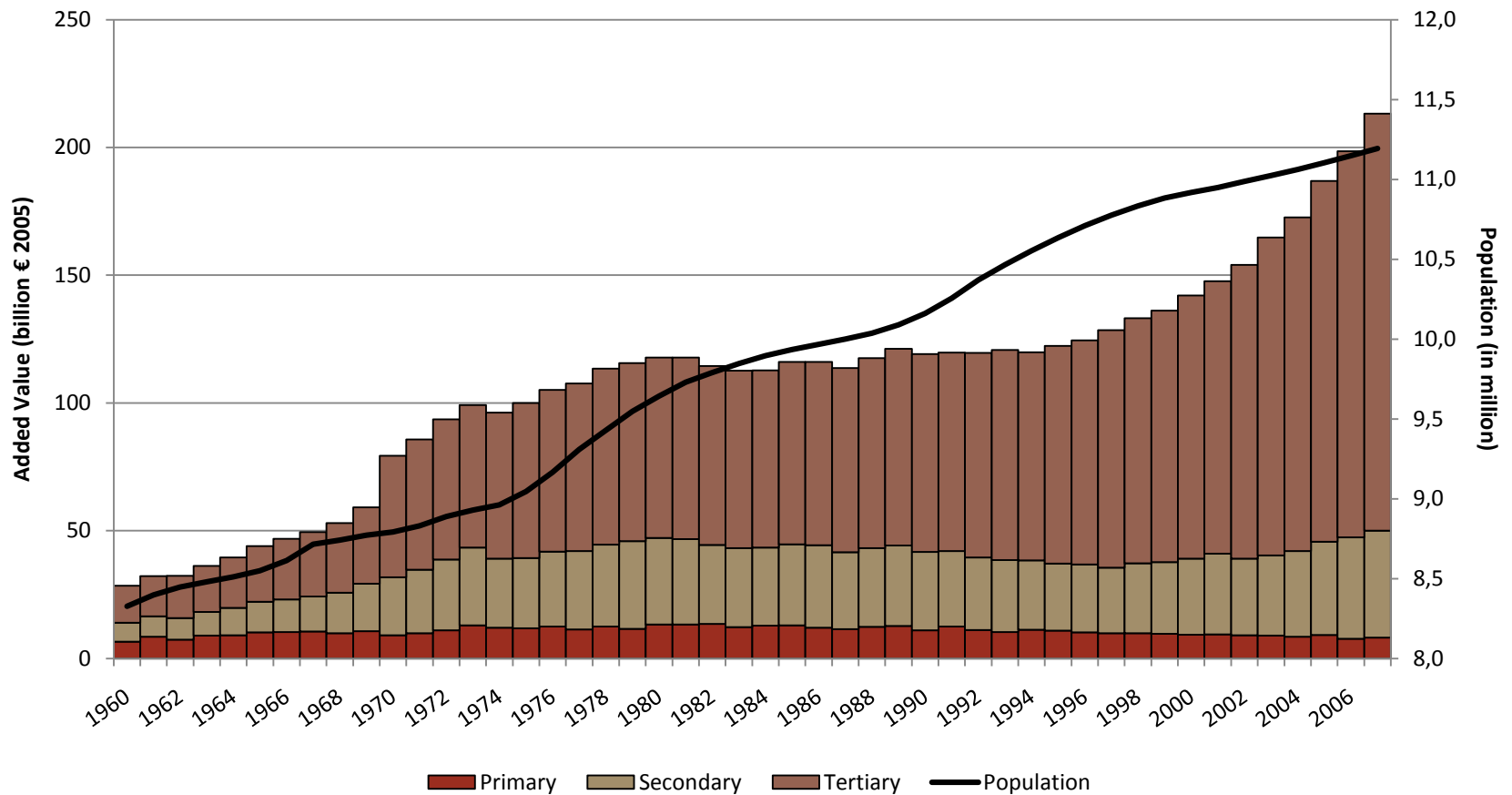
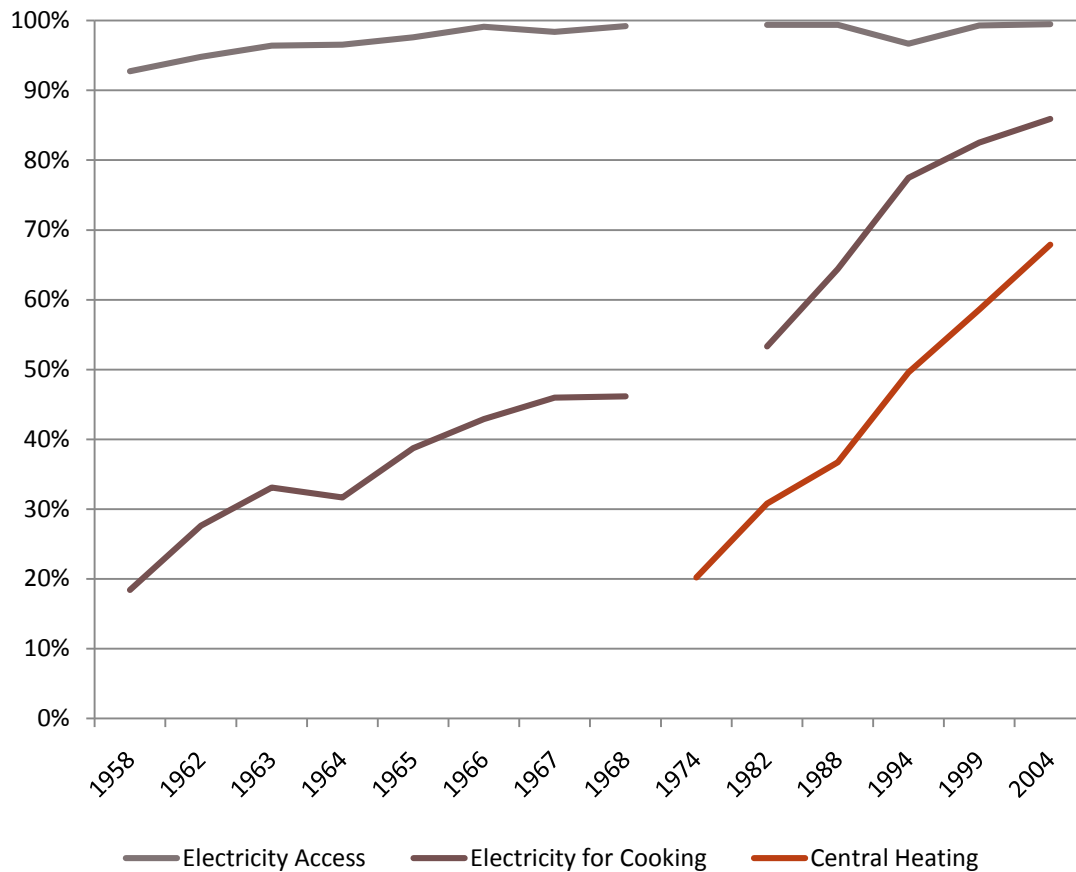


Figure 1. Population and Gross Domestic Product (GDP) of Greece

Energy Policies

- From 1973-1995:
 - ▣ Policies aiming to minimize energy imports dependency
 - ▣ Turn to indigenous lignite
- From the mid-1990s:
 - ▣ Emphasis on environmental protection (Kyoto Protocol)
 - ▣ Introduction of natural gas
- During the current decade:
 - ▣ Further emphasis on environmental protection, RES penetration and energy efficiency improvements (EU Directives)

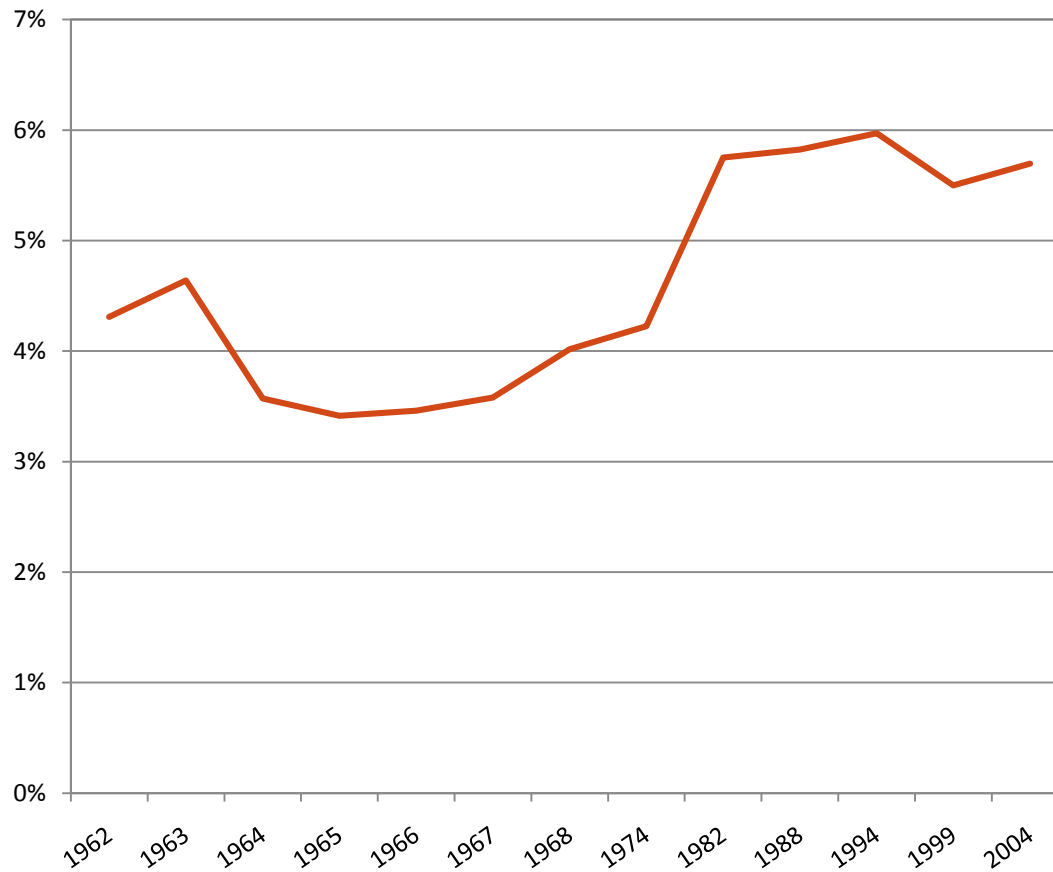
SOC1. Accessibility



- 1950: Foundation of the Public Power Corporation
- Gradual and quick electrification of the whole country
- Continuous improvement of energy services during the period under study

Figure 2. Share of households with access to electricity or commercial energy

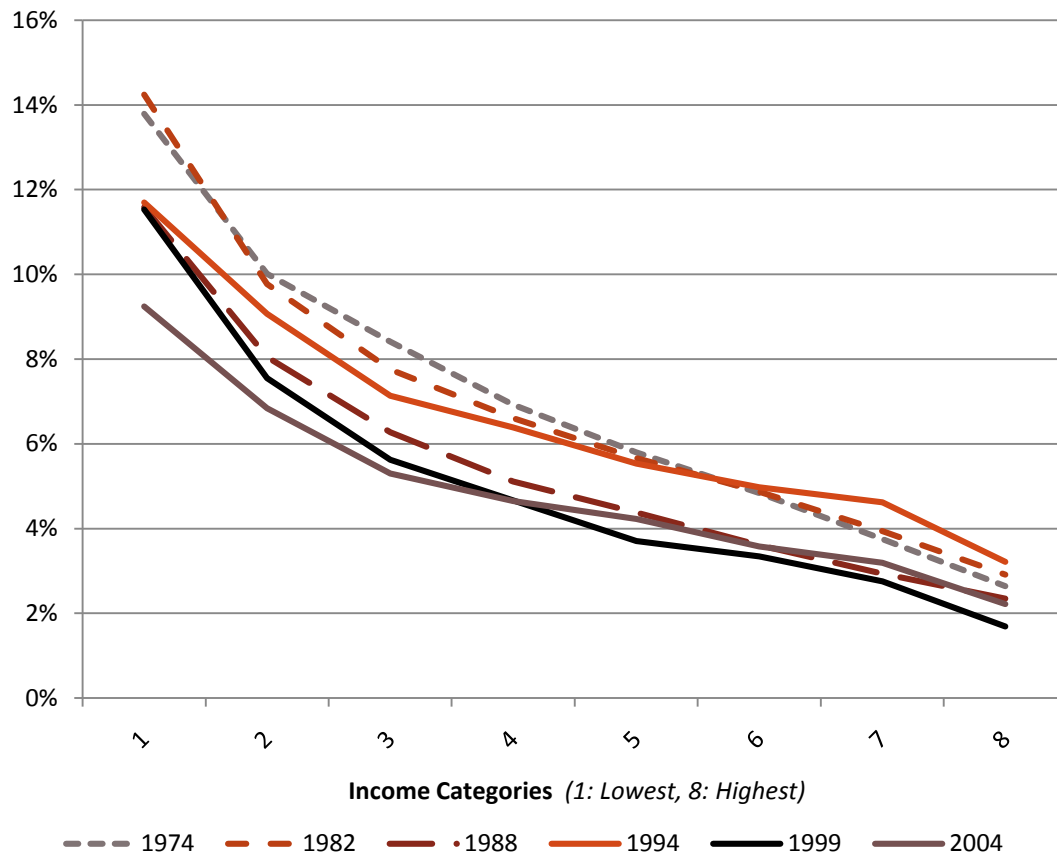
SOC2. Affordability



- The ratio has slightly increased in the last 30 years
- Fuel prices are increasing at a higher rate than income

Figure 3. Share of household income spent on fuel and electricity

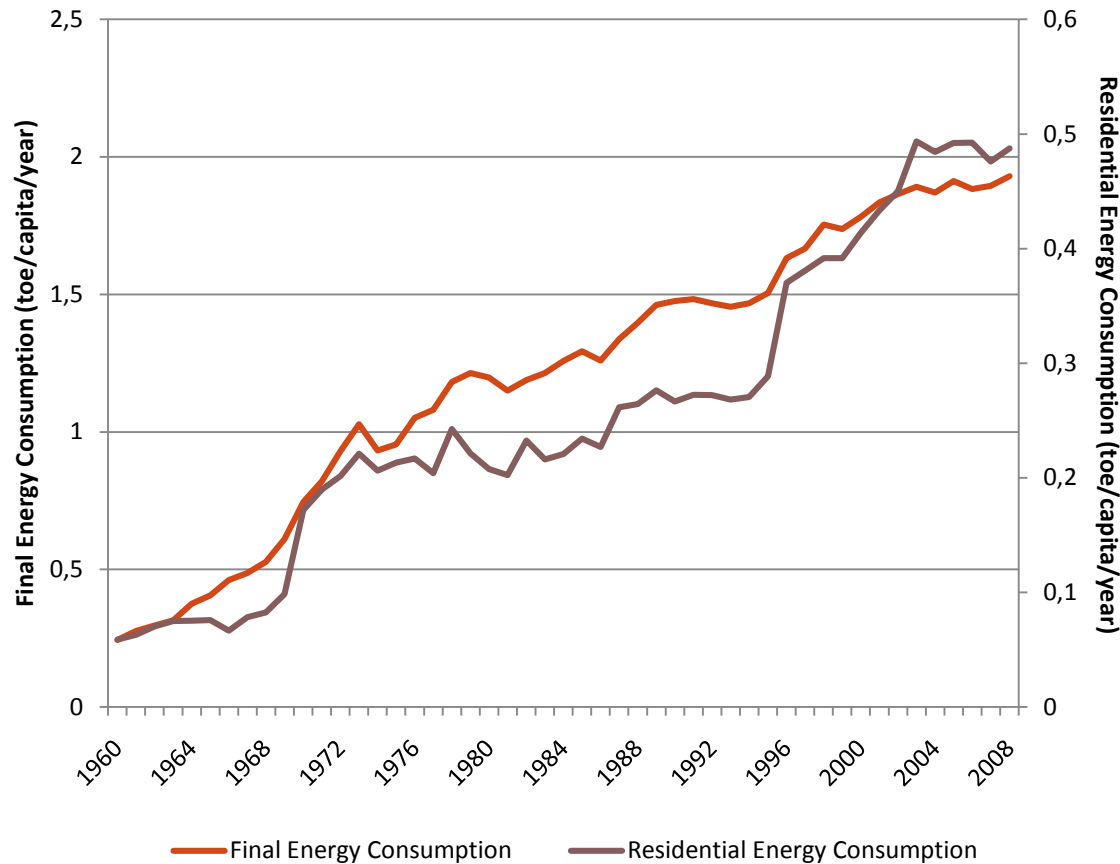
SOC3. Disparities



- The share of household expenditure on energy has decreased for all 8 income categories
- The gap between high and low income families has slightly narrowed over time

Figure 4. Share of household expenditure on energy for 8 different income groups

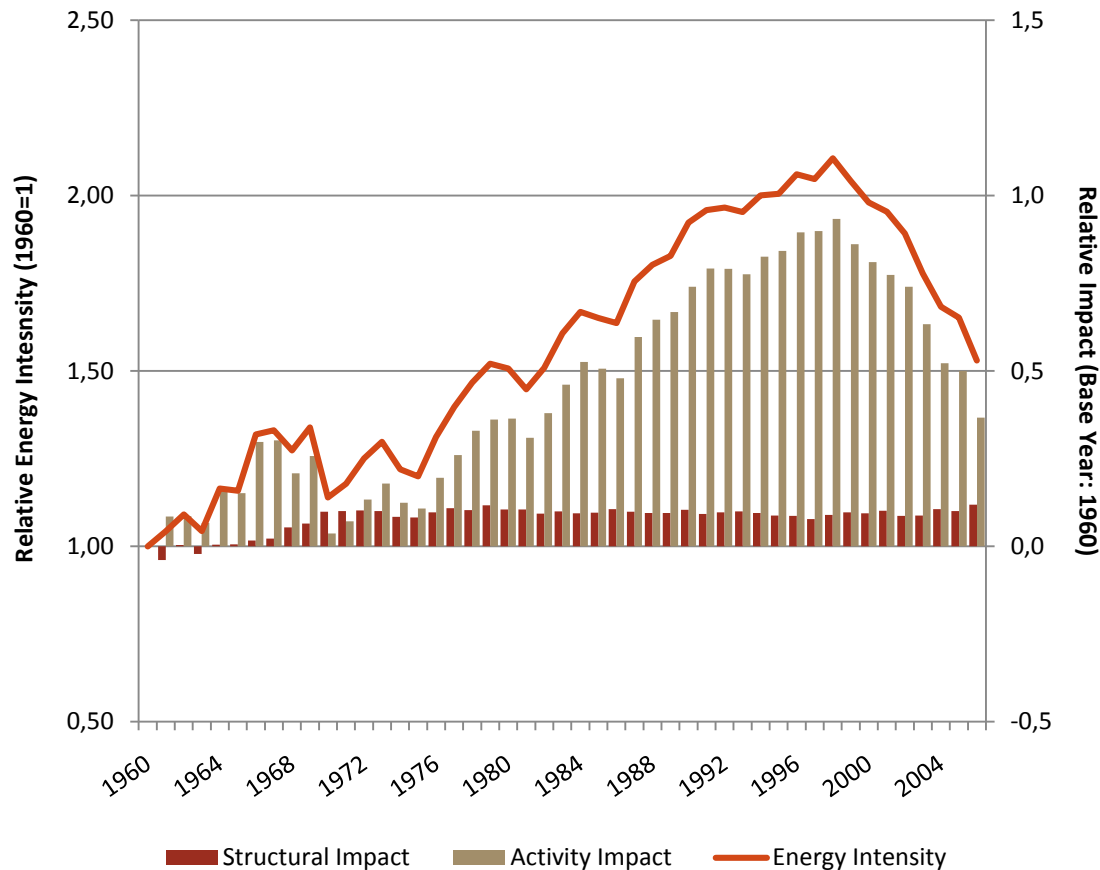
ECN1. Overall Use



- Higher energy consumption:
 - During dictatorship
 - After the assignment of the Olympics
 - Different reasons in each period
- Steady energy consumption per capita during the rest of the period

Figure 5. Final and residential energy consumption per capita

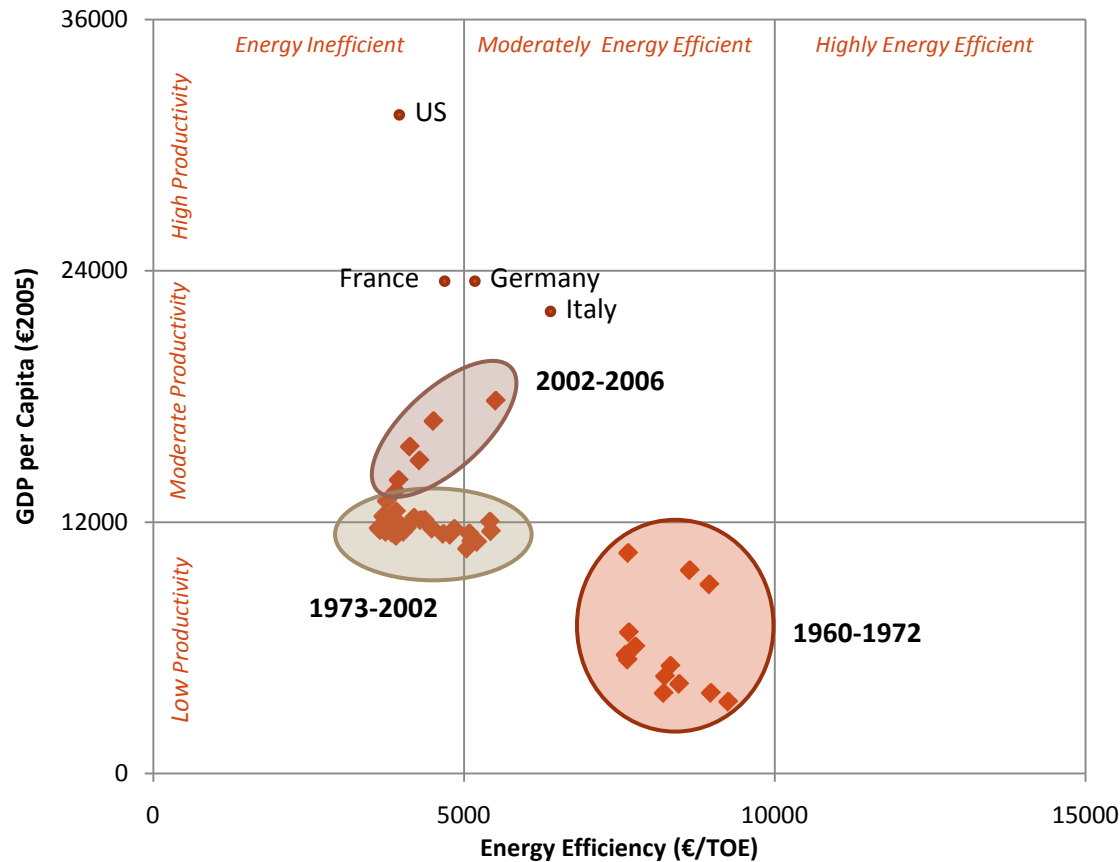
ECN2. Energy Intensity



- Decomposition of the energy intensity
- Structural Impact: Refers to the changes in the structure of the economy or the contributions of the main economic sectors
- Activity Impact: Refers to the overall growth of the economy

Figure 6. Total primary energy supply per unit of GDP (Primary Energy Intensity)

ECN2. Energy Intensity



- Increasing productivity but decreasing efficiency
- Lignite has caused the decrease in efficiency

Figure 7. GDP per Capita vs. Energy Efficiency

ECN3. Security

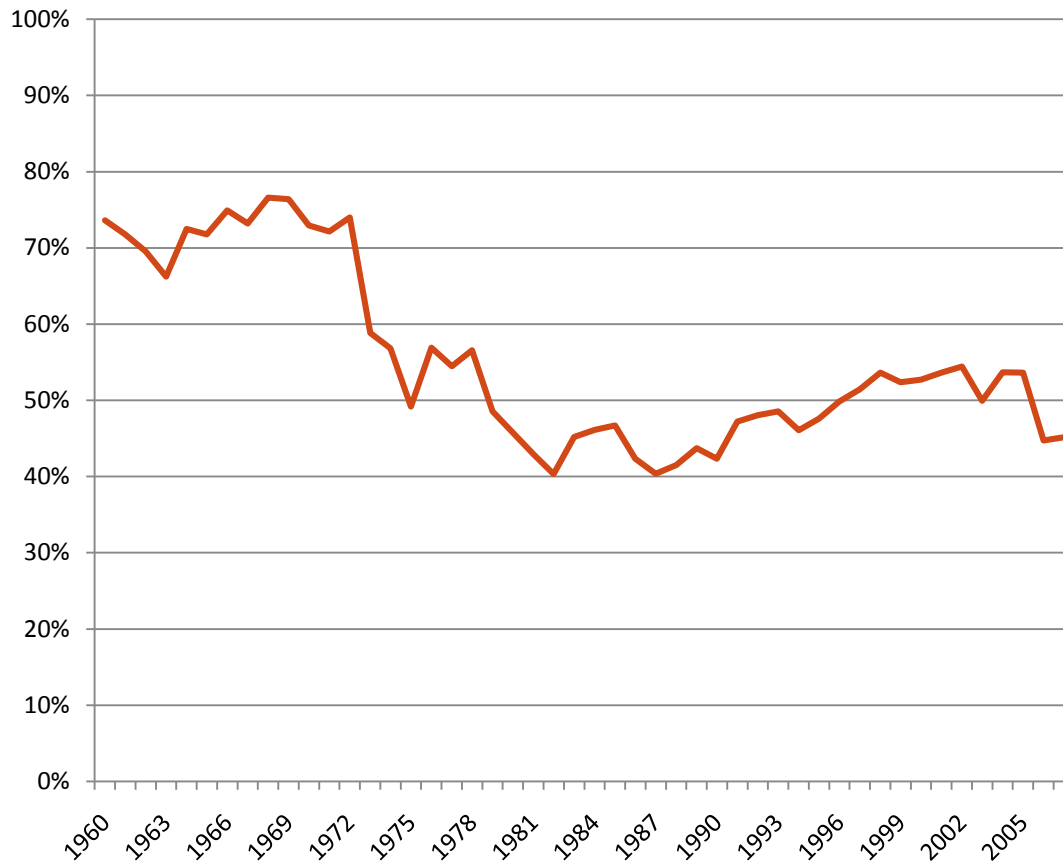
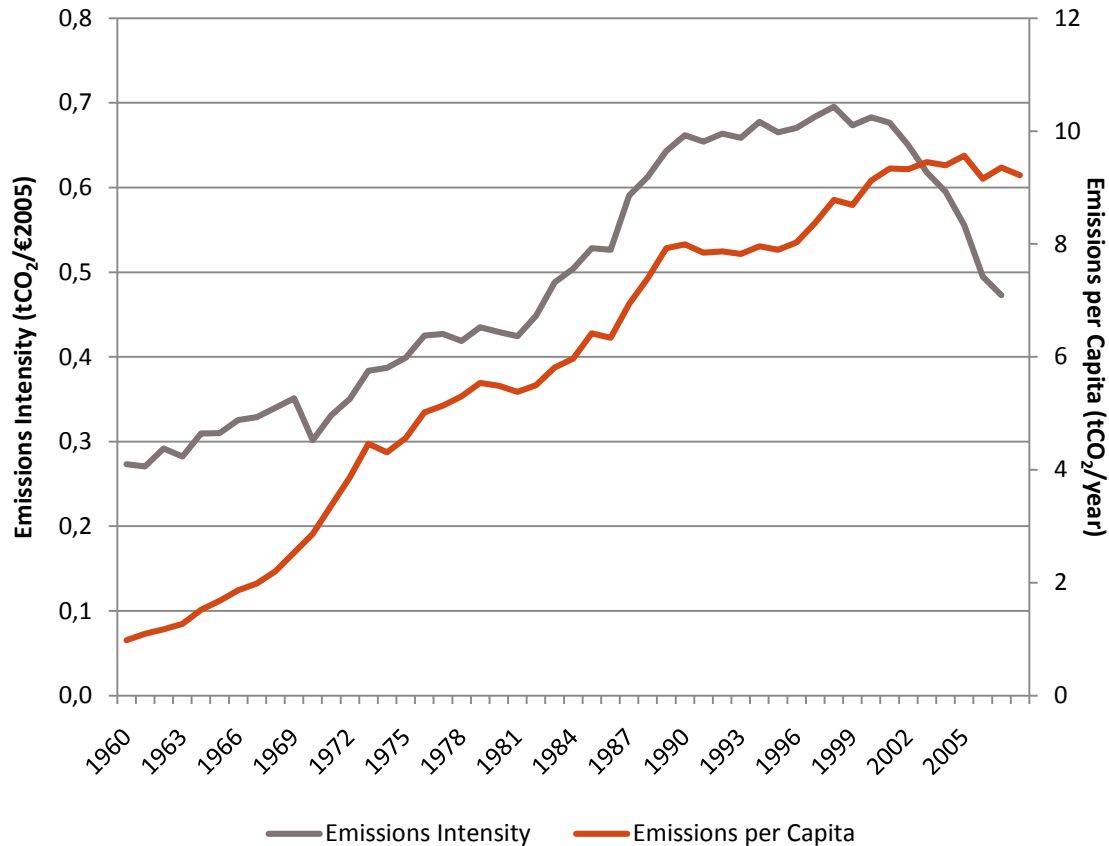


Figure 8. Energy imports per total amount of primary energy supply

- High energy dependency during the first years of the period due to imported fossil fuels
- Decrease because of the policies aiming to minimize dependence on imports (1973-1979)
- Increase over the last years due to the substitution of indigenous lignite by natural gas

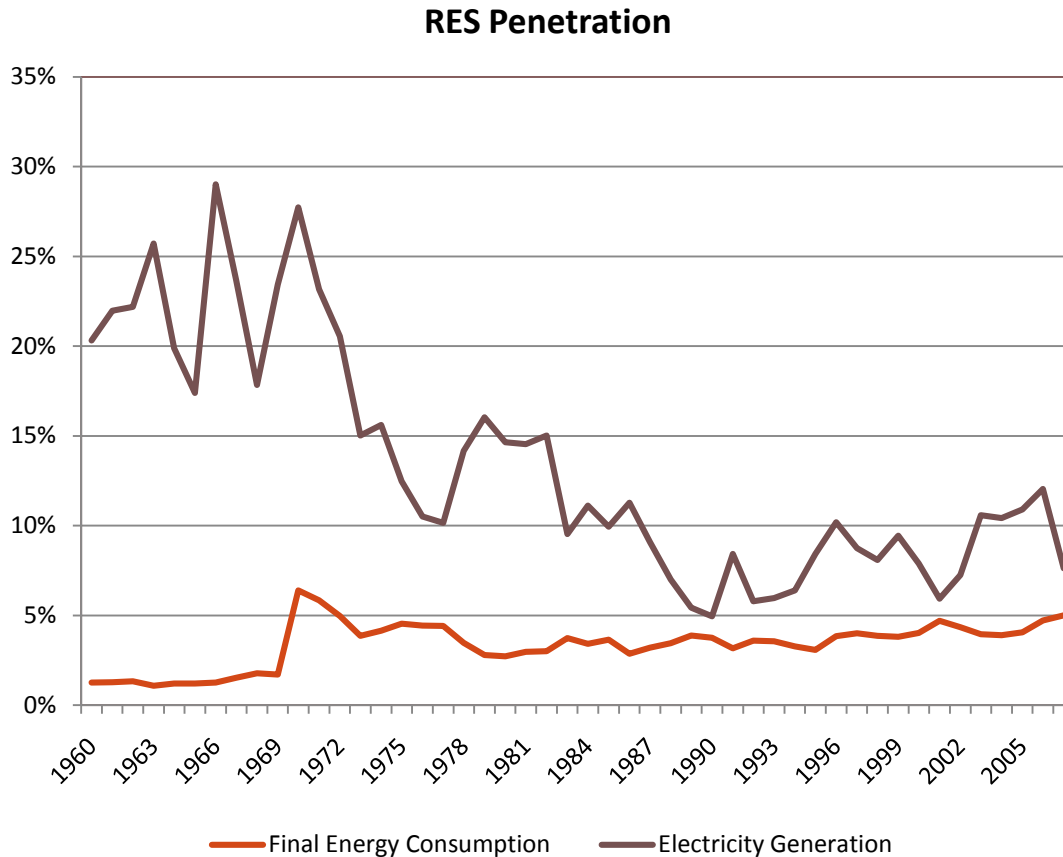
ENV1. Climate Change



- Increasing emissions until 1990
- Stabilization from 1990 onwards
- The decrease in emissions intensity is due to the increase of GDP rather than in emissions' reduction

Figure 9. GHG emissions per capita and per unit of GDP (Emissions Intensity)

ENV2&3. RES Penetration



- Targets for 2020:
 - ▣ 20% FEC
 - ▣ 40% Electricity
- Fluctuations in electricity generation are due to varying ratio of the available hydroelectric capacity used for this purpose
- The spike of 1969 is not real and is due to the lack of data for biomass consumption in the previous years

Figure 10. Share of RES in final energy consumption and in electricity generation

Conclusions

- Regarding environmental dimension, positive trends are observed in all indices. However, there is a lot to be done in order to achieve the objectives set by the EU.
- Regarding social dimension, accessibility has substantially improved, disparities between low and high income households have narrowed but the prices are increasing with a higher rate than the income.
- Energy intensity is declining but due to the GDP growth rather than energy efficiency improvements. Energy security is worsening because of the increase of natural gas share against indigenous lignite.

Proposed Energy Policies

- Further penetration of RES and substitution of indigenous lignite with imported fossil fuels (i.e. natural gas) will:
 - ▣ Improve environmental sustainability and help achieve environmental targets
 - ▣ Improve the productivity of the energy system
 - ▣ Not influence energy security, if the Natural Gas-RES ratio is balanced and is followed by energy saving measures
- Social sustainability is difficult to predict especially during the current economic crisis

Further Research

- Construction of an overall index expressing the progress towards sustainable development.
- Incorporate it in an existing energy planning software, to evaluate energy policies

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Thank you for you attention!

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