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THE ECONOMIC OPPORTUNITY OF ENERGY EFFICIENCY

AN OVERVIEW OF THE LEGAL AND REGULATORY FRAMEWORK, PROGRAMS AND ENERGY SERVICES EVALUATION IN EUROPE AND IN PORTUGAL AND OF THE POSSIBLE IMPLEMENTATION OF THE PRESENT PROPOSAL ON THE ENERGY SERVICES DIRECTIVE

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Abstract

The economic development requires a bigger access to energy sources, which amplifies energy demand. In Portugal, the increase energy demand allied to an economic development and scarce endogenous energy sources allows us to conclude that this will be a critical issue in a near future.

While effective market forces and good information can accelerate energy efficiency improvements, market failures and barriers can inhibit efficiency gains. In such cases, certain government interventions may be useful in focusing market interest on energy efficiency. These include codes, standards, voluntary agreements, special financing arrangements and clustering small projects into investment portfolios. Although much attention has been given to the potential strategic role of renewable energy, increased end-use efficiency offers comparable if not greater near-term potential. Furthermore, it also generally less expensive per unit of energy saved than is an incremental unit of new energy supply (whether it is renewable or fossil-based). Thus, increased end-use efficiency investment is consistent with sound business practices.

The implementation of the IEM and IGM was the way found to reduce efficiency barriers in the supply side but the demand side remained forgotten. However, full economic and environmental efficiency can only be achieved by including the demand-side into the competition and developing an Internal Market for energy services and programmes. The analysis of the energy policy, a strategy and economics of DSM activities is one of the actual subjects in the sector and that interest to all actors at the market.

In this report we analyse the evolution and the consumption energy trends in some European countries, establishing when possible the link with Portugal. We also describe "driving forces" of the energy consumption in the Europe and identify the legal and regulatory frame of this problem. Furthermore, we also identify policies that have improved the management of the consumption (to the level of offers as of the search) and finally we establish an economical impact estimation for the production and household consumption the Energy Services Directive proposal of December 2003.

The results will confirm our expectation regarding the Portuguese energy consumption trend. We will conclude that, although difficult to implement due to structural and organisational reasons, the implementation of an energy efficiency strategy should be done and that EDP can obtain profit in its incitation.

Le développement économique exige un plus grand accès aux sources d'énergie, qui détermine la demande d'énergie. Au Portugal, cette demande en conjugaison au développement économique et à de sources d'énergie endogènes rares nous permet de conclure qu'il sera une problématique critique dans un future proche.

Si le marché (par lui-même) allié à l'amélioration des flux d'information introduit une augmentation de l'efficacité énergétique, les barrières de ce même marché peuvent empêcher le profit attendu. Dans ces cas, certaines interventions du gouvernement peuvent être utiles dans l'intérêt d'appeler l'attention du marché sur l'efficacité énergétique. Ces interventions incluent des codes, des normes, des accords volontaires, coordination spéciales d'investissement. On donne aujourd'hui beaucoup d'importance au potentiel stratégique des énergies renouvelables mais l'efficacité dans l'utilisation finale donne un potentiel d'épargne, sinon plus grand, certainement comparable. En autre, on considère qu'une unité d'énergie épargnée est moins chère que la même unité produite (soit-elle de sources renouvelables ou fossiles). Ainsi, l'augmentation de l'investissement dans l'efficacité énergétique de l'utilisation finale est conforme les "best practices" dans la gestion.

La création des marchés internes de l'électricité de du gaz fut le moyen trouvé par la Union européenne pour réduire les barrières d'efficacité dans la coté de l'offre mais dans la coté de la demande ils demeurent presque oublies. Cependant, on peut seulement attendre l'efficacité économique et environnementale en incluant la chaîne énergétique de valeur. Cet a dire, aussi la coté de la demande doive être incluse dans la concurrence et en développant un marché pour les services et les programmes d'énergie. L'analyse de la politique, la stratégie et la gestion économique des activités DSM c'est une des sujets actuels dans le secteur énergétique qu'intérêt a tous les acteurs dans le marché.

Dans ce rapport on analyse l'évolution et les tendances énergétiques de consommation dans quelques pays européens, en liaison le plus possible avec le Portugal. On présente aussi les plus important variables dans cette consommation en Europe et on identifie le cadre légal et régulateur de ce problème. En outre, on identifie aussi les politiques qu'ont amélioré la gestion de la demande et finalement n établie une estimative de l'impact économique des coûts de production évités dans la

production d'électricité et pour le secteur résidentiel, selon la proposition de Directive des Services Energétiques.

On peut conclure que les résultats obtenus confirmeront notre prévision sur la tendance portugaise de la consommation d'énergie et aussi que malgré d'exécution difficile, à cause de raisons structurels et organisationnelles. Une stratégie d'efficacité énergétique doit être développée et que EDP peut obtenir des profits avec sa promotion.

O desenvolvimento económico requer um maior acesso às fontes de energia o que implica um aumento na procura de energia. Em Portugal, este aumento aliado ao desenvolvimento económico e à escassez de recursos endógenos permite-nos concluir que será um tema critico num futuro próximo.

Embora o mercado (por si só) aliado à melhoria da informação introduza um aumento de eficiência energética, as barreiras inerentes ao mercado poderão inibir esses mesmos ganhos. Nesses casos, determinadas intervenções do governo podem ser úteis focalizando o mercado na eficiência energética. Estas intervenções incluem códigos, normas, acordos voluntários, coordenações especiais do financiamento aglomerando-se em *portfolios* de investimento. Embora muita atenção seja dada ao potencial estratégico das energias renováveis, a eficiência energética na utilização final oferece um potencial de poupança senão maior, certamente comparável. Adicionalmente, considera-se que é menos dispendiosa uma unidade de energia poupada do que uma unidade de energia produzida (quer seja de fontes renováveis ou fósseis). Assim, o aumento do investimento na eficiência da utilização final de energia é consistente com as melhores práticas de negócio.

A criação de um Mercado Interno de Electricidade e de um Mercado Interno de Gás foi a maneira encontrada pela UE para reduzir as barreiras de eficiência no lado da oferta enquanto do lado da procura continuou relativamente "esquecido". Contudo, a eficiência económica e ambiental poderá ser alcançada incluindo toda a cadeia energética de valor, ou seja, também o lado da procura na competição e adicionalmente desenvolvendo um mercado interno para serviços e programas de energia. A análise da política, de uma estratégia e da economia de actividades de gestão da procura é uma das problemáticas actuais no sector interessando a todos os actores presentes no mercado.

Neste relatório analisamos a evolução e as tendências de energia do consumo em alguns países europeus, estabelecendo quando possível a ligação com Portugal. Descrevemos também as forças impulsionadoras do consumo de energia na Europa, identificando o quadro legal e regulador deste problema. Além disso, identificamos também as políticas que melhoraram a gestão da procura e finalmente estabelecemos uma estimativa do impacto económico em termos de custos evitados para a produção de electricidade e para o sector residencial partindo da proposta de Directiva dos Serviços Energéticos de Dezembro de 2003.

Os resultados confirmarão a nossa expectativa a respeito da tendência portuguesa do consumo de energia. Concluiremos também que, embora difícil efectuar devido às razões estruturais e organizacionais, a execução de uma estratégia da eficiência de energia deve ser feita e que a EDP pode obter o lucro com a sua incitação.

Table of contents

List of figures and tables

Acronyms, definitions and units

Abbreviation	Description	Definition
ADENE	Agência para a Energia	Portuguese Energy Agency
ANIMEE	Associação Portuguesa das Empresas do Sector Eléctrico e Electrónico	Portuguese Electric and Electronic Equipment Association
BaU	Business-as-Usual	
CAE	Contratos de aquisição de energia	Contract for the acquisition of energy
CAGR	Compound Annual Growth Rate	Yearly growth rate over a specified period that can be calculated by taking the nth root of the total percentual growth rate where n is the number of years of the period considered. $CAGR = \left(\frac{End\_value}{Begin\_value}\right)^{\left(\frac{1}{number\_years}\right)} - 1$
CFL	Compact Fluorescent Light	
CHP	Combined Heat Power	
Commission	European Commission	
DGGE	Direcção Geral de Geologia e Energia	Directorate-General of Geology and Energy
DG TREN	Direcção Geral de Energia e Transportes da Comissão Europeia	
E4	Energy Efficiency and Endogenous Energies Programme	Through the promotion of energy efficiency and the use of endogenous energy sources, the programme seeks to upgrade the competitiveness of the Portuguese economy and to modernise the country's social fabric, while simultaneously preserving the standards of living of future generations by reducing gas emissions, especially the CO2 responsible for climatic change.
EFTA	European Free Trade Association	
Energy Efficiency Programme		It is a specific activity undertaken by energy companies and other actors and targeted to energy end-users. These programmes are not directly paid by customers or by the market agents that directly benefit from it, but financed through financial schemes.
ENR	Energia(s) Renovável(eis)	Renewable Energy (ies)
EPC	Energy Performance Contracting	Contract made between an ESCO and a consumer where a certain performance is guaranteed and the payment depends on the actual performance achieved (measured in terms of energy cost reduction).
ERSE	Entidade Reguladora dos Serviços Energéticos	Portuguese Energy Regulator
ESCO	Energy Service Company	It is a company offering energy efficiency services but not selling energy that is not produced on site.
EU	European Union	

Abbreviation	Description	Definition
FEI	Final energy intensity	
GDP	Gross Domestic Product	
HVAC	Heating, Ventilation, Air-Conditioning	
IEA	International Energy Agency	
IEM	Internal Electricity Market	
IGM	Internal Gas Market	
IIASA	International Institute for Applied Systems Analysis	
INE	Instituto Nacional de Estatística	National Statistics Institute
IRP	Integrated Resource Planning	It is a plan in which there is a socio-economic balance between the activities of the supply side regarding energy production and distribution and the investments made by the supply side and the consumers aiming energy efficiency. The demand side measures can be information, campaigns and other types of assistance - concerning energy conservation activities about energy efficiency and concerning private electricity production.[1]
MURE	Mesures d'Utilisation Rational d'Énergie	
Least-cost Planning		Approach to planning that considers demand management solutions as well as strategies to increase capacity; considers all significant impacts (costs and benefits), including non-market impacts (i.e., the so-called externalities.
OCDE	Organisation de Coopération et Développement Economique	
PEI	Primary energy intensity	
POE	Plano Operacional de Economia	Economic Strategic Plan
PPP	Purchasing Power Parity	Theory that states that exchange rates between currencies are in equilibrium when their purchasing power is the same in each of the two countries.
PRE	Produtores em Regime Especial	Special Producers. Comprises small-hydro up to 10MVA, ENR and CHP producers)
RCCTE	Regulations on the Characteristics of the Thermal Performance of Buildings	
RGCE	The Regulation for Energy Management	
RNT	Rede Nacional de Transporte	National Electric Energy Transmission Network
RSECE	Regulation on HVAC Systems in Buildings	
SEI	Sistema Eléctrico Independente	Independent Electric System
SEP	Sistema Eléctrico Público	Public Service Electric System

[1] Report *the road towards an energy-efficient future* (2003).

Abbreviation	Description	Definition
SENV	Sistema Eléctrico Não Vinculado	Non-binding electric system
SME	Small and Medium Enterprises	
tce	Tonne of coal equivalent	
TFC	Total Final Consumption	Equals the sum of consumption of energy by the different end-use sectors.
toe	Tonne of oil equivalent	
TPES	Total Primary Energy Supply TPES = Indigenous production + Imports + Stock changes - Exports - Bunkers	Total amount of primary energy consumed from all sources in a given year. Primary energy includes losses.
UN	United Nations	
WB	World Bank	

Unit	Conversion
1 Barrel	158 Litres
1 toe	7,13 barrel = 10^7 kcal= 41,86GJ = 11.6MWh
1W	1 J/s
1MWh	3,6 x 10^9 J = 0,22 toe
1GWh	1000MWh = 3,6 x 10^{12} J
1toe	2/3 toe
k€	Thousands of Euros (10^3€)
M€	Millions of Euros (10^6€)
B€	Billions of Euros (10^9€)
GJ	10^9 Joules = 1000MJ (10^6J)
Mtoe	Mega toe (10^6toe)

1. Introduction

Every day millions of people make decisions that determine how energy is used (e.g. commuting to work, producing goods, rendering services, heating houses). Economic development requires an increased access to energy. The increase in the life standards of the populations implies an increase in the level of comfort required; additionally, we live today in a society more and more dependent on electric and electronic equipments.

Context

Energy use causes more than half of the greenhouse-gas (GHG) emissions to which global climate change is associated with. There are two broad (and complementary) means of reducing the energy-related emissions of GHG. The first one is to develop renewable zero-emission energy sources, but this will continue to instigate energy consumption. The second one is to reduce the demand for energy among end-users. Although much attention has been given to the potential strategic role of renewable energy, increased end-use efficiency offers comparable, if not greater, short-term potential. Furthermore, end-use efficiency measures are generally less expensive per unit of energy saved than an incremental unit of new energy supply is (whether it is renewable or fossil-based). Thus, increased end-use efficiency investments are consistent with sound business practices.

The energy efficiency and the Demand Side Management (DSM) Programmes have a fundamental role in the increase of the reliability of the electrical system and in the reduction of costs of demand peaks during periods of high of prices. Nowadays, it is recognized that it is very expensive to keep great capacities of production to sustain small variations in the demand in order to balance energy supply and demand.

The subject of energy efficiency came up with the oil crisis of the 70's, during which governments understood that a complete dependency on oil to render energy needs would make them exposed to dangerous risks. Energy efficiency policies were set up to reduce oil consumption in order to minimize this problem, as well as to reduce the environmental impacts linked to its use. Consequently, the volume of primary energy needed to produce a Gross Domestic Product (GDP) unit was significantly lowered. During the counter-shock period, when the oil prices decreased, the energy policies softened but the environmental policies had spread, giving a strong impulse to this trend.

The great energy consuming industries of the Organization du Commerce et Développement Economique (OCDE) countries were the ones that more quickly eliminated energy waste, with the dislocation of some plants to other regions and the investment in new technologies. In parallel, governments have launched programmes regarding energy economy through taxes, subventions and the adjustment of regulations (e.g. for buildings) (Martin-Amouroux Jean Marie, 2003).

The energy crisis in the 70's brought energy issues to the centre of the economic policy. In 1973, the Member States based 60% of their energy consumption in oil products. In 2000, this share had fallen to 40% (Source: IEA). Nevertheless, the perspective in a Business-as-Usual (BaU) scenario is to see EU's oil dependency increase up to 70% in 2020 (European Commission, 2001). Therefore, the European Union (EU) has set up an objective of ensuring an energy provision to mitigate risks associated with oil dependency, through the increase of competition and the liberalisation of the energy sector.

Problem statement

The reduction of the power intensity is a high-priority objective for any economy (regarding that it does not affect the volume of activity and the quality of the service). All the effects derived from a policy of reduction of the power intensity are positive:

- The productive processes have to be more efficient, with consequent advantages in terms of competitiveness;
- The polluting emissions are reduced, with obvious environmental advantages;
- The power invoice is reduced, which implies an improvement in the balance of payments.

In this sense, it is necessary and opportune to define this Energy Efficiency Policy for three fundamental reasons:

- The high dependency on imported energy (demonstrated by the fact that in Portugal 89% of the primary energy that uses is imported, while in EU the average is around 50%). In addition, this dependency affects not only economic and commercial sectors, but has also significant environmental effects since it is mainly based on fossil products;
- During the last years, the Portuguese economy has grown at a higher Compound annual Growth Rate (CAGR) than the European average, which has allowed for a significant improvement in real convergence. However, this evolution has been followed by an important growth of the power demand, with a CAGR even higher than the economy's in some years;
- The implementation of the Energy Efficiency Policy will promote a significant reduction of emissions of atmospheric polluting agents, in line with international guidelines.

The implementation of the Directives 96/92/EC and 98/30/EC regarding the creation of the Internal electricity market (IEM) and the internal gas market (IGM) represented a great restructure of the electricity and gas markets of the Member States through the unbundling and competition. This was the way found to reduce efficiency barriers on the supply side, but the demand side remained forgotten. However, full economic and environmental efficiency can only be achieved by including the demand-side into the picture and by developing an internal market for energy services and programmes.

Economic development requires a wider access to energy sources. In addition, the increase of urbanisation and industrialization promotes a worldwide increase in energy demand. Populations demand higher comfort levels that can keep up with their improved lifestyles, which leads to an increase in energy demand.

In Portugal, the increased energy demand, together with economic development and scarce endogenous energy sources, allow us to conclude that this will be a critical issue in a near future.

While effective market forces and good information can accelerate energy efficiency improvements, market failures and barriers can inhibit efficiency gains. In such cases, certain government interventions may be useful in orienting the market to energy efficiency, such as regulation, codes, standards, voluntary agreements, special financing arrangements and clustering small projects into investment portfolios.

We consider that the analysis of the politics and strategy of the Demand Side Management (DSM) is one of the main issues in the sector with interest to all actors in the market:

- To the Government, to which it is interesting to reduce the country's energy invoice and to improve the energy intensity ratio (consumption for each generated unit of GDP);
- To the Regulator, since this type of initiatives improves the satisfaction of the consumer, who pays for the energy that he actually needs and uses, therefore minimizing waste;
- To the operator, that at the first sight would be the least interested but it might gain with the shifting of its core business from selling kWh to selling an energy service.

We can summarize the objectives of this report in six points:

- Describe the "driving forces" of energy consumption in Europe;
- Register the evolution and the trends of energy consumption in some OCDE countries;
- Identify the legal and regulatory context of this problem;
- Discuss the impacts of these trends, taking into account the European politics of energy and the possible future energy context;
- Identify politics that have improved the management of the consumption (at both the demand and the supply level);
- Assess the impact of a 1% reduction in Portuguese household energy consumption for the period of 2004 - 2009.

These six points will help us understand the relative savings potential in Portugal by comparing it to other European countries. We will see that the initial stage of each country (regarding economical, cultural and technological factors) deeply influences the results, which consequently leads to an unusual disparity in the savings potential.

However, we have found a lot of willingness to promote a true energy efficiency policy and to control it; we will see that the trend is to observe (even in Northern countries, usually more energy efficiency proactive) a reduction in implementation of these programmes mainly due to the new liberalised energy context. This context stimulates investment and efficiency in production. In addition, so far the European energy strategy adopted legislation promoting efficiency in the supply side of the chain, leaving the demand side in the “shadow”.

The recent proposal of a Directive on Energy Services may change this trend but it will mean another “revolution” in the energy sector. Utilities will have to prepare themselves to change their business form selling kWh to selling energy services and Governments and Regulators may have to adapt themselves to this new reality.

In a growing consumption market like the Portuguese, with improvable energy efficiency awareness, EDP may face a change in its business. This might be an opportunity to EDP set up a new business model as part of its strategy improve its relationship with the customer.

EDP is a Portuguese company in charge of the production and distribution of energy. It was founded in 1976 as the result of the process of nationalization of several regional companies. It lived as a monopoly until the 90’s, when the privatisation and liberalization process in Portugal started with the creation of the Iberian Electricity Market (MIBEL). The unbundling process obliged EDP to change from a vertically integrated company into a group composed of several companies, each one operating in a specific step of the energy chain in Portugal and in Spain. Nowadays, EDP is the 3rd Iberian operator, with 5.8 M clients, €6900 M of revenues and ~7900 MW of installed capacity, and the only Group in this region with production and distribution in both countries (figures of 2003). EDP it is also present in South America (mainly Brazil) and in Africa and Macau. The recent acquisition of Hidrocantabrico (HC) will help EDP to strongly position itself in the Iberian market and to gain a dual position in electricity and gas.

Nowadays, EDP represents ~97% of the electricity commercialised in Portugal and has a solid customer relationship. However in order to face market changes this relationship may have to be strengthen which may imply, in a near future, the increase of energy efficiency in demand side or other DSM activity.

Structure, methodology and limits

We organized this work in one introduction, eight chapters and final perspectives.

In Chapter 2, we begin by defining briefly energy intensity and energy efficiency, analysing their limits. Afterwards (in chapter 3), we present what we consider as the key energy consumption drivers. In chapter 4, we benchmark the energy consumption evolution in some selected countries of the EU. In order to guarantee the report’s consistency, we have used statistical data of IEA and EU. Chapter 5 talks about the legal framework that defines the energy efficiency policy context in Europe and in Portugal. Subsequently, we analyse the possible barriers to energy efficiency in general and in the Portuguese case in particular (chapter 6). Chapter 7 presents the energy policy in Europe and in Portugal regarding energy efficiency. In Chapter 8, we present the energy efficiency mechanisms and services in Europe including some of the best practices. Finally, we present the impacts of a possible implementation of the Energy Services Directive in the household sector in Portugal (Chapter 9).

Although we begin by presenting all the energy consumption sectors in different countries, we will only detail those sectors that are more important to EDP: industry and household/services. We would also like to say that the group of countries was chosen for precise reasons specified further in chapter 4. We have divided the countries according to their areas of influence: North and South. The first group includes Finland, France and Germany. In the southern group, we have selected Portugal, Greece, Italy and Spain.

We will see some interesting similarities in some of these countries, namely France, Germany and Greece, Portugal and Spain. While Finland shows an uncharacteristic behaviour in the northern group, Italy shows this same behaviour in the southern group. Sometimes Italy has a behaviour of a northern country and sometimes it doesn’t.

Nevertheless, there are also other countries that may help us to understand the Portuguese energy context and the European one (e.g. the Netherlands, Sweden or the UK). This was felt also concerning energy efficiency programmes and services.

At the beginning of this report we were aware of the difficult job we would face to link the Portuguese energy consumption evolution to other countries’ and to evaluate the impacts of energy efficiency programmes and services in this short deadline. This problem became even clearer as we realised the true complexity of the issue, the subjectivity in measuring the results and the scarce research available about Portugal. Other aspect was to access recent data used in the cross-country analysis. Some of the available reports are dated from 1998 (e.g. Energy Policies of IEA Countries – Greece 1998 Review) which makes rather difficult to evaluate the real evolution so far. In order to maintain the homogeneity of the data we have chosen to keep the same data source but knowing that this would represent a source of error.

In chapter 9 we have faced some limitations concerning the availability of data, which forced us to make assumptions about several variables. In some cases these assumptions may not interfere with the real result but in other cases the may. We are aware that these simplifications led us to increase the margin error but without these, our calculation would have been very difficult. In this chapter there are some data considered to be confidential and therefore should be kept to the jury members only.

2. Economic and Energy Indicators

The complexity and diversity of energy end-uses makes the definition of indicators a very important subject.

The objective of this chapter is to present macro economic indicators of development and consumption and introduce the concept of energy intensity, energy efficiency and sustainability. These are considered by the economists as a set of very reliable indicators to evaluate the energy policy of a plant, household, region or country. For each one, we will see that even if these indicators are of great importance, they are possible sources of errors and they may even lead to the misunderstanding of reality.

2.1. Gross Domestic Product, Energy Consumption

There are two indicators that we can consider as the best referenced in the energy efficiency field: one regarding economic development (Gross Domestic Product) and another one regarding Final Consumption of Energy.

Both present advantages and limits in their use that may cause some problems when comparing values between two regions or countries, two types of fuel, etc. We will start by defining them and subsequently defining their limits of use.

2.1.1. Gross Domestic Product

GDP stands for Gross Domestic Product and is of great importance to evaluate the economic performance of a region or a country. Nowadays, it is considered as one of the fundamental indicators to evaluate the growth, evolution structure and capacity of the economy.

GDP can be defined as the total value of goods and services produced in a country (or region) during a certain period of time (normally a trimester or year), that is, the total of what it is produced with the resources used in the economy, valuing each final good or service by the market price. GDP is an indicator of a society of the economic well being mainly when this is analysed in its per capita variable. However, GDP is not a perfect indicator, i.e., many factors that influence a society well being cannot be verified or measured through this indicator. For its calculation, we take only in account the production inside the country's geographic borders. It does not matter if national or foreign companies made this production. The internal product can be express in terms of "gross" but also in terms of "net" value. If we take in account the depreciation through time of the machinery (or another type of asset), we are considering the "net" product. When we do not take into account the depreciation we are considering the "gross" product.

The GDP's calculation can be carried out by two distinct ways:

- The demand side method: the calculation becomes fulfilled through the economy's sum of all the consumption:

  Expenditure – Investment + Exports - Consumption of imported products

- The value added method: the GDP is calculated summing up the benefit generated by all goods and services in the different sectors of the economy or branches of the economic activity. In this case, it can be useful to calculate the GDP per activity (agriculture, communications, transport, construction, etc.).

One of GDP's limits referenced by economists is that the commercial flows that stimulate the specialization of the different economies in function of its respective competitive advantages are not necessarily balanced and can result in a deficit or exceeding commercial balances.

Another problem lies in the calculation method. For example, currently in Portugal it is considered that about 20% of the commercial flow is made through informal (or underground) economy and therefore impossible to trace and take into account.

GDP includes only the final goods value (the value of the intermediate goods is already enclosed in the final goods price). Consequently, we will have a problem of double counting if we add final with intermediate goods.

The value of the GDP is normally showed in US dollars but it has to be adjusted by the purchasing power parity (PPP) of each country or region.

Purchasing power parities are obtained as the averages of the price ratios between the different countries for a basket of goods and services representing the whole of a well-defined classification. They can be used to convert the values of the countries' economic aggregates expressed in national currency into a common currency.

The PPP, which are calculated for all the uses of the GDP, reflect the ratios between price levels in the different countries; they indicate the amount of a national currency required to buy in each country the same basket of goods and services, which are included in the uses of the GDP.

Therefore, when prices are converted with the PPP method using the GDP parity the following conclusion is possible: if 1GJ of energy costs 10 PPP in country A and 5 PPP in country B, this means that after eliminating the differences between the general level of prices in the two countries, this gigajoule of energy is twice as expensive in country A than in country B.

While using PPP exchange rates for comparison is an improvement over using actual exchange rates, it is still imperfect, and comparisons using the PPP method can still be misleading. Comparing standards of living using the PPP method implicitly assumes that the real value placed on goods is the same in different countries. In reality, what is considered a luxury in one culture could be considered a necessity in other country and the PPP method does not account for this. Additionally, the PPP method could also have difficulty accounting for differences in quality between goods in one country and equivalent goods in another.

Summarizing, we understand this indicator's importance as a form to express the economy's development but we also recognize its limitations.

2.1.2. Energy Consumption

The calculation of energy consumption is not simple and the problems happen when accounting the non-commercial consumption (like biomass) and the end-use consumption (specially understanding a household breakdown structure).

The term "energy consumption" is somewhat confusing because:

- It may be given by the addition of primary energies including biomass, fuels, hydroelectric-power energy, other renewable energies and nuclear power;
- Alternatively, may it be understood by the sum of the final energy demand by uses: electricity, transport, stationary use, not energetic use.

Consumption calculation limits lie on the difficulty of harmonization of the energy measure. Different criteria are used for such measure. For example, IEA considers for the TPES calculation the income of the hydroelectricity power, solar and wind power energy as 100% while it considers the income of the geothermal of 10%. But the standard followed by others is that the income of primary energy of the hydroelectric power and other ENR is similar to thermal power plants, i.e., ~40%[2].

According to J.M.Bourdaire (2000), Energy consumption is a quantitative concept when stated in kWh, Joules or toe or a qualitative concept when expressed in association with the well-being.

2.2. Energy Efficiency

Energy efficiency is an interesting and useful method to analyse energy use. In a qualitative perspective, it may be considered as an "extravaganza" concept related to the way energy is used to render services or products. In a technical perspective, an increase of energy efficiency occurs when the energy input decreases for a given level of service or the level of service increases for a given input.

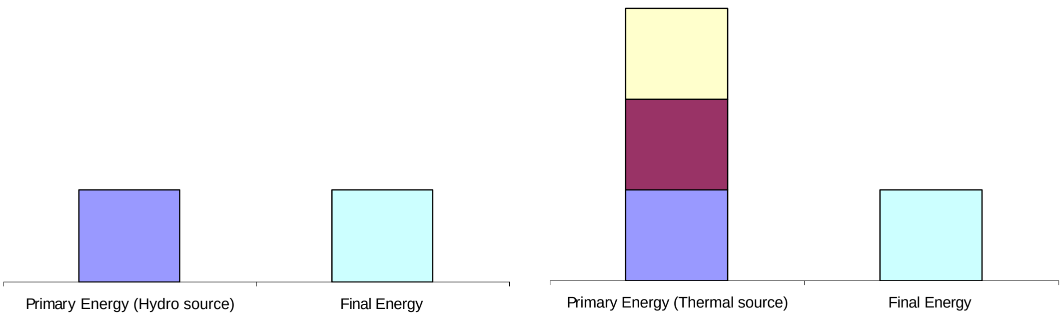
The evaluation of energy efficiency can be made by two indicators: *the primary energy efficiency* and the *final energy efficiency*:

[2] So using the first model a country as Brazil for example, is much more efficient due to strong ratio of the hydroelectric power in its economy, when reality it is not.

- The primary energy efficiency is the result of the ratio between primary energy consumption and the GDP and is useful when evaluating the economy as a whole, considering the transformation as well as the use of energy;
- The final energy efficiency is given by the ratio between the final energy consumption and the GDP and is used if our objective is to restrict the analysis to the use of energy.

As we will, see the gap between these two indicators is increasing and this is due to the results of the increased amount of energy produced from thermal sources with productivity ratios of around 0.35 (so we need ~3 units of primary energy to produce 1 unit of final energy) while energy produced from hydroelectric sources has a ratio of ~1 (Figure 3.1).

Figure 2.1: Primary energy and final energy efficiency



Source: the author

The definition of energy efficiency can be presented in different ways. When, for example, one installs house isolation, we can say that from the point of view of engineering this is more energy efficient. For the same service supplied, one spends less heating. In the same way, in industry we can say that the reduction of energy expended in production of the one unit represents an energy economy and therefore an increase of energy efficiency.

It happens that, as referred by IEA, these microeconomic increases of energy efficiency may not be viewed at a macroeconomic level due to a structural effect[3] of the increase in the number of appliances. We can also observe energy efficiency in how we organize ourselves as a society through indicators like waste recycling ratio, how we commute to work, how we live, etc.

There is also another variable equally important but also very difficult to measure: the consumer behaviour. The consumer is a unique entity with unique needs. Only each one of us knows how to evaluate our comfort level and the quantity of energy needed to obtain it. Due to financial problems one might have to reduce his energy consumption, which should not be consider as energy efficiency because the service rendered is not the same.

In summary, energy efficiency has a wider meaning than what is normally understood because it is related to a technological, behavioural and economical change.

The energy efficiency limits come from its dependents weakness of calculation (economic development and energy consumption indicators) and it has a strong political component. This indicator was “created” to aim our energy economy to a given objective. In other words, why should we want to measure energy efficiency? European economies are upset about productivity, preservation of the environment, waste management, etc. Therefore, the indicators are changed depending on the policy objective. For example, if a policy aims to control greenhouse effect, the indicator will be CO2 emissions. When a policy aims to control productivity, the indicator will be energy consumption per GDP unit, and so on...

[3] The structural effect, according to Villa (2000), depends on the structural variation of the added value of the companies and the variation of the average willingness of households to consumption.

Although it is difficult to relate energy, efficiency only to a measure of intensity this is perhaps the best form of reaching a good value. As we said previously, it is important to perceive what it is "behind" the data to better evaluate our results.

2.3. Energy Intensity

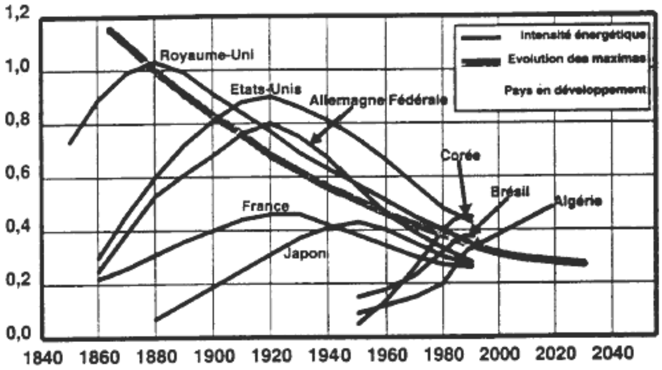
Economists believe that the best long-term energy efficiency indicator for an economy is the energy intensity ratio evolution through time. Since energy needs to be assessed relatively to the amount of product or service provided, energy-use rates, commonly called energy intensities, are the measures ordinarily used to assess efficiency trends. Energy intensities reflect not only energy efficiency but also changes in other effects such as weather and extent of occupancy. However, the advantage in considering individual energy intensities is that we may easily measure and track them over time.

Energy intensity can be defined by the ratio between energy consumption and an activity economic variable. If we relate, for example, energy consumption with population we will have energy intensity per capita.

Regarding its limits, one should use energy intensity carefully because the values obtained might not correspond to the reality. Even being a "blind" indicator in the sense that it doesn't take in consideration the production context of a certain region or country, one of the advantages of energy intensity is the fact of distinguishing countries for which the production structure and techniques are relatively homogenous and stable during time.

During the 19th and 20th centuries, we can observe the energy intensity evolution in the first industrialized economies (UK, USA, West Germany, France, Japan) as well as in other economies (Brazil, Korea, Algeria) (Figure 2.2).

Figure 2.2: Energy Intensity curve



Source: Jean-Marie Martin (1988)

The analysis of this figure leads us to conclude that the evolution trend of the economies is bell-shaped. Increases up to a maximum, stabilizes in a platform and then decreases.

A "tunnelling effect" can be observed between the different industrialized economies. The maximum reached by a country will not be reached by the following country and so on. Therefore, countries that had a later industrial start have a lower intensity slope (this is also related with the type of industry of specialization in each country).

Advanced industrialized societies use more energy per unit of economic output and far more energy per capita than poorer societies. Energy use per unit of output does seem to decline over time in the more advanced stages of industrialization, which reflects the technological advances for energy production as well as changes in the composition of economic activity (shift from industry to services societies). Nevertheless Toman (2003) states that even with trends towards greater energy efficiency and other dampening factors like technological effects, total energy use and energy use per capita continue to grow in advanced industrialized countries, and even more rapid growth can be expected as their income increases.

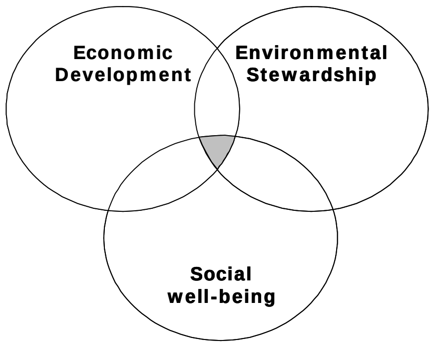
2.4. Sustainability

In 1987, the World Commission on Environment and Development developed a definition of sustainability that was included in its findings, which became known as the Brundtland Report. This stated that sustainable development could be defined by meeting the needs of the present without compromising the ability of future generations to meet their own needs.

Sustainability is getting more and more important to companies as their social responsibility increases. However, it is very difficult to achieve a sustainable development in a global market in which our competitors may be placed in a country where there is a different point-of-view about sustainable development.

Looking at scheme of energy indicators for sustainable development, we will find in grey the area where sustainability is achieved (Figure 2.3). It is a combination of these three perspectives that allows us to reach sustainability. As we see, sustainability requires an integrated view of the world; it requires multidimensional indicators that show the links among a community's economy, environment and society. For example, the Gross Domestic Product (GDP) is generally reported as a measure of the country's economic well-being: the more money being spent, the higher the GDP and the better the overall economic well-being as supposed to be. However, GDP reflects only the economic activity, regardless of its effect on the community's social and environmental health.

Figure 2.3: Sustainability area



Source: the author

The key objectives of energy sustainability are to ensure supply of energy at competitive prices, to reduce adverse impacts of energy use to acceptable levels, and to encourage consumers to meet their needs with less energy input through improved energy efficiency. The correspondent indicators concern the depletion of fossil fuel reserves, the capacity of nuclear and renewable energy sources, energy usage by sector, and fuel prices. Regarding the environment, the key objective of sustainable development is to limit emissions of greenhouse gases, which may contribute to global warming and climate change. Indicators of relevance are global temperature change and emissions of greenhouse gases.

The limits of these indicators are mainly three. First, the difficulty in finding a consensual definition of sustainable development. Since 1987, economists and scientist struggle to find the most appropriate definition. This uncertainty leads to different points-of-view in different countries. Secondly, the difficulty of finding a worldwide set of indicators accepted by all countries. If we consider the CO2 emissions per GDP unit, Portugal is one of the top European emitters. However, if we consider the CO2 emissions per capita, this value is much lower (as we will see in 4.5.2). Thirdly, the global economy that (as we said) act as and incentive to companies to delocalise to countries where the value of public good is less considered and therefore sustainability has not the three-dimensional aspect as shown in Figure 2.3.

2.5. Wrap up

There is no magical indicator that resumes all the society’s economical, social and environmental well-being. The indicators and concepts presented in this chapter give us a version of the reality but it is up to each one of us to analyse the results and understand where they comply or not, which are the limits of each indicator and their simplifications. These economic and energy indicators were presented in this chapter because the will be used across this paper[4]. Therefore, without a complete comprehension of their implications, using them will misunderstand and reveal untruths.

In the next chapter we will see which are, in our opinion the most important drivers in energy consumption.

[4] Although we could also introduce in this chapter the concept of energy productivity, we preferred to include it in chapter 4.5 integrated in a banchmark analysis.

3. Energy consumption drivers

Before presenting the benchmark analysis of the energy consumption in Portugal and in some other OCDE countries, it is important to understand which are the consumption key drivers and their evolution along time.

Energy consumption does not grow without a justification. It may be considered as a function of demographic evolution, economic evolution, energy price trend and weather.

We will now discuss each one of these drivers presenting their definitions, trends and limits.

3.1. Demographic evolution

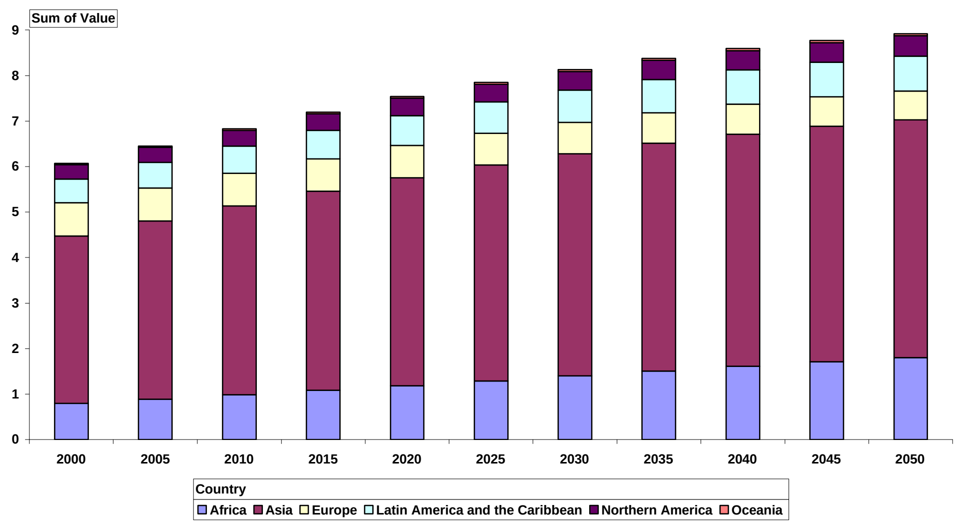
People depend on energy to meet their personal or professional needs. With the increase of quality of life people tend to consume more energy, as we will see further on. This allied to an increasing demographic trend will pressure natural resources, making the access to energy sources more difficult and/or more expensive.

Demographic evolution is important in the estimation of the power consumption, by several reasons. On one hand, for the calculation of the active population and the possibilities of economic growth, as well as by its impact in the public finances. On the other hand, it is necessary for the evaluation of the houses and the rates of familiar equipments and automobiles. The demographic trends indicate that a significant growth of the population it is taking place in the last years, fundamentally, to the migratory phenomenon.

Even with the birth rate decreasing, world population is increasing at a high pace and a slow down is not expected.

As we can see from the next figure, Asia will be the responsible for the demographic growth in the next 50 years, which is already causing disturbs in energy markets. The Africa population will grow more slowly than the Asian mainly due to a lack of living conditions linked with geo-political convulsions, Europe and North America tend to stabilize and even diminish in number of inhabitants.

Figure 3.1: Population regional distribution (billions)

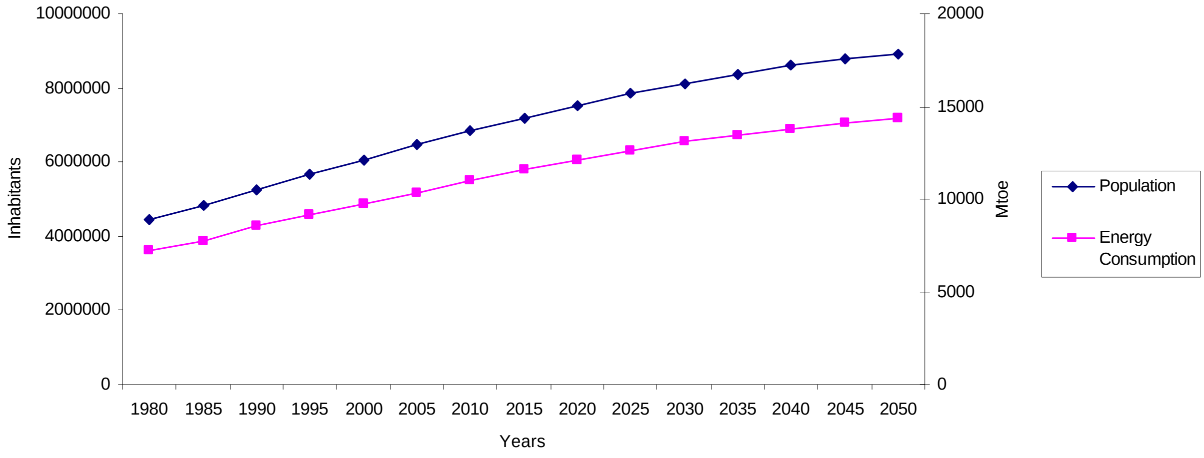


Source: adapted from UN World Population Prospects 1998

This trend of a growing population will continue (at a slower and slower rate) until 2050. This creates a great pressure on the available resources and its potential scarcity will most certainly affect our consumption habits. The fertility rate for women shows a downward trend followed by an increasing energy consumption per capita (Goldemberg and Johansson, 1995). It looks like per capita energy use also reflects many other factors such as emancipation of women, standard of living, education, etc.

If the per capita energy consumption remained similar to 1995 values (all the other variables remaining constant), the total annual energy consumption would be of ~12Gtoe in 2020 and ~14Gtoe in 2050.

Figure 3.2: World population evolution vs. energy consumption evolution (thousand of inhabitants)



Source: the author

Also important is the rural/urban balance. Currently there are five cities with more than 15 million inhabitants[5] (UN 2001). One esteems that in 20 years there will be 11, almost all of them located in developing countries (exception are Tokyo and New York). Consequently, the populations of these cities will loose access to a primary energy source (e.g. biomass) and start to depend on secondary energy sources to satisfy their needs in the cities. This trend increases the pressure on fossil energy sources, more adapted to supply power, which will be delivered on urban agglomerations.

In the developed countries, we may also observe a decrease on primary energy sources due mainly to the spread of the energy infrastructures (e.g. electricity or gas replacing wood) and the increase of the comfort needs pushing the consumption to higher levels.

3.2. Economic evolution

The economic evolution (together with demographics) is a key driver in energy consumption.

At international level, the forecasts point towards a continuation of the intensification process of worldwide commerce and economic globalization. In western countries, the economic growth remains influenced by the demographic changes derived from immigration from less developed countries, although at the same time, more intensive energy productions move towards third countries.

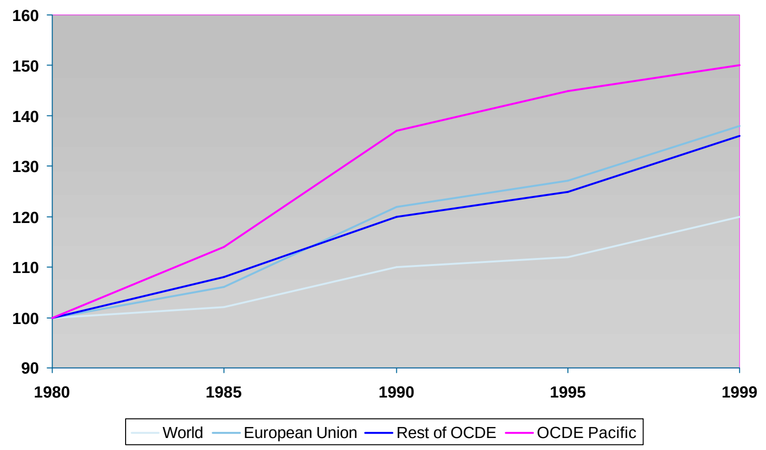
In this context, the Portuguese economy closely tied to the economic policy in the European, will slightly register rates superior to present by the existence of the greater margin of growth and equalise the effect that is derived from the integration process (as we will see further on in Chapter 4).

The level of GDP in the world grew by 20% in the past 20 years, while the OCDE level grew by ~38%. The largest development was in the Pacific region where, between 1980 and 1999, GDP grew ~50%[6]. In 19 years, the per capita GDP in Europe passed of 11.990€/Hab. (4 times worldwide average GDP) to 16.570€/hab (six times worldwide the average GDP).

[5] Tokyo, Mexico City, São Paulo, New York and Mumbai (Bombay).

[6] We may link the abnormal growth in the Pacific region to the growth of the South Korean economy that boomed in the 80's and 90's (for example is the fourth world cement producer).

Figure 3.3: GDP per capita relative evolution per region



Source: adapted from 2001 Annual Energy Review

Wrap up

Energy saving is not only a matter of more efficient technology in terms of end-use or supply, but also in terms of demand (people's conduct and "way of life"). While politicians express a need for a more environmental oriented attitude for energy saving actions and technology, implementing the necessary measures is revealing to be more difficult. According to Norgard (2001), this is due to a higher priority given to GDP than to "real progress".

In countries with a high GDP, such as the OECD countries, growth in GDP is constrained mainly by demand. In this situation, energy savings can bring progress, but hamper the growth in GDP.

Direct energy savings, by using more energy efficient appliances, houses, cars and other end-use technologies, will cause a decline in GDP due to lower production of energy, but an increase in real progress due to less depletion of resources and less pollution.

Encouraging people to extend the lifetime of their stock of durable goods like clothes, houses, furniture, vehicles, etc is a indirectly way to save energy, since production of these goods can be reduced. **Indirect energy savings** may increase or decrease GDP, but they will definitely increase progress due to lower pollution, less resource depletion, more leisure time, etc.

Usually, GDP shows a positive correlation with energy consumption. We will see further on that this correlation is more visible in less developed countries or in countries that are still in a tertiarisation process. For those countries with a higher services share, normally the consumption stabilizes while GDP increases.

We will see this happening in countries like France or Germany. In these countries, the economic development surpassed the maximum predicted by J.M.Martin (Figure 2.2) and has been decreasing continuously. In recent years with the introduction of high value services with insignificant energy consumption, this ratio has been increasing.

The conclusion is that we should always look for a correlation between GDP and consumption because it may give us some clear explanations about the country (region's) economic evolution.

3.3. Energy price trend

The price level of energy constitutes another driver of energy consumption. Consumers respond to prices and other economic signals. There are many times when consumers – residential, commercial and industrial – are willing to reduce their demand when prices are high.

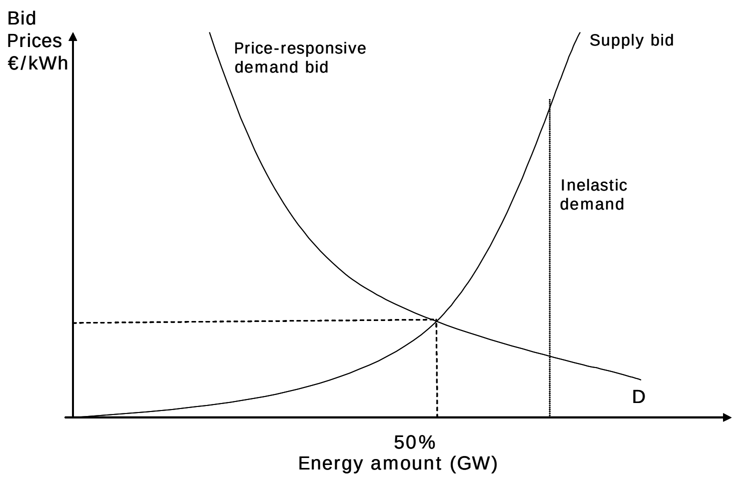
There are three main factors that influence a demand's price elasticity:

- **The availability of substitutes -** This is probably the most important factor influencing the elasticity of a good or service. In general, the more substitutes, the more elastic the demand will be and vice-versa. Therefore, we say that a product is an inelastic product because of its lack of substitutes. Thus, while a product within an industry is elastic due to the availability of substitutes, the industry itself tends to be inelastic. Usually, energy is inelastic because it has few if any substitutes;

- **Amount of income available to spend on the good** - This factor affecting demand elasticity refers to the total a person can spend on a particular good or service. Thus if there is an increase in price and no change in the amount of income available to spend on the good, there will be an elastic reaction in demand: demand will be sensitive to a change in price if there is no change in income;
- **Time** - If the price of gasoline goes up €3 per litre, a traveller, with very little available substitutes, will most likely continue buying his or her weekly gasoline. This means that gasoline is inelastic because the change in the quantity demand will have been minor with a change in price. However, if that person finds that he or she cannot afford to spend the extra €3 per litre and begins to kick the habit over a period, the price elasticity of gasoline for that consumer becomes elastic in the long run. This was what happened in the 70's in the oil shocks.

The short-term price elasticity (or demand elasticity) is low, i.e. people do not radically modify their habits from one day to another. However, as people eventually change their habits with time, the medium/long term elasticity is higher. According to Stoft (2002), the long-run response to a 10% increase in price is likely to be found between 5-15%.

Figure 3.4 Wholesale electric market supply and demand curves



Source: adapted from Stoft (2002)

Increase in prices may cause delocalisation of industries that are high consumers of energy to regions has lower taxes and the investment in new and more efficient equipment.

The average price of Brent crude oil fluctuated at low levels over the period from 1991 to 1999. In 1996 and 1997, tensions in the Gulf led to price rises, which did not last. The dip in prices in 1998 has been attributed largely to the decrease in demand associated with the Asian economic crisis (Source: Eurostat 2004). In 2000, the upward movement in oil prices continued as demand increased through a combination of economic upturn and a cold winter in the United States (Source: site www.platts.com). From the 3rd quarter of 2000 until the end of 2001 prices started to fall again. At constant 1995 prices Brent crude oil rose by 59% in the period 1991- 2000 while the overall increase during the period 1991-2002 (taking into account the fall in 2001 and 2002) - was 29%.

For coal, we see a blurred picture. We only have data from 1994 onwards (Source: EDP based on IEA data), which shows some volatility. The 1996 peak of $45, according to IEA, followed by a decrease and a second peak of 42, can be explained by the growth in China and an increase in total OECD demand and supply led by the USA.

The average gas import prices, for natural gas and LNG remained rather stable in the EU-15 from 1992 to 1998 at around 2.2 €/GJ. After falling moderately in 1999 the gas import prices followed a steep increase over the next two years showing a link to crude oil prices but with a small delay (which is rather usual). In 2002, there was a fall in natural gas prices reflecting the drop in oil prices of 2000-

2001.

Electricity prices in Europe rose until 1993 and then diminished to ~31€/GJ. Household prices are affected by weather conditions with colder temperatures pushing up demand and prices. Over the period (1990-2003), electricity cost at current prices increased by 19%, but it is notable that most of that change took place in 1991 and 1992. At 1995 constant prices, domestic electricity price fell by 14%.

Table 3.1: Energy prices evolution in the EU15

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Brent[7]	n.a.	16,2	14,9	14,6	13,4	13,1	16,4	17,0	11,7	17,1	31,4	27,7	26,6
Coal[8]	n.a.	n.a.	n.a.	n.a.	40,2	46,2	45,0	43,8	39,3	34,3	34,9	42,8	n.a.
NG[9]	n.a.	n.a.	2,16	2,27	2,12	2,14	2,22	2,53	2,21	1,86	3,17	4,14	3,55
Electricity[10]		35,55	36,14	36,59	36,47	34,90	34,29	33,67	32,89	31,59	31,38	31,12	30,85

Source: Platts, Eurostat, EDP

Until 2012, a stable growth of the worldwide demand of petroleum is expected (at around annual 2.5%[11]), but also it will increase the OPEC production (annual ~3.2%). For that reason, the average price of crude the esteem that will be located in a band between 25 and 35 euros/barrel until 2012, as a result of the price evolution of the crude in the international markets. The prices of the natural gas also will stay relatively stable in real terms, since the anticipated increase of demand is covered easily by the existing reserves, in addition to the technological improvements anticipated in exploration and production. The prices of the coal will continue being below the crude and the gas prices in all the period. However we believe that the most important trend that could interfere with this levelling in coal price, is the development of China and India.

In the UE, the prices to final consumer will stay in levels similar to the present ones due to the abandonment of the most expensive productions as we will see further on in chapter 4.

The price effect is one of the most effective measures of modifying energy consumption but this causes a decrease in comfort and in competitiveness and although this may be considered as a energy efficiency measure we believe that is more of a conjectural measure which may cause some savings but also disturb economic growth. However, the variation in energy price is much more visible to industry, because for them is an important production factor than for household consumer. In fact, only with a oil crisis, like the ones in the 70's, we will see some household habits change, but even so, we personally believe that people would try to adapt as soon as possible to the new situation.

3.4. Weather

Weather can be considered as a stochastic driver and sometimes its erratic behaviour drastically influences the consumption.

Usually, the weather impact on energy consumption, tend to decrease when GDP increases. Two reasons may justify this:

- In developed countries people tend to have more electric appliances which consumption is independent from weather (PC, TV, etc.) but have a calorific contribution in cold or moderated temperatures;
- The improvement of the buildings energy performance; this factor is more important in countries where heating invoices tend to be high (e.g. Denmark or Finland). For example in Denmark, a demand controlled ventilation project which involved the implementation of

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[7] ECU/€ current prices per barrel. Source Eurostat Energy ,Transport and Environmental indicators (2004).

[8] Source EDP database.

[9] ECU/€ per GJ. Source Eurostat Energy ,Transport and Environmental indicators (2004).

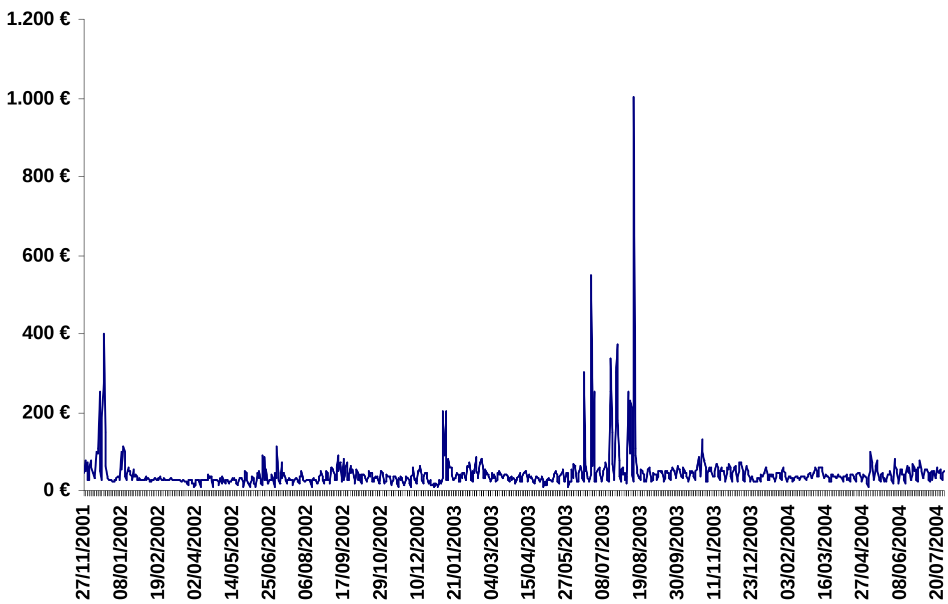
[10] Tax-Inclusive household electricity prices. Source Eurostat Energy ,Transport and Environmental indicators (2004).

[11] According to Diário Económico quoting Widvey, Norwegian oil ministry in 17/09/2004.

natural ventilation, demand-controlled ventilation and adjustable control systems, allowed to reduce heat consumption to a 1/3 and electricity consumption to half[12].

However, accidental weather conditions may generate a tremendous electric crisis because they are unpredictable. This was the case of France, where in 2003 the intense heat caused the increase of the water temperature obliging EdF to shut some of the production in nuclear power plants (especially in south east of France) allied to predicted maintenance of some others caused a peak in consumption and in energy prices (Figure 3.5).

Figure 3.5: Maximum price per MWh paid in POWERNEXT from November 2001 to July 2004



Source: adapted from Powernext

Another example is Germany, where the network has an installed capacity of 12GW in wind power, and consequently the effects of wind conditions are more “visible”. The electricity production by wind presents some uncertainty due to its unwieldy character, which obliges the system to have a reserve power of other energy sources (usually fuel or gas). This demands the optimisation of the demand projection and the control of the generation in order to assure the correct equilibrium between offer and demand.

Therefore, while being a driver for energy consumption, climate is a complex factor to account for since it is not only virtually impossible to estimate its future evolution, but also because it is very hard to predict the consumers’ reaction to climate change. While models are being made to help energy companies to predict weather changes, its uncertain character will always be present and energy companies will always have to react on time to demand variations due to the weather.

3.5. Wrap up

Although there are other consumption drivers like technological revolution (and evolution) and geopolitical aspects like another oil crisis, we believe that these four drivers are the key ones in order to better understand energy consumption. We must notice that these drivers are interdependent. There is no doubt that improved institutional capacity will promote economic growth, but it cannot prevent an economic crisis if energy prices skyrocket. New technology can result in improved efficiency of energy services but it may be expensive and require the costly replacement of capital stock. New energy sources may appear, but the full costs may be much greater than in existing fuels’.

[12] Further details in http://www.rehva.com/projects/etiaq/Html/Case-study_Denmark.htm

However, even if the drivers cannot be analysed by themselves, we can used them to predict some trends and to evaluate policy decisions. As we saw, all of them show limits that we can use to criticize the results. Like there is not one magical indicator to help us, the same happens in energy consumption drivers. There is not one "magical" driver 100% correlated to consumption but we believe that these four, when analysed as a whole, show us a "correct" trend.

4. European consumption benchmarking

The European Union is the one of the biggest energy consumers representing 15% of energy consumed worldwide in 2002. If we add the remaining countries of the OCDE, the percentage goes up to 50% (Report 2001 Annual Energy Review). It is curious however, to verify that the disparity between the countries deeply influences the EU energy context and policy options. This heterogeneity does not allow the implementation of one energy policy.

In this paper, we focused our attention on the EU and in the main differences between some countries. We have selected some countries for a deeper analysis based on two criteria: their energetic context (resources, energy choices) and their socio-economical context (GDP evolution, weather similarity, cultural similarity).

We have divided the countries according to their areas of influence: North and South.

The first group includes Finland, France and Germany. Finland was chosen because of its scarce resources and ambitious energy policy. France was selected because of its singularity in electricity production. Germany was chosen because, even if its market, resources or cultures are very different from the Portuguese ones, its dynamic economy makes it interesting to evaluate its behaviour through time.

In the southern group, we have selected Portugal, Greece, Italy and Spain. Greece was chosen due to its resemblance in terms of development, weather conditions and geographic situation. Italy because it choose an energy policy based in diminishing self-production and increasing imports and Spain because it is the Portuguese natural market.

It is difficult to choose one best indicator to analyse a given energy policy. Therefore, from a myriad of possible indicators we have chosen a group in order to compare the selected countries.

The major issue in writing this part of the report was to guarantee the homogeneity of the data. It is very difficult to find cross-country data with the same period or based in the same assumptions. Even reports from the same source (e.g. Odyssée Database) differ from one country to another.

This chapter is divided in six parts. The first evaluates the economic growth and the demographic evolution. The second the energy supply and the electricity production, while the third part analyse the energy consumption trends in an absolute way and in correlation with the GDP. The fourth part makes a brief analysis of electricity share in different economic sectors. The fifth part is about productivity, i.e. energy intensity and CO_2 emissions (per GDP unit and per capita). The sixth and final part, analyses the electricity prices in our group of countries.

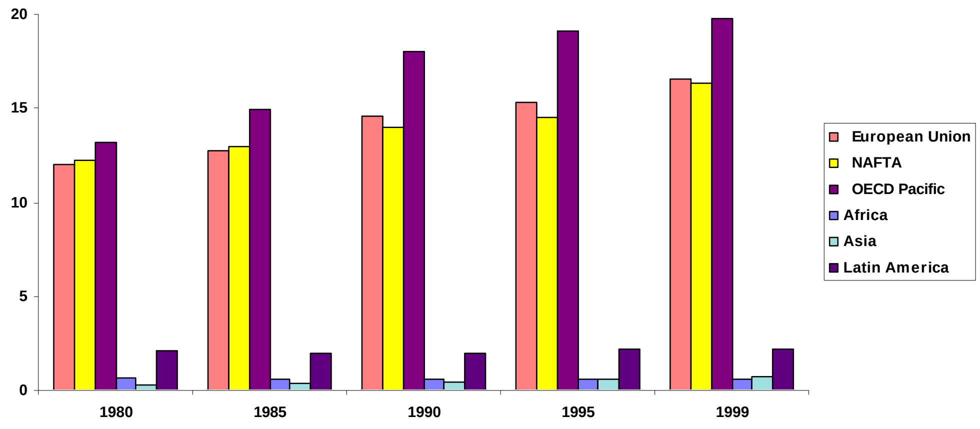
4.1. General context

In this part we begin by evaluate the economic growth and the demographic evolution in our group of countries.

4.1.1. Economic growth

The economic growth analysis of these countries is one of the key factors to understand the impact of the energy efficiency policies. Economic performance is measured by the GDP evolution either it's sum either per capita. The world's GDP was on average 4 times less then the OCDE regions' in 1980 and of 5 times less in 1990 (Figure 4.1). This evolution shows that the gap between OCDE and the rest of the world, even though the developing countries has increased in 19 years their GDP per capita.

Figure 4.1: GDP per capita evolution by region (in K€$_{90}$)

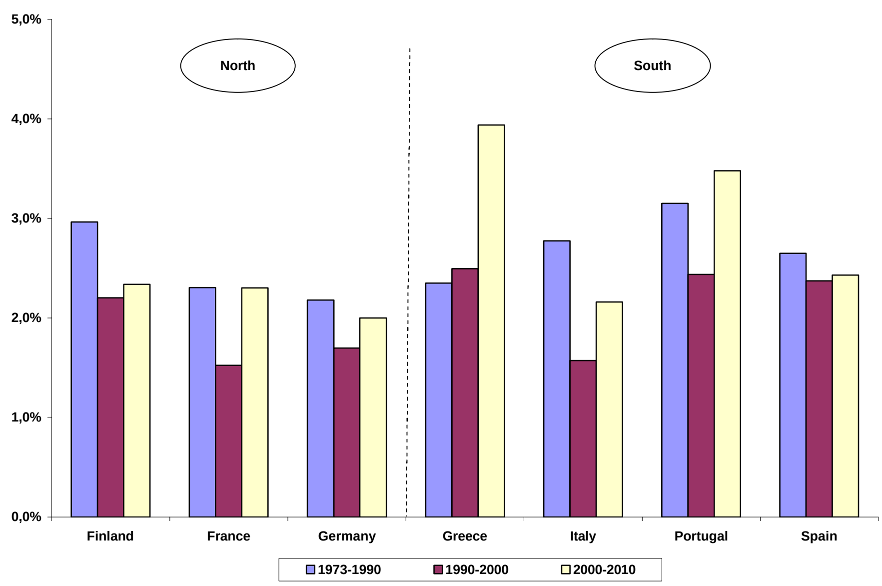


Source: adapted from the Report 2001 Annual energy review

The Figure 4.2 shows that in general the GDP growth follows a similar pattern throughout the years. We believe that this due to the interdependent nature of these economies.

The fall between 1990 and 2000 may be explained by several facts: the German integration in 1989 which costs were reflected in the 90's, the recession period in Europe in the early 90's and the Gulf war in 1991. Although we can speak of recession from 2000 (and increased with the September 11th impacts), IEA still assumes a growing prevision until 2010, when compared with the previous period. In fact, in spite of recession periods like the one in 2002-2003 where the GDP grew below 0% in several countries, there is the expectation of a growth of around 3% in the EU in future years (see also Table 12.6).

Figure 4.2: CAGR of GDP in selected countries

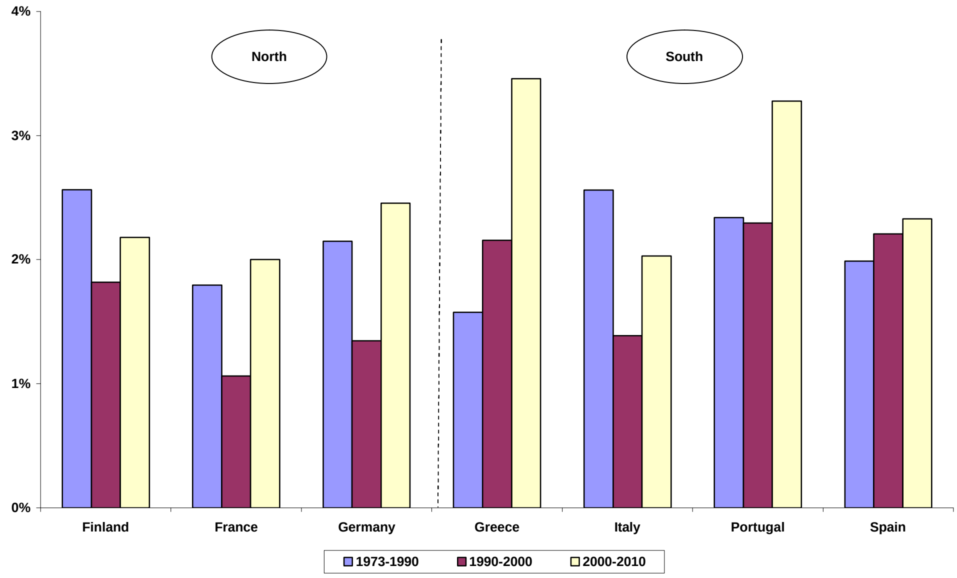


Source: adapted from IEA Energy policy review 2003

The stage of economic development and the standards of living in each country influence the link between economic growth and energy demand. Advanced economies with high standards of living tend to have high-energy use per capita. We can easily observe the German integration effect in the period 1990-2000 where the CAGR decreased 38% (when compared to the previous period). The GDP annual growth per capita tends to be of around 2-2.5% except for Portugal and Greece, which are still in a less developed phase and therefore have a higher prevision of growth (Figure 4.3) (see also Table

12.7). As we will see, this trend in Portugal and Greece implies a bigger demand in energy.

Figure 4.3: CAGR of GDP per capita between 1973 and 2010



Source: adapted from: IEA Energy Policy Review

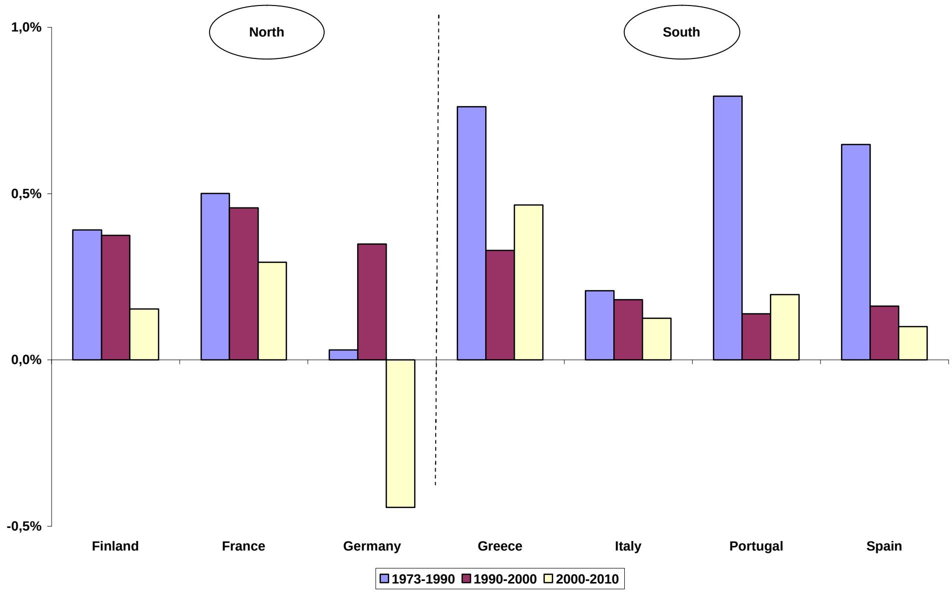
4.1.2. Trends in demographic evolution

According to Giampietro (1994), "a development policy without a population programme is like mopping the floor with the water turned on". Any serious policy concerned with energy saving, environmental sustainability, increasing jobs, and improving the standard of living has to be based on reducing population pressure. This applies to both developed countries (e.g. Western Europe) and to developing countries.

The evolution of the population is one of the most important drivers of energy consumption (as we saw in 3.1). In Europe, it is predicted a continuous slow down of the population growth. As we can see in the Figure 4.4, the population growth has suffered a massive breakdown in Portugal in the last 20 years, but the most serious case is the forecast for Germany in 2010, with a negative growth of 0.4% (further details in Table 12.8). This abnormal behaviour in Germany is probably, once more, due to its integration with the Eastern side, which was accomplished in 1989 but statistically visible throughout the 90s' until 2010.

Even if the demographic evolution in the selected countries shows a decreasing trend (the highest value in 2010 belongs to Greece with a CAGR of ~0.5%) which is a characteristic of the developed countries, we will see further, on that the per capita energy consumption is higher in these countries than in the ones with higher CAGRs'. We may, therefore, conclude that the demographic evolution, in Europe in general and in these countries in particular, is negatively correlated with the per capita energy consumption, i.e. the structural effect of reduction is annulated by a much higher consumption effect. If this trend of decrease continues after 2010, the structural effect can become more important than the consumption one and lower the overall energy consumption.

Figure 4.4: CAGR in population between 1973 and 2010

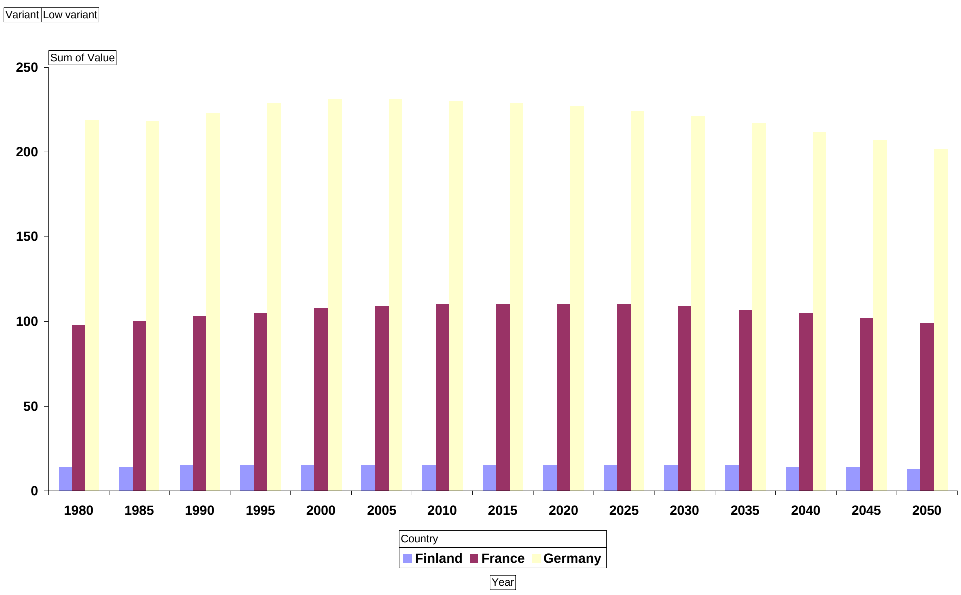


Source: adapted from IEA Energy Policy Review

Europe can afford to escape the demographic trap with which many developing countries are already struggling. However, it must set the goal of an adequate quantity of arable, pasture and forestland available per capita. It will offer the option of using some biomass production for energy, and it will reduce the pressure on land, water, air, energy, and biological resources. In fact, the lower the population density, the larger the choice of possible alternative energy sources.

As we can see in the Figure 4.5, the population density is not uniform among the northern countries. Germany's density in 2000 is 15 times higher than Finland's and twice the French's (further details in Table 12.9). Finland's geographic and climatic conditions contribute to this situation.

Figure 4.5: Population density in Finland, France and Germany (per sq. km)

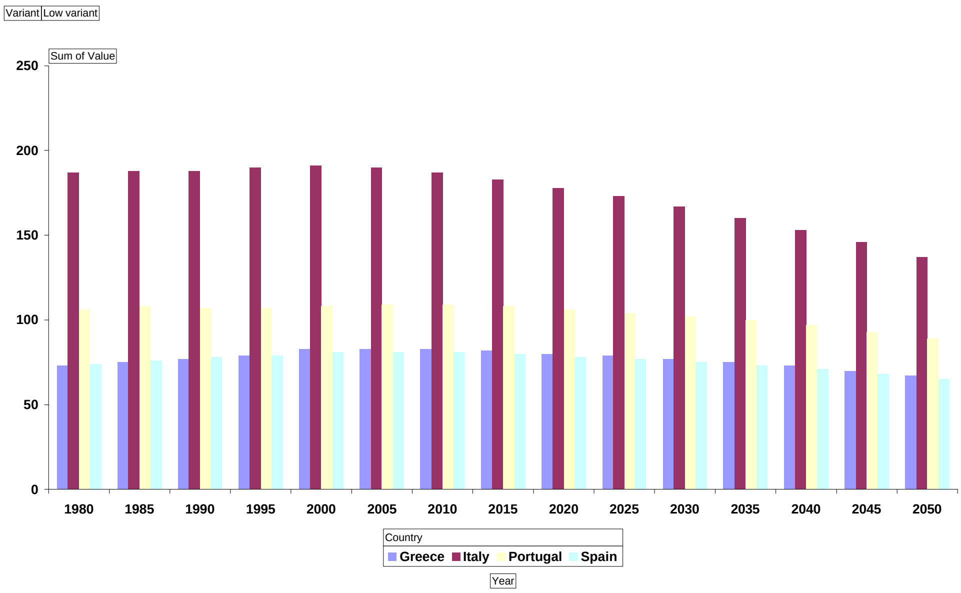


Source: adapted from UN World Population Prospects: The 2002 Revision and World Urbanization Prospects: The 2001 Revision.

Although the decreasing trend of population density has been more aggressive in south European countries (Figure 4.6) (further details in Table 12.9), we may consider that the population density is decreasing as a whole in Europe. This trend is most certainly due to the demographic evolution (as the countries population tends to decrease), to better transportation systems (allowing people to commute every day), to the increase of GDP per capita (allowing people to live away from their place of work and still maintain their life style) and to the increase of use of IT (that allows people not to be physically present at work).

The southern countries show a higher density than the northern ones. This may limit the choice of energy sources to supply these populations. The lower the density the broader the alternatives, but also the most costly is their implementation. Another issue is that the higher the density is the more powerful power plants are needed to supply a region, which may also interfere in the technology chosen.

Figure 4.6: Population density in Greece, Italy, Portugal and Spain (per sq. km)



Source: adapted from UN World Population Prospects: The 2002 Revision and World Urbanization Prospects: The 2001 Revision.

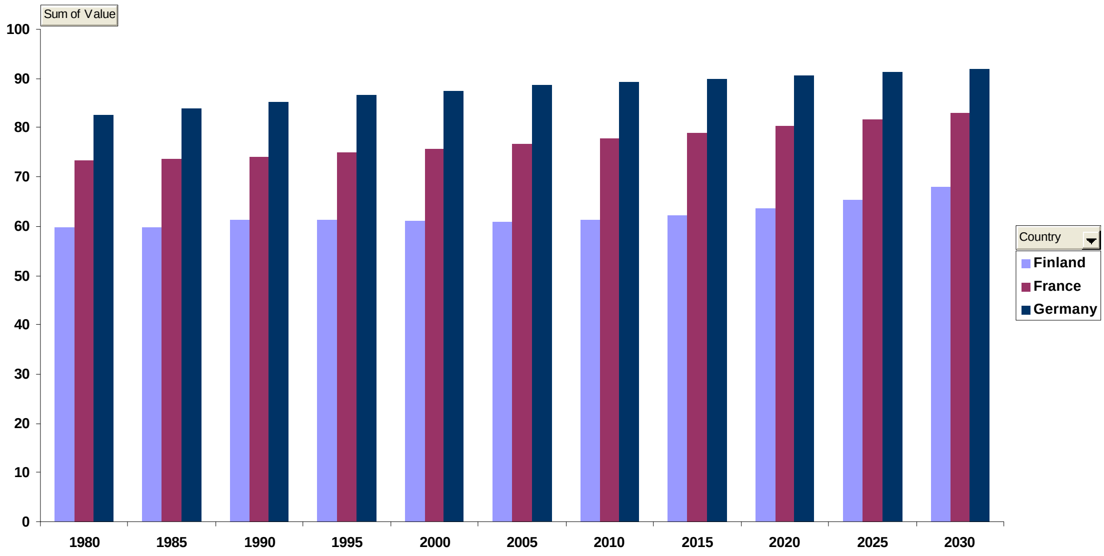
People leave rural areas and move to urban centres to escape adverse rural conditions (e.g. deteriorating of agricultural lands, poor market infrastructures, and lack of supporting institutions). At the same time, many urban areas attract people from the countryside because they generally offer more opportunity (e.g. access to better jobs, education, health care, and higher living standards).

The analysis of the evolution of the urban population share is also very important because the needs of the urban population may differ considerably from the needs of the rural one, which influences the energy system. Urban areas present special environmental challenges, due partly to the concentration of human numbers and partly to their role as centres of industrial production. Extensive resources must be devoted to provision of the food, water, energy and raw materials required to sustain city life. As urban agglomerations grow, the search for additional resources extends further and further into the suburbs. In urban areas people depend almost exclusively on electricity and natural gas to supply their energy needs (other than transportation[13]) leaving behind other energy sources like coal or biomass.

In north European countries, there is a considerable difference between countries (10-15%) (Figure 4.7) (Further details in Table 12.10) is related with the industrialisation past. France and Germany started their industrialisation process after England in the mid nineteen-century, which pulled many people to the urban areas. Finland had an agrarian society until the Second World War (WWII). The massive industrialisation took place from the 40's onwards in which large industrial communities rose in the countryside.

[13] Transports continue to be oil products captive.

Figure 4.7: Urban population share in the north European countries (%)

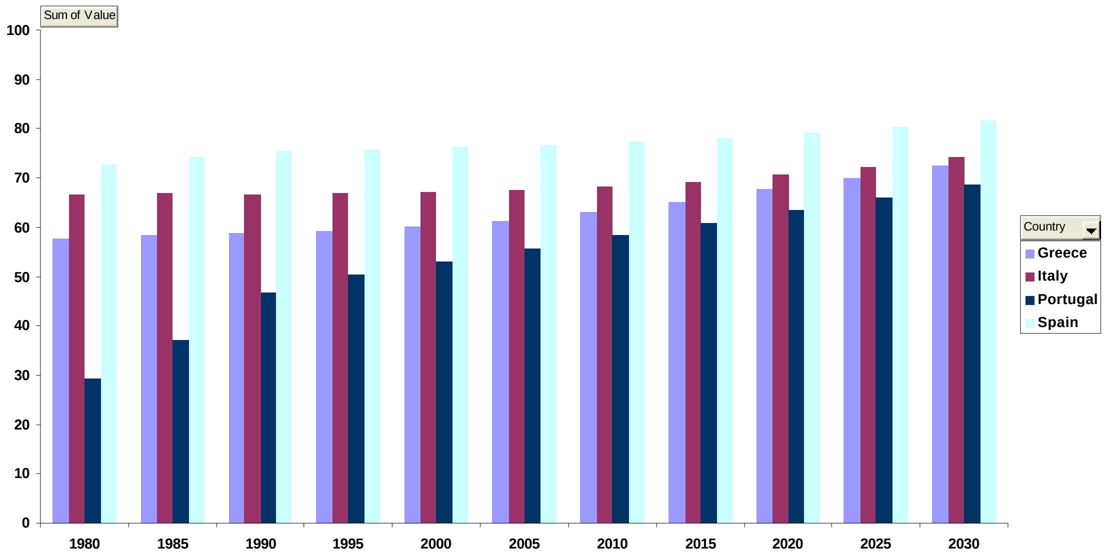


Source: adapted from UN World Population Prospects: The 2002 Revision and World Urbanization Prospects: The 2001 Revision.[14]

In the southern countries, we can observe the rapid growth in urban population in Portugal, especially between 1980 and 1990, which corresponds to, and industrialisation phase after the revolution of 1974 and to which contributed, most certainly, the country's entry to the EU in 1986.

Although Greece and Spain do not show a very different development stage from Portugal their geographical condition namely the arid of their interior tended to agglomerate populations in urban centres sooner than in Portugal.

Figure 4.8: Urban population share in the southern European countries (%)

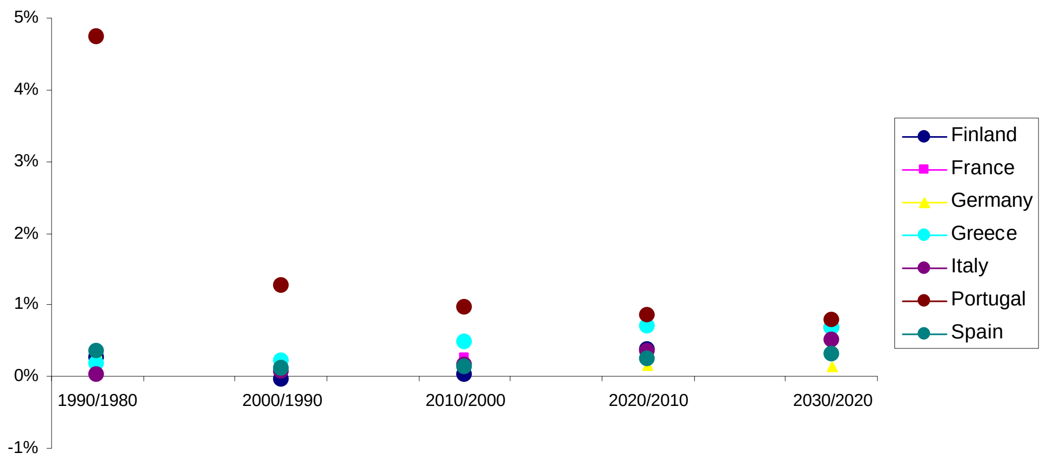


Source: : adapted from UN World Population Prospects: The 2002 Revision and World Urbanization Prospects: The 2001 Revision [14]

[14] Data only available until 2030.

It is also interesting to analyse the annual growth rate of the urban population for each country. From the Figure 4.9 we can observe a slight increase of urban population along the years in the generality of countries (further details in Table 12.11). The interesting about this next figure is not the figures by themselves but the trend observed in which Portugal seems to be the exception, with the strongest increase in urban population of all countries and with high discrepancies relatively to the others (mainly in the 80's and 90's) (CAGR of ~5% between 1980/90 and then tending to 1% in the following decades). Its fast development, due to the industrialization and the modernization of the agriculture, led to a strong movement of the population towards the big urban centers. Migration levels will tend to decrease along the time and from 2010 onwards Portugal will tend to become aligned with the other countries.

Figure 4.9: CAGR of urban population in some European countries



Source: adapted from UN[15] [16]

4.2. Energy supply and production

In this part of the chapter, we will take a closer look to energy supply and the evolution of the electricity consumption mix until 2010 in the selected countries.

This chapter intends to present a benchmark on energy consumption of several European countries. However we cannot benchmark consumption without analysing supply and production. That is why this part was introduced in this chapter. We will begin by identifying the main differences between countries in terms of TPES CAGR and per capita. Subsequently we will discuss the trends of each country in electricity production share per fuel.

4.2.1. Energy supply

The interesting aspect of the next figure is to notice on one hand, the disparity between our group of countries and in the other hand their specific evolution. Finland has an enormous TPES per capita especially due to its severe weather conditions and energy intensive industry. We can also observe the stable trend in Germany around 5% of annual growth in the period of 1973-2010, while France has a higher value in 2010. This can be caused by the increase of net imports in Germany between 1990 and 2010 (CAGR of +1.7%) while the production diminishes (CAGR of -2.3%). The opposite happens in France where, for the same period the imports increase +2.1% and the production +0.8% (further details in Table 12.16). In Portugal is expected to increase the TPES CAGR due to an increase of +2.2% of imports and +1% in production, until 2010.

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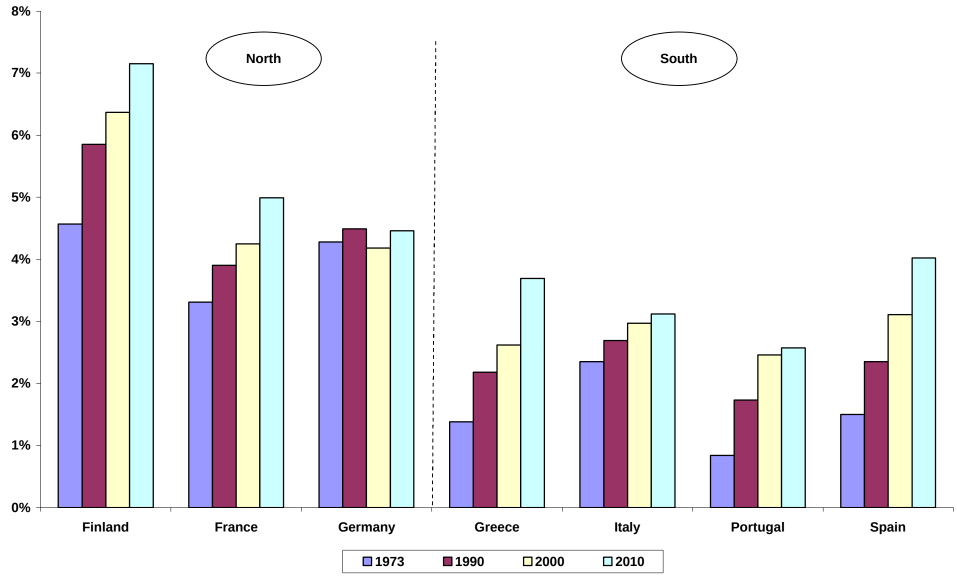
[15] World Population Prospects: The 2002 Revision and World Urbanization Prospects: The 2001 Revision.

[16] Data only available until 2030.

The Portuguese TPES went from 1/3 of the French one in 1973 to 1/2 of it in 2010. The Portuguese gap is therefore decreasing and its TPES is expected to continue growing but at a slower rate. Countries like Spain and Greece are expected to reach Germany's values in 2010.

Figure 4.10: Evolution of the TPES per capita

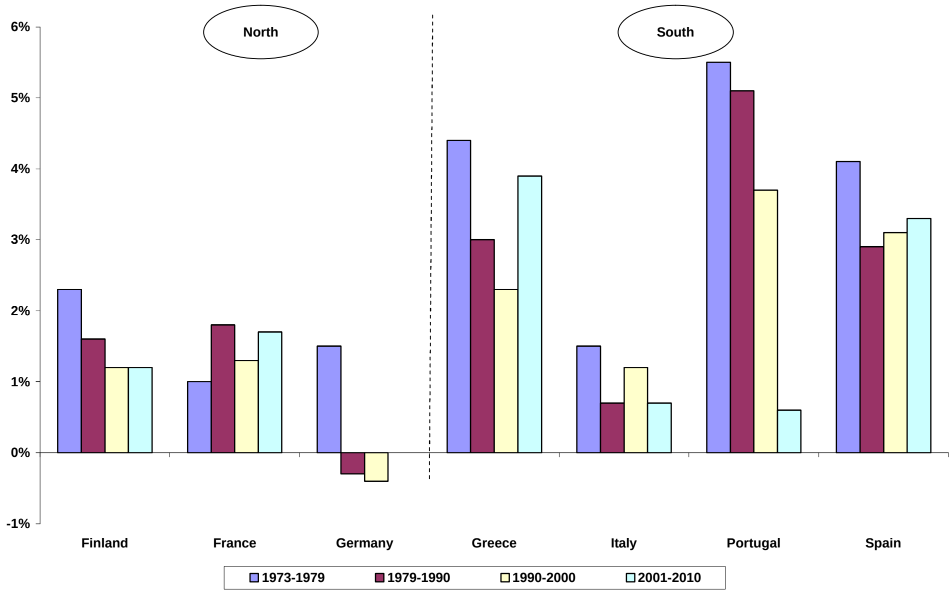


Source: adapted from IEA Energy Policy Review

In the Figure 4.11, we can see that the TPES annual average growth varies across countries. There is a considerable difference between the three southern countries (Portugal, Greece and Spain) and the northern ones plus Italy.

Greece's high average annual growth of 3.9% is partially linked with the introduction of natural gas in the energy mix in 1996 (CAGR of 147% in 1996-2000 and of 7.5% in 2000-2005). In Portugal, it is forecasted a CAGR of ~1% between 2001 and 2010 linked with the stabilisation of natural gas supply (CAGR of 701% in 1997-1998 and 9.4% in 2005-2010) and of solar/wind energy supply (CAGR of 25% in 1997-98 and 4% in 2005-2010). This trend can compensate the increasing demand diminishing the structural effect.

Figure 4.11: Evolution of TPES CAGR between 1973 and 2010



Source: adapted from IEA Energy Policy Review

4.2.2. Trends in electricity production share by fuel

The electricity production mix is very different from one country to another. This is caused by natural resources scarcity or energy policy options. We will observe in each country the evolution of the electricity production mix between 1973 and 2010. In this period, we can observe the consequences of the oil crisis and the entrance, especially in the southern countries, of the natural gas.

Further details on the figures presented in this point are available on Table 12.13 and Table 12.14.

Finland

Finland made a great effort to diversify its energy sources. While in 1973 the electricity production was based on hydroelectricity (40.3%) followed by oil (31.6%), in 2010 the scenario will be probably completely different, with nuclear (~37%) and maintaining Coal, Hydro, Gas and Renewable combustibles at around 12-14% of share.

The pursuit of this effort leads the Finnish Government to continue its 3E's strategy: Energy Security, Economic development and Environmental sustainability. This strategy can be understood looking into the aspects:

- The climate

Finland is one of the coldest countries in Europe with less 20 days of sunshine per year than Norway or Sweden. Electricity production is very important to fulfil heat needs. Therefore, it is essential the access to a source of energy like the nuclear one: cheap in fuel cost, with low fuel price volatility, and with an improved performance in colder environments. Finland has four nuclear reactors (2656MWe net total) generating about one third of the electricity consumed.

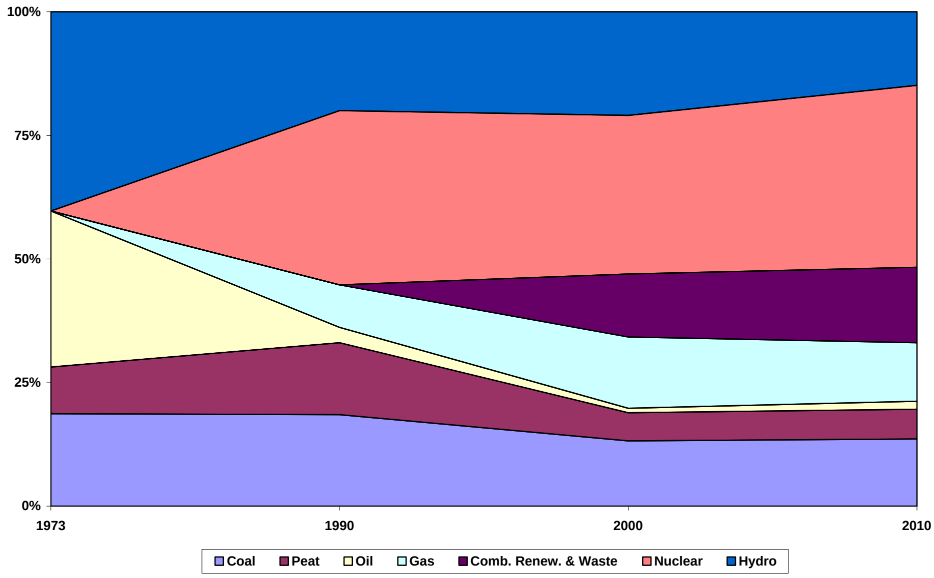
- Natural resources

On supply side we must notice that Finland has scarce natural resources which imply a lot of imports (~70% of all energy consumed is imported) and the share of electricity imported is around 12% (source: TVO online). Russia is the main trade partner in electricity and natural gas imports. Through a diversified energy mix, the Finnish Government reduces energy risks regarding supply and price.

In 2002 Finland's parliament voted (107 for -92 against) to approve a fifth nuclear reactor to be in operation in 2009 by TVO (43% public owned, 57% private). This will be the first nuclear reactor constructed in a liberalised context.

On demand side, we must notice the country's cold climate and its energy intensive industry make the reliable supply of energy important.

Figure 4.12: Electricity production evolution by type of fuel in Finland



Source: adapted from IEA Energy Policy Review

France

France is truly a case study in this subject. Not having any important energy resources (some natural gas at Aquitaine and some coal but economically not exploitable), France has chosen the nuclear pathway to their electric production.

The French nuclear programme started right after the WWII, in 1945 with the creation of the CEA, with the objective to pursuit "les recherches scientifiques et techniques en vue de l'utilisation de l'énergie atomique dans divers domaines de la science, de l'industrie et de la défense nationale". The decision of the Government (Mr. Messner) in 1973 of launching a massive nuclear programme guarantee today electric independency and nowadays France is the European greatest electricity exporter.

France started by buying the license of a Westinghouse technology and modify it afterwards, aside from that France invested in an ambitious nuclear programme in terms of R&D and diffusion. We can say that today France has its own technology and an outstanding expertise in this issue. With this, it has accumulated more than 30 years of experience and expertise, which they want to maintain.

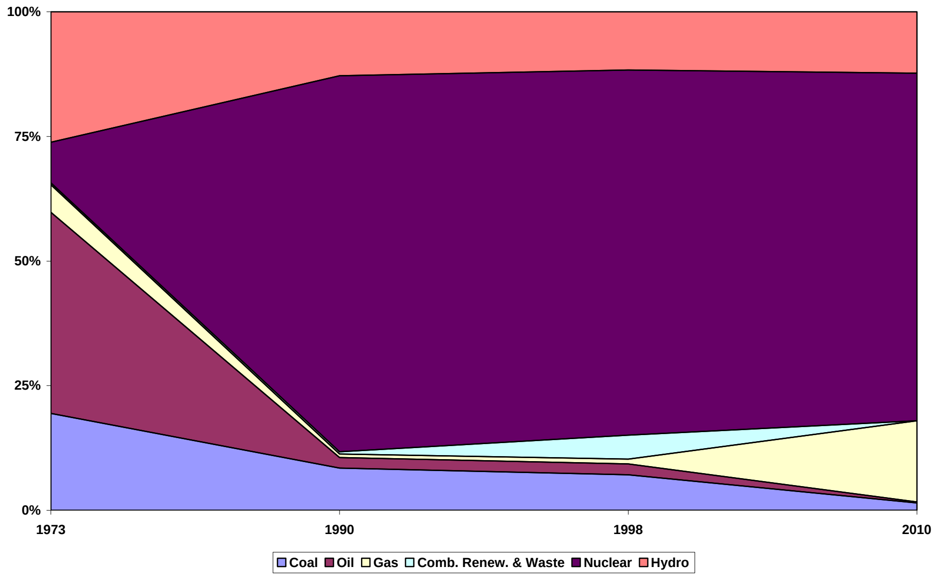
The total cost of the programme has been evaluated in 10% of the GDP in 1990[17]. This programme was mainly financed by the government and the favourable conditions on how loans were negotiated to build the nuclear power plants allow them to have a production system completely paid which reduces the energy cost. Nevertheless, we are curious to understand how EDF (and the Government) are planning in the future to substitute some of the units. Even if, for the time being, this question does not arise, this problem already concerns some French economists.

It is with no surprise that we observe a huge share (77% in 1998, 70% in 2010) of nuclear power in the French electricity production while other energy sources are residual. The entire hydroelectric potential is fully explored; therefore, we may expect a slow descending share in hydroelectricity in the next years.

Natural Gas imported from Norway, Russia and from Algeria (LNG), is growing but it will remain as a secondary choice. We believe that only a great environmental pressure regarding nuclear waste or an accident may change this trend.

[17] Source: Société Française d'Énergie Nucléaire: www.sfen.org

Figure 4.13: Electricity production evolution by type of fuel in France



Source: adapted from IEA Energy Policy Review

Germany

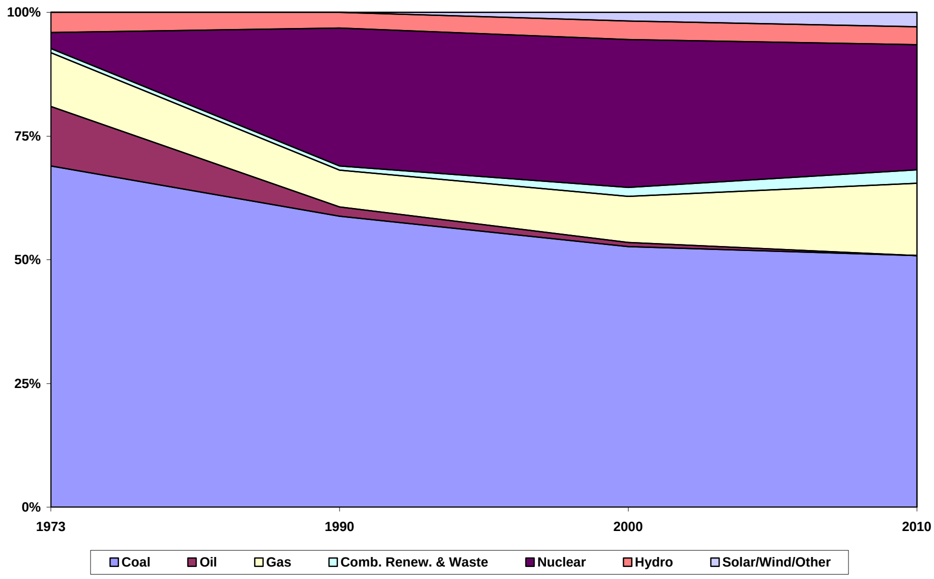
Historically Germany continues to focus its electricity production in solid fuels. Although in a downwards trend coal will still represent ~50% of the electricity.

In November 2003, Germany closed the first of its 19 nuclear power plants launching a withdrawal from atomic energy. Germany's centre-left government struck a deal with energy industry in 2000 to close all nuclear power plants until 2025. It is still unclear if Germany can meet the deadline and how it will replace the nuclear energy (which provides 25% of its electricity) while also meeting commitments to cap its emissions of greenhouse gases produced by fossil fuels.

Germany has about 12GW of wind farms, which is the biggest park in the world, and is previewed to grow to twice as much until 2010. This country is clearly betting in wind sources to substitute oil products such as heavy fuel.

This option may cause some problems concerning the security of supply due to the random character of climate conditions. German has also the highest solar capacity installed in Europe. In 1999, the government launched a 100.000 roofs programme for photovoltaic. Under the six-year programme, the German government assigned a bank to issue 10-year, interest free loans that recipients must repay in eight annual fees. At the end of 2000, total installed capacity was 80MW and it has more than doubled during 2001.

Figure 4.14: Electricity production evolution by type of fuel in Germany



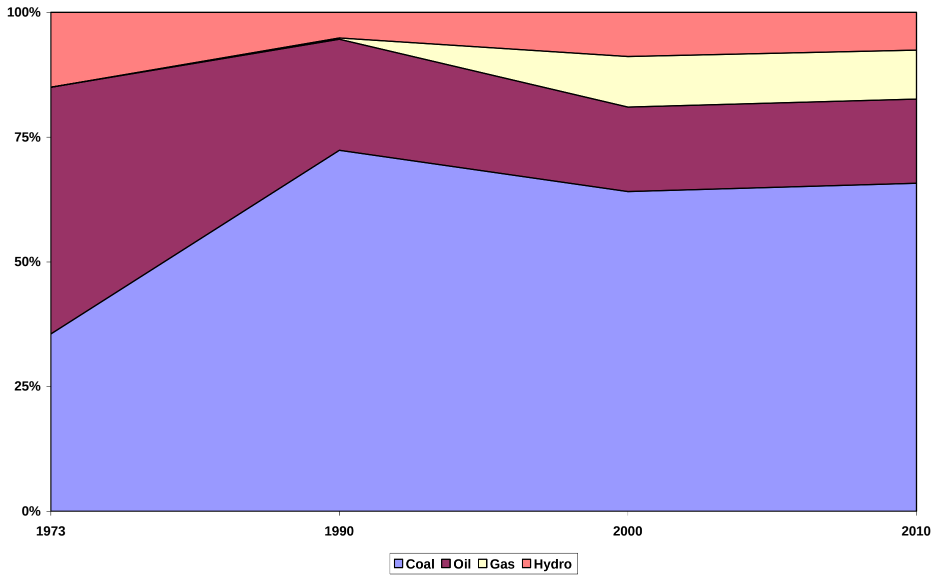
Source: adapted from IEA Energy Policy Review

Greece

Among IEA countries, Greece has a relatively small electricity supply system. Lignite is the primary energy source, accounting ~2/3 of total generation. In fact, Greece's 80% of indigenous energy production is based on lignite and all but 1% of this source consumption is used for power production. The use of this energy source was developed after the oil shocks of the 70's in order to reduce the fuel invoice for their baseload oil fired power plants. Heavy fuel, natural gas and hydroelectric stations provide the supply of the remainder. The islands rely almost exclusively of heavy oil and diesel. Due to its geographical situation and the subsequent huge investments that would be required to install throughout the archipelago sophisticated and small production units powered by natural gas, there is a trend of a stable production mainly by coal in the mainland (92.5% of the electric generation and 3.6% of average annual growth rate) and by fuel oil and diesel in the islands (7.5% of the electric generation and an average annual growth of 7.3%).

Greece is rather "isolated" situation and its neighbour's economic situation adds some problems of interconnection with Albania, FYROM and Bulgaria and a sub aquatic interconnection with Italy.

Figure 4.15: Electricity production evolution by type of fuel in Greece



Source: adapted from IEA Energy Policy Review

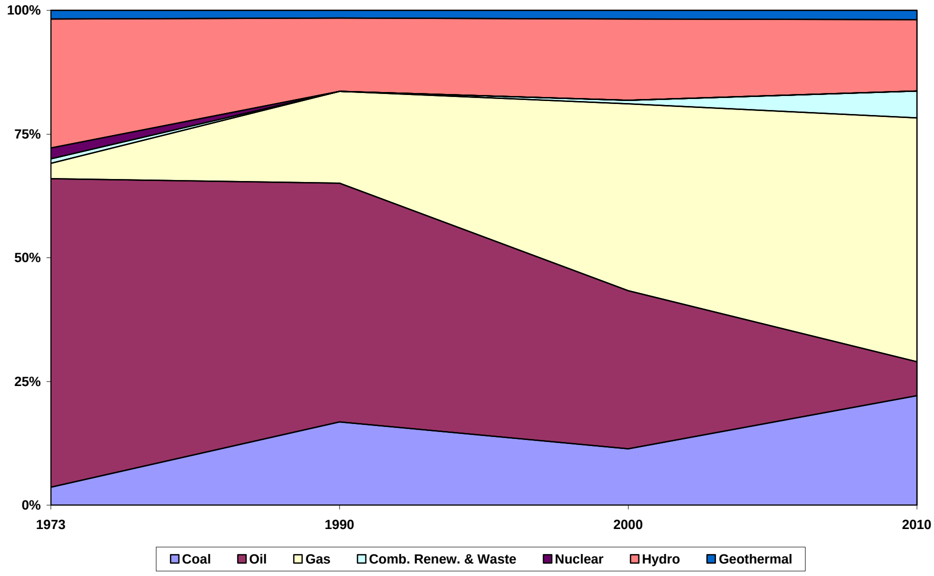
Italy

Italy has a distinct fuel mix with no nuclear and almost all of its supply is derived from fossil fuels in which there is a relatively small quantity of coal and a large share of electricity production from natural gas. This ~40% today, i.e. more than the double of the EU average, and will reach 50% in 2010. In the 1990's a large majority of additional power plants were gas-fired. Consequently, between 1990 and 2000 the share of gas in electricity production doubled from 20% to 40% while the share of oil decreased from 48% to 32%. The share of coal dropped from 19% to 11% between 1990 and 2000 but is expected to raise its share up to ~25%, as the Italian government aims the diversification of the primary energy mix.

Imports play an important role in electricity supply. In the 1990's net electricity imports reach 14-16% and these come mainly from Switzerland and France.

According to IEA Energy Policy Review (2003), the Italian authorities often underline the singularity of Italy's electricity production mix in which the role of natural gas is excessively high. Italy is in a diversification process through the promotion of renewable energy sources and increase role of coal but these options of diversification are limited because Italy's decision to roll-out nuclear in 1987.

Figure 4.16: Electricity production evolution by type of fuel in Italy



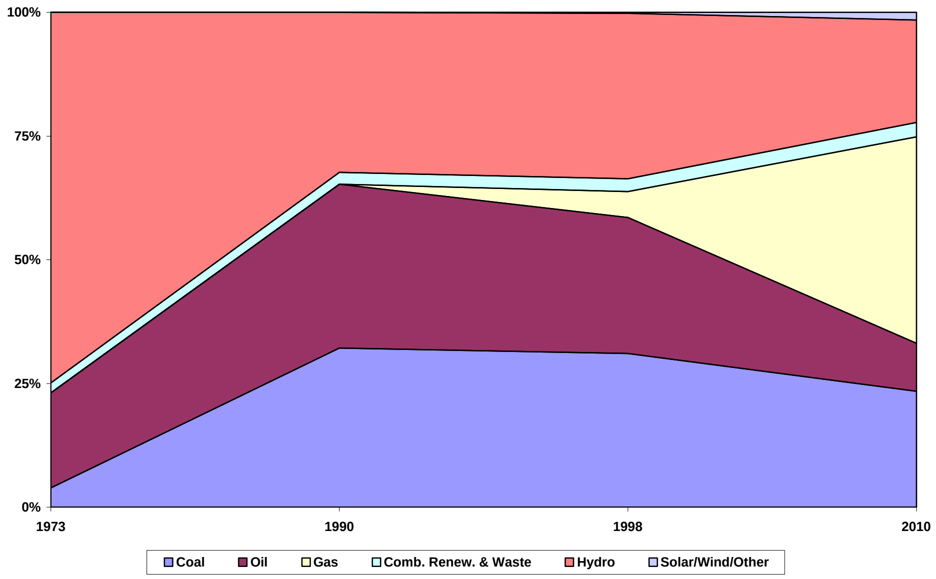
Source: adapted from IEA Energy Policy Review

Portugal

Portugal is in a stage of diversification its energy sources. Being a country without any natural resource the energy policy of minimising risk pushes the country to an effort of diversification (Figure 4.17). In 2003, electricity consumption was 46TWh, compared to 23.5Twh in 1990.With a tradition and expertise in hydroelectricity but (like in many other European countries) without any other major dams to build we observe the slow decrease of hydroelectricity in the total energy share. At the same time, we see the raise of coal technology in order to secure energy production through a fuel with less volatility than oil. Natural gas appears in 1998 in the electricity production mix and it is expected to be number one in 2010. By not having a nuclear programme, Portugal energy sources to produce electricity rely on thermal sources and a small part on renewable source (other than hydroelectric). It is intention of this government to increase this share in order to achieve a higher energy independency and fulfil Kyoto obligations.

Imports and exports depend on hydro conditions in the Iberian Peninsula. There are five interconnections with Spain but more are in development to support the creation of the MIBEL.

Figure 4.17: Electricity production evolution by type of fuel in Portugal



Source: adapted from IEA Energy Policy Review

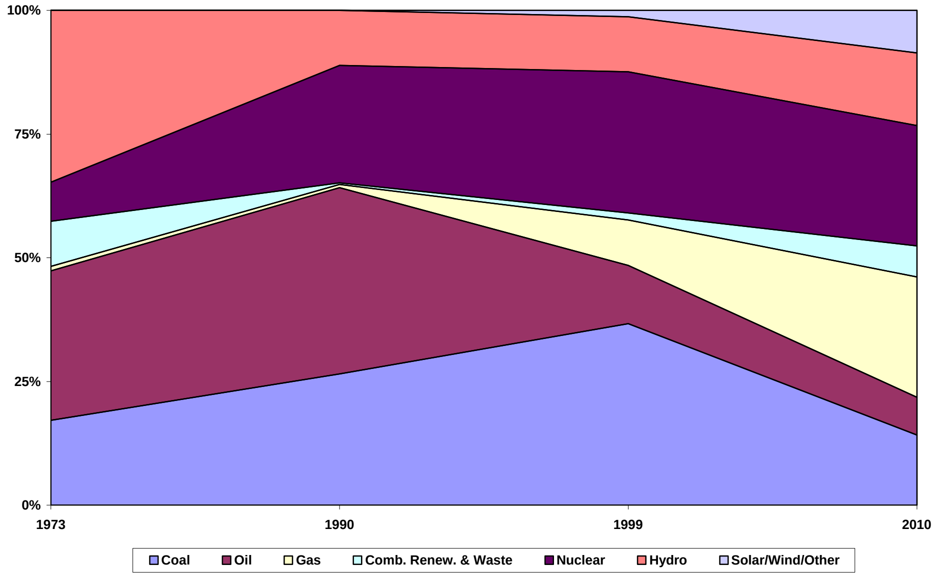
Spain

An increasing electricity demand (6% average annual growth rate in 98-2000) and a sensitive hydro system led the Spanish government to rethink the national supply system. In 2010, the generation mix will be completely different from what it is today. By 2010, the share of nuclear is expected to be 24%, natural gas 24%, hydroelectric power 14.7%, renewable 15%, coal 14% and oil 7%.

Electricity production mix in Spain will be quite diversified with four sources with more than 14% of share. This may help Spain to reduce energy price risk. Additionally, this country is trying to upgrade their interconnections with the Continental area through the Pyrenees, which is difficult to do due mainly to environmental causes.

Spain imports come mainly from Portugal and France and its exports go to Portugal, France, Andorra and Morocco.

Figure 4.18: Electricity production evolution by type of fuel in Spain



Source: adapted from IEA Energy Policy Review

4.2.3. Wrap up

As a wrap up, we would like to point out the major trends taking into account "the big picture".

We saw that the TPES evolution per capita is higher in northern countries due to their economic development and climate conditions. However, we observe a trend in the southern countries in diminishing the gap to the northern ones. This is visible in Spain and Greece.

The TPES CAGR shows, has expected higher values in southern countries (except Italy) indicating a converging trend with the northern ones.

In the Table 4.1, we can observe the ranking if the three biggest energy sources in 1973 and in 2010 for the different countries. This reflects the energy options made after 1973.

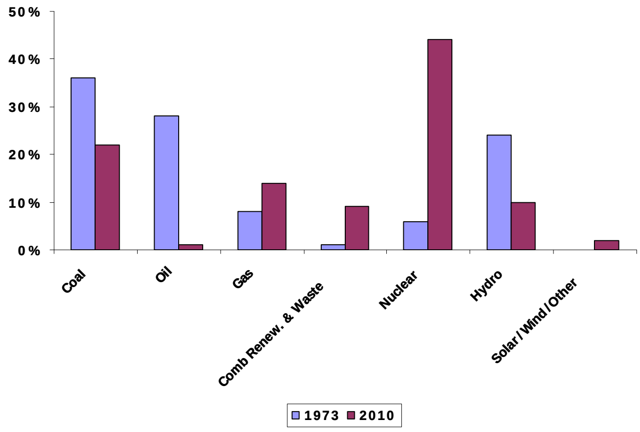
Table 4.1: Energy source ranking for electricity production in 1973 and 2010

Ranking	Finland		France		Germany		Greece		Italy		Portugal		Spain	
	1973	2010	1973	2010	1973	2010	1973	2010	1973	2010	1973	2010	1973	2010
1st	Hydro	Nuclear	Oil	Nuclear	Coal	Coal	Oil	Coal	Oil	Gas	Hydro	Gas	Hydro	Gas
2nd	Oil	C.Renew. & Waste	Hydro	Gas	Oil	Nuclear	Coal	Oil	Hydro	Coal	Oil	Coal	Oil	Nuclear
3rd	Coal	Hydro	Coal	Hydro	Gas	Gas	Hydro	Gas	Coal	Hydro	Coal	Hydro	Coal	Hydro

Source: adapted from IEA

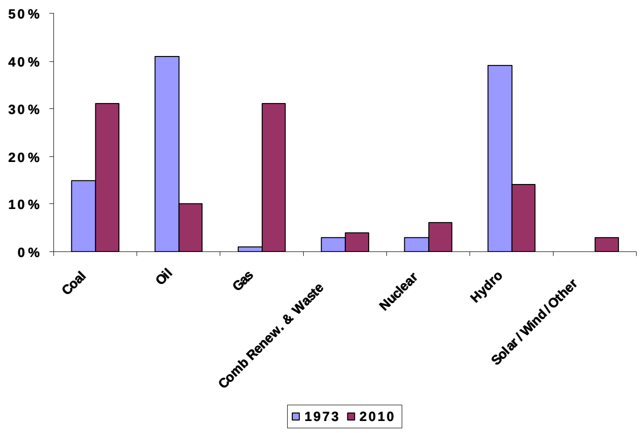
The differences in the fuel mix are visible both in the northern and southern countries. The northern countries are reducing their oil share to almost zero while increasing the nuclear share (Figure 4.19). The southern countries still maintain a considerable share of oil and have increased drastically their gas share (from 1% up to 31%). Hydroelectric had almost 40% of the overall southern production will reach 2010 with 14% (Figure 4.20) (further details in Table 12.12).

Figure 4.19: Overall fuels mix in electricity production in the northern countries



Source: the author

Figure 4.20: Overall fuels mix in electricity production in the southern countries



Source: the author

In all countries, we see natural gas technologies increasing their share in the electricity production. This trend is caused by the market organisation that allows and helps the development of this technology. An advantage of this is that natural gas is a good trustworthy technology cleaner and with a better performance than coal, which does not have the waste problems of nuclear technology. However, the electricity production is becoming dependent of natural gas, which will increase the pressure on its price.

Regarding coal, strategies differ from one country to another. France will abolish it (0.2% in 2010); Finland will decrease its share (~19% in 1973 to 14% in 2010) and so will Germany. Italy will increase its share up to 22%, while in Portugal it will decrease from 38% to 22% (Table 12.13 and Table 12.14).

Oil it is continually decreasing its share in electricity production. The most aggressive period of reduction occurred between 1973 and 1990 due to the 2 oil crisis and the shift of oil products to captive sectors (like transports) or non-energy industry (like oil chemistry). In Greece, this source still presents a share of 17% and the trend is to stabilise until 2010[18]. The other southern countries will depend from oil at a lower extent (10% on average), while in the northern ones this weight will be irrelevant (1% on average).

[18] Indigenous production of crude oil provides less than 3% of total refinery intake of crude. Production is expected to end by 2005 but a new effort is being made at Western Greece to develop new areas of exploration (Source: IEA).

Hydroelectric power will continue to decrease its share because almost all the potential is already exploited. In Portugal, it will pass from 74% in 1973 to 21% in 2010, taking the 3rd place in the ranking. The other renewable sources will have a residual weight in electricity production.

The options made by each country after the oil shocks are visible in the previous figures. The heterogeneity of electricity production mix, limited by international commitments and European internal rules and objectives, challenges the EU to set-up an European energy policy.

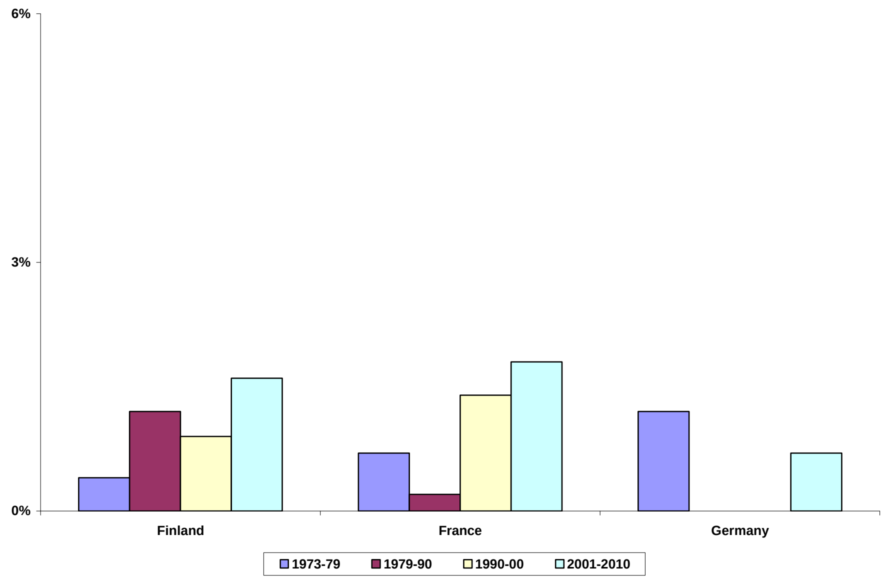
4.3. Energy consumption

In this part we will see the final consumption (CAGR, per GDP unit, and per type of fuel) and the electricity consumption per capita.

4.3.1. Final consumption

The evolution of final energy consumption is clearly different between these two groups of countries as showed in the next Figure 4.21 and Figure 4.22. This indicator includes the final consumption in all sectors (industry, household, services and agriculture) of all energy sources in one country.

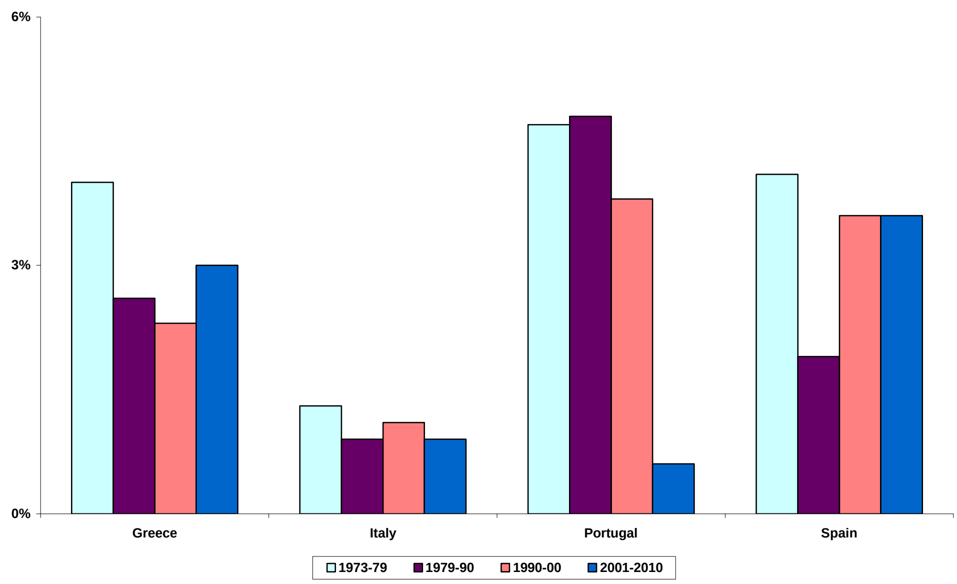
Figure 4.21: CAGR in TFC for northern countries



Source: adapted from IEA Energy Policy Review

We can observe in the next Figure that in Portugal the CAGR between 2001 and 2010 will be much lower than in the previous periods. This is probably due to the introduction of the natural gas in 1998 and the consequent fuel switching and efficiency improvement.

Figure 4.22: CAGR in TFC for southern countries



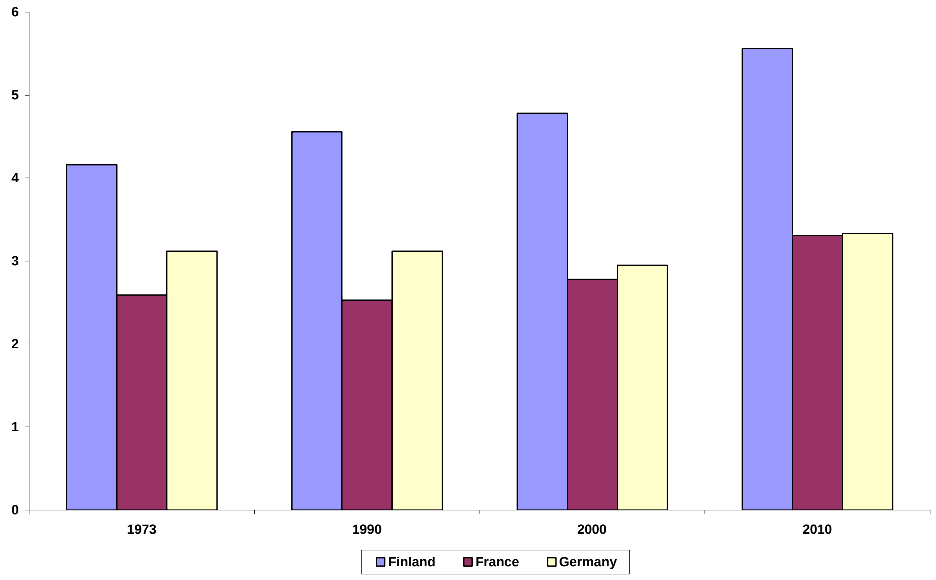
Source: adapted from IEA Energy Policy Review

The energy consumption is another indicator of the country's development. The more developed it is, the higher the need for energy. We can easily see in the following graph (Figure 4.23) that the countries with an earlier development consume more energy than the other ones. Should one expect that this trend changes and that the consumption in the more developed countries will slow down? We think so, although for the moment that can only be observed in Germany.

The final consumption in Finland is higher than in other countries due to special needs of heat for more than 300 days per year, which adulterates this graphic. In addition, the energy intensive industry (paper mills) also helps to increase this ratio.

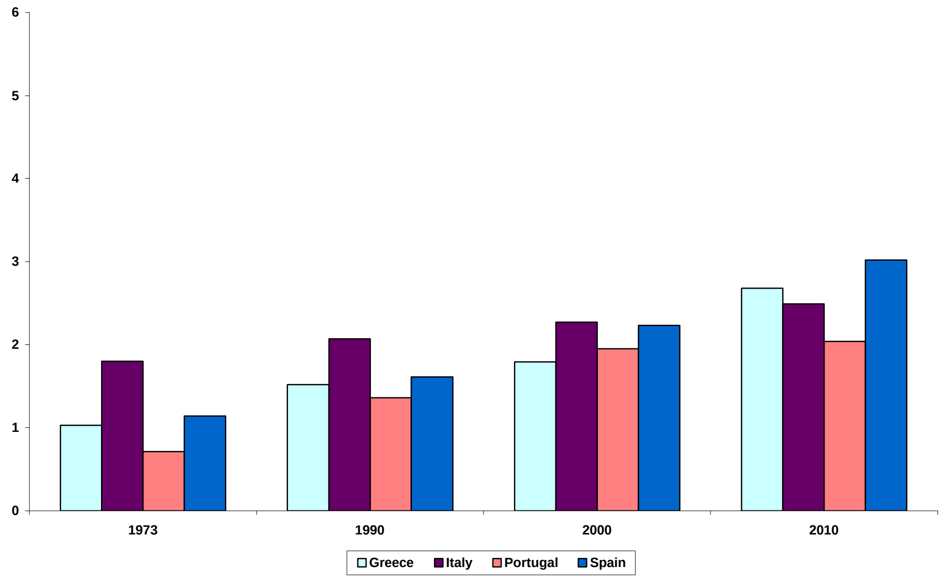
Nevertheless, we would like to point out the difference between the Figure 4.23 and the Figure 4.24. We can notice that consumption is levelling equally or higher than approximately 3toe/person and that this level will not be reach by any of the southern countries other than Spain.

Figure 4.23: TFC per capita in northern countries (toe per person)



Source: adapted from IEA Energy Policy Review

Figure 4.24: TFC per capita in southern countries (toe per person)



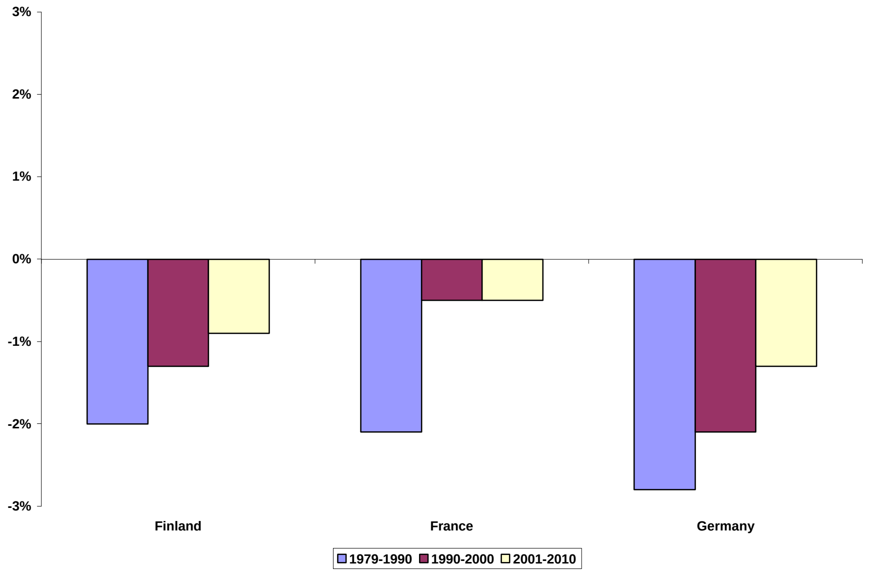
Source: adapted from IEA Energy Policy Review

4.3.2. Final consumption per GDP unit

We can observe in the following figure that the final energy consumption growth per GDP unit trend has been always negative in the north countries is higher in the southern countries (except for Italy) than in the northern ones. This ratio tends to decrease in the southern countries and to become less and less negative in the northern ones (e.g. Germany, France and Finland). Italy has a unique behavior, once it doesn't fit either group of countries.

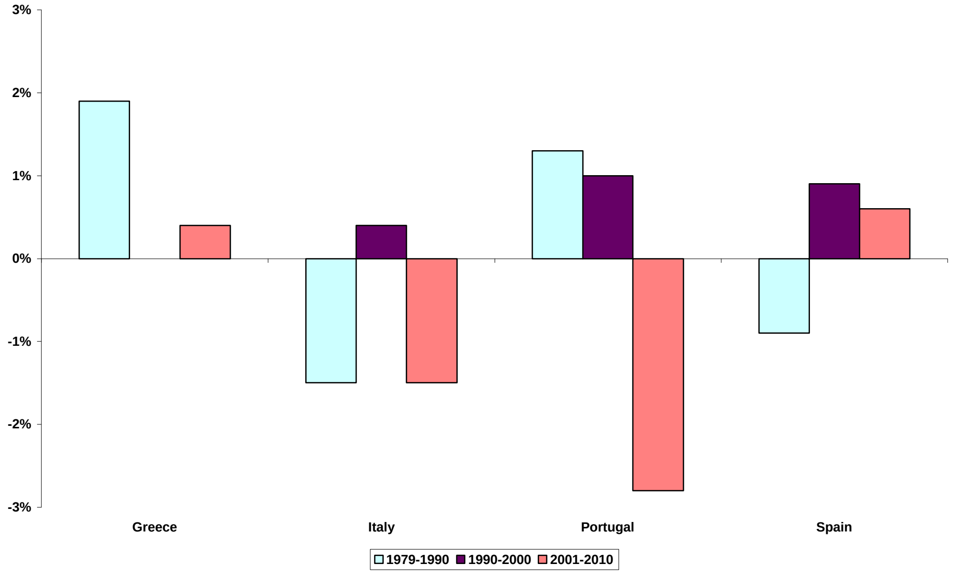
In Portugal a strong fall in energy consumption per GDP unit is expected from 2001 to 2010. This decrease can be related to the increase of the services sector, the displacement of the industry or the creation of micro-industries of high added value but low energy consumption. This trend is only previewed for Portugal in 2001-2010 but was already verified in all the northern countries since 1979.

Figure 4.25: TFC per GDP unit annual growth ratio in Northern countries



Source: adapted from IEA Energy Policy Review

Figure 4.26: TFC per GDP unit annual growth ratio in southern countries



Source: adapted from IEA Energy Policy Review

4.3.3. Final consumption per type of fuel

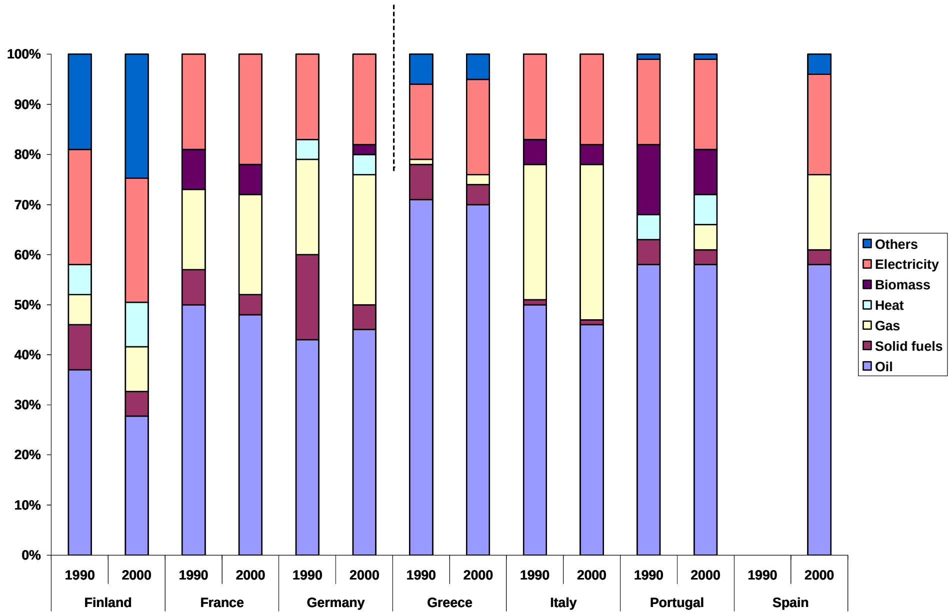
When analysing the final consumption per fuel in our group of countries (Figure 4.27 and the details in Table 12.1) we can easily observe three characteristics:

- The fuel mix is more balance in the northern countries plus Italy. Although the number one source in all countries, oil has less importance in northern ones (plus Italy), showing a more diversified energy mix. The southern countries show a stable consumption of oil.
- We also see the decreasing of the solid fuels part in the final consumption across all countries in particular in Germany where passed form 17% to 9% in 10 years. The opposite happens to electricity, which shows a share of around 20% and is the second most important source in almost all countries.
- Concerning specifically natural gas, we see in the northern countries plus Italy a higher

consumption. In fact, in Italy and in Germany is even the second most important source. Historically these countries have a bigger tradition in natural gas technologies, which explains its penetration rate. However, we see in the southern countries a positive evolution in this fuel. In Portugal, the increase in natural gas consumption can be attributed to the completion of the Maghreb-Europe pipeline in 1996.

This evolution trend can also be confirmed when analysing EU trend in Figure 12.2.

Figure 4.27: Final consumption per type of fuel



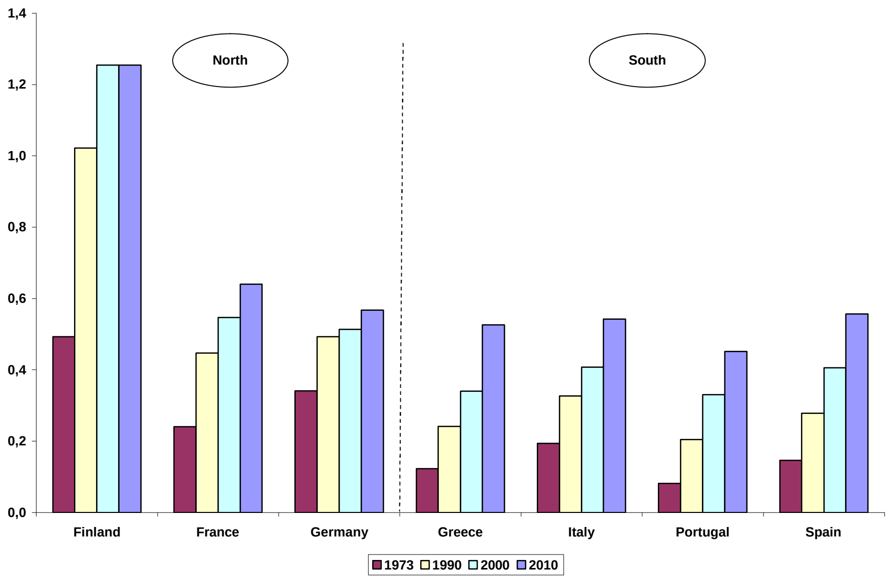
Source: author

4.3.4. Electricity consumption

The electricity consumption per capita shows an increase evolution similar in all countries. Portugal follows this trend and it is expected to arrive 2010 with the level of the others. Finland due to its climatic conditions shows a per capita consumption twice as high the French one. However, while in Finland the trend is to stabilize, the rest of the countries show an increasing trend. As expected, the northern countries show a slighter lower growth rate than the southern ones (Figure 12.1). Therefore, in spite of a history of higher energy consumption, the northern countries levels (except Finland) and the southern ones in absolute terms have been converging to each other.

By analysing the next figure, it seems that in 2010 we will reach a peak in electricity consumption at around 0.5-0.6 toe/person (except for Finland). The stabilisation seen in this figure is the result of the increase share showed in Figure 4.29 and Figure 4.30.

Figure 4.28: Evolution of the electricity final consumption per capita (toe/person)



Source: adapted from IEA Energy Policy Review

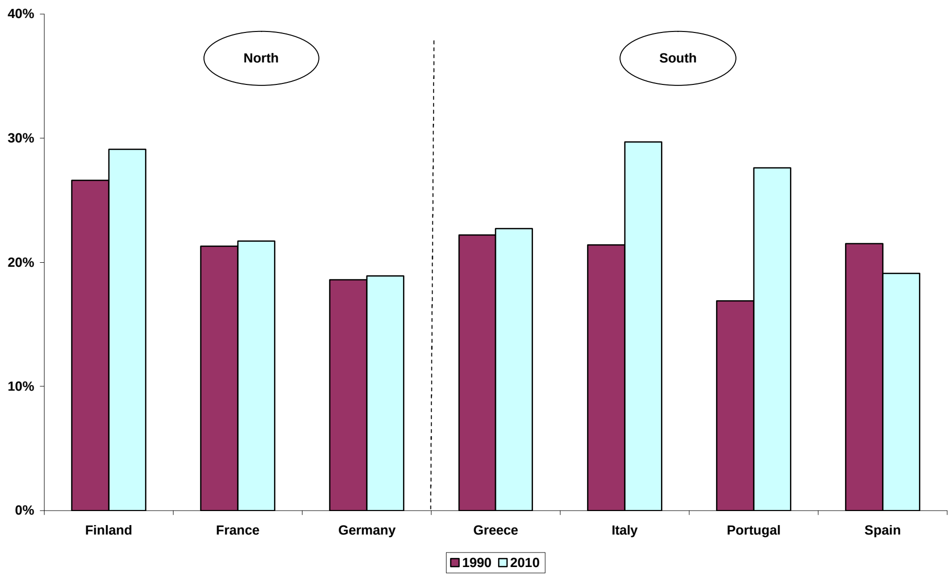
4.4. Sectorial analysis: industry vs. household and services

In this part we will see the evolution of electricity share in industry and household/services sectors and the overall energy efficiency by economic sector.

4.4.1. Evolution of electricity share

The electricity share in industry is expected to increase slightly in northern countries. This trend is also showed in Greece. In Spain, this share will decrease due to the increase of natural gas penetration in this sector. Portugal will see their electricity share increase until 2010, which means that there is room for improvement either in providing electricity energy services or in fuel switching (see also).

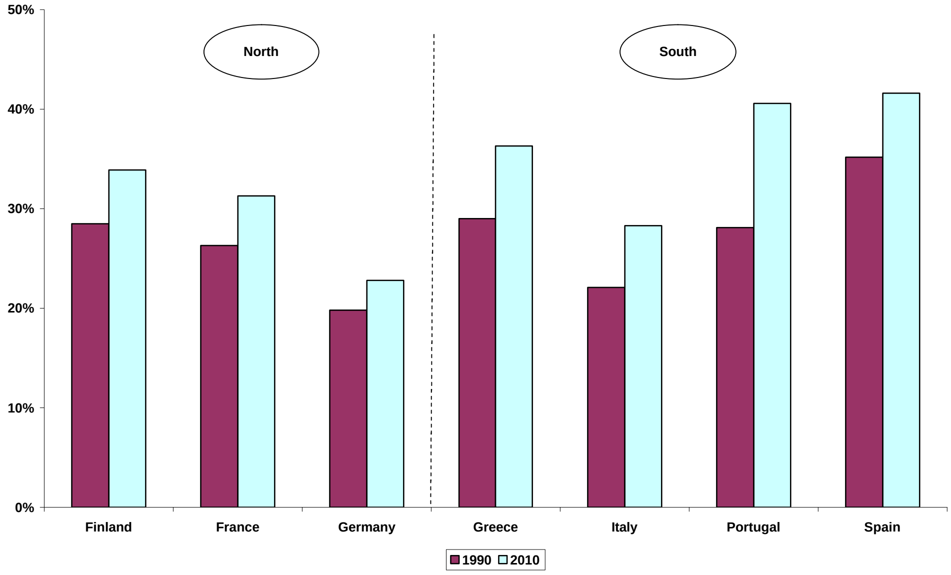
Figure 4.29: Electricity share in industry



Source: adapted from IEA Energy Policy Review

In the household sector, the trend is similar in all countries. Portugal is the one that shows the highest increase (~13% in 10 years), which gives an idea about the increasing demand of this final source.

Figure 4.30: Electricity share in households and services



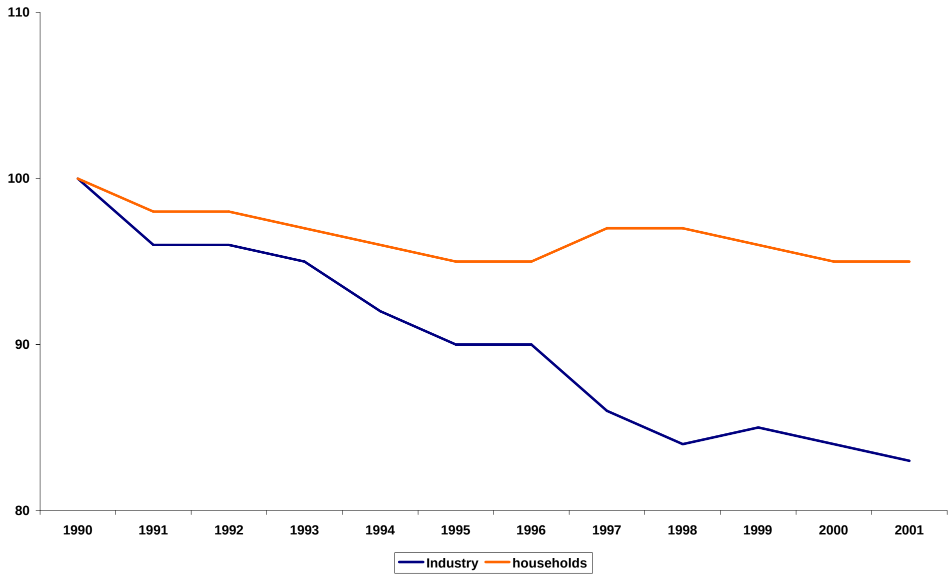
Source: adapted from IEA Energy Policy Review

4.4.2. Energy efficiency by sector

As we can see in the next figure, in the EU, most of the improvement in energy efficiency comes from the industry that presented a somewhat regular efficiency gain of 1.8%/year between 1990 and 2001. In 2001, the industry is almost 20% more efficient than in 1990. In households, the progress is rather modest, with only 5% efficiency improvement in the past 10 years and a set back in 1996.

The explanation for this trend can reside in the fact that industry in more willing to invest in energy efficiency than household consumers do. Industry due to fact that energy is one of the main production factors, analysis the cost-benefit in a more rational way than household consumers do. On the other hand, the market fragmentation in industry is less than in household, which allows a better co-ordination in energy efficiency programmes.

Figure 4.31: Energy efficiency evolution between 1990 and 2001



Source: adapted from Odyssée database

4.4.3. Wrap up

There is room for improvement for the electricity share either in industry or in household/services sectors, which is clearly visible in Portugal and Italy for industry and in all countries for household and services.

This may represent an opportunity for energy companies to increase electricity share. As we will see in chapter 9, electricity represents nearly 85% of captive uses in household consumption.

As expected, energy efficiency evolution has been in a gain evolution especially for industry, while the household sector shows a more levelled trend.

4.5. An estimation of energy productivity

The Oxford Advanced Learner's Dictionary (1989) defines "Productivity" as:

- The ability to produce; state of being productive
- Efficiency especially in industry, measured by comparing the amount produced with the time taken or the resources used to produce it.

The same dictionary defines Productive as:

- Having the quality or power of producing, especially in abundance
- Effective in bringing about
- A yielding or furnishing results, benefits or profits

Resource productivity measures the efficiency with which we use energy and materials throughout the economy - in power generation, manufacturing, services, households and the built environment as a whole. By improving it, we can cut costs and generate more value from finite stocks of non-renewable resource inputs.

Certainly, improvements in resource productivity will not in themselves deliver sustainable development. Resource productivity is about the economic and environmental elements of sustainable development, with little applicability to the social aspects. Even within the economic/environmental axis, assessing policy options in the light of resource productivity will be a complement, not a substitute for proven and successful techniques and policy instruments. These include identification of situations where the market fails to deliver desirable outcomes, and action to make polluters pay the price for the costs their activities impose on society. However, energy productivity does provide an additional lens through which to view the policy challenges and opportunities.

In this part we will begin by introducing the trends in energy intensity. Subsequently we will show the CO2 emission trends either per GDP unit and per capita.

4.5.1. Trends in energy intensity

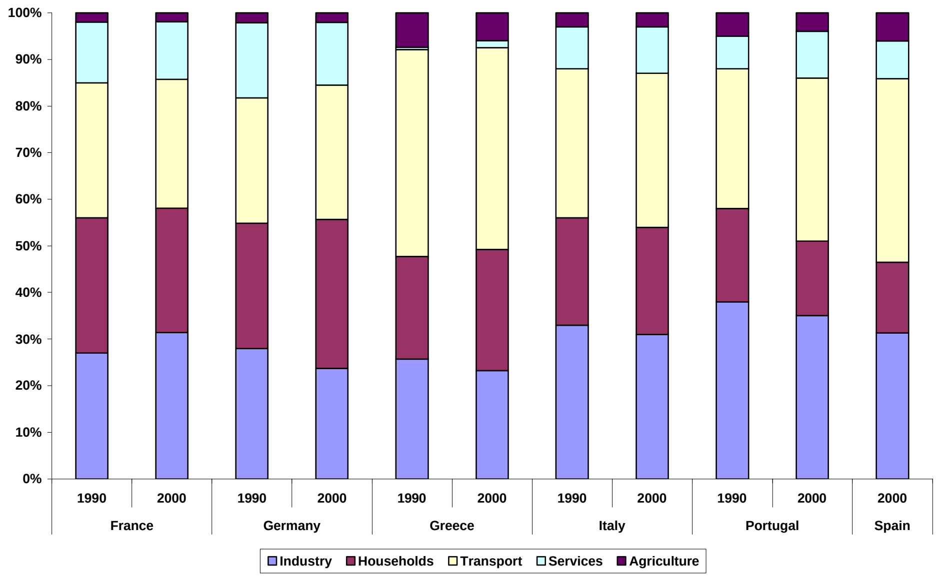
All developed countries, irrespective of their initial level of development, have experienced the movement of labour out of agriculture and into industry, followed by a growth of the services at the expense of both industry and agriculture. This transition between sectors allowed economies to reduce their energy intensity per unit of GDP.

The Figure 4.32 (values in Table 12.2 and Table 12.3) shows the sectorial evolution between 1990 and 2000. Portugal is the where industry still has the highest energy consumption, probably due to lack of investment in new technologies and the late start in natural gas infrastructures (only in 1998) which influences this situation. On the opposite situation is Germany, which decreased its energy consumption in industry by 7% in 10 years, due to fuel-switching and improved technology allied with delocalisation.

The household sector is increasing its consumption in general. The exceptions are Italy with a variation of 0% and Portugal, which decreased 4% in 10 years. The services sector increases slightly its consumption by ~1% except for Germany in which decreases by 2%.

In Portugal, we observe a slight decrease in energy consumption of industry following the trend in most of the other countries. Nevertheless, Portugal still has the highest industry share (35% in 2000). In households, the energy consumption share decreased from 20% to 16% in 10 years, which is opposite to the trend showed in the rest of the countries. In services, the Portuguese trend was similar in the other countries: a slight increase of 3% in 10 years.

Figure 4.32: Sectorial energy consumption



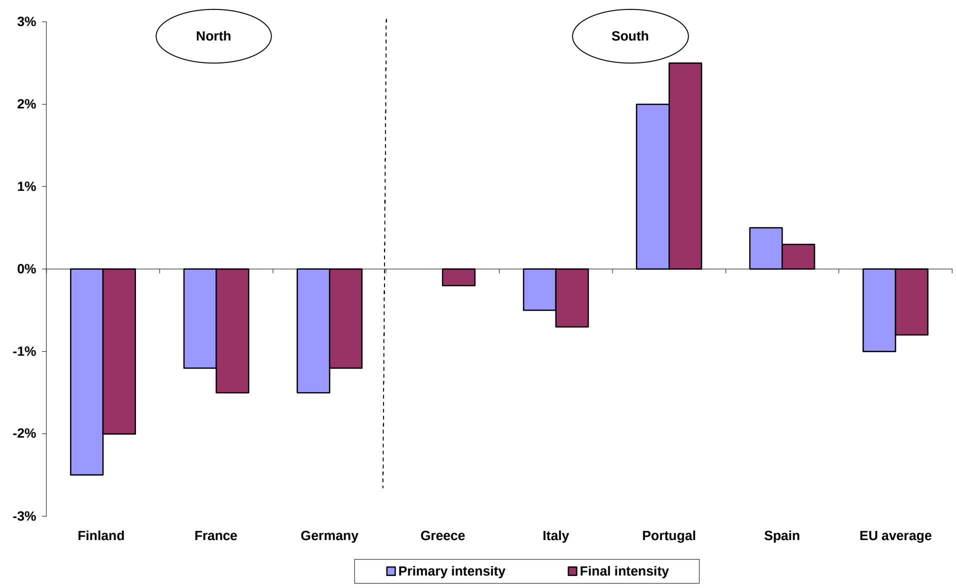
Source: adapted from IEA Energy Policy Review

In the 90's final energy intensities sharply decreased in northern countries plus Italy and Greece. This is linked with an overall improvement of power plants efficiency, penetration of gas-combined cycles and cogeneration.

If no significant change occurs in the structure of electricity generation, the faster growth of the electricity consumption for final users, when compared to fossil fuels results in a widening gap between primary and final intensities, because of increased losses in the electricity sector. However with the introduction of CHP and cogeneration came disturb this trend.

In Portugal and in Spain the variation of primary and final energy intensities are positive. This is probably linked with an economical growing trend showed between 1990 and 2000.

Figure 4.33: Variation of primary and final energy intensities between 1990 and 2000

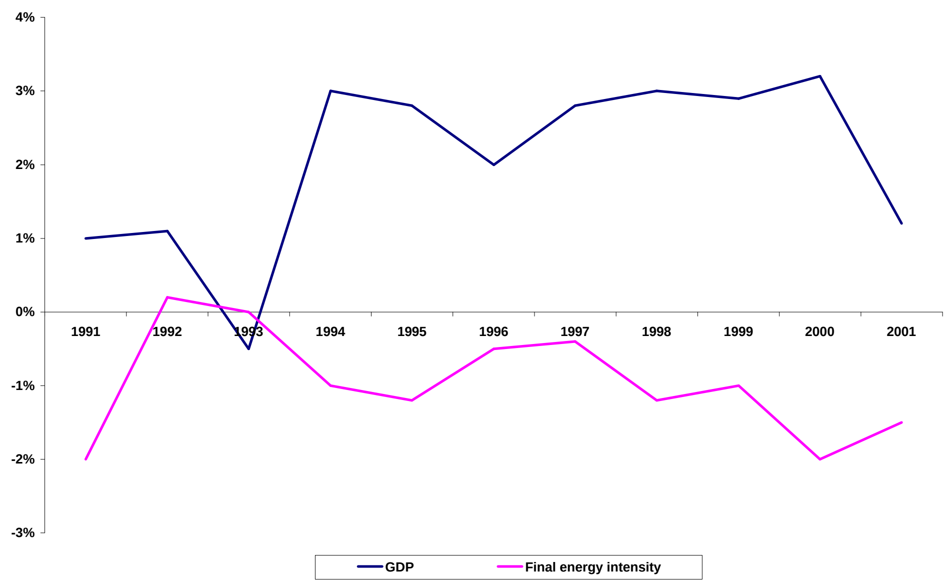


Source: adapted from IEA Energy Policy Review

The relationship between the energy intensity and the economic growth in EU shows that between 1991 and 2001, they were negatively correlated and so it was their growth. When the GDP increased, the energy efficiency increased.

This trend can be explained by the improvement of individual technologies, conversion processes and end-use devices progress, and as inefficient technologies are retired in favour of more efficient ones, the amount of primary energy needed per unit of economic output - the energy intensity - decreases. Other things being equal, the faster the economic growth, the shorter the obsolescence time, the higher the turnover of capital, and the greater the energy intensity improvements. We might even state that some countries improve faster, especially where current intensities are high and economic growth and capital turnover are rapid.

Figure 4.34: Rate of growth of GDP and final energy intensity in EU



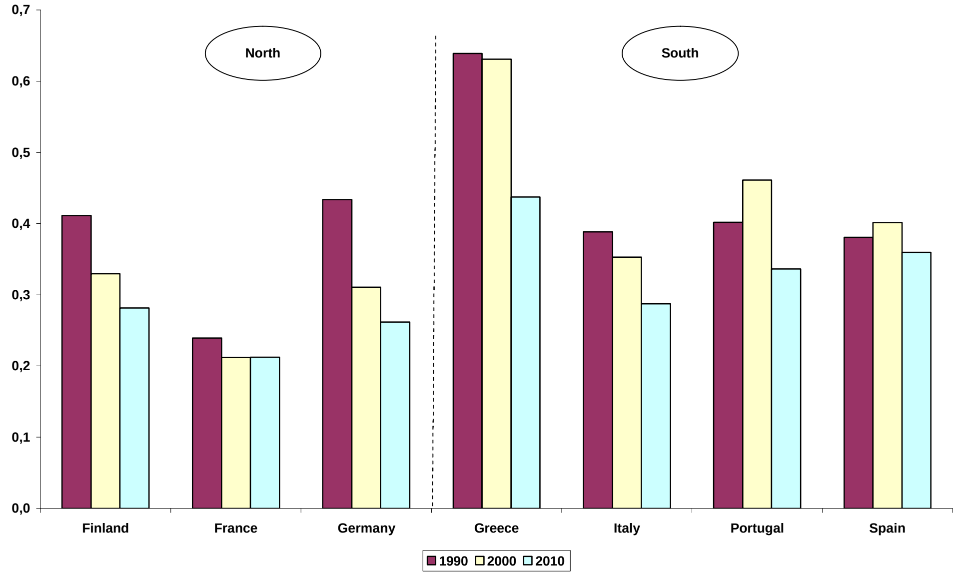
Source: adapted from ENERDATA database

4.5.2. Trends in CO2 Emissions

We saw in Figure 4.34 that in developed countries energy intensity is negatively correlated to GDP, which means that in a scenario of business-as-usual CO2 emissions increase with GDP. A positive correlation between GDP and CO2 emissions was only observed during the oil shocks of the 1970's, which entailed a very specific incentive to close the most energy intensive power plants (Quirion 2004). Therefore, a variation in BaU emissions is usually almost proportional to variations of GDP.

The CO2 intensity per GDP unit is following a trend of general reduction (Figure 4.35), which is more aggressive in the northern countries reflecting their effort to reduce CO2 emissions. In France has the lowest emissions due to their nuclear power, CO2 emissions are stable, while Greece has the highest ones because of their energy mix. Portugal is within the average of about 0.5t. Regarding the effort of reduction, the CAGR (see also Table 12.4) shows that Germany will have the biggest cut (-2.5%) while Portugal will decrease -0.9%.

Figure 4.35: CO2 emissions per GDP unit (t CO2/1000US$95)

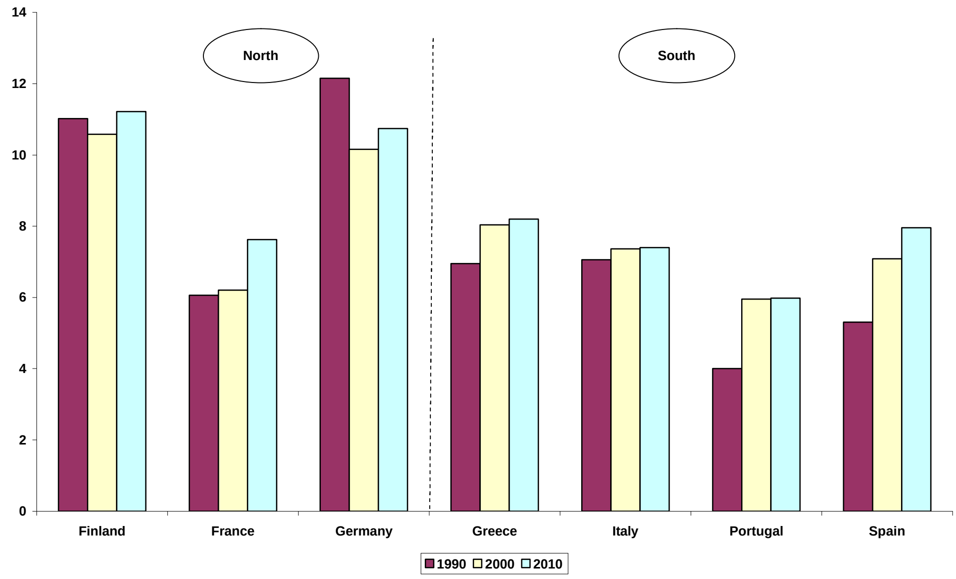


Source: adapted from IEA Energy Policy Review

The general trend for CO2 emissions per capita is stabilization between 2000 and 2010, except for Spain and France. This is the result of the Member States effort to control their emissions in conformity with the Kyoto Protocol. However, if we compare the previous figure with the next one we observe that the northern countries have a lower CO2 emissions per GDP unit and higher CO2 emissions per capita, and vice-versa to the southern countries. This shows the positive correlation between emissions and GDP. However, the elasticity of CO2 emissions per GDP also varies with energy mix. Portugal and Greece have a similar level of development (GDP Portugal = 0.9 GDP Greece) but completely different emissions (Figure 4.35 and Figure 4.36).

We can observe in the Table 12.5 that in all countries the trend in of increasing the CO2 emission per capita (slightly in Portugal but considerably in France) while the CO2 emissions per GDP shows an opposite trend, except in France. In Portugal and Greece, this trend is considerable reaching -3% and -3.5% respectively, which may be linked to fuel switching.

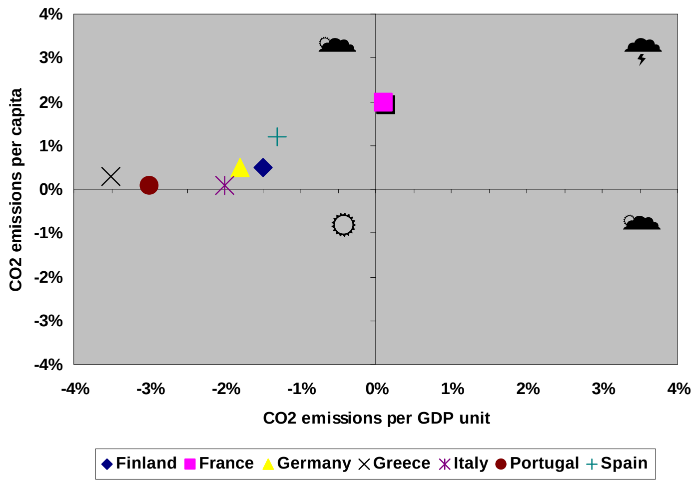
Figure 4.36: CO2 emissions per capita (tonne CO2 per capita)



Source: adapted from IEA Energy Policy Reviews

When we plot the CO2 emissions per GDP unit and per capita for the period of 2000-2010 (Figure 4.37), we can observe that only France is not following the trend of the other countries. In this country the expected value for CO2 emissions per GDP unit will be null, which shows a remarkable economical efficiency: their emissions will grow at the same pace of their GDP growth, while in the other countries there will be a reduction, i.e. in these countries some environmental improvement can still be achieved which is quite visible in Portugal and Greece, as mentioned before.

Figure 4.37: CO2 emissions evolution trend wrap up in several European countries from 2000 to 2010.



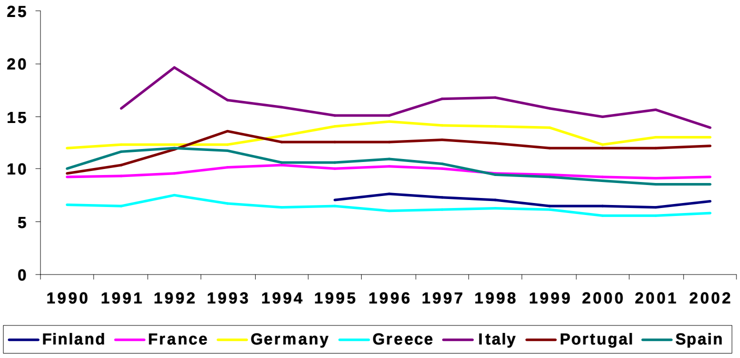
Source: the author

4.6. Energy prices

We can see in the next figure the general trend of stabilisation in the household energy prices (3500KWh per year) between 1990 and 2002 with an average CAGR of -0,14% (view Table 12.5). The highest price was reached in Italy (1992 – 19,68€/100kWh) and the lowest was the Greek one in 2001 (5,64€/100kWh). According to IEA Energy Policy Review (2003) the Hellenic government tends to use retrain rises in the electricity price as a macro-economic policy designed to control inflation.

We can also see the trend of convergence between prices. In 1994 the difference between the highest and the lowest price was 7.5 c€/kWh (and reached 7.8 c€/kWh in 1995) but have been decreasing gradually and in 2000 was only 5.3c€/kWh. The reason for this trend is the improvement of interconnections and in the gradual opening of markets allowing competition between producers.

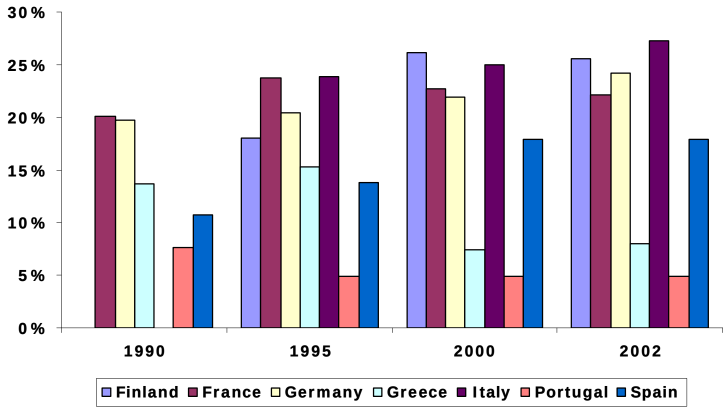
Figure 4.38: Energy prices for household consumers (3500 KWh per year, Ecu/€ per 100kWh)



Source: adapted from Eurostat

In terms of taxes, we observe that the taxes have usually the highest value in Italy and in Finland. From this figure we can also say that the heterogeneous character in taxation in these countries and in the rest of Europe also influences the electricity consumption.

Figure 4.39: Taxes in electricity (considering a consumption of 3500KWh per year)



Source: adapted from Eurostat

4.7. Wrap up

First of all, we would like to say that like any other projection, the consistency of the data presented depends on so many variables that it is very difficult to determine their estimated effectiveness. Therefore any conclusion is naturally made believing that these projections will verify. At the end of this chapter, we can conclude:

- Although the gap between northern economies and southern ones is decreasing, in 2010 there will still be a gap. In general, Italy shows the behaviour of a northern country; however, we believe that this behaviour is the result of the northern Italy economy pulling the southern one. The decreasing trend of the northen and southern economies is a result of the economic and social cohesion policy followed by the EU, which allowed Portugal for example to pass from
- As expected, the total final consumption (TFC) is growing at a much faster pace in southern

countries than in northern countries. Although these still consume more energy per capita, they follow a stabilising trend at around 3toe/person. This trend, we assume, is also being followed by the southern countries in their growth. Portugal shows a trend of moderate increase and it is expected to arrive 2010 with 2toe/person of TFC, while Spain will reach Germany and France with 3toe/person. This slow down in TFC per capita in Portugal in the period 2001-2010 is probably a consequence of two things: delocalisation and growth of less energy intensive industries and fuel switching.

- Regarding the structure of electricity production, we see that natural gas is the fastest growing component of the fuel mix, spurred on by its desirable environmental properties and by the growth of the natural gas resource base over the past decade. Gas competes most directly with coal, which has lost substantial market share in recent years. While nuclear energy continues to play a major part in European energy, the industry's long-term future appears increasingly uncertain.
- We can also observe that the energy mix in electricity production is maybe linked to CO2 emission trading objectives. It would probably be interesting to observe the mix beyond 2010. The options for 2010 were forecasted 15/20 years ago and therefore to take into account the actual options at today we should look further. Only in 2020-2025, we may observe the impact of the Kyoto Protocol and the Emission trading directive the countries' energy mix.
- Efforts to phase out nuclear power completely in Germany, for example, are ongoing, and enjoy the support of major political parties and segments of the public. In other EU countries such as France, however, nuclear power provides more than half of the electricity consumed. In the longer term, European energy integration and deregulation may pose an even more serious challenge than popular opposition has thus far to the future viability of the European nuclear power industry. Cheaper, less capital-intensive, and possibly less risky fuel sources like natural gas could undermine future investments in nuclear plants. Renewable energy plays a small but growing role in the European energy mix. As more countries impose carbon taxes and renewable portfolio standards, renewable energy is expected to gain a larger market share in upcoming years.
- The countries show a similar evolution in electricity consumption. Even if northern countries show a higher consumption, southern countries are converging to the same value at around 0.5toe/person.
- Electricity share tends to increase at a higher pace in household and services then in industry. In this last sector is more visible the transfer to natural gas.
- The relationship between the energy intensity and the economic growth shows that between 1991 and 2001 they were negatively correlated and so was their growth. When the GDP increased, the energy efficiency increased.
- CO2 emissions differ a lot when analysed in absolute and per capita. The higher consumers in absolute are the lower consumers per capita (Portugal and Greece). However, the trend in these countries is to reduce the CO2 emissions per GDP and stabilize those per capita. In the other countries, this is also happening. The explanation can be given by technology improvements and policy implementation.

5. Policy development and regulation: capturing the economic opportunity of energy efficiency

The objective of setting up a legal framework for energy efficiency is because the market may be considered as incapable (by itself) to overcome the opposing barriers to energy efficiency. To this matter Golove and Eto (1996) consider that market failures are well accepted among economists as providing a legitimate basis for government intervention.

But how can we identify a market failure? Basically market failure occurs when markets are not working optimally (do not bring about economic efficiency) i.e. there is a Pareto sub-optimal allocation of resources. In simple terms, the market may not always allocate scarce resources efficiently in a way that achieves the highest total social welfare. However, Franzini (2001) states that according to Coase any Pareto relevant externality, i.e. any deviation from Pareto efficiency, may be overcome if property rights are well defined and there are no transactions costs. Therefore this has to be the goal of any energy efficiency policy.

According to the economic theory if we only continue to consider the supply side of the energy chain, this will not be the most efficient process available. So, in order to have an energy chain truly efficient and if we aim the elimination of “slack” across this chain, we have to start considering the demand side as energy efficiency “buyer”.

In this chapter, we will start by introducing and setting up the energy policy context in Europe and discussing the need of defining an energy efficiency policy at a European level and present the energy savings potential. We will then discuss the role of energy efficiency in a liberalised market context and in what extent the actors’ tasks have changed with the market change. Subsequently we will discuss which the energy efficiency policy goals are.

5.1. The need to define an energy efficiency policy

The introduction of an energy efficiency legal framework may collide with the IEM and IGM Directives in some aspects (as we will see in chapter 8), so it's very important to have a policy that introduces clear principles, definitions, harmonises targets, establishes a list of possible means of action and organise reporting.

We will begin by analysing what are the main economic benefits of introducing an energy efficiency policy. Subsequently, we will discuss the reasons why it is important to implement it and the saving potential achievable.

5.1.1. Economic benefit

The economic benefit is only one of many motivations for energy efficiency, and it is often not the primary one (other may include resources optimisation or environmental impacts mitigation). However, sometimes the optimum policies for maximizing economic development benefits may be different from the optimum policies from a resource planning or environmental impact perspective[19].

Economic benefits may be defined as “…benefits which create additional real income for people through the expansion of salaries and profits” (Weisbrod 1995). Although we can set monetary values for environmental benefits in benefit/cost analysis, and those benefits can be very real, their value is not necessarily translated into “real” money in peoples' pockets. That is why we must look carefully to energy policies and that is why it is important to evaluate the value of overall benefits in a benefit/cost analysis and their impacts on the economy.

The economic argument against energy efficiency policies is that they are not compatible with the increasing competition companies are facing. However, electric companies may have, in some cases, a number of advantages over other actors in delivering end-use energy efficiency, or at least participate in these activities. In a competitive environment, energy companies might be affected by energy

[19] For example, from a public policy perspective, the most appropriate form of energy efficiency programs may be dictated by any combination of these motivations.

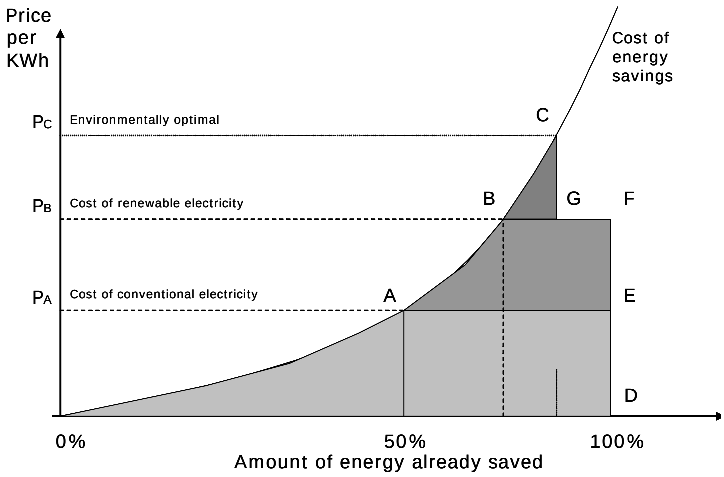
efficiency policies. Therefore, it is necessary to establish a strong commitment through an effective policy in order to work as an incentive to energy companies to promote energy efficiency.

Evolving to an economically rational energy policy

A simple model presented by Norgard (2001) help us to understand the economic benefit of energy savings.

End-use energy savings should be considered as an environmental protection measure, as these are in general more benign than any clean energy supply system. However, most energy saving policies do not specifically ascribe any value to these environmental benefits from end-use savings, as they often do when subsidising renewable energy (Norgard 2001). According to the same author energy taxes in some countries account for some of this, but usually they are small and insufficient, especially for the industry. The following simplified model will be used to illustrate some basic features about the role of energy savings in an economically rational energy policy, aiming at environmental sustainability.

Figure 5.1: Incremental savings per kWh



Source: adapted from Norgard 2001

It is generally accepted that the socio-economic cost of saving a kWh of energy in the prevailing energy systems is much lower than providing one (Norgard 2001). However, the cost of saving another kWh of energy increases with energy that has already been saved.

Even if we consider all the "tunnelling" options[20], the overall macroeconomic picture will be that not all of a country's energy consumption can be saved and that there are differences in the cost of savings.

It seems obvious from Figure 5.1, that the critical level of energy savings with a conventional system is the point "A", where the curve intercepts the line indicating the cost of providing a kWh from a conventional supply system based on fossil fuels, nuclear or other no sustainable resources, assuming that no external environmental cost are included. According to Norgard (2001), a value of ~50% for A corresponds to a usual situation for electricity savings.

The total annual cost of the original system would be represented by the square under the line "cost of conventional electricity" (area [0 P_A E D]), but the total annual cost after savings is the shaded area under the curve for "cost of energy savings" up to the point "A", and after that the horizontal conventional supply line (i.e. the area [0 A E D]).

To reach the critical mix of savings and renewable energy supply, savings should be carried to point "B", where the marginal cost of saving another kWh equals the cost of providing a kWh from

[20] As for example when insulating a house in a cold climate which will require no investment in a heat distribution system and therefore becomes cheaper than a somewhat less insulated house.

renewable energy sources[21]. Therefore the total annual cost of the original system would be represented by the square under the line "cost of conventional electricity" (area of [0 PB F D]), but the total annual cost after savings is the shaded area under the curve for "cost of energy savings" up to the point "B", and after that the horizontal conventional supply line (area [0 B F D]).

If a more general environmental optimisation view should be applied, it should recognise the energy savings as being environmentally more benign than even renewable energy supply. Consequently, savings should be continued up to the point, where the savings curve at point "C" intersects the horizontal cost line for renewable energy supply, when including external environmental costs of the renewable supply systems. The shaded area [B C G] represents the cost of this system.

As Norgard states, in this simple model, "an economically rational energy policy towards sustainability should be based on accepting a marginal cost of saving a kWh higher than the cost of providing a kWh, even from renewable energy sources" and we should be apt to pay considerably more for one kWh saved that for one kWh produced. However, the rational economic arguments presented above do not reflect the real world. An example of this is the city of Kawagoe in Japan. The city administration launched a campaign aimed at reducing its annual electricity consumption by 1% every year. After 4 years, the city had saved (had essentially no investment) 5% of electricity and around 2.5 M$ [Kawagoe City, 2000 referenced in Norgard, 2001). The money saved was spent on paper recycling and other environmental purposes, including 0.35 M€ in subsidies to very expensive photovoltaic systems. None of the money saved was planned to be spent on further energy savings, which could lead to higher savings than the output from the investment in photovoltaic systems. In other words, they jumped from the cheapest options on the left side at the Figure into the expensive right side.

An argument for this non-rational energy policy is that photovoltaic systems constitute a new technology in need of governmental subsidies to make it into the market. It seems that because many energy saving options are in fact cost-effective, the energy saving policies are often limited to those savings only, ignoring the many other options after point "A" in figure, not to mention those beyond point "B".

5.1.2. Creating an energy efficiency policy

The best way to support a coherent development of energy efficiency is to have a harmonised policy action at the EU level supported by the correct instruments.

In this point, our opinion is convergent with Swann's (1996), which states that there is a need to define a harmonised policy framework. The reasons for this are:

- The need to complete the efficiency energy chain. The IEM and IGM Directives brought efficiency to the supply side but not for the demand side. In order to create a competitive market in the demand side across the EU, it's necessary to harmonise targets;
- The economic and social benefits to the EU Members States in reducing demand and energy costs. The convergence between States will increase with the harmonisation of an energy efficiency policy;
- The International commitments made by the EU (like the Kyoto Protocol). By a harmonised policy, Member States can arrive more successfully to their emissions objective. In the communication from the Commission number COM (2000) 88-FINAL is referenced that energy efficiency and energy services are one of the proposed policies and measures to mitigate climate change.

Two of the major instruments in order to guarantee a policy success are monitoring and subsidiarity.

The importance of monitoring and controlling is reflected in the possible consequences of faking results. In fact, this newly integrated energy market, without the lack of a clear definition for e.g. monitoring and public reporting of results, risks an unclear application of funding.

Getting a good picture of the results can help the Commission to establish fair consequences to Member States if they do not follow EU obligations. This process should be as clear as possible in order not to harm the energy efficiency European policy.

[21] For simplification, we ignore the fact, that exploitation of renewable energy also has a growing marginal cost (partly due to the random character of most renewable sources like solar and wind).

Subsidiarity is an important issue as the different Member States contribute differently to the global EU status. As the development gap between these 25 countries as high as today it doesn't make any sense to ask Portugal, for example, to contribute the same way as Germany or France. Therefore, the best scenario is not to aim for a single target, but for a different target according to the level of development, market structure, competition stage, etc.

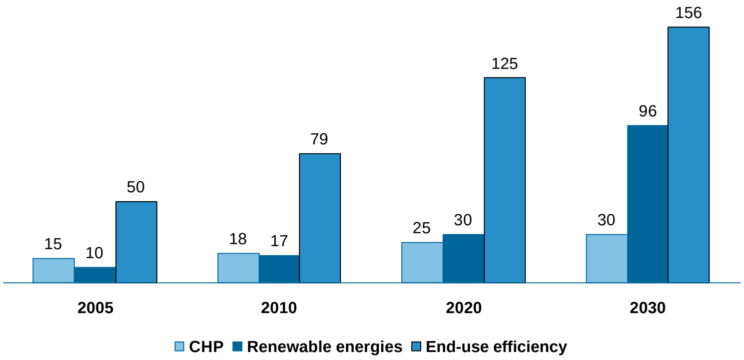
As a wrap up we would like to say that we believe that a legal framework regarding energy efficiency should be put in place (as it most certainly will be, we just do not know when…) and the EU should try to design it in a way that takes into account the issues previously presented.

5.1.3. Energy savings potential

There is a large potential for cost-effective end-use energy efficiency. This potential was called by Lopes (2000) as a “free lunch that you could even be paid to eat”. Although, some argue that this potential is just the result of engineering calculations and that we should, at the most, speak about a "no-regret" option. According to Morthorst (1994), no-regret options exist when it is economically attractive for society to undertake these options and at the same time reduce CO2 emissions.

In order to understand the energy efficiency potential we must relate it to other measures/technologies. The Wuppertal institute published in 1998 a comparison relating end-use efficiency, renewable energies and CHP contributions with CO2 reductions (Figure 5.2). As we can see the end-use contribution has a much higher potential (~4 times in 2010) to reduce CO2 emissions than the other two experiences. Also interesting to notice is that only in 2020 renewable energies will pass CHP contribution to CO2 emissions reduction.

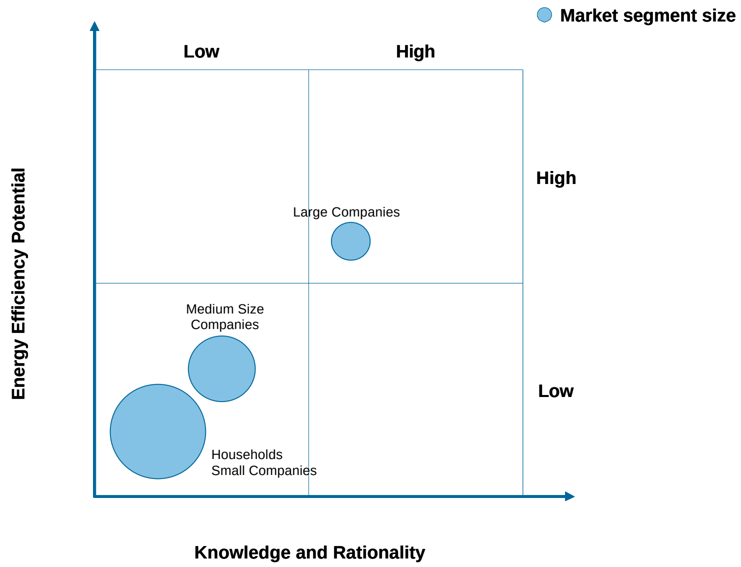
Figure 5.2: Contribution in TWh/year to CO2 emissions reduction



Source: adapted from Wuppertal

When putting energy efficiency potential in a knowledge matrix (Figure 5.3) is easy to see that in large companies market segment the changes might not be as drastic. The companies are more aware of energy efficiency than the general consumer is and for them energy is sometimes a production cost factor that is responsible for a good part of the final cost (e.g. 30% in cement industry).

Figure 5.3: Energy efficiency potential/ knowledge and rationality matrix



Source: the author

Industry

If we analyse the most important crosscutting industry categories, we are able to find the real potential in energy efficiency but without taking into account any economical or commercial factors regarding the investments.

In the next figure adapted from the Atlas Project[22], both end-use and energy conversion are listed with regard to potential energy savings on industrial primary energy in the long term. The last column shows an estimate of the technical long-term savings potential in each category. As we can see categories with large potential energy savings on industrial primary energy use, are furnaces and burners, co-generation and motors and drives. However, if we analyse the figure in terms of long-term savings, the largest potential is in lighting.

Table 5.1 Estimated EU savings on primary energy by implementation of crosscutting improvement technologies in 1996

	Primary Energy use (%)	Long Term Savings (%)
End Use Technologies		
Motors/Drives	**13**	10-20
Separation/Drying	2-4	5-30
Refrigeration	~8	>20
Lighting	1	~40
Waste heat recovery	n.a.	5-40
Energy Conversion Technologies		
Boilers	~7	15
Furnace/burners	**30**	5-30
Cogeneration	**~15**	8-15

Source: adapted from the Atlas Project

Although no share of industrial primary energy use is given for process integration and waste heat recovery, the savings potential in these categories is rather large (up to 25% for process integration, and up to 40% for waste heat recovery). Uncertainties about the potential energy savings in these two categories, are however, rather large. It is also important to realise that the total savings of each

[22] Site : http://europa.eu.int/comm/energy_transport/atlas/homeu.html

category cannot be easily added up, because technologies may not be independent, e.g. heat pumps and refrigeration or heat pumps and waste heat recovery.

Household

The U.S. experience, in the household sector show us that the saving potential is real and can be obtained up to 65%. The main savings can be reached in water heaters and clothes washers/dryers.

Table 5.2: Estimated USA long-term savings by end-use

	Long Term Savings (%)[23]
Refrigerators and Freezers	9-17
Water Heaters	34-65
Central and Room AC	28-41
Heat Pumps	27-35
Cooking equipment	8-47
Clothes washers	35-63
Clothes dryers	23-65

Source adapted from McMahon James in CRC Handbook (1998)

However while reaching industry is easier given their fragmentation (less players) and the importance that energy has in the output price, reaching savings among the general consumers is more difficult. The regular consumer does not know how much he spends in energy every month and its energy budget is relatively less important than other like food or house rent.

Another issue is the inelastic (at least in short-term) characteristic of energy consumption. Even if prices rose from one day to another our energy consumption would remain the same for a certain period (like it happen in Europe in the 70's oil crisis) until we adapt and change our habits. This issue is important because it demonstrates that people are neutral up to a certain level to energy prices increase. This inelastic characteristic is showed by, in the Figure 12.3 a 0% variation in price growth leaded to energy consumption CAGR of -3% in Europe. In the Figure 12.4 shows in Finland that a CAGR of 24% in price was accompanied by energy consumption CAGR of only -4%.

According to Darby, the highest savings (~20%) verified in 38 studies between 1975 and 2000 were achieved by using interactive cost and power display units: a smartcard meter for prepayment of electricity and an indicator showing the cumulative cost of operating an electric cooker.

In Portugal

In Portugal, there is also a great potential of energy efficiency in electricity consumption. According to Simões (2001) the following results were obtained through a Least Cost Planning (or IRP) pilot project carried out by EDP Planning Department and the University of Coimbra, based on the substitution of the existent equipments for more efficient ones available in the market in 1992 (the time frame for the study was 1992 to 2000):

- 27% saving per year (4236.3 GWh/yr) in the industry sector, in which motors represent more than half of the saving potential;
- 34% saving per year (3525 GWh/yr) in the residential sector, in which refrigerators represent the largest saving potential followed by freezers, lighting and clothes washers;
- 40% saving per year (4508.6 GWh/yr) in the services sector, in which lighting is more than half of the savings potential, followed by space cooling.

It is important to notice that in spite of these results only representing a technical potential and not considering the utilisation patterns and the difficulties with the implementation of these new equipments, they can help us to set our goals.

[23] Values vary depending on the technology used.

5.2. Energy efficiency in liberalised markets

The development of liberalisation and market forces transformed the dynamics of energy industry as well as of the energy consumers. Within this new environment, energy will be generated, traded and consumed like other commodities. Competition and new incentives have a deep influence on energy efficiency policies, both on the supply and on the demand side.

The entire energy sector in Europe was pushed to rethink itself. Planning and monopolised supply structures have failed to deliver economic efficiency in competitive markets. The electricity sector needs to be more consistent with market economies.

Electricity liberalisation appears as a reply to this issue. The most profound changes and the most important driving mechanisms in the liberalisation of energy markets are the introduction of consumer choice and the simultaneous abandonment of institutionalised and geographical monopolies. In general, competition will cause a downward pressure on prices and costs, as these are "inextricably associated with higher demand in spite of a short-term inelasticity of demand." (Kemper 2002). This effect is mostly due to a combination of excessive monopoly cost structures and "structural overcapacity" which slows when multiple previously contained trading areas are merged into one market.

From a macro and microeconomic point of view, the advantages of liberalisation are several: improved utilisation of fixed assets (generation plants and grids) leading to economically correct investment decisions, and to reduced consumption of resources within the overall system (i.e. reduced operations expenses through restructuring and cost cutting), consumers are placed in a more powerful position in a competitive market place, the efficient pricing of electricity reflecting demand fluctuations/trends, costs and availability of natural resources, higher receptiveness of industry to economic signals, which creates a sector more responsive to the use of taxes and instruments for the internalisation of environmental costs.

In this chapter, we will begin by introducing in how the roles in the energy sector have changed and what are the main impacts of this liberalisation. At the end, we will be able to understand which key drivers for this change and its advantages and disadvantages are.

5.2.1. Redefinition of roles

The changes in the industry following liberalisation were remarkable. This complete transformation of the industry was caused by a combination of legal and regulatory requirements, mounting market forces and widespread privatisation of energy industry. The consequences are, for good and for bad, a profit-oriented industry with the characteristics of most other competitive industries. The key words now are "profit maximisation".

Transmission companies will become regulated monopolies. Regulation limits profits, but rewards those companies that demonstrate an ability to improve efficiency and to cut costs. The central aim is to attain fair and non-discriminatory transmission charges. Tariffs should be kept low by controlling the profits and the cost level of the natural monopolies. (Esnault 2003)

The generation and retail of electricity will evolve into two different and very competitive industries. Substantial overcapacity will punish high cost generators. With the exception of depreciated generation plants with low to moderate marginal cost, generation will decrease its margin business. Industry will focus on the cost structure and make efforts to improve the efficiency and utilisation of their assets.

Unlike most other commodity businesses, electricity retailing is characterised by low capital investments. The grid company takes care of the physical supply and no electricity customer needs to be concerned about supply security when choosing a supplier. Retail of electricity will be a low margin business where economies of scale require significant volumes of clients in order to reach adequate returns (Kemper 2002).

In competitive electricity markets, consumers may escape captivity to enjoy freedom of choice, which makes them more powerful individually and as a group. When markets are liberalised, consumer's expectations are focused on price cuts and savings, contributing to a stronger consumer focus on energy costs in general, which could make him more receptive to economic efficiency projects. Governments reorganise new functions such as policymaking, licensing, ownership, regulation and policy implementation in a clearer way.

5.2.2. Effects of liberalisation on energy efficiency

The liberalisation process has significantly changed energy markets. These changes can be observed in different areas. We will now overview some of the areas where the changes were important.

Generation & Transmission

The most significant consequence on the energy generation business is the improvement in overall economic efficiency. Competitive pressures force generators to examine every opportunity to cut cost and restructure their businesses.

Liberalisation knocked-out the least cost-efficient plants, specifically those with high operations and fuel cost. Typically, such plants are the least fuel-or energy efficient plants in industry. The development of environmental regulation and emission taxes/quotas will further punish such capacity and contribute to an improvement of energy efficiency.

The energy trade tends to expose the generation overcapacity, which will favour the low cost producers. Consequently, some generation capacity will be permanently obsolete. The improved utilisation of generation capacity will postpone new investments until electricity price prospects exceed the cost of new capacity.

In the longer run when considering the effects of investments in new capacity, liberalisation will favour a different technology mix in power generation. New investments in generation are likely to be directed towards smaller size plants with higher efficiencies and more favourable environmental impacts. Such projects are characterised by lower capital investments and much shorter lead times. (Esnault 2003b)

In transmission, those companies that are able to demonstrate efficiency improvements will retain a higher profit. Conditions such as previous investment levels, structure and cost level of the transmission industry collectively indicate a significant potential for efficiency improvements.

A more restrictive practice in accepting grid investments by the regulator may reward grid companies for better utilisation of existing capacity and for stimulating end-use energy efficiency. Moreover, this incentive may increase grid consumption that represents an important revenue source. Therefore, this sends a contradictory signal, since a reduction of grid investments and higher loads and energy throughput may eventually lead to lower energy efficiency in the transmission system. A good market architecture and regulatory system may mitigate this and ensure an optimal level of energy efficiency.

Energy price

By nature, most electricity systems lack storage capacity and electricity markets experiences volatility due to the need for continuous balancing of demand and supply. Volatility in the electricity market is due to the hourly, daily, and seasonal uncertainty associated with fundamental market drivers and the physics of generation and delivery of electricity.

Lower prices will fuel demand growth and consumers will eventually substitute other energy forms with electricity. This may sidetrack the development of district heating schemes/heat pumps and make natural gas and fuel oil less competitive heating sources. From an energy efficiency point of view, this is undesirable as electricity is often a less efficient heating source[24].

Future electricity prices will also reflect the costs of producing power. The increasing reliance on natural gas-fired power plants means that these plants will continue to play a major role in setting the market prices for electricity.

In fact, natural gas and electricity tend to be more volatile than oil due to the lack of supply "pillows" to absorb fluctuations in the supply-demand balance. We can always have access to strategic oil stocks, etc. but natural gas a lower storage capacity than oil, and electricity (by its nature) cannot be

[24] In general, if the have the same access to an energy source and an intensive use, gas tends to be more competitive than electricity. This advantage of gas is positively related with the time of use, i.e. an intermittent use would probably favour an electricity appliance. The other aspect we want to refer is the infrastructural one. While electricity is spread around Portugal, the gas infrastructure is more concentrated, which implies that the transportation of gas to areas where there is none, is very expensive.

stored. Therefore, demand of both natural gas and electricity is immediately affected by the temperature (which can swing largely in a short period).

When energy prices fall, consumers are less likely to incur in energy efficiency investments due to poorer project economics. On the contrary, lower energy prices demand for energy. Liberalisation in a market such as electricity may change relative prices between energy carriers and cause substitution effects, which may significantly escalate demand for electricity.

This transitional challenge is exacerbated by consumer expectations, which, in a normal case of liberalisation, are biased towards the prospects of immediate price reductions. Without adequate information about the long-term effects of the market liberalisation on prices, this may shift consumer behaviour and focus them away from the long-term savings potential of energy efficiency investments.

Another potential challenge to energy efficiency is the uncertain price environment caused by liberalisation. Markets are characterised by price volatility and, especially in a period of transition into a mature market environment, price developments may be hard to predict. There are more and more people intervening in the market at the same time and the subsequent increasing transactions cause additional volatility. Thus, price fluctuation and volatility are natural part of open and market-based economies.

A new breed of energy services companies will emerge in the wake of liberalised energy markets. The introduction of a professional outsourced energy purchasing function brings added benefits to the client, such as improved energy consumption statistics and data management. This enables the end user and the services company to better assess the economics of optional energy efficiency measures.

Access to information

Prices change in response to news, which influences the market participants' views on if it is time to buy or sell. The development of IT increases the accessibility to the relevant information, on one hand, and accelerates the reaction of the markets' participants to such news, on the other. However, it is not clear whether the quality of news is improved due to the development of information technologies is not certain. The exact state of the supply-demand balance, which drives price changes, is generally unknown.

Investment

It seems that electricity and gas prices will also remain volatile under the market reforms. This in addition with uncertainties regarding regulation cause investors some worry in their investments in energy. Either they search safe investments with 99% of guarantee of quick return (like in small CHP plants) or they do not invest at all. Nowadays building a nuclear power plant without the support of the government is questionable from the investment point-of-view. Liberalisation in this way, manipulated the array of choices available for an investor.

DSM in liberalised markets

Many DSM programmes capture cost-effective energy savings that would not otherwise be achieved. From the viewpoint of a profit-oriented utility, DSM is often uneconomic. Contributing to improved energy efficiency among its customers reduces energy sales and revenues. In a first instance, increased sales to other customers will replace this loss by without the need to increase generation capacity. However, the DSM cost causes a profit loss, which cannot be recovered unless the utility is allowed to adjust rates or is somehow compensated.

The reduction in the volume of DSM activity in the USA is generally attributed to the introduction of competition. Some utilities have chosen to abandon DSM altogether but many utilities are using DSM as a means of providing a value-added service to their industrial customers, in some cases only to "at-risk" customers — customers that may choose to purchase power elsewhere.

The purpose of and need for DSM have consequently changed in the current more competitive supply market. Increasingly, the financing of energy efficiency programmes is transferred to fixed grid charges or transmission tariff elements (e.g. Denmark or Italy). Consequently, the prospects of utility financed DSM-activity in liberalised markets do not look bright. Some efforts will be made by energy suppliers that believe in DSM as a means of adding customer value and building customer loyalty. Provided a proper regulatory approach, incentives may however be created to establish DSM (load shifting) as a cost-effective alternative to grid expansion projects.

5.3. Wrap up or the goals of an energy efficiency policy

Governments develop energy efficiency policies with the aim of improving efficiency within the overall energy chain. Frequently, these policies and instruments serve political goals of reducing the growth in energy consumption and of mitigating adverse environmental effects of energy production and consumption.

Policies seem to aim at avoiding discontinuities in energy efficiency measures and governments assume an active role in promoting energy efficiency in a more challenging environment.

However, these policies face different changes in a competitive market. The most significant ones are:

- Prospects of falling energy prices followed by consumption growth,
- Fading incentives to the energy industry to perform end use energy efficiency measures, and
- The need to device policy instruments that function consistent with a new market framework in which commercial motives and economic signals become more important.

Liberalisation, ideally, satisfies the political objectives of lower consumer prices and improved sector efficiency. However, what we observe is the fuel price increasing and energy demand and consumption growing as well. At the same time, the economics of innovative and efficient energy technologies deteriorate.

From a macro-economic point of view, the emergence of efficient energy markets brings advantages that monopolies and regulation fail to deliver because they imply a better resources allocation. Available resources are more efficiently allocated and prices tend to reflect the availability or the “value” of resources, which leads to “correct” energy prices, and these provide the most important signal to determine the level of energy efficiency.

The energy efficiency policy needs to address the question whether the market delivers an economically efficient level of energy efficiency. Reduced energy efficiency incentives due to lower prices may not be wrong as long as the market works correctly.

So a careful combination of market forces and environmental policy instruments has the potential of contributing to a politically acceptable fuel mix in generation, end-use energy mix and consumption growth pattern.

In the competitive sectors of generation and retailing, emphasis must be placed on facilitating the effective functioning of the market and safeguarding a competitive market structure. Markets and private ownership are behaviourally more biased towards short-term considerations than governments and centrally planned sectors. This will most likely lead to market cycles and greater variability in energy prices. Governments need to accommodate this fact when formulating policies and in the choice of policy instruments.

Regardless of the environmental or energy security rationale, energy efficiency policies have also been supported by the fact that significant economic improvements are associated with efficiency improvements. However, such economic potential exists in many other sectors and does not justify in itself government intervention or incentives.

Consequently, efficiency policies are developed within a political environment of many and potentially conflicting opinions and stakeholders. This leads to the fact that energy efficiency instruments frequently serve several objectives such as mitigating environmental effects and reducing consumption growth, in addition to improving energy efficiency in the technological sense.

6. Barriers to energy efficiency

A barrier to energy efficiency can be defined by everything that can be against the promotion of the energy efficiency in the society.

Some economists argue that in a fully liberalised market (i.e., “perfect” competition which as we know is an utopia) all obstacles to energy efficiency are removed since customers receive the correct signals and the only imperfection would be the incorrect internalisation of external costs. Therefore, price will be equal to marginal cost in order to maximise economic efficiency. However, the Wuppertal Institute in its 2000 paper has a different view, states that the only imperfection that may be changed in competition market is the level of prices since this may help the convergence to the marginal cost. It also insist that this will only arrive in many years (decades) and so, for now, the price will be equal to the short run marginal costs.

One will always have barriers to energy efficiency. These barriers not only reflect the sociological perspective but also the end-use perspective. In this chapter, we will begin by introducing which type of barriers we consider has the most relevant to energy efficiency. Subsequently we will introduce our perspective regarding this issue in the Portuguese context.

6.1. Type of barriers

When analysing the barriers to energy efficiency we faced with the difficulty of deciding which are the most relevant, and the doubt on how are they are linked. We considered most of the barriers as structural barriers, i.e. barriers on how the market is organised creating difficulties to competitors to enter.

We will not refer any specific author because these findings were a result of our own reasoning and of considerations dispersed in many papers listed in references chapter. In order to understand the barriers, we have divided them in three different types: Infrastructural and technological, Financial and Market barriers.

1. Infrastructure and technological barriers
    - **Over capacity in energy production** – depending on the interconnections with other countries and their energy policies, the over capacity of production can be a barrier to the energy efficiency. When overcapacity exists, it can be more difficult to implement programmes of energy efficiency because the agents do not feel as much the need for them.
    - **Product availability** – several opportunities to produce and to conserve energy depend on new technologies, which might not be available in some countries or regions. In addition, the lack of maintenance and support will also constitute a barrier to the success.
2. Financial barriers
    - **Return on investment perspective** – in a liberalized context, the agents will prefer immediate savings and fast return on the investments in detriment of politics of energy efficiency that have slower returns.
    - **Lack of capital** – one of the reasons why consumers will not invest in energy efficiency measures is their lack of capital. A certain measure can be very cost-effective, with a fast payback, but it will not be implemented unless the consumer can meet the up-front capital costs.
    - **Economic returns estimation** – different consumers may have different ways of estimating the economic return on their investment. Programmes may consider specific loans or interest rates in order to attract specific consumers.
    - **Misplaced incentives** – energy providers may not be motivated to promote energy efficiency. In a liberalised market it is the role of the regulator (on behalf of the Society) to force energy providers to act.
    - **Price policy non-inclusive** – price should not omit neither environmental nor production, transport and distribution costs. The problem occurs when these costs are diffuse.

- **Import taxes –** energy efficient products may have import taxes, which may reduce their market competitiveness.
- **Electric tariffs –** the price of energy can be one of the barriers to energy efficiency when for example less efficient technologies are cheaper. Tariffs should reflect the marginal cost of producing electricity and not the average cost. In the USA, where energy price is low (for historical reasons) the only period where was easy to increase energy efficiency was between the two oil crisis. In 1975 the USA Congress approved the "Energy Policy and Conservation Act" aimed at increasing oil production by giving price incentives. This act also created the Strategic Petroleum Reserve (SPR), and required an increase in the fuel efficiency of automobiles[25].

3. Market barriers

- **Lack of knowledge -** it is considered as one of the most important barriers. The lack or the imperfect knowledge of the consumers, vendors, manufacturers and policy makers may hamper the introduction of efficiency measures, even if their economic value makes sense. Consumers are very often unaware of the best practices to conserve energy. Vendors are the link between the manufactures and the clients, so they are in a strategic position to advice customers. Manufactures, constructers and architects also need to be aware of new standards and trends in energy efficient technologies. The importance of this barrier is confirmed by Torleif (1996) who shows that in the Norwegian market, 50% of the industry didn't invest in energy efficiency due to lack of knowledge.
- **Low market competition:** lack of competition or imperfect competition (even if we know that perfect competition is utopia) is a possible generator of barriers to energy efficiency.
- **Consumer instability –** in a liberalized market context, consumer loyalty is one of incertitude's with which the economic agents have to deal with. They may adopt energy efficiency measures in order to secure clients, but they can also choose not to take the risk of investing in a client and then loose it to a competitor.
- **Economic agent expectations** – each economic agent has a different expectation regarding the evaluation, attractiveness and convenience of a given measure. According to Swicher (1997) the agents take into account the following factors when considering an investment in energy efficiency measures:
    - Discount rate to evaluate benefits and costs (governments discount rates of around 4%-12%, utilities in Europe of around 8%-12%, residential households of around 35%-70%);
    - Future evolution of energy cost and prices;
    - Perception of risks and uncertainties involved in adopting the measures.

6.2. The Portuguese perspective

Which are the more relevant barriers for the Portuguese market? Which are the ones that more problems may bring to energy efficiency? In this part, we have identified what we consider the most relevant barriers and we have analysed them in the Portuguese energy context. We try to understand if these barriers may pose a problem and if yes, how. At the end, we also discuss if the Iberian electricity market will constitute itself a barrier or an incentive to efficiency.

6.2.1. What are the most relevant barriers in Portugal?

We have identified nine relevant barriers in the Portuguese context.

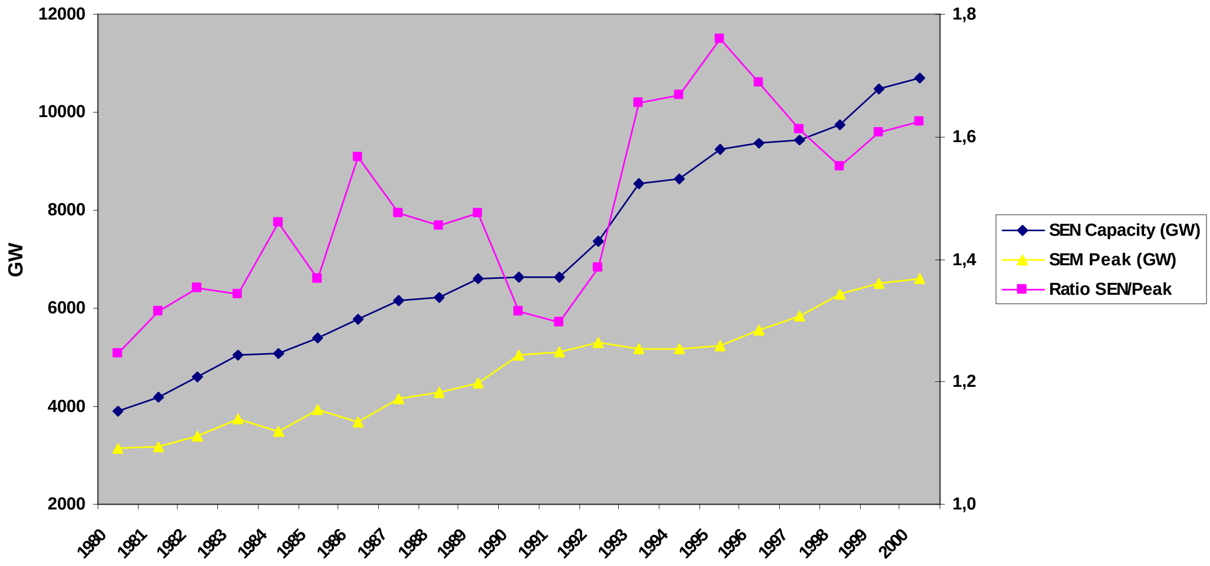
[25] In Department of Energy site: www.doe.org.

Infrastructure and technological barriers (overcapacity and product availability)

By comparing the evolution of installed power in the SEN[26] with the annual peak of consumption (Figure 6.1), we can determine power reserve between 1980 and 2000. With the creation of energy markets, the trend is towards the reduction of this power reserve, as the overcapacity of production is one of the effects of the monopolistic organisation of the electric power systems (Esnault 2003b when quoting Averch and Johnson 1962). According to Esnault (2003b) quoting Maloney (2001), the ratio between peak and capacity in the USA passed from 1.5 to 1.2, which leads to the conclusion that the introduction of competition is expressed by a decrease of the installed capacity and therefore by a decrease of the reserve capacity.

In Portugal, the generation overcapacity is mainly due to the level of rain occurred in the previous year. In fact, the Portuguese generation system differs a lot from a dry year to a “wet” year. This causes important changes in the “overcapacity” ratio. Although we esteem that in SEP, this overcapacity will increase with the development of independent power producers and auto-producers using (RES) and (CHP) under a special regime, we believe that like in the U.S.A. this ratio will soon decrease and that this barrier will disappear.

Figure 6.1: SEN Capacity, Peak and Ratio between 1980 and 2000



Source: adapted from ERSE 2001

In Portugal, the overcapacity is due to the annual hydrological “sensibility” of the system and therefore we cannot talk about overcapacity in its usual sense but we should talk about more or less hydrological sensibility affecting the reserve capacity. This required capacity considers:

- The temperature effect on the annual peak load (a maximum increase of 3% on the expected peak was assumed)
- The capacity limitation of the hydro subsystem in average hydro conditions and the additional capacity limitation between dry and average hydro conditions, in the period of the year where peak demand is expected to occur (between December and January).

[26] Read also chapter 12.2 to understand the Portuguese electric system.

Another problem raised is the limited interconnection with Spain and limited access to the European internal market due to the geographical location and the small interconnection capacity between Spain and France. According to ERSE, the strengthen in the transmission system will allow the increase Portuguese peak capacity from 11% in 2004 to 17% in 2006 and 23% in 2008[27]. With the increasing interconnection, this barrier trend is to disappear.

Return on investment perspective

The decrease in overcapacity was one of the objectives of the liberalisation process. However, if we want the market more efficient, we also must guarantee the actors enough profit to continue investing in new technologies. Therefore, we have in one hand an objective of diminishing the investment in new power plants and in the other the desire of energy efficiency, which will require new investments. So where is the balance? We believe that investing in plants with less power and with a more attractive return on investment will make the balance. This issue involves not only private producers but also the Government strategy for energy supply in Portugal.

The liberalisation of the energy sector and the set up of the MIBEL implied the change from a centralised planning to a competition model in the activity of electricity production within SEP. One of the main changes that had to be made was the review of the obligations, commitments and guarantees attributed to the producers. The current contractual regimen that ties the producers within the SEP are the contracts of acquisition of electric energy (CAE), celebrated between the entailed producers and the TSO (REN) for long periods of time (some of them up to 2027).

The change of the legal and regulatory framework associated to the implementation of the MIBEL makes the production revenues dependent of the market conditions and prices, introducing therefore risk and uncertainty in the contractual regimen. CAE's extinguish before the term of the stated period, motivated for alterations of the legal framework is not foreseen in the contract, and for that it necessary to define mechanisms that guarantee to the producers a compensation equivalent to the maintenance of the contractual balance. The process that will lead to the anticipated extinguishing of the CAE celebrated between the producers and RNT consisted in the establishment of the general principles of the methodology to adopt and the main parameters of valuation of the compensation. This was followed by the calculation of the costs of maintenance of the contractual balance (CMEC) and the setting of the corresponding compensations of the respective payment to the producers and of the inherent repercussion in the tariffs.

Regarding the demand side, the problem is more complex because even if many initiatives have a short period of payback our incentives do not seem well orientated in this direction. We believe that improvement could be done in this issue.

Lack of capital

This barrier may be very important in Portugal where people tend to invest only if they see a fast return. According to Almeida (2000) the payback period of energy efficiency investments, should be under 5 years.

Many consumers will not make investments in energy efficiency because they lack capital to buy new energy-efficient equipment or make the required re-investment in their installations. In addition, energy efficiency might not be his priority for investment. For instance, a consumer considering the purchase of a new refrigerator might prefer a less efficient model if it is available in a certain colour. An industrial customer may prefer to spend capital on a new line of products rather than consider a re-investment in existing installations. Furthermore, it is often not the person who pays the energy bill who is responsible for the selection and purchase of energy-using equipment.

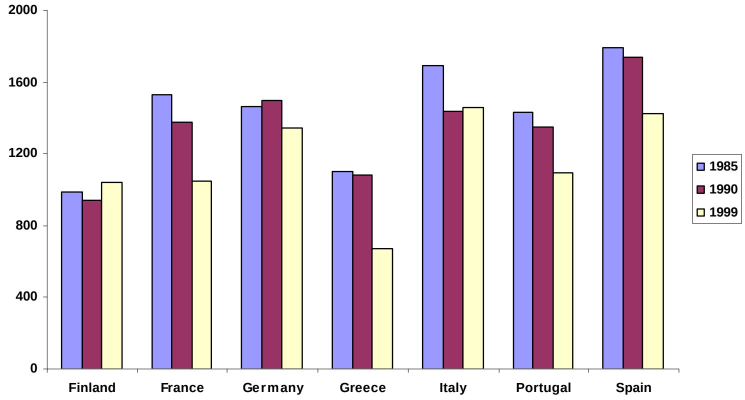
[27] Source: Jornal de Negócios 23/07/04

Electric tariffs

Electricity rates (tariffs) in many instances have been a barrier to attracting consumers to invest in energy efficiency. Very often tariffs do not reflect the marginal costs of producing electricity. Traditional incentives encourage sales of kWh (for an electric utility), and discourage efficiency measures. This may be related with the investment issue in a liberalised market as said before. Since 1990, the average electricity prices fell in the EU as a whole. Electricity showed a regular decrease of 1.5% per year, less than in Portugal (2.3%).

If we compare electricity prices among some Member States (Figure 6.2), we verify that the Portuguese electricity price is levelled with the Finnish and the French ones. This means that the percentage of GDP per capita spent in electricity in much higher in Portugal than in the other countries, as their GDP is 1.82 and 16 times higher.

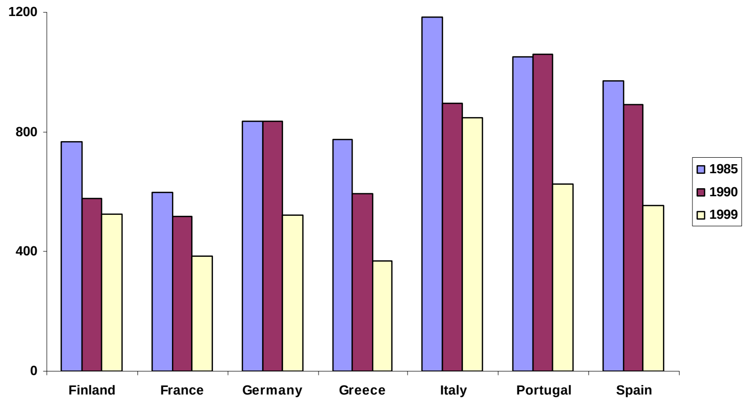
Figure 6.2: Electricity prices to household consumers in constant 1990 € per toe



Source: 2001 Annual Energy Review[28]

However, we see that Portugal and Italy are the countries in which (in 1999) the electricity price is higher for industrial consumers, which may help the implementation of an energy efficiency policy.

Figure 6.3: Electricity prices to industrial consumers in constant 1990 € per toe

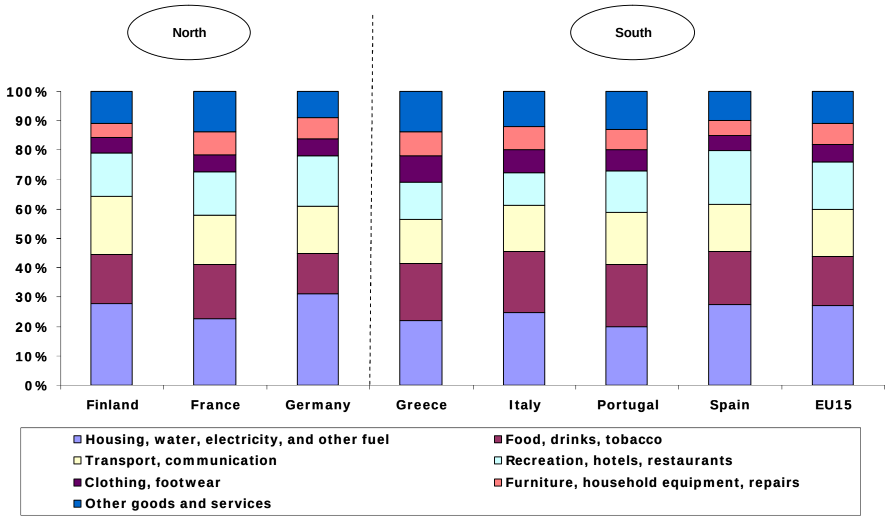


Source: 2001 Annual Energy Review[29]

[28] All taxes included.

We can see that the consumer expenditure is relatively homogenous across the selected countries (Figure 6.4). Germany has the biggest rate of commodities consumption, representing 31% of the overall household budget, while in Portugal it only accounts for 20% (further details in Table 12.20). The fact the electricity consumption is made through indirect ways (e.g. via TV, refrigerator, washing machine) increases the lack of consumer awareness to this issue.

Figure 6.4: Consumer expenditure percentage in 1999



Source: Eurostat - Living conditions in Europe Statistical pocketbook Data 1998-2002

Knowledge

According to Winward (1988), evidences show that the message about energy saving and the environment has been understood by consumers in every country but that few actually link energy saving to their own personal behaviour. Understanding a message is clearly not enough to spur people to action: much work remains to be done developing people's abilities to identify what they can to improve the situation. Only the conjugation of information and formation in a national wide campaign that should be repeated every year can change people's ideas about energy efficiency.

Lack of information or imperfect knowledge on the part of consumers, vendors, manufacturers and policy makers may hamper the introduction of efficiency measures in situations where they make technical and economic sense. Consumers are frequently unaware of practices and technologies available to conserve energy. Developers, architects, and facilities managers often have misconceptions about new or unfamiliar technologies.

Another issue is the target audience. We may be aiming the campaign an audience that, even if it is the one that pays the electricity bill, is not its biggest user. For example, in the case of two working parents with two kids and a house cleaner, if the campaign is targeted to the parents, it will be difficult for them to implement it at home, because they spend their day outside and arrive at night. This small example shows us the importance of targeting correctly the real users and not to the clients in general.

Technology availability

Usually, the less efficient appliances are the cheapest. The fact that the cost is one of the more important factors influencing consumer choices act as a barrier to energy efficiency. The EU has already set several legal initiatives in order to limit the use of inefficient appliances (e.g. the Eco-design Directive - COM(2003) 453 final 2003/0172 (COD)). This Framework Directive will establish

[29] Excluding refundable VAT

eco-design requirements (such as energy efficiency requirements) for all energy using products in all sectors (residential, tertiary and industrial). This will ensure coherent EU-wide rules for eco-design and that disparities between national regulations do not become an obstacle to the intra-EU trade. This proposal does not directly introduce binding requirements for specific products, but does define conditions and criteria for setting requirements regarding environmentally relevant product characteristics (such as energy consumption) and allows them to be improved quickly and efficiently.

In Portugal, this issue can still be considered as a barrier when linked to the knowledge barrier. Regarding this issue the consumers' demand of energy efficiency appliances (because of their awareness) will push the industry to higher levels of efficiency, with less costs involved than with any legal initiative.

Consumer instability

This is one of the major risks faced by energy companies in a liberalised market. The client is not as captive as before as he may change of retail seller several times.

According to The Guardian[30] from June 27, 2003, in this post-deregulation scenario, consumers have been subjected to fraudulent and coercive selling, with rival companies pressurising customers into transferring their energy supply. “Shoppers have been deceived into signing-up for holiday information, only to discover later on that they had in fact also changed energy supplier and, in arguably the most appalling case, Virgin Energy sales reps forged signatures from dead people on energy transfer forms”.

The combination of miss-selling and billing errors is also undermining the consumer's confidence and his most effective weapon of complaint - changing supplier. On the other hand, it can also act as a way to retain customers if the company’s credibility is recognized.

The whole point of deregulation was to create greater customer choice, but according to this newspaper, recent figures show that two out of three customers did not change their existing supplier, even though they may be paying up to 22% more for their energy. This may be explained by three reasons:

- Customer inertia
- Access to impartial comparative data on prices and deals
- Bad reputation of sales representatives.

Political issues

Even if the Government has managed to set up a national strategy and create legal initiatives in order to increase energy efficiency, their implementation needs to be improved. A clear definition of the actors’ tasks is necessary to “put into motion” the legal framework. This aspect is very important in the Portuguese legal context because without it the legal initiative can be viewed as "empty" regarding its practical effects. This can act as a barrier to energy efficiency.

Regulatory structure

Given the Portuguese legal, economical and even cultural context, the initiative of setting up an incentive to energy efficiency integrated in tariff formula is highly positive and its results should not be evaluated form only one regulatory period. Nevertheless in our opinion, the regulatory system as-is, is the most important barrier to energy efficiency.

This is due to a combination of two formulas: one regarding the profit resultant from the SEPs’ commercialisation activity (article 78 of the Portuguese Tariff Code), and the one concerning the revenues from the distribution of electric energy (Art. 76 of the same code).

[30] 27 June 2003. Site: http://money.guardian.co.uk

The revenues allowed to the binding distributors within the ambit of the activity of commercialisation in the SEP, in the year *t,* are given by the following equation. This is a function of the value of fixed assets allocated to this activity multiplied by a rate of capital cost plus amortisation of these fixed assets and the annual structural cost of less an adjustment term.

Equation 1: Revenues equation

$$\tilde{R}_t^{CE} = \sum_j \tilde{R}_{j,t}^{CE} = \sum_j Act_{j,t}^{CE} \times \frac{r^{CE}}{100} + Amt_{j,t}^{CE} + C_{j,t}^{CE} - \Delta_{j,t-2}^{CE}$$

$\tilde{R}_t^{CE}$ Revenues allowed within the ambit of the activity of Commercialisation in the SEP, in the year *t*

$\tilde{R}_{j,t}^{CE}$ Revenues allowed by voltage level or type of supply *j,* in the year *t*

j Voltage level or type of supply NT (VHV, HV and MV), BTE and BTN

$Act_{j,t}^{CE}$ Average value of the fixed assets by level of voltage *j* allocated to this activity, net of amortisation, in the year *t*, given by the simple arithmetical average of the values at the beginning and end of the year

r^{CE} Percentual rate of remuneration permitted to the fixed assets related to the SEP Commercialisation activity, defined for the regulatory period, as a percentage

$Am_{j,t}^{CE}$ Amortisation of the fixed assets allocated to this activity, by voltage level or type of supply *j*, in the year *t*

$C_{j,t}^{CE}$ Annual costs of the commercial structure by voltage level *j* allocated to the SEPs' commercialization activity accepted by ERSE, in the year *t*

$\Delta_{j,t-2}^{CE}$ Adjustment in the year *t* of the revenues of the SEPs' commercialization activity, by level of voltage or type of supply *j*, relative to the year *t-2*

The adjustment term ($\Delta_{j,t-2}^{CE}$) in the previous expression is given by the Equation 2. This is function of the difference between revenues (invoiced and allowed) and the sum of the total cost of DSM Programme(s), 50% of the difference between estimated benefits and the costs of the DSM Programme.

Equation 2: Adjustment term

$$\Delta_{j,t-2}^{CE} = \left[Rf_{j,t-2}^{CE} - \tilde{Rf}_{j,t-2}^{CE} - GP_{j,t-2} - 0.5 \times \left(BGP_{j,t-2}^{CE} - CGP_{j,t-2}^{CE} \right) \right] \times \left(1 + \frac{i_{t-1}^{CE}}{100} \right)^2$$

$Rf_{j,t-2}^{CE}$ Revenues invoiced by the binding distributors by voltage level *j*, in the year *t-2*

$\tilde{R}_{j,t-2}^{CE}$ Revenues allowed to the binding distributors within the ambit of the activity of the Commercialisation in the SEP by voltage level *j*, to take effect in the year *t-2*

$GP_{j,t-2}$ Costs allocated to this activity relative to the DSM programme by voltage level, accepted by ERSE in the year *t-2*, in accordance with the report of the execution of the "Demand Side Management Programme"

$BGP_{j,t-2}^{CE}$ Estimated benefits in the "Demand Side Management Programme" presented for the year *t-2* by the binding distributors

$CGP_{j,t-2}^{CE}$ Estimated costs in the "Demand Side Management Programme" presented for the year *t-2* by the binding distributors

i^{CE}_{t-1} EURIBOR three-month interest rate

As we can see, these two formulas clearly establish the method to calculate the DSM benefit. However, according to the Art. 76 of the same code, the revenues allowed to the binding distributors within the ambit of the activity of the Distribution of electric energy, in the year t, are given by the following expression, which is a function of the fixed revenues (that until now ERSE always considered as zero) and of the unitary component of the Distribution activity times the energy delivered.

Equation 3: Revenues from the activity of the Distribution of Electric Energy

$$\tilde{R}^{D}_{t} = \sum_{j=1}^{2}\left(F^{d}_{j,t} + P^{D}_{j,t} \times E^{D}_{j,t} - \Delta^{D}_{j,t-2}\right)$$

$\tilde{R}^{D}_{t}$ Revenues allowed within the ambit of the activity of the Distribution of Electric Energy, in the year *t*

$F^{D}_{j,t}$ Fixed component of the revenues from the activity of the Distribution of Electric Energy, in the year *t*, by voltage level *j*

j Voltage level

$P^{D}_{j,t}$ Variable unitary components of the revenues of the activity of the Distribution of Electric Energy, at the voltage level j, in Euros, per kWh

$E^{D}_{j,t}$ Electric Energy delivered by the distribution network at the voltage level j to binding and non-binding clients, in the year t, per kWh

$\Delta^{D}_{j,t-2}$ Adjustment of the revenues of the activity of the Distribution of Electric Energy, in the year t-2, by voltage level j.

As a result, we conclude that the revenues of the distribution activity are 100% correlated with the energy delivered. Therefore, EDP benefits from the increase of this parameter in order to maximise its profits.

Consequently, there is an issue regarding the balance between Equation 1 and Equation 3: the revenues that are lost in the third equation have to be recovered in the first one. Otherwise, its implementation would not be advantageous.

Even if the Tariff Code shows that there is awareness to the issue of energy efficiency, we believe that there is room for improvement with a regulatory change regarding profit incentives. For example, the energy sold (in the previous formula) by a % factor taking in account company's actives, km of electric lines, number of clients, etc., diminishing hence the weight of kWh sold in the final profit.

A similar situation happens with the rate-of-return regulation, where energy companies are pushed to build more supply infrastructures in order to increase their profit. In this case, a reply to this anti-energy efficiency situation could be made through three incentives:

- The utility earns a percentage of the money spent on DSM.
- The utility earns a bonus in €/kWh or €/kW based on the energy or capacity saved by DSM programme.
- The utility earns a percentage of the net resource value of a DSM programme. Net resource value is the difference between the electricity production costs avoided by the utility with the programme and the costs required running the programme.

The third approach is by far the most popular because it aligns the utility's interest with society's interest in promoting energy efficiency only when it is cost effective (Eto 1996). Under the first two approaches, the utility has an incentive to pursue DSM programs without regard to their cost effectiveness.

6.2.2. MIBEL as a barrier or incentive to energy efficiency

The opening to competition in energy markets lies in the desegregation of the value chains and in the creation of markets vertically integrated, where only natural monopolies escape to competition. In this context, the flow of data becomes more complex and owning information becomes the raw material of competition (Esnault 2003).

MIBEL is organized as spot and forward market with bilateral contracts working as a natural complement to the market in order to allow a balance between supply and demand. As in the majority of the European electric markets, bilateral contracting allows contracts between any kind of producers and other qualified agents and establishes the terms in which the traders and the producers can sell energy previously acquired from other producers and external agents. This stimulates competition up in the value chain.

Although not being the focus of this paper, we will discuss the advantages and disadvantages of the creation of an energy market to both the supply and the demand. From the point of view of the supply, we can say that the creation of this type of markets favours energy efficiency, once it allows every operator to access market in equivalent conditions, thereby eliminating one of the biggest barriers to efficiency. However, prices become more volatile and reactive to the balance supply-demand in the short term (Esnault 2003). Therefore, the exchange markets give a bigger power to the producers because as soon as the margin between production and demand diminishes, some operators may go from price-takers to price-makers. An example of this is what happened in the USA, where a regulatory context together with an implicit willingness to control the price by the producers nearly led to the bankruptcy of the energy companies in the State of California.

However, what is the influence of the creation of the MIBEL in the energy efficiency on the demand side? It does not seem to exist any influence once MIBEL has the energy producers and retail market as target. This way, it eliminates barriers in the supply side, levelling the energy producers and retail. MIBEL would influence the energy demand only if it was to be created a market to which industrial clients could access. Should the energy efficiency be promoted through other instruments?

6.3. Wrap up

The market rarely delivers energy efficiency improvements spontaneously, as there is no market push. Consumers are not providing a pull towards energy efficiency, usually because they are ignorant of (or indifferent to) the range on the market, or the energy implications of their purchases. Whilst consumers are concerned about climate change and generally understand the causal role of fossil fuels, they believe either that they have done everything or that one person cannot make a difference. Without a positive design focus from manufacturers or a clear demand from consumers, no part of the market will deliver energy efficiency naturally: policy has to provide the drive.

In Portugal, one of the most important barriers to energy efficiency is the regulatory system. This limits companies to effectively implement a DSM Programme. In this matter, we believe that there is room for improvement that would push energy efficiency further.

7. Energy policy frameworks in the European Union regarding energy efficiency

The European Union has its own ("formal") energy policy since the first oil crisis. Actually, the energy problem in Europe was always very important and to prove it we can say that two out of three treaties that created EU are "energy" treaties, namely CEEA (Communauté Européenne d'Energie Atomique) and CECA.

The European Union is the major catalyst driving energy efficiency policies and programmes throughout the region. While there are some countries that are playing an exemplary and leading role, most are following the lead of the Commission, the European Parliament and the Council of Ministers. Much is at stake because the EU climate change strategy and energy strategy are depending on their successful implementation.

The European Union also has some major technical and non-technical programmes to further help to promote energy efficiency. These programmes play an important facilitation role and have brought experts from around the EU together to look for harmonised solutions. The European Union has set the process in motion but it has to continue to play a supportive and monitoring role to ensure that all directives are effectively implemented. It also has to ensure a regular evaluation of all its programmes and directives to provide better guidance for the development of future policies and programmes.

The energy sector is very capital intensive, which requires high investments with environmental impact, both during production and utilization, and with an obvious strategic importance to the State Members. The energy policy is fundamental, as these investment decisions have to been taken many years in advance.

In this chapter, we will start by presenting the European energy policy and legal framework in which it is based on. We will then present the Kyoto Protocol impacts on energy efficiency. Subsequently we will present the critical energy directives implemented and finally we will overview the Portuguese legal framework regarding energy efficiency.

7.1. European energy policy

The role of the EU in terms of energy efficiency policies and programmes has evolved since the first oil crisis, in part because the EU itself has evolved politically and institutionally. Going back to the 1970s, there were a number of directives (for example, on appliance labelling) that were poorly implemented by Member States. There were also programmes to develop new technologies, through both research and demonstrations, starting in the late 1970s. There was a major change in 1989 with the creation of the THERMIE programme, a high profile, high budget demonstration programme that put a high priority on energy efficiency. THERMIE's goal was to promote energy technologies (not only related to energy efficiency) and over the years it has become a part of the Commission's research programme.

In 1998 a Communication on Energy Efficiency set out the broad objectives of a **European Energy Efficiency Strategy**[31], calling for an improvement in energy intensity of 1% per year. The set up of an **Action Plan** followed the Communication in 2000[32], stated that if energy intensity of final consumption can be improved by an additional 1% per year above the baseline expectations, then two-thirds of the available cost-effective savings potential would be achieved by 2010. This would contribute about 40% of the EU's commitment in meeting the Kyoto target.

The Action Plan focused on three types of measures: to enhance the integration of energy efficiency into other Community non-energy policies and programmes (e.g. regional and urban policy); to re-focus and reinforce existing and successful Community energy efficiency measures; new common and co-ordinated policies and measures.

The **European Climate Change Programme**, which was established in 2000 to identify the most environmentally and cost-effective measures to help the EU meet its Kyoto Protocol obligations, gave

[31]European Commission, Energy Efficiency in the European Community - Towards a Strategy for the Rational Use of Energy, Communication from the Commission, Brussels, 29.04.1998 [COM (1998)246 final].

[32] European Commission, Communication from the Commission to the Council, the European Parliament, the Economic and Social Committee and the Committee of the Regions, *Action Plan to Improve Energy Efficiency in the European Community*, Brussels, 26.04.2000, COM (2000)247 final.

considerable emphasis to energy efficiency. The programme recommended measures in all end-use sectors:

- Increased use of combined heat and power generation;
- Improvement of energy efficiency standards for electrical equipment;
- Improvement of efficiency standards for industrial process;
- Improved energy efficiency limiting carbon dioxide emissions (for boilers, construction products, etc.);
- Increased energy services for small and medium enterprises (SMEs);
- Development of a framework for voluntary agreements; public procurement of energy efficient end-use technologies;
- Energy audits and heating performance certificates;
- Improvement of building/lighting performances; building design and infrastructure planning;
- A European campaign for more fuel-efficient driver behaviour.

The Communication and Action Plan, together with the European Climate Change Programme, represent the main thrust of the EU approach to energy efficiency for its member states and now for the accession countries.

There are several legal obligations on member states and there are programmes that promote energy efficiency policy and technology development. The importance of the EU is that the obligations are not only on the part of the member states but also on the accession countries.

Many transition economies, that are not accession countries, are influenced by the legislation, since many of the countries are considering adopting for example labelling schemes.

The main programme for EU member states is the SAVE programme (which will be discussed in 9.2.1), part of the Energy Framework Programme (1998-2002) 18, which is the only Community programme dedicated to the non-technical issues related to energy efficiency. The legislative programme, with its directives, is related but separate to SAVE. There are five main elements of SAVE. They are:

• Studies and other related actions aimed at the implementation and completion of EU measures, studies concerning the effects of energy pricing on energy efficiency, and studies with a view to establishing energy efficiency as a criterion within European Union programmes;

• Sectarian targeted pilot actions;

• Measures to foster the exchange of experience;

• Monitoring of energy efficiency progress;

• Specific actions in favour of energy management at regional and urban level.

7.2. The Kyoto objectives and energy efficiency

In 1992, the Framework Convention on Climate Change was ratified by 169 countries with the objective of returning carbon dioxide emissions to 1990 levels by the year 2000. Furthermore, at Kyoto in December 1997, it was agreed that strengthened commitments should be made beyond 2000, including a provision for the EU to reduce the level of greenhouse gas emissions by 8% by the period 2008-2012.

The emissions reduction targets agreed by the EU are challenging goals, which will require concerted action by each Member State. Therefore a programme specifying how the target will be achieved: the share of the burden between fuels, the contribution expected from each end-use sector and the contribution expected from new renewable energy sources. In this issue, improving end-use energy efficiency will have a high priority because of the large potential savings that can be achieved.

Table 7.1: The economic potential for CO_2 savings through end-use energy efficiency in the EU

	Energy consumption 1995 (TWh)	Potential CO_2 savings in 2010 (referenced to 95)
Domestic & Tertiary	4164	22 %
Industry	3117	17 %
Transport	3140	14 %
TOTAL	10421	18 %

Source: adapted Communication towards a strategy for the rational use of energy

Many countries already have a national energy efficiency programmes in place covering different mechanisms (information, fiscal, subsidies, legal) and some electricity and gas companies throughout the world offer their customer's advice on the efficient use of energy through marketing initiatives. However, in order to follow the Kyoto commitments, further change in measures will be necessary and all existing programmes will need to be reviewed accordingly.

A successful programme of action to achieve the required CO_2 reduction target is likely to require substantial investment. It is anticipated that most EU States will look to industry - particularly the energy sector - for assistance in meeting their international obligations rather than raising all the necessary additional revenue through general taxation (Baggs 1999).

Energy efficiency can be a highly cost-effective means of reducing greenhouse gas emissions and stabilizing their concentration in the atmosphere (Evans 2001). Under the Kyoto Protocol, countries are encouraged to reduce emissions domestically, though this gives them flexibility on how they will achieve their targets.

There is a pressing need to renew commitment at both the Community and Member State level to promote energy efficiency more actively. This is especially true in the context of the Kyoto agreement to reduce CO_2 emissions, where improved energy efficiency will play a key role in economically meeting the target. In addition to a significant positive environmental impact, improved energy efficiency will lead to a more sustainable energy policy and enhanced security of supply, among other benefits.

An objective like this calls for rigorous decisions in energy policy aimed mainly at:

- Reducing energy intensity through energy management and energy saving;
- Reducing carbon intensity, in particular by promoting renewable energies.

EU policy regarding the Protocol stresses the need to take the most cost-effective measures to achieve the desired environmental results. We can identify different measures linked with energy efficiency:

- Encouraging energy savings and energy management;
- Further supporting the SAVE and the JOULE-THERMIE programmes which help to reduce CO_2 and support the new energy saving technologies;
- Promoting a debate in the energy supply industry to promote more efficient production and services and to transform them into service companies;
- Promoting operations under the environmental agreements and making use of the potential reduction in CO_2 emissions in the motor vehicles sector;
- Accelerating the promotion of renewable energy sources (thanks JOULE-THERMIE and ALTENER programmes), research, tax incentives and discussions with energy production companies;
- Taking account the energy dimension and climate change when public contracts are awarded;
- Promoting CHP production initiatives, as co-generation can contribute to the reduction in emissions;
- Encouraging ways of producing electricity which offer the possibility for introducing zero carbon fuels or using low carbon fuels;

The EU position concerning Kyoto can be resumed by this sentence: "The climate change challenge is by definition an international one. That is why the Member States will have to make substantial efforts with respect to energy efficiency and in order to respect the decisions taken in Kyoto."[33]

In Portugal, a relevant policy area, not included explicitly in the national energy policy, is the compliance with Kyoto Protocol within the Portuguese environmental policies. The Portuguese government, under the Kyoto Protocol, assumed the commitment not to increase its emissions of greenhouse gases (GHG: CO2, CH4, N2O, HFC, PFC, SF6) in more than 27% of the 1990 emissions, and recognised that the climate change problem is a national priority (Law 93/2001 of August the 8th).

Accordingly, the National Climate Change Programme established several emission ceilings for the sectors responsible for the GHG emission, as any sector that uses electricity and the electricity generators. This will contribute to promote energy efficiency in Portugal.

The National Climate Change Plan (NCCP), published in 2003, is Portugal's national strategy to control and reduce emissions of greenhouse gases, in line with the commitments given by Portugal under the Kyoto Protocol and of burden sharing within the EU. This Plan has a package of measures and instruments, based on the following principles:

- Adoption of a positive, constructive national response to the commitments given by Portugal to reduce emissions of greenhouse gases, by promoting an integrated package of measures which safeguards and reinforces other environmental and sectorial objectives and the competitiveness of the Portuguese economy;
- Application of the polluter/user pays principle;
- Involvement of industry and stakeholders in the nation's efforts to reduce GHG emissions.

Regarding the Climate Change National Plan (PNAC), it interferes with energy efficiency from demand-side. As the levels of GHG emissions in Portugal are expected to be higher than in the reference scenario, the PNAC proposes a set of additional measures in order to reduce this gap. One of the measures is the reduction of the electricity consumption by 1.3TWh until 2010. The PNAC recognises that the electricity distributors should be encouraged to implement DSM measures through a national strategy and created incentives that allow companies to cover its DSM costs. According to PNAC, it is necessary to:

- Define a regulatory framework base that removes the barriers to energy efficiency;
- Create a public levy to fund energy efficiency;
- Oblige electricity companies to use an IRP resource planning;
- Establish financial incentives to energy efficiency.

Although PNAC does not quantify any measures, we believe that these objectives are achievable. Reducing 1.3TWh in 7 years corresponds roughly to a yearly reduction of 185GWh. We will see further on that if the Energy Services Directive is implemented as-is, the obligation of reduction could reach up to 387GWh/year.

7.3. Energy Directives

The EU already adopted several measures to increase energy efficiency. Some are concerning the offer and some are concerning the demand side. In this point, we describe succinctly their objectives and how they relate between themselves.

The 1997 White Paper on renewable energy proposed a 12% share of renewable energy sources in total primary energy consumption. This has been translated into a share of 22% of consumption of electricity of produced from renewable energy sources. Member states will be required to set their own targets.

[33] Commission Communication of 14 May 1997 on the energy dimension of climate change.

In November 2000, the EU Commission presented the Green Paper "Towards a European strategy for the security of energy supply"[34], with the objective of presenting an overview of the principal questions and risks linked to the future growth of European dependence on energy.

In March 2001, the EU set a Proposal for a Directive of the European Parliament and of the Council amending the Directives 96/92/EC and 98/30/EC concerning common rules for the internal market in electricity and natural gas[35]. The objective was to speed up the completion of the internal energy market. The proposal derives also from the Green Paper on security of energy supply. The proposal is divided into two major groups:

- Quantitative proposals regarding progressively freeing all electricity and gas consumers to choose their supplier, in order to ensure that they benefit from the advantages of opening of the market and to guarantee competition Member States;
- Qualitative proposals designed to improve structural aspects of the Community market and ensure equivalent access to the market throughout the EU.

On 10 May 2001, the European Commission adopted a proposal for a Directive on the promotion of electricity from renewable sources in the EU internal electricity market. The strategic objective of the proposal is to create a framework for the medium-term significant increase of renewable-sourced electricity in the EU and to facilitate its access to the internal electricity market.

Recently, the Commission has proposed a multi-annual strategy action in the field of energy entitled, Intelligent Energy for Europe (2003-2006)[36]. This will support the European Union’s energy policies. Its aim is to support sustainable development in the energy context, making a balanced contribution to achieving the general objectives of security of energy supply, competitiveness, and environmental protection. The strategy is structured in four fields:

- SAVE – improvement of energy efficiency and promotion of rational use of energy, in particular in the construction and industry sectors,
- ALTENER - promotion of new and renewable energy sources for centralised and decentralised production of electricity and heat and their integration into the local environment and the energy systems
- STEER - support of initiatives related to all aspects of energy transportation, diversification of fuels, and the promotion of renewable fuels (bio-fuels) and energy efficiency in transport
- COOPENER - support of initiatives related to the promotion of renewable energy sources and energy efficiency in the developing countries.

There is also a fifth filed of transversal issues:

- Think globally act locally. Projects to strengthen local actions by local actors with European cooperation, to support creation of new local and regional energy management agencies, and to support creation of a high-level reflection group of major stakeholder in local actions in energy.
- Financing mechanisms & incentives, including analysis of existing financing schemes as well as development and promotion of innovative financing instruments and incentives.
- Monitoring & evaluation of policies and measures for renewable energy and energy efficiency with indicators and modelling of future trends and policy impacts, leading to better design of future policies.

In 2002, the Commission published a draft of a cogeneration directive to promote wider use of cogeneration[37], with the objective to create a framework, which can support and facilitate the installation and proper functioning of electrical cogeneration plants where a useful heat demand exists or is foreseen.

[34] COM(2000) 769 - Not published in the Official Journal

[35] COM(2001) 125 final - Official Journal C 240 E of 28.08.2001

[36] further reading in www.managenergy.net

[37] Directive of the European Parliament and of the Council on the promotion of cogeneration based on a useful heat demand in the internal energy market [COM (2002) 415 final]

7.3.1. Directive 2003/54/CE

This Directive establishes the common rules for the IEM and IGM and amends the Directives 96/92/EC and 98/30/EC concerning rules for the IEM and IGM. With this amendment of the EU IEM and IGM Directive, markets should be open for all electricity consumers in 2007, while it should be open for non-household consumers in 2004. Large parts of the text are to guarantee that power companies are treated equally in the electricity market

An important part of the Directive is probably that electricity will be labelled so the costumers can see the contribution of each energy source to the electricity purchased. According to this electricity suppliers should specify:

- The percentage contribution of each energy source to the fuel mix for the electricity supplied;
- The contribution to CO2 and nuclear waste of their electricity consumption.

In our opinion, this Directive has no impacts on demand side efficiency except the indirect impact in consumer awareness.

7.3.2. Emission trading Directive

The aim of the proposed directives is to reduce greenhouse gas emissions in a cost-efficient fashion, with introduction of GHG emission ceilings and trading.

All greenhouse gas emitters in EU that are covered by the emissions cap and trading directive must have enough greenhouse gas "allowances", to be allowed to emit their greenhouse gases. The EU countries' governments will allocate greenhouse gas allowances to companies in their respective countries. These allowances can be traded between companies if they choose to do so. Each year, companies must submit a number of allowances that corresponds to their actual emissions. If they do not have enough allowances, they will have to pay a fine. The holding and tracking of allowances will be done through an electronic register. The sectors to be covered are energy, iron, cement, glass, ceramics, pulp, paper, and board. Only larger installations are covered (e.g. combustion).

The first phase of the scheme is between 2005 and the end of 2007, before the Kyoto Protocol's commitment period. In this phase, the Commission believes that the EU would greatly benefit from experience of greenhouse gas emissions trading, so that it is prepared for the international emissions trading under the Kyoto Protocol that will begin in 2008. During 2005-2007 it is proposed that allowances should be allocated to participating installations free of charge and that there is a lower common level of penalty for non-compliance of 40 EUR/tons of CO2.

From 2008, the countries can agree to auction 5% of the allowances while the remaining 95% should be given for free. The penalty for non-compliance will increase to 100 EUR/tonne of CO2. Also from this date on, the exchange of allowances between installations in two different Member States will give rise to the adjustment - through the national registries - by a corresponding number of tons of the total quantity of emissions allowed for each Member State following the burden-sharing agreed with the ratification of the Kyoto Protocol.

The following table shows the quantified emission limitation or reduction commitments to EU Member States, according to the Council Decision of 25 April 2002 concerning the approval, on behalf of the European Community, of the Kyoto Protocol to the UN FCCC (Framework Convention on Climate Change), and the joint fulfilment of commitments thereunder (2002/358/EC),

We see that Germany has aimed for a reduction of 21%, Italy 6.5%, France and Finland 0% while Greece, Portugal and Spain are allowed to increase their emissions by 25%, 27% and 15% respectively.

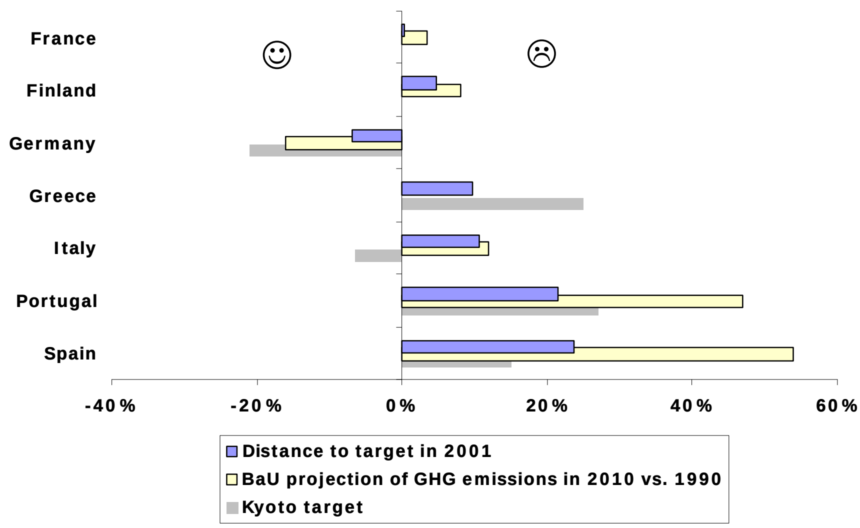
Table 7.2 Quantified emission commitment as laid down in Annex B of the Kyoto Protocol (percentage of base year or period)

EU	92%
Finland	100%
France	100%
Germany	79%
Greece	125%
Italy	93.5%
Portugal	127%
Spain	115%

Source: EU Commission EU 2002/358/EC

The European Commission regularly reports the progress regarding these targets regularly through the Monitoring Mechanism. The latest available progress report contains the following figure(further details in Table 12.21). As we can observe, among the selected countries, only Germany is in a good situation to fulfil the Kyoto protocol. No other countries are in line with their targets. Other countries like Italy will heavily depend on CDM/JI mechanisms and, even so, a deviation of 12% is expected. Finland has set ambitious targets regarding their industrial patchwork (mainly heavy industry like paper mills) and its deviation may be due to its strong growth in industry and electricity sector.

Figure 7.1: Distance to target indicators (in index = percent) of the Kyoto Protocol and burden sharing targets of some EU Member States



Source: Ecofys 2003

7.3.3. Energy Services Directive Proposal

The liberalisation of energy markets has been accelerated by the UE Directives 96/92/EC and 98/30/EC. The subject of energy efficiency has not had the deserved attention by the Commission up to now, but the new Directive on energy services may modify this situation.

The objective of the Energy Services Directive proposal is to complete the internal market for energy by developing and encouraging energy efficiency on the demand side. It is foreseen that the Member States will set targets to promote and support energy efficiency services (e.g. third party financing) and programmes, especially for smaller consumers such as households and SMEs. This includes a supportive framework for the implementation and the financing of energy services, adjusted to the liberalised market of each Member State.

This Directive proposes a minimum energy efficiency target of 1% of the total electricity and gas sales, to be reached through energy services each year.[38] With compliance by 2006, this measure may save between 40 and 55 Mt CO_2/year by 2010.[39].

The draft of this proposal, which was presented in December of 2003 still remains in discussion. We think that as it has many implications in the energy sector, the Commission may have some difficulty in letting it out. Establishing an energy saving obligation and promoting energy services has a tremendous implication to the electric business, as energy retailers may face a new challenge: selling services instead of selling KWh.

We have several comments regarding this proposal. Here we are going to point out the main aspects that we believe that can endanger the efficiency of this instrument.

The Directive points out that the objective of 1% is mandatory. An "almost mandatory" objective should be considered as an alternative option. We believe that for a country like Denmark this objective is easier to reach as they have started their energy efficiency programmes in the 70's, but Portugal has not done much yet. It is perhaps preferable to set an indicative objective but where amendments would be sufficiently high in send the signal to the economic agent in order to make them, if possible, apply the Directive.

The proposal suggests a free offer of energy services until 5% of the market is covered by these services. We believe that this measure will not act as an incentive to energy efficiency. The companies will transfer their costs (even the 5% stated as “free”) through the value chain until it reaches the final consumer. In market economy, the term free is doubtful. We think that costs are transferred from one agent to another (through taxes or price internalisation). In this case, we would prefer to see a national fund being created and supported by all customers. We believe that the audits should be paid through this fund (as in Denmark). If a client wants a more specific service, he should pay individually for its cost.

Also, the proposal talks about the incentives to the increase in the volume of energy transmitted or in the sale of energy, integrated in regimes of tariff regulation in monopolistic segments of the network of energy distribution. The proposal argues that these incentives should be eliminated and that this can be done through tariff structures that take into account sales volume, number of clients, etc. We agree that the tariff should not be only function of the sales volume. In the Portuguese regulatory system, the tariff price-cap leads us to that, since profits depend on the fixed costs (considered zero for now) and variable costs multiplied by the energy sales volume. This should be changed, since the distribution tariff should not depend only on the energy sales volume because that exposes the company to volume risk. We believe that it would be better to replace this variable (energy sales volume) by a weighted variable in which the company’s assets, the km of line, the energy sold, etc. would be taken into account.

In Italy, a percentage that reduces the weight of the volume in the final price was introduced in the tariff. The revenues from a consumers segment are not 100% proportional to the units sold but only 25%, thereby reducing the profits linked to the increase in sales above the level established by the regulator. This problem does not exist in countries where the regulatory system rewards based on the rate-of-return.

We have estimated the impacts of the implementation of this Directive in the household sector in Portugal in chapter 9.

7.4. Portuguese policy framework

The Portuguese energy policy has aimed to liberalise the market ensuring security of supply, improving energy efficiency and mitigating environmental problems (IEA 2000). From the nationalisation period right after the 1974 revolution to the creation of the Iberian market Portugal as changed considerably. Joining the EU in 1985 helped Portugal to set ambitious targets in energy diversification, competition and environmental achievement. This is also shown in the legal initiatives presented.

[38] Proposal for a Directive of the European Parliament and of the Council on energy end-use efficiency and energy services [COM(2003) 739 final]

[39] Report *Road towards an energy efficient future*

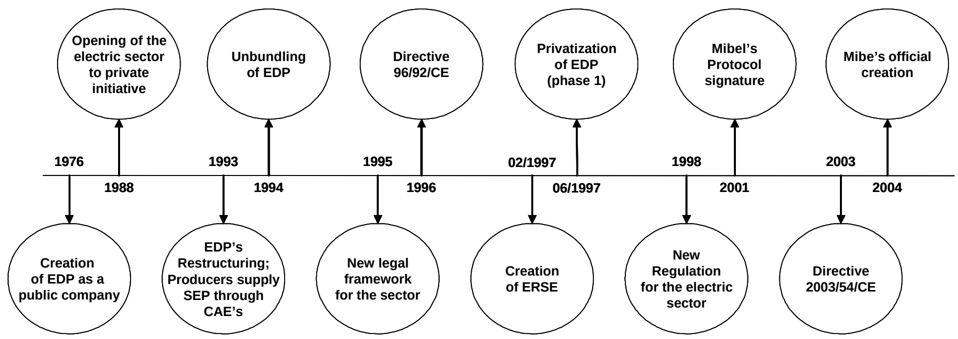
In this part, we will consider the timeline from 1976 when EDP was created from four regional electricity companies up to 2004 when Mibel was created. Subsequently we will analyse the main legal instruments of the Portuguese energy policy and we will comment this policy regarding energy efficiency. We will see that even if the legal instruments exist, their implementation could be improved in order to achieve the proposed targets. Portugal has energy efficiency potential (as shown in 5.1.3), and it just need some incentive to carry them out.

7.4.1. From monopoly to liberalisation

The Portuguese electric sector has gone through of profound changes since the late 80's, when the production and distribution of electric energy was opened up to private initiative (Decree-Law no. 449/88). In 1991, the restructuring of this sector continued with the Decree-Law no. 99/91, which established the general principles of the legal regime of the activities of production, transmission and distribution of electric energy. The bases of the organisation and functioning of the National Electric System (SEN), in its actual legal framework were set by the Decree-Law no. 182/95) (further details in 12.2). The Decree-Laws nos. 183/95, 184/95, 185/95 and 187/95, of July 1995 approved the general legal regimes of the production, distribution and transmission of electric energy, as well as independent regulation, through the creation of the Regulatory Entity of the Electric Sector (ERSE). On 2002, ERSE becomes the Regulatory Entity of the Energetical Services, and therefore extends its competences to the domain of natural gas regulation.

The Directive 96/92/CE of the European Parliament and the Council resulted in widespread changes to the legal and organisational panorama of the electric sector. The National Electric System (SEN) has suffered many alterations. On the meanwhile, a new EU Directive, for which an agreement was reached on November 2002 and is preparing in order to review the Directive 96/92/CE of the European Parliament, constituting one more step towards the creation of an European energy market that is becoming increasingly open and integrated.

Figure 7.2: Portuguese timeline evolution for the electric sector

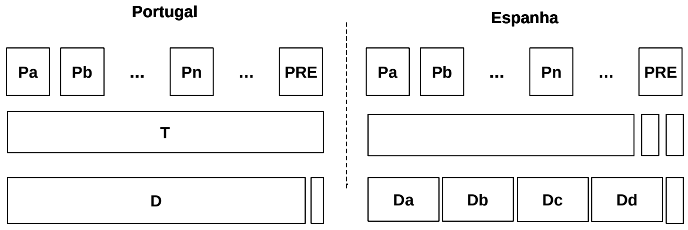


Source: the author

In January of 2004, the economy ministries of Portugal and Spain agreed on the creation of the Iberian electricity market (MIBEL). The regulatory entities of Spain (CNE) and Portugal (ERSE) drew up a joint proposal to define the organisational model for the market. This should lead to the development of a fluid and efficient competitive market, with mechanisms of follow-up and control that ensure the satisfaction of the consumers' needs, a guaranteed supply, and compatibility between the objectives of energy efficiency as well as the incentive of renewable energies in both countries.

Before the creation of the Iberian market, Portugal and Spain had several electricity producers (Pa,...,Pn) and the PRE (Special Producers). Regarding the distribution Portugal had one major player while Spain had four major players. This represented for Portugal a market of 38TWh and 5.7 million consumers while for Spain represented 198TWh and 22.5 million consumers.

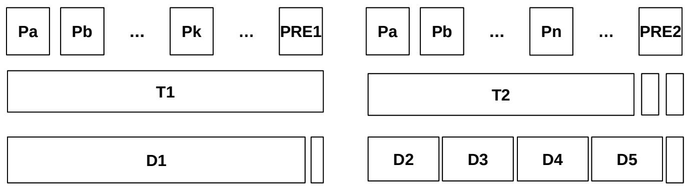
Figure 7.3: Iberian electricity market before the Mibel.



Source: Jorge Vasconcelos 2004

With the creation of the Mibel, we will now have two major transport companies and five distributors competing for a 245TWh market with 29 millions consumers. The Iberian partners are preparing their future integration in an European market.

Figure 7.4: Iberian electricity market with the Mibel.



Source: Jorge Vasconcelos 2004

7.4.2. The Portuguese legal framework

The Portuguese legal framework regarding energy efficiency is composed mainly by a general policy Programmes that assure that these goals are achieved.

The main legal framework is composed by the Prime Programme, the E4, the RGCE, RSECE, RCCTE, Energy certification on boilers, Energy certification on buildings and the P3E.

From the Energy Programme to PRIME Programme

The Portuguese Energy Programme (mainly financed by the SIURE - Incentive System for the Rational Use of Energy[40]) adopted by the Parliament in July 1994[41] had the goals of improving energy efficiency, diversifying energy sources (mainly with the introduction of natural gas) and promotes endogenous renewable energy.

Afterwards a new programme was created in 2000 called POE (Operational Plan of Economy), which aims to promote an increase of productivity and competitiveness of the Portuguese companies in the global market and is particularly targeted to the industry, tourism, commercial and services sectors. This programme has a timeline from 2000 to 2006.

However, in July 2002, the government defined a set of strategic actions aiming to reinforce the Portuguese economy competition through the PPCE (Economy Growth and Productivity Programme) programme. This programme is also intended to introduce a new way of manage public funding. The creation of the PPCE obliged the redefinition of the POE, which gave place to the presentation of a new programme called PRIME (Economy Modernization Incentive Programme). This substitutes POE since August 8, 2003 (Ministry Council Resolution number 101/2003) and in terms of resources

[40] Law 188/88, Law 35/95.and DEspacho normative 11B/95

[41] Law 195/94

mobilization, has a total cost (both public and private) of over €8085 million (in which 29% come from structural funds, namely the European Regional Development Fund and the European Social Fund).

In its objectives, PRIME has a part dedicated to energy. Its objectives are

- To ensure the operation of the national supply system, without discontinuity and at affordable prices
- To reduce the external dependency of the national energy system, and to foster the development of local energy resources, by using new and renewable energy sources
- To reduce the dependency of the energy sector on oil, and to diversify primary energy sources and supply origins, namely by promoting the use of other fuels, such as natural gas
- To foster energy conservation and rational use, as well as to reduce energy intensity in all activity sectors, thus contributing to the reduction of the energy bill and the country's external dependence
- To reduce the environmental impact of energy production and use
- To increase the effectiveness and efficiency of the national offer of energy products and services.

The programme states: "Portugal will only be able to reduce its energy consumption and its pollutant emissions by promoting energy and environmental awareness among Industry, Building Industry, Services and even in the Tourism sector". It continues saying that "Energy is a strategic sector for national economy competitiveness growth, either by reducing the energy bill, by externalities such as the environmental ones, or by its contribution to the technological modernisation of Portuguese economic agents and businesses".

E4

Through the launch of the E4 Programme (Energy Efficiency and Endogenous Energies) in 2001, the Portuguese Government took the initiative with a set of multiple, diversified measures aimed at promoting a consistent and integrated approach to energy supply and demand. Seeking to simultaneously secure supply, reduce the energy bill and preserve the environment, the E-4 strategy relies on three main lines of action:

- Diversifying energy sources available in the market and increasing the security of services provided by energy suppliers;
- Promoting the improvement of energy efficiency, thereby contributing to reduce the GDP energy intensity and the external energy bill, on the one hand, and responding to climate change, on the other hand, paying special attention to opportunities to optimise the demand-side efficiency;
- Promoting the use of endogenous energy sources, namely hydro, wind, biomass, solar (both thermal and Photovoltaic) and waves, establishing a compromise between technical/economic viability and environmental constraints.

The initiatives (legislation, incentive schemes) introduced in 2001/2002, aiming at stimulating the market (private investors), not only for ENR electricity sources, but also for CHP, solar thermal use and building energy efficiency, are underway. These are namely:

- Decree-Law defining the conditions regulating the awarding and management of grid interconnection points for Independent Power Producers (IPP)
- Decree-Law establishing a range of favourable feed-in tariffs for ENR electricity sources
- Decree-Law regulating the delivery of electrical energy into the low-voltage grid (micro-generators, including photovoltaic)
- National programme for supporting wide diffusion of solar water heating
- National programme on building energy efficiency
- Adapting or broadening the scope of financial incentives for energy efficiency and use of endogenous energies in the framework of the POE/PRIME Programme (Operational Programme for Economical Development).

Regulation for Energy Management (RGCE) - Law 58/82, of 26 February 1982

The Regulation for Energy Management (RGCE) has been introduced in 1982 and targeted mainly the industrial sector. RGCE is applied to energy-intensive companies and establishes goals for the progressive reduction of specific energy consumption. In addition, the RGCE has been made mandatory (for every company that applies to a grant for energy projects) to carry out an energy audit every 5 years and an energy management plan for the subsequent 5 years. The RGCE has also forced companies to monitor their energy management plans in order to assure its successful implementation. It has been elaborated other mandatory documents that define the energy consumption reference values for specific sectors.

All energy consuming facilities meeting one or more of the following conditions are covered:

- Energy consumption of more than 1000 toe in the last 12 months
- Equipment with total nominal power rating of more than 0.3 toe per hour
- Any one item of equipment with nominal energy consumption of more than 0.3 toe per hour

The regulation obliges companies to control the results of the energy savings measures and assures the successful execution of the rationalisation plans. The objective was to reduce the specific consumption of energy by at least 5% over the five-year period.

Regulation on HVAC Systems in Buildings (RSECE) - Decree-Law 118/98, of May 7th)

The RSECE was approved in 1998 replacing the existing Quality Regulations on HVAC Systems for Buildings (RQSECE) - which is not currently being enforced due to procedural constraints. The RSECE defines the rules to be followed when HVAC systems are installed, to ensure:

- Energy efficiency of systems and equipments used insure indoor thermal comfort and air quality requirements;
- Quality and safety of the facilities;
- The respect for environment.

Regulations on the Characteristics of the Thermal Performance of Buildings (RCCTE) - Decree-Law 40/90, of February 6th

The RCCTE was published in February 1990, and has been in force since January 1991. According to this regulation, new building designs and large re-investment works with a minimum useful area 300m2 meet minimum thermal requirements. The RCCTE ensures that indoor thermal comfort requirements are met without excessive energy consumption, thus preventing effects like condensation in walls.

RCCTE's establishes the maximum amount of energy needed to meet the nominal heating and cooling requirements, taking exclusively into consideration the building envelope. Portugal was divided into three winter and summer areas taking into account the respective degree of climatic severity, i.e. the harsher climatic severity in one area, the more demanding thermal characteristics of the building envelops.

Energy Certification of Boilers

The European directive n.º 92/42/EEC of 21 of May concerning the efficiency requirements for new hot water boilers fired with liquid or gaseous fuels, was transposed to the Portuguese law by the Law 136/94 of 20 of May.

Energy Certification of Buildings

During 2000 a pilot project of energy certification of buildings was concluded, aiming to test a method of certification already identified in a SAVE project. The correspondent budget reached € 86 000. This energy certification ensures that the buildings are in accordance with the RCCTE and RSECE for a proper construction in terms of energy losses and gains through the building envelope and acclimatization systems.

P3E (Energy Efficiency in Buildings) National Programme - Ministers Council Resolution nº 154/2001

In 2001, the Ministry of Economy introduced the National Programme for the Energy Efficiency in Buildings (P3E), which aggregates all the building measures pointed out by the E-4 programme. The main objectives of this programme are the same of E-4 Programme for the services and tertiary sectors; however, those measures are more detailed in the P3E. The P3E is still running and its results are mainly three legal initiatives regarding the technical regulations concerning buildings. These new regulations replace the RCCTE and the RSECE and they will demand a higher thermal quality of buildings and higher energy efficiency in their systems. The expectation is that these instruments are expected to reduce energy consumption and CO2 emissions in the building sector.

The Energy Certification of buildings results of the Directive on energy performance of buildings (Directive 2001/91/CE). This could be extremely important in the future because it classifies the building according to its energy consumption (A, B, C…) and will become one more element to consider by potential buyers.

7.4.3. Wrap up

The discussion around energy efficiency is 20 years old. However, even if a great effort was made in the last years to improve the national legal framework there is still a lot to be done especially regarding its implementation. As we saw, legal initiatives come from the beginning of the 80's (RGCE) but their success is rather dubious.

The fast development of the Portuguese energy consumption increases the need of an energy efficiency policy. This is recognised by all actors (Simões 2001) as it is the great efficiency potential still not explored in our country (see also 5.1.3).

A significant number of mechanisms exist but they remain not effectively implemented or have no significant results. We believe that there is a great work to do in terms of developing ways to control the results and eliminating grey areas of responsibility. These grey areas allow unsuccessful results regarding a given programme, which is the first step to its malfunction. An example of this is the E4 Programme. The E4 was a critical Programme to the promotion of renewable energy sources in Portugal. We think in some ways it has been a relative success (e.g. wind energy)[42], but it has been a failure in other energy sources with great potential (even bigger than wind) like solar energy and PV energy.

It seems that the targets of this programme are in some area considered ambitious. For example, and quoting Mr. João Mendes[43] (interviewed to the Review *Água&Ambiente*[44]): "The E4 sub-programme AQSpP (Solar Heat Water for Portugal), which establishes 1 million of m3 of solar panels in 2010 (…) assumes the installation of 150 thousand m3 per year (…) but our industrials guarantee that the market is absorbing only 6 to 7 thousand m3(…). This reality shows the huge inertia in evidence in our market that will have to be surpassed by supplementary initiatives in the next years, if we want to reach the E4 objectives".

However, in wind energy the expectation is more optimistic. The Ministry of economy published in May 2004 the progress of the wind energy in Portugal (Figure 7.5) where shows the progress made until now: 282MW (7.5% of the 3750MW) are already in production, 1255Mw representing 33.4% are

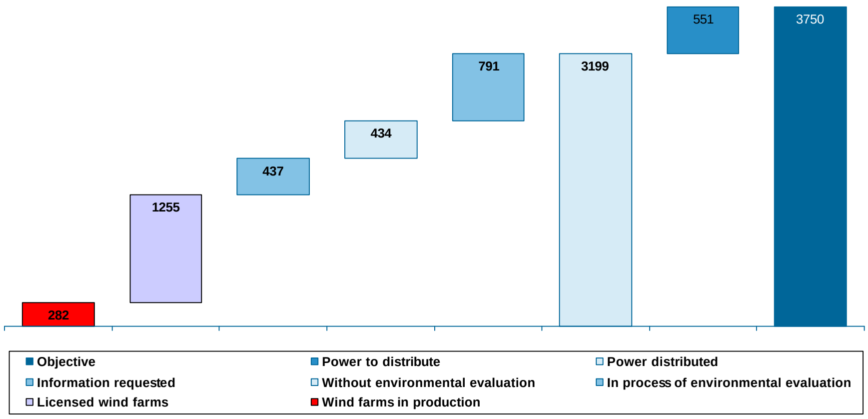
[42] Although all the almost 4000MW are licensed, their construction has not yet started mainly due to promoter's will to force the government to increase the funding as the target objectives reach the end of the deadline of 2010. Nevertheless, when compared to other energy sources also integrated in E4, this might be considered as a success.

[43] President of SPES, the Portuguese Solar Energy Association

[44] Site: http://www.ambienteonline.pt

licensed, 1962MW (44.3%) are in process of licensing leaving only 551MW (14.6%) to attribute. We believe that the commitment of the government and the most favourable incentives push wind energy to its objective. Nevertheless, it will be necessary a CAGR of 58.6% between 2004 and 2010 in order to achieve the objective proposed (further details in Table 12.22).

Figure 7.5: Wind energy progress in Portugal up to 2010 (in MW)



Source: Ministry of Economy, DGGE

In our opinion, issues regarding the delimitation of roles and co-ordination between the actors leave room for improvement in the Portuguese energy policy. Nevertheless, we believe that it would be interesting to evaluate the E4 results and understand exactly why some sources are more attractive than others, to see what can we change in the future in order to not repeat the same mistakes. We believe that the most important take away from these programmes are the learning's for the future.

Furthermore, regarding the Directive 2001/77/EC of the European Parliament and of the Council of 27 September 2001 on the promotion of electricity from renewable energy sources in the internal electricity market we observe a target for Portugal in 2010 of 39% (including the large hydroelectric power plants. According to the same report of the Ministry of Economy, nowadays we already produce ~35% of our energy from ENR sources, as we can see in the next table.

Table 7.3: Renewable energy production by source in 2004 and 2010

	2004			2010		
	MW	GWh/y	Consumption	MW	GWh/y	Consumption
Large Hydroelectric	4153	12975	30,1%	4938	14700	25,6%
Wind	292	472	1,1%	3750	7500	13,0%
Small Hydroelectric	295	1025	2,4%	400	1250	2,2%
Biomass	11	43	0,1%	150	400	0,7%
Landfill gas	3	0	0,0%	50	200	0,3%
Waste to Energy	70	457	1,1%	130	900	1,6%
Waves	0	0	0,0%	50	125	0,2%
Photovoltaic	2	0	0,0%	150	175	0,3%
Total	4826	14972	34,8%	9618	25250	43,9%

Source: Ministry of Economy, DGGE

This means that the annual growth rate of the contribution of renewable energy sources in gross consumption will have to increase 9.1% (including large hydro) (Table 12.22). The compliance with this target might be achieved either by increasing the supply of electricity produced from renewable energy sources or by decreasing the consumption of electricity. In order to guarantee success in the final objective of reaching this target more aggressive legal actions should be put in place for the demand side.

When comparing the Portuguese policy with for example the Danish we understand why Denmark is more advance in energy efficiency. Denmark has been changing priorities in its energy needs for the past 30 years and was able to reduce oil dependency from 93% to 10% and coal dependency from 90% to 40% in 20 years to reduce GHG emissions (Kiiru 2003). However, the changes in the Danish energy saving policy were not free. Its financing has been based on energy taxes, CO2 taxes and subsidies. The government, local authorities, power production and distribution utilities and final consumers undertook energy savings. Therefore, there is the commitment to energy efficiency by all actors in the value chain.

In 1996, an additional effort was made in order to increase energy efficiency: the creation of the Danish Electricity Savings Trust with an annual budget of 15M€ (by the Danish Energy Authority[45]). This is a fund supported by final consumers and set up to promote savings in electricity consumption. This Trust provides grants for the development, marketing, saving appliances and installation of central heating plants. Additionally, the Government as also set up a special fund of 15M€ to R&D in energy efficiency.

Although the differences between an aggressive policy (like Danish one) and a less aggressive one (like the Portuguese) show different results we can take this as an example in what can done in this subject. We believe that a consensual legal framework, involving all actors and an implementation strategy will bring results to the overall energy chain. In this matter, the Government has a critical role in putting in motion all actors and in setting incentives to energy efficiency.

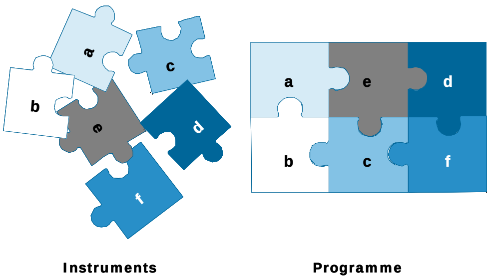
[45] Source: site www.ens.dk

8. Policy mechanisms, programmes and services engaging energy efficiency

The liberalisation on the supply-side will not reduce or eliminate by itself market barriers on the demand-side as presented in the previous chapter. In addition, competitions will disincentive investments in energy efficiency because it would reduce sales and the incentive to increase sales in a competition market is overwhelming; price reduction reduces the attractiveness of energy efficiency investments. In this context, price signals and taxes may not be sufficient to regulate demand and to reduce barriers. Therefore, a support policy framework is needed to successful implement this objective. The optimal policy combines incentives to energy efficiency investment, reduces barriers and therefore reduces transaction costs[46] by introducing technology and energy efficiency services.

Energy efficiency programmes are based on mechanisms and instruments that ensure are used for systematic implementation. These programmes have costs and risks, which have to be taken into account. The programmes combine information, advice, supplier's formation, financial incentive, etc. like pieces of a puzzle and combine them together to improve success (Figure 8.1). These paid programmes financed through the energy prices or taxes are best fitted to promote energy-efficient appliances or similar mass initiatives.

Figure 8.1: Instruments and programmes

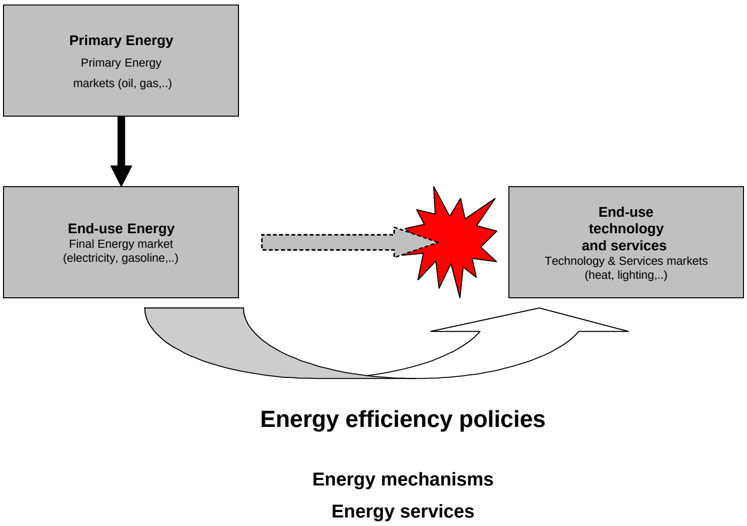


Source: the author

The existence of energy efficiency programmes is due essentially to the recognition that the market by itself is not able to reach a level of desirable energy efficiency for the society or the political objectives.

[46] The concept of Transaction Costs was introduced by Coase in 1937 in order to explain that the existence of companies is a way of a market alternative co-ordination. Coase conceives the company as a way to eliminate the price system inherent to the market and therefore as a way to eliminate costs. This economist showed different transaction costs: discovery costs or costs to find the market price, negotiation costs between agents and contract conclusion costs between agents.

Figure 8.2: Energy efficiency policies context



Source: the author

In this chapter, we will analyse some policy instruments/mechanisms used in the EU and in Portugal, looking into some examples of implementation and evaluating them from a qualitative point of view (part 8.1). We also give a look into energy efficiency programmes and services implemented throughout EU (parts 8.2 and 8.3). We chose this method of describing policy mechanisms as the puzzle pieces showed in the previous figure. We begin by describing each piece and we finish by describing how the pieces can be combined.

We are aware that is missing the quantitative aspect of the evaluation but this would require another report. The examples will try to demonstrate how policy can create a framework that will enable energy companies to maintain their competitive position and still implement energy efficient programmes and services.

The information was gathered from the report *Energy Efficiency Programmes and Services in the Liberalised EU Energy Markets* from the Wuppertal Institut fur Clima Umwelt Energie GmbH, March 2003, from the report *Developing Mechanisms for Promoting Demand-Side Management and Energy Efficiency in changing Electricity Businesses* (Research Report No 3, Task VI) of the IEA DSM Programme, August 2000 and from the IEA information newsletters on energy efficiency (available online). This was completed with some articles and our investigation on the subject. For further reading, we recommend the mentioned reports.

One of the biggest difficulties was collecting the data for two reasons: a) it is not easy to obtain the correct data for some countries; b) the access to this data in a liberalized market is getting more difficult because it is considered as classified and privileged information to the companies' strategy.

8.1. Policy mechanisms motivating energy efficiency

Policy instruments are initiatives with the objective of overcoming the policy and programmatic barriers that hinder the success of energy efficiency initiatives.

There are several mechanisms available in energy efficiency policy. The issue is to understand what type of mechanism is appropriate in the actual market context of the Member States and to evaluate the impact of these mechanisms and their trade-off.

It is complicated to evaluate only from the quantitative point of view the mechanism effectiveness (e.g. amount of saved energy). It varies with the context and the process of implementation the effectiveness, the ability to overcome barriers, its adaptability, its financial effectiveness and its social and environmental impacts.

From all the possible mechanism, we have selected the most important ones and we have divided them into five groups:

- **Funding mechanisms** to provide funding to other energy efficiency programmes undertaken by energy companies, ESCO's and others;
- **Control mechanisms** to regulate targets and objectives of the energy efficiency programmes;
- **Fiscal mechanisms** to eliminate externalities to energy efficiency programmes (eg: taxes on energy, tax exemptions, etc.);
- **Support mechanisms** to provide support for behavioural changes by end-users and energy campaigns (eg: energy centres, voluntary agreements, etc.);
- **Market mechanisms** to use market forces to encourage behavioural changes by end-users and energy companies (e.g.: labelling, information, etc.).

This does not mean that these types should work independently, it is even suggested that they work much better when combined. Among numerous mechanisms we will refer those we believe to be the most important ones and that have the biggest impact (further reading is available in reference).

In this part, we will start by identifying and evaluating the mechanisms that better adapted to the European energy context (Table 8.1). We analyse separately the Funding and the control mechanisms and we include in other mechanisms the Fiscal, Support and Market mechanisms. This way, we can take a deeper look on those we consider the more relevant ones.

Afterwards we make a tour on the existing mechanisms implemented in Portugal and will try to evaluate them.

Table 8.1: Brief description of the mechanisms used in each country

Type	Country	Brief description
Funding Mechanisms	UK	Climate Change levy
	Norway	Public charge to fund regional energy agencies and information programmes
	Denmark	Public charge to fund fuel switching and energy efficiency
	USA	Company funds customers' energy efficiency programmes.
Control Mechanisms	Belgium	Obligation to save 1% of 2 years consumption
	Denmark	Obligation to inform customers on energy savings
	Germany	Voluntary agreements with an objective of 35% GHG reduction
	Netherlands	Industrial companies' adherents to voluntary agreements are committed to be on the top 20% in energy efficiency at world level
	Finland	Voluntary agreements cover 75% of all industry
Other Mechanisms	Denmark	Distribution companies allowed tariffs rise to cover energy efficiency cost.
	Italy	Removing of pressure of the KWh sold by increasing other variables
	France	Fiscal measures
	Denmark	CO2 tax for household and public services
	Germany	"Ecological tax"
	Netherlands	Environmental tax

Source: the author

8.1.1. Funding mechanisms

1. Public benefits charge for energy efficiency

This mechanism is a charge or tax imposed on certain actors of the electricity market and it may be calculated as a rate per unit of quantity of energy delivered to a customer, a rate per unit of value of energy purchased by a customer or even as a fixed charge per client. It can generate funds to implement new energy efficiency programmes, or to maintain/increase the existing ones.

The scope of the mechanism may vary depending on the programme's objective. If the intent is to preserve funding for existing energy efficiency activities, then the charge should affect only clients currently participating in those activities. If the objective is to ensure that all clients pay a uniform charge, then the charge will be imposed on customers who have not participated in those activities.

This mechanism can have a wide range of impacts on the electricity business depending on what extent it raises the electricity price. If electricity businesses have access to funds they ensure profitable energy efficiency activities, if not they will experience reduced sales. Taxes on energy raise energy prices. In this sense, energy actors push the surcharge in the energy value chain until reaches the final consumer. Therefore, we may say that the implementation of a specific charge may imply a limited savings compared to the high price increases.

In industry, this surcharge will be reflected in the final product cost and therefore may compromise the product competitiveness without reaching significant results. In households, the price elasticity is low in a short term, so people will not lower their consumption because of that. However, in the long-term energy companies may see their energy sales being reduced due to the implementation by customers of cost-effective energy efficiency measures in order to avoid paying taxes.

There are also some disadvantages in this mechanism: it does not transform energy companies into providers of energy services and its implementation may cause high transaction costs (e.g. tendering procedures). The fund collected can be redistributed in four ways: through tendering procedures, through application procedures, using an independent body or directly invested by energy companies in DSM programmes under independent body supervision.

A climate change levy is in place in the **UK**, since April 2001, part of which will be used to support energy saving technologies and practices (through a "carbon trust"). The aim of the Carbon Trust is to help the UK move towards a sustainable, low carbon economy whilst maintaining business competitiveness. The Trust's first year funding is up to £50 million, from Climate Change Levy.

The Climate Change Levy (CCL), effective 2001, was introduced on energy use in the non-domestic sector (industry, commerce, agriculture and the public sector). Its aim is to encourage energy efficiency and help meet the United Kingdom's targets to reduce GHG emissions. It applies to gas, electricity, liquefied petroleum gas (LPG) and coal.

The rates of the levy are based on the energy content of the different energy products. They are equivalent to 0.43 p/kWh for electricity, 0.15 p/kWh for gas, 1.17 p/kilogram for coal and 0.96 p/kilogram for LPG. Fuel oils do not attract the levy as they are already subject to hydrocarbon oil duty. The levy is added to energy bills before VAT is applied. Some users are exempt from paying the levy (e.g. residential energy users, charities and very small businesses). The levy package, including the Climate Change Agreements, is expected to save at least 5 million tonnes of carbon per year by 2010.

The revenues generated from the levy are recycled back to businesses via a 0.3% cut in the main rate of employers' National Insurance Contributions and additional support for energy efficiency measures. The scheme is worth around £200 million in the period 2001-2003, depending on take-up.

Also in **Norway**, in the mid-1990s, the electricity companies encouraged the setting up of Regional Energy Efficiency Centres. By 1999, 19 regional Energy Efficiency Centres had been established. Utilities could collect a supplementary charge of up NKr 0.003 per kWh on transmission tariffs at the lowest grid level to finance energy efficiency activities carried out through these centres.

The **Danish** Government set a supportive framework based essentially in the Electricity Saving Trust. This extends conversion grants, currently available to electric heating consumers in areas without collective heat supply, to consumers of electric heating in areas with district heating and natural gas supply.

A minor portion of the subsidy grants will be used for other purposes, especially regarding the development, market introduction and market dissemination of efficient appliances. In addition to the substitution of electrical heating, the Electricity Saving Trust has introduced several other activities. Buy A-products is a campaign for energy efficient lights (CFLs) and electrical household appliances.

Buyer clubs for public institutions and housing associations have been a valuable means to facilitate the purchase of energy efficient appliances. A homepage for consumers to find the retailers with the lowest prices on A-labelled white goods is another popular initiative.

From 1998 onwards the scheme has been financed by a fixed amount of DKK 0.006 per kWh sold, levied on the electricity consumption of households and the public sector. The sum available is expected to be DKK 90 million a year and has a target of a cumulated saving of 750 GWh over 10 years leading to reduction of the Danish total CO2 emission of 1% (Wuppertal 2000).

2. Financing of energy by electricity businesses

This mechanism is based in the client's contribution, instead of subsidies and rebates by government. Its major objective is to have cost effective end-use energy efficiency paying for itself and clients making economic benefits from improvements.

In a competitive market this can be a good opportunity for energy companies retaining customers and for increase their relationship with clients, which opens a wide financial business opportunities and schemes.

A critical issue will be the ability to retain the customer, securing a long-term revenue stream, because of the difficulty to maintain any energy efficiency financing arrangement if the customer changes electricity supplier.

Previous experiences come all from the **USA** and none from Europe. For example, the Energy FinAnswer is a Pacific Corp programme (http://www.pacificpower.net) that provides money at a competitive market rates to commercial customers for cost-effective energy efficiency programmes.

The customers can choose to finance these measures with their own source of funds or consider FinAnswer funding. The funding for cost-effective measures are based on the projected annual kilowatt-hours (kWh) saved. After the measures are installed and inspected, an Energy Services Charge will be added to customers' monthly bill to repay the funding plus interest. The rates are competitive with other offers in the marketplace. Loan durations are negotiated in order to assure a positive cash flow.

8.1.2. Control mechanisms

1. **Obligations to reach a energy savings target through energy efficiency programmes and services**

This mechanism is a legal requirement imposed by the government on electricity companies and large customers to include efficiency outcomes in their retail sales mix or wholesale purchases.

These obligations of energy savings are set for the different actors. It may be set by law or by the regulator and it may be stated in the license or be considered as an extension to public service obligations.

The type of funding of this mechanism is critical as it may hinder its development. In principle, demand retailers may be forced to meet the targets at their own cost, however this would financially harm them. The most efficient way would be to allow retailer to recover the cost associated with investments in energy efficiency technologies and applications.

Penalties must be carefully designed and equitable in order to ensure that compliance occurs. Another issue is the quantification and monitoring of the results and how to ensure reliable data.

Since January 2002, there are several energy efficiency obligations on electricity transmission, distribution and supply companies in Flanders (**Belgium**). Transmission and distribution operators are obliged to save 1% of the energy sold 2 years in their area. This programme allows fuel switching and only direct measures are accepted (indirect measures like information and awareness are not considered in the accounting). They are also obliged to prepare yearly a plan of indirect and direct measures. These plans must be accepted by the regulator.

2. **Energy efficiency agreements negotiated with the energy industry**

Voluntary agreements supported by funding mechanisms and by the guidance of a state-owned service organisation have proved to be successful tools in energy efficiency. These involve a formal agreement between a government entity and a business organisation with a compromise to carry out specific actions to increase efficiency. Although the overall saving potential would be bigger with an obligatory target, this voluntary nature is a good way to know how far companies are willing to go and to reach a satisfactory target while involving all actors in place.

In order to avoid problems like setting too low target objectives should be set by sector in order to reach each sector singularity. Another problem the increase of transaction costs when setting these schemes therefore these should be compared to the benefits reached with in the agreements.

Voluntary agreements now exist in most countries (Netherlands, Germany, Spain, Finland, France, Belgium, Italy, etc.).

In **Germany**, new agreements were signed in November 2000 with an objective of a 35% reduction of GHG emissions by 2012 compared to 1990 (28% of which for CO2).

In the **Netherlands**, 29 voluntary agreements terminated in 2000. New agreements (based on benchmarking) are in place since then in which industrial companies are committed to belong to the top 20% in energy efficiency performance at world level (Enerdata, 2003).

In **Finland**, a first round of voluntary agreements failed, lacking the information and motivation actions. In order to not repeat, this experience an Energy Information Centre (MOTIVA) was created. With the objective of carrying out energy audits, information campaigns, etc. The Industry Ministry is funding 50% of audits and 15% of the investments. Current voluntary agreements cover 75% of all industry, 50% of energy sector and 30% of local government. The financial incentives for companies and organisations to sign these agreements consist in 10% subsidy for the energy audits and a 10% subsidy for the implementation of the investments proposed in the energy audit report. The target is to have 10% less specific heat consumption in buildings in 2005 and 15% less in 2010 compared to 1998. There is also the target to stop the increase in electricity consumption and reverse the trend before 2005.

8.1.3. Other mechanisms

There are also other important mechanisms that we are going to address briefly, but we will not analyse them in depth.

1. **Actions in price regulation**

When performing energy efficiency activities, energy companies face direct costs with the programme and loss of revenues.

In a performance-based regulation, these can be recovered outside the price cap so that this component is not loaded with the same pressure to reduce costs as the components under the cap.

With a scheme like this, the energy company is able to recover revenues lost due to a specific energy efficiency programme. However, under certain regulatory systems these costs cannot be recovered and hence creating a very unattractive scenario. This results in a lack of sensitivity of energy the company profits to energy efficiency programmes, in the variation of energy price, and in the reduction of the bill due to generation, transmission and distribution costs.

In **Denmark**, each distribution network company is allowed to raise tariffs by an amount sufficient to cover its energy efficiency cost. The average increase of around 0.05 €/kWh achieved 4% of energy consumption savings since 1992.

In the **Netherlands**, Energy distribution companies (gas and electricity) are grouped together as EnergieNed. This organisation executes the Environmental Action Plans (MAP). In ist last revision (MAP 2000), there was a target of 17 Mt of CO2 reduction in 2000. In the period 1991-1997, 73% of this target was realised (12.5Mt). The focus is on addressing the energy use of small-scale end-users through advisory services and subsidy schemes for energy conservation. MAP is financed by a MAP-levy of a maximum of 2% of the energy tariff. The specific target groups are households, public and office buildings and industry. On the production side, there are three main areas: heat market (CHP and heat distribution), new technologies and renewable energy.

2. **Remove pressure to increase sales from price regulation**

A reduction in the weight of energy sales in revenues regulated formula would better reflect the structure of costs and at the same time reduce pressure to increase sales.

The success of this measure depends on the regulatory system in place. If we have a system where the amount of energy sold is the only item on which depends the retailer profits, it means that a reduction in the kWh sold due to a energy efficiency programme will cause a profit reduction, hence the “cannibalisation” of its own business. Retailers will only seriously adopt energy efficiency programmes (not only for the image and marketing benefit) when this system changes. If we had a regulatory system where the profit is a function of the rate-of-return, this would not be an issue at all.

In **Italy**, two regulation measures have been introduced to remove pressure to increase sales and to make companies profits neutral to or positively affected by energy efficiency activities.

Firstly, total revenues are no longer 100% proportional to the kWh sold, but only 25%. Secondly, costs of energy efficiency programmes incurred by distributors can be recovered through a small fraction of the tariff. Each distributor has to have evidence of the programmes carried out, obtaining this way energy efficiency certificates that he can trade on the market with other distributors.

3. **Subsidies and tax exemptions**

This mechanism provides actors with incentives regarding energy efficiency. Taxpayers get a reduction for tax they pay when investing in energy efficiency activities.

Subsidies on energy conservation technologies can be an effective instrument for stimulating energy efficiency if the energy efficiency option:

- Has net benefits without the subsidy;
- Has a low market share and needs an incentive to overcome the barriers of market introduction;

- Its lifetime is not too short (10 years or longer) (Wuppertal 2002).

The last two conditions are necessary to reduce the share of free riders collecting the subsidy and to increase the market multiplier effect of the government subsidy. However, subsidy requires large government funds, which indicate that this policy instrument is only feasible when applied for specific technologies only.

An example of the implementation of this measure is **France**, where the government established fiscal mechanisms to promote energy efficiency in industrial sector by setting up fiscal advantages. In the household sector, there are several financial incentives to improve existing households focusing on the most effective GHG reduction projects. According to IEA, the incentives are as follows:

- Tax reductions: income tax reductions were available from 1990 for heat insulation improvements, heating regulation, the replacement of boilers or, in some instances, the installation of a wood stove in main residences built before 1982. The tax reduction is valid for any type of work (not only energy management improvements) if it is carried out by professionals;
- Grants for housing improvements: this government subsidy is to help low-income homeowners improve their main residence if it is over 20 years old;
- Grants from ANAH (the National Housing Improvement Agency): this grant aims at helping improve privately owned rented housing units built more than 15 years ago;
- Grants for rental and social housing improvements (PALULOS): this grant assists organisations to improve the rental housing units they own or manage for social welfare purposes, rented to house low-income people, and which are more than 15 years old.

In industry the financial benefits are:

- Subsidies for Audits and Feasibility Studies: Since 1983, financial support of up to 50% of the cost is provided to companies that carry out an energy audit or a feasibility study. ADEME has reinforced its intervention in this area by subsidising both “light” studies (“pre diagnosis”) or more specific ones (“diagnosis” and feasibility studies);
- SOFERGIE: this fund was created in 1980 (by a group of companies that finances energy saving investments) to facilitate lease financing for energy management with the hope that this funding would give structure to a body of “third-party investors” who would identify, analyse, carry out and finance investment in “turn-key” energy conservation projects remunerated out of the resulting savings;
- FIDEME: the Fonds d'Intervention pour l'Environnement et la Maîtrise de l'Energie (Investment Fund for Environment and Energy Management) aimed at small and medium companies was launched by ADEME. The subscription to this fund guaranteed by ADEME with the banking sector started on 21 October 2002 and ended 31 December 2002. Total funding was € 45.7 million.

4. Regulation

Regulatory measures are often used because they seem an effective, less complicated and more direct instrument than those discussed so far. We believe that it is very difficult to address correctly all the barriers for market penetration of a specific energy conservation tool with financial and behavioural instruments only. Regulation may be successful especially in households, where consumers are very insensitive to stimuli to change their investment behaviour.

However, regulatory measures can strongly interfere with existing interests and market competition. This means that the knowledge of the policy maker on the particular matter should be extensive. Furthermore, there is a tendency to develop less rigid regulatory measures, which disturb the market behaviour as little as possible.

Most of energy conservation technologies are available at comparable conditions and investment costs in different countries, which can be perceived as a favourable result of a more liberalised EU market. According to Uyterlinde (1999), regulation is most effective and has the least side effects when it is conducted at the highest (EU) level. Specific attention should be paid to institutional structures in the different countries because these structures are essential for the effectiveness of regulatory measures in the countries.

8.1.4. Policy mechanisms evaluation in Portugal

There seems to exist an increasing commitment to energy efficiency in Portugal but it seems that these are not implemented or enforced, or have no significant results. We will analyse them one by one and try to understand the reasons for that.

Recovery of direct costs and recovery of net lost revenues due to energy efficiency initiatives

According to the tariff regulation, document Art. º 127 par. 17 and 18 (ERSE 2004), the distributors must send a DSM plan to ERSE, until the final of the previous year to the beginning of the period of regulation. This document should present the objectives and programs to be executed, during each year of the period of regulation, with the correspondent costs and benefits. The distributors are also obliged to send to ERSE, until the 1st of May of each year, a report of execution of the plan, describing shares executed, costs incurred and benefits reached.

In addition, 50% of the social benefits achieved by the programme can be recovered but without a clear definition of what can be considered DSM in the scope of such cost-recovery, it is too risky to spend considerable resources on preparing a bigger plan that might be flunked afterwards. Furthermore, the recovery of the invested costs will only take place two years after (Artº 78 ERSE 2004), which harms the return on the investments.

ERSE lets the electricity companies to take the lead. In our opinion, until all roles and technical definitions (percentage of reduction, costs per percentage saved, etc.) are set, it will be difficult to increase DSM initiatives. Some authors also ratify this opinion by saying that “there is a further need to clarify the compensation mechanisms, to define premiums for the reduction of environmental impacts, to differentiate different levels of DSM activities according to their positive effect and to specify a minimum effort level (regarding sales volume and energy efficiency evolution)” (Almeida, et al., 2000).

Obligation to perform a certain level of DSM programmes and/or to adopt Integrated Assessment of Supply and Demand Options

This obligation was never enforced. Only one concrete action resulted from this: the elaboration of a study funded by the EU SAVE Programme (Least Cost Planning/IRP in Portugal), which identified the savings potential for the country in 1994. There is no mention at all to DSM (Almeida, et al., 2000).

Regulation on Energy Consumption (RGCE)

By the end of 2000, 549 installations (whose annual consumption represented about 4 million tep) had performed energy audits and drawn up plans for energy efficiency, which were then submitted to DGE. The consumption of these installations represents more than 50% of the total energy consumption in the industrial sector. The main industrial sub-sectors covered by the RGCE regulation are Food and Drinks, Textiles, Wood and Cork, Pulp and Paper, Chemistry and Cement, Ceramics and Glass. This value is clearly below the identified potential industry (annual savings of 27% without the replacement of equipments) and below the goal of 5% reduction for the five-year period of the implementation of the RCGE (IEA, 2001.b).

The application of the regulation is based in the compliance with certain indicators of the energy consumption/unit or product produced (many times expressed in weight). Nevertheless, due to the change in the industry in these last years, it is difficult to evaluate the effectiveness of the RGCE in changing energy consumption standards. The production processes have been changed due to quality and environmental concerns, more than due to energy consumption reductions.

Financing of energy efficiency

One of the main problems with this type of policy instruments is the fact that their effectiveness is threatened if no strict enforcement mechanisms exist.

Another issue involves the clear definition between supply side efficiency measures and demand side. We notice that 65% of the funds were distributed to projects aiming the improvement in supply infrastructures (both electricity and natural gas), and 18% of funds for the generation of energy using renewable resources (Simões 2001).

The redefinition of the POE and the consequent creation of the PRIME Programme (that, as we saw, includes an energy objective) may act as a catalyst to energy efficiency if the projects presented are valid and if the subsidy is well applied.

Regulation on the Thermal Characteristics and Thermal Behaviour of Buildings (RCCTE) and regulations on Energy Systems for the Acclimatisation of Buildings (RESECE)

This regulation was the first step to improve thermal comfort in buildings, quantifying the needs of the building in terms of energy and consumption and taking into account the rational use energy.

These regulations have definitely had influence in improving the energy efficiency of buildings. However, many projects still do not have the required building thermal study and this is not properly enforced (Simões 2001).

Recently the Government published the Portaria nº 817/2004 and the Decree-Law nº 68/2004, establishing a household technical certificate (Ficha Técnica da Habitação in Portuguese). This document aims the household promoters and obliges them to inform the customer, through a certificate, of the household characteristics. This legal initiative applies to all houses sold or rented after 16/08/2004. The guarantee of compliance of this certificate is the responsibility of the household promoter and the household technical manager (responsável técnico da obra in Portuguese).

In our opinion this is a good document because will create another market variable to customers better chose their household. Now, it is important that the readiness of the document is high, i.e. the public needs to understand the importance of what is written. Another issue is the energy consumption of the household. This document clearly informs the household characteristics but does not inform of the average energy consumption of a typical household. Like in the automobile industry, we have the average fuel consumption for a given type of use. We should also have the average consumption for a type of use.

8.1.5. Wrap up

There are clear signs of government awareness for the relevance of energy efficiency and electricity end-use efficiency. The legal instruments exist but their implementation needs to be improved.

Regarding energy policies, the Portuguese government seems to focus still on improving the supply infrastructures, especially for the natural gas, in order to secure the reduction of dependency from oil. Energy efficiency in the demand side (especially electricity efficiency) is still a secondary priority. The primary issue in Portugal is still customers' demand. Acknowledging these problems, many authors have studied ways to improve these instruments and have made many suggestions in that sense. In addition, the tariff scheme does not help, as it is only function of energy sold (kWh). In this regulatory context, it will be difficult for companies like EDP to enforce a major programme of energy efficiency.

Independently of these suggestions, essentially the existing DSM policy instruments are not effective because they are not enforced. Until the uncertainties regarding the practicalities of the DSM implementation are clarified (who should promote the DSM, what DSM activities are relevant and how they should be funded), the existent (or new) policy instruments that will have poor chances of success.

At the moment, the Portuguese energy sector is still drifting away from sustainability, which seems to clash against the environmental commitments and gives the wrong signals to the Portuguese society, regarding the relevance of the environment in the economic sustainability.

Up until now we saw the type of mechanisms that can be implemented (and already are) by several European countries. However, in order to increase their effectiveness these can be integrated in wider programmes either at national or European level. The following parts will overview some of the specificities of these programmes as well as the importance of energy services in surpassing energy efficiency barriers. We will see that these services increase the overall result in efficiency but they need specific conditions to proliferate successfully.

8.2. Energy efficiency programmes

Now that some of the "puzzle pieces" are described, we will pass to the description of some energy efficiency programmes. These are set at a national level but frequently under the European "umbrella". From all the fields referred in chapter 7.3 to support EU energy strategy only one applies specifically to energy efficiency: The SAVE Programme. We will begin by describing this Programme: budget and objectives. Subsequently we will discuss the best practice in efficiency programmes.

8.2.1. SAVE I and SAVE II Programmes

The original SAVE programme was not approved until October 1991. SAVE was designed to focus on the non-technical measures needed to promote energy efficiency, complementing the earlier technological focus, and was the only EU programme solely dedicated to energy efficiency.

The EU main energy efficiency programme supports the Commission’s energy efficiency legislative programme and the Directives cover:

- Appliance labelling for a wide range of products
- Appliance efficiency standards
- Boiler efficiency
- Measures to limit carbon dioxide emissions by improving energy efficiency (Council Directive 93/76) (in six areas including energy certification of buildings; the billing of heating, air-conditioning and hot water costs on the basis of actual consumption; third-party financing in the public sector; thermal insulation of new buildings; regular inspection of boilers; and energy audits of undertakings with high energy consumption)
- Energy Performance of Buildings. The directive on Energy Performance of Buildings aims to promote the energy performance in buildings by introducing a framework for: an integrated methodology for measuring energy performance; application of minimum standards in new buildings and certain renovated buildings; energy certification and advice for new and existing buildings; and inspection and assessment of boilers and heating/cooling systems. The directive was published January 2003 and compliance is foreseen the latest by 4 January 2006.

The original SAVE programme had a budget of 35M€ and was regarded as a means to reach the EU target of reducing energy intensity by 20% between 1986 and 1995. Nevertheless, when SAVE was evaluated it was shown that in spite of vigorous efforts to reach the 20% goal only a 12% improvement had been reached (Salas 2000). This evaluation concluded that this programme should be continued because it made a significant contribution to EU capacity and its projects where like “rings on water” leading to replications with local and regional impacts. Therefore, in December 1996 begins the SAVE II programme. This Programme started with a budget of 45M€ and a timeline between 1996 and 2000 (subsequently extended until 2002) was a less legislative programme but financially more important.

The goal of this programme was to improve energy intensity 1% per year above the normal rate of improvement along with an estimated CO_2 emissions reduction of ~200Mt per year by the end of the 5^{th} year.

The SAVE II is considered a fundamental instrument to EU energy policy. In spite of limited resources, it has achieved much success even if this is not reflected in improvements in energy intensity: CAGR between 1990 and 1996 was 0 and CAGR between 1985 and 1990 was -2% (Janssen 2000).

One of the results of SAVE can be fund in The Odyssée Project[47]. This project was the result of an initiative of the French energy and environmental agency ADEME. It has been subsidised by funds from the European Commissions' SAVE programme right from the beginning. ADENE, the Portuguese Energy Agency is responsible for the Portuguese contribution.

Within the initial phases of the project the database, a network of institutions and the method of analysing had been developed. In the meantime, the project has been converted into a continuous process. Project work covers improvement of data reliability and indicators set as well as annual data update and reporting. The visible result of this project is the database ODYSSEE. It provides an easy

[47] Source: http://www.ademe.fr/partenaires/odyssee/default.htm

access to the indicators. The database contains indicators for different sectors for all EU countries and for Norway.

The energy efficiency indicators used within this project refer to the economy as a whole, to a sector or to an end-use: industrial process, mode of transport or energy services in the household or in the services sector. Three types of indicators are being calculated in order to describe and characterise energy efficiency trends:

- Economic ratios, relating an energy consumption to a macro-economic variable ("energy intensities");
- Technical-economic ratios, relating an energy consumption to an indicator of activity measured in physical terms ("unit consumption" or "specific consumption");
- Energy saving indicators that provide an assessment of quantities of energy saved, in absolute values (e.g. Mtoe) or in relative terms ("energy efficiency index" and "energy savings rate").

8.2.2. Best practice in energy efficiency programmes

When we establish as a criteria to identify the best energy efficiency programmes we must realize that the choice of customer groups and technologies as well of programme cannot be understood without the countries policy framework for energy efficiency. This determines the extent and focus of the energy efficiency programme implementation, evaluation and documentation.

Furthermore, successful energy efficiency programmes are always a combination of several activities interacting and mutually enforcing each other (Wuppertal 2000), which makes that classification evermore difficult.

At the EU level (in general) as well as on the Portuguese level, the current policy framework is not very favourable to the implementation of energy efficiency programmes as it focus on price competition and volume. For now, efficiency is only considered by the supply side and has not been extended to demand side. In our opinion we will pass from a “war” between prices and in medium term, when price stabilize we will pass to a “war” between services and this will be the field where energy efficiency will act. Therefore, the regulators and/or governments have developed different frameworks allowing energy companies to share the bourdon of energy efficiency programmes.

There are three types of targets considered in the EU energy efficiency programmes: investment saved, kWh/toe saved or saved CO2.

As we can see in the Table 8.2, the target is usually set by the Government alone (Denmark) or by the Regulator in association with the Government (Netherlands). Nevertheless, we can notice some exceptions like France where the target is set between the energy agency and a major company. This is due to the relative lightweight of the regulator (CRE) in energy efficiency in France; in fact, the energy agency (ADEME) is supported by the Government and has an important role in energy efficiency in France. As we can see, France is the only country to set and investment target without setting any quantitative targets.

Another exception is given by Germany where the Government set the target with the Energy Companies Association. The German government prefers voluntary measures to regulatory ones because it believes that competitiveness will push industry to implement the most-cost effective (IEA 2002).

Table 8.2: Targets of the energy efficiency programmes

	Type of target			Responsibility for definition of target
	Investment	Saved kWh/toe	Saved CO2	
Belgium	-	X	-	Government sets target. Grid operator calculates budget needed.
Denmark	-	X	-	Government
France	X	-	-	ADEME & EDF
Germany	-	-	(X)	Agreement between energy companies association and the government
Italy	-	X	-	Government
Netherlands	-	-	X	Novem & Government

Source: adapted from Wuppertal 2000

The funding can be based in taxes and/or tariffs. As we can see, most of the Member States have chosen to fund their energy efficiency programmes through tariffs, to hand in the management of this fund to the energy companies and its evaluation to the government/independent authority. The exception is once more France, where ADEME and EDF combined with local authorities manage and evaluate the funding.

Table 8.3: Funding source of the energy efficiency programmes

	Founding Source		Actor	
	Taxes	Tariffs	Administration	Evaluation
Belgium	-	X	Network Companies	Government
Denmark	-	X	Network Companies	Electricity Companies Association
France	X	X	ADEME, EDF, local authorities	ADEME, EDF, local authorities
Germany	(X)	(X)	DENA	Institute that evaluates CO2 reductions
Italy	-	X	Distribution Companies and National Fund	Gas & Electricity Authority
Netherlands	X	-	Energy Companies	Novem

Source: adapted from: Wuppertal 2000

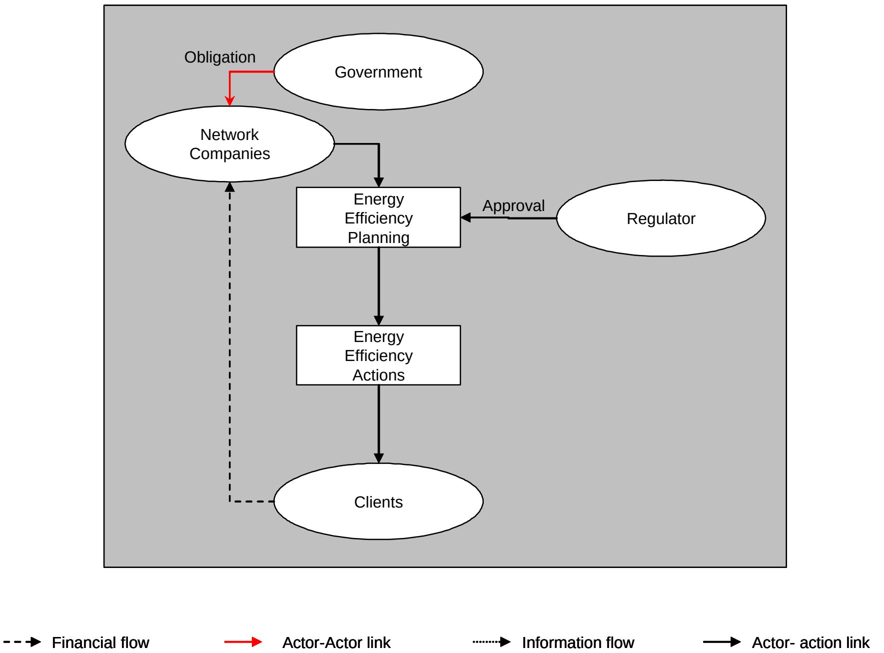
In terms of organisational structure for the programmes, it is difficult to evaluate which country has the best organisation. The question is which one works better and reduces “grey areas” that may hinder the success of the programme(s).

As an example, we will look to the energy efficiency schemes in Flanders (Belgium), Italy and France. These examples consist in three different approaches to energy efficiency organisational methods.

Usually a government entity (a ministry for example) is in charge of setting and coordinating targets (like in Belgium, Italy and Netherlands). These targets may be set to network (Belgium) or distribution companies (Italy) or even electricity retailers (Netherlands).

In Belgium (in the Flanders Region), the Electricity utility association evaluates and plans the energy efficiency activities, which will be performed by the Network companies. Customers pay these activities directly to network companies. In this scheme, the curious aspect is the direct link between the Government and network companies and the relative independency of these in setting up the energy efficiency plan and the financing scheme, in which 100% is provided by clients.

Figure 8.3: The energy efficiency obligations scheme in Flanders

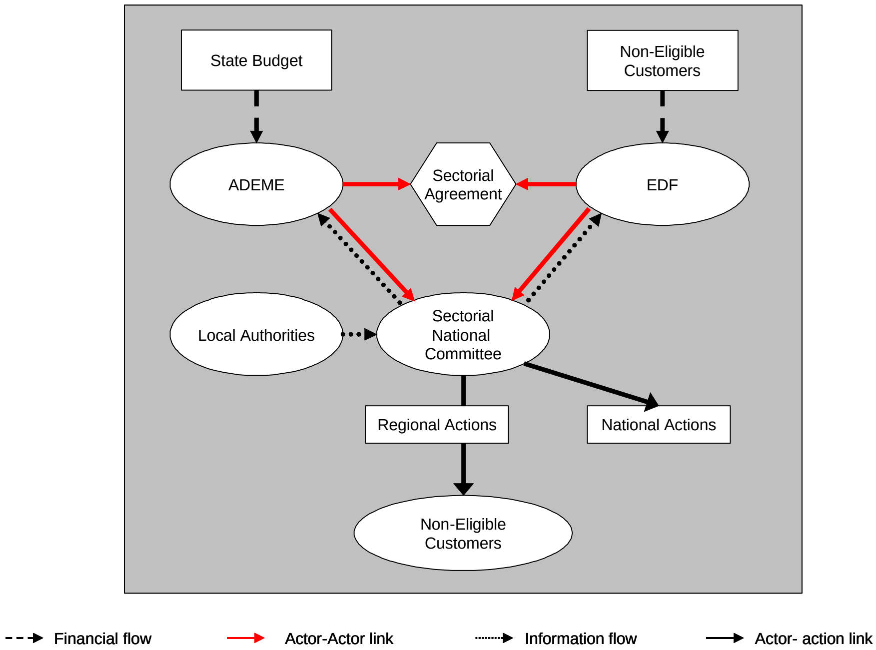


Source: adapted from: Wuppertal 2000

In France, the relationship between the different actors is as described in Figure 8.4. ADEME and EDF and financed respectively by the Government and by customers. The Sectorial National Committee (supported by ADEME and EDF and local Authorities) plans National and Regional Actions to benefit the general public.

This scheme shows some interesting characteristics. The first of which is the notion of Public Service. In France, the State is expected to fund these kind of activities, therefore is with no surprise that we see a public organism (ADEME) in charge. Secondly, we can observe the importance of local authorities in this scheme, which is critical for the success of the activities. Thirdly is the fact that the French system does not include the CRE (French Regulatory Commission).

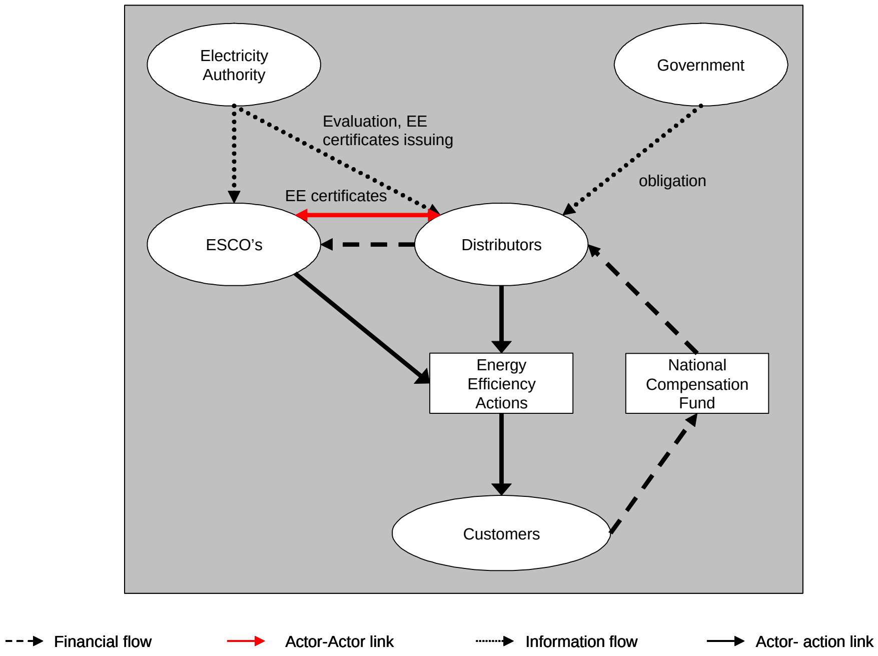
Figure 8.4: The energy efficiency obligations scheme in France



Source: adapted from Wuppertal 2000

In Italy, the most interesting aspect is the market of energy efficiency certificates pushed by the Electricity authority, responsible for their issue, the ESCOs and the Distributors that trade these permits between them. Another aspect is the financing scheme, which is made through a National Fund dispersed to Distribution companies.

Figure 8.5: The energy efficiency obligations scheme in Italy



Source: adapted from Wuppertal 2000

8.2.3. Wrap up

There is not only one organisational structure that guarantees the success of the programme. We can identify more or less complicated structures depending on the country's legal organisation and culture. Here we have showed three types of structures. The Belgium one more simple and direct than for example the French one but this structure allows a better implementation as it involves almost all actors in place. The Italian system is based on a market of white certificates between ESCOs and distributors.

The funding options are different but the objective is the same: providing an economically sustainable energy efficiency programme. Apart from that the issue is of involving all actors in order to guarantee the maximum success of the programme.

8.3. Energy services

Like energy programmes, energy services play a growing importance role in energy efficiency and they should also be considered in this chapter. Their weight will increase with the expected publish of the Energy Services Directive. According to the Commission, the long-term potential market for performance contracting of energy services and energy efficiency measures in the EU has been estimated to be in excess of 25 billion euro.

An Energy Service can be defined as a service related with end-use energy paid by the consumer. Energy efficiency services are of great importance because the service provider's profit results from an improvement in the end-use efficiency not from the trade of energy.

Even the traditional energy companies selling only kWh are becoming conscientious that the consumer is interested in the service provided from energy as the useful kWh, and not in the kWh in electric lines. The former utilities started to integrate subsidiary service companies in their business plans (usually unbundled by accounting) or to generate "free" services associated with their product.

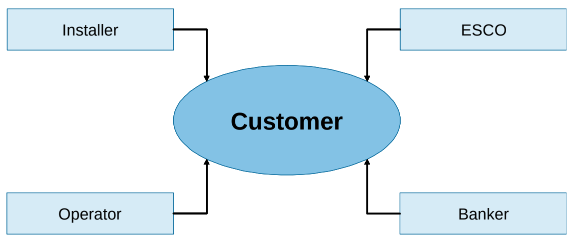
The key idea is that the contractor (ESCO) has a better knowledge of energy design and management and therefore energy efficiency than the consumer, as well as cost advantages. An energy performance contract (EPC) can take different forms depending on the type of client, technology, services provided.

We can distinguish three market segments for energy services: households, median size industry and large industry.

Households and small companies can be in the scope of energy services but only those using mass media diffusion or regional energy centres, due to its fragmentation. On the other hand, medium and large size industry are the most interesting targets for energy services. We will now take a deeper look to energy services in this market segment.

In the Figure 8.6, we can observe that in the "traditional" model the customer centralizes all the management of energy, establishing independent relations between Installer, ESCO, Operator and Banker. This type of relationship will change to something more integrated.

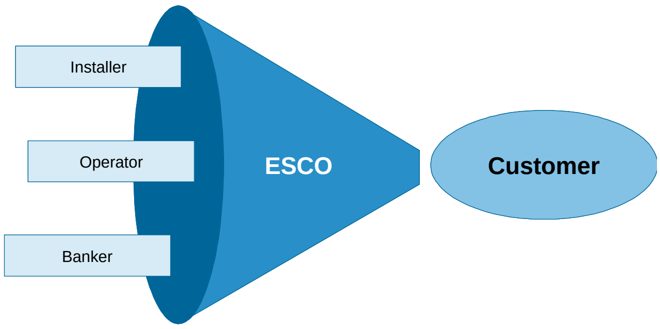
Figure 8.6: The "traditional" ESCO/Customer relationship model



Source: Wuppertal Institut fur Clima Umwelt Energie GmbH[48]

The alternative is to have the ESCO working as a service provider, diminishing the transaction costs for the customer and for the ESCO due to negotiation advantage gained with the rest of the providers. In addition, the customer will see in ESCO his energy partner responsible for his plant energy management, which represents a guarantee for the customer.

Figure 8.7: The future ESCO/Customer relationship model



Source: Wuppertal Institut fur Clima Umwelt Energie GmbH[48]

When energy companies are ready to integrate "sustainable development" into their strategic plans, they start giving considerable importance to the development of the services, which is also a way to escape the fierce price competition in the energy market of what alternatively is a pure commodity.

The inclusion of more services and less product leads to energy savings, but it also means that utilities are more often judged on the total cost of their core service (motion, heated square meters...) and since efficiencies become internal lever for that, the utilities make the best use of them. The important innovation lies in selling the final service (in terms of lit area of instance) instead of means (kWh, lamps, etc.).

In general, the ESCO activity is poorly developed in the Western Europe. The IEA has estimated that the overall investment in Europe amounts to around 0.2% of the total potential investment. There are many indicators of this, one of which is the small number of specialized companies working in the

[48] *Energy Efficiency Programmes and Services in the Liberalised EU Energy Markets* from Wuppertal Institut fur Clima Umwelt Energie GmbH, March 2003

field. The Commission identified over 600 companies offering ESCO services in their broadest sense, around 500 of which are in Germany, as shown in Table 8.4.

Table 8.4: ESCO evolution in Europe

	Date of the first ESCO	Number of ESCO in 2003
Finland	1987	3
France	1970	15
Germany	1990	500
Italy	1980	50
Portugal	n.a.	5
Spain	n.a.	10

Source: European Commission

Success factors

The experience from Europe and North America allowed us to determine the main factors that influence the success of the Energy Services industry:

1. The overall market and regulatory conditions for industrial development.

2. The risk profile of the industry players. The investment in industrial facilities is inherently more risky to ESCO due to the very real risk of bankruptcy or factory closure, when compared to investment in public sector buildings, where its purpose or degree of occupation may change but the institution itself continues to operate. Options to reduce the risk of investing in the industrial sector include shortening the payback period. This means that the credit risk remains but the ESCO is exposed for a shorter period.

3. The degree to which it is possible to establish and maintain a partnership between the industrial customer and the ESCO. This relationship involves two aspects:

- The establishment of a new relationship. The consumers might have a real scepticism and mistrust about the ESCO objectives. The view that what the ESCO offering is 'too good to be true' is a commonplace. Closely linked to this difficulty, is the issue of employee security. A frequent consequence of outsourcing is the loss of jobs. While some of these will normally be transferred to the ESCO, some may not be. It is natural that those who may have to lose from an outsourcing arrangement will not facilitate the new contact.
- The management of an existing relationship. To get the best results from an Energy Services agreement, it is important that both sides of the partnership maximise the energy efficiency improvement. A business model that enables this co-operation will be critical, and it will need to be based on a shared savings approach. A real danger for outsourcing relationships is a climate of suspicion between the parties. They should work as partners and share objectives.

4. The flexibility of offering. If the overall goal of the ESCO activity is the implementation of cost-effective energy efficiency programmes, then it is important that its providers have more than one alternative in terms of energy solutions. They should be able to offer a diverse package of efficiency and service solutions that include operational end use solutions and high capital cost supply side investments (including CHP). If only a restricted range of services is available, for example 'only CHP' or 'only DSM', then the full energy efficiency benefits are unlikely to be achieved and cost savings may not be maximised. In a competitive industry with narrow margins, volatile pricing and growing competition, it will be essential for ESCO providers to offer as wide a range of services as possible to their clients.

Main sources of profitability

The profitability of industrial companies will depend on their ability to:

- Free-up resources and capital for core activities.
- Secure a professional focus on energy efficiency and ensure smart energy purchases yielding lower energy costs.

- Establishing long-term contractual arrangements, which may bring greater certainty regarding energy costs and therefore allow for a more effective business planning.

For the ESCO, some of these benefits will be more easily achieved by utility companies such as electricity or gas utilities because of their market presence:

- Fuel Switching. Outsourcing is a catalyst for fuel switching. This may bring benefits such as lower fuel costs, lower maintenance and operation costs, and lower environmental compliance costs.
- End use efficiency. The outsourcing contract may include performance targets. The challenge, and therefore the opportunity, for the provider is to reduce the energy consumption of the host. This may be done solely through installing a CHP plant. However, if the contract allows, the provider may have opportunities to improve efficiency of end use of energy in the industrial site, through low-cost or ‘no-cost’ measures that can reduce energy consumption.
- Tariff management. In liberalised energy markets, where suppliers of fuel and electricity are competing for customers, there are opportunities for switching supplier to get improved energy prices. CHP / IEO providers may be in privileged conditions to negotiate energy supply contracts, both due to their access to the market (aggregation of the energy purchasing across a number of contracts into a soul contract) and through superior market knowledge. Additionally, there are opportunities to manage the tariffs. The access of utilities to energy and electricity markets brings significant benefits over industrial and other non-utility providers. For example, the cost of natural gas to the utility may be substantially lower than to other gas consumers. In Belgium, the electricity utility Electrabel also owns the gas company Distrigas. The cost of gas to Electrabel is around half of other Belgium consumers on the Belgian market (EBRD 2003). In fully liberalised markets, where tariffs are no longer used, then market knowledge and purchasing skills may yield the same benefits.
- Portfolio operation. Being a portfolio operator in the electricity market may bring benefits in terms of balancing contractual requirements with actual performance. The provider can reduce his market exposure and risk when he has a number of outsourced contracts or if he is player in the electricity market.
- Cost of capital. Depending on the size of the industrial operator, the cost of capital may be more expensive than for the service provider. Again, there is an advantage for an utility, where the cost of capital is lower than for non-utility providers. These costs are affected by the rating of the company, whether it is able to hedge across other activities and the regulations concerning its operations. In a study undertaken by EBRD (2003), EDF was estimated to have a requirement for a return on capital of only 6%, whilst for other utilities this number was 10% and for non-utility providers 12%.

8.3.1. Examples of implementation of energy services

In the USA, ESCO providers tend to use a “guaranteed savings” model rather than one based on shared savings. In return for the savings guarantee, the customer is expected to support more of the business risk of the contract.

Energy Services for industry, however, present a specific set of challenges largely based on the greater level of investment required. For this reason, even in the USA, the provider normally assumes responsibility for financing the projects and efficiency measures, sharing the savings with the customer afterwards.

The business models used by providers in the USA vary, reflecting the heterogeneity of customers and their requirements. The Trigen-Cinergy Solutions partnership has been one of the most effective of the last decade. In summary, its business model has been based primarily on a supply solution, CHP, with an additional offer of a partially integrated portfolio of customised services, including the supply of natural gas and electricity. As an example, Trigen-Cinergy aims to:

- Generate savings with no capital required from the host facility.
- Manage non-core operations, including utility infrastructure operations, energy and fuel management, process optimisation, etc.
- Manage power and gas marketing.

Ownership of energy supply assets can be retained by the client or bought by the provider.

In the US, contractors normally support the fuel price risk and then arbitrage that risk. This is particularly the case of those companies with wide energy utility capabilities. Cases where the customer retains fuel responsibility are those where there is a significant on-site fuel stream, for example in the petrochemical sector or the pulp & paper industry. In the case of additional services, utility-based providers can also deliver water and waste services.

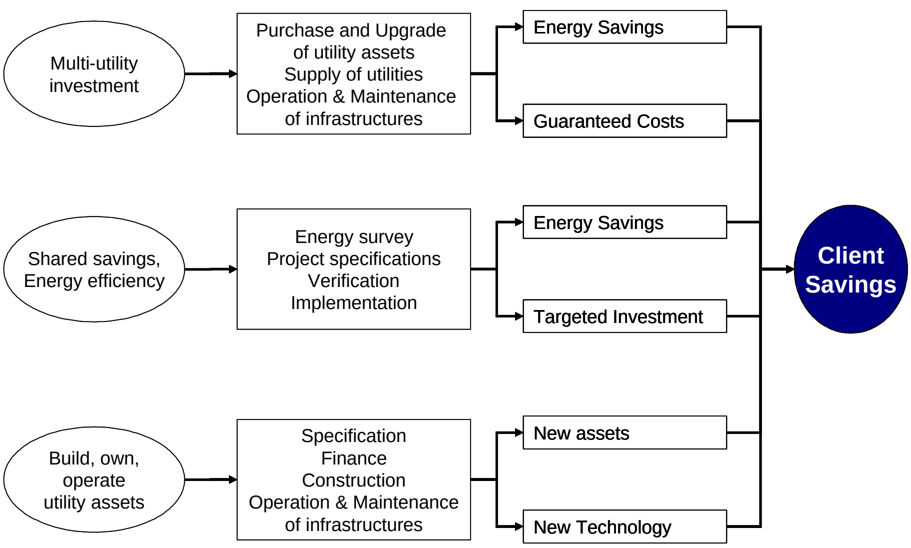
In order to more effectively limit the possibility of a client risking the commercial viability of a contract, providers ask that customers be open, as far as possible, about their financial condition. This is consistent with the partnership culture that is such an important ingredient of effective energy services agreements. Thus also makes it more unlikely that an industrial client will want to work with a contractor who may also work for one of his competitors (e.g. two major brewing companies are unlikely to use the same outsourcing company and in practice, in the US, they do not).

Business model arrangements also vary in Europe but this activity here has been much more limited than in North America. Here we present the RWE solutions model, which represents a very complete offer. RWE is one of the most important multi-utility groups in Europe. Its core business is centred in generation and sale of energy and water services. RWE Solutions describes itself as an infrastructure management company and aims to take full responsibility for all secondary services, i.e. the management of the after-products of electricity, gas and water (e.g. steam, compressed air, heating/cooling), producing a single invoice.

The business models being promoted by RWE Solutions fall into one of three main categories:

- Multi–utility investment. In this case, RWE Solutions will purchase and upgrade utility assets, supply utilities and operate and maintain utility infrastructure. Utilities such as steam, compressed air, treated water and effluent treatment are supplied at fixed prices and any required investment in a new plant aims to achieve efficiency gains.
- Shared Savings Energy Efficiency Programmes. In this case, RWE Solutions identifies, develops and implements energy efficiency projects and the net savings are shared with its clients. Clients receive the benefit of new assets without any investment or additional staff.
- Build, Own and Operate utility assets. In this case, RWE Solutions constructs, finances, operates and maintains new utility assets such as CHP, boilers, refrigeration plant or effluent treatment plants. Clients receive the benefit of new assets without having to make any investments.

Figure 8.8: RWE solutions for energy services outsourcing



Source: adapted from RWE

RWE claims to be able to tailor its offering according to whatever the customer is looking for, whether it relates to risk sharing, reimbursement arrangements or ownership. This is important because each customer has a different point of view regarding risk or outsourcing.

Being an utility company, with assets of electricity, gas and water supply services in several European countries, RWE is able to provide a reasonably comprehensive range of services, which gives it an advantage in the marketplace. In addition, its ability to provide financing for projects directly on its own balance sheet is an advantage for customers that do not wish to put any capital investments on their balance sheet.

8.3.2. Wrap up

The energy services industry will grow, as its customers became able to focus their attention on their core business. Energy businesses will leave all the energy management to these new business partners.

To utilities, this will mean a reduction in product sales (kWh) but also an opportunity to deliver an integrated service with the ability of improving the retention of customers.

The example showed in this chapter allowed us to demonstrate how an important energy player adapted itself to a new business. RWE through a flexible offering retains its customers and creates a new market.

For household consumers, the Energy Services provided can include audits (as the energy services Directive proposes), or even renting services. According to Thomas (2000), a survey in Germany to 3000 customers showed surprisingly good results in a proposed renting service of washing machine and fridge-freezer. The services comprised the free delivery, installation, repairs, hotline and removal of the appliance. In addition, the percentage of people who showed interest in this service considered that it should be performed by utilities. Overall, Thomas shows that this service is perceived as something new. The interested customers seem to like the freedom and flexibility provided by this service.

9. Quantitative analysis of the implementation of the Energy Services Directive to the household sector

What effort has to be made by EDP in order to achieve a successful compliance with the Energy Services Directive proposal? The answer to this question is not easy. EDP is the only energy distributor (in a regulated monopoly) and therefore sells the total amount of energy to a wide broad of consumers. EDP has almost 5.800.000 clients (Source: Relatório & Contas EDP 2003) ranging from household to large industrial consumers and the company to has to apply this Directive to all of economic sectors.

As we saw previously, perhaps the most important trend in energy consumption over the last few decades has been the rapid increase in the share of electricity consumption (Figure 4.29 and Figure 4.30). This is partly the result of an increased growth in the electricity intensity in the household and service sectors. Rising income combined with falling prices of appliances (due to technological revolution), has led to a significant expansion of the electric appliances market for which there is no realistic alternative fuel source.

Lifestyle changes (e.g. working hours, the need to save time, etc.) have lead to a greater mechanisation in the home. Nowadays, households own more appliances and use them more often. Over time products that were once considered as luxuries, became necessities (e.g. washing machines, dishwashers, microwaves, etc.).

This chapter is structured in five parts. The first two parts concern the estimation of some data regarding the household sector and its electrical appliances in Portugal. The third part concerns the estimation of the production cost avoided with the implementation of the Energy Services Directive proposal "as-is". The fourth parts estimates the energy audits costs with the implementation of the same Directive proposal. The fifth part uses the estimated data of the first two chapters to determine the viability of the implementation of this Directive proposal in the household sector in Portugal.

In this chapter, we have faced some limitations concerning the available data, which forced us to make assumptions about several variables. We understand that while in some cases, the assumptions did not interfere with the real result, in other cases they did. An example is when, in order to establish the production cost, we assume that the power plants are fully paid over-night, which in “real life” does not happen.

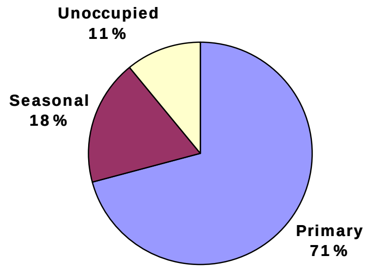
We are aware that these simplifications led us to increase the error margin, but considering the available data, without this our calculation would be very difficult. We have based our assumptions in published papers and statistical data validated by INE, IEA data and EDP internal data.

Some data in this chapter namely EDP data and household market data is confidential and was allowed to be used under a confidentiality condition, therefore should be kept to the jury members only.

9.1. The household sector in Portugal

According to the INE database, we can assume that the entire household sector in Portugal is electrified (99,5% to be exact), representing 3.551.229 houses in 2001 and 3.745.542 in 2004 (we will use this value in other calculations, ignoring the residual percentage of the non-electrified houses) (further details in Table 12.18). It also important to notice that according to INE, 3.551.229, corresponds to the number of houses used as a primary residence (71%), therefore excluding the seasonal or secondary houses (18%) and the unoccupied ones (11%). In our calculation, we have decided not to consider the secondary residences because their occupancy is normally exclusive: when a family is the secondary residence is usually absent from the primary one.

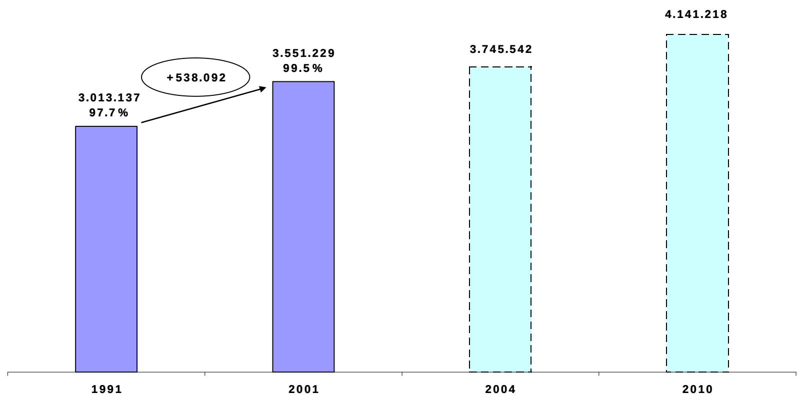
Figure 9.1: Household distribution per type of use in 2001



Source: INE database

As we see, 538.092 houses were electrified between 1991 and 2001 (Figure 9.2). This value may be considered roughly equivalent to the quantity of new houses because the market is almost saturated[49]. We have also calculated the expected values for 2004 and 2010 considering the CAGR between 1991 and 2001 (1,7%). The growth of 1,7% is a conservative value. According to EDP, the CAGR of the number of household clients[50] CAGR between 1996 and 2001 was 2,1%, increasing to 2,3% between 2001 and 2002 and decreasing to 1,7% between 2002 and 2003.

Figure 9.2: Portuguese evolution of the electrification in the household sector between 1991 and 2010



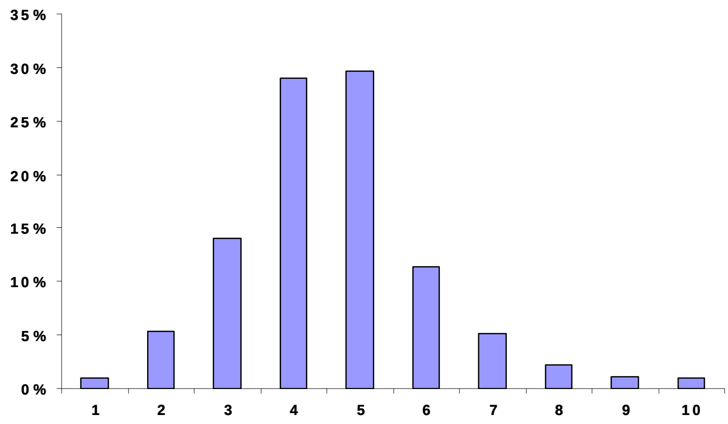
Source: adapted from INE database and the author

As we can see in the next figure, 30% of the households had five rooms, followed by 29% that had four rooms in 2001(further details in Table 12.17). Therefore, the dwellings in Portugal had in average 4.55 rooms. We will consider that the average number of rooms per dwelling is constant until 2009.

[49] This means that all the existing houses are already electrified.

[50] We are considering here the low-tension (<41KVA) evolution hence this is the one that better reflects the household characteristics.

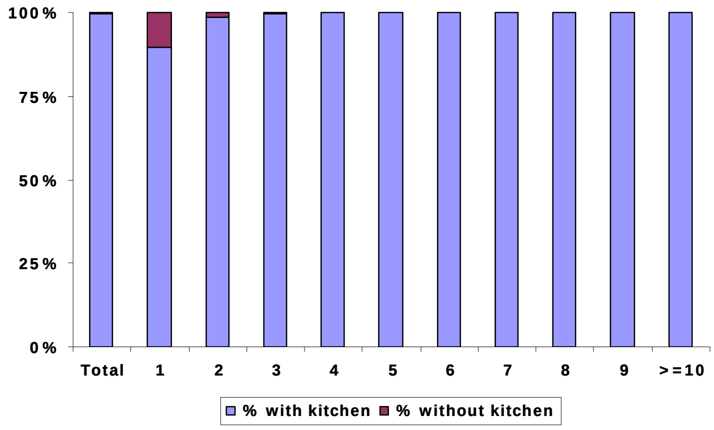
Figure 9.3: Distribution of the average number of rooms per house in 2001



Source: The author

According to INE (CENSOS 2001[51]), the concept of a room includes WC and kitchen. We can see in the next figure (and in Table 12.19), apart from houses with one room, almost all the other houses have a kitchen. The INE also states that 99,4% of the houses have at least a toilet (CENSOS 2001)[52]. Therefore, we will accept as true that on average the entire household sector is equipped with a kitchen and one WC.

Figure 9.4: Share of houses with and without kitchen per number of rooms in 2001



Source: The author

The weighted average of the dwellings area in Portugal is 84,5m^2 per dwelling (further details in Table 12.27) considering the 1997 analysis made by INE. This is the last value available in the Portuguese statistics, and consequently our best "shot". In 7 years, the household market has changed and these figures have become obsolete, however as we do not have any other information source, we will consider them.

[51] Site: http://www.ine.pt/censos2001/censos.asp

[52] Unfortunately, the INE database has no information on the percentage of dwellings with more than one WC.

Wrap up

The assumptions made about the household sector are summarized in the next table.

Table 9.1: Assumptions made in the household sector in Portugal

	Value
Number of primary dwellings in 2001	3.551.229 dwellings
Number of primary dwellings in 2004	3.745.542 dwellings
CAGR households 1991-2001	1,7%
Average number of new dwellings per year	53.809 dwellings
Average number of rooms per dwelling in 2001	4.55 rooms
Share of electrified dwelling in 2001	100%
Share of dwellings with kitchen facilities in 2001	100%
Share of dwellings with WC facilities in 2001	100%
Average area per dwelling in 1997	84,5 m^2

Source: The author

9.2. Household appliances

The household appliances that consume more energy are refrigerators, TV/audio appliances, washing machines and light bulbs. Hence, it has been a priority to increase the energy efficiency in some of these appliances. As we can see in Table 9.2, only 7.5% of the average household energy consumption corresponds to appliances that could switch fuel, namely water heater[53]. The rest corresponds to captive electricity uses.

Table 9.2: Share of electricity consumption per appliance in one household in 1998

Appliance	Share of consumption	
Refrigerators	22%	92,5% electricity captive
Light bulbs	12%	
Washing machine	5%	
Dishwasher	3%	
TV+ audio+ cable	11%	
Other appliances	25%	
Water heater	5%	7,5% non-captive
Heater	17%	

Source: ADENE 2004

According to Euromonitor (2003), the average replacement cycles for household appliances is:

- Refrigerators 6-9 years
- Washing machines 6-9 years
- Dishwashers 3-5 years

We will assume the maximum number of years for each appliance.

According to the INE database, there is some saturation in appliances such as refrigerators (97.1%) and in washing machines (82% and CAGR of 3.62%), while in dishwashers (17.1%) there is still room for growth.

We will consider that the refrigerators and the washing machines penetration level are saturated, and therefore constant. For the dishwashers we will consider an increasing level of penetration at the same

[53] This study includes in "other appliances" end uses like cooking, which is frequently made in gas ovens, therefore non-electrical captives. That is why we tend to consider the value of 92.3% of electricity captive uses as an exaggerated value. For example, EDP in 1997 considered this value as 85%.

rate verified earlier (CAGR of 6%). Consequently, we can calculate the existing units by multiplying the number of houses estimated in Figure 9.2 by the penetration level in each appliance.

Table 9.3: Evolution of the penetration of some household appliances

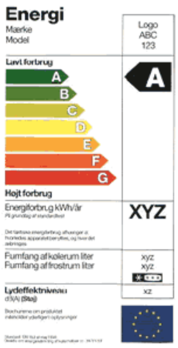
	1995		2000		2004	
	#	%	#	%	#	%
Refrigerators	3.106.324	94.5	3.495.591	97.1	3.659.394	97.1
Washing machines	2.391.276	72.8	2.959.677	82.2	3.078.835	82.2
Dishwashers	420.851	12.8	614.315	17.1	809.037	21.6

Source: adapted from INE database

The efficiency class of an appliance reflects its technological state in a given moment. The correlation between energy consumption and the average consumption of and equipment of its category, defines the level of energy efficiency.

Several appliances have been adopting the energy label in order to inform consumers of the energy characteristics of that appliance. The legal framework has been set in a phased way: 1995 for cold appliances, 1996 for dryers and washing machines, 1999 for dishwashers, 2000 for light bulbs and recently, in 2003, for electric ovens.

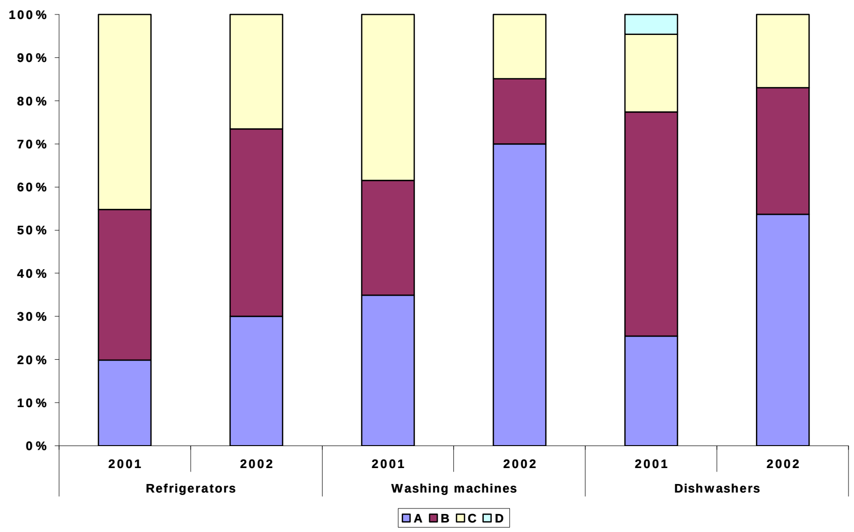
Figure 9.5: Standard EU energy label



Source: site http://www.clasponline.org

The sales distribution per efficiency class in 2001 and 2002 in refrigerators, washing machines and dishwashers shows the predominance of A and B classes in all appliances (further details in Table 12.23). We will consider that the share of the sales appliances in 2002 will remain constant in the period 2004-2009.

Figure 9.6: Household appliance sales per efficiency class (A,B and C) in Portugal



Source: adapted from AGEFE[54]

The CAGR between 2001 and 2002 for each appliance shows the decrease of the C class in all appliances and of the B in washing machines and dishwashers. Class A is growing at a high pace especially for washing machines and dishwashers. In this last appliance, ~5% of the 2001 sales corresponded to the D class but in 2002, this value decreased to zero. In compliance with the Decree-Law 214/98, there are no more D class in cold appliances in the market since this year.

Table 9.4: Variation of appliance sales per efficiency class (A,B and C) in 2001-2002

	A	B	C	D
Refrigerators	10,2%	8,5%	-18,7%	-
Washing machines	35,1%	-11,5%	-23,5%	-
Dishwashers	27,7%	-23,8%	-1,5%	-4,7%

Source: adapted from AGEFE[54]

9.2.1. Refrigerators

According to the INE database, the refrigerator market has evolved at a small pace between 1995 and 2000 (CAGR of ~2%). With a penetration of ~97%, we can consider this market saturated.

The market of refrigerators includes what we call the “new” ones (that drive the market growth) and the “substitution” ones (that only replace the obsolete units).

The “new” market can be assumed as the difference in the existing models in two consecutive years. Therefore, we can say that the quantity of sales between 1995 and 2004 is,

3.659.394 – 3.106.324 = 553.070 units

The quantity of sales between 1995 and 2004 was, of 553.070 units or in average 61.452 units per year. This corresponds to the “new models”.

Let us now consider that the life of a refrigerator is 9 years (according to Euromonitor), at the end of which, the consumer replaces it for a new model not keeping the old one[55]. Therefore, we can say that

[54] From Fagor, Aspes, Edesa, Ariston, Indesit, Míele and Samsung data.

[55] In the northern countries, which are considered to be more developed than Portugal, the trend is to overcome the 100% barrier of refrigerator ownership. In fact, people tend to keep the old refrigerator (e.g. in the garage) and buy a new one. This behaviour causes some difficulty to police makers because the campaigns to reduce energy consumption through an incentive to buy a new model are often doomed. We will consider that this does not happen because it is difficult to determine the percentage of customers doing it.

the total volume of refrigerators sold each year in order to substitute the old ones, is 1/9 of the total market volume of the previous year:

- Number of refrigerators in 2004 = 3.659.394 units
- Number of refrigerators in 2003 = 3.659.394 – 61.452 = 3.597.942 units
- Replacement rate = 9 years
- Substitution models in 2004 = 3.597.942 / 9 = 399.771 units

The next table shows the expected evolution in this appliance.

Table 9.5: Estimation of the “substitution” models sales

	2003	2004	2005	2006	2007	2008	2009
Existing units	3.597.942	3.659.394	3.720.846	3.782.298	3.843.750	3.905.202	3.966.654
Substitution models		399.771	406.599	413.427	420.255	427.083	433.911

Source: the author

Therefore, the expected sales per efficiency class are determined by the sum of the “new” and “substitution” model sales combined with the share of sales per efficiency class presented in Table 12.23. The results obtained are presented in the next table.

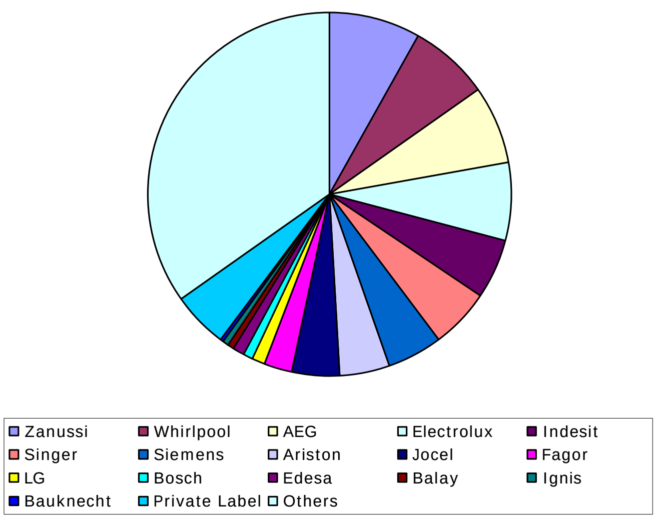
Table 9.6: Expected sales per efficiency class

	2004	2005	2006	2007	2008	2009
A	138.367	140.415	142.464	144.512	146.561	148.609
B	200.632	203.602	206.573	209.543	212.513	215.483
C	122.224	124.034	125.843	127.652	129.462	131.271
Total	461.223	468.051	474.879	481.707	488.535	495.363

Source: the author

According to Euromonitor (2003), this sector is one of the most competitive in the domestic electrical appliances market. Typically different brands will have little to choose between them either in terms of styling or performance, so much competitive activity comes down to price. The next figure presents the major players in refrigerators in Portugal in 2002 (further details in Table 12.28). As we can see, six companies (Zanussi, Whirlpool, Electrolux, Indesit, Singer and Siemens) control ~40% of the market.

Figure 9.7: Brand shares of refrigerators retail sales in 2002



Source: Euromonitor 2003

9.2.2. Washing machines

From Table 9.3, we can observe that the washing machines total existing units in 2004 will reach 3.078.835 units, while in 1995 there were only 2.391.276 units. This market is still growing at a CAGR of ~3.6%, which shows that this market is expanding.

The difference between the number of units in 1995 and 2004 gives us the total new units sold in these 5 years:

3.078.835 – 2.391.276 = 687.559 units

If we consider that the sales are equally distributed throughout the years, we will have an annual sale of "new" models of 76.395 units.

Let us now consider that the life of a washing machine is 9 years (according to Euromonitor), at the end of which, the consumer replaces it for a new model not keeping the old one. Therefore, we can say that the total volume of washing machines sold each year in order to substitute the old ones, is 1/9 of the total market volume of the previous year:

- Number of washing machines in 2004 = 3.078.835 units
- Number of washing machines in 2003 = 3.078.835 – 76.395 = 3.002.440 units
- Replacement rate = 9 years
- Substitution models in 2004 = 3.002.440 / 9 = 333.604 units

The next table shows the expected evolution in this appliance.

Table 9.7: Estimation of the "substitution" models sales

	2003	2004	2005	2006	2007	2008	2009
Existing units	3.002.440	3.078.835	3.155.230	3.231.625	3.308.020	3.384.415	3.460.810
Substitution models		333.604	342.093	350.581	359.069	367.558	376.046

Source: the author

Therefore, the expected sales per efficiency class are determined by the sum of the "new" and "substitution" model sales combined with the share of sales per efficiency class presented in Table 12.23. The results obtained are presented in the next table.

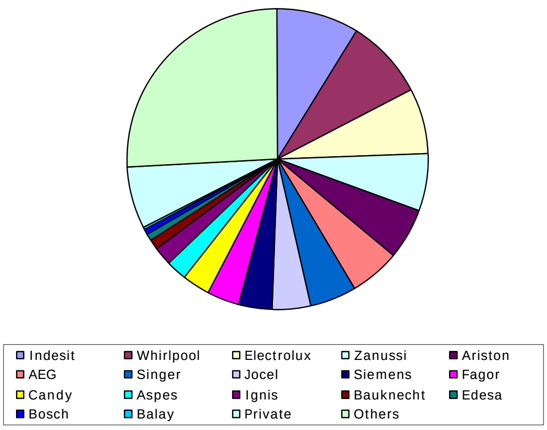
Table 9.8: Expected sales per efficiency class

	2004	2005	2006	2007	2008	2009
A	287.000	292.941	298.883	304.825	310.767	316.709
B	61.910	63.192	64.473	65.755	67.037	68.319
C	61.090	62.355	63.619	64.884	66.149	67.414
Total	409.999	418.488	426.976	435.464	443.953	452.441

Source: The author

According to Euromonitor data, the home laundry appliances sector remains highly competitive with eight key national brand owners comprising 17 brands fighting for market position (Figure 9.8). The leading national brand owners are Indesit, Whirpool, Electrolux, Zanussi, Ariston and AEG, which together accounted for 41.5% of the sector in 2002 (further details in Table 12.29).

Figure 9.8: Brand shares in washing machines retail sales in 2002



Source: The author

9.2.3. Dishwashers

From Table 9.3, we can observe that the dishwashers total existing units in 2004 will reach 809.037 units, while in 1995 there were only 420.851 units. This market is growing at a high pace (CAGR of ~6.5%).

The difference between the number of units in 1995 and 2004 gives us the total new units sold in these 5 years:

809.037 – 420.851 = 388.186 units

If we consider that the sales are equally distributed throughout the years, we will have an annual sale of "new" models of 43.131 units.

Let us now consider that the life of a washing machine is 5 years (according to Euromonitor), at the end of which, the consumer replaces it for a new model not keeping the old one. Therefore, we can say that the total volume of dishwashers sold each year in order to substitute the old ones, is 1/5 of the total market volume of the previous year:

- Number of washing machines in 2004 = 809.037 units
- Number of washing machines in 2003 = 809.037 – 43.131 = 765.906 units
- Replacement rate = 5 years
- Substitution models in 2004 = 765.906 / 5 = 153.181 units

The next table shows the expected evolution in this appliance.

Table 9.9: Estimation of the "substitution" models sales

	2003	2004	2005	2006	2007	2008	2009
Existing units	765.906	809.037	852.168	895.299	938.430	981.561	1.024.692
Substitution models		153.181	161.807	170.434	179.060	187.686	196.312

Source: the author

Therefore, the expected sales per efficiency class are determined by the sum of the "new" and "substitution" model sales combined with the share of sales per efficiency class presented in Table 12.23. The results obtained are presented in the next table.

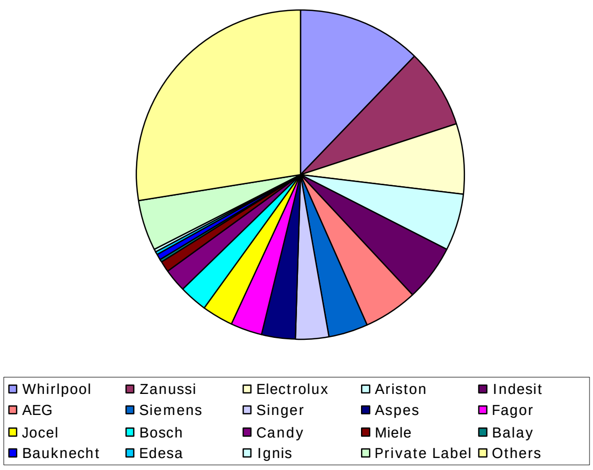
Table 9.10: Expected sales per efficiency class

	2004	2005	2006	2007	2008	2009
A	105.420	110.052	114.684	119.316	123.949	128.581
B	57.716	60.252	62.788	65.324	67.860	70.396
C	33.373	34.840	36.306	37.772	39.239	40.705
Total	196.312	204.938	213.565	222.191	230.817	239.443

Source: The author

According to Euromonitor, the dishwashers market is more concentrated with Whirlpool as a "comfortable" market leader, with 12.1%. However, it is followed by Zanussi, Electrolux, Ariston and Indesit with shares from 7.8% to 5.6%. These five brands count for 38% of the market (Figure 9.9) (further details in Table 12.30).

Figure 9.9. Brand shares in dishwashers retail sales in 2002



Source: The author

9.2.4. Light bulbs

In this part of the chapter, we intend to estimate the number of light bulbs in Portugal. In 9.1 we estimated the household sector in Portugal (number of dwellings, the average amount of rooms per house and the average area per dwelling). Now we will estimate the number of light bulbs per room. At the end, we will have the amount of light bulbs in Portugal.

We assumed in 9.1 that the entire household sector is electrified ignoring the non-electrified, i.e. household sector includes in 2004 3.745.542 primary houses. We have also assumed an average household to have five rooms including two bedrooms, a living room, a kitchen and a WC.

Let us now assume that each bedroom has two light bulbs, the living room has three, kitchen one, the bathroom one more and an extra (for the balcony, etc...). Hence, we can consider that the average number of light bulbs in a dwelling is 10. If we consider that, in most of the houses, the kitchen and the WC have fluorescent light bulbs (hence already of low consumption), we can assume a total of light bulbs per dwelling to be equal to eight.

Therefore, the total light bulbs in the Portugal, in the household sector, can be assumed as:

$$8 \times 3.745.542 = 29.964.336 \text{ units}$$

As we saw previously, the household sector grew by 538.092 units in 10 years (Figure 9.2), i.e. 53.809 houses per year.

The market of lights will have to supply these 53.809 houses plus the replacement lamps needed to the existing houses. Regarding the new houses, we can assume that these will need around 430.472

lamps (8x53.809).

Let us now consider that the life of a light bulb is 2 years[56], at the end of which, the consumer replaces it for a new model. Therefore, we can say that the total volume of light bulbs sold each year in order to substitute the old ones, is half of the total market volume of the previous year:

- Number of light bulbs in 2004 = 29.964.336 units
- Number of light bulbs in 2003 = 29.964.336 – 29.533.864 = 430.472 units
- Replacement rate = 2 years
- Substitution models in 2004 = 29.553.864 / 2 = 14.766.932 units

The next table shows the expected evolution in this appliance.

Table 9.11: Estimation of the "substitution" models sales

	2003	2004	2005	2006	2007	2008	2009
Existing units	29.533.864	29.964.336	30.394.808	30.825.280	31.255.752	31.686.224	32.116.696
Substitution units		14.766.932	14.982.168	15.197.404	15.412.640	15.627.876	15.843.112
New units		430.472	430.472	430.472	430.472	430.472	430.472
TOTAL		15.197.404	15.412.640	15.627.876	15.843.112	16.058.348	16.273.584

Source: the author

This value is based on our estimation, which is a result of a simplified calculation as you can see. Nevertheless, the result is consistent with the values given by ANIMEE. According to this Association, the units sold in Portugal in 2003 reached the 23 million units. This value is higher than our own because we do not take into account with the shared households (like hotels and hospitals) and seasonal or secondary dwellings.

We believe that our calculation is conservative because the number of light bulbs in each house is probably higher.

9.3. Estimation of the production cost effects of the implementation of the Directive

The implementation of the Energy Services Directive may cause different effects. Some may already be analysed and accounted for but for others it is still too soon to do that. While we can estimate the cost benefit of reducing consumption and even estimate the energy audits cost, the proposal is dubious when refers to energy meters. It says that meters should inform the user about consumption and cost. This could mean a substitution in all ~6 million meters. Until the directive does not inform clearly what is the level of information desired it is unpredictable to foresee anything.

One of the direct effects of the Directive is the 1% saving per year. This effect can be analysed by estimating the production avoided with this Directive's implementation.

The method adopted in this paper assumes an average cost of production, which is function of an average cost per technology (€/MWh) and of the production mix in each country. Subsequently, we will apply the Directive's method of calculation in order to evaluate its overall benefit. It is important to notice that the calculation made for Portugal is based on EDP figures, while for other countries it is based on IEA figures of electricity output and of CAGR in electricity consumption.

9.3.1. Average cost of production of one MWh

The cost of production per technology presented in the next table does not consider the sub-technologies or any other specificities; it only states the average cost. We can consider the fuel costs

[56] Considering 2h per day switched on and a maximum life of 1000h.

as relatively homogenous because the international markets are very efficient, therefore homogenising the price throughout the countries.

It is important to mention that the cost avoided in production is not 100% correlated with the variation in production. In fact, even if the power plant does not produce anything it will always have some O&M costs[57]. Another important aspect that we do not consider in this production cost are the personnel costs. These are fixed costs[58] that vary a lot with the technology and sub-technology, the age of the power plant, level of automation, etc. Finally, we also consider that power plants are fully amortized and we do not take into account additional investments resulting for example from, i.e. electricity production mix changes, new technology and the decommission of old power plants. We are aware that these assumptions increase the error in our calculation.

In the next table, we present the variable costs per technology assumed in this paper. As we can see, fuel oil is the most expensive followed by CHP, coal, nuclear power in which the operation & maintenance costs are more important that the fuel cost and, in last, hydroelectric in which we considered the fuel cost null.

Table 9.12: Variable costs per technology in 2003 (€/MWh)

	Fuel	O&M	Total
Fuel oil	38	4	42
CHP	29	2,5	31,5
Coal	15	3,5	18,5
Nuclear	5	9	14
Hydroelectric	0	2	2

Source: EDP

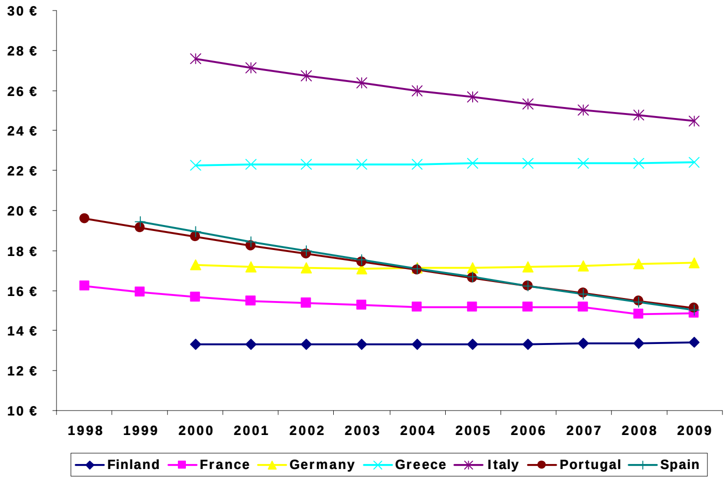
Considering the cost per technology presented in the previous table and the percentual evolution of each technology in the electricity fuel mix (Table 12.13 and Table 12.14), we have found the average cost per MWh for each country.

In the next figure, we see that countries with bigger share of nuclear power (like France or Finland) show a lower cost per MWh than countries that are more dependent of coal or oil (like Italy or Greece) (further details in Table 12.26). We can also observe the countries in which a fuel switching is occurring (e.g. Portugal, Spain and Italy) show a negative slope in their expected production cost (read also chapter 4.2.2 to compare fuel mix trends).

[57] Another limit that is important to observe is the producers' margin. In our analysis, we will not consider the margin lost by the producer for each MWh saved. We consider that the producer will recover the margin in the MWh produced.

[58] Fixed in the sense that either you produce or not, the costs are not avoided.

Figure 9.10: Average electricity production cost (€/MWh)



Source: the author

9.3.2. Average cost of one gram of CO2 emitted

The cost of emitting one gram of CO2 includes the direct cost (the direct evaluation) and the net social cost, i.e. how much the society gains in not producing that gram of CO2 (the indirect evaluation).

While the direct costs are easy to estimate because they just depend on the production mix, the indirect costs depend on many variables sometimes difficult to evaluate or to monitorize (e.g. the value given to public assets, mortality rates, morbidity rates[59], environmental costs, societal costs (regarding labour, for example), etc. In this part, we will only consider the direct costs. A deeper study should also reflect the indirect ones in order to full internalisation of their consequences.

In the next table, we present the average CO2 equivalent emissions per GWh. These figures do not take into account any sub-technology, the age of the power plant or other variable that may induce a different emission rate. They are simply indicative values. We do not include nuclear power or hydroelectric power because its CO2 emissions are null.

Table 9.13: Average CO2 emissions per technology

Source	Emissions (ton /GWh)
Coal	~360
Fuel oil	~288
Natural Gas	~202

Source: site http://www.umweltbundesamt.de

Following a similar process to the previous one, we determine the average CO2 emission costs and the amount of CO2 avoided with a 1% reduction in electricity production.

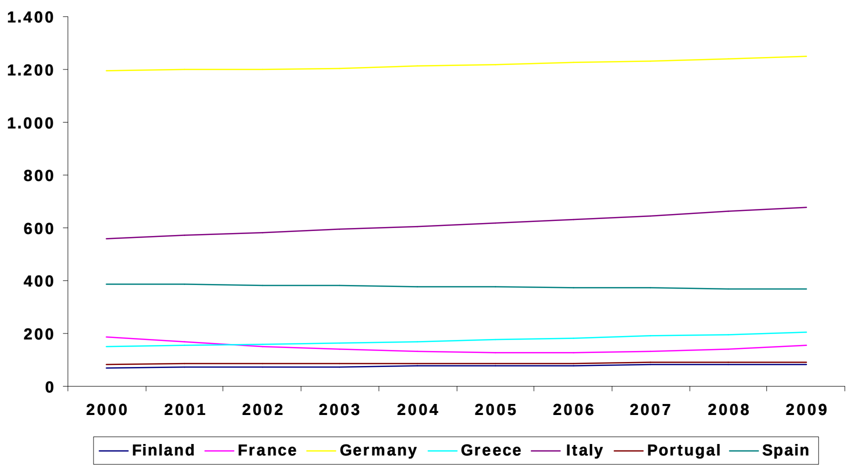
The method followed begins by multiplying the electricity production share of each technology (Table 12.13 and Table 12.14) by the emissions presented in the previous table (Table 9.13), in order to determine the average equivalent emission per year for each country, showed in Table 12.36. Subsequently, we multiply the total electricity production (in that year) by the equivalent emissions (in the same year), obtaining the amount of tonnes produced in a given year (Figure 9.11). Finally, we

[59] The incidence of infections and diseases which are reflected in labour productivity and in health costs

multiply this value by the expected value of the CO_2 (that we will assume €10 per tonne[60]), therefore obtaining the total avoided cost in each country (Figure 12.6).

As we can see, the CO_2 emission costs are stable in most countries. This can be explained by the effort made to not increase their emissions and the assumption made that the vlue of the CO_2 tonne is constant, which is unlikely to be true.

Figure 9.11: Average CO2 emissions costs (M€)



Source: the author

9.3.3. Impact estimation

In this part of the chapter, we will evaluate the direct impact of the implementation of the Directive. The impact can be evaluated by comparing the production cost and the CO_2 cost in a BaU scenario with a scenario where the Directive is implemented.

We have used EDP figures to determine the average production in Portugal and the CAGR expected for electricity consumption. For the other countries, we have chosen to use IEA figures.

There are several limits of this calculation. One is the expected growth of electricity consumption and its evolution until 2009. Another one regards the production and the CO_2 costs determined in the previous part. This would have to be determined considering the specificities of each production structure (technology and sub-technology, age of the power plants, O&M costs, specific CO_2 emissions, etc.). To finalise there are also costs incurred in the avoided production in terms of margin lost that are not being considered.

Here we will present the calculation only for Portugal, leaving the results for the other countries to the chapter 12.3.

Portugal

The EDP Distribuição energy balance sheet (between 2000 and 2003) gives information about the energy output evolution throughout the years (Table 9.14).

The Energy Services Directive proposal states that we should consider the average of the output in the five previous years to obtain the reference value of savings (COM (2003) 739 final, 2003)[61]. From Table 9.14, we can observe that between 2000 and 2003 the average sales were ~38.7TWh. 1% of this number (387GWh) is the reference value for energy savings, therefore EDP should be able to save 387GWh/year in order to comply with this Directive.

[60] This might be a conservative value. However, according to EDP, the value should be between 7 and 12€ per tonne.

[61] Because there is no data available for all countries for the previous five years, we have considered only four years.

Table 9.14: Energy output in Portugal (GWh)

	2000	2001	2002	2003	Average 2000-2003
Electricity output	38.735	40.121	36.960	39.002	38.705

Source: adapted from EDP Distribuição

Let us consider a growth in consumption of 4% per year; we can therefore expect to obtain the following values of energy consumption (between 2004 and 2009).

Table 9.15: Directive implementation effects (GWh)

	2004	2005	2006	2007	2008	2009
Expected	40.563	42.185	43.872	45.627	47.452	49.351
Cumulative saving effect	387	774	1.161	1.548	1.935	2.322
Combined effect	40.176	41.411	42.711	44.079	45.517	47.028

Source: the author

We will get a total savings of 6 x 387 = 2.32TWh in 2009.

The combined effect results from subtracting the cumulative saving effect (due to energy efficiency measures undertaken by EDP) from the expected energy consumption. This value will be the maximum energy output allowed.

If we consider the MWh production cost as showed in Table 12.26, the overall production costs will evolve according to Table 9.16. The direct cumulative savings which result from reducing the production of energy with the implementation of this Directive, will reach 35M€ in 2009 however, we should add the avoided CO_2 emissions which represent a gain of 4.3M€ in 2009. Therefore, the overall gain will reach ~39M€.

Table 9.16: Electricity production costs and savings in all sectors (M€)

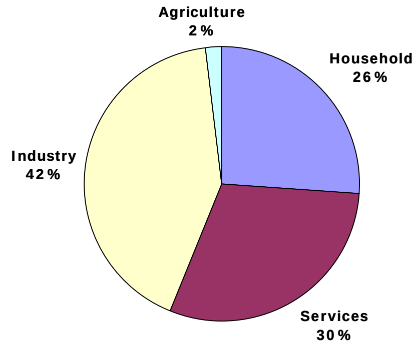
	2004	2005	2006	2007	2008	2009
Production cost	690	700	711	725	736	745
Production cost with Directive	683	687	692	701	706	710
Direct cumulative savings	7.0	13.0	19.0	24.0	30.0	35.0
Direct CO2 cumulative savings	0.8	1.6	2.3	3.0	3.6	4.3
Total savings	7.8	14.6	21.3	27.0	33.6	39.3

Source: CPPE and the author

In order evaluate the effort that has to be made within the household sector, we will have to see how much of the energy consumption (Table 9.14) and of the cumulative savings (Table 9.15) are due to the household sector.

From the Figure 9.12 we can observe that only 26% of the energy consumption comes from the household sector. Therefore, the savings each year for household are 26% of 387 GWh: 101 GWh (assuming that all the sectors have the same potential of reduction, which is probably not true).

Figure 9.12: Energy consumption share per economic sector in 2000



Source: adapted from ERSE 2001

The annual saving effort to be implemented in the household sector will have the costs and benefits presented in the next table.

Table 9.17: Electricity production costs and savings only in household sector (M€)

	2004	2005	2006	2007	2008	2009
Production cost	179	182	185	189	191	194
Production cost with Directive	178	179	180	182	184	185
Direct cumulative savings	1	3	5	7	7	9
Direct CO2 cumulative savings	0,2	0,4	0,5	0,9	1,3	2,1
Total savings	1,2	3,4	5,5	7,9	8,3	11,1

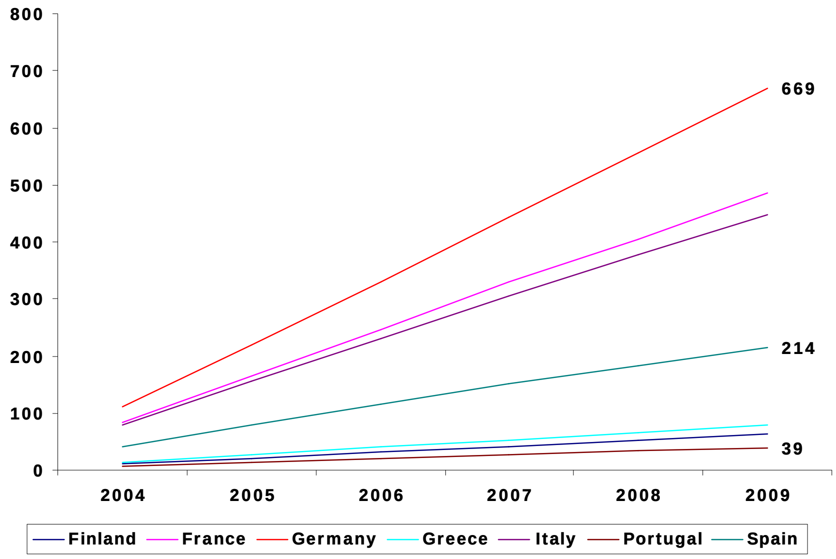
Source: the author

Wrap up

We can observe in the next figure the impacts of this Directive on the production cost. As we can see in the Table 9.17, the evolution of these costs is mainly due to the production avoided. However, if the tonne of the CO2 increases beyond 10€, its importance in the overall savings will increase.

In this figure, we can identify three groups of countries. Portugal, Greece and Finland present the lowest savings. Spain is in the middle of the range and Italy, France and Germany present the highest savings.

Figure 9.13: Evolution of the overall savings (production + CO2 avoided) (M€)



Source: the author

The previous figure only shows the absolute savings, which does not reflect the effort that has to be made by each country. The only way to compare these efforts is by considering the same reference for all savings. Therefore, we will adjust the absolute savings of each country to the Portuguese context using the production mix of each country but considering an adjustment to their energy consumption. The Table 9.18 shows the adjustment factors, which consist in the quotient between each country's energy consumption and Portugal's.

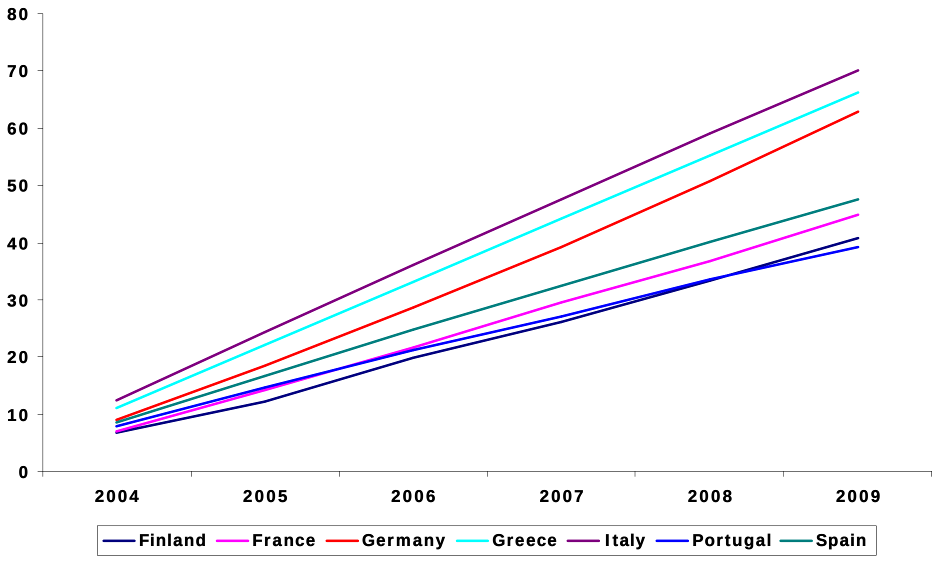
Table 9.18: Energy Consumption multiplication factors

	2004	2005	2006	2007	2008	2009
Finland	1,6	1,6	1,6	1,6	1,5	1,5
France	11,8	11,6	11,4	11,2	11,0	10,8
Germany	12,2	11,9	11,6	11,3	11,0	10,7
Greece	1,2	1,2	1,2	1,2	1,2	1,2
Italy	6,4	6,4	6,4	6,4	6,4	6,4
Portugal	1	1	1	1	1	1
Spain	4,8	4,7	4,7	4,6	4,6	4,5

Source: The author

As we can see (Figure 9.14), this gives us a different perspective of the overall savings. The gap between countries is reduced and the slopes become more or less the same. Portugal continues to have the lowest saving but Italy and Greece become the countries with the higher savings.

Figure 9.14: Overall savings (with reference to Portugal) (in M€)



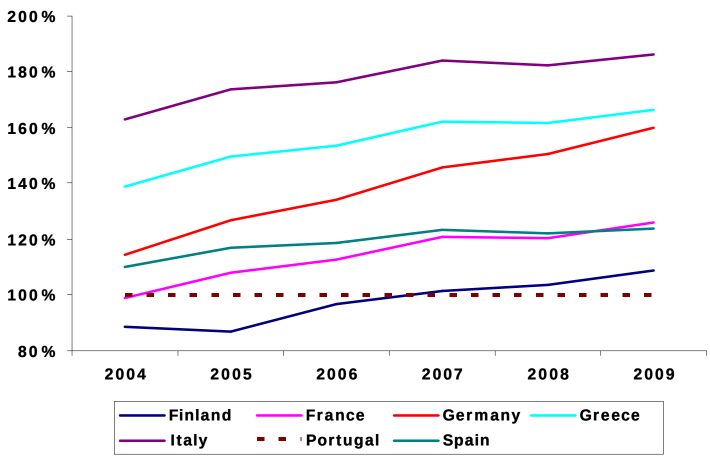
Source: The author

We can apply the multiplication factors presented in the Table 9.18 separately to the production savings (Table 12.59) and to the CO2 savings (Table 12.60). We can now compare the saving effort of each country with the Portuguese effort, as we can see in the next two figures (further details in Table 12.61 and Table 12.62).

In the Figure 9.15, we can see that Portugal makes the lowest effort to save in production. Italy and Greece make the highest effort, 86% higher than Portugal for Italy and 66% for Greece (in 2009).

France faces a levelling effect between 2007 and 2009, linked to the slight change in the production mix and its consequent costs. The major share of electricity continues to be produced by nuclear power but there is a reduction on production by coal and an increase in production by natural gas. This creates a combined effect of a slightly positive slope in the savings graphic (further details in Table 12.13 and in Table 12.37).

Figure 9.15: Production saving effort compared to Portugal

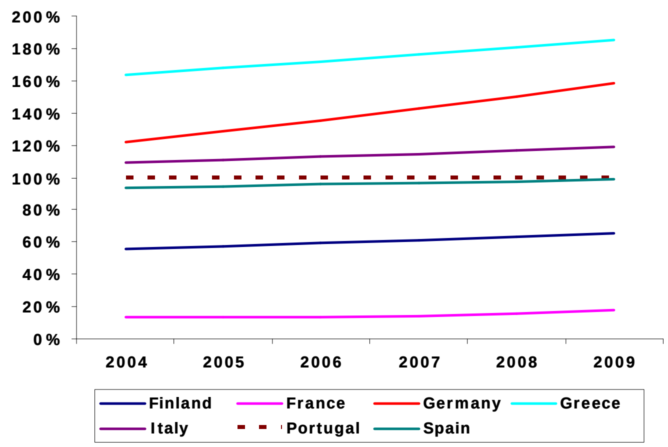


Source: the author

An almost similar trend is followed by the CO2 saving effort. We observe countries like Greece, Italy and Germany making a bigger effort to save in CO2 than Portugal but the rest making a lower effort. Greece and Italy save much more than France or Finland because of their production mix. While the first two countries base their production in coal and fuel oil, the other two base it in hydroelectricity and in nuclear, therefore emitting much less CO2. In fact, to reach to the Greece's CO2 saving effort, France would have to invest a lot, as their production system is already optimised.

This analysis is naturally limited by a production costs estimation error, which is reflected in the final result. This expected error appears because in the beginning of this analysis we started by stating that the energy production cost per technology are those showed in Table 9.12. However, when we calculated the avoided production cost we used the average production cost weighted by the production mix of each country. But the issue is that, when we avoid the production we do not avoid the average production cost but the marginal production cost of the most expensive fuel.

Figure 9.16: CO2 saving effort compared to Portugal



Source: the author

When we analyse these three previous figures, we can say that the savings potential differs from one country to another. From Figure 9.14 we can observe that Portugal presents the lowest savings potential, which is due to an already relatively low production mix in terms of thermal sources (see also Chapter 4) and therefore to a lower capability to save energy production. On the contrary, there are countries like Italy or Greece, which are highly intensive in thermal sources and therefore present a high savings potential. In Portugal, the reduction effort has to be made in terms of CO2 emissions rather than in terms of energy production (see Figure 9.15 and Figure 9.16), since there is room for improvement regarding CO2.

9.4. Estimation of the energy audits costs

According to the Directive proposal: "energy audits shall be provided for free to their customers as long as 5% of them are not covered by energy services".

The text may have different interpretations. Let's assume that the text means the audits have to be free of charge until 95% of the customers are covered by energy services. Let's also assume the term "covered" means, to have access to an energy service.

In this part we will see the viability of the Directive implementation regarding the energy audits.

Impacts

Assuming an annual consumption of 0.4 toe per person (Figure 4.24) and an average of 3.5 persons per dwelling, we will have an annual consumption of 16MWh per dwelling.

Let's now consider that the cost of a specialized technician certified to perform energy audits is 8€ per hour, that this technician works 8 hours per day and that each audit takes him about half an hour. He will perform 16 audits per day, or 3872 audits per year. Therefore, in order to carry out audits to all the primary dwellings in Portugal (3.745.542 in 2004, according to Table 9.1) within a reasonable period (5 years) we would need ~210 technicians. This estimation assumes that everybody is at home and willing to be audited and therefore there is no need for a 2nd visit.

However, what saving would we have to have in each dwelling in order to compensate for a free audit? As we saw, the technician charges 4€ per audit. Let's consider that all training is already included in this charge. Assuming an average production cost of 0.0173 €/MWh (Table 12.26), this would mean a saving of 231MWh per dwelling, i.e. 14 times the average energy consumption of a Portuguese household (assuming 16MWh=1.4toe of annual energy consumption per dwelling).

Wrap up

As we can see, the implementation of the audits as described in this Directive will be very difficult. Or the state subsidizes the audits, which will be reflected in the national budget (already very constrained), or the charge is assumed by the regulator and passed to the consumer through the tariffs. This would mean a raise in the tariffs and a consequent discontentment among the customers. The Directive proposal does not refer any price cap in the tariffs so we can assume that a raise in the tariffs is the orientation suggested by the EU in order to cover the audits charge. However, this raise will give the wrong impression about the term "free".

9.5. Viability of the Energy Services Directive implementation in the household sector

After understanding how EDP production will be affected by this Directive, it is now time to understand how EDP can implement it in order to reach the expected savings level (~387GWh per year or 101GWh in the household sector).

We have limited our scope to the household sector for two reasons. Firstly, in spite of being more fragment sector, we have a clearer idea of its overall equipments (even if it is difficult to evaluate consumption habits). Secondly, because the household sector is the one that needs to receive a bigger incentive to energy efficiency as we saw in Figure 4.30.

Regarding the services and the industrial sectors, we did not have access to significant information that allowed us evaluate the global impact of the programme implementation. Additionally, even if industry (in Portugal) still has a long way to go regarding energy efficiency it is the sector with the highest awareness to this issue. The "market" itself acts as an incentive.

We have chosen to evaluate the impact of four appliances refrigerators, washing machines, dishwashers and lights, which, according to EDP, correspond to 60% of household electricity consumption. The correlation between price and energy efficiency does not exist or is dominated by brand or design. In the next table, we can see the comparison between two refrigerator models of two well-known brands. Although the MIELE model has a higher efficiency and a lower consumption for a higher volume of fresh food, it is €84 cheaper.

Table 9.19: Comparison between two refrigerator models

Brand	Model	Energy Efficiency	Energy Consumption (KWh/year)	Volume fresh food (litres)	Price (€)
Míele	KT 4253 SD	A+	248	224	615
De Dietrich	DRC326JE1	B	409	166	699

Source: the author based on MIELE and De Dietrich 2004 catalogues

For each efficiency class and for each type of appliance we chose as a reference models form the market leaders on Portugal (see 9.2.1, 9.2.2 and 9.2.3).

At the end of this part, we will have a general idea of the implementation impact regarding the household sector.

9.5.1. Refrigerators

Let us assume that a refrigerator is used on average 8760h per year and that it works always in optimal conditions.

We have chosen three models available on the market with the following characteristics:

Table 9.20: Reference values for refrigerators in Portugal

Ref.	Brand	Efficiency class	Price (€)	Capacity (l)	Annual energy consumption (kWh)
R1	AEG Santo3253-7DT	A	480	246	314
R2	ZANUSSI ZK25-10F	B	440	246	480
R3	ZANUSSI ZK23-10R	C	390	223	560

Source: the author

The difference between these three types of refrigerators is presented in the next table. As we can observe, the R1 is 90€ more expensive than the R3 but spends less 246KWh per year.

Table 9.21: Energy efficiency comparison with R1

Ref.	Difference in price (€)	Difference in Consumption (KWh)
R2	-40	+166
R3	-90	+246

Source: the author

The implementation of a substitution measure would imply the financing of the additional cost of the R1 to customers interested in buying a R2 or R3. The benefit per unit would be the energy savings (KWh) per unit multiplied by the unitary cost of energy production (from Table 12.26 between 1998 and 2009 the average unitary cost in Portugal will be 17.3€/MWh).

For example, for R2 we must multiply the annual saved energy by its average cost (166 x 0.0173 = 2.87€).

We must then add the CO_2 cost avoided which results in from multiplying the CO_2 cost per tonne (€10) by the average number of tonnes emitted by GWh, in Portugal (Table 12.36) and by the number of KWh saved in each efficiency level (e.g. for R2 it will be 10€/tonne X 181.6 tonnes/GWh x 166KWh = 0.3 €).

In order to take into account that the benefit will occur throughout the lifetime of the appliance (9 years), we should calculate the NPV of this benefit (second column) based on a discount rate of 5% and an inflation of 2%. Only than we can compare it with the cost, which is done in the last column (further details in Table 12.31).

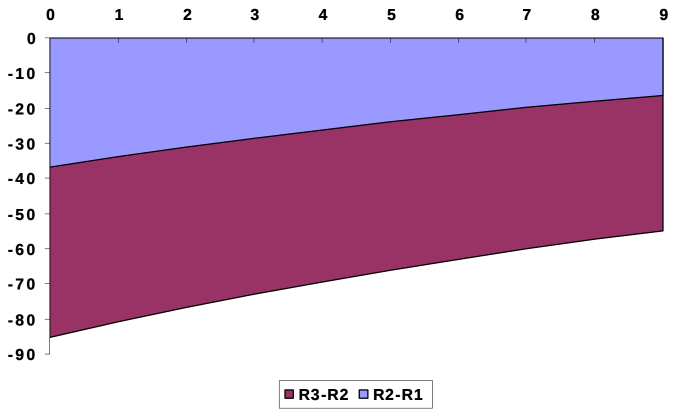
Table 9.22: Refrigerators balance report (€ per unit)

	Direct cost	Direct benefit	Balance
R2 to R1	40	26,6	-13.4
R3 to R1	90	39,5	-50.5

Source: the author

We can see in the next figure the cash-flow evolution in the appliance life cycle. We see that the benefit will not cover the total amount of the cost especially for the R3 -R1 (further details in Table 12.31).

Figure 9.17: Cash-flow evolution in refrigerators (€)



Source: the author

9.5.2. Washing machine

Let's assume that a washing machine is used in average 4 times per week, i.e. 208 times per year. Let's also assume that the machine works always on normal cycle (up to 850 rpm), with worm water and at full load.

We have chosen three models available on the market with the following characteristics:

Table 9.23: Reference values for washing machines

Ref.	Model	Price (€)	Capacity (Kg)	Rpm	Efficiency Class	Energy Consumption per cycle[62] (kWh)
W1	Indesit WIL 85	379	5	800	A	0.95
W2	Whirlpool AWM 508/2	349	5	800	B	1.15
W3	Indesit WI6	300	5	600	C	1.50

Source: the author

The difference between these three types of washing machines is presented in the next table. As we can observe, the W1 is 120€ more expensive than the W3 but spends less 72.8KWh per year.

Table 9.24: Energy efficiency comparison with W1

Ref.	Difference in Price (€)	Difference in consumption (KWh)
W2	-30	+41.6
W3	-79	+114.4

Source: the author

The implementation of a substitution measure would imply the financing of the additional cost of the W1 to customers interested in buying a W2 or W3. The benefit per unit would be the energy savings (KWh) per unit multiplied by the unitary cost of energy production (from Table 12.26 between 1998 and 2009 the average unitary cost in Portugal will be 17.3€/MWh).

For example, for W2 we must multiply the annual saved energy by its average cost (41.6 x 0.0173 = 0.71€).

We must then add the CO_2 cost avoided which results in from multiplying the CO_2 cost per tonne (€10) by the average number of tonnes emitted by GWh, in Portugal (Table 12.36) and by the number

[62] According to the manufactures, one cycle equals one use of the machine.

of KWh saved in each efficiency level (e.g. for W2 it will be 10€/tonne X 181.6 tonnes/GWh x 41.6KWh).

In order to take into account that the benefit will occur throughout the lifetime of the appliance (9 years), we should calculate the NPV of this benefit (second column) based on a discount rate of 5% and an inflation of 2%. Only than we can compare it with the cost, which is done in the last column (further details in Table 12.32).

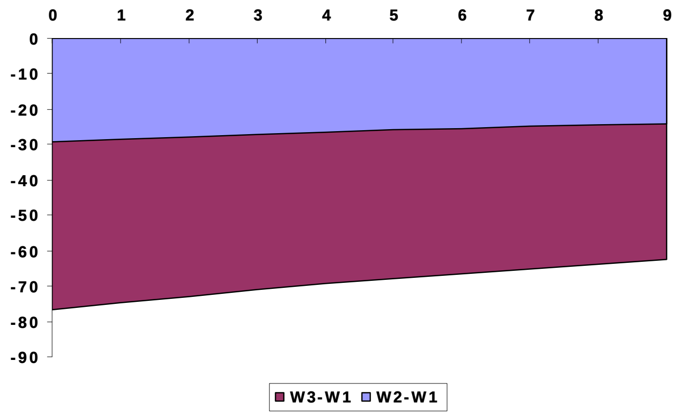
Table 9.25: Washing machines balance report (€ per unit)

	Direct cost	Direct benefit	Balance
W2 to W1	30	8,8	-21.2
W3 to W1	79	20,6	-58.4

Source: the author

We can see in the next figure the cash-flow evolution in the appliance life cycle. We see that the benefit will not cover the total amount of the cost especially for the W3 -W1 (further details in Table 12.32).

Figure 9.18: Cash-flow evolution in washing machines (€)



Source: the author

9.5.3. Dishwasher

Let us assume that a dishwasher is used, in average 365 times per year (once a day). Let us also assume that the machine works always on normal cycle, with worm water.

We have chosen three models available on the market with the characteristics showed in the next table.

Table 9.26: Reference values for dishwashers

Ref.	Model	Price (€)	Efficiency class	Energy consumption per cycle (kWh)
D1	Whirlpool ADG 151	390	A	1.00
D2	Indesit IDL 50	370	B	1.24
D3	Zanussi ZDI6041B	330	C	1.64

Source: the author

The difference between these three types of washing machines can is resumed in the next table. As we can observe, the D1 is 142€ more expensive than the D3 but spends less 215.3 KWh per year.

Table 9.27: Energy efficiency comparison with D1

Ref.	Difference in Price compared to D1 (€)	Difference in consumption compared to D1 (KWh)
D2	-20	+88
D3	-40	+235

Source: the author

The implementation of a substitution measure would imply the financing of the additional cost of the W1 to customers interested in buying a D2 or D3. The benefit per unit would be the energy savings (KWh) per unit multiplied by the unitary cost of energy production (from Table 12.26 between 1998 and 2009 the average unitary cost in Portugal will be 17.3€/MWh).

For example, for D2 we must multiply the annual saved energy by its average cost (88 x 0.0173 = 1.52€).

We must then add the CO2 cost avoided which results in from multiplying the CO2 cost per tonne (€10) by the average number of tonnes emitted by GWh, in Portugal (Table 12.36) and by the number of KWh saved in each efficiency level (e.g. for D2 it will be 10€/tonne X 181.6 tonnes/GWh x 88KWh).

In order to take into account that the benefit will occur throughout the lifetime of the appliance (5 years), we should calculate the NPV of this benefit (second column) based on a discount rate of 5% and an inflation of 2%. Only than we can compare it with the cost, which is done in the last column (further details in Table 12.33).

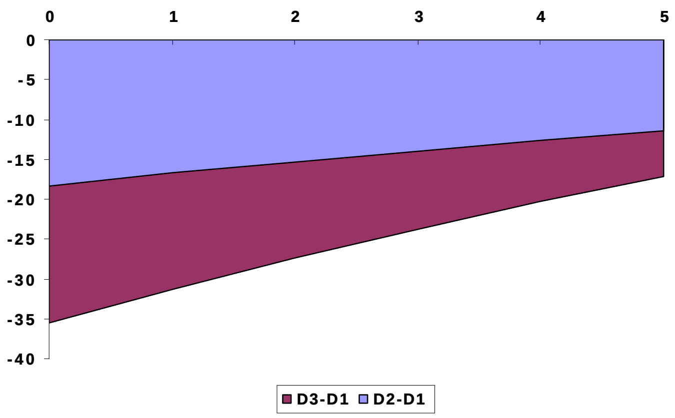
Table 9.28: Dishwashers balance report (€ per unit)

	Direct cost	Direct benefit	Balance
D2 to D1	20	11,4	-8,6
D3 to D1	40	27,1	-12,9

Source: the author

We can see in the next figure the cash-flow evolution in the appliance life cycle. We see that the benefit will not cover the total amount of the cost especially for the D3 -D1 (further details in Table 12.33).

Figure 9.19: Cash-flow evolution in dishwashers (€)



Source: the author

9.5.4. Light bulbs

Let us assume that a household light bulb is used on average during 1460h per year (4h/day). Let us also assume two types of light bulbs: an incandescent light bulb (IL) and a compact fluorescent light bulb (CFL). The first type will be represented by the model 60W E27 Standard Philips that costs 0.75€

and the second one by the model 14W-75W E27 Ecotone Philips which costs 4€.

The difference between these two types of lights is summarized in the next table. As we can see, the CFL is 3.25€ more expensive than the IL but spends less 68KWh per year.

Table 9.29: Unitary comparison between two types of light bulbs

	Price per unit (€)	Difference in price compared to CFL (€)	Annual consumption per unit (KWh)	Difference in consumption compared to CFL (KWh)
CFL	4	-	20	-
IL	0,75	-3,3	88	+68

Source: the author

The implementation of a substitution measure would imply the financing of the additional cost of the CFL to customers interested in buying a IL. The benefit per unit would be the energy saving (KWh) multiplied by the unitary cost of energy production (from Table 12.26, between 1998 and 2009 the average cost will be 17.3€/MWh), added by the cost of the CO2 emission avoided. It is important to notice that the benefit will last throughout the life of the product, therefore we have to calculate the present value of the annual benefit through 3 years (further details in Table 12.34).

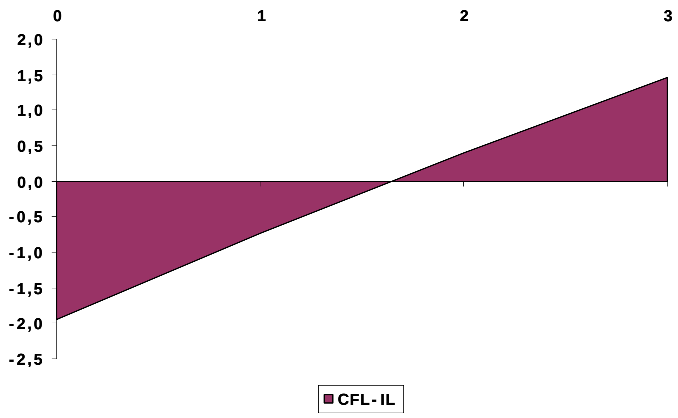
Table 9.30: Light bulbs balance report (€ per unit)

	Direct cost	Direct benefit	Balance
IL to CFL	3.3	9	+5.7

Source: the author

We can see in the next figure (further details in the Table 12.33), the cash-flow evolution during the light bulbs life cycle. We see that the benefit will compensate for the total cost. In fact, it will be necessary only 2 years to break-even.

Figure 9.20: Cash-flow evolution in light bulbs (€)



Source: the author

9.5.5. Implementation plan

As we saw in 9.3.3, the household sector in Portugal will need to save ~101GWh per year. The issue is to know how we can reach this value with a cost effective programme. We have already studied and quantified the saving potential in refrigerators, washing machines, dishwashers and light bulbs.

We saw that the application of a substitution programme to some of the appliances does not seem to present a positive payback. We must notice that all our calculations are optimistic because we do not account for any transaction costs or programme set-up costs (marketing, advertisement, administrative).

Based on the data on household appliances from the chapter 9.2, we have compared the impact of acting on 10% of each market (Table 9.31). We have disregarded the less beneficial investments, namely R3-R1, W3-W1 and D3-D1.

Table 9.31: Implementation plan (number of appliances that correspond to 10% of each market)

	%	2004	2005	2006	2007	2008	2009
R2-R1	10	20.360	20.657	20.954	21.251	21.548	21.845
W2-W1	10	6.319	6.447	6.576	6.704	6.832	6.960
D2-D1	10	6.025	6.279	6.532	6.786	7.040	7.293
IL-CFL	10	1.500.000	1.500.000	1.500.000	1.500.000	1.500.000	1.500.000

Source: the author

The values of expected savings are presented in the next table.

Table 9.32: Expected savings (GWh)

	2004	2005	2006	2007	2008	2009
R2-R1	3,38	3,43	3,48	3,53	3,58	3,63
W2-W1	0,26	0,27	0,27	0,28	0,28	0,29
D2-D1	0,53	0,55	0,57	0,60	0,62	0,64
IL-CFL	102,00	102,00	102,00	102,00	102,00	102,00
TOTAL	106,17	106,25	106,33	106,40	106,48	106,56

Source: the author

As we can see, the major role is played by light bulbs. Acting on 10% of this market has a much higher impact than addressing 10% of any other appliances market. We could even act only on the light bulbs market and do nothing regarding the other appliances, and we would still get a saving of 102GWh, which would be sufficient to comply with the Directive.

Cost – Benefit analysis

Let's then consider that the implementation of this plan will only be viable in the light bulbs market (with a saving effect of 102GWh per year). The programme would cost ~4.9 M€ but it would result in a benefit of 13.5M€. Therefore, its implementation would generate a net benefit of ~8.6M€.

Table 9.33: Implementation cost-benefit analysis

Light bulbs	Market share	Implementation (€ per year)		
		Cost	Benefit	Net benefit
1.500.000	10%	4.875.000	13.447.342	8.572.342

Source: the author

9.5.6. Wrap up

As we said before, this result should be regarded as an academic result. Some relevant factors are being simplified and/or deliberately ignored. However, taking as true the assumptions made, the results is remarkable. We can see the lightning influence in the overall consumption, and how can a small investment change so drastically the consumption curve.

10. Perspectives

First of all, it is important to understand why we call this last chapter “perspectives” and not “conclusions”. We consider that the issue of energy efficiency is continuously in debate and new progresses occur every day (in technology and/or in policy). We saw that an EU proposal for a Directive on energy efficiency and energy services is currently in discussion and therefore this subject is not over. In this chapter, we want to overview the most important problems raised along this paper, which should be seen as the conclusions of this document but not as the conclusion of the issue.

In an economy like the Portuguese one, characterized by a high growth potential and a high dependency on energy imports, there are several advantages of the reduction of the power intensity. For this reason, energy efficiency should be considered as an economic lever to improve competitiveness with impacts at the socio-economic and environmental level. In a scenario of economic growth, the improvement of energy saving and power efficiency will contribute to the improvement of the competitiveness in those sectors for which the energy constitutes a fundamental input.

The increase of energy consumption in Portugal is positively correlated to the economic development

The stage of economic development and the standards of living in each country influence energy demand. Advanced economies with high standards of living tend to have high-energy use per capita. In addition, the demographic evolution in most European countries is negatively correlated with the per capita energy consumption, meaning that a decrease in population is surpassed by the strong increase of its energy consumption.

Energy consumption is different between northern and southern economies. In this paper, we have analysed this difference and how Portugal will evolve in the next years. In southern economies, the final consumption is growing at a much faster pace than in the northern ones, which follow a trend of stabilisation at around 3toe/person. We predicted that this trend will also be followed by the southern countries later on. Portugal shows a trend of moderate increase and it is expected to arrive to 2010 with a consumption of 2toe/person, while Spain will reach Germany and France’s levels with 3toe/person. In Portugal, we also saw the importance of electricity in the final consumption that will growth from up to 40% in 2010 for household/services sector, the highest value expected among our group of countries. Hence, we can preview that business opportunities will appear for the Portuguese electricity players.

The electricity production mix is very different from one country to another. This is influenced by natural resources and its energy policy options. We observed the evolution of the electricity production mix between 1973 and 2010 in each country. In this period, we can observe the consequences of the oil crisis and of the entrance of the natural gas, especially in the southern countries. The oil crisis made economies change their fuel sources to produce electricity. The diminishing importance of oil and coal and the increase of nuclear, natural gas and (more recently) renewable energy sources are still consequences of the 70’s.

The European diversification and security strategy previews a future where the production of electricity will be based in coal, hydro, gas and, for some countries, nuclear power. This trend is already visible in IEA projections. We see that natural gas shows the highest growth rates in the fuel mix, spurred by its desirable environmental properties and by the growth of the resource base over the past decades. Gas competes most directly with coal, which has lost substantial market share in recent years. While nuclear energy continues to play a major part in the European energy its long-term future appears increasingly uncertain.

Another important issue in Europe is the environmental responsibility. The energy mix in electricity production will be linked to CO2 emission trading objectives. It would be interesting to observe the mix beyond 2010. The options for 2010 were forecasted 15/20 years ago and therefore to take into account the actual options at today we should look further. Only in 2020-2025 we will be able to observe the impact of the Kyoto Protocol and of the emission trading Directive in the countries’ energy mix. Renewable energy plays a small but increasing role in the European energy mix. As more countries impose carbon taxes and renewable portfolio standards, renewable energy is expected to gain a larger market share in the upcoming years.

Between 1991 and 2001, energy intensity and economic growth in the EU were negatively correlated and so it was their growth. When the GDP increased, the energy efficiency also increased.

The growing consumption in Portugal is linked with the development of new infrastructures, while in northern countries the infrastructures are all set. This growing consumption linked with economic development cannot be hampered by a mandatory Directive. This would jeopardize the country's development rate and therefore increase the convergence gap between Portugal and the rest of Europe.

The implementation of an energy efficiency policy brings benefits to the economy and the society

The potential of energy efficiency programmes is consensual. However, we would need a bottom-up evaluation in each economic sector in order to fully identify and quantify this potential. While we may have a general idea about the appliance penetration in household sector, in services and in industry, it is very difficult.

The economic benefit is only one of many advantages of energy efficiency, and it is often not the primary one (other may include resources optimization or environmental impacts mitigation). The economic argument against energy efficiency policies is that they are not compatible with the increasing competition that utilities are facing. However, these companies may be offered, in some cases, a number of advantages over other actors in delivering end-use energy efficiency, or at least in participating in these activities. Therefore, it is necessary to establish a strong commitment and incentive among energy companies so that they promote energy efficiency.

The savings potential of energy efficiency exists in all countries and in all economic sectors. In Portugal, this potential is around 34% of the overall consumption in the household sector and 40% in services sector. As expected, the industry sector shows the lower potential. In fact, industry tends to be more efficient because energy is an important production factor and efficiency is crucial in a competitive market.

The effects of liberalisation were vast. This complete transformation of the industry was caused by a combination of legal and regulatory requirements, mounting market forces and widespread privatisation of energy industry. The consequences are a profit-oriented industry with the characteristics of most other competitive industries. The key words now are "profit maximisation".

Industry will focus on the cost structure and make efforts to improve the efficiency of their assets. Unlike most other commodity businesses, electricity retailing is characterised by low capital investments. Retail of electricity will be a low margin business where economies of scale require significant volumes of clients in order to reach adequate returns, which may influence their perspective regarding energy efficiency in demand side.

In competitive electricity markets, consumers may escape captivity to enjoy freedom of choice, which makes them more powerful individually and as a group. When markets are liberalised, consumers' expectations are towards price cuts and savings, contributing to a stronger focus on energy costs in general, which could make consumers more receptive to economic efficiency projects. Governments create and clarify new functions such as policymaking, licensing, ownership, regulation and policy implementation.

The reduction in the volume of DSM activity in some countries is generally attributed to the introduction of competition. Some utilities have chosen to abandon DSM altogether but many utilities are using DSM as a means of providing a value-added service to their industrial customers. The purpose of DSM has consequently changed. Increasingly, the financing of energy efficiency programmes is transferred to fixed grid charges or transmission tariff elements (e.g. Denmark or Italy). Consequently, the prospects of an utility financed DSM-activity in liberalised markets do not look bright. Some efforts will be made by energy suppliers that believe in DSM as a means of adding customer value and building customer loyalty. Provided a proper regulatory approach, incentives may be created to establish DSM (load shifting) as a cost-effective alternative to grid expansion projects.

Barriers to energy efficiency will always exist but they can be mitigated

One will always have market barriers to energy efficiency, even in a perfect competition. These barriers not only reflect the sociological perspective but also the end-use perspective. Economical signs should be sent in order to act as an incentive to energy efficiency to energy companies and customers.

The barriers can be divided in three types: infrastructural and technological, Financial and Market barriers. In each, we have identified several barriers with more or less impact to energy efficiency. In the Portuguese context, we have identified nine barriers than may interfere with energy efficiency. Among them, we would like to refer two that we consider critical.

The first one is customer awareness, which in Portugal is low (like in many other countries). However, the issue is that costumer can be the "lever" needed by industry to change, for example, appliances technology. This lack of awareness makes energy efficiency an issue not considered when buying an electrical appliance but design and price are. The fact that we were not able to establish a correlation between energy efficiency and price is symptomatic of this problem. The correlation exists between price and brand or price and "extras" or even between price and design, but not between the most important variables. We conclude that energy it is not primary concern to the Portuguese customer. Even if the country endogenous energy resources are scarce, the Portuguese customer has not begun thinking about it or discussing it.

The second barrier that hampers energy efficiency is the regulatory structure. When we analysed the tariff code regarding this issue, it is clear that the incentive is there but the revenues lost in distribution activity have to be recovered in commercialisation. Therefore, if this does not happen, the incentive present in the Tariff code will not be taken. Therefore, even if the Tariff Code shows a clear awareness to the issue of energy efficiency, we believe that there is room for improvement with a regulatory change regarding profit incentives. In order to reduce this barrier, the Italian Government set up a tariff formula not 100% correlated to the KWh sold but also the company's assets, which as much important as the energy sold. We believe that this is the kind of solution to adopt. In our opinion, while a regulatory reform does not change the method of calculation of the distribution profits energy efficiency will not be effectively implemented by energy companies. However, these companies play a critical role in energy efficiency. While a win-win situation has not been set up either for customers, companies and government this process of implementing an efficiency policy will continue fragile and unrealistic.

To finalize, the current situation regarding energy efficiency in Portugal is difficult due to the vicious circle in which all actors seem to be. Additionally, the regulatory structure needs to be improved as a clear statement of the willingness of DSM Programmes implementation.

Policy mechanisms and energy services are being implemented with success throughout Europe and may shift the power business of selling KWh to selling light

Liberalisation on the supply-side will not reduce or eliminate by itself, market barriers on the demand-side. In this context, price signals and taxes may not be sufficient to regulate demand and to reduce barriers. Therefore, a support policy framework is needed to successfully implement this objective. The optimal policy combines incentives to energy efficiency investment, reduces barriers and therefore reduces transaction costs by introducing technology and energy efficiency services.

Several EU Member-States adopted different policy mechanisms according to the country's internal organisation, mechanism impact, etc. Their ways of finance and results differ from one country to another. The issue was to understand what type of mechanism is appropriate in the actual market context of the Member States and to evaluate the impact of these mechanisms and their trade-off. We have found complicate to evaluate only from the quantitative point of view the mechanism effectiveness (e.g. amount of saved energy) because it varies with the context and the process of implementation the effectiveness, the ability to overcome barriers, its adaptability, its financial effectiveness and its social and environmental impacts.

In Portugal, there are clear signs of government awareness for the relevance of energy efficiency and in particular electricity end-use efficiency. The legal instruments exist but their implementation needs to be improved. Regarding energy policies, the Portuguese government seems to focus still on improving the supply infrastructures, especially for the natural gas, in order to secure the reduction of dependency from oil. Energy efficiency in the demand side (especially electricity efficiency) is still a secondary priority.

However, even if a great effort was made in the last years to improve the national legal framework there is still a lot to be done especially regarding its implementation. As we saw, legal initiatives come from the beginning of the 80's (RGCE) but their success is rather dubious. In fact, at the moment, the Portuguese electricity sector is still drifting away from sustainability, which seems to clash against the environmental commitments (Kyoto Protocol and the Directive on the promotion of electricity from renewable energy sources) and gives the wrong signals to the Portuguese society (EDP and consumers), regarding the relevance of the environment in the economic sustainability.

We believe that there is a great work to do in terms of developing ways to control the results and eliminating grey areas of responsibility. These grey areas allow unsuccessful results regarding a given programme, which is the first step to its malfunction. An example of this is the E4 Programme. The E4 was a critical Programme to the promotion of renewable energy sources in Portugal. We think in some ways it has been a relative success (e.g. wind energy), but it has been a failure in other energy sources with great potential (even bigger than wind) like solar energy and PV energy. It seems that the targets of this programme are in some area considered too ambitious and the reality shows the huge inertia in evidence in our market that will have to be surpassed by supplementary initiatives in the next years.

We believe that a consensual legal framework, involving all actors and an implementation strategy, will bring results to the overall energy chain and should be considered as an opportunity to create value. In this matter, the Government has a critical role in putting in motion all actors and in setting incentives to energy efficiency.

Regarding the promotion of energy services, these should help utilities to enlarge the range of products offered and to improve customer relationship. Concerning the industrial sector in Portugal, where 99.9% of companies in Portugal are SME, we can see that the effort of implementing services will be huge. This sector is structured in very small companies, a lot of them with a familiar tradition. However, the degree of implementation and diversification of energy services will definitely depend on the reward scheme set-up associated because energy companies feel a comprehensible responsibility to deliver positive results to shareholders. Across Europe, previous experience helped us to determine the main factors that influence the success of the energy services industry. First, the overall market conditions to develop this industry. In this matter the legal and regulatory context are crucial. Secondly, the risk profile of industry players, which appears from factory close or bankruptcy. However, it can be mitigated through financial engineering. Thirdly, the degree in which it is possible to establish (and maintain) a partnership between an industrial customer and the energy service company. In competition, retaining customers will be increasingly difficult and therefore it will be critical to maintain clients through trustworthy relationships. Finally, the flexibility of the offering. The energy companies should be able to offer a flexible pack adjustable to customers demand.

It is unpredictable to say when energy companies will start selling services instead of KWh. However, we may say that it seems that the market is gradually being prepared for that. It is important for any energy company (including EDP) that any market change would not prejudice their business.

By shifting from selling KWh to selling also services, EDP would not cannibalize its own core business but it would shift to an unregulated area with a great profit potential in Portugal. This market may be an opportunity for EDP to reinforce its strategic position in the customer house/industrial sectors. EDP has a history of good and trustworthy customer relationship that could be reinforced. However, before a regulatory structure change it would be impossible to implement these services.

The EU sets new legal initiatives to push energy efficiency further

Even if efficiency has been one of Europe’s concerns, the implementation of the Energy Services Directive “as-is” will raise many issues in terms of implementation and control. The implementation of this Directive, in the proposed conditions, is like creating a mandatory framework to ancient non-mandatory targets. In our opinion is like creating a ceiling to Emission Trading, IEM and IGM Directives.

The proposal in its actual text raises a lot questions in terms of definitions, concepts and implementation and control. Although we analysed its implementation impact in the Portuguese household sector and the overall production savings revenues gain in that implementation, we believe that this proposal should be improved. As an example, it will be difficult to verify in all sectors involved who is complying the targets. We saw that is economically possible for an Energy company to comply with some objectives of the Directive but a deeper study should be made in order to fully understand all the implications of this implementation. Although all energy distribution and retail companies are involved, it seems that some of the measures are directed to power industry.

While the saving objective is reachable, the free audits objective (according to our interpretation) will be difficult to implement without a surcharge to the customer or without aid form the Government.

The elimination of the revenue per energy sold is positive, regarding that energy companies receive the difference in lost revenues through the tariff.

It was difficult to estimate the impacts of the Directive implementation in the household sector and the savings in production. We believe that it would be interesting to determine an exact quantitative analysis of the Directive impact in Portugal in order to reduce the error margins that we have made in this paper. This analysis should involve a multi-disciplinary team in order to cover all aspects from production to set-up a campaign.

Additionally, it would be interesting to know how much can customers be persuaded by an energy efficiency campaign in Portugal. What impact would have massive information on media and in schools? This study would probably help understand the awareness limits in our country.

Regulation can play a critical role in energy efficiency

Since the beginning of the privatisation of the energy industry, regulators have played an important role in shaping the energy industry. With the supply of all forms of energy almost open to all consumers, we could say that the objective of regulation the liberalisation is almost finished. The market will be fully opened and regulation should, therefore aim its efforts to other subjects, like energy efficiency.

Energy efficiency concerns to all energy actors in place. The importance of the existence of a regulator with energy efficiency concerns is based on the justification of the regulation existence itself. The regulator acts as an agent of the society, in order to organize the markets that are not in a liberalised context.

From the regulatory point-of-view, energy efficiency adapts to all regulatory systems, if they leave room for the implementation of DSM Programmes. Meaning, that DSM targets and control implementation and revenues recovery should be approved by all agents in the market.

The new regulatory period approaches and we believe than some of these issues can be changed for the next triennium. However, we believe that in this matter, an EDP proactive attitude may not be of any help to the issue. In a time where the regulatory period ends and with the Directive proposal in discussion, EDP should let other agents take the lead in this issue. It might be interesting to determine the impacts caused on the tariffs by this proposal implementation in different regulatory scenarios.

The savings potential in Portugal with the Energy Service Directive implementation is lower than in other countries due to its electricity production and economical context

In our calculation we have set some hypothesis concerning the production cost per technology as well as the production mix evolution according to IEA data. Based on these assumptions, we showed that the energy savings potential in Portugal is lower than in the rest of the countries studied. In our opinion, this is due to two factors: the production mix and the economical context (which influence the consumption characteristics).

Regarding the production mix, we saw in chapter 4 that Portugal is relatively highly dependent on hydroelectric electricity production. This dependency is reflected in a lower savings capability. On the contrary, countries like Italy or Greece present a higher dependency on thermal sources and therefore show a higher savings potential. The gap between northern and southern economies is not visible as their production mix (and energetic options) deeply differs from one country to another.

Regarding the economical context, any limitation on energy consumption in a growing economy like the Portuguese one will impact its economical development. It is expected a growing consumption trend in Portugal in the household sector and in basic infrastructures. This leads us to the conclusion that any efficiency measure in Portugal (as in any other southern economy), for example light bulbs replacement, may become a “ghost measure” due to the structural effect of the growing consumption, i.e. the benefit of replacing a light bulb is eliminated with the acquisition of a microwave oven, for example. We believe that northern economies are best fitted regarding this issue: their domestic consumption has stabilized and their infrastructures are in place.

The conjugation of these two factors in Portugal leads to a complex scenario to which we can also add the fact that the awareness to environmental issues in the southern Europe is living a delay comparing with the northern European countries. Any initiative of the European Union regarding energy efficiency on the demand side will have to take into account these aspects, in order to avoid putting at risk the economical and social convergence objective for southern economies in general and for Portugal in particular.

Can Europe be a tertiary community?

To finalize these perspectives on energy efficiency we would like to point out the issue on Europe industrial perspectives. The pertinence of this question arises from the problem of delocalisation of industry.

As we know, Europe's development came from its agriculture and especially from its industry. Countries like The northern European economies based their development in a strong industrialisation in the late 19th century (for most of them). The period after the Second World War brought low price energy and a need of quick development, the so-called glorious years. However, the 70s' brought oil crisis and a need to review the all industry structure, in terms of either energy sources or organizational methods. From this point onwards, industry started to focus on their core business and started to outsource support activities.

At the same time, Europe started to set stricter labour, social, economical and environmental regulations, which lead some industry to search of other countries in which these internalisations have not occurred yet. This process of delocalisation is visible in cement industry or paper industry. Therefore, it seems that European companies have the economic headquarters of companies while other countries have the production headquarters.

After this small introduction our question is: How much can an economy be based on services? How much is an industrial sector needed?

Unfortunately, we do not have the question and in our search, we were unable to find an answer to this question.

Even if we believe in the economical interest in setting an energy efficiency goal and an energy services industry we must be aware of its consequences not only for the power industry but also especially for industry in general, for transports, etc.

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12. Annex

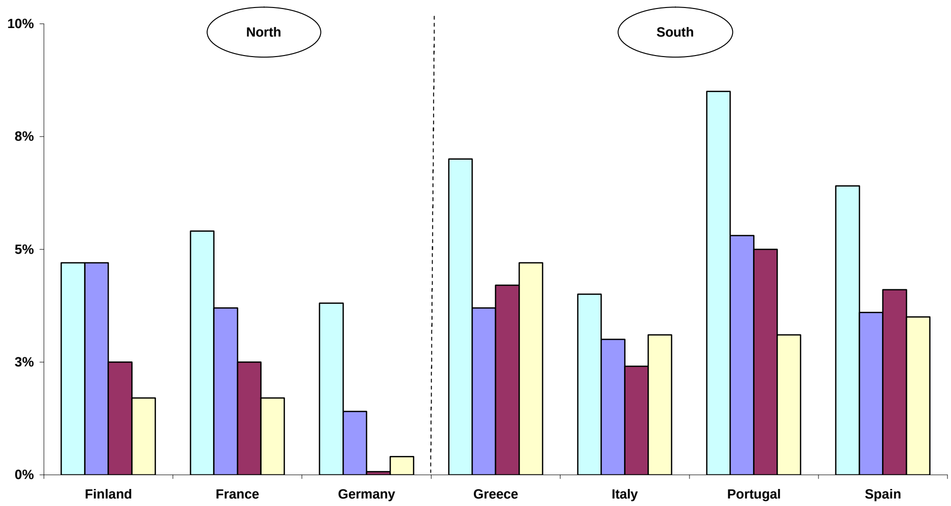
12.1. Tables and Figures

Table 12.1: Final Consumption per fuel in 1990 and in 2000

	Oil		Solid fuels		Gas		Heat		Biomass		Electricity		Others	
	1990	2000	1990	2000	1990	2000	1990	2000	1990	2000	1990	2000	1990	2000
Finland	37%	28%	9%	5%	6%	9%	6%	9%	0%	0%	23%	25%	19%	25%
France	50%	48%	7%	4%	16%	20%	0%	0%	8%	6%	19%	22%	0%	0%
Germany	43%	45%	17%	5%	19%	26%	4%	4%	0%	2%	17%	18%	0%	0%
Greece	71%	70%	7%	4%	1%	2%	0%	0%	0%	0%	15%	19%	6%	5%
Italy	50%	46%	1%	1%	27%	31%	0%	0%	5%	4%	17%	18%	0%	0%
Portugal	58%	58%	5%	3%	0%	5%	5%	6%	14%	9%	17%	18%	1%	1%
Spain	n.a.	58%	n.a.	3%	n.a.	15%	n.a.	0%	n.a.	0%	n.a.	20%	n.a.	4%

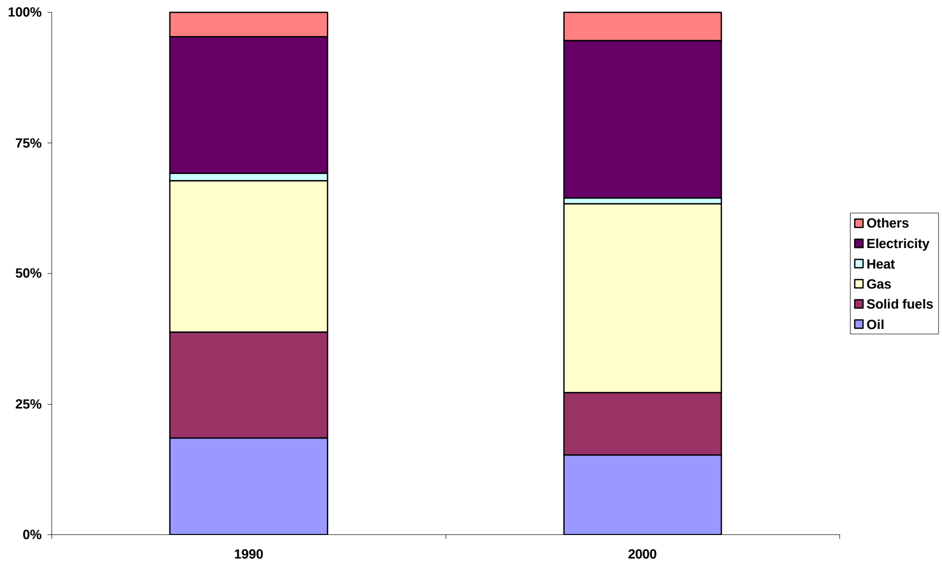
Source: adapted from Odyssée

Figure 12.1: Electricity growth rates in final consumption in northern countries



Source: adapted from IEA Energy Policy Review

Figure 12.2: Fuel mix in EU



Source: adapted from ENERDATA

Table 12.2: Sectorial energy consumption in 1990

	Industry	Households	Transport	Services	Agriculture
Finland	n.a.	n.a.	n.a.	n.a.	n.a.
France	27%	28%	29%	13%	2%
Germany	33%	25%	25%	15%	2%
Greece	26%	22%	44%	1%	7%
Italy	33%	23%	32%	9%	3%
Portugal	38%	20%	30%	7%	5%
Spain	n.a.	n.a.	n.a.	n.a.	n.a.

Source: adapted from IEA

Table 12.3: Sectorial energy consumption in 2000

	Industry	Households	Transport	Services	Agriculture
Finland	n.a.	n.a.	n.a.	n.a.	n.a.
France	24%	29%	32%	14%	2%
Germany	26%	31%	28%	13%	2%
Greece	23%	26%	43%	2%	6%
Italy	31%	23%	33%	10%	3%
Portugal	35%	16%	35%	10%	4%
Spain	31%	15%	39%	8%	6%

Source: adapted from IEA Energy Policy Review

Table 12.4: CO2 emissions per GDP unit (tonne. CO2 per 1000$US95)

	1990	2000	2010	CAGR 1990-2010
Finland	0,4	0,3	0,3	-1,9%
France	0,2	0,2	0,2	-0,6%
Germany	0,4	0,3	0,3	-2,5%
Greece	0,6	0,6	0,4	-1,9%
Italy	0,4	0,4	0,3	-1,5%
Portugal	0,4	0,5	0,3	-0,9%
Spain	0,4	0,4	0,4	-0,3%

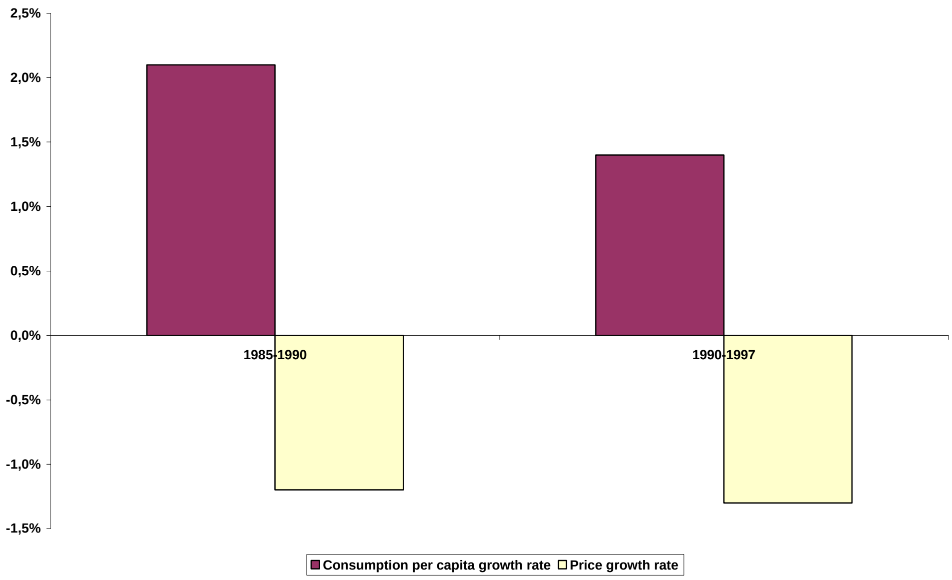
Source: adapted from IEA Energy Policy Review

Table 12.5: Average energy prices for household customers (3500KWh/year in Ecu/€ per 0,1MWh, taxes excluded)

	Finland	France	Germany	Greece	Italy	Portugal	Spain
1990	n.a.	9,25	12,04	6,60	n.a.	9,62	10,06
1991	n.a.	9,35	12,33	6,48	15,71	10,36	11,62
1992	n.a.	9,60	12,38	7,53	19,69	11,90	12,03
1993	n.a.	10,19	12,30	6,77	16,55	13,58	11,71
1994	n.a.	10,34	13,10	6,36	15,86	12,56	10,59
1995	7,03	10,06	14,04	6,47	15,09	12,57	10,56
1996	7,70	10,22	14,47	6,09	15,08	12,59	10,92
1997	7,27	10,05	14,19	6,19	16,71	12,78	10,50
1998	7,06	9,62	14,00	6,27	16,82	12,50	9,46
1999	6,56	9,49	13,89	6,22	15,70	12,01	9,29
2000	6,45	9,28	12,33	5,64	15,00	11,94	8,95
2001	6,37	9,14	12,99	5,64	15,67	12,00	8,59
2002	6,97	9,23	12,99	5,80	13,90	12,23	8,59
CAGR 1990-2002	-0,12%	-0,02%	0,63%	-1,07%	-1,11%	2,02%	-1,31%

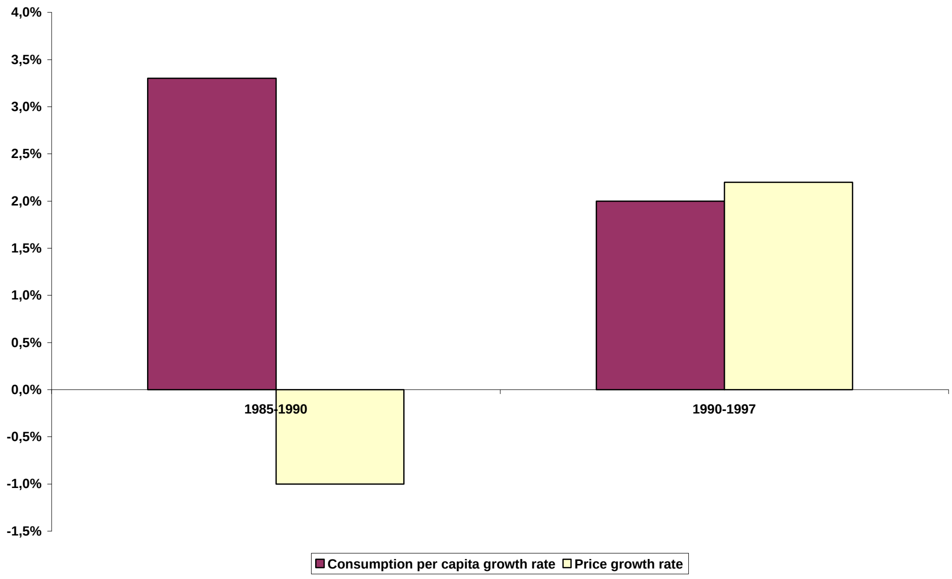
Source:Eurostat

Figure 12.3: Household consumption per capita and price growth rates in EU



Source: the author

Figure 12.4: Household consumption per capita and price growth rates in Finland



Source: the author

Table 12.6: GDP CAGR in selected countries

	1973-1990	1990-2000	2000-2010
Finland	3%	2%	2%
France	2%	2%	2%
Germany	2%	2%	2%
Greece	2%	2%	4%
Italy	3%	2%	2%
Portugal	3%	2%	3%
Spain	3%	2%	2%

Source: adapted from IEA Energy Policy Review

Table 12.7: GDP per capita CAGR

	1973-1990	1990-2000	2000-2010
Finland	2,6%	1,8%	2,2%
France	1,8%	1,1%	2,0%
Germany	2,1%	1,3%	2,5%
Greece	1,6%	2,2%	3,5%
Italy	2,6%	1,4%	2,0%
Portugal	2,3%	2,3%	3,3%
Spain	2,0%	2,2%	2,3%

Source: adapted from IEA Energy Policy Review

Table 12.8: Population CAGR between 1973 and 2010

	1973-1990	1990-2000	2000-2010
Finland	0,39%	0,37%	0,15%
France	0,50%	0,46%	0,29%
Germany	0,03%	0,35%	-0,44%
Greece	0,76%	0,33%	0,47%
Italy	0,21%	0,18%	0,13%
Portugal	0,79%	0,14%	0,20%
Spain	0,65%	0,16%	0,10%

Source: adapted from UN

Table 12.9: Population density in selected countries (inhabitant per sq Km)

	Finland	France	Germany	Greece	Italy	Portugal	Spain
1980	14	98	219	73	187	106	74
1985	14	100	218	75	188	108	76
1990	15	103	223	77	188	107	78
1995	15	105	229	79	190	107	79
2000	15	108	231	83	191	108	81
2005	15	109	231	83	190	109	81
2010	15	110	230	83	187	109	81
2015	15	110	229	82	183	108	80
2020	15	110	227	80	178	106	78
2025	15	110	224	79	173	104	77
2030	15	109	221	77	167	102	75
2035	15	107	217	75	160	100	73
2040	14	105	212	73	153	97	71
2045	14	102	207	70	146	93	68
2050	13	99	202	67	137	89	65

Source: adapted from UN

Table 12.10: Urban population share in selected countries

	Finland	France	Germany	Greece	Italy	Portugal	Spain
1980	59,8%	73,3%	82,6%	57,7%	66,6%	29,4%	72,8%
1985	59,8%	73,7%	84,0%	58,4%	66,8%	37,2%	74,2%
1990	61,4%	74,1%	85,3%	58,8%	66,7%	46,7%	75,4%
1995	61,4%	74,9%	86,5%	59,2%	66,9%	50,4%	75,9%
2000	61,1%	75,7%	87,5%	60,1%	67,2%	53,0%	76,3%
2005	60,9%	76,7%	88,5%	61,4%	67,5%	55,6%	76,7%
2010	61,2%	77,8%	89,3%	63,1%	68,2%	58,3%	77,3%
2015	62,1%	79,0%	90,0%	65,2%	69,2%	60,9%	78,1%
2020	63,5%	80,3%	90,7%	67,7%	70,6%	63,5%	79,2%
2025	65,4%	81,7%	91,3%	70,1%	72,3%	66,1%	80,4%
2030	67,9%	83,0%	91,9%	72,4%	74,3%	68,7%	81,7%

Source: adapted from UN

Table 12.11:Urban population CAGR between 1980-2020

	Finland	France	Germany	Greece	Italy	Portugal	Spain
1990-1980	0,26%	0,11%	0,32%	0,19%	0,02%	4,74%	0,35%
2000-1990	-0,05%	0,21%	0,25%	0,22%	0,07%	1,27%	0,12%
2010-2000	0,02%	0,27%	0,20%	0,49%	0,15%	0,96%	0,13%
2020-2010	0,37%	0,32%	0,16%	0,71%	0,35%	0,86%	0,24%
2030-2020	0,67%	0,33%	0,13%	0,67%	0,51%	0,79%	0,31%

Source: adapted from UN

Table 12.12: Average share per source in electricity production in northern and southern countries

	North		South	
	1973	2010	1973	2010
Coal	36%	22%	15%	31%
Oil	28%	1%	41%	10%
Gas	8%	14%	1%	31%
Comb Renew. & Waste	1%	9%	3%	4%
Nuclear	6%	44%	3%	6%
Hydro	24%	10%	39%	14%
Solar/Wind/Other	0%	2%	0%	3%

Source: adapted from IEA Energy Policy Review

Table 12.13: Electricity production share per source in northern countries

	FINLAND				FRANCE				GERMANY			
	1973	1990	2000	2010	1973	1990	1998	2010	1973	1990	2000	2010
Coal	19%	19%	13%	14%	19%	9%	7%	2%	69%	59%	53%	51%
Peat	9%	15%	6%	6%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Oil	32%	3%	1%	2%	40%	2%	2%	-	12%	2%	1%	-
Gas	-	9%	14%	12%	6%	1%	1%	16%	11%	7%	9%	15%
Comb. Renew. & Waste	-	-	13%	15%	-	-	5%	n.a.	1%	1%	2%	3%
Nuclear	-	35%	32%	37%	8%	75%	77%	70%	3%	28%	30%	25%
Hydro	40%	20%	21%	15%	26%	13%	12%	12%	4%	3%	4%	4%
Geothermal	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	-	-	-	-
Solar/Wind/Other	-	-	-	-	-	-	-	-	-	-	2%	3%

Source: adapted from IEA Energy Policy Review

Table 12.14: Electricity production share per source in southern countries

	GREECE				ITALY				PORTUGAL				SPAIN			
	1973	1990	2000	2010	1973	1990	2000	2010	1973	1990	1998	2010	1973	1990	1999	2010
Coal	36%	72%	64%	66%	4%	17%	11%	22%	4%	32%	31%	23%	19%	40%	37%	14%
Peat	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oil	50%	22%	17%	17%	62%	48%	32%	7%	19%	33%	28%	10%	33%	57%	12%	8%
Gas	-	-	10%	10%	3%	19%	38%	49%	-	-	5%	42%	1%	1%	9%	24%
Comb. Renew. & Waste	-	-	-	-	1%	-	1%	5%	2%	2%	3%	3%	10%	1%	1%	6%
Nuclear	-	-	-	-	2%	-	-	-	-	-	-	-	9%	36%	29%	24%
Hydro	15%	5%	9%	8%	26%	15%	16%	14%	75%	32%	33%	21%	38%	17%	11%	15%
Geothermal	-	-	-	-	2%	2%	2%	2%	-	-	-	-	n.a.	n.a.	n.a.	n.a.
Solar/Wind/Other	-	-	-	-	-	-	-	-	-	-	-	2%	-	-	1%	9%

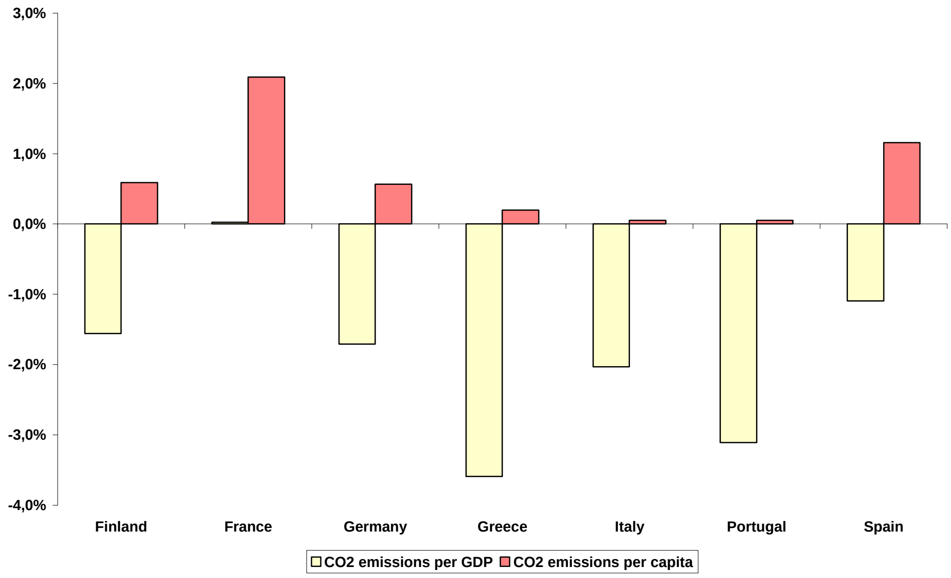
Source: adapted from IEA Energy Policy Review

Table 12.15: Variation in electricity share in industry and other sectors between 1990 and 2010

	Industry	Other sectors
Finland	2.5%	5.4%
France	0.4%	5.0%
Germany	0.3%	3.0%
Greece	0.5%	7.3%
Italy	8.3%	6.2%
Portugal	10.7%	12.5%
Spain	-2.4%	6.4%

Source: adapted from IEA Energy Policy Review

Figure 12.5: CAGR in CO2 emissions per GDP and per capita in 2000-2010



Source: adapted from IEA Energy Policy Review

Table 12.16: CAGR of Production and net imports for the selected countries between 1990 and 2010

	Production	Net Imports
Finland	2,3%	0,2%
France	0,8%	2,1%
Germany	-2,3%	1,7%
Greece	4,5%	6,8%
Italy	1,8%	0,6%
Portugal	1,0%	2,2%
Spain[63]	-1,1%	5,2%

Source: adapted from IEA Energy Policy Review

[63] Values available for the period of 1990-1999.

Table 12.17: Distribution of houses per number of rooms in Portugal

Number of rooms	Number of houses	%
1	36.912	1%
2	191.124	5%
3	497.238	14%
4	1.030.627	29%
5	1.054.107	30%
6	403.071	11%
7	183.587	5%
8	79.343	2%
9	39.003	1%
>=10	36.217	1%
TOTAL	3.551.229	100%

Source: adapted from INE 2001

Table 12.18: Electricity diffusion shares in Portugal 2001

	1991				2001			
	With	%	Without	%	With	%	Without	%
Houses	3.013.137	97.7	70.009	2.3	3.551.229	99.5	16.433	0.5

Source: adapted from INE database

Table 12.19: Distribution of households with or without kitchen or kitchenette per number of rooms available in 2000

	1	2	3	4	5	6	7	8	>=9	TOTAL
With	33.118	188.063	495.023	1.029.322	1.053.775	402.928	183.515	79.315	75.163	3.540.222
Without	3.794	3.061	2.215	1.305	332	143	72	28	57	11.007
TOTAL	36.912	191.124	49.723	1.030.627	1.054.107	403.071	183.587	79.343	75.220	3.551.229
%with	89,7	98,4	99,6	99,9	100	100	100	100	100	99,7
%without	10,3	1,6	0,4	0,1	0	0	0	0	0	0,3

Source: adapted from INE database

Table 12.20: Household consumption expenditure in 1999

	Finland	France	Germany	Greece	Italy	Portugal	Spain	EU15
Housing, water, electricity, and other fuel	28%	23%	31%	22%	25%	20%	27%	27%
Food, drinks, tobacco	17%	19%	14%	20%	21%	21%	18%	17%
Transport, communication	20%	17%	16%	15%	16%	18%	16%	16%
Recreation, hotels, restaurants	15%	15%	17%	13%	11%	14%	18%	16%
Clothing, footwear	5%	6%	6%	9%	8%	7%	5%	6%
Furniture, household equipment, repairs	5%	8%	7%	8%	8%	7%	5%	7%
Other goods and services	11%	14%	9%	14%	12%	10%	10%	11%

Source: adapted from EUROSTAT

Table 12.21: GHG emissions real and projection figures for the selected countries

	Kyoto target	Distance to target in 2001	BaU projection of GHG emissions in 2010 vs. 1990
Finland	0%	4,7%	8%
France	0%	0,4%	3,5%
Germany	-21%	-6,8%	-16%
Greece	25%	9,8%	n.a.
Italy	-6,5%	10,7%	12%
Portugal	27%	21,6%	47%
Spain	15%	23,8%	54%

Source: adapted from Ecofys 2003

Table 12.22: CAGR of the Renewable energy production in Portugal

	CAGR 2004-2010
Large Hydroelectric	2,1%
Wind	58,5%
Small Hydroelectric	3,4%
Biomass	45,0%
Landfill gas	-
Waste to Energy	12,0%
Waves	-
Photovoltaic	-
Total	9,1%

Source: Ministry of Economy, DGGE

Table 12.23: Sales per efficiency class in Portugal

		A	B	C	D
Refrigerators	2001	19,9%	35,0%	45,2%	
	2002	30,0%	43,5%	26,5%	
Washing machines	2001	34,9%	26,6%	38,4%	
	2002	70,0%	15,1%	14,9%	
Dishwashers	2001	26,1%	53,2%	18,5%	4,7%
	2002	53,7%	29,4%	17,0%	0,0%

Source: adapted from AGEFE64

Table 12.24: Retail value (M€) for some household appliances in Portugal

						Expected						
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Refrigerator	102	121	139	144	143	145	147	149	151	154	156	158
Washing machines	86	90	101	104	104	107	110	113	117	120	123	127
Dishwashers	36	39	45	47	46	47.7	50	51	52	54	55	57

Source: Euromonitor 2003

[64] From Fagor, Aspes, Edesa, Ariston, Indesit, Míele and Samsung data.

Table 12.25: Cost in electricity production per technology (€/MWh)

Coal	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Finland			3,5	3,5	3,5	3,5	3,5	3,6	3,6	3,6	3,6	3,6	3,6
France	1,4	1,2	1,0	0,9	0,8	0,7	0,6	0,5	0,5	0,4	0,4	0,3	0,0
Germany			9,7	9,7	9,7	9,6	9,6	9,5	9,5	9,5	9,4	9,4	0,0
Greece			11,8	11,9	11,9	11,9	11,9	12,0	12,0	12,0	12,1	12,1	0,0
Italy			2,1	2,1	2,2	2,2	2,2	2,3	2,3	2,4	2,4	2,5	0,0
Portugal	5,7	5,6	5,5	5,3	5,2	5,1	5,0	4,9	4,8	4,6	4,5	4,4	0,0
Spain		6,8	6,6	6,4	6,3	6,1	6,0	5,8	5,7	5,5	5,4	5,2	0,0
CHP	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Finland			4,5	4,4	4,4	4,3	4,2	4,1	4,0	3,9	3,9	3,8	3,7
France	2,9	3,1	3,2	3,3	3,5	3,7	3,8	4,0	4,2	4,4	0,0	0,0	0,0
Germany			2,9	3,1	3,2	3,3	3,5	3,7	3,8	4,0	4,2	4,4	0,0
Greece			3,2	3,2	3,2	3,2	3,1	3,1	3,1	3,1	3,1	3,1	0,0
Italy			11,8	11,9	12,0	12,1	12,1	12,2	12,3	12,4	12,5	12,6	0,0
Portugal	1,6	1,6	1,6	1,5	1,5	1,5	1,4	1,4	1,4	1,3	1,3	1,3	0,0
Spain		3,5	3,4	3,3	3,2	3,2	3,1	3,0	2,9	2,8	2,8	2,7	0,0
Oil	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Finland			0,4	0,4	0,4	0,4	0,5	0,5	0,5	0,6	0,6	0,6	0,7
France	1,0	0,8	0,6	0,5	0,4	0,3	0,3	0,2	0,2	0,2	0,1	0,1	0,0
Germany			0,3	0,2	0,1	0,1	0,1	0,0	0,0	0,0	0,0	0,0	0,0
Greece			7,1	7,1	7,1	7,1	7,1	7,1	7,1	7,1	7,1	7,1	0,0
Italy			13,4	12,8	12,3	11,8	11,3	10,8	10,4	9,9	9,5	9,1	0,0
Portugal	11,6	11,3	11,0	10,8	10,5	10,3	10,0	9,8	9,6	9,4	9,1	8,9	0,0
Spain		5,0	4,8	4,7	4,6	4,5	4,4	4,3	4,1	4,0	3,9	3,8	0,0
Nuclear	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Finland			4,5	4,6	4,6	4,7	4,7	4,8	4,9	4,9	5,0	5,1	5,1
France	10,7	10,6	10,5	10,5	10,4	10,3	10,2	10,2	10,1	10,0	9,9	9,8	0,0
Germany			4,2	4,1	4,0	4,0	3,9	3,8	3,8	3,7	3,6	3,6	0,0
Spain		4,0	3,9	3,8	3,7	3,6	3,5	3,4	3,3	3,3	3,2	3,1	0,0
Hydro	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Finland			0,4	0,4	0,4	0,4	0,4	0,4	0,3	0,3	0,3	0,3	0,3
France	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,0
Germany			0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,0
Greece			0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,0
Italy			0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,0
Portugal	0,7	0,7	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,5	0,5	0,5	0,0
Spain		0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,0

Source: the author

Table 12.26: Average cost of each MWh produced (€/MWh)

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	**Average**
Finland	n.a.	n.a.	13,3	13,3	13,3	13,3	13,3	13,3	13,3	13,3	13,4	13,4	**13,3**
France	16,2	15,9	15,7	15,5	15,4	15,3	15,2	15,2	15,2	15,2	10,7	10,5	**15,4**
Germany	n.a.	n.a.	17,3	17,2	17,1	17,1	17,1	17,1	17,2	17,3	17,3	17,4	**17,2**
Greece	n.a.	n.a.	22,3	22,3	22,3	22,3	22,3	22,3	22,4	22,4	22,4	22,4	**22,3**
Italy	n.a.	n.a.	27,6	27,2	26,7	26,4	26,0	25,7	25,3	25,0	24,8	24,5	**25,9**
Portugal	19,6	19,1	18,7	18,3	17,8	17,4	17,0	16,6	16,2	15,9	15,5	15,1	**17,3**
Spain	n.a.	19,4	18,9	18,5	18,0	17,5	17,1	16,7	16,2	15,8	15,4	15,0	**17,2**

Source: the author

Table 12.27: Average area per dwelling in Portugal (1997)

Area (m2)	%	Weighted average	Total (m2)
<19	0,9	0,2	84.5
20 – 29	2,6	0,8	
30 – 39	6,9	2,7	
40 – 59	20,5	12,1	
60 – 79	23,7	18,7	
80 – 99	20,9	20,7	
100 – 119	11,5	13,7	
>120	13,1	20,8	

Source: INE database and the author

Table 12.28: Brand shares of refrigerators in 2002

	2001	**2002**
Zanussi	6,9%	8,1%
Whirlpool	6,1%	7,1%
AEG	6,4%	7,0%
Electrolux	7,4%	6,9%
Indesit	4,9%	5,4%
Singer	4,5%	5,3%
Siemens	4,2%	4,9%
Ariston	4,1%	4,6%
Jocel	4,5%	4,1%
Fagor	2,8%	2,4%
LG	0,9%	1,1%
Bosch	1,0%	1,0%
Edesa	1,1%	0,9%
Balay	0,5%	0,6%
Ignis	0,5%	0,6%
Bauknecht	0,3%	0,3%
Private Label	4,5%	5,2%
Others	39,3%	34,6%
Total	99,9%	100,0%

Source: Euromonitor 2003

Table 12.29: Brand shares of washing machines in 2002

	2001	2002
Indesit	8,0%	8,8%
Whirlpool	7,9%	8,8%
Electrolux	6,9%	6,8%
Zanussi	5,8%	6,1%
Ariston	5,2%	5,5%
AEG	5,1%	5,5%
Singer	4,8%	5,0%
Jocel	4,3%	4,1%
Siemens	3,2%	3,7%
Fagor	3,3%	3,2%
Candy	3,0%	3,1%
Aspes	1,8%	2,1%
Ignis	1,9%	2,0%
Bauknecht	1,1%	1,0%
Edesa	0,9%	1,0%
Bosch	0,5%	0,5%
Balay	0,4%	0,4%
Private	5,8%	6,6%
Others	30,1%	25,8%
Total	100,0%	100,0%

Source: Euromonitor 2003

Table 12.30: Brand shares of dishwashers in 2002

	2001	2002
Whirlpool	11,4%	12,1%
Zanussi	7,7%	7,8%
Electrolux	7,4%	7,1%
Ariston	5,2%	5,6%
Indesit	4,8%	5,5%
AEG	4,9%	5,1%
Siemens	3,9%	4,1%
Singer	3,3%	3,3%
Aspes	3,2%	3,3%
Fagor	3,2%	3,1%
Jocel	3,2%	3,0%
Bosch	2,7%	2,8%
Candy	2,0%	2,1%
Miele	1,0%	1,1%
Balay	0,5%	0,5%
Bauknecht	0,4%	0,4%
Edesa	0,3%	0,4%
Ignis	0,2%	0,2%
Private Label	4,5%	5,0%
Others	30,2%	27,5%
Total	100,0%	100,0%

Source: Euromonitor 2003

Table 12.31: NPV calculation for the refrigerators (in €)

R2 to R1	Cost	Future value	Discount	NPV	Free Cash Flow
0	-40	3,17	1,00	3,17	-36,83
1		3,17	0,93	2,96	-33,86
2		3,17	0,87	2,77	-31,10
3		3,17	0,81	2,58	-28,51
4		3,17	0,76	2,41	-26,10
5		3,17	0,71	2,25	-23,85
6		3,17	0,66	2,10	-21,75
7		3,17	0,62	1,96	-19,78
8		3,17	0,58	1,83	-17,95
9		3,17	0,54	1,71	-16,24
TOTAL	-40			26,63	

R3 to R1	Cost	Future Value	Discount	NPV	Free Cash- Flow
0	-90	4,70	1,00	4,70	-85,30
1		4,70	0,93	4,39	-80,91
2		4,70	0,87	4,10	-76,81
3		4,70	0,81	3,83	-72,98
4		4,70	0,76	3,57	-69,41
5		4,70	0,71	3,34	-66,07
6		4,70	0,66	3,12	-62,95
7		4,70	0,62	2,91	-60,04
8		4,70	0,58	2,72	-57,33
9		4,70	0,54	2,54	-54,79
TOTAL	-90			39,47	

Source: the author

Table 12.32: NPV calculation for the washing machines (in €)

W2-W1	Cost	Future Value	Discount	NPV	Free Cash Flow
0	-30	0,80	1,00	0,80	-29,20
1		0,80	0,93	0,74	-28,46
2		0,80	0,87	0,69	-27,77
3		0,80	0,81	0,65	-27,12
4		0,80	0,76	0,60	-26,52
5		0,80	0,71	0,56	-25,95
6		0,80	0,66	0,53	-25,43
7		0,80	0,62	0,49	-24,93
8		0,80	0,58	0,46	-24,47
9		0,80	0,54	0,43	-24,05
TOTAL	-30			8,82	

W3-W1	Cost	Future Value	Discount	NPV	Free Cash Flow
0	-79	2,19	1,00	2,19	-76,81
1		2,19	0,93	2,04	-74,77
2		2,19	0,87	1,91	-72,86
3		2,19	0,81	1,78	-71,08
4		2,19	0,76	1,66	-69,42
5		2,19	0,71	1,55	-67,87
6		2,19	0,66	1,45	-66,42
7		2,19	0,62	1,35	-65,07
8		2,19	0,58	1,26	-63,81
9		2,19	0,54	1,18	-62,63
TOTAL	-79			20,63	

Source: the author

Table 12.33: NPV calculation for the dishwashers (in €)

D2-D1	Cost	Future Value	Discount	NPV	Free Cash Flow
0	-20	1,68	1,00	1,68	-18,32
1		1,68	0,93	1,57	-16,75
2		1,68	0,87	1,47	-15,28
3		1,68	0,81	1,37	-13,91
4		1,68	0,76	1,28	-12,63
5		1,68	0,71	1,19	-11,44
TOTAL	-20			11,43	

D3-D1	Cost	Future Value	Discount	NPV	Free Cash Flow
0	-40	4,49	1,00	4,49	-35,51
1		4,49	0,93	4,19	-31,31
2		4,49	0,87	3,92	-27,40
3		4,49	0,81	3,66	-23,74
4		4,49	0,76	3,41	-20,33
5		4,49	0,71	3,19	-17,14
TOTAL	-40			27,12	

Source: the author

Table 12.34: NPV calculation for light bulbs (in €)

CFL-IL	Cost	Future Value	Discount	NPV	Free Cash Flow
0	-3,25	1,30	1,00	1,30	-1,95
1		1,30	0,93	1,21	-0,74
2		1,30	0,87	1,13	0,40
3		1,30	0,81	1,06	1,45
TOTAL	-3,25			8,96	

Source: the author

Table 12.35: Energy consumption compared to Portugal

	2004	2005	2006	2007	2008	2009
Finland	6,66	12,20	19,77	26,21	33,44	40,82
France	7,02	14,24	21,71	29,47	36,64	44,90
Germany	8,98	18,49	28,58	39,30	50,68	62,80
Greece	11,04	22,08	33,11	44,13	55,15	66,17
Italy	12,28	24,30	36,07	47,63	58,99	70,19
Portugal	7,80	14,56	21,29	26,98	33,64	39,27
Spain	8,46	16,70	24,72	32,54	40,15	47,56

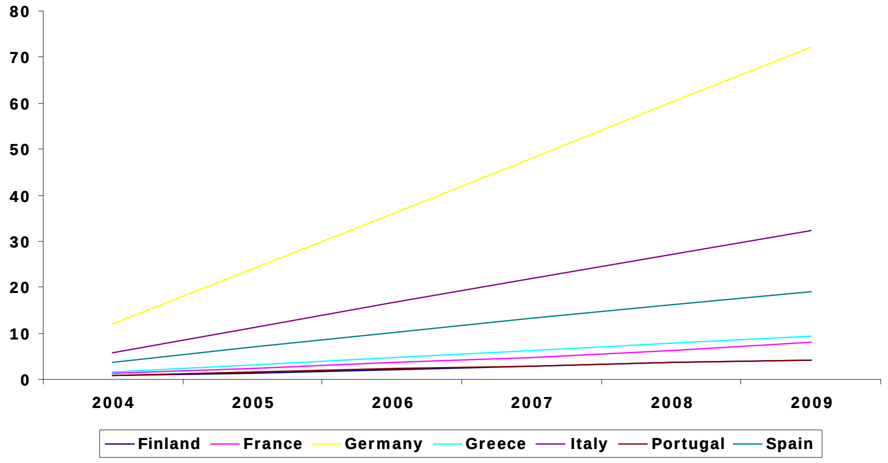
Source: the author

Table 12.36: Equivalent CO2 emissions per year

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Average
Finland	99,7	99,5	99,3	99,2	99,0	98,9	98,8	98,7	98,7	98,6	
France	35,3	31,3	28,0	25,5	23,7	22,6	22,1	22,4	23,5	25,5	
Germany	210,8	210,0	209,6	209,4	209,3	209,4	209,6	209,9	210,2	210,6	
Greece	299,1	299,6	300,1	300,6	301,0	301,5	302,0	302,5	303,0	303,5	
Italy	208,0	205,5	203,2	201,0	199,0	197,1	195,4	193,8	192,4	191,1	
Portugal	201,3	196,6	192,1	187,6	183,3	179,0	174,9	170,8	166,9	163,0	181,6
Spain	184,3	179,7	175,1	170,7	166,4	162,2	158,1	154,1	150,2	146,4	

Source: the author

Figure 12.6: CO2 costs avoided (M€)



Source: the author

Table 12.37: Share of the production cost due to each source

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Finland												
Coal	n.a.	n.a.	26%	26%	26%	27%	27%	27%	27%	27%	27%	27%
CHP	n.a.	n.a.	34%	33%	33%	32%	31%	31%	30%	30%	29%	28%
Oil	n.a.	n.a.	3%	3%	3%	3%	4%	4%	4%	4%	4%	5%
Nuclear	n.a.	n.a.	34%	34%	35%	35%	36%	36%	37%	37%	37%	38%
Hydro	n.a.	n.a.	3%	3%	3%	3%	3%	3%	3%	2%	2%	2%
France												
Coal	8%	8%	7%	6%	5%	5%	4%	4%	3%	3%	2%	2%
CHP	18%	19%	20%	22%	23%	24%	25%	26%	28%	29%	28%	29%
Oil	6%	5%	4%	3%	3%	2%	2%	2%	1%	1%	1%	1%
Nuclear	66%	67%	67%	68%	68%	68%	67%	67%	66%	66%	67%	66%
Hydro	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
Germany												
Coal	n.a.	n.a.	56%	57%	56%	56%	56%	56%	55%	55%	54%	54%
CHP	n.a.	n.a.	17%	18%	19%	20%	20%	21%	22%	23%	24%	25%
Oil	n.a.	n.a.	3%	3%	3%	3%	4%	4%	4%	4%	4%	5%
Nuclear	n.a.	n.a.	34%	34%	35%	35%	36%	36%	37%	37%	37%	38%
Hydro	n.a.	n.a.	3%	3%	3%	3%	3%	3%	3%	2%	2%	2%
Greece												
Coal	n.a.	n.a.	53%	53%	53%	53%	53%	54%	54%	54%	54%	54%
CHP	n.a.	n.a.	35%	35%	35%	35%	35%	35%	35%	34%	34%	34%
Oil	n.a.	n.a.	32%	32%	32%	32%	32%	32%	32%	32%	32%	32%
Nuclear	n.a.	n.a.	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Hydro	n.a.	n.a.	4%	4%	4%	4%	3%	3%	3%	3%	3%	3%
Italy												
Coal	n.a.	n.a.	8%	8%	8%	8%	9%	9%	9%	9%	10%	10%
CHP	n.a.	n.a.	43%	44%	45%	46%	47%	48%	49%	50%	50%	51%
Oil	n.a.	n.a.	48%	47%	46%	45%	43%	42%	41%	40%	39%	37%
Nuclear	n.a.	n.a.	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Hydro	n.a.	n.a.	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Portugal												
Coal	29%	29%	29%	29%	29%	29%	29%	29%	29%	29%	29%	29%
CHP	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%
Oil	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%
Nuclear	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Hydro	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Spain												
Coal	n.a.	35%	35%	35%	35%	35%	35%	35%	35%	35%	35%	35%
CHP	n.a.	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%
Oil	n.a.	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
Nuclear	n.a.	21%	21%	21%	21%	21%	21%	21%	21%	21%	21%	21%
Hydro	n.a.	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%

Source: the author

12.2. The Portuguese electric system

The National Electric System (SEN) is composed by the Public Service Electric System (SEP) and by the Independent Electric System (SEI). This last one, comprises the Non-Binding Electric System (SENV) and the Special Producers (PRE).

Within the SEP, the principal participants are the National Transmission Grid (RNT), which is operated under a public-service concession regime by Rede Eléctrica Nacional, S.A. (REN), the Binding Producers (generators) (PV) and the Distributors of electric energy who are bound to the SEP by means of a contractual regime (DV). This is planned in a centralised way and the licences are a subject of a tendering process of 15 to 75 year, assuming an exclusive relationship with the National Electric Energy Transmission Network (RNT) through CAE's.

The Binding Producers have commercial relations with REN by way of exclusive long-term supply contracts. Binding Distribution operators are obliged to supply SEP customers with the electricity these have contracted, subject to the tariffs and conditions laid down by the electricity regulator.

The SEI comprises the Non-Binding Electricity System (SENV) and the Special Generation Regime (PRE). The SENV is composed of Non-Binding Producers (PNV) and Non-Binding Customers (CNV) (this customers are entitled to use the SEP's networks if they pay the respective access tariffs).

The PRE is characterised by the generation of electricity using cogeneration and renewable energy sources. The producers deliver electricity to the SEP's network within a specific legislation that contemplates both technical and tariff issues.

The grid operation and the public distribution are regulated activities.

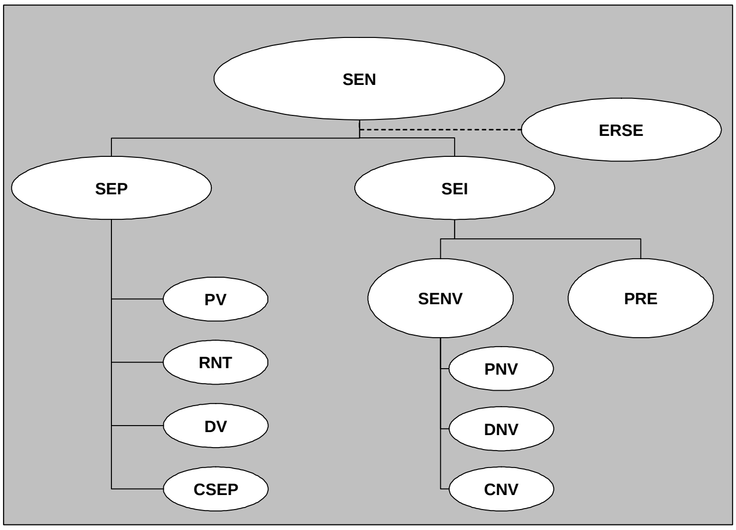
The expansion of SEP generation capacity is decided accordingly to expansion plans approved by the Minister of Economy and published by DGGE. In accordance with current law, REN is responsible to carry out the Expansion Plan for the Public Service Electricity System. As a general rule, the construction of each new generation capacity of SEP is subject to tendering procedure.

The generating units of SEP are subjected to central dispatching. A part of the electricity generated by auto-producers is used to supply their own consumption (self-consumption). The remainder is sold to the grid company, which has the obligation of buying it accordingly to buy back tariffs.

The regulator (ERSE) supervises the compliance with the SEP's functioning rules and the relationship between the SEP and the SENV, to formulate the eligible criteria for customers to join the SENV and to regulate the activities conducted within the ambit of the SEP. Namely to fix tariffs and prices for electricity as well for other services supplied by RNT concessionaire and by the holders of binding distribution licenses.

In the SEP, there are three Generation Companies, one Distribution Company and one Grid Operator. For each island (Madeira and Azores) there is a local company that operates the electric system in the areas of generation and distribution.

Figure 12.7: Organization of the SEN

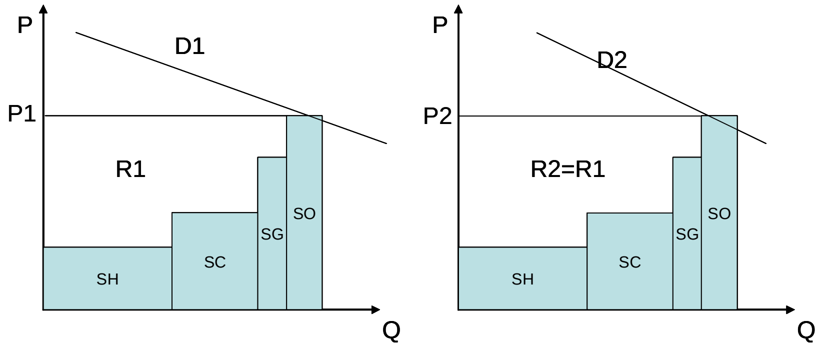


Source: adapted from ERSE

12.3. Production margin calculation

Let's imagine a supply based on Hydro (SH), Coal (SC), Natural Gas (SG) and Fuel Oil (SO) showed in the next figures. In order to meet the demand D1, the price will be agreed will be P1 and the revenues will be R1, i.e. the area above the marginal cost of production and below P1. A similar price is reached when the demand is D2. Although different from D1, D2 will be fixed at a price P1 and the revenues will be R2=R1.

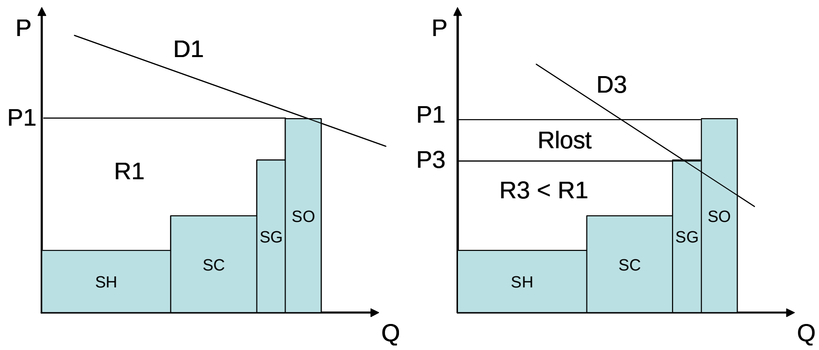
Figure 12.8: Compared supply-demand equilibrium



Source: the author

If the demand reached D3, the price will be fixed in P3 and the revenues will be R3. Therefore, the lost revenues will be given by the area above P3 and below P1.

Figure 12.9: Compared supply-demand equilibrium



Source: the author

This Rlost is the revenue lost by the production. In the specific Portuguese case, we contracts called CAE (Energy Acquisition Contract) which guarantees a fixed revenue per power plant. In competition, these contracts will disappear and will be replaced by the CMEC. For now, 90% of the production is on CAE and therefore the margin is guaranteed by the next year tariff increase. However, when CMEC's replace the CAE's it will more difficult to calculate this margin.

12.4. Directive implementation impacts

Finland

According to IEA, the electricity output between 2000 and 2010 is expected to evolve according to the next table.

Table 12.38: Electricity output in Finland (GWh)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Electricity output	69.780	71.315	72.884	74.488	76.126	77.801	79.513	81.262	83.050	84.877

Source: adapted from IEA

Considering all the output as consumed[65], we may say that the average consumption between 2000 and 2003 will be 72.117GWh, and 1% of this will be 721GWh. Therefore, this will mean a cumulative effect of 4.3TWh of savings in 2009.

Table 12.39: Directive implementation effects (GWh)

	2004	2005	2006	2007	2008	2009
Expected	76.126	77.801	79.513	81.262	83.050	84.877
Cumulative saving effect	721	1.442	2.164	2.885	3.606	4.327
Combined effect	75.405	76.359	77.349	78.377	79.444	80.550

Source: the author

If we consider the MWh production cost as showed in Table 12.26, the overall production costs will evolve according to Table 9.16. The direct cumulative savings, which result from reducing the production of energy, with the implementation of this Directive (according to the published proposal), will reach 58M€ in 2009 however, we should add the avoided CO2 emissions which represent a gain of 4.3 M€ in 2009. Therefore, the overall gain will reach ~62M€.

Table 12.40: Electricity production costs and savings in all sectors (M€)

	2004	2005	2006	2007	2008	2009
Production cost	1012	1034	1058	1080	1113	1137
Production cost with Directive	1002	1016	1029	1042	1065	1079
Direct cumulative savings	10	18	29	38	48	58
Direct CO2 cumulative savings	0,71	1,43	2,14	2,85	3,56	4,27
Total savings	10,71	19,43	31,14	40,85	51,56	62,27

Source: the author

France

According to IEA, the electricity output in France will be as presented in the next table.

Table 12.41: Electricity output in Germany (GWh)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Electricity output	523.423	531.798	540.307	548.952	557.736	566.659	575.726	584.938	594.297	603.805

Source: adapted from IEA

Considering that all the output is internally consumed, we may say that the average consumption between 2000 and 2003 will be 536.121GWh, and 1% of this will be 5.361GWh. Therefore, this will mean a cumulative effect of 34TWh of savings in 2009.

Table 12.42: Directive implementation effects (GWh)

	2004	2005	2006	2007	2008	2009
Expected	557.736	566.659	575.726	584.938	594.297	603.805
Cumulative saving effect	5.361	10.722	16.084	21.445	26.806	32.167
Combined effect	552.375	555.937	559.642	563.493	567.491	571.638

Source: the author

[65] According to IEA, the electricity exports are negligible and imports account for 7% of the electricity output.

If we consider the MWh production cost as showed in Table 12.26, the overall production costs will evolve according to Table 9.16. The direct cumulative savings, which result from reducing the production of energy, with the implementation of this Directive will reach 338M€ in 2009 however, we should add the avoided CO2 emissions which represent a gain of 4.3 M€ in 2009. Therefore, the overall gain will reach ~486M€.

Table 12.43: Electricity production costs and savings in all sectors (M€)

	2004	2005	2006	2007	2008	2009
Production cost	8477	8595	8729	8880	6333	6348
Production cost with Directive	8396	8432	8485	8555	6047	6009
Direct cumulative savings	81	163	244	326	398	479
Direct CO2 cumulative savings	1	2	3	4	6	8
Total savings	82	165	247	330	404	486

Source: the author

Germany

According to IEA, the electricity output in Germany will be as presented in the next table.

Table 12.44: Electricity output in Germany (GWh)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Electricity output	567.544	570.381	573.233	576.099	578.980	581.875	584.785	587.708	590.647	593.600

Source: adapted from IEA

Considering that all the output as consumed, we may say that the average consumption between 2000 and 2003 will be 571.814 GWh, and 1% of this will be 5.718 GWh. Therefore, this will mean a cumulative effect of 34TWh of savings in 2009 (i.e. in 6 years, Germany will save almost the annual Portuguese electricity output).

Table 12.45: Directive implementation effects (GWh)

	2004	2005	2006	2007	2008	2009
Expected	578.980	581.875	584.784	587.708	590.647	593.600
Cumulative saving effect	5.718	11.436	17.154	22.873	28.591	34.309
Combined effect	573.262	570.439	567.630	564.835	562.056	559.291

Source: the author

If we consider the MWh production cost as showed in Table 12.26, the overall production costs will evolve according to Table 9.16. The direct cumulative savings, which result from reducing the production of energy, with the implementation of this Directive will reach 597M€ in 2009 however, we should add the avoided CO2 emissions which represent a gain of 4.3 M€ in 2009. Therefore, the overall gain will reach ~669M€.

Table 12.46: Electricity production costs and savings in all sectors (M€)

	2004	2005	2006	2007	2008	2009
Production cost	9908	9976	10053	10138	10231	10332
Production cost with Directive	9811	9780	9758	9744	9736	9735
Direct cumulative savings	97	196	295	395	495	597
Direct CO2 cumulative savings	12	24	35	48,00	60	72
Total savings	109	220	330	443	555	669

Source: the author

Greece

According to IEA, the electricity output in Greece will be as presented in the next table.

Table 12.47: Electricity output in Greece (GWh)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Electricity output	49.427	51.108	52.846	54.642	56.500	58.421	60.408	62.462	64.585	66.781

Source: adapted from IEA

Considering all the output as consumed, we may say that the average consumption between 2000 and 2003 will be 52.005 GWh, and 1% of this will be ~520 GWh. Therefore, this will mean a cumulative effect of 3.1TWh of savings in 2009.

Table 12.48: Directive implementation effects (GWh)

	2004	2005	2006	2007	2008	2009
Expected	56.500	58.421	60.408	62.462	64.585	66.781
Cumulative saving effect	520	1.040	1.560	2.080	2.600	3.120
Combined effect	55.980	57.381	58.847	60.381	61.985	63.661

Source: the author

If we consider the MWh production cost as showed in Table 12.26, the overall production costs will evolve according to Table 9.16. The direct cumulative savings, which result from reducing the production of energy, with the implementation of this Directive will reach 70M€ in 2009 however, we should add the avoided CO2 emissions which represent a gain of 4.3 M€ in 2009. Therefore, the overall gain will reach ~79M€.

Table 12.49: Electricity production costs and savings in all sectors (M€)

	2004	2005	2006	2007	2008	2009
Production cost	1262	1305	1350	1397	1446	1496
Production cost with Directive	1250	1282	1316	1351	1387	1426
Direct cumulative savings	12	23	35	47	58	70
Direct CO2 cumulative savings	2	3	5	6	8	9
Total savings	14	26	40	53	66	79

Source: the author

Italy

According to IEA, the electricity output in Italy will be as presented in the next table.

Table 12.50: Electricity output in Italy (GWh)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Electricity output	269.816	278.180	286.804	295.695	304.861	314.312	324.056	334.101	344.459	355.137

Source: adapted from IEA

Considering all the output as consumed, we may say that the average consumption between 2000 and 2003 will be 282.6243 GWh, and 1% of this will be ~2.826 GWh. Therefore, this will mean a cumulative effect of 17 TWh of savings in 2009.

Table 12.51: Directive implementation effects (GWh)

	2004	2005	2006	2007	2008	2009
Expected	304.861	314.312	324.056	334.101	344.459	355.137
Cumulative saving effect	2.826	5.652	8.479	11.305	14.131	16.957
Combined effect	302.035	308.660	315.577	322.796	330.327	338.179

Source: the author

If we consider the MWh production cost as showed in Table 12.26, the overall production costs will evolve according to Table 9.16. The direct cumulative savings, which result from reducing the production of energy, with the implementation of this Directive will reach 415M€ in 2009 however, we should add the avoided CO2 emissions which represent a gain of 4.3 M€ in 2009. Therefore, the overall gain will reach ~448M€.

Table 12.52: Electricity production costs and savings in all sectors (M€)

	2004	2005	2006	2007	2008	2009
Production cost	7926	8065	8211	8364	8526	8697
Production cost with Directive	7853	7920	7996	8081	8177	8282
Direct cumulative savings	73	145	215	283	350	415
Direct CO2 cumulative savings	6	11	17	22	27	32
Total savings	79	156	232	305	377	448

Source: the author

Spain

According to IEA, the electricity output in Spain will be as presented in the next table.

Table 12.53: Electricity output in Spain (GWh)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Electricity output	209.968	214.167	218.451	222.820	227.276	231.822	236.458	241.187	246.011	250.931

Source: adapted from IEA

Considering all the output as consumed, we may say that the average consumption between 2000 and 2003 will be 216.451 GWh, and 1% of this will be ~2.163 GWh. Therefore, this will mean a cumulative effect of ~13 TWh of savings in 2009.

Table 12.54: Directive implementation effects (GWh)

	2004	2005	2006	2007	2008	2009
Expected	227.276	231.822	236.458	241.187	246.011	250.931
Cumulative saving effect	2.164	4.327	6.491	8.654	10.818	12.981
Combined effect	225.113	227.495	229.968	232.533	235.193	237.950

Source: the author

If we consider the MWh production cost as showed in Table 12.26, the overall production costs will evolve according to Table 9.16. The direct cumulative savings, which result from reducing the production of energy, with the implementation of this Directive will reach 195M€ until 2009 however, we should add the avoided CO2 emissions which represent a gain of 4.3 M€ in 2009. Therefore, the overall gain will reach ~214M€.

Table 12.55: Electricity production costs and savings in all sectors (M€)

	2004	2005	2006	2007	2008	2009
Production cost	3887	3864	3842	3820	3798	3776
Production cost with Directive	3850	3792	3737	3683	3631	3581
Direct cumulative savings	37	72	105	137	167	195
Direct CO2 cumulative savings	4	7	10	13	16	19
Total savings	41	79	115	150	183	214

Source: the author

Wrap up

Table 12.56: Production saving costs (M€)

	2004	2005	2006	2007	2008	2009
Finland	10	18	29	38	48	58
France	81	163	244	326	398	479
Germany	98	196	295	395	495	597
Greece	12	23	35	47	58	70
Italy	73	145	215	283	350	415
Portugal	7	13	19	24	30	35
Spain	37	72	105	137	167	195

Source: the author

Table 12.57: CO2 saving costs (M€)

	2004	2005	2006	2007	2008	2009
Finland	1	1	2	3	4	4
France	1	2	4	5	6	8
Germany	12	24	36	48	60	72
Greece	2	3	5	6	8	9
Italy	6	11	17	22	27	32
Portugal	1	2	2	3	4	4
Spain	4	7	10	13	16	19

Source: the author

Table 12.58: Overall saving costs (M€)

	2004	2005	2006	2007	2008	2009
Finland	11	19	31	41	52	62
France	83	165	247	330	404	487
Germany	110	220	331	443	555	669
Greece	13	26	40	53	66	79
Italy	79	156	231	305	377	448
Portugal	8	15	21	27	34	39
Spain	41	79	116	150	183	214

Source: the author

Table 12.59: Compared savings in Production (M€)

	2004	2005	2006	2007	2008	2009
Finland	6,22	11,31	18,41	24,39	31,13	38,02
France	6,92	14,03	21,40	29,04	36,07	44,15
Germany	8,00	16,48	25,47	35,03	45,20	56,02
Greece	9,73	19,45	29,17	38,88	48,58	58,27
Italy	11,41	22,56	33,49	44,21	54,74	65,11
Portugal	7,00	13,00	19,00	24,00	30,00	35,00
Spain	7,71	15,22	22,53	29,65	36,59	43,35

Source: the author

Table 12.60: Compared savings in CO2 (M€)

	2004	2005	2006	2007	2008	2009
Finland	0,44	0,90	1,36	1,83	2,31	2,80
France	0,11	0,21	0,31	0,43	0,57	0,76
Germany	0,98	2,01	3,11	4,26	5,49	6,78
Greece	1,31	2,63	3,94	5,26	6,58	7,90
Italy	0,87	1,73	2,58	3,42	4,25	5,08
Portugal	0,80	1,56	2,29	2,98	3,64	4,27
Spain	0,75	1,48	2,19	2,89	3,56	4,22

Source: the author

Table 12.61: Production savings effort compared with Portugal

	2004	2005	2006	2007	2008	2009
Finland	89%	87%	97%	102%	104%	109%
France	99%	108%	113%	121%	120%	126%
Germany	114%	127%	134%	146%	151%	160%
Greece	139%	150%	154%	162%	162%	166%
Italy	163%	174%	176%	184%	182%	186%
Portugal	100%	100%	100%	100%	100%	100%
Spain	110%	117%	119%	124%	122%	124%

Source: the author

Table 12.62: CO_2 savings effort compared with Portugal

	2004	2005	2006	2007	2008	2009
Finland	55%	57%	59%	61%	63%	65%
France	13%	13%	14%	14%	16%	18%
Germany	122%	129%	136%	143%	150%	159%
Greece	164%	168%	172%	176%	180%	185%
Italy	109%	111%	113%	115%	117%	119%
Portugal	100%	100%	100%	100%	100%	100%
Spain	94%	95%	96%	97%	98%	99%

Source: the author