



INTERNATIONAL  
HELLENIC  
UNIVERSITY

**EU Energy Policy  
&  
Effects of Implemented Policies in  
Renewable Energy Penetration**

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SID: 3302100001

SCHOOL OF SCIENCE & TECHNOLOGY

A thesis submitted for the degree of  
*Master of Science (MSc) in Energy Systems*

SEPTEMBER 2011

THESSALONIKI – GREECE





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# Disclaimer

This dissertation is submitted in part candidacy for the degree of Master of Science in Energy Systems, from the School of Science and Technology of the International Hellenic University, Thessaloniki, Greece. The views expressed in the dissertation are those of the author entirely and no endorsement of these views is implied by the said University or its staff.

This work has not been submitted either in whole or in part, for any other degree at this or any other university.

Marinos Kanellakis

26<sup>th</sup> of September, 2011

# Abstract

This dissertation was written as a part of the MSc in Energy Systems at the International Hellenic University. It summarizes the energy policy of the European Union and the renewable energy penetration progress.

The introduction helps us understand the importance of the policies and how challenging is the task to shift from a fossil fuel-based energy mix to renewable energy-based one. The second chapter summarizes the most important implemented energy policies classified into eight broad categories. It gives an overall picture of the EU's energy policy and the framework of the Renewable Energy penetration development. In the third chapter the progress of renewable energy penetration in the EU is presented through statistics and graphs, showing the effects of implemented policies. Finally, in the fourth chapter, an elementary approach of the future penetration of renewable energy in the final energy mix is presented. After the implementation and comparison of five regression specifications, the one selected was used for long-run forecast up to 2020.

Also I would like to thank my supervisor Dr. Theodoros Zachariadis, as well as Dr. Georgios Martinopoulos and Dr. Theologos Dergiades for giving me valuable guidance.

Kanellakis Marinos

26<sup>th</sup> of September, 2011

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## Abbreviations

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ACER	Agency for the Cooperation of Energy Regulators
AEEP	Africa-Europe Energy Partnership
AR	Autoregressive
BASREC	Baltic Sea Region Energy Cooperation
CCS	Carbon Capture & Storage
CFSP	Common Foreign and Security Policy
CHP	Combined Heat & Power
CIP	Competitiveness and Innovation Program
CIS	Commonwealth of Independent States
COR	Committee of the Regions
DG	Directorate General
DSO	Distribution System Operator
EC	European Commission
ECCP	European Climate Change Program
ECEEE	European Council for an Energy Efficient Economy
ECSC	European Coal and Steel Community
EEA	European Environment Agency
EEC	European Economic Community
EERA	European Energy Research Alliance
EMAS	Eco-Management and Audit Scheme
EMC	Electromagnetic Compatibility
ENTSO	European Network of Transmission System Operators
EP	European Parliament
EPBD	Energy Performance of Buildings Directive
ESC	European Economic and Social Committee
ESD	European Savings Directive
ESTIF	European Solar Thermal Industry Federation
ETP	Energy Technology Platform
ETS	Emissions Trading Scheme
EU	European Union
EU-15	Germany, Italy, France, Belgium, Luxembourg, Netherlands (1951); Denmark, United Kingdom, Ireland (1973); Greece (1981); Spain, Portugal (1986); Austria, Finland, Sweden (1995)
EU-25	EU-15 plus Czech Republic, Cyprus, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovenia and Slovakia (2004)
EU-27	EU-25 plus Romania and Bulgaria (2007)
FP	Framework Program
FP7	Seventh Framework Program (2007-2013)
GDP	Gross Domestic Product
GHG	Greenhouse Gases
GWP	Global Warming Potential
IEA	International Energy Association



ISO	Independent System Operator
ITER	International Thermonuclear Experimental Reactor
ITO	Independent Transmission Operator
ITRE	Committee on Industry, Research and Energy
JTI	Joint Technology Initiatives
LCP	Large Combustion Plant
LNG	Liquid Natural Gas
NAP	National Allocation Plan
NEEAP	National Energy Efficiency Action Plan
NGO	Non-Governmental Organisation
NPP	Nuclear Power Plant
NREAP	National Renewable Energy Plan
OECD	Organisation for Economic Co-operation and Development
OLS	Ordinary Least Squares
OU	Ownership Unbundling
PSO	Public Service Obligation
PV	Photovoltaic
R&D	Research & Development
RD&D	Research Development & Demonstration
RE	Renewable Energy
RE-GO	Renewable Energy Guarantees of Origin
RES	Renewable Energy Sources
RES-E	Renewable Energy Sources for Electricity
RES-H	Renewable Energy Sources for Heating & Cooling
RES-T	Renewable Energy Sources for Transport
RFCS	Research Fund for Coal and Steel
ROC	Renewable Obligation Certificates
SETIS	Strategic Energy Technologies Information System
SET-Plan	Strategic Energy Technology Plan
SME	Small Medium Enterprise
SRA	Strategic Research Agenda
TEN-E	Trans-European Energy Networks
TPA	Third Party Access
TSO	Transmission System Operator
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
VAT	Value Added Tax
VIU	Vertical Integrated Undertaking



# 1

## Introduction

The EU and the world are at a cross-road concerning the future of energy. Climate change, increasing dependence on oil and other fossil fuel, growing imports, and rising energy costs are making our societies and economies vulnerable. These challenges call for a comprehensive and ambitious response.

In the complex picture of energy policy, the renewable energy sector is the one energy sector which stands out in terms of ability to reduce greenhouse gas emissions and pollution, exploit local and decentralized energy sources, and stimulate world-class high-tech industries. The EU has compelling reasons for setting up an enabling framework to promote renewables. They are largely indigenous, they do not rely on uncertain projections on the future availability of fuels, and their predominantly decentralized nature makes our societies less vulnerable. It is thus undisputed that renewable energies constitute a key element of a sustainable future.

Significant developments have taken place in European energy policy since 2000, driven by increasing concern about global warming, and the effect of rapidly increasing energy prices on competitiveness and security of supply in EU. The European Commission has risen to the challenges, proposing a range of policies to address them. While there have been concerns, for example by some member states regarding some of the policies, overall the proposals by the European Commission are sound. They correctly reflect the energy challenges faced by the world today, and their implementation will bring global benefits.

In particular, the Commission's goals in the field of energy and environment are highly ambitious, but pursuing them will be necessary not only to ensure the EU contribution to the mitigation of climate change, but also to send a global signal that meaningful action can and ought to be taken now. To ensure that the very ambitious targets are being achieved in a balanced manner, it will be necessary to ensure regular reviews and constant tracking of the implementation of the whole policy package.

## 1.1. A World Energy Review

As is evident from the Figure 1.1 the total energy consumption increases at a rate of 2,28% annually over the last 25 years. Pace has accelerated after 2002 mainly due to the high growth rate of the Chinese economy. 2009 was the only year in recent history that negative growth was observed but in 2010 rebounded strongly with an increase of 5,6%, the largest increase in percentage since 1973. Chinese energy consumption grew by 11,2%, and China surpassed the US as the world's largest energy consumer with a global energy share of 20,3%. Energy consumption grew by 6,7% in Japan, 4% in Europe and 3,7% in the United States.

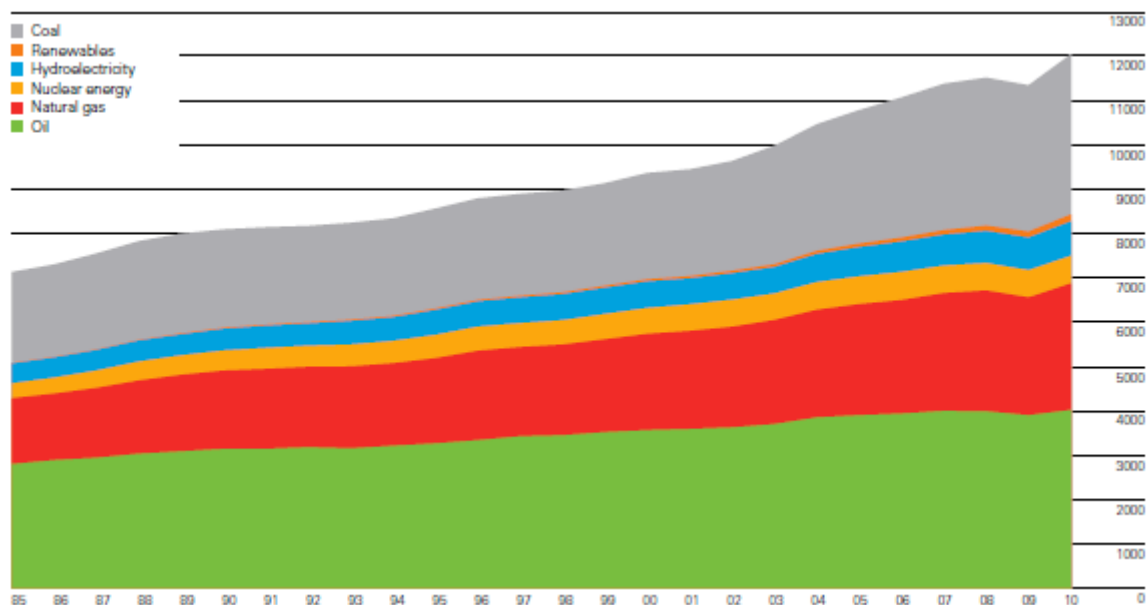


Figure 1.1. World primary energy consumption by fuel (Mtoe) [6].

All forms of energy grew strongly, with *growth in fossil fuels suggesting that global CO<sub>2</sub> emissions (Figure 1.2) from energy use grew at the fastest rate since 1969* and we can estimate that fossil fuels still account about 80% of the global fuel mix.

Oil remains the world's leading fuel, at 33,6% of global energy consumption, but it continued to lose market share for the 11th consecutive year. After falling for two consecutive years, global oil consumption grew by 2,7 million barrels per day (b/d), or 3,1%, to reach a record level of 87,4 million b/d. This was the largest percentage increase since 2004 but still the weakest global growth rate among fossil fuels.

World natural gas consumption grew by 7,4%, the most rapid increase since 1984. Consumption growth was above average in all regions except the Middle East. The US had the world's largest increase in consumption (in volumetric terms), rising by 5,6% and to a new record high. Russia and China also registered large increases – the largest volumetric increases in the country's history in each case. Consumption in other Asian countries also grew rapidly (+10,7%), led by a 21,5% increase in India.

Coal consumption grew by 7,6% in 2010, the fastest global growth since 2003. Coal now accounts for 29,6% of global energy consumption, up from 25,6% 10 years ago. Chinese consumption grew by 10,1%; China last year consumed 48,2% of the world's coal and accounted for nearly two-thirds of global consumption growth. But consumption growth was

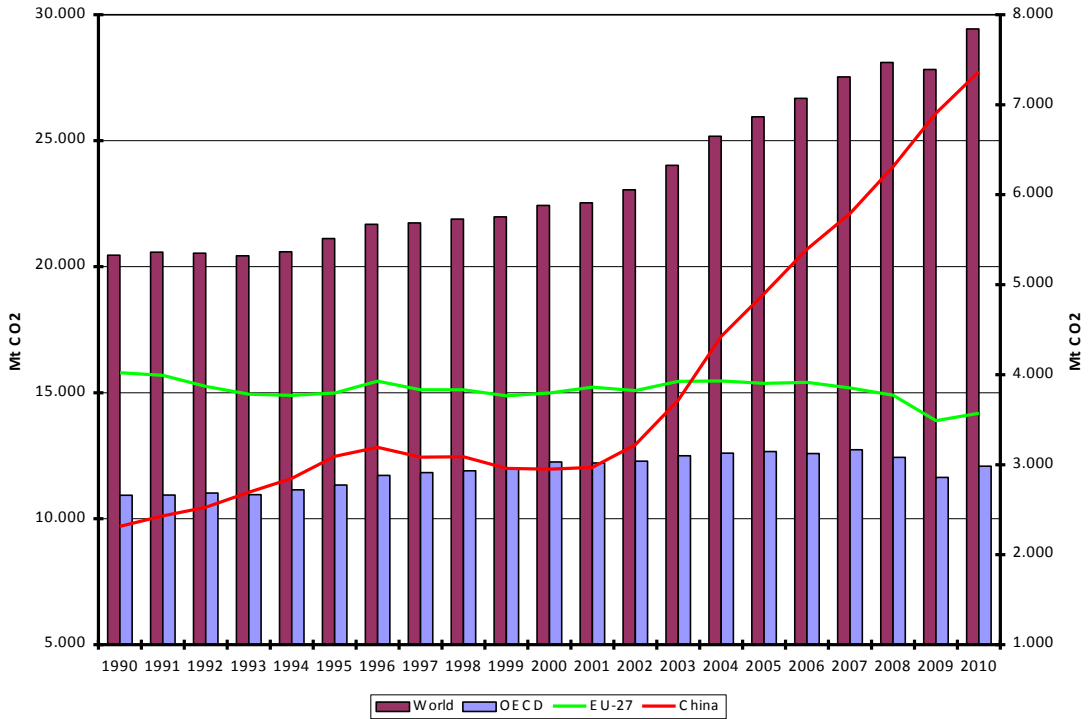
robust elsewhere as well: OECD consumption grew by 5,2%, the strongest growth since 1979, with strong growth in all regions.

Global hydroelectric and nuclear output each saw the strongest increases since 2004. Hydroelectric output grew by 5,3%, with China accounting for more than 60% of global growth due to a combination of new capacity and wet weather. Worldwide nuclear output grew by 2%, with three-quarters of the increase coming from OECD countries. French nuclear output rose by 4,4%, accounting for the largest volumetric increase in the world.

Other renewable energy sources continued to grow rapidly. Global biofuels production in 2010 grew by 13,8% constituting one of the largest sources of liquids production growth in the world. RE used in power generation grew by 15,5%, driven by continued robust growth in wind energy (+22,7%). The increase in wind energy in turn was driven by China and the US, which together accounted for nearly 70% of global growth. These forms of RE accounted for 1,8% of global energy consumption, up from 0,6% in 2000 [6].

Consistent with the surge in energy consumption, CO<sub>2</sub> emissions from fuel combustion boomed by 6% in 2010 and exceeded their 2009 levels by 30%.

Emissions from OECD countries represented 41% of the world emissions, but increased at a slower pace than the world average (3,8%). In the United States, emissions rose faster than in Europe (4% vs. around 3% on average in Europe), while Japan experienced a surge in its emissions (+7,6%) after a severe drop in 2009. In 2010, US emissions are 12% above their 1990 levels.



**Figure 1.2.** CO<sub>2</sub> emissions from fuel combustion (reference approach).  
**Data Source:** [7]

In Asia, CO<sub>2</sub> emissions grew dramatically due to economic growth and the fossil-based energy mix. China, the world’s largest emitter (35% more than the US), posted a 6,7% increase in its emissions and has a growing share of world emissions (25% in 2010). CO<sub>2</sub> emissions also increased sharply in other large emitters among emerging countries, such as India (+5%) and Russia (+11%).

Energy consumption mix is different around the world (Figure 1.3). It varies greatly depending on the primary energy reserves available in each region as well as political decisions on the use of nuclear energy. China's growth is fuelled by coal in the extraordinary percentage of about 70% while Middle East uses its own oil and natural gas. By far the best diversified fuel mix is that of the EU and all its energy policies aim at much greater improvement.

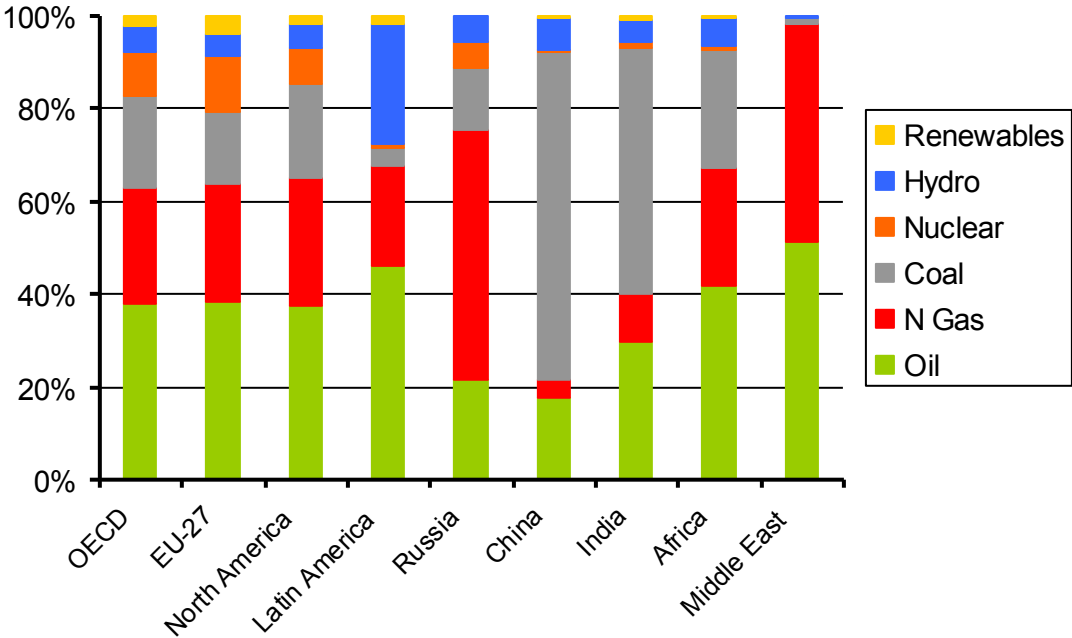


Figure 1.3. Primary energy consumption mix for 2010.  
Data Source: [6]

Economic recovery has led to an increase in total energy consumption per unit of GDP (energy intensity), for the first time in more than 20 years (+ 0,5%), thanks to more developed countries (Figure 1.4). The highest increase in energy intensity was in the European Union (+2,5% compared to -1,7% on average before the crisis). This poor performance was mainly due to the industrial sector, where energy consumption did not decrease at the same pace as the value added.

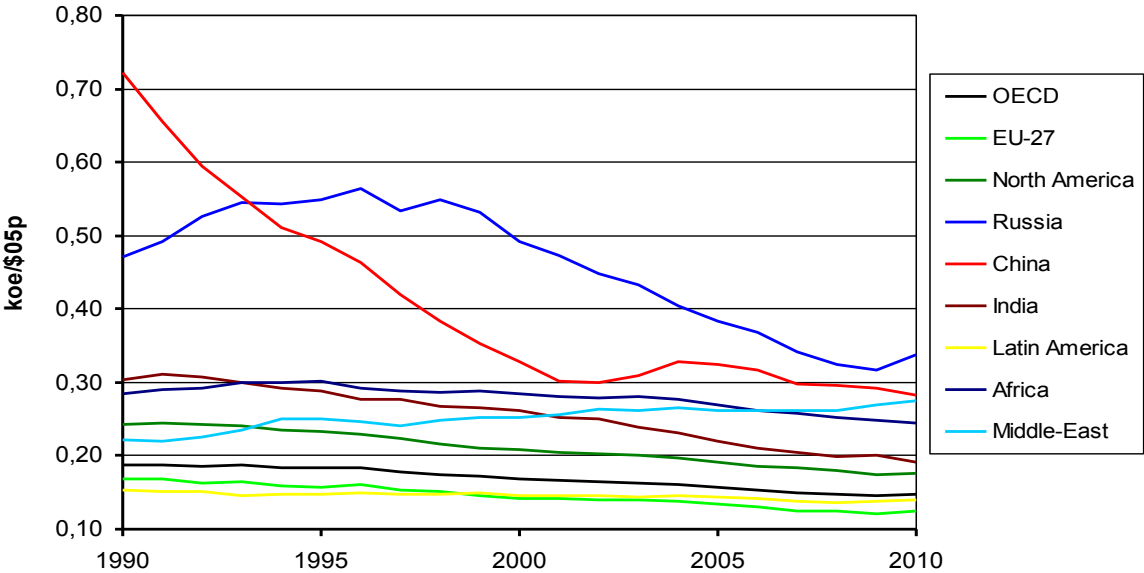


Figure 1.4. Energy intensity of GDP at purchasing power parities.  
Data Source: [7]

Energy intensity differs depending on world regions. It is three times higher in CIS than in European countries. India is on a par with world average, with energy intensity levels 60% higher than in Europe. High energy intensity in the CIS, Middle East, China and other Asian developing countries is mainly explained by the predominance of energy-intensive industries and low energy prices.

However what we have mentioned up to now are mere numbers and technical terminology that shows only one dimension of energy. Energy is not just fuels, power plants and the end-use technologies. Energy has socio-economic dimensions and also fits into a broader social context. It is important to recognize the major economic and social trends occurring worldwide such as increasing globalization, urbanization, population growth, energy sector privatization and rapid technological innovation [1]. All of these trends influence energy strategies and policies and should be taken into account by policymakers.

**Increasing Globalization.** Although globalization is not benefiting all nations and regions, it is a fact that trade barriers are falling and world trade is growing. The global economy is becoming more integrated through mergers and acquisitions, joint ventures, the telecommunication revolutions and the expansion of multinational companies. Multinational companies are playing an increasing role in fossil fuel production and distribution, ownership of gas and electric utilities and manufacturing RE technologies. As companies and markets become increasingly international so too policy interventions through coordinated action and policy harmonization.

**Restructuring & Privatization.** Many nations are privatizing formerly government-owned utilities, petroleum and natural gas companies and other institutions. This is being done ostensibly to reduce inefficiency and attract private capital to the energy sector. At the same time efforts are being made to increase the transparency of policymaking, reduce government subsidies and liberalization of energy markets. Successful policies must engage the private sector and catalyze private investment in the desired technologies on a large scale. However restructuring and privatization do not guarantee that investments in new energy supplies will occur, that efficiency and energy services will be improved or that costs will be reduced. Power shortages and cost increases, for example, have occurred in developing countries such as Brazil and India following electric sector restructuring and privatization.

**Rapid Technological Innovation.** Technological innovation is accelerating and affecting every sector of our daily life. Penetration of these end-use technologies affects energy use both directly, through improved appliance and process controls and the use of electricity by electronic devices, and indirectly through structural changes that save energy. Rapid technological evolution is also occurring in energy sector (production, conversion and end-use). However the scope of these innovations is not equally shared with a growing technology gap between rich and poor nations, as well as between richer and poorer segments of some nations.

**Urbanization.** The rapid urbanization of the world's population over the twentieth century is described in the 2005 Revision of the UN World Urbanization Prospects report. The global proportion of urban population rose dramatically from 13% (220 million) in 1900, to 29% (732 million) in 1950, to 49% (3,2 billion) in 2005. The same report projected that the figure is likely to rise to 60% (4,9 billion) by 2030.

The proliferation of giant cities like Tokyo, Seoul, Mexico City, New York, Mumbai etc. presents special challenges related to transport, air quality, provision of basic services and employment. As urbanization accelerates, energy use in urban areas increases rapidly. On the other hand urbanization can facilitate the dissemination of new energy technologies and presents the opportunity to design more efficient and sustainable habitats and transport systems as cities expand.

**Population Growth & Standards of Living.** For several years population has been increasing faster than many vital non renewable and renewable resources. This means that the amount of these resources per person is declining in spite of the contribution of modern technology. World population at the start of 2010 was over 6,8 billion people. It has doubled in the past 45 years and it is increasing by over 140 people every minute [8]. While populations of some industrialized countries have stabilized, over 3 billion people live or struggle to exist in countries where population is still growing rapidly with doubling times of less than thirty years. Another issue that comes up with this growth is the quality of life which is high in the developed countries and low in developing ones. Since the developing countries like India and China wants to reach the standards of living of the developed world this means that energy policies must be sophisticated enough to provide practical solutions for a sustainable future.

## *1.2. Sustainability*

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Sustainable energy development should provide adequate energy services for satisfying basic human needs, improving social welfare and achieving economic development throughout the world while it does not endanger the quality of life of both current and future generations and does not threaten critical ecosystems (definition according to H. Rogner and A. Popescu).

So, as discussed in previous paragraphs, current energy sources and patterns of energy use are unsustainable. Continuing to consume even greater amounts of fossil fuels will cause too much damage to the environment, risk unprecedented climate change and rapidly deplete petroleum resources. Current trends in energy supply and demand will also exacerbate inequity and tensions among nations, tensions that fuel regional conflict and outbursts. A high growth, fossil fuel-intensive energy future presents a variety of problems and challenges for humanity. These problems and challenges are the answer to the question why we need Renewable Energy Sources (RES) [4]:

- **Climate Change**

In the debate over climate change and its origin three facts seem incontrovertible:

- i) the earth's climate is changing and generally warming
- ii) the concentration of CO<sub>2</sub> in the atmosphere has risen steadily since the Industrial Revolution when fossil fuels started to be burned in large quantities and
- iii) CO<sub>2</sub> is a greenhouse gas that absorbs infrared radiation reflected from the ground and prevents it escape into space. Most authorities link these three facts and conclude that CO<sub>2</sub> derived from fossil fuels is largely responsible for the observed global warming.

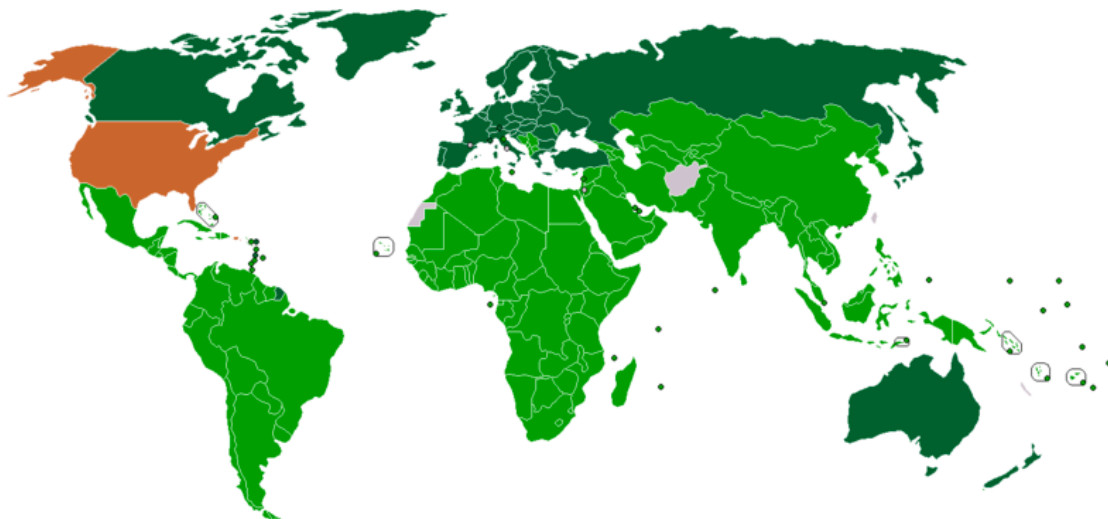
The factors that control climate are very complex and only partly understood. CO<sub>2</sub> is released in vast quantities from natural processes and balanced by a similar quantity taken up by photosynthesis and re-absorption in the oceans. By comparison anthropogenic releases of CO<sub>2</sub> from combustion processes are small. With extensive deforestation taking place, however, one of the principal sinks for CO<sub>2</sub> is being removed and this is compounding the effect of burning fossil fuels. Independent analyses have shown a net increase in atmospheric carbon. Carbon dioxide (GWP=1) is not the only greenhouse gas. There are others like Nitrous oxide with GWP of 310, Methane with GWP of 21, HFCs with GWP of 100-3.000, PFCs with GWP of 5.000-10.000 and Sulfur hexafluoride with GWP of 23.000.

Despite the complications arising from natural phenomena, the evidence that greenhouse gases are largely responsible for climate change is growing even stronger. The global



temperature is increasing while data that demonstrate the concentration of CO<sub>2</sub> in air has increased from ~270ppm before the Industrial Revolution to 393ppm today (June 2011) [3]. A recent conference of climate scientists concluded that the world should be aiming to keep the concentration of CO<sub>2</sub> below 400ppm to avoid serious climatic consequences and potential long term problems that would lead to catastrophic positive feedbacks. Its concentration is predicted to rise to 700ppm or even higher by the end of this century with clearly catastrophic consequences.

The first tentative steps to combat global warming were taken at the UNFCCC that was held in Kyoto in December 1997. The resulting Kyoto Protocol called for the industrialized nations to reduce their emissions by at least 5% below baseline 1990 levels by 2008-12 and got into force in February 2005. Obviously is too early to gauge the extent to which the Kyoto Protocol may be proved to be successful but it should be acknowledged that the initiative is only a first small step towards carbon free energy.



**Figure 1.5.** Kyoto Protocol participation map 2010 (Green-countries that have ratified the treaty; Dark green-Annex I and II countries that have ratified; Grey-not yet decided; Brown-no intention of ratifying) [18].

- **Atmospheric Pollution**

Since the 1960s there has been a marked increase in road traffic worldwide. At first this gave rise to serious air pollution called photochemical smog, especially in sunny climates where photochemical reactions among the automotive exhaust gases led to the formation of this kind of smog. Cities like Los Angeles, Athens and Tokyo experienced this severe pollution. This problem was partially solved with catalytic converters and over the years legislation on the transport sector has almost solved it.

Except road vehicles, ships and trains are subject to less legislation and frequently emit visible plumes of particulate pollution along with gases. Industries that are heavy users of energy and therefore potential polluters are iron and steel, cement manufacture, paper and board and especially power station. Coal burning power stations emit sulfur dioxide, which arises from the sulfur contained in the coal, and also nitrogen oxides produced during combustion. It is these gases that give rise to acid rain which is detrimental to the natural habitat. Technologies exist for the suppression of these acid gases but are not yet universally employed. In some countries power stations are licensed as to the quantity of the sulfur dioxide that they may discharge which encourages them to burn low sulfur coal.

The march of technology has made major inroads into solving the problems of air pollution in the more advanced countries while the legislation is often less strict and power station technology less sophisticated in developing nations. Nevertheless modern technology will be employed as these countries' economies become more affluent. Although air pollution is not

nearly as severe a problem as it once was, a transition to RE use would improve matters further [4].

- **Inequity**

Energy consumption, like income, is distributed very inequitably around the world. Per capita energy consumption of commercial fuels and electricity is growing more rapidly in developing countries but the OECD nations still consume many times more commercial energy per capita than developing nations. There are also substantial disparities in energy use within countries, both in industrialized and developing, with wealthier households to consume much more energy than poorer households.

In 2009 more than 1,4 billion people globally lacked access to electricity, 85% of them in rural areas, and the number of people relying on traditional biomass for cooking was estimated to be around 2,7 billion. Given this inequitable distribution of commercial energy consumption, it is not surprising that greenhouse gas emissions and contribution to global warming are highly skewed as well [9].

- **Source Depletion & Security of Supply**

The total primary energy consumption throughout the world has increased from about 6.000 Mtoe in 1973 to more than 12.000 Mtoe in 2011, a *100% rise in 37 years* and is projected by the IEA to reach 16.500 Mtoe by 2030. This increase is a result of growth in world population and a general rise in prosperity. There is a well established link between the GDP of a nation and its energy consumption, although nations are now trying hard to break this link.

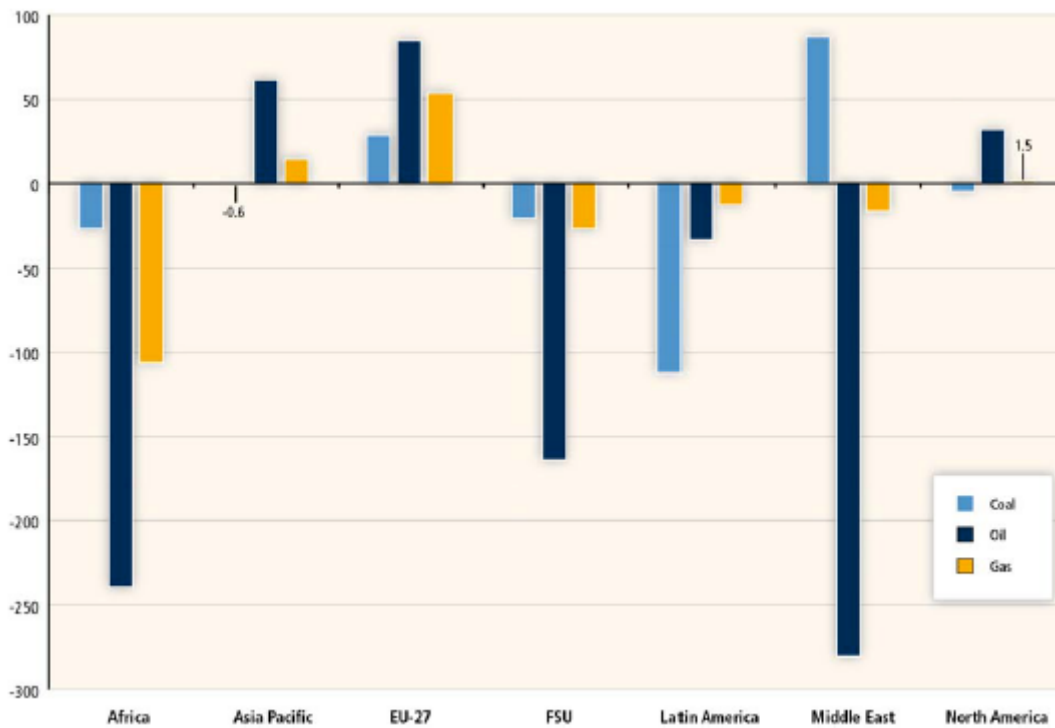
In looking ahead to 2030, it is predicted that the percentage of the world energy market supplied by fossil fuels will not change greatly compared with today's supply. So, gas will rise, coal and oil will decline slightly and nuclear will fall as old nuclear stations are retired and not replaced.

Many geologists and petroleum engineers are of the opinion that the earth's ultimate reserves of petroleum are around  $2 \cdot 10^{12}$  barrels, of which over 40% has been used already. The concept of reserves is open to debate and some authorities opt for  $3 \cdot 10^{12}$  barrels. Nevertheless, it is claimed that over 90% of the available oil has been discovered and mapped. Some important oil producing regions (e.g. USA, North Sea) have passed their peak production rates and are in decline while others are expected to peak within 10 years. Moreover the rate at which oil is being pumped greatly exceeds the rate at which new reserves are found. Even when new oilfields have been identified, substantial investment of time and money is required, particularly off shore in deep water with high risk for accidents and oil spills [4].

It is important to distinguish between reserves in place and excess production capacity available at short notice. Among the major producing countries, only Saudi Arabia has excess capacity that could be brought into use quickly. Elsewhere the exploitation of fresh reserves will require substantial investment and concerns has been expressed that the necessary capital may not be available. If these developments are not serious enough an even more alarming fact is that over 60% of conventional oil is concentrated in just five Middle Eastern countries: Saudi Arabia, Iraq, Iran, Kuwait and United Arab Emirates. New oil fields will no doubt be discovered but are unlikely to compare in size with those of Middle East and will not change significantly the overall picture.

The requirement for petroleum will doubtless intensify as developing countries aspire to Western style mobility. Present indications suggest that there will be growing competition for oil-not in the distant future but within the next two decades when world production peaks and starts to decline. This has been dubbed "The Big Rollover". From that point on there will be oil shortages and a new political dynamic in which countries compete for limited supplies. Unless there is a widespread acceptance of this disturbing prospect and an urgent response, just five Arab countries with probably Canada and Venezuela will effectively control the supply of

petroleum. Among oil-importing nations, notably USA, Japan and EU, there is a real cause for concern over adequate supplies will be available.



**Figure 1.6.** Energy imports as the share of total primary energy consumption (%) for coal (hard coal & lignite), crude oil and natural gas in 2008. Negative values denote net exporters of energy carriers [2].

It is difficult to guess what the response will be from the oil-rich countries to this developing situation. They may decide to restrict production for political reasons, to extend the life of their reserves or to force up the price of oil products. Rather than falling back to lower levels it is widely forecast that, in the medium term, oil prices will continue to spiral upwards. So, for all these reasons countries strive to be self sufficient in energy and tend to favor the use of any indigenous resources that they may have.

A sustainable energy future is possible through much greater energy efficiency and much greater reliance on RES compared to current energy patterns and trends. Greater energy efficiency would reduce growth in energy consumption, decrease investment requirements and improve energy services in poorer households and nations. Shifting from fossil fuels to RES in the coming decades would address all the problems associated with a business as usual energy future.

### 1.3. Barriers to RE Use

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According to many studies RES could provide all of the energy consumed in the world. The theoretical potential of RE is much greater than all of the energy that is used by all the economies on Earth. The challenge is to capture it and utilize it to provide desired energy services in a cost-effective manner. Compared, for example, with the worldwide primary energy supply of 2008 (492 EJ, IEA 2010), bioenergy could provide 3,1 times more,

hydropower 0,3, ocean energy 15, wind energy 12, solar energy 7.900 and geothermal energy 2,8 times more [2].

The question that comes up is that, since RES can be the sustainable solution of the world's energy problem why their penetration is at such a low level.

A wide range of barriers limit the introduction and deployment of RE technologies throughout the world. The significance of the different barriers varies among sectors, institutions and regions. Some of the barriers will shrink as energy efficiency and RE technologies (see Appendix A1) advance and gain market share, but others are likely to persist unless directly confronted through policy interventions.

Some are technical in nature, some related to human behavior, others are due to flaws in the ways markets operate and others related to public policies and institutions. Taken as a whole these barriers are inhibiting the transition to a more sustainable energy future. It is important to understand the nature and scope of these barriers before considering the policies and programs for removing or overcoming them.

### **Limited Supply Infrastructure**

The physical system for transporting energy from where it is produced to where it is used is often unable to integrate sources of renewable energy for which it was not originally designed. Much of the world's electricity systems were not designed around harvesting renewable energy resources such as solar or wind, and often significant investments in modernization and expansion of the available infrastructure are necessary to connect these new resources. For example, for low penetration levels (up to 20%) of wind power in a system, system operation will hardly be affected. The established control methods and system reserves available for dealing with variable demand and supply are more than adequate for dealing with the additional variability at wind energy penetration, depending on the nature of a specific system. For higher penetration levels, some changes to systems and their method of operation may be required to accommodate the further integration of wind energy, but as mentioned before this means capital intensive investments.

Although production of RE technologies is increasing rapidly, it is still not large enough to achieve significant economies of scale and drive down production costs. With limited production and sales, marketing and transaction costs can be high and as long as prices are high, demand will remain limited. Also RE technologies can be costly in countries where they are not yet manufactured relative to locally produced energy sources.

Small scale RE technologies such as solar heating and electricity systems or larger scale wind and biomass conversion technologies may not be available in some countries. The demand for RE technologies may be too low or too diffuse to justify local production, import or marketing. This creates a vicious cycle –private firms are reluctant to enter the RE business in new regions where the technology is not yet established and the market never gets established without the presence of equipment suppliers.

### **Quality Problems**

It is important to select systems of adequate quality and systems that are following a defined standard. They must be long lasting, user friendly and repairable by local technicians. Also the warranty of components and overall system must be considered. Standards don't always exist for system components something that has led to significant variation in quality between apparently similar devices with a major impact on the energy output.

Energy quality issues also come from the nature of the RES. The output of a PV system for example depends on the solar intensity and cloud cover which means that it depends on weather conditions, time of the day and day of the year. In the same way the inconstant wind speed and direction affects the output of a wind turbine.

The impacts of the above mentioned quality problems can be voltage dips and swells, short or long interruptions, harmonics, surges and transients, flicker, unbalance and EMC problems. So we end up having important wastage costs due to poor power quality.

### **Insufficient Information & Training**

Smooth market function requires low-cost access to good information and the requisite skills for all concerned. However, in specific markets, skilled personnel who can install, operate and maintain RE technologies may not exist in large numbers. Project developers may lack sufficient technical, financial and business development skills. Consumers, managers, engineers, architects, lenders or planners may lack information about RE technology characteristics, economic and financial costs and benefits, geographical resources, operating experience, maintenance requirements, sources of finance and installation services. The lack of skills and information may increase perceived uncertainties and interfere with decision making.

### **Lack of Money or Financing**

Renewables developers and customers may have difficulty obtaining financing at rates as low as may be available for conventional energy facilities. In addition to having higher transaction costs, financial institutions are generally unfamiliar with the new technologies and likely to perceive them as risky, so that they may lend money at higher rates. High financing costs are especially significant to the competitive position of renewables, since renewables generally require higher initial investments than fossil fuel plants, even though they have lower operating costs. A study by the Lawrence Berkeley Laboratory found that financing costs can greatly affect the price and competitiveness of wind energy, since most of the cost is in capital and little is in operation. The access to credit is especially problematic in rural areas of developing countries where poorer households lack acceptable collateral.

### **Pricing & Tax Barriers**

RE measures can be disadvantaged if the price for conventional energy sources is subsidized or structured so that it is not based on actual costs. Energy prices rarely reflect the full costs to society associated with conventional energy production and use, including social and environmental costs. Likewise buyback rates offered by utilities may not reflect all the benefits of renewables-for example the value of supply diversification, increased system reliability, peak demand reduction etc. These pricing distortions make it difficult for RES to compete with conventional energy sources.

Tax policies can discourage the adoption of capital intensive renewable technologies. This is the case when businesses are allowed to deduct fuel purchases from revenues when calculating income taxes but must depreciate RE devices over many years. Some countries subject imported RE technologies or components such as PV cells and wind turbines to high import duties, thereby driving up their cost. Also renewables can be discouraged by the tax breaks such as “depletion allowances” provided to conventional fossil energy resources.

### **Legal & Regulatory Barriers**

In many countries, power utilities still control a monopoly on electricity production and distribution. In the absence of a legal framework, independent power producers may not be able to invest in RE facilities and sell power to the utility or to third parties under so called ‘power purchase agreements’. Utilities may negotiate power purchase agreements on an individual ad hoc basis, making it difficult for project developers to plan and finance projects on the basis of known and consistent rules. Also utilities may not allow favorable transmission access to RE producers, or may charge high prices for transmission access. Transmission access is necessary because some RE resources, like windy sites and biomass fuels, may be located far from population centers. Transmission or distribution access is also necessary for direct third-party sales between the RE producer and a final consumer. New transmission

access to remote RE sites may be blocked by transmission access rulings or right of way disputes.

Restrictions on siting and construction are also common. Wind turbines, rooftop solar hot water heaters, PV installations and biomass combustion facilities may all encounter building restrictions based upon height, aesthetics, noise or safety, particularly in urban areas. Wind turbines have faced specific environmental concerns related to siting along migratory bird paths and coastal areas. Urban planning departments or building inspectors may be unfamiliar with RE technologies and may not have established procedures for dealing with siting and permitting. Competition for land use with agricultural, recreational, scenic or development interests can also occur.

### **Political Obstacles**

Many governments favor conventional fossil fuel sources and electric generation technologies over RE technologies due to tradition, familiarity, the size, economic strength and political clout of the conventional energy industries. In the case of developing countries other key institutions such as multilateral development banks have resisted lending for RE projects due to their small size, complexity, high perceived risk, and other factors.

Vested interests can exert pressure in the political arena to block the adoption of policies favorable to RES. Electric utilities, fossil fuel producers and vendors of conventional energy technologies often oppose financial incentives or market reserves for renewables.

In the US for example, most electric utilities oppose market reserves for renewable electricity and are preventing the adoption of such reserves in many states. Also oil companies oppose and are preventing the adoption of market reserves for renewable based fuels. RE industries are relatively immature and much less influential in the political arena than conventional energy suppliers.

### **Public Reception**

Despite the fact that the great majority of people support the RE technologies, many of them are opposed to their installation when it comes for their region, making the RE project developers face the so called *Not in My Back Yard (NIMBY)* problem. The most common fears that the locals provide are the visual impact, noise nuisance and interference in electromagnetic waves. They believe that these impacts will drive down their property values and will have a negative effect on tourism. However surveys show that these fears get eliminated as the years passing by and everyone gets more and more familiar with the RE technologies.

Some of the barriers listed above inhibit off-grid applications while others apply more to grid connected. Also we all understand that for some countries they might seem minor problems that can be faced while in poor and developing ones might take years to be overcome. However without targeted policy initiatives to overcome these barriers, RES in all likelihood will remain niche technologies that contribute relatively little to worldwide energy supply in the next few decades.

## **1.4. Policy Options**

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In order to overcome the previously mentioned barriers we need to implement different types of policies by also having in mind the economic and social context of energy. The policy initiatives are needed to increase the availability and deployment of renewable energy use and can be grouped into the following 13 categories:

**Research Development & Demonstration.** Government or private funded RD&D can be an important policy for advancing energy efficiency and renewable energy technologies. RD&D tends to be more effective when it involves collaboration between research institutes and the private sector, when it is coordinated with other policies such as financial incentives, market reserves or regulations and when it focuses on a broad range of designs. RD&D on clean energy technologies merits expansion. In addition, greater international collaboration in RD&D on clean energy technologies, including collaboration between industrialized and developing nations, could provide a number of benefits including cost and risk sharing, more rapid learning and faster deployment of clean energy technologies worldwide.

**Financing.** Financing can help increase the adoption of energy efficiency and renewable energy technologies, especially in developing countries. Financing schemes should be designed to support energy efficiency and renewable energy businesses, minimize transaction cost, support high quality products and work through established financing channels such as commercial banks. Financing without subsidies can be a viable long-term policy, but lower income groups in all likelihood will need subsidies to afford clean energy technology. Financing is most effective in combination with other policies such as financial incentives and the creation of marketing, delivery and service infrastructure.

**Financial Incentives.** Financial incentives provided by governments or utilities can be an effective tool for stimulating the adoption of energy efficiency and renewable energy technologies. Incentives should reward energy savings or renewable energy output rather than reward investment, be sustained over many years in order to build up markets and drive down costs and phase out gradually as costs drop and other barriers are removed. Financial incentives can also be used to stimulate commercialization and initial markets for innovative technologies. In designing incentive programs for developing countries, it is important to support rather than hinder local manufacturing and marketing of energy efficiency and renewable energy measures.

**Pricing.** Taxing fossil fuels based on their social and environmental costs can increase energy efficiency, reduce energy consumption and encourage introduction of renewable energy sources. Taxing the carbon content of fossil fuels can be an effective policy if the tax is large enough and a portion of the revenues is used for incentives for energy efficiency and renewable technologies. It is also important to reduce or eliminate subsidies on conventional energy sources in ways that don't harm low income consumers. Paying avoided costs or retail prices for renewable energy or cogenerate power supply to the electric grid can support the adoption of these technologies. Finally, differential taxes based on the relative energy efficiency of different products or activities is a promising but underutilized energy policy.

**Voluntary Agreements.** Voluntary agreements between government and the private sector can be an effective policy in RES deployment and increasing energy efficiency. Voluntary agreements tend to work best when industries fear they will face taxes or regulations if meaningful energy efficiency and use targets are not established and met, when thorough monitoring and evaluation take place and when companies that achieve significant results are recognized.

**Regulations.** Regulations can have the form of laws or codes & standards set in order to provide a framework which will help towards a target. This target can be RE use, energy efficiency measures, mitigation of environmental impacts of energy use etc. Regulatory oversight on the energy sector not only shows the way but also protects and manages the interests of all stakeholders with an aim to safe and sustainable growth of the sector. Also regulations are adapted and get improved all the time in order to fulfill their target more accurately and quickly.

**Information Dissemination & Training.** Information and training can help address some of the barriers limiting the adoption of RES. Training can be valuable for ensuring that RE technologies are installed and used properly. Information dissemination and promotion can increase the awareness and adoption of RE measures. They tend to be more effective when they are targeted to decision makers at time that technologies enter the market and when combined with other policies such as financing incentives and regulations.

**Procurement.** Government led procurement can help to commercialize and build markets for innovative energy efficiency and RE technologies. It has been used mainly for energy efficiency measures so far but gradually governments purchase significant amounts of RE technologies and green power. Government procurement should be carried out in ways that support the development of viable markets for these technologies over the long run.

**Market Reforms.** Utility sector privatization and increased competition can lead to efficiency improvements and emissions reduction in the supply of electricity. Utility sector restructuring can advance end-use energy efficiency, RE development and increased access to electricity supply with specific policies adopted to address these needs. Such policies include RE obligations, encouraging marketing of green power, rate discounts for low income households and small surcharges on retail electricity service to fund clean energy activities. In addition interconnection and cooperation among energy markets of different countries are two promising strategies to provide better services and improve the security of supply.

**Market Obligations.** Market obligations can result in substantial acquisition of RES or energy efficiency measures. In particular renewable portfolio standards are expanding renewable energy implementation in the electricity sector in countries around the world. RE acquisition is done on a competitive basis, thereby driving down the cost of renewable electricity sources. Market obligations can also be used to stimulate the development and commercialization of innovative vehicle technologies or renewable fuels. Likewise emissions cap and trading schemes can help to stimulate energy efficiency improvements and RE development if these policies are carefully designed.

**Capacity Building.** Capacity building is critical for implementing clean energy technologies on a large scale. All countries need energy efficiency and RE centers and programs at national and local levels. Capacity building is also needed to staff and train private companies that manufacture, market and trade these technologies. Capacity building should be given greater priority in energy assistance projects for developing and transition countries.

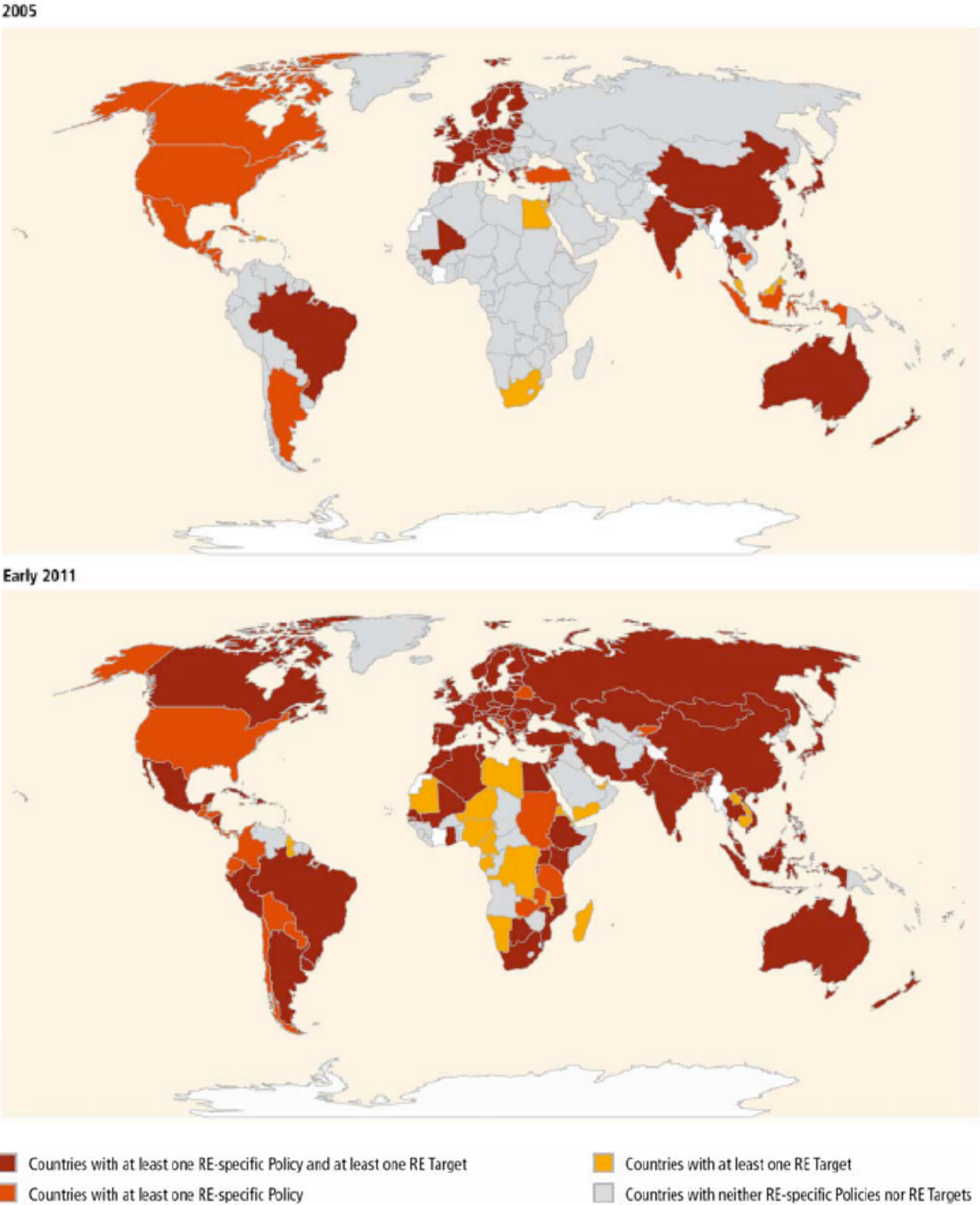
**Planning Techniques.** Careful energy and transportation planning can help nations, regions and cities move towards a more sustainable future. Integrated resource planning helps to define the optimal set of demand side and supply side investments for meeting future energy service needs. It can include environmental considerations and it usually leads to increased energy efficiency and RE use measures. Integrated land use and transport planning helps to expand public transportation systems, locate new housing and commercial development near public transport facilities and reduce urban sprawl. Doing so can cut fuel use and provide other benefits.

**Supporting Tools.** Supporting tools are not exactly policy options but they play a major role in the policy implementation. Supporting tools can be programs or entities established in order to supervise the progress of implemented policies and help all the stakeholders involved in the energy market. This can be done through coordination of efforts or/and financial support provided with an aim to assure a sustainable sector growth and a smooth transition towards new circumstances.



In recent years an increasing number and variety of RE policies have driven substantial growth in RE technologies something that has led to significant rise in the level of investment since 2004/5.

Until the early 1990s, few countries had enacted policies to promote RE. Since then, and particularly since the early-to mid-2000s, policies have begun to emerge in a growing number of countries at the municipal, state/provincial and national levels, as well as internationally.



**Figure 1.7.** Countries with at least one RE target and/or at least one RE-specific policy. This figure includes only national-level targets and policies (not municipal or state/provincial) and is not necessarily all-inclusive [2].

Initially, most policies adopted were in developed countries, but an increasing number of developing countries have enacted policy frameworks at various levels of government to promote RE since the late 1990s and early 2000s. Of those countries with RE electricity policies by early 2010, approximately half were developing countries from every region of the world.

Most countries with RE policies have more than one type of mechanism in place, and many existing policies and targets have been strengthened over time. Beyond national policies, the number of international policies and partnerships is increasing. Several hundred city and local governments around the world have also established goals or enacted renewable promotion policies and other mechanisms to spur local RE deployment.

The focus of RE policies is shifting from a concentration almost entirely on electricity to include the heating/cooling and transportation sectors. These trends are matched by increasing success in the development of a range of RE technologies and their manufacture and implementation as well as by a rapid increase in annual investment in RE and a diversification of financing institutions, particularly since 2004/5.

According to The Global Trends in RE Investment 2011 report which was prepared for the UN by Bloomberg New Energy Finance, global investment in renewable energy sources grew by 32% during 2010 to reach a record level of US\$211bn (see Appendix A2). The main growth drivers were backing for wind farms in China and rooftop solar panels in Europe. Also developing nations invested more in green power than rich nations for the first time last year.

## 1.5. The Role of Policies

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The success of policy instruments is determined by how well they are able to achieve various objectives or criteria. The main criteria are [2]:

**Effectiveness:** the extent to which intended objectives are met, for instance the actual increase in the amount of RE electricity generated or share of RE in total energy supply within a specified time period.

Beyond quantitative targets, factors may include achieved degrees of technological diversity (promotion of different RE technologies), which is considered a crucial factor for dynamic effectiveness (long-term sustained growth that enables innovation and the development of a manufacturing base), or of spatial diversity (geographical distribution of RE supplies).

**Efficiency:** the ratio of outcomes to inputs, or RE targets realized on economic resources spent, mostly measured at one point in time (*static efficiency*); also called cost effectiveness. *Dynamic efficiency* adds a future time dimension by including how much technology development and innovation is triggered by the policy instrument. Reducing the risks to investors is crucial for minimizing costs of financing, which in turn reduces project costs.

**Equity:** the incidence and distributional consequences of a policy, including dimensions such as fairness, justice and respect for the rights of indigenous peoples. Equity can be assessed, in part, by looking at the *distribution* of costs and benefits of a policy and/or by evaluating the extent to which it allows the *participation* of a wide range of different stakeholders (e.g., equal rights to independent power producers and to incumbent utilities).

**Institutional feasibility:** the extent to which a policy instrument is likely to be viewed as legitimate, gain acceptance, and be adopted and implemented. Institutional feasibility is high when policies are well adapted to existing institutional constraints.

Economists traditionally evaluate instruments for environmental policy under ideal theoretical conditions; however, those conditions are rarely met in practice, and instrument design and implementation must take political realities into account.

In reality, policy choices must be both acceptable to a wide range of stakeholders and supported by institutions. In market economies, instruments need to be compatible with markets. An important dimension of institutional feasibility addresses the ability to implement policies once they have been designed and adopted.

Other criteria are also examined in the literature, including subcategories of the four set out above. But most literature focuses on effectiveness and efficiency of policies, which are therefore the main criteria that serve as the basis of evaluation, however, criteria for judging how well policies work will depend on the policy goals of the jurisdiction that enacts and implements those policies.

The role of different policies combined with their success is important for a particular technology to make its way through the market [1]. Certain policies such as research and development, financial incentives and procurement initiatives are most appropriate for stimulating commercialization and initial markets for new technologies. Other policies such as financing, voluntary agreements and information dissemination are used to accelerate adoption once a technology is established in the marketplace. Policies such as regulations and market obligations are often used to maximize market share or complete the market transformation process. However these are general rules and thus there are exceptions.

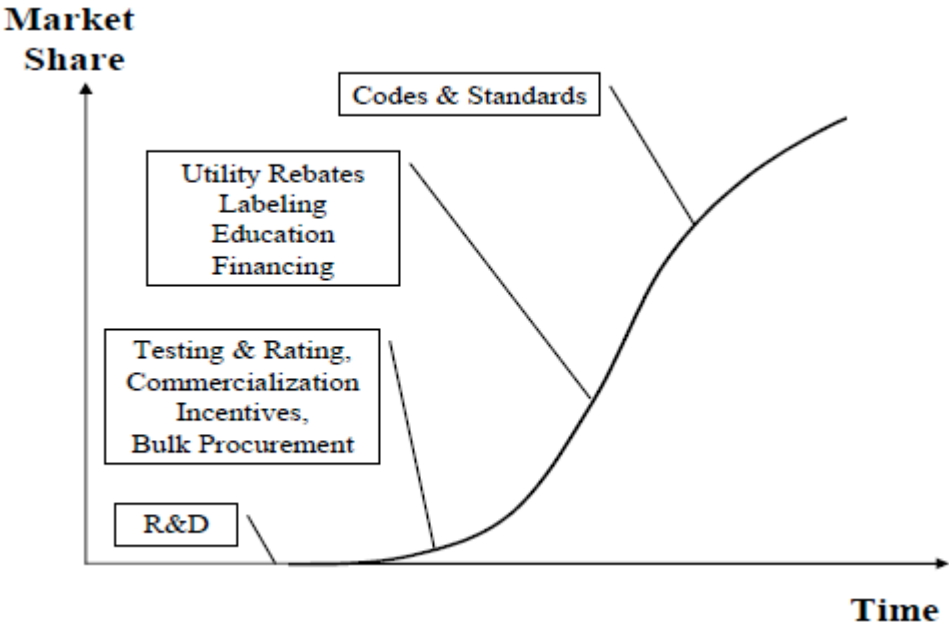


Figure 1.8. Role of policies in new technology’s market share through time [1].

An integrated approach to market transformation often consist of a combination of “technology push” through RD&D, “demand pull” through financial incentives, education and training, procurement or market obligations and “market conversion” through codes and standards. In addition some actions such as energy pricing reforms, capacity building and planning techniques can facilitate the effective implementation of other more focused policies. An integrated approach can also account for and address the multiple barriers that are likely to exist in any country or locale.

The appropriate mix of policies in any particular situation depends on technological attributes, the barriers that exist and market conditions. This conceptual framework is sometimes referred to as the “innovation system”. The innovation system consists of a wide range of factors including the knowledge base, the prices and relative performance of competing technologies, the behavior of different actors in the marketplace, the networks among these actors, institutions that can foster or impede innovation and the cultural context. In some cases it is possible to advance RE technologies through existing innovation systems while in other cases the barriers are too great and it is necessary to create new ones [1].

If decision makers intend to increase the share of RE and, at the same time, to meet ambitious climate mitigation targets, then long-standing commitments and flexibility to learn from experience will be critical. Some analyses conclude that large, low-carbon facilities such as nuclear power, or large coal (and natural gas) plants with CCS can be scaled up rapidly enough to meet CO<sub>2</sub> reduction goals if they are available. Alternatively, the expansion of natural gas fired turbines during the past few decades in North America and Europe, and the rapid growth in wind and solar technologies for electric power generation demonstrate that modularity and more widely distributed smaller-scale units can also scale rapidly to meet large-scale energy demands. The technological and economic potential for each of these approaches and their costs have important implications for the scale and role of RE in addressing climate change. To achieve GHG concentration stabilization levels that incorporate high shares of RE, a structural shift in today’s energy systems will be required over the next few decades. Such a transition to low-carbon energy differs from previous ones (e.g., from wood to coal, or coal to oil) because the available time span is restricted to a few decades, and because RE must develop and integrate into a system constructed in the context of an existing energy structure that is very different from what might be required under higher penetration RE futures [5].

A structural shift towards a world energy system that is mainly based on renewable energy might begin with a prominent role for energy efficiency in combination with RE; policies that extend beyond R&D to support technology deployment; the creation of an enabling environment that includes education and awareness raising; and the systematic development of integrative policies with broader sectors, including agriculture, transportation, water management and urban planning. The appropriate and reliable mix of instruments is even more important where energy infrastructure is not yet developed and energy demand is expected to increase significantly in the future.

# 2

## EU Energy Policy

Energy policy came to the fore in Europe with the oil crisis of the 1970s. Before this time most Western European Governments were engaged in nuclear power development. In some countries Governments also involved themselves in the supply of oil, coal and/or natural gas. Renewable energy sources, with the exception of hydropower in countries having significant hydropower potential, attracted very little interest. Starting in the '70s, this has changed. Nowadays, there are considerable concerns in Europe over security of energy supply, environmental issues, competitiveness of the European economies, and regional development.

In December 1995, the European Commission issued the white paper, "An Energy Policy for the European Union". In issuing the paper, the Commission established an official basis on which to build a common, community-wide energy policy. In the Commission's view, a common energy policy will further economic integration within the EU and contribute to the realisation of a single European market. According to the white paper, energy policy must form part of the general aims of the EU's economic policy, which focuses on market integration and deregulation, aiming to minimise its policy interventions. An EU energy policy would aim to enhance European economic competitiveness and supply security, and contribute to the achievement of the EU's broader policy goals relating to job creation and environmental protection.

EU's energy policy aims at addressing growing environmental concerns associated with the energy sector, such as global climate change, and to transform this growing concern for sustainability into opportunities for global economic and technological leadership. This overarching goal is supported by activities in three main energy policy areas market liberalisation, energy security, and protection of the environment and climate.

**Market Liberalisation:** One of the most important energy and economic policy goals of the European Commission is the creation of a single, integrated European energy market. Currently, each of the EU's 27 Member States is at a different point on the path to the liberalisation of its energy industries, and each state has a unique set of energy institutions and regulatory structures. The Commission aims to further each of its three main energy policy concerns, competitiveness, supply security and environmental protection, through the creation of trans-European energy networks. A key action facilitating the development of these networks will be the Community-wide reduction of existing regulatory barriers and the introduction of competition in the energy industries, especially gas and electricity.

**Security of energy supply:** Ensuring energy supply security is a second key objective of EU energy policy. The EU is currently approaching 55% (2008) import dependence, and this trend appears likely to continue for the foreseeable future. The EU is also seeking to enhance its energy security through a variety of policy actions aimed at diversifying both Europe's internal fuel mix and its external sources of energy supply. The Commission considers all major fuel types (fossil, nuclear, renewable) and energy efficiency important elements of long-term energy security and is encouraging Member States to maintain a broad portfolio of energy supply options and to ensure that there is a broad internal energy resource base.

**Protection of the environment & climate:** The third major objective of EU energy policy is environmental protection. The Commission believes that the goals of greater economic competitiveness and environmental protection are not necessarily in conflict, and that policies that move the industry to invest in new, cleaner, and less energy-intensive technologies (principally in the energy efficiency and renewable areas) will prove an advantage rather than a penalty to European firms in the long term [5].

## 2.1. Institutions

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The European Union (EU) is a political and economic community with supranational and intergovernmental features. It is more than just a federation of countries, but not a federal state. It is a new type of structure that does not fall into any traditional legal category. Its political system is historically unique and has been constantly evolving over more than 50 years. It is now composed of twenty-seven member states, with about 500 million inhabitants, and a GDP of € 12,28 trillion in 2010 according to Eurostat.

The origin of the European Union (as it is known today) was the European Coal and Steel Community (ECSC), founded in 1951 by the Federal Republic of Germany, France, Italy and the Benelux countries (Belgium, the Netherlands and Luxembourg), which expired in 2002. These six countries formed the European Economic Community (EEC) through the Treaty of Rome, which was signed in 1957 and took effect on 1 January 1958. They also formed the European Atomic Energy Community (Euratom), which continues to exist alongside the EU. The name of the EEC was changed to the European Community (EC) under the Maastricht Treaty in 1992, which also included the *Treaty on the European Union* (EC Treaty).

There have been seven waves of enlargement since the original six created the EEC: In 1973, Denmark, Ireland and the United Kingdom; in 1981, Greece; in 1986, Portugal and Spain; in 1995, Austria, Finland and Sweden; in 2004, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, the Slovak Republic and Slovenia; and in 2007, Bulgaria and Romania. All member states of the European Union are democratically governed, with a wide variety of structures, ranging from highly federalised states to constitutional monarchies.

The key to decision-making in the EU is to find sufficient consensus among the *European Commission*, the *Council* (in which all member states are represented), the *European Parliament (EP)*, and local authorities and social partners, which are represented at EU level through the *European Committee of the Regions (COR)*, and the *European Economic and Social Committee (ESC)*. For this process the roles of the various institutions are all clearly defined in the European Treaties and in European case law [5].

Most decisions in energy policy are therefore taken in a *co-decision process* (Figure 2.1) (Article 251 of the EC Treaty) by the Council (ministers from the 27 member states) and the EP. The final legislation is a text agreed in this way, which might be quite different from the original Commission proposal.

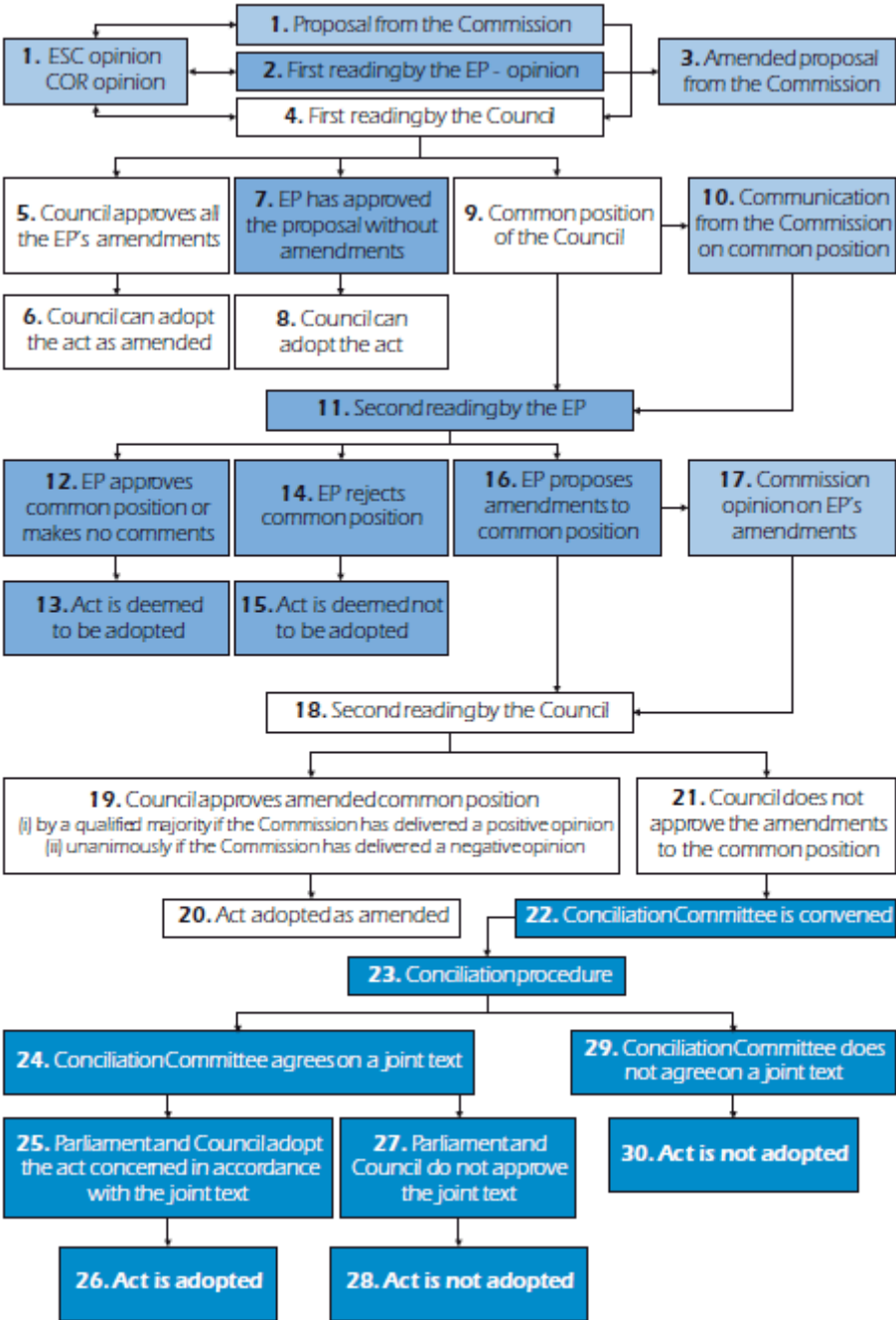


Figure 2.1. Structure of the Co-Decision process [5].

In the Common Foreign and Security Policy, decisions are taken by the European Council and the Council of Ministers. The EP is kept informed and is consulted on the broad orientations and choices. The Commission may make proposals, but does not have exclusive competence. Increasingly, and in line with changes in the Lisbon Treaty, the European Council (heads of state and government of member states and the Commission president) is involved in the wider energy policy development. At successive summits, notably in March 2006, March 2007 and March 2008, the European Council has been moving towards increasingly detailed indications of what Europe's energy policy should be, based largely on proposals from the European Commission. This confirms the growing relevance of energy policy to wider strategic considerations.

The **European Commission** is the executive body responsible for the policy development and administration of the European Union. It is the third part of the institutional triangle that manages and runs the EU, together with the Council of Ministers and the European Parliament. As the EU's executive arm, the Commission implements the decisions taken jointly by the European Council and Parliament, and it has wide powers to manage EU common policies, such as research and technology, overseas aid, regional development. It also manages the budget for these policies. Its members are appointed for a five-year term by agreement between the member states, each of which has the right to propose one Commissioner. Their appointment is subject to approval by the European Parliament. The Commission is also answerable to the Parliament for its actions. As "Guardian of the Treaties", it has to ensure that the regulations and directives adopted by the Council and Parliament are being implemented in all the member states. If they are not, the Commission takes the offending party to the European Court of Justice to oblige it to comply with EU law. An important principle is that the Commission is independent of member state, industrial or financial interests.

In all areas of EU competence, the Commission has exclusive power to propose legislative measures – an important right of initiative. However, it usually only makes proposals following widespread consultations with interested parties, such as social or economic stakeholders, citizens, or pressure groups. Accordingly, the Commission also has a role in assembling and analysing information on market developments, public opinion and strategic considerations with a view to better defining new policy proposals. It also has the task of ensuring that member states apply EU legislation. This helps ensure that all member states implement policies in a timely fashion and in a climate of openness and solidarity. Therefore, compliance monitoring, review and follow-up of member states are key activities of the Commission.

The European Commission is organised in Directorates-General. The most important of these in the area of energy policy are:

- **DG Energy (ENER)** which is the lead DG responsible for energy policy making.
- **DG Mobility & Transport (MOVE)** responsible for transport policy.
- **DG Competition (COMP)**, the Union's competition watchdog.
- **DG Environment (ENV)** which is responsible for environmental legislation such as pollution control and emissions trading.
- **DG Enterprise & Industry (ENTR)** which is responsible, among others, for the Sustainable Industrial Policy, the Lisbon Strategy on growth and jobs, and the analysis of the effects of energy and environmental policy on industry.
- **DG External Relations (RELEX)** which is now merged into the European External Action Service (**EEAS**) and is responsible for the relations with countries outside the EU.
- **DG Research & Innovation (RTD)** which is responsible for energy research, jointly with DG-ENER & DG-MOVE.
- **DG Trade (TRADE)** which is responsible for the EU's trade policy.
- **The Joint Research Centre (JRC).**



**Eurostat** is the statistical service responsible for producing energy statistics and outlooks. It is part of the European Commission.

The **Euratom Treaty** creates a specific framework and decision-making process for nuclear energy, defining specific tasks and powers of the Euratom Community. Although the European Parliament does not have the same formal powers as under the EC Treaty, the Commission consults the European Parliament on legislative proposals within the scope of the Euratom Treaty. This difference could be reduced within the projected Lisbon Reform Treaty (12th Protocol modifying the Euratom Treaty). The Euratom Supply Agency is responsible for monitoring the uranium supply situation in the EU. It is independent and only administratively overseen by DG-EN.

The **European Environment Agency** (EEA) is working for the EU in data collection and distribution in the area of environmental protection. It is responsible for preparing reports to the UNFCCC, and assists the Commission with information in the preparation of environmental and energy regulation. The Commission is a member of the EEA executive board [5].

## 2.2. Energy Policy Development

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EU policy development follows important political principles expounded in the Treaties and political statements, notably:

- *Subsidiarity*: in the EU context, this means taking EU action where it adds value, and leaving alone matters best done at national level.
- *Proportionality*: not going beyond what is necessary to achieve the objectives.
- *Better regulation*: avoiding burdensome legislation, consulting widely on all proposals, and assessing the full impact of proposals before they are made, is a principle which has a prominent place in the Lisbon Reform Agenda for Growth and Jobs and is also an important guide.

The aim is to ensure that policies are developed in the most democratic, representative, transparent and consensual way possible with clear justifications and balanced assessment of options. All legislative proposals are accompanied by “impact assessments” which outline the advantages/benefits and drawbacks/costs of different policy actions, and justify the course taken in the proposed policy.

Reflecting these requirements, new energy policy proposals are prepared on the basis of wide stakeholder consultations, including national authorities, regional bodies, industrial associations, individual companies, consumers and their associations and non-governmental organisations (NGOs). A number of consultation groups also exist, including the Madrid and Florence Forums (for gas and electricity markets, respectively), the Gas Coordination Group, the Oil Supply Group, the Amsterdam (Sustainable Energy) Forum, the Berlin (Fossil Fuels) Forum and the Prague/Bratislava (Nuclear) Forum. Internet consultations may also take place, while *Eurobarometers* and other surveys are also used. This means that proposals made by the European Commission have already been largely tested for their relevance, appropriateness and timeliness. Significant consultations undertaken by the Commission however also take place when required or on an informal level. Independent studies may also be commissioned into specific issues in order to help develop and implement policy initiatives.

Consultations also take place within and between the different EU institutions. Within the European Commission, Inter-Service Groups and formalised Inter-Service Consultations (involving representatives of all interested Directorates-General) smooth the preparation of new initiatives. There is also close contact between the European Commission and the European Parliament committees, specifically for energy with the ITRE and Environment (ENVI) Committees as well as the temporary Climate Change (CLIM) Committee. Together with member states, the Council's Energy Working Group provides the framework for examining the Commission's proposals. Informal co-ordination is carried out by the regular meetings of the Energy Directors-General group of the Commission, although this is not an institutional body.

The Commission's role as watchdog is important to ensure the implementation of policy across the EU. At the same time, national regulatory authorities (set up under relevant directives) also have a role in ensuring that national legislation applying EU rules is properly implemented in the member states.

The Council of Ministers, comprising members of national governments, together with the European Parliament, whose members are directly elected by EU citizens, are, broadly speaking, the bodies which jointly take legally binding decisions in the EU (though the Commission has sometimes delegated powers to act autonomously). The European Economic and Social Committee (ESC) and the Committee of the Regions (COR) are also consulted, and give their opinions on policy statements/proposals. Under the Lisbon Treaty, national parliaments will have a stronger role. This ensures full democratic oversight.

Acknowledging the sensitivities regarding some aspects of energy policy in member states, EU energy policy actions have respected, and will continue to respect, two principles:

- Member States are ultimately responsible for their national energy mix.
- Indigenous energy resources are a national, not European, resource.

Notwithstanding this, member states have in the past accepted legally binding, although non-enforceable EU targets for specific energy sources, such as renewables, and are negotiating legally binding, enforceable, national targets within the framework of the draft Renewables Directive. Importantly, the EU has for more than a decade agreed legal provisions for the opening-up of energy networks within the internal energy market and encouraging cross-border collaboration, interconnection and energy flows.

The EU has also developed an external energy policy, acting in areas of its own competence, such as economic, technical and financial co-operation, with agreements covering trade, investment, infrastructure development and so on (e.g. Energy Community Treaty, Energy Charter Treaty), etc. Energy issues also come up in the framework of political co-operation under the EU's Common Foreign and Security Policy (Title V, Treaty on European Union). While the CFSP is somewhat involved, most of the Commission's external competence derives from the EC Treaty.

Energy policy developments at EU level have gained momentum in 2005 when a new political will emerged among member states to work together more closely in energy matters and to strengthen the common policy in certain fields. This was first expressed at the G8 Summit at Gleneagles in July 2005 in an action plan covering climate change, clean energy and sustainable development, and this theme was taken up during the UK presidency of the EU in the second half of 2005. The next major step was taken at the Hampton Court informal summit of EU leaders in October 2005, when heads of EU states and governments called on the Commission to urgently set out how the EU could work together in energy matters. Climate change, international geopolitics and the establishment of the internal energy market were important drivers of these political changes [5].

## 2.3. Legal Basis & Legislative Framework

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All EU energy legislation is based on the EU Treaties (including Euratom), since the creation of the Union. A European coal policy existed under the European Coal and Steel Community (ECSC) from 1952 until 2002, when the ECSC expired. In nuclear policy, the EU has a clear remit only through the Euratom Treaty of 1957.

Because there is currently no specific article on energy in the currently ratified EU Treaties, energy-related legislation has so far been introduced under the following legal basis:

- Environment (Art 175);
- Approximation of laws (Art 81-97);
- Trans-European networks (Art 154);
- Difficulties in the supply of products (Art 100);
- Research (Art 166); and
- External relations (various articles in the treaties).

European legislation can be divided into three forms:

**Directives** are directly binding on Member States, but often flexible to take into account different national and administrative traditions. This implies States have discretion to decide how they align legal and administrative systems. Directives can contain requirements that take into account the specific conditions of a Member State. Provisions requiring Member States to gather information and report do not have to be transposed into binding national legislation. The term framework directives are used for directives setting out general principles, procedures and requirements for legislation in different sectors.

**Regulations** are directly binding on Member States and superior to any conflicting national law. They are not transposed into national law since they are to be applied directly by national courts and national administrative body. This form is usually used when a unified system is needed; the purpose is precise, as are the requirements to the Member States.

**Decisions** are individual legislative acts directly binding for the parties to whom they are addressed. They are usually very specific in their scope and can be used for specifying detailed administrative requirements or update technical aspects of regulations or directives.

Important role on policy making and law development play the green and white papers issued as official documents by the Commission:

A **green paper** is a discussion document intended to stimulate debate and launch a process of consultation, at European level, on a particular topic. A green paper usually presents a range of ideas and is meant to invite interested individuals or organizations to contribute views and information. It may be followed by a white paper, an official set of proposals that is used as a vehicle for their development into law [18].

The **white paper** is an authoritative report or guide that helps solve a problem. White papers are used to educate readers and help people make decisions and are often requested and used in politics, policy, business, and technical fields. Policy makers frequently request white papers from universities or academic personnel to assist policy developers with expert opinions or relevant research [18].

## 2.4. Renewable Energy

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Back in 1986 a Council resolution highlighted the promotion of renewable energy as one of the Community's energy objectives. Efforts concentrated on R&D programmes and the European Parliament continuously argued for an action plan to promote renewable energy. In the Commission White Paper from 1995 *"An Energy Policy for the European Union"* the three main objectives for the Community energy policy were identified: improved competitiveness, security of supply and protection of the environment. Renewable energy was recognised as a factor to help achieve these objectives and a strategy for renewable energy was proposed and cited in the indicative work programme attached to the White Paper (European Commission, 1997:6). Finally, in 1997 the White Paper *"Energy for the Future - Renewable Energy Sources of Energy - White Paper for a Community Strategy and Action Plan"* came. This Community strategy confirms an indicative target of a 12% share of renewable energy sources in total final energy consumption by 2010.

Besides the RE White Paper, main drivers behind Community initiatives on renewable energy are the energy strategy set in the *"Green Paper Towards a European Strategy for the security of energy supply"* (2000) and the climate change strategy set in the *"European Climate Change Programme"* (2000).

At the end of 2001 the *Directive on the Promotion of the Electricity Produced from Renewable Energy* was adopted. In accordance with the White Paper, the overall indicative target of this directive was to increase, by 2010, the share of renewable energy in final energy consumption to 12%. An indicative target was set for the electricity to 22,1% of total EU-15 gross consumption from renewable energy sources in 2010 (2001/77/EC: art. 3.4). In the Accession Treaty, published April 2003, national targets were adopted for the new Member States. The total renewable electricity target for EU-25 was 21% of overall electricity consumption by 2010. To reach this goal the directive set *indicative targets* for the share of renewable electricity production per EU Member State.

Not before 2003 was the Directive *"on the promotion of biofuels or other renewable fuels for transport"* (2003/30/EC) adopted. The Directive stipulated that Member States should set national indicative targets to raise the share of biofuels in their transport fuel market. These should be based on the reference values of an increase to 2% by 2005 and 5,75% by 2010 of the share of biofuels in diesel and petrol for transport purposes calculated on the basis of energy content.

In March 2007, the heads of states and governments of the 27 EU member states adopted a binding target of 20% renewable energy from final energy consumption by 2020. Combined with the commitment to increase energy efficiency by 20% until 2020 and to reduce greenhouse gas emissions by at least 20% within the same period (or respectively 30% in case of a new international agreement), Europe's political leaders paved the way for a more sustainable energy future for the European Union and for future generations. In January 2008, the European Commission presented a draft directive on the promotion of the use of energy from Renewable Energy Sources (RES) which contains a series of elements to create the necessary legislative framework for making 20% renewable energy become a reality. The Directive sets the legislative framework that should ensure the increase of the 8,5% renewable energy share of final energy consumption in 2005 to 20% in 2020 and, if properly transposed into national law, will become the most ambitious piece of legislation on renewable energy in the world. The RES Directive (DIRECTIVE 2009/28/EC) (EC, 2009) was approved by the European Parliament in December 2008, by the Council at the end of March 2009, published in the Official Journal in June 2009 and will then need to be transposed in national law [5].

The implemented policies on renewable energy use are:

### **1. National Targets**

Up to Directive 2009/28 the targets set were indicative. For each member state there were indicative targets for RES-E share (Directive 2001/77/EC) and a 5,75% share of biofuels and other renewable fuels in transport for all member states (Directive 2003/30/EC) for 2010.

Today there are *binding national targets* for renewable energy shares of final energy consumption in 2020, (including a 10% renewables in transport target for all member states): these are calculated on the basis of the 2005 share of each country plus both a flat rate increase of 5,5% per member state as well as a GDP-weighted additional increase to come up with the numbers as outlined in the table in the Directive 2009/28/EC. Furthermore, the new directive closed the legislative gap for the heating and cooling sector which is expected to grow rapidly in the next decade.

Also interim targets per country are set for 2011/12, 2013/14, 2015/16 and 2017/18 as a percentage share of their 2020 target. These interim targets are crucial for monitoring the progress of renewable energy development in a member state, although they are, unfortunately, only of indicative nature.

### **2. National Renewable Energy Action Plans (NREAPs)**

NREAPs (introduced with the Directive 2009/28/EC) are considered crucial towards the 2020 mandatory targets and they must be adopted by all Member States. They set out their targets for the shares of energy from renewable sources in transport, electricity, and heating and cooling in 2020 and adequate measures to achieve these targets. Member states should notify their national action plans to the Commission for examination by June 2010 at the latest.

These plans should provide for two things: to give member states the flexibility to decide for themselves how they want to meet their national targets, but at the same time to create investor security and help to mobilize private capital by setting clear goals and mechanisms on the national level. National action plans should include detailed mandatory outlines and targets for the different renewable energy sectors (heating/cooling, electricity and transport fuels), which show the way ahead on the national level. In addition, support measures to meet the national targets must be outlined.

### **3. Renewable Energy Guarantees of Origin (RE-GO)**

RE-GO were introduced in the EU with the first renewables directive (2001/77/EC). Under the directive, member states had to establish a system under which RE-GOs were to be issued to all producers of renewable electricity, where is required to prove the share or quantity of energy from renewable sources in their energy mix, on request by a central body, from 23 October 2003. They are accompanied by a unique identification number. Some of the information specified in a RE-GO are the energy source from which the energy was produced, the start and end dates of production, whether it relates to: electricity or heating or cooling, the date and country of issue etc.

The expectation at the time of the introduction was that the establishment of the RE-GO system would eventually enable trade between member states and it was seen as necessary to facilitate trade and increase transparency for consumers. The directive did not require member states to accept RE-GOs purchased in another member state as counting towards the national indicative target, but it left open the possibility for any member state to allow this.

The option of trade of Guarantees of Origin between member states issues concerns about the risk of trade being detrimental to the development of renewables. The reasons for allowing restrictions in tradability of Guarantees of Origin are that:

- The development of higher-cost renewables would be stifled
- Trading RE-GOs and existing support systems in most member states may be incompatible

- Windfall profits may accrue to existing producers of (low-cost) RE because of the existence of considerable non-economic barriers, and governments may have less incentive to eliminate non-economic barriers to the large-scale diffusion of renewables.

The impact assessment estimates the costs of not allowing trading at up to € 8 billion per year by 2020 [5]. As a consequence of this cost assessment, the proposal includes the provision for trading Guarantees of Origin despite the risks outlined above, but in some instances restricts it to cases where the member states have achieved their interim targets and entered into a bilateral agreement enabling this trade, or allows member states to restrict it in order to give themselves control over the use of the renewables potential within their borders, to avoid the risks outlined above.

#### **4. Grid Priority Access & Operation**

Member States must take the appropriate steps to develop transmission and distribution grid infrastructure, intelligent networks, storage facilities and the electricity system, in order to allow the secure operation of the electricity system as it accommodates the further development of electricity production from RES.

Also it must be ensured that TSOs and DSOs guarantee the transmission and distribution of electricity produced from RES. Priority and guaranteed access to the grid must be provided by the TSOs; when dispatching electricity generating installations, they are to give priority to generating installations using RES in so far as the secure operation of the national electricity system permits, based on transparent and non-discriminatory criteria.

#### **5. Cooperation Mechanisms**

Cooperation mechanisms can be used by Member States in order to reach their targets.

Member States are allowed to make arrangements for the statistical transfer of a specified amount of energy from renewable sources from one Member State to another.

Two or more Member States are allowed to cooperate on all types of joint projects relating to the production of electricity, heating or cooling from renewable energy sources. That cooperation may involve private operators.

One or more Member States are allowed to cooperate with one or more third countries on all types of joint projects regarding the production of electricity from renewable energy sources. Such cooperation may involve private operators.

Two or more Member States are allowed to decide, on a voluntary basis, to join or partly coordinate their national support schemes. In such cases, a certain amount of energy from renewable sources produced in the territory of one participating Member State, may count towards the national overall target of another participating Member State, if the Member States make a statistical transfer of specified amounts of energy from RES from one to another or set up a distribution rule agreed by participating Member States that allocates amounts of energy from RES between them.

The basic idea of all the above mentioned mechanisms is to fulfil part of a Member State's RES target in another country by providing financial support, with the potential advantage of accessing cheaper RES-E and RES-H in other countries.

#### **6. Restrictions on Biofuels & Bioliquids**

The binding nature of the 10% target has triggered the very important debate on sustainability criteria and a certification scheme. This scheme will serve as an example for biofuels production standards globally. The industry is committed to strict but practical sustainability standards that apply for domestic production as well as imports that will eventually be applied to all energy sources be it biomass, food or fossil fuels.

Also GHG emissions from the use of biofuels and bioliquids must be calculated and expected to be lower than or equal to the emissions reported under the heading 'cultivation' in part D of Annex V of the Directive 2009/28/EC.

## 7. Support Schemes

The six main categories of support instruments are: feed-in tariff (FIT), feed-in premium (FIP), quota obligation (QO), investment grants (IG), tax exemptions (TE) & fiscal incentives (FI) [12].

EU-27	RES-E						RES-H			RES-T	
	FIT	FIP	QO	IG	TE	FI	IG	TE	FI	QO	TE
AT	X						X	X		X	X
BE	X		X	X	X		X	X			X
BG	X					X	X		X	X	
CY	X			X			X			X	X
CZ	X	X		X			X			X	X
DE	X					X	X		X	X	X
DK		X						X		X	X
EE	X	X				X	X		X		X
ES	X	X			X					X	X
FI				X	X		X			X	
FR	X						X	X	X	X	X
GR	X			X	X		X	X			X
HU	X			X			X				X
IE	X						X			X	X
IT	X		X					X			X
LT	X			X			X	X		X	X
LU	X			X			X			X	X
LV	X			X	X		X			X	X
MT	X			X		X	X				X
NL		X			X	X	X	X		X	
PL			X		X	X	X			X	X
PT	X						X		X	X	X
RO			X							X	X
SE			X		X		X	X			X
SI	X	X				X	X			X	X
SK	X				X		X			X	X
UK	X		X		X		X	X		X	X

Table 2.1. Main RES support schemes in EU-27 per sector [12].

**Feed-in tariff** is a fixed and guaranteed price paid to the eligible producers of electricity from renewable sources, for the power they feed into the grid. Feed-in tariff systems have been historically and currently still are the main instruments of support in the EU. They are used in the following Member States: France, Germany, Spain, Greece, Ireland, Luxembourg, Austria, Hungary, Portugal, Bulgaria, Cyprus, Malta, Lithuania, Latvia and Slovakia. Most countries use a differentiation according to technology, which facilitates the development of a range of technologies due to the different level of tariffs they receive. However, a few countries, including Cyprus and Estonia do not differentiate according to technologies and apply a common feed-in tariff for all technologies.

The advantage of tariffs, compared to feed-in premiums and quota obligations, lies in the long-term certainty of receiving a fixed level support, which lowers investment risks considerably. The costs of capital for RES investments observed in countries with established tariff systems have proven to be significantly lower than in countries with other instruments that involve higher risks of future returns on investments. Also, the weighted average costs of capital are notably higher in countries with quota obligations, compared to tariff-based systems. By guaranteeing the price and providing a secure demand, feed-in tariffs reduce both the price and market risks, and create certainty for the investor regarding the rate of return of a project. The lower cost for the investor result lower average support cost for society.

The cost-efficiency of tariffs for society decreases when policy makers overestimate the cost of producing renewable electricity. This is because the level of tariffs is based on future expectations of the generation cost of renewable electricity. When these turn out lower than

expected, producers receive a windfall profit. It is therefore important that tariffs are reviewed regularly in order to adjust the system to the latest available generation cost projections and to stimulate technology learning. Furthermore, payments should be guaranteed for a limited time period (approx. 15-20 years) that allows recovery of the investment, but avoids windfall profits over the lifetime of the plant.

In tariff systems, RES generators do not sell the produced electricity on the power market, but a single buyer, e.g. the TSO, fulfils this role. Therefore the producers are generally not stimulated to adjust their production according to the price signals on the market (i.e. electricity demand), unless this is provided by other means (e.g. peak/off-peak tariffs). This may be a disadvantage in terms of market compatibility.

In a **feed-in premium** system, a guaranteed premium is paid in addition to the income producers receive for the electricity from renewable sources that is being sold on the electricity market. Feed-in premium systems have gained ground over the last years and are used as main support instruments in Denmark and the Netherlands. In Spain, Czech Republic, Estonia and Slovenia premiums exist in parallel to the tariff system. These Member States have introduced the possibility to choose between feed-in tariffs and premiums for a selection of technologies. The flexibility and coverage of the systems differs from country to country.

Premium systems provide a secure additional return for producers, while exposing them to the electricity price risk. Compared to feed-in tariffs, premiums provide less certainty for investors and hence, imply higher risk premiums and total costs of capital. There are different design options for premium systems. Premiums that are linked to electricity price developments, e.g. limited by cap and floor prices, provide higher certainty and less risk of over-compensation than fixed premiums.

The level of premiums is based on future expectations regarding the generation costs of renewable electricity and the average electricity market revenues. Therefore premium systems also embody the risk of inducing additional costs for society and windfall profits for producers when production costs are over-estimated, or electricity prices and learning rates are underestimated by policy makers. Time limits and a regular review of cost projections and adjustment of premiums based on these projections is therefore also important in feed-in premium systems. Both Denmark and the Netherlands have applied such practices. Denmark has put a cap on the overall return for producers, thereby limiting societal costs. In the Netherlands the level of the premium is determined annually and an overall cap is set on the total cost of the support.

In premium systems, the renewable electricity producer participates in the wholesale electricity market. The advantage of premiums is therefore that producers of renewables are stimulated to adjust their production according to the price signals on the market (i.e. electricity demand), at least if they have fuel costs. This can be beneficial for power system operation.

**Quota obligations** have been introduced in Belgium, Italy, Sweden, UK, Poland and Romania. In countries with quota obligations, governments impose minimum shares of renewable electricity on suppliers (or consumers and producers) that increase over time. If obligations are not met, financial penalties are to be paid. Penalties are recycled back to suppliers in proportion to how much renewable electricity they have supplied. Obligations are combined with renewable obligation certificates (ROCs) that can be traded. Hence, ROCs provide support in addition to the electricity price and used as proof of compliance. A ROC represents the value of renewable electricity and facilitates trade in the green property of electricity. Quota obligations with certificates expose producers to market signals, which can be beneficial from a power system operation perspective.

Another related advantage of quota obligations compared to feed-in tariff and premium systems, is the fact that support is automatically phased out once the technology manages to compete. Tradable certificates represent the value of the renewable electricity at a certain time. When the costs of renewable technologies come down through learning, this is represented by the adjustment of the price of certificates. On the other hand, this might be a



challenge for plants already in operation that did not profit from this technological learning. Furthermore, certificate prices are volatile to other market influences (e.g. exercise of market power).

Uncertainty about the current and future price of certificates increases financial risks faced by developers. This uncertainty can have a negative impact on the willingness to invest. Because producers do not only sell their electricity on the market, but also their certificates, the risk on the certificate market is added to the risk on the electricity market. This uncertainty increases the level of risk premiums and cost of capital. As these costs are usually transferred to consumers, the societal costs of renewable electricity support are usually higher than under feed-in tariff and premium systems.

Depending on the design, quota obligations tend to stimulate the development and deployment of lower-cost technologies and generally discard innovations in more costly options. This is particularly the case for quota obligation systems that are technology-neutral and do not make a distinction between renewable energy options. For more mature technologies such as biomass combustion and possibly onshore wind, such a system may be appropriate, but can lead to windfall profit if the marginal price is set by more expensive technologies. Depending on the specific market and resource conditions, less mature technologies would best be supported under a quota obligation system with technology or band specifications.

Also, to stimulate less-mature options under a quota obligation system, these technologies are sometimes combined with more targeted support (tariffs or premiums) for more expensive RES-E options. Such a combination of instruments has been introduced in the UK for solar PV and has been introduced in Italy for a range of smaller projects and options.

Hence, technology banding or a combination of support instruments could address specific learning rates for less mature technologies, while at the same time providing adequate support from more mature technologies.

On a national level, **investments grants** for RES-E are available in several Member States and are often devised to stimulate the take-up of less mature technologies. In Finland, investment grants and subsidies are the only support available on a national level.

**Tax incentives** or exemptions are often complementary to other types of renewable energy incentive programmes. They are powerful and highly flexible policy tools that can be targeted to encourage specific renewable energy technologies and to impact selected renewable energy market participants, especially when used in combination with other policy instruments. A wide range of tax incentives are present in the EU. Some countries, including Spain, the Netherlands, Finland and Greece provide tax incentives related to investments (including income tax deductions or credits for some fraction of the capital investment made in renewable energy projects, or accelerated depreciation). Other Member States, including Latvia, Poland, Slovakia, Sweden and the UK, have devised production tax incentives that provide income tax deduction or credits at a set rate per unit of produced renewable electricity, thereby reducing operational costs. Investment and production tax exemptions are most prominently present in the EU10.

A fifth and related category are **fiscal incentives**, including soft or low-interest loans that are loans with a rate below the market rate of interest. Soft loans may also provide other concessions to borrowers, including longer repayment periods or interest holidays. On a national level, soft-loans are available in Germany, Netherlands, Bulgaria, Estonia, Malta and Poland.

**Tenders** are used for larger-scale projects and most commonly for offshore wind. Tendering schemes for offshore wind are employed in the Netherlands, UK, Denmark and Spain. Its advantages include the amount of attention it draws towards renewable energy investment opportunities and the competitive element incorporated in its design. Its handicap is that the

overall number of projects actually implemented so far has proven to be very low (For further information on support schemes per RES technology see Appendix A3).

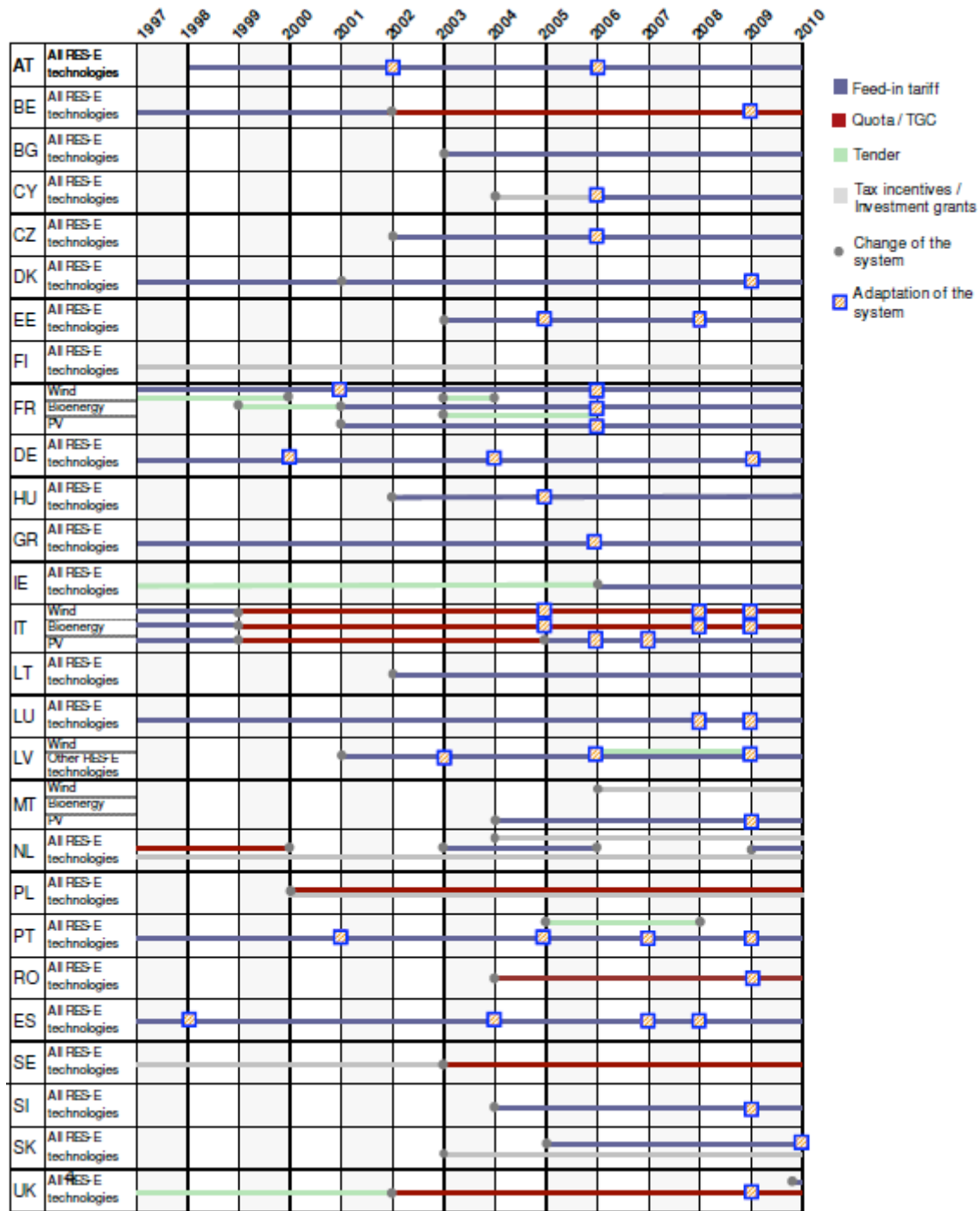


Figure 2.2. Main support schemes for RES-E and policy changes 1997-2010 [11].

## 8. RES Technologies in Buildings

The new RES directive (2009/28) introduced the integration of RE technologies in buildings. Member States must submit, in their building regulations and codes, appropriate measures in order to increase the share of all kinds of energy from renewable sources in the building sector. Through these measures, by 31 December 2014, Member States must require the use of minimum levels of energy from renewable sources in new buildings and in existing buildings that are subject to major renovation (especially RE technologies that achieve a significant

reduction of energy consumption like heating and cooling systems). RE technologies' integration in buildings is one of the major pillars towards the *nearly zero-energy buildings* concept which will be implemented from 2018 and on (see next paragraph).

### **9. Information & Training**

Member States must ensure that information on support measures is made available to all relevant actors, such as consumers, builders, installers, architects, and suppliers of heating, cooling and electricity equipment/systems and of vehicles compatible with the use of energy from renewable sources.

They also must ensure that information on the net benefits, cost and energy efficiency of equipment and systems for the use of heating, cooling and electricity from renewable energy sources is made available either by the supplier of the equipment/system or by the national competent authorities. In cooperation with local and regional authorities, they must develop suitable information, awareness-raising, guidance or training programmes in order to inform citizens of the benefits and practicalities of developing and using energy from RES.

### **10. Reporting & Monitoring**

On the one hand each Member State must submit a report to the Commission on progress in the promotion and use of energy from renewable sources by 31 December 2011, and every two years thereafter. The sixth report, to be submitted by 31 December 2021, will be the last report required. The reports will provide detailed information on the whole progress of the renewable penetration and the framework for their promotion.

On the other hand, on the basis of the reports submitted by Member States, the Commission will report every two years to the European Parliament and the Council. The first report must be submitted in 2012 and it will be a valuation and a criticism on the progress of the Member States' renewable policy implementation.

### **11. Supporting Tools**

One of the most important supporting tools on the RE sector is the *RE-Shaping project*. The core objective of the RE-Shaping project is to assist Member State governments in preparing for the implementation of the RES Directive and to shape a European policy for RES in the medium to long term. The past and present success of RE policies will be evaluated and recommendations derived on how to improve future RES support schemes. The main target groups of the RE-Shaping project are European, national and regional policy makers in the field of RE, regulators, DSOs / TSOs as well as national industry associations [19].

## **2.5. Energy Efficiency & Savings**

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Energy efficiency has been identified as a cornerstone in the Commission's energy policy and one of the pillars of the Commission's *20 20 by 2020* policy targets. The Commission is aiming for an improvement of at least 20% of the EU's energy consumption compared to business-as-usual projections for 2020. This objective corresponds to achieving approximately 1,5% of real energy savings per year up to 2020. If successful, this would mean that by 2020 the EU would use approximately 13% less energy than today, saving € 100 billion and around 780 millions tonnes of CO<sub>2</sub> each year, around 20% of the current emissions [5].

Energy efficiency policies are recognised to be important because they can assist with achieving other EU targets. For example, enhanced energy efficiency will lower total energy use and therefore make the renewable energy target easier to attain. The Commission

therefore has a range of policies and measures in place or under development that affect energy efficiency across many sectors. These cover research funding, finance for energy efficiency, fiscal policies and education. EU has a significant array of directives aimed at promoting energy efficiency. Some of the most important implemented policies on the effort for energy savings and efficiency increase are:

### **1. National Targets**

Each Member State must take cost effective, practical and reasonable measures designed to contribute towards achieving an overall *national indicative energy savings target* of 9% of the ninth year of application of the Directive 2006/32/EC (ESD). This target must be set and calculated in accordance with the provisions and methodology of Annex I of the ESD. The national energy savings in relation to the national indicative energy savings target must be measured as from 1 January 2008.

For the purpose of the first NEEAP, each Member State must establish an intermediate national indicative energy savings target for the third year of application of this directive, and provide an overview of its strategy for the achievement of the intermediate and overall targets. The intermediate target has to be realistic and consistent with the overall national indicative energy savings target.

### **2. National Energy Efficiency Action Plans (NEEAPs)**

Member States must submit to the Commission the following NEEAPs:

- a first NEEAP not later than 30 June 2007;
- a second NEEAP not later than 30 June 2011;
- a third NEEAP not later than 30 June 2014.

All NEEAPs must describe the energy efficiency improvement measures planned to reach the targets and, as well as to comply with the provisions on the exemplary role of the public sector and provision of information and advice to final customers. The second and third NEEAPs must also include a thorough analysis and evaluation of the preceding NEEAP.

### **3. Cogeneration**

Cogeneration not only can increase energy efficiency, but also improves security of supply. In order to promote and develop high efficiency cogeneration the next measures have been taken:

- *Guarantees of origin.* The origin of electricity produced from high-efficiency cogeneration can be guaranteed according to objective, transparent and non discriminatory criteria laid down by each Member State. They must also ensure that this guarantee of origin of the electricity enable producers to demonstrate that the electricity they sell is produced from high efficiency cogeneration and is issued to this effect in response to a request from the producer.
- *Support schemes* and
- *Grid priority access* like the RE systems.

### **4. Public Procurement**

In the Annex VI of the ESD there is a list of eligible energy efficient public procurement measures. Member States must ensure that the public sector applies at least two requirements from this list.

Recognising that the procurement of energy-efficient equipment and appliances by public institutions is one way to stimulate a market for energy-efficient products, on 10 July 2007 the European Council adopted a new regulation for implementing the EU-US Energy Star programme in the EU. It requires EU institutions and the relevant member state government authorities to use energy efficiency criteria no less demanding than those defined in the Energy Star programme when purchasing office equipment. This is the first time that the

Council and the European Parliament have set mandatory energy efficiency criteria for public procurement. The Commission has also developed a handbook for guiding energy-efficient public procurement [5].

## 5. Improvement of Building's Energy Performance

Energy consumption for buildings-related services accounts for approximately one third of total EU energy consumption. The Commission considers that, with initiatives in this area, significant energy savings can be achieved, thus helping to attain objectives on climate change and security of supply. Towards the promotion of the improvement of the energy performance of buildings the next measures have been taken:

- *Energy performance calculation & requirements.* Each Member State has adopted a methodology for calculating the energy performance of buildings and setting the minimum energy performance requirements (when setting requirements, Member States may differentiate between new and existing buildings and between different categories of buildings) according to the general framework set out in the Energy Performance of Buildings Directive (EPBD).
- *Energy performance certificate.* When buildings are constructed, sold or rented out, an energy performance certificate is made available to the owner or by the owner to the prospective buyer or tenant, as the case might be. The energy performance certificate includes the energy performance of a building and reference values such as minimum energy performance requirements in order to make it possible for owners or tenants of the building or building unit to compare and assess its energy performance. The validity of the certificate shall not exceed 10 years.
- *Display of certificates.* For a building with a total useful floor area of over 500m<sup>2</sup>, for which an energy performance certificate has been issued and is occupied by public authorities and frequently visited by the public, the energy performance certificate must be displayed in a prominent place clearly visible to the public. On 9 July 2015, this threshold of 500m<sup>2</sup> will be lowered to 250m<sup>2</sup>.
- *Heating & cooling systems.* Regular inspection and reporting on inspection of heating and air-conditioning systems of the buildings.
- *Nearly zero-energy buildings.* In order to increase the number of nearly zero-energy buildings, Member States must draw up national plans which include targets differentiated according to the category of building. After 31/12/2018 all new buildings occupied and owned by public authorities are to be nearly zero-energy buildings and by 31/12/2020 all new buildings are to be nearly zero-energy buildings. Towards this target the potential integration of CHP and RE systems will contribute.
- *Financial incentives & market barriers.* For the transition towards nearly zero-energy buildings and the improvement of building's energy performance, Member States must take appropriate steps to provide financing and other instruments. By 30 June 2011, Member States should draw up a list of existing and, if appropriate, proposed measures and instruments including those of a financial nature. This list must be updated every three years and communicated to the Commission through the NEEAPs.

## 6. Metering Energy Consumption

As far as it is technically possible, financially reasonable and proportionate in relation to the potential energy savings, final customers for electricity, natural gas, district heating and/or cooling and domestic hot water must be provided with competitively priced individual meters. These meters reflect accurately the final customer's actual energy consumption and provide information on actual time of use.

When an existing meter is replaced, such competitively priced individual meters should always be provided, unless this is technically impossible or not cost-effective in relation to the estimated potential savings in the long term. Also, when a new connection is made in a new

building or a building undergoes major renovations, as set out in the EPBD, such meters should always be provided.

## **7. Improvement of Energy Related Products**

In order to maximize the environmental benefits from improved design of the energy related products and improve their energy efficiency, two Directives have been established towards this direction.

The Directive 2009/125/EC (which repealed Directive 2005/32/EC) establishes a framework for the integration of environmental aspects in the design and development of energy-using products (*eco-design requirements*) to ensure the free movement of these products within the internal market. It defines the principles, conditions and criteria for setting environmental requirements for the products and it will apply to all energy-using products which are placed on the market. It will also cover parts which are intended to be incorporated into products which are placed on the market as individual parts for end-users, the environmental performance of which can be assessed independently.

The Directive 2010/30/EU (which repealed the Directive 92/75/EEC) establishes a framework for the harmonisation of national measures on end-user information, particularly by means of *labelling and standard product information*, on the consumption of energy, thereby allowing end-users to choose more efficient products. This directive shall apply to energy-related products which have a significant direct or indirect impact on the consumption of energy and, where relevant, on other essential resources during use. The introduction of the system of labels and fiches concerning energy consumption or conservation is accompanied by educational and promotional information campaigns aimed at promoting energy efficiency and more responsible use of energy by end-users.

## **8. Taxation**

Taxation is seen as a powerful tool for providing incentives for energy efficiency, and the Commission is planning a range of energy efficiency tax related work. Taxation of energy products is to a certain extent harmonized at EU level. The Energy Taxation Directive 2003/96/EC already now sets forth minimum rates for the taxation of energy products used as motor fuels and heating fuels as well as electricity. However, the Directive has become outdated and inconsistent. Taxation based on volumes of energy products consumed cannot address EU's energy and climate change targets. It also fails to set economic incentives to foster growth and stimulate job creation. Taxation of energy products must better take account their energy content and their impact on the environment.

The EC has already presented its proposal to overhaul the outdated rules on the taxation of energy products in the European Union. The new rules aim to restructure the way energy products are taxed to remove current imbalances and take into account both their CO<sub>2</sub> emissions and energy content. Existing energy taxes would be split into two components that, taken together, would determine the overall rate at which a product is taxed. The Commission wants to promote energy efficiency and consumption of more environmentally friendly products and to avoid distortions of competition in the Single Market. The proposal will help Member States to redesign their overall tax structures in a way that contributes to growth and employment by shifting taxation from labor to consumption. The revised Directive would enter into force as of 2013. Long transitional periods for the full alignment of taxation of the energy content, until 2023, will leave time for industry to adapt to the new taxation structure.

In addition, there were discussion about the value-added tax (VAT), and how it influences energy efficiency. Current EU rules on VAT, elaborated in the 2006 VAT Directive (2006/112/EC), specify that Member States must subject supplies of goods and services to a rate of at least 15%, with the exception of a broad range of areas deemed essential, including energy, where countries are free to apply reduced rates of no less than 5%. Discussions led to recent amending directives and regulations for greater flexibility on VAT rates to encourage energy efficiency [5].

## 9. Fiscal incentives

Direct fiscal incentives for these purposes are, or have been, used in a number of EU Member States. In most cases they take the form of a subsidy or rebate provided after the purchase (The Netherlands) or paid directly at the check-out (Spain, Hungary, Denmark), in some cases delivered only in case of replacement of the old appliance (Spain, Hungary). In Italy the consumers receive a tax credit for the purchases of energy-efficient (A+ and A++) refrigerators and freezers (delivered only in case of the replacement of the old appliance). The purchases of condensing boilers are promoted in France through a tax credit and Austria through region-specific subsidy schemes. There are also a wide range of programmes, including various subsidy schemes, promoting the purchases of compact fluorescent lamps (CFLi) in EU countries.

Direct fiscal incentives address the same policy objective as reduced VAT rates thus represent in this sense an alternative instrument. They have a number of advantages compared to reduced VAT rates [16]:

First, subsidy schemes can be better targeted to specific consumer groups, e.g. low income households. This helps to address distributional concerns of energy taxation. Targeting may also alleviate the free-rider problem, namely the fact that the benefit of a reduced VAT rate also goes to the consumers, who would purchase an energy-efficient appliance in any case. Hence the same target can be achieved more cost-effectively. In addition, direct fiscal incentives are likely to be more visible to consumers and thus may have a stronger signalling effect than reduced VAT rates. Second, contrary to direct tax incentives VAT reduced rates are not effective in the case of taxable economic agents which can deduct VAT paid on inputs. Third, direct fiscal incentives would not probably create the risk of distorting cross-border trade in the same way as reduced VAT rates, if they are targeted only to the residents of a country. Fourth, subsidies delivered at the check-out or as income tax credits to consumers are more certain to reach the consumer than reduced VAT, which may not be entirely passed through to retail prices. The same does not apply, however, to corporate tax credits given to the manufacturers. Fifth, direct subsidies can be more calibrated to the product characteristics:

(a) Some products need higher subsidies than others to motivate consumers. Reduced VAT may not sufficiently bridge the upfront price gap (which is the most relevant market failure for VAT to tackle) in case of large price difference between energy efficient and less efficient products and of (downward) price effects on the old stocks of less efficient products.

(b) Some products to be promoted also often have other better standards (of luxury) than the ones the specific policy wants to promote.

(c) The VAT instrument lacks flexibility in terms of tackling a possible rebound effect (e.g. it cannot be required that a purchase subject to a reduced rate concerns a replacement of an old appliance).

On the other hand, compared to reduced VAT rates, the creation of a subsidy scheme can be administratively more complex than the differentiation of rates in an existing tax regime (VAT) and thus may entail higher administrative costs. Finally, it must be taken into consideration that direct fiscal incentives, unlike reduced VAT rates, belong to the sole competence of the EU Member States and that therefore their use remains inevitably dispersed if the Member States do not coordinate their action in this regard.

## 10. Education & Awareness

Consumers' purchasing decisions influence the success of the energy efficiency policies. The Commission therefore plans a number of educational measures to raise public awareness of the importance of energy efficiency, including education and training programmes on energy and climate change issues. It also organises competitions to reward the most energy-efficient school in the EU. In addition, it considers that public authorities should set an example. The Commission itself plans to obtain EMAS certification for all the buildings it owns, and then to extend the initiative to all EU institutions. Furthermore, the Commission plans to adopt

guidelines on tenders and to set up networks for cities to exchange good practices concerning energy efficiency in urban areas [5].

## 11. Monitoring & Evaluation

Impact assessment, monitoring and evaluation are to be an integral part of the Commission's energy efficiency policy process. Any new policy, revisions or recasts to existing policies must be accompanied by an impact assessment report. These reports are themselves reviewed by the Impact Assessment Board within the European Commission.

There is no general requirement to undertake an *ex post* evaluation of directives or Commission policies. However, monitoring requirements are usually written into the relevant directives. For example, articles 14 and 15 in the ESD (Directive 2006/32/EC) outline in detail how the national energy efficiency action plans will be evaluated and the process for reviewing the overall energy services framework [5].

## 12. Supporting Tools

One of the most important policy supporting tools on energy efficiency is the European Council for an Energy Efficient Economy (ECEEE), a non-profit, independent organisation. ECEEE offers governments, industry, research institutes and citizen organisations a unique resource of evidence-based knowledge and reliable information, promotes the understanding and application of energy efficiency in society and assists its target groups – from policy makers to programme designers to practitioners – with making energy efficiency happen. ECEEE participates actively in the European policy making process. The organisation participates in a number of EU policy making and advisory fora, and frequently comments on European energy policy through position papers and responses to public consultations. It has also held expert workshops and briefings for policy makers. It has co-operated with the EC, the Parliament and the EU presidency, to hold expert seminars. These institutions appreciate the competence and integrity offered by ECEEE's network of members [20].

## 2.6. Internal Energy Markets

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EU efforts to reform electricity and gas industries started in the middle of the 1990s, and the aim to build a fully competitive internal market for gas and electricity is a principle embedded in the creation of the European Union. Making the energy sector in Europe competitive and more efficient is seen as part of the response to growing concerns on the competitiveness of European industries in globalising markets.

Negotiations between the EU authorities, the member states and the market stakeholders during the 1990s culminated in an Electricity Directive in 1996, (Directive 96/92/EC) and, in 1998, in a Gas Directive (Directive 98/30/EC), that introduced a first set of common rules for the EU energy market. With only relatively few and brief experiences with market liberalisation in Europe and in the rest of the world, and with relatively strong opposition from some EU member states, the first market directive only included soft reform provisions. For example, the EC encouraged but did not mandate the establishment of an independent regulatory authority within each country to supervise the market.

With regard to electricity, the directive gave the largest customers the possibility to choose their supplier. It also included provisions to grant open access to the grids, but without a regulated access framework, and also included requirements to unbundle transmission system operator functions through accounting procedures from vertically integrated



companies. It also introduced the concept of a single buyer, acting in the internal energy market but appointed to be the sole supplier in a specific domain.

For natural gas, the directive aimed at opening the gas networks to third parties (third-party access – TPA), and allowing free choice of suppliers for the largest customers. This was to be achieved through accounting unbundling of the vertically integrated gas operators, thus allowing competition for supplies and customers through the natural monopoly network. The reform was intended to create a more appropriate competitive framework, spurring gas-to-gas competition, thus increasing economic efficiency and lowering costs for the final consumers in markets frequently dominated by monopolies. At the time, wide divergences in prices paid by large industrial consumers, despite similar wholesale prices, highlighted the lack of competitiveness in EU gas markets in an era of low oil prices.

Even before the implementation of the first directives was completed, there was a push to accelerate gas and electricity market liberalisation. The reason for this was that the first directives did not provide much of the legislative framework necessary for comprehensive and targeted liberalisation, and had therefore led to uneven results. When the inadequacies in the light-handed approach towards regulation and unbundling in the first market directives became clear, a new process was launched leading towards a second liberalisation package.

In March 2002, the European Council decided on market opening for all business energy users in 2004 and full market opening in 2005. In 2003, the second market directives were adopted (gas: 2003/55/EC; electricity: 2003/54/EC), together with Regulation (EC 1228/2003) on conditions for access to the network for cross-border exchanges in electricity and full market opening for all customers was agreed for 1 July 2007. The directives were to be implemented by member states by transposing them into their relevant national legislation by 1 July 2004, whereas the regulation was immediately applied. The main parts of the directive and the regulation were:

#### Directive

- A stepwise opening of retail markets towards full market opening for all customers by 1 July 2007.
- Stricter provisions for the unbundling of transmission networks, leaving only the options of legal separation (establishing a separate company) or full ownership unbundling. Provisions for local low-voltage networks are less strict.
- Provisions for the mandatory establishment of independent regulators.

#### Regulation

- New detailed provisions on cross-border electricity trade.

In 2001 the European Council requested the Commission to provide detailed assessments of the implementation of the market directives on an annual basis, and these were required by the second market directive to be finalised by 2005. The series of annual benchmarking reports culminated in a comprehensive report in 2005. In general, the benchmarking reports are very critical about *the lack of implementation of directives and regulations in a large number of Member States*, they point out that in many of them the provisions that are being implemented focus on the letter of the legislation and not on the spirit of creating a true internal market.

The sector inquiry, as well as the Green Paper and the March Council conclusions, led the Commission to propose a *third liberalisation package in 2007*. This agreement materialised in proposals for a third market directive and for a new regulation on cross-border electricity trade. The proposals were mainly aimed at strengthening the requirements and provisions in the second market directive, and maintain the vision for a truly competitive internal market. Despite the fact that a group of eight member states rejected the proposal for full ownership

unbundling negotiations led to the adoption of Directive 2009/72/EC for electricity, Directive 2009/72/EC for gas, Regulation 713/2009 for establishing an Agency for the cooperation of Energy Regulators, Regulation 714/2009 for cross-border exchanges in electricity and Regulation 715/2009 for natural gas transmission networks [5].

The most important implemented policies on market reforming are:

### **1. Designation of Independent Regulatory Authority**

All Member States must designate a single national regulatory authority at national level. The regulatory authority must be independent and exercise its powers impartially and transparently. In order to achieve this, Member States must ensure that the regulatory authority is legally distinct and functionally independent from any other public or private entity. Its staff and persons responsible for its management act independently from any market interest and do not seek or take direct instructions from any government or other public or private entity when carrying out the regulatory tasks.

The duties of the regulatory authority is to oversee and monitor the whole electricity and gas market in order to facilitate their regular function and the rights and obligations of each one of the legal entities and undertakings involved in the markets.

### **2. Regional Cooperation**

Member States' and regulatory authorities' cooperation for the purpose of integrating their national markets at one and more regional levels can be the first step towards the creation of a fully liberalised internal market.

Regulatory authorities and Member States must promote and facilitate the cooperation of transmission system operators at a regional level, including on cross-border issues, with the aim of creating a competitive internal market in electricity and gas, foster the consistency of their legal, regulatory and technical framework and facilitate integration of the isolated systems forming electricity islands that persist in the Community. The geographical areas covered by such regional cooperation shall include cooperation in geographical areas defined in Regulation 714 and 715/2009 [40] [41].

### **3. Unbundling of Transmission System Operators (TSOs)**

The Directive 2009/72/EC determines three models for the unbundling of the TSOs: The Ownership Unbundled TSO (OU), the Independent System Operator (ISO) and the Independent Transmission Operator (ITO).

In the OU model the same person or persons are entitled directly or indirectly to exercise control over an undertaking performing any of the functions of generation or supply, does/do not have the right to exercise control directly or indirectly or exercise any right over a TSO or over a transmission system and vice versa. The same person or persons are not entitled to appoint members or be a member of the supervisory board, the administrative board or bodies legally representing the undertaking, of a TSO and directly or indirectly to exercise control or exercise any right over an undertaking performing any of the functions of generation or supply. The OU model is accompanied by a strong functional unbundling.

The ISO model is an alternative to the OU model. The setting up of a system operator or a transmission operator that is independent from supply and generation interests should enable a VIU to maintain its ownership of network assets whilst ensuring effective separation of interests, provided that such independent system operator or transmission operator performs all the functions of a system operator. So, the ISO model maintains the assets to the VIU and requests a strong regulatory environment to function. It is the alternative solution for the Member States where on 3 September 2009 an undertaking owning a transmission system was a part of a VIU.

The ITO is the second main model set out by the electricity directive. The main difference between the ISO and the ITO is the lack of the non-control obligation, which is a prerequisite

in both the OU TSO and the ISO. The main rule for the function of the ITO is that it must be equipped with all human, technical, physical and financial resources necessary for fulfilling their obligations under this directive, as well as carry out the activity of electricity transmission.

#### **4. Unbundling of Distribution System Operators (DSOs)**

When a DSO is a part of a VIU, legal and functional unbundling measures must be applied. In particular, the DSO must be independent at least in terms of its legal form (legal unbundling), organization and decision making from other activities not relating to distribution (functional unbundling). Those rules shall not create the obligation to separate the ownership of assets of the DSO from the VIU. In addition to these requirements, where a DSO is a part of a VIU, it must be independent in terms of its organization and decision-making from the other activities not related to distribution.

Member States may decide not to apply the unbundling measures to integrated electricity undertakings serving less than 100.000 connected customers or serving small isolated systems.

#### **5. Unbundling & Transparency of Accounts**

Member States or any competent authority they designate, including the regulatory authorities and the dispute settlement authorities, have right of access to the accounts of natural gas and electricity undertakings if it is necessary to carry out their functions.

Electricity and natural gas undertakings, whatever their system of ownership or legal form, shall draw up, submit to audit and publish their annual accounts in accordance with the rules of national law concerning the annual accounts of limited liability companies. Undertakings which are not legally obliged to publish their annual accounts shall keep a copy thereof at the disposal of the public at their head office.

Electricity and natural gas undertakings must, in their internal accounting, keep separate accounts for each of their transmission and distribution activities as they would be required to do if the activities in question were carried out by separate undertakings, with a view to avoiding discrimination, cross-subsidisation and distortion of competition. They must also keep accounts, which may be consolidated, for other electricity and gas activities not relating to transmission or distribution. Revenue from ownership of the transmission or distribution system must be specified in the accounts and where appropriate, they must keep consolidated accounts for other, non-electricity/gas activities. The internal accounts must include a balance sheet and a profit and loss account for each activity [40] [41].

#### **6. Third Party Access (TPA)**

Member States must ensure the implementation of a system of TPA to the transmission and distribution systems based on published tariffs, applicable to all eligible customers and applied objectively and without discrimination between system users. Those tariffs, or the methodologies underlying their calculation, are to be approved and published prior to their entry into force.

The TSO or DSO can refuse access where it lacks the necessary capacity or where the access to the system would prevent them from carrying out the PSOs. Clearly specified reasons must be given for such refusal based on objective and technically and economically justified criteria which must be consistently applied. The system user who has been refused access can make use of a dispute settlement procedure. The TSO or DSO must provide relevant information on measures that would be necessary to reinforce the network. The party requesting such information may be charged a reasonable fee reflecting the cost of providing such information.

#### **7. Dispatching & Balancing Rules**

National regulatory authorities must determine the criteria on which the dispatching of generating installations and the use of interconnectors will be based. These criteria must be published and applied in a non-discriminatory manner, ensuring the proper functioning of the

internal market in electricity. The criteria must also take into account the economic precedence of electricity from available generating installations or interconnector transfers and the technical constraints on the system.

Dispatching priority must be given to generating installations using renewable energy sources and CHP. For reasons of security of supply, priority can be given to the dispatch of generating installations using indigenous primary energy fuel sources, to an extent not exceeding, in any calendar year, 15% of the overall primary energy necessary to produce the electricity consumed in the Member State.

TSOs must comply with minimum standards for the maintenance and development of the transmission system, including interconnection capacity. They must adopt rules for balancing the electricity system and charging system users of their networks for energy imbalance.

## **8. Public Service Obligations (PSOs)**

One of the main rules for the organization of the electricity and gas sectors is the possibility of the Member States to impose on undertakings PSOs. PSOs belong to the universal services, which came as a consequence of the liberalization of the energy market, and are considered as the right of all households to be supplied at a reasonable, easily and clearly comparable and transparent price. The main elements of the universal services are the obligation to connect, the quality and regularity of supply and prices. In the above ambit, the establishment of last resort, the protection of remote customers and the universal services to small enterprises are included. Ensuring universal services may be one of the reasons for imposing a PSO, especially in less developed markets.

The PSOs may be related to security, including security of supply, regularity, quality and price of supply, environmental protection, including energy efficiency, energy from RES and climate protection. In the area of final customer protection, the protection of vulnerable customer is included. Supplying vulnerable customers is recognized as an important task.

## **9. Subsidies**

Under current EU legislation, it is possible to provide for subsidies in energy markets. Traditionally, the most important subsidies have been to support coal production, or its gradual phase-out. With the emerging policy objective of decarbonising energy supply, subsidies have become available to renewable energy as well. For energy security and diversification of supply, Member States are also allowed to set public service obligations (PSOs), supporting the use of a particular fuel financially.

The design of subsidies varies by Member State. It is possible for subsidies to be paid largely in a manner that is compatible with an open energy market, or that the subsidy is paid in a way that precludes the active participation of the subsidised energy producer in the market. State subsidies which provide an economic advantage to certain undertakings and have the potential of distorting competition and which affect trade between Member States have to be approved by the Commission. However, according to case law, measures (involving for example renewable electricity feed-in tariffs) which are designed according to the relevant legislation fall outside of the Commission's state aid control remit.

The Commission aims to persuade Member States to grant less state aid in general and to redirect spending to horizontal purposes of common interest, such as environmental protection and allow them, within certain limits, to continue to encourage state aid for renewable energy and energy efficiency.

The European Council meeting of spring 2006 asked for further work on appropriate incentives and disincentives, and called for the reform of subsidies that have considerable negative effects on the environment and are incompatible with sustainable development, with a view to gradually eliminating them. The Commission stressed in Green Paper on market-based instruments for environment and related policy issues [COM(2007)140] that it will work with Member States towards this objective [5].

## 10. Review & Reporting

The Commission must monitor and review the application of the electricity and gas market directives and should submit an overall progress report to the EP and the Council for the first time by 4 August 2004, and thereafter on an annual basis. Every two years, the progress report must also include an analysis of the different measures taken in the Member States to meet PSOs, together with an examination of the effectiveness of those measures and, in particular, their effects on competition in the energy market. Where appropriate, the report may include recommendations as to the measures to be taken at national level to achieve high public service standards, or measures intended to prevent market foreclosure.

By 3 March 2013, the EC must submit, as part of the general review, to the EP and the Council, a detailed specific report outlining the extent to which the unbundling requirements have been successful in ensuring full and effective independence of TSOs, using effective and efficient unbundling as a benchmark.

## 11. Supporting Tools

Towards the difficult task of energy market liberalization, policy supporting tools seem to play crucial role. Some of the most important will be presented here.

With the regulation 713/2009, the *Agency for the Cooperation of Energy Regulators (ACER)* is established. The purpose of the ACER is to assist the regulatory authorities in exercising at Community level, the regulatory tasks performed in the Member States and, where necessary, to coordinate their action. The types of the ACER's acts are to issue opinions and recommendations addressed to TSOs, regulatory authorities, the EP and the Council or the Commission, to take individual decisions in the specific cases and submit to the Commission non-binding framework guidelines on conditions for access to the network for cross-border exchanges in electricity and the natural gas transmission networks.

The *Council of European Energy Regulators (CEER)* is the voice of Europe's national regulators of electricity and gas at EU and international level. Through CEER, a non-for-profit association, the national regulators cooperate and exchange best practice. A key objective of the CEER is to facilitate the creation of a single, competitive, efficient and sustainable EU internal energy market that works in the public interest. [63]

The establishment of the *European Network of Transmission System Operators (ENTSO)* for electricity and gas, aims at cooperation of the TSOs at Community level through the ENTSO in order to promote the completion and functioning of the internal market in electricity/gas and cross-border trade and to ensure the optimal management, coordinated operation and sound technical evolution of the European electricity/gas transmission network. The ACER will monitor the execution of ENTSO's tasks and report to the Commission.

## 2.7. Security of Energy Supply

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The European Union is dependent to varying degrees on energy imports of oil, gas, coal and electricity. Some individual member states may be self sufficient in one of these energy sources, or overall net exporters. Since 2005, some major events made energy security of supply a major issue in European energy policy. These events include the rapid rise of fossil fuel prices since 2004; the interruption of gas supplies from Russia in January 2006, with resulting gas shortages in a number of EU Member States, and the continuing threat that disputes between neighbouring suppliers and transit countries will affect supplies of gas and oil to the EU; a major electricity blackout in November 2006, affecting large parts of north-western Europe, and caused by a transmission system management failure in northern

Germany; the development of the internal energy market; and the political commitment of the EU to a transition to high-efficiency, low-carbon energy system [5].

As a consequence of these events and developments, energy security policy has been recognised as a major challenge for the EU-27, with action at European level being required. All the policies mentioned in the previous chapters up to now aim at security of energy supply as one of their major targets. The fuel and suppliers diversification through RE penetration and external energy relations is one pillar. Another is the aim for a single, integrated European energy market through the internal market reform so as to help the so important internal trade. However there are a few more specific policies in security of supply that must be mentioned:

### **1. Measures on Security of Gas Supply**

The Regulation 994/2010 (which repealed the Directive 2004/67/EC) establishes provisions aimed at safeguarding the security of gas supply by ensuring the proper and continuous functioning of the internal market in natural gas. Towards this direction a list of market and non-market based security measures is provided and Member States must establish preventive action plans and emergency plans. A Gas Coordination Group is established to facilitate the coordination of measures concerning security of gas supply.

### **2. Measures on Security of Electricity Supply**

The Directive 2005/89/EC establishes measures aiming at safeguarding security of electricity supply so as to ensure the proper functioning of the internal market for electricity and to ensure:

- an adequate level of generation capacity;
- an adequate balance between supply and demand and
- an appropriate level of interconnection between Member States for the development of the internal market.

It also establishes a framework within which Member States are to define transparent, stable and non-discriminatory policies on security of electricity supply compatible with the requirements of a competitive internal market for electricity.

### **3. Increasing Interconnections & Enforcing Infrastructure**

The Trans-European Networks – Energy program aims at increasing the interconnections in both electricity and gas sector and enforce their infrastructure.

In the electricity sector, the primary aim of the TEN-E programme is to establish additional internal interconnections to support trade of electricity within the EU, equivalent to cross-border transmission capacity corresponding to at least 10% of installed generating capacity, following a EC decision in spring 2002. This commitment recognises the importance of cross border transmission capacity in realising the vision of an internal electricity market. TEN-E identifies major transmission axes, major bottlenecks in these corridors and additional priority projects of regional importance; 196 priority electricity transmission projects were decided in 2003, 32 of them categorised as being of European interest and 164 of common interest.

In the gas sector, the main aim of the TEN-E programme is to provide additional routes and access to more sources of gas, to increase diversification. Projects can either be pipelines, or LNG import terminals, or storage [5].

### **4. Emergency Oil Stocks**

EU member states are obliged to hold emergency oil stocks under Directive 2006/67/EC, which is the codification of older legislation dating back to 1968. Stocks have to cover 90 days of consumption in most Member States (except eight states with a transition arrangement) and 67,5 days for net exporters or countries in an almost balanced position regarding imports. They should be held in the form of petroleum products, fuel oil, diesel, or gasoline. Member States have to report on their stockholding on a monthly basis, but are free to choose the arrangements they deem appropriate for the stockholding. At the end of September 2007, only

two member states were not complying with the stockholding arrangement. Non-compliance can lead to an infringement procedure by the Commission. In case of a supply disruption, the EU Oil Supply Group will consult on releasing the stocks.

Following a decision by the European Council in 2007, the Commission started work on amending the framework of oil stockholding in the EU with the aim to make it more compatible with the tested IEA emergency stockholding system. This led to the Directive 2009/119/EC which will be into force from 31 December of 2012.

## **5. National Emergency Plans**

Member States are to have procedures in place and contingency plans to be implemented in the event of a major supply disruption. These procedures will enable competent authorities to release quickly, effectively and transparently some or all of their emergency and specific stocks, and will impose general or specific restrictions on consumption in line with the estimated shortages, by allocating petroleum products to certain groups of users on a priority basis. Also, in order to meet local crisis, a Member State may release emergency stock in amounts lower than the compulsory minimum level set by the Directive 2006/67/EC.

## ***2.8. Environmental Protection***

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Commission policies to reduce emissions of CO<sub>2</sub> date back to 1991, and the first comprehensive policy was launched by the Commission in the form of the European Climate Change Programme (ECCP) in 2000, which is currently in its second phase. The goal of the ECCP is to identify and develop all the necessary elements of an EU strategy to implement the Kyoto Protocol, and it has led to the adoption of a wide range of new policies and measures.

The Kyoto Protocol was ratified in 2002. It was committed to an 8% reduction of GHG emissions during the commitment period 2008-2012, compared to base-year emissions, which vary between Member States. This target was distributed among the then EU-15 through a burden-sharing agreement in 2002. The latest EU-12 are not subject to the burden-sharing agreement but instead have to fulfil their targets as signatories of the Protocol. The burden-sharing agreement stipulated that not more than 50% of emissions reductions in any Member State could come from the use of the Kyoto flexible mechanisms (clean development mechanism and joint implementation), but otherwise left the development of national policies to reduce GHG emissions up to Member State governments. For the post-Kyoto regime, the EU will again aim to have a single target assigned to it, and redistribute it internally.

Until 2005, the Commission pursued climate change policy solely as a co-operative exercise within the Kyoto framework. With the date of expiry of this framework by 2013 coming closer, and a perceived lack of urgency on the part of international partners, a policy change took place. As a consequence, in 2007 the EU agreed to pursue unilateral GHG emissions reductions of 20% by 2020, while offering to step these up to 30% in the case of a new global agreement being found.

Air pollution was one of the early areas of the Commission's energy and environment policy, and pollution control legislation is now affecting transport and power generation in particular. Most affected are coal-fired power stations, in particular because of the legislation restricting SO<sub>2</sub> emissions. In the area of transport, NO<sub>x</sub> and particles are being controlled, with implications for diesel vehicles.

The most important policy instruments affecting the energy sector are the Integrated Pollution Prevention and Control Directive (IPPCD, Directive 96/61/EC, as amended), regulating a broad range of industrial and agricultural activities as well as the Large Combustion Plant Directive (LCPD, Directive 2001/80/EC, which has replaced the old LCP Directive 88/609/EEC from 1988), setting out minimum requirements for emissions to air from these plants. Industrial installations covered under the IPPC Directive are responsible for 83% of the EU's SO<sub>2</sub> emissions, 34% of NO<sub>x</sub> emissions, 43% of particles and 55% of volatile organic compound (VOC) emissions, according to the Commission.

Renewable energy penetration and energy efficiency policies aim at mitigating the climate change and environmental protection. Some more specific policies though are:

### **1. EU Emissions Trading System (EU ETS)**

The EU ETS is the first and biggest international scheme for the trading of greenhouse gas emission allowances, the EU ETS covers some 11,000 power stations and industrial plants in 30 countries. Launched in 2005, the EU ETS works on the "cap and trade" principle. This means there is a "cap", or limit, on the total amount of certain greenhouse gases that can be emitted by the factories, power plants and other installations in the system. Within this cap, companies receive emission allowances which they can sell to or buy from one another as needed. The limit on the total number of allowances available ensures that they have a value.

At the end of each year each company must surrender enough allowances to cover all its emissions, otherwise heavy fines are imposed. If a company reduces its emissions, it can keep the spare allowances to cover its future needs or else sell them to another company that is short of allowances. The flexibility that trading brings ensures that emissions are cut where it costs least to do so.

The number of allowances is reduced over time so that total emissions fall. In 2020 emissions allowances will be 21% lower than in 2005.

The ETS now operates in 30 countries (the 27 EU Member States plus Iceland, Liechtenstein and Norway). It covers CO<sub>2</sub> emissions from installations such as power stations, combustion plants, oil refineries and iron and steel works, as well as factories making cement, glass, lime, bricks, ceramics, pulp, paper and board. Nitrous oxide emissions from certain processes are also covered. Between them, the installations currently in the scheme account for almost half of the EU's CO<sub>2</sub> emissions and 40% of its total greenhouse gas emissions.

Airlines will join the scheme in 2012. The EU ETS will be further expanded to the petrochemicals, ammonia and aluminium industries and to additional gases in 2013, when the third trading period will start. At the same time a series of important changes to the way the EU ETS works will take effect in order to strengthen the system.

The success of the EU ETS has inspired other countries and regions to launch cap and trade schemes of their own. The EU hopes to link up the ETS with compatible systems around the world to form the backbone of a global carbon market [51].

### **2. National Allocation Plans (NAPs)**

National allocation plans (NAPs) are plans that set out each Member State's allocation of CO<sub>2</sub> emission allowances under the EU ETS. NAPs fix both the total of emission allocations available in each Member State and the allocation made to each installation covered by the scheme. By placing a cap on the total number of emission allowances, NAPs create the scarcity needed for a functioning market in allowances to develop. This in turn enables companies to limit or reduce their emissions at least cost.

Member States are required to draw up their NAP well in advance of each ETS trading period and to have it approved by the European Commission. NAPs for the second ETS trading period, running from 2008 to 2012, should be submitted to the Commission by 30 June 2006. This deadline needs to be respected so that the Commission can take decisions on all 25



NAPs and member states could take their final allocation decisions by the end of 2006, well before the second trading period starts.

The second trading period under the ETS coincides with the five-year period – known as the ‘first commitment period’ - in which the EU and member states must meet their targets for limiting or reducing emissions of greenhouse gases under the Kyoto Protocol on climate change. For many Member States the NAPs for 2008-2012 are likely to play an important part in ensuring their targets are achieved.

### **3. Emission Limit Values for LCP**

The Directive 2001/80/EC sets specific emission limit values for Large Combustion Plants (LCP) of thermal input equal or over 50kW.

### **4. Vehicle labelling**

For motor-vehicle it isn't electrical efficiency that is indicated through labeling but information on fuel consumption and/or CO<sub>2</sub> emissions. The EU Directive (1999/94/EC) obliges car manufacturers and distributors to display information on fuel consumption and CO<sub>2</sub> emissions of new passenger cars in showrooms and within any marketing activity (CO<sub>2</sub> label). The labels include mandatory data on CO<sub>2</sub> emissions (g/km) and fuel consumption (l/100km and/or km/l). The EU directive allows the member states plenty of room for national implementation; as a result, the labelling systems differ within Europe.

CO<sub>2</sub> labeling is a practical method to inform consumers about the fuel economy and environmental standards of the new cars. But as the buying decisions are strongly influenced by costs, size, power, manufacturer and safety of the car, the impact on the consumer decision is quite low. For this reason, relative comparison methods on the labels are preferable. CO<sub>2</sub> labeling may lead to a growing awareness about environmental impacts of car use and in combination with tax incentives (e.g. the "Green motor tax" in Denmark or Vehicle Registration Tax in Ireland), it may already help shifting consumer decisions to more environmental friendly cars.

### **5. Vehicle Emission Standards**

European emission standards define the acceptable limits for exhaust emissions of new vehicles sold in EU member states. The emission standards are defined in a series of European Union directives staging the progressive introduction of increasingly stringent standards.

Currently, emissions of nitrogen oxides (NO<sub>x</sub>), total hydrocarbon (THC), non-methane hydrocarbons (NMHC), carbon monoxide (CO) and particulate matter (PM) are regulated for most vehicle types, including cars, lorries, trains, tractors and similar machinery, barges, but excluding seagoing ships and aeroplanes. For each vehicle type, different standards apply. Compliance is determined by running the engine at a standardised test cycle. Non-compliant vehicles cannot be sold in the EU, but new standards do not apply to vehicles already on the roads. No use of specific technologies is mandated to meet the standards, though available technology is considered when setting the standards. New models introduced must meet current or planned standards, but minor lifecycle model revisions may continue to be offered with pre-compliant engines.

Voluntary agreement between the European Commission and European Automobile Manufacturers Association (ACEA) to limit the amount of CO<sub>2</sub> emitted by passenger cars sold in Europe is known as ACEA agreement. Signed in 1998, the agreement sought to achieve an average of 140 g/km of CO<sub>2</sub> by 2008 for new passenger vehicles sold by the association's cars in Europe. This target represents a 25% reduction from the 1995 level of 186 g/km and is equivalent to a fuel economy of 5,8 l/100 km or 5,25 l/100 km for petrol and diesel engines respectively. However, the average for the whole car market for 2008 was 153,7 g/km, so the target has not been achieved. The ultimate EU target, to which these agreements are to contribute, is to reach an average CO<sub>2</sub> emission (as measured according to Commission Directive 93/116/EC) of 130 g/km for all new passenger cars by 2015.

## **6. Fuel Quality**

The Directive 2009/30/EC, which amended the Directive 98/70/EC and 99/32/EC, set technical specifications on health and environmental grounds for fuels and a target for the reduction of life cycle GHG emissions.

Fuel suppliers are responsible for monitoring and reporting life cycle greenhouse gas emissions per unit of energy from fuel. From 1 January 2011 and every year on they must report to the authority designated by the Member State on the greenhouse gas intensity of fuel and energy supplied within each Member State, by providing the total volume of each type of fuel or energy supplied, indicating where purchased and its origin and life cycle greenhouse gas emissions per unit of energy.

The directive also provides environmental specifications for market fuels to be used for vehicles equipped with positive and compression ignition engines as well as rules for calculating the GHG emissions from biofuels.

## **7. Provisions for Industrial Activities**

For industrial activities set in detail in Annex 1 of the Directive 2010/75/EU, Member States must take the necessary measures to provide that installations are operated in accordance with the principles set in article 11 of the directive. Besides these general principles governing the basic obligations of the operator, there are special provisions for:

- Combustion plants
- Waste incineration and co-incineration plants
- Installations and activities using organic solvents
- Installations producing titanium dioxide

## **8. Carbon Capture & Storage (CCS)**

The Directive 2009/31/EC establishes a legal framework for the environmentally safe geological storage of carbon dioxide to contribute to the fight against climate change. The purpose of environmentally safe geological storage of CO<sub>2</sub> is the permanent containment of CO<sub>2</sub> in such a way as to eliminate or prevent, as far as possible, negative effects and any risk to the environment and human health. Also criteria for the selection of storage sites and storage permits are provided.

## ***2.9. Nuclear Energy***

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Nuclear energy is currently the largest single source of low-carbon electricity in the EU, equivalent to 260 Mtoe, or 14% of the EU total energy supply. There are 144 nuclear power plants (NPPs) operating in 14 Member States and in 2009 these provided 27% of the total electricity generated in the Union. European NPPs are among the most efficiently operated reactors in the world. Those operating today, and the 68 NPPs that operated previously and were retired from service, have delivered significant amounts of baseload electricity.

Nuclear fuel cycle facilities in Member States employ leading-edge technologies and have sufficient capacity to supply EU requirements. Technologies available include reprocessing, which makes more efficient use of the energy available in uranium through recycling and reduces the volume of spent fuel waste. Some Member States also have the most advanced programs in the world to safely dispose of spent nuclear fuel in deep geological repositories.

Nuclear power remains a controversial issue and the EU nuclear reactor fleet is ageing. Power uprates and lifetime extensions, in some cases to 60 years, of several EU reactors have improved performance and output. Despite this, EU nuclear generating capacity will decline from now on, unless significant investment is forthcoming in the near future for plant lifetime extensions and the replacement of facilities reaching the end of their operating lives. Without this investment, this low-carbon source of baseload electricity generation could be reduced from 31% to 21% of the total electricity generated in the EU in 2020. Reduced electricity generation in NPPs will make the ambitious EU goal of a 20 to 30% reduction of carbon dioxide emissions by 2020 even more challenging.

Electricity generation in NPPs enhances EU efforts to reduce greenhouse gas emissions and clean air initiatives as it is a low-emission technology with no direct emissions of CO<sub>2</sub>, NO<sub>x</sub>, SO<sub>x</sub>, ozone and particulate matter. Nuclear power also enhances EU security of energy supply, since uranium is widely distributed and about 50% of global mine production comes from reliable, politically stable trading partners. In 2006, Canada, Australia and the United States supplied about 40% of the natural uranium to EU utilities.

Within the EU there are widely differing attitudes to the acceptability of nuclear power and *it is up to each member country to choose to include it as part of its energy mix*. Similarly, nuclear regulation is a national responsibility. Regulatory approval processes for NPPs are typically long and add to investor uncertainty, and they differ from country to country. While regulation will remain a national responsibility, there are moves for greater co-operation internationally, for example the Multi-National Design Evaluation Process and the activities of the Western European Nuclear Regulators' Association [5].

However after the accident in Fukushima on 3 March 2011 EU released a statement calling for the following priorities:

- Review the safety of all EU nuclear power plants through stress tests. The assessments will be conducted by independent national authorities. The EC will assess initial findings by the end of 2011.
- Request that similar “stress tests” be carried out in neighboring countries and worldwide.
- The highest standards for nuclear safety should be implemented and continuously improved in the EU and promoted internationally.
- The EC will review the existing legal and regulatory framework for the safety of nuclear installations and will propose by the end of 2011 any necessary improvements.

## 2.10. Research & Development

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R&D is considered as a top priority policy sector in EU, with significant contribution towards the energy efficiency and RES targets and penetration. Collaborative R&D, including energy R&D, has a long history in the EU. The Commission has traditionally been in charge of preparing and developing programs with a dual focus on achieving R&D results and on creating an integrated European research landscape.

European energy R&D funding is today primarily aiming to integrate R&D efforts across borders, by building long-term partnerships and increasing effective exchange of R&D results at European level. The EU support programs therefore run in parallel with national support programs, but have now become an important source of funding for R&D institutions in the EU. With the recent strong focus on creating a competitive low-carbon economy in Europe,

energy R&D has also become a key element in the Commission's low-carbon strategy. This is backed by other European institutions, most importantly the European Council, that on 14 March 2008 emphasized the need for sustained investment in R&D and an active take-up of new technologies in energy. The main R&D programs in the EU are:

### **1. The Framework Program (FP)**

The multi-annual Framework Program for Research and Technology Development (FP) is the main instrument for the implementation of European energy research policy, and for the provision of funding by the EU to R&D activities since 1984. It covers almost all aspects of European research. The FP is the EU's main financial and legal instrument to implement the European Research Area. The current Seventh Framework Program (FP7) is running from 2007 to 2013. It comprises four specific sub-programs: Cooperation (including energy), Ideas, People, and Capacities, and is part of the Lisbon Agenda of the EU.

The Commission, Parliament and the Council together decide on the FP, as set out in the European Treaties. The Commission plays a key role in the development of the FP, and attempts to use it to support overall policy goals.

Under the structure of FP7, energy research is split into nuclear R&D, managed by the Euratom Directorate of DG ENER, with the program running from 2007 to 2011, and non-nuclear energy research, from 2007 to 2013. Under the energy theme of the FP7 Co-operation Program, nine subject areas for non-nuclear energy research have been identified, as set out below. These continue to be strongly focused on energy supply technologies:

- Hydrogen and fuel cells
- Renewable electricity generation
- Renewable fuel production
- Renewables for heating and cooling
- CCS technologies
- Clean coal technologies
- Smart energy networks
- Energy efficiency and savings
- Knowledge for energy policy making

The bulk of nuclear spending in FP7 is allocated to the ITER fusion reactor project at Cadarache in France. For fusion energy, the priorities are the realization of the ITER project, including an accompanying program for the exploitation of the ITER device and the preparations for the development of demonstration reactors. In the nuclear fission R&D area, FP7 priority activities include the following three areas:

- Waste management, including geological disposal.
- Reactor systems, including nuclear installation safety and development of advanced reactor concepts.
- Radiation protection.

### **2. Strategic Energy Technology Plan (SET-Plan)**

The European Council agreed on an "Energy Policy for Europe" in March 2007, backing the Commission's proposals on energy and climate change, and underlining the need to strengthen energy research, in particular to accelerate the competitiveness of sustainable energies, notably RE and low-carbon technologies and the further development of energy efficient technologies. The Council decision acknowledged that low-carbon technologies will play a vital role in reaching the EU's energy and climate change targets.

Because of the timing of the start of FP7, it had not been possible to reflect this in the design of the FPAs, and energy technology innovation therefore had a relatively low priority in the funding allocation of FP7. To rectify this to some extent, the Commission adopted the SET

Plan on 22 November 2007. Its main goal is to accelerate the development and implementation of low-carbon technologies, and to help overcome the issue of funds already allocated for the period 2007 to 2013 under FP7.

The time horizon of the SET Plan includes both a 2020 perspective and a long-term vision to 2050. It also sets out the key EU technology challenges for the next ten years to meet the 2020 targets and also the technology challenges that will have to be addressed to put the EU on course to achieve the 2050 vision. The plan aims to provide a twin-track approach, of reinforcing research to lower costs and improve performance; and of continuing proactive support measures to create business opportunities, stimulate market development and address the non-technological barriers that discourage innovation and the market deployment of efficient and low carbon technologies. The SET-Plan includes:

- The European Industrial Bioenergy Initiative
- The European CO<sub>2</sub> Capture, Transport and Storage Initiative
- The European Electricity Grid Initiative
- The Fuel Cells and Hydrogen Joint Technology Initiative
- The Sustainable Nuclear Initiative
- Energy Efficiency – The Smart Cities Initiative
- The Solar Europe Initiative
- The European Wind Initiative

The SET-Plan also includes the next supporting tools:

The *SET-Plan Steering Group (SET-Group)* which coordinates the implementation of the SET-Plan by providing a high-level discussion platform and a flexible framework for strategic planning and implementation. It works to maximize the cost-effective contribution that technology can make to achieving Europe's energy goals.

The *European Energy Research Alliance (EERA)* which aims to accelerate the development of new energy technologies with the help of Joint Research Programs supporting the SET-Plan by concentrating activities and resources, combining national and EU sources of funding and maximizing complementarities and synergies.

The *SET-Plan Information System (SETIS)*. It supports the strategic planning and implementation of the SET-Plan. It makes the case for technology options and priorities, monitors and reviews progress regarding implementation, assesses the impact on policy, and identifies corrective measures if needed. SETIS works in close collaboration with European stakeholders such as the ETPs, industrial stakeholders, trade associations, international organizations and the finance community [59].

### **3. Research Fund for Coal and Steel**

The industry-focused research program of the Research Fund for Coal and Steel (RFCS) is complementary to and managed outside FP7. It was created when the ECSC Treaty expired in July 2002. With a yearly budget of around € 60 million, financed by the interests accrued each year by the assets of the ECSC (€ 1.600 millions) at the time of the Treaty's expiry, the fund supports research projects in the areas of coal and steel [5].

### **4. Supporting Tools**

Some of the most important R&D program's supporting tools are presented below:

The *Energy Technology Platforms (ETPs)* bring together R&D stakeholders, led by industry, to define medium- to long-term research and technological development objectives. There are seven ETPs: Hydrogen and Fuel Cells (established in 2003), Solar Photovoltaics (2005), Zero-Emission Fossil Fuels (2005), Smart Grids (2006), Biofuels (2006), Solar Thermal (2006) and Wind (2006). ETPs help the stakeholders establish long-term Strategic Research Agendas (SRAs), and contribute directly to the FP7 work plans, ensuring that EU-funded R&D is relevant for users. In order to secure implementation of their SRA, a primary objective of the

ETPs is to influence industrial and research policy, at EU, national and regional levels, and to encourage public and private investments in R&D and innovation in key technological areas. The SRAs have provided input which was taken into account when designing FP7 and will continue to impact on the annual work programs of the FP7.

The *Joint Technology Initiatives (JTIs)* have been developed by some ETPs. The concept of JTIs was introduced in FP7 as a way of creating public-private partnerships in European R&D. In a limited number of cases, JTIs may be set up to implement ETP SRAs (or parts thereof) where these have achieved such an ambitious scale and scope that existing instruments are not appropriate. To help identify such cases where a JTI could be of particular relevance, identification criteria have been developed by the Commission. While ETPs allow public and private stakeholders to jointly define research needs, JTIs are a way of implementing large-scale applied and industrial focused research activities, based in part on the needs identified by ETPs.

The *Competitiveness & Innovation Program (CIP)* and especially its Intelligent Energy for Europe pillar are aiming to complement the FP7 activities by addressing non-technological barriers and providing support to accelerate investment and stimulate the market uptake of innovative technologies across the Community. This program is run by the Executive Agency for Competitiveness and Innovation. The key aim of the CIP is to create an EU-wide network of actors capable of participating in European as well as national, regional and local initiatives furthering sustainable energy use. This EU-wide infrastructure is expected to allow the extensive sharing of experiences through dedicated networks [5].

## 2.11. External Relations

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International energy policy must pursue the common goals of security of supply, competitiveness and sustainability. While relations with producing and transit countries are important, relations with large energy-consuming nations and particularly emerging and developing countries are of growing significance. Cooperation with supplier and transit countries takes place within multilateral frameworks such as the World Trade Organization and the Energy Charter Treaty, through regional initiatives such as the Energy Community Treaty (to which the European Community is a party) and in the bilateral context through Partnership and Cooperation Agreements and Free Trade Agreements, which provide legally binding rules for the energy sector.

By the end of 2011 the Commission is about to present concrete proposals to reinforce the overall consistency and efficiency of our external energy policy, involving Member States, various external policies of the EU and external support programs. Some of the most important external relations of the EU are:

### 1. EU-Russia Energy Partnership

Russia and the European Union are natural partners in the energy sector. The energy partnership aims to improve the investment opportunities in Russia's energy sector in order to upgrade and expand the energy production and transportation infrastructure, as well as improve their environmental impact, to encourage the ongoing opening up of energy markets, to facilitate the market penetration of more environmentally friendly technologies and energy resources and to promote energy efficiency and energy savings.

Russia is already the largest single energy partner of the EU and is bound to become even more integrated in Europe's energy equation. Russia has been a most reliable energy supplier, always respecting the dates, amounts and prices concluded even during periods of

internal political turbulence or dramatic world market developments. In this respect, Russia deserves to play a role in the EU internal energy market subject, however, to conditions of reciprocity in market principles, mechanisms and opportunities, as well as equivalent environmental standards.

The Energy Dialogue with Russia has rapidly become one of the key issues in bi-lateral EU-Russia relations and one in which the format of frank, open discussions have already permitted substantial progress to be made [51].

## **2. Africa-Europe Energy Partnership (AEEP)**

The AEEP is a long-term framework for structured political dialogue and co-operation between Africa and the EU on energy issues of strategic importance, reflecting African and European needs. Through the Partnership, Africa and Europe work together to develop a shared vision and common policy answers, and to stimulate specific actions that address the energy challenges of the 21st century.

AEEP initiatives contribute to existing national, regional and continental energy objectives and strategies in Africa, and take into account the necessary social and environmental standards. The overall objective of the AEEP is improved access to reliable, secure, affordable, cost-effective, climate friendly and sustainable energy services for both continents, with a special focus on achieving the Millennium Development Goals in Africa. In order to achieve its overall objective, the AEEP will focus its efforts on concrete, realistic, visible targets to be attained by 2020, as agreed by the First High Level Meeting of the AEEP held in Vienna on 14–15 September 2010. Some of these targets are the increase of electricity interconnections both within Africa and between Africa and the EU; doubling the use of natural gas use in Africa, and exports to the EU; increase the RES installed capacity; improving energy efficiency in Africa in all sectors etc [52].

## **3. EU-US Energy Cooperation**

The EU and the US share a long tradition working together to promote strong economic growth. This is pursued through multilateral and bilateral mechanisms. Bilaterally, the EU-US annual presidential Summits have fostered cooperation.

Ensuring security of energy supply, developing competitive markets and meeting the environmental challenges are at the top of the EU and US political agendas. The EU and the US have agreed to develop a strategic cooperation on energy and energy security, presented in a joint declaration at the EU-US Vienna Presidential Summit on 21st June 2006. This cooperation will contribute to increased regional stability, greater security of supply and finally, new business opportunities. The dialogue with the US is part of the EU external policy to serve Europe's energy interests [51].

## **4. The Baltic Sea Region Energy Cooperation (BASREC)**

In October 1999, the energy ministers of the Baltic Sea region countries and the European Commission decided in their conference in Helsinki to set up the Baltic Sea Region Energy Cooperation (BASREC). The countries participating in BASREC are Denmark, Estonia, Finland, Germany, Iceland, Latvia, Lithuania, Norway, Poland, Russia, and Sweden. The Commission is a full member represented by Directorate-General Energy and Transport.

The main issues addressed are security of energy supply and the growing dependency from Russia, gas transit routes, progress on electricity and gas interconnection, energy efficiency, climate change, and renewable energies [51].

## **5. EU-China Energy Cooperation**

Since more than 30 years the European Commission and China enjoy diplomatic relations, enshrined in the EU-China Trade and Economic Cooperation Agreement signed in 1985. Over the course of the last decades a series of Sectoral Dialogues have been established where the EU and China cooperate in specific areas. EC-China relations on energy are one of these dialogue series, and in fact constitute one of the most constructive areas of cooperation

between the EC and China. Today the relations are marked by a mutual understanding of the added value of cooperation in the field of energy.

Energy cooperation has been in existence since 1994 and is one of the earliest Sectoral Dialogues between the European Commission and its Chinese partner in EU-China foreign relations. Two main bilateral forums on energy allow for close cooperation. Conferences between the Directorate-General for Energy and the Chinese Ministry of Science & Technology take place on a bi-annual basis, alternating between China and Brussels since 1994. Furthermore an annual energy dialogue with the National Energy Administration of China is being pursued since 2005. In addition, energy issues are also being discussed between Heads of States at the EU-China summits, which take place once a year. The most recent one took place in October 2010.

Six priority areas have been identified for cooperation between the EC and China in the field of energy: Renewable energy, smart grids, energy efficiency in the building sector, clean coal, nuclear energy and energy law [51].

## **6. European Neighborhood Policy (ENP)**

The ENP was developed in 2004, with the objective of avoiding the emergence of new dividing lines between the enlarged EU and our neighbours and instead strengthening the prosperity, stability and security of all. This ENP framework is proposed to the 16 of EU's closest neighbours – Algeria, Armenia, Azerbaijan, Belarus, Egypt, Georgia, Israel, Jordan, Lebanon, Libya, Moldova, Morocco, Occupied Palestinian Territory, Syria, Tunisia and Ukraine.

Central to the ENP are the *bilateral Action Plans* between the EU and each ENP partner (12 of them were agreed). These set out an agenda of political and economic reforms with short and medium-term priorities of 3 to 5 years. Following the expiration of the first Action Plans succession documents are being adopted. The ENP is not yet fully 'activated' for Algeria, Belarus, Libya and Syria since those have not agreed Action Plans.

In 2009, the EU and its ENP partners further strengthened energy cooperation and ENP partners progressed in their sector reform. Bilateral cooperation with ENP partners generally continued under the ENP Action Plans and the Energy Memoranda of Understanding and Declarations (Azerbaijan, Egypt, Jordan, Morocco and Ukraine).

At regional/multilateral level, the EU and the Eastern partners launched cooperation under the *Eastern Partnership*. The six Eastern partners participated in the first meetings (May and November 2009) of the Eastern Partnership Platform on Energy Security. The Platform will promote the implementation of mutual energy support and security mechanisms by initiating work on 'Security of Supply Statements'. The Platform furthermore covers energy efficiency and renewable energy. The EU and the Eastern partners continued implementing the 2006 energy roadmap agreed by ministers under the 'Baku initiative' for EU-Black Sea/Caspian energy cooperation. They continued cooperation in the areas of market integration, regulatory convergence, networks, energy efficiency and renewable energy.

The Mediterranean ENP partners and the EU pursued implementation of the priority action plan 2008-2013, decided by Euro-Mediterranean energy ministers. They continued work towards the longer-term objective of establishing Euro-Mediterranean gas and electricity rings. Partners further worked on the Mediterranean Solar Plan. Other areas of cooperation cover regulatory convergence, the creation of a Maghreb electricity market and a Euro-Mashraq natural gas market, energy efficiency, renewable energy and statistical matters. The EU and the Mediterranean partners continued their cooperation through the Cairo-based Regional Centre for Renewable Energy and Energy Efficiency for Middle East and North Africa countries, which is supported by the European Commission, Denmark and Germany [51].

EU energy policy has an impact beyond EU borders, first because of the size of the population and the number of countries it affects, and secondly because of its design, with recent policy proposals being explicit about the aspiration of the EU to become a global leader in creating



sustainable energy policy. As a consequence of this ambition, and the realisation of the responsibilities thrust upon it, the Commission has developed some energy policies that are at the cutting edge of global energy policy development. In particular with integrating energy into the broader sustainability objectives and approaching policy issues in an integrated way, by drawing together energy security, cost, and environmental policies into a comprehensive framework. This is highly commendable, and the Commission is encouraged to continue on this path.

Since 2006, helped by political commitments in the European Council and clear indications from the EP, the Commission is developing and driving a strong, coherent energy policy at EU level, which recognises the increasingly pressing challenges of growing imports of energy, while addressing the environmental impact of energy production and use. In response to compelling and growing global energy security and climate change challenges, the Commission has developed a clear and comprehensive energy policy built upon three intrinsically linked elements:

- Sustainable development and building a low-carbon future.
- Decisive actions to achieve the long-held European goal of a single energy market.
- Energy security and external relations.

These closely interlinked challenges are very difficult to resolve and the Commission is highly commended for offering a range of bold and politically demanding proposals that are essential to success in overcoming them. The energy security/climate change endeavour is taking place at a timely moment for action. The timing also shows the critical risk of failure to deliver the internal market. This will add uncertainties that are detrimental for competitiveness and security of supply and for meeting the challenging political goals; failure to achieve the environmental goals will affect energy security as well.

The Commission has launched a wide-ranging and ambitious agenda. It is however by no means clear that the resources available are allocated in a manner that is commensurate to the goals pursued. Policy implementation, execution and monitoring normally require more resources and sophisticated organisation than policy planning, and a shortage of resources could lead to inadequate compliance, with grave consequences for the achievement of the targets [5].

# 3

## RES Penetration Progress

The effort, towards increasing RE penetration, as a Union and not individually, started with the White Paper of 1997, "*Energy for the Future - Renewable Energy Sources of Energy - White Paper for a Community Strategy and Action Plan*". This Community strategy confirms an indicative target of a 12% share of renewable energy sources in total final energy consumption by 2010. The target was characterized ambitious but realistic and a good policy tool, giving a clear political signal and impetus to action.

At the end of 2001 the *Directive on the Promotion of the Electricity Produced from Renewable Energy* (2001/77/EC) was adopted. In accordance with the White Paper, the overall indicative target of this directive was to increase, by 2010, the share of renewable energy in final energy consumption to 12% with the total renewable electricity target to 21% (adapted to 2004 EU expansion) of overall electricity consumption.

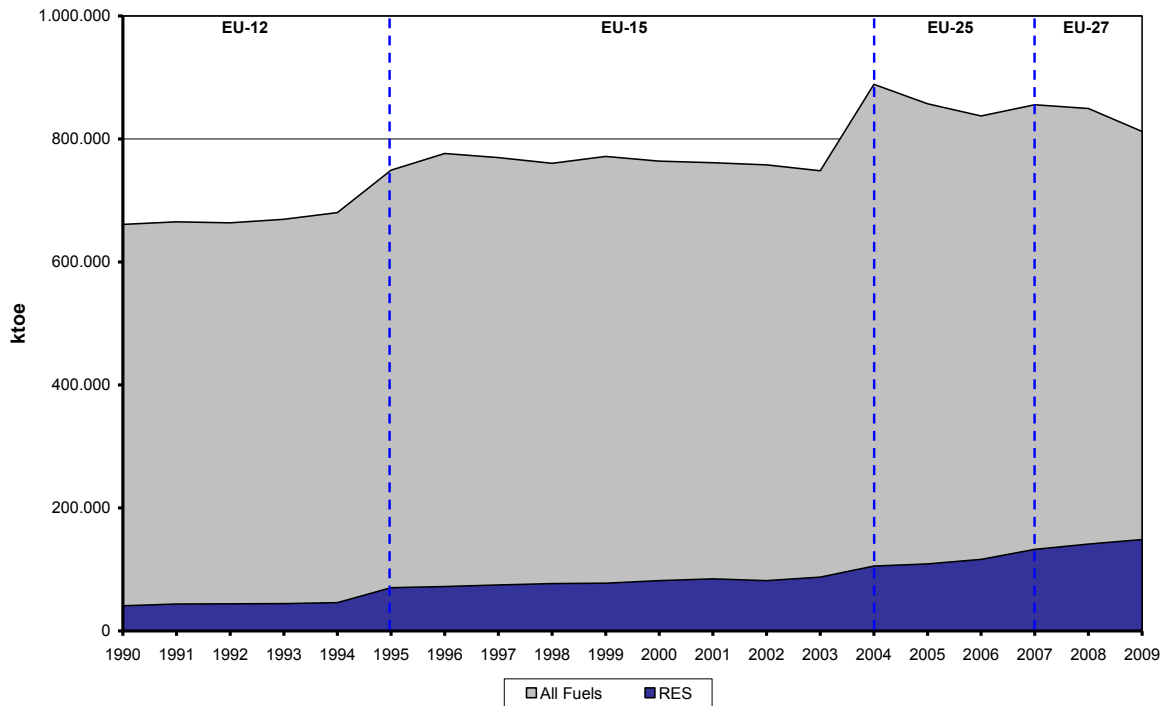
In 2003 the Directive "*on the promotion of biofuels or other renewable fuels for transport*" (2003/30/EC) was adopted. The Directive stipulates that Member States should set national indicative targets to raise the share of biofuels in their transport fuel market up to 5,75%, by 2010, of the share of biofuels in diesel and petrol for transport purposes calculated on the basis of energy content.

Although significant progress has been made, the 2010 targets set out by the Commission in the 2001 and 2003 directives regarding renewables in general, renewable electricity and renewable transport fuels have not been achieved as was admitted through the MEMO 11/54 of January 2011.

Overall it is clear that the first phase (up to 2010) of the effort has come to its end, without the desirable results, and the second one, towards the 2020 targets, has started in the mid of a financially tough period for EU.

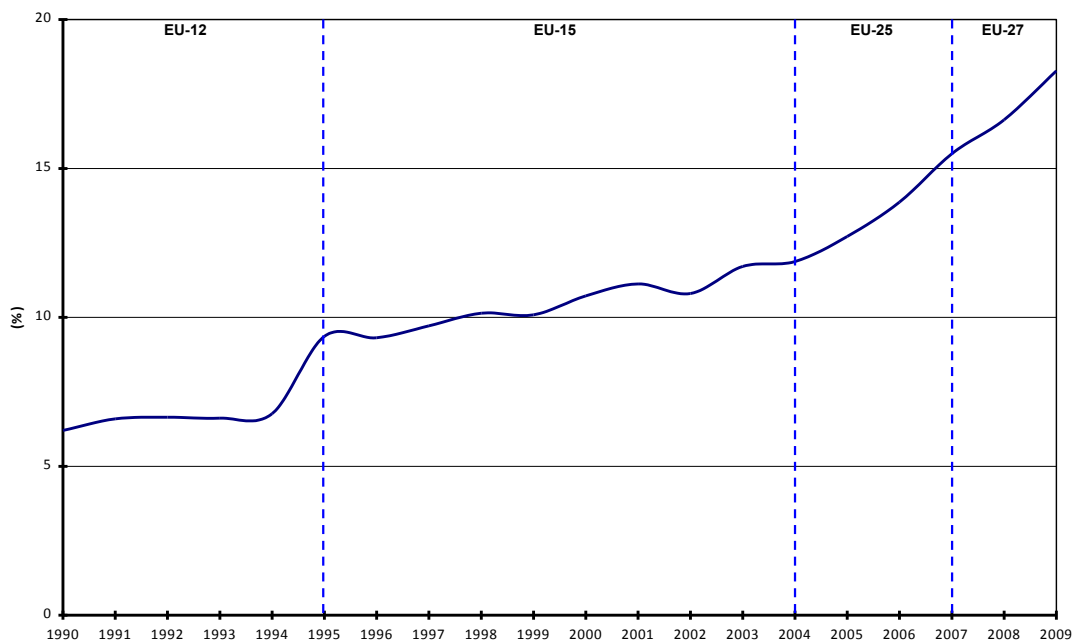
### 3.1. Overall Progress

During the past decade, the EU has emerged as the world's leading region in developing and implementing renewable energy technologies.

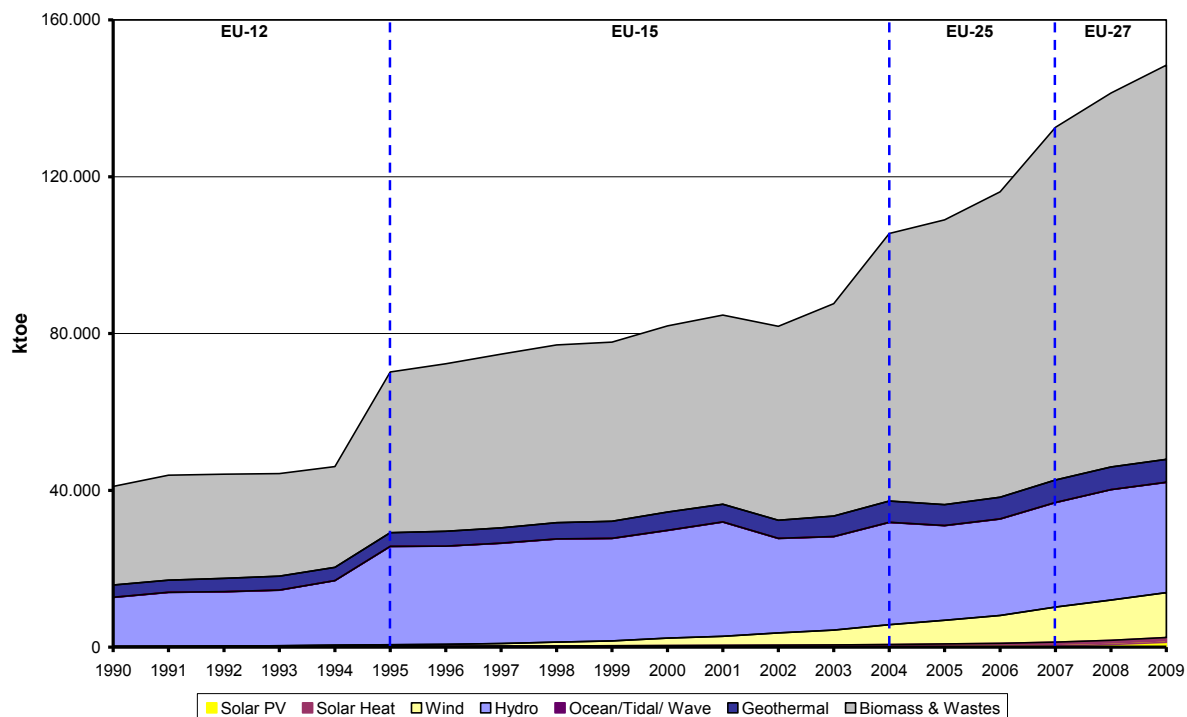


**Figure 3.1.** Primary energy production in EU.  
Data Source: [10]

Renewable energy share in primary energy production was 6,2% in 1990 and rose to 9,7% in 1997. A significant increase can be observed after the implementation of the first RES and biofuels directives with 18,3% RES share in 2009.



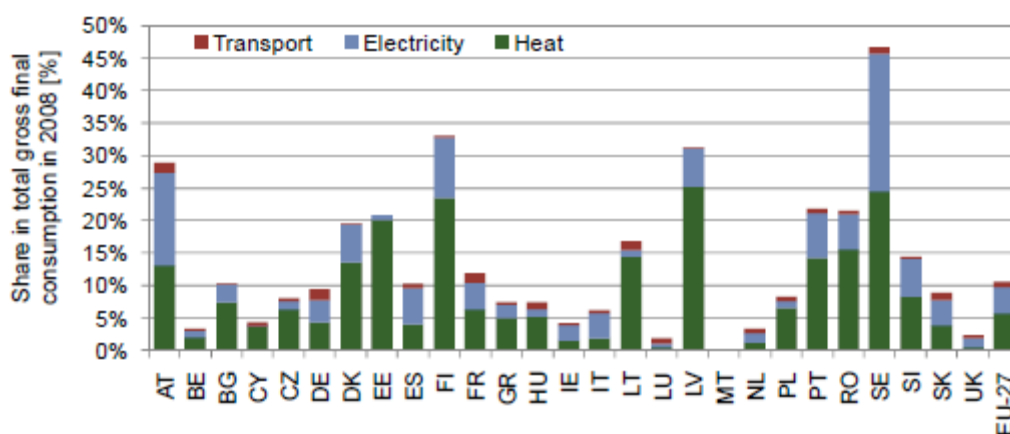
**Figure 3.2.** RES share in primary energy production.  
Data Source: [10]



**Figure 3.3.** RES in primary energy production.  
**Data Source:** [10]

RES in primary energy production were increased by 82,3% from 41Mtoe (1990) to 75Mtoe (1997). A further 98,6% increase occurred up to 148Mtoe (2009) with an average rate of 9% over the last seven years.

In the next figures the status of renewable energy sources at the member state level is presented. In Figure 3.4 the share of RES in total gross final consumption is shown for the year 2008 for all EU member states. This figure shows a large variance between countries, with Sweden consuming almost half of the total final energy in the form of RES, while Malta has a share close to zero. Seven member states have already achieved a share of 20% RES in gross final consumption, whereas biomass in the heating sector and hydropower in the electricity sector are still the dominant sources (Figure 3.4). In most member states, the total RES generation is dominated by renewable heating, followed by RES-E. Biofuels in the transport sector show only a minor but quickly growing contribution to RES in total final consumption. In absolute figures, almost 50% of the total final energy from RES is contributed by the three countries Germany, France and Sweden, as can be seen from Figure 3.5.



**Figure 3.4.** RES per sector in total gross final consumption in 2008 [22].

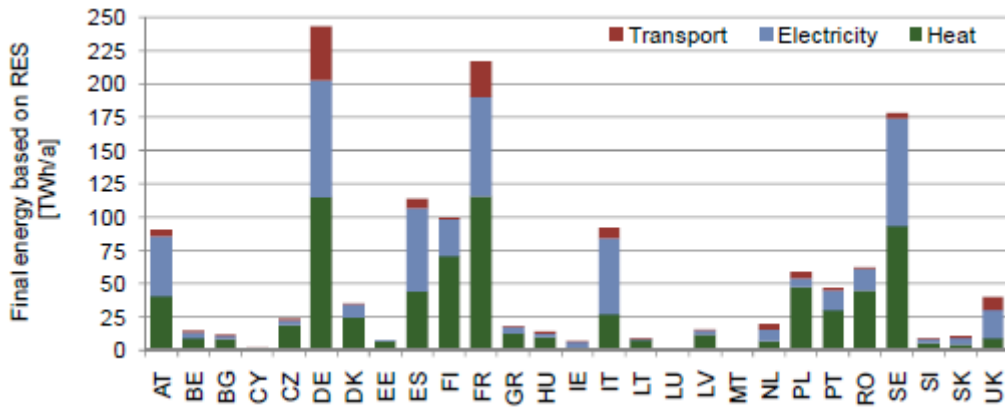


Figure 3.5. Final energy from RES in 2008 [22].

In spite of this progress the 12% target was missed. According to the MEMO 11/54 issued by the Commission on 31 of January 2011, the EU failed to meet the overall 12% from RES in final energy consumption with only a few Member States having reached their quotas.

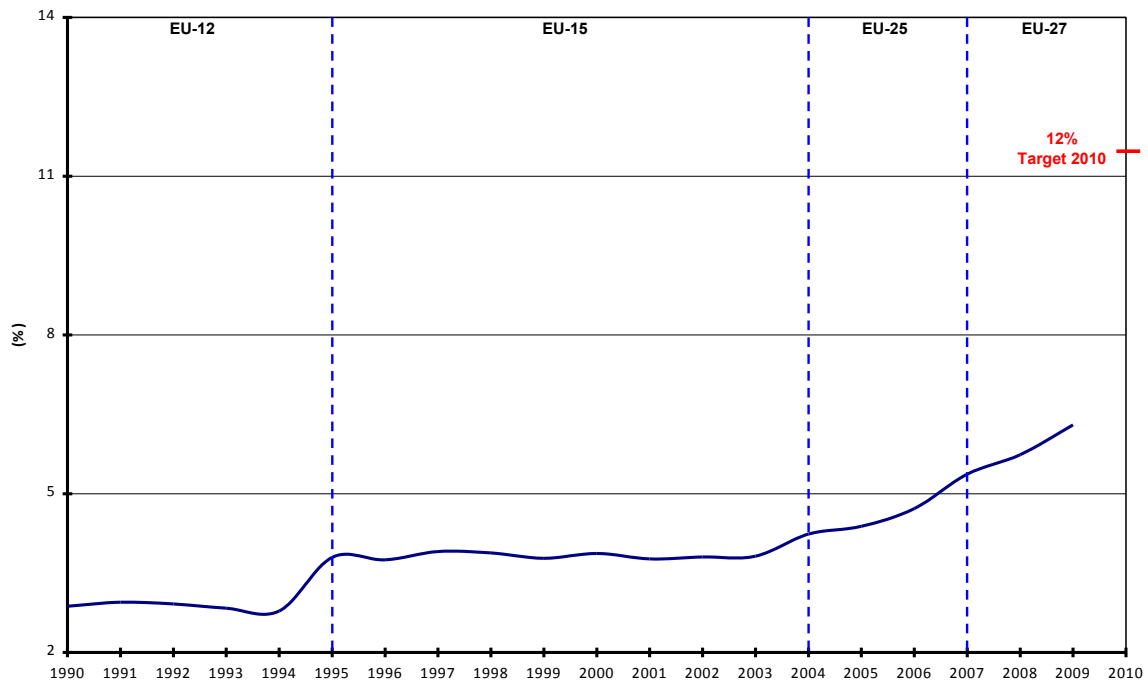


Figure 3.6. RES share in final energy consumption.

Data Source: [10]

There are several reasons for this. Even though the cost of most renewable energy sources is declining, in some cases quite dramatically, at the current stage of energy market development renewable sources will often not be the short term least cost options. In particular, the failure to systematically include external costs in market prices gives an economically unjustified advantage to fossil fuels compared with renewables.

Another important reason is the complexity, novelty and decentralised nature of most renewable energy applications result in numerous administrative problems. These include unclear and discouraging authorisation procedures for planning, building and operating systems, differences in standards and certification and incompatible testing regimes for renewable energy technologies.

The development recorded so far is made up of generally patchy and highly uneven progress across the EU, highlighting that national policies have been inadequate for achieving the EU target. While ambitious policies creating investor certainty have been adopted in some Member States, national policies have proven vulnerable to changing political priorities. The absence of legally binding targets for renewable energies at EU level, the relatively weak EU regulatory framework for the use of renewables in the transport sector, and the complete absence of a legal framework in the heating and cooling sector, means that progress to a large extent is the result of the efforts of a few committed Member States. The differences in the regimes for electricity, biofuels and heating and cooling established at EU level are reflected in the development of the three sectors: clear growth in electricity, the recent start of solid growth in biofuels, and slow growth rates for heating and cooling. For all the previously mentioned reasons EU decided to implement a more strict policy by adopting the new RES Directive (2009/28/EC) in order to strengthen the framework towards the 2020 targets.

### 3.2. Electricity (RES-E)

In Figure 3.7 the historical development of electricity generation from renewable sources (RES-E) in the European Union is presented. Data is provided by Eurostat until 2008 as this is the most recent year for which data is available from the Eurostat databases (RES include the large hydro according to Eurostat).

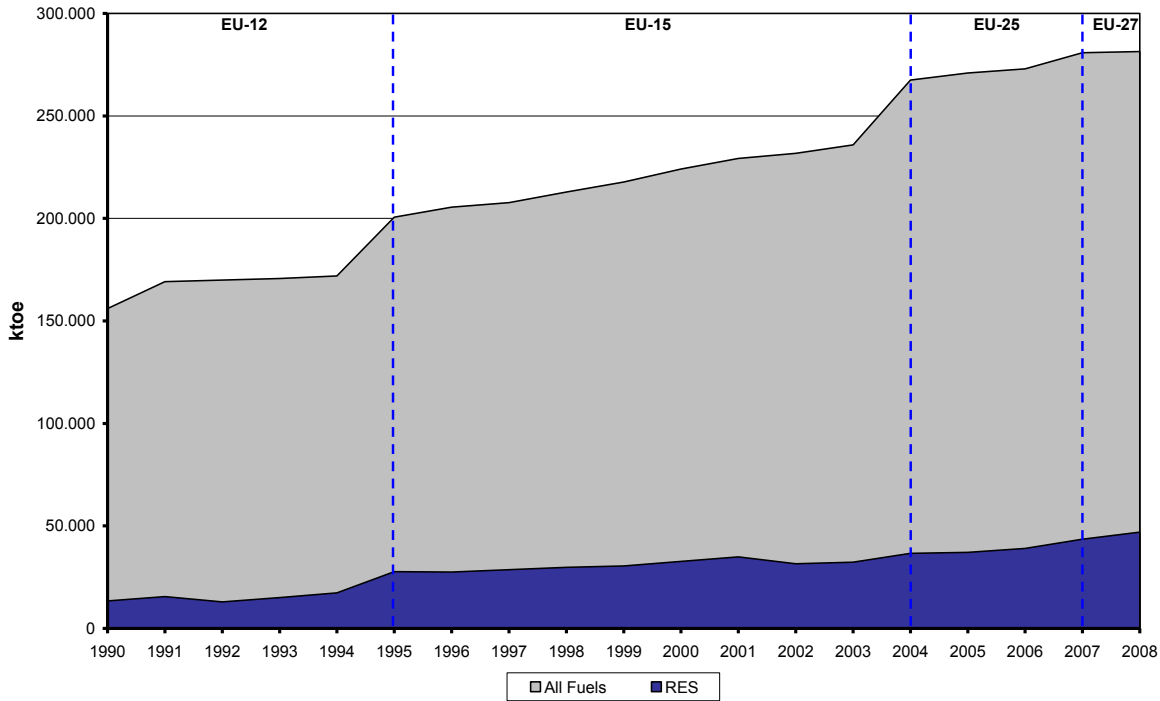
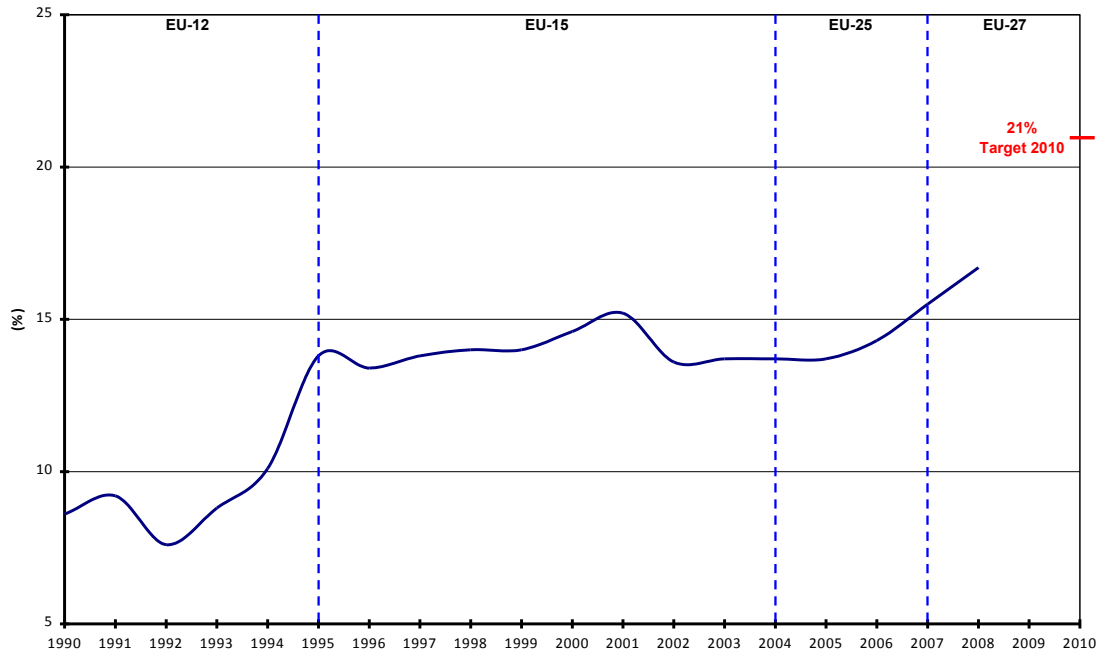


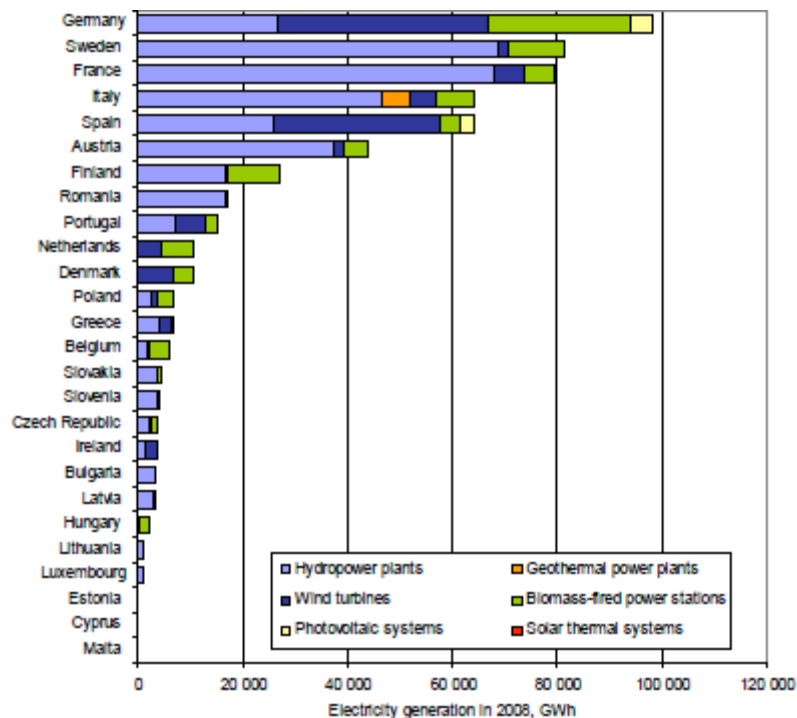
Figure 3.7. Electricity final energy consumption.  
Data Source: [10]

In 1997, when the European Commission initiated discussions on a European renewable energy policy, the share of renewable electricity in the European Union was 13,8%. By 2008, 16,7% of the European Union's final electricity consumption was from renewable energy sources: a 21% increase from 1997 levels. In the same period electricity consumption increased from 207,7 Mtoe (1997) to 281,4 Mtoe (2008), a 35,5% increase.



**Figure 3.8.** Share of RES in final electricity consumption.  
**Data Source:** [10]

Important policies like indicative targets for Member States, support schemes evaluation, GOs, efforts to simplify administrative procedures and grid priority access were introduced with the Directive 2001/77/EC at the end of 2001. From 2002 up to 2008 the increase in total electricity gross final energy consumption was 49% while from 1997 up to 2002 it was 10%. So, the first RES directive set strong foundation for the growth of RES-E. However, EU missed the 21% target of 2010. According to the MEMO 11/54, the EU as a whole reached just over 18% with only seven out of twenty seven Member States expected to meet their 2010 share.

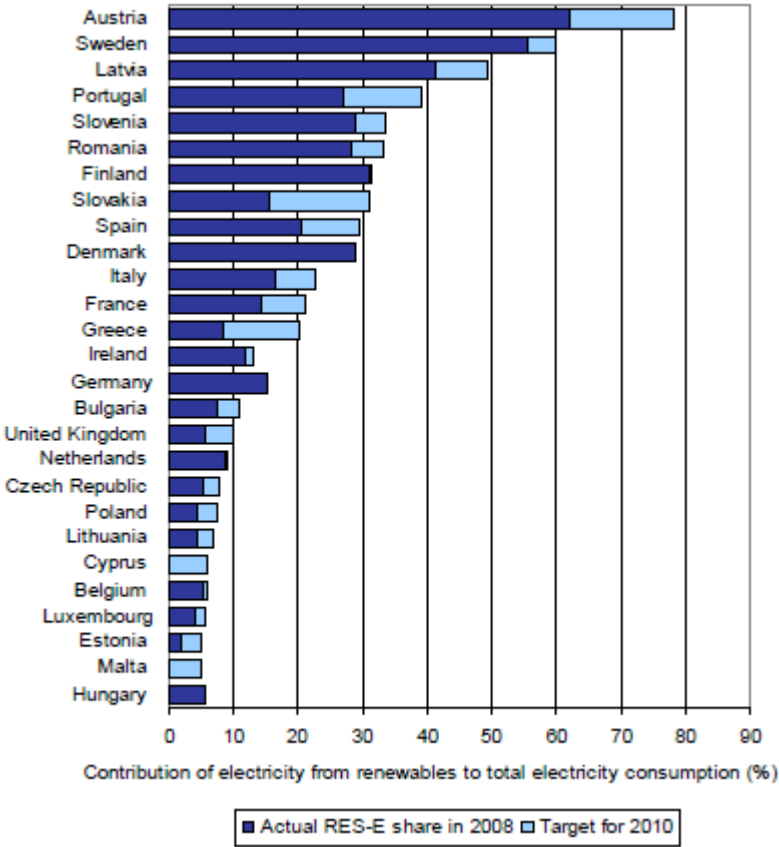


**Figure 3.9.** RES-E generation in 2008 per Member State [55].

In Figure 3.9 the renewable electricity profiles of each EU Member State are presented for the year 2008. As hydropower is the largest renewable electricity source in Europe, the countries, which have significant hydropower assets, dominate the total RES-E production as well.

Wind power production is most notable in Germany, Spain, and Denmark, while the top countries in producing electricity from biomass are Germany, Sweden, Finland, the Netherlands, Italy, and France. Only Italy has notable power generation from geothermal power plants. In Germany and Spain, photovoltaic power generation has increased in the recent years and is at present a significant source of electricity. Only Spain has solar thermal electricity generation, and the figures are still too low to show in graphics.

EU has regularly assessed how Member States are progressing towards the 2010 targets. The last progress report showed that the EU will not achieve the RES-E target in 2010 (EC 2011). Only Hungary and Germany had already achieved their targets in 2008 and a few Member States (Denmark, Ireland, Lithuania, Poland and Portugal) are still likely to achieve their 2010 targets for renewable electricity in electricity generation. Targets for RES-E by Member State and the situation in 2008 are presented in Figure 3.10 [55].



**Figure 3.10.** Member States' progress towards their indicative energy targets for electricity in 2008 [55].

There are many reasons for different progress rates among Member States [56] [57]. Earlier analysis of Member States' different support schemes shows that stability is a critical feature of an effective system, in order to facilitate investment. Consequently, "stop-and-go" regimes that run out of budget, as well as policy and rule changes hamper the development of renewable electricity. Despite some improvements, such as the development of premium feed in tariffs and more detailed technology banding, it remains essential to improve support schemes, particularly for those Member States with slow rates of progress.



Several non-cost related barriers are also significant constraints on the growth of renewable electricity. It is for this reason that Directive 2001/77/EC requires actions to be taken to improve consumer information (the creation of guarantees of origin), reform administrative procedures and ensure better grid access for renewable electricity.

Examination of the guarantee of origin regime reveals that it has still not been implemented fully by all Member States, with problems of reliability, double counting and the risk of disclosure of the same energy to two different groups of consumers. This has undermined the consumer market for renewable electricity in general; a market which could have been a further source of revenues and hence investment. Whilst Directive 2001/77/EC allows Member States to agree to transfers of guarantees of origin to count towards another Member State's target (enabling a member State to reach its target more cost effectively), no such agreements have been established and no such transfers have occurred.

The administrative procedures associated with planning and developing renewable energy capacity have been the subject of careful examination in previous Commission reports. However, little progress appears to have been made on any of the Commission's recommendations for administrative reforms. Procedures continue to be complicated, with multiple authorities requiring consultation when applying for construction, development or environmental permits. Surveys suggest that the time lags involved and the uncertainty of the process remain major bottlenecks.

The problems of gaining connection to the electricity grid often result from a lack of adequate rules on grid connection and from a failure to dedicate sufficient administrative resources to process applications. Technical problems are also disruptive, with limited capacity of the grid to incorporate more variable renewable electricity and a general lack of strategy to address the problem. There are also financial constraints, with different and often opaque connection charging rules and risk of discrimination against smaller distributed power generators compared to large incumbent conventional energy producers.

The issues associated with grid access highlight the role that large power producers play in the less than perfectly competitive internal market. The inadequacies of the energy market highlighted recently in the Commission's third internal energy market package have also contributed to the difficulties for producers of renewable electricity to gain access to the market and to compete fairly. This issue has also been addressed by the Commission and the timely adoption and implementation of the package will ensure significant steps are taken to level the energy market playing field.

The above reasons for the slow progress in developing renewable electricity are not new. Directive 2001/77/EC addresses them explicitly. However, despite the Directive and the monitoring and guidance of the European Commission, some Member States have failed to take adequate measures. Since 2004, the Commission has been obliged to start 61 legal proceedings against Member States for non-compliance with the Directive. Italy has had the most cases, with 13, followed by Spain with 6, Austria with 4 and the Czech Republic, France, Latvia and Poland with 3 each. Of these 61 cases, 16 have not yet been resolved. The European Commission will continue to monitor Member States' compliance with the Directive and will open infringement cases wherever necessary. However the poor progress and number of infringement proceedings also implies that the legal framework is not sufficiently strong. This is one reason for the new Directive on renewable energy.

A better focus on Administrative barriers and grid access problems will help understand why they play a major role in progress of RES-E penetration. Directive 2001/77/EC requires that electricity from renewable energy sources has guaranteed access to the grid and requires Member States to set rules for sharing and bearing the cost of various grid investments necessary to integrate it. Member States are also permitted to give priority access to

networks.COM(2006)84810 noted that grid connections and extensions needed to be simplified and stated that the Commission would "continue to co-operate closely with grid authorities, European electricity regulators and the renewables industry to enable a better integration of renewable energy sources into the power grid..." SEC(2008)5711 noted that despite the requirements of Directive 2001/77/EC, project developers still faced different grid-related barriers, which were mainly related to insufficient grid capacity, non-transparent procedures for grid connection, high connection costs and long lead times to obtain authorisation for grid connection. High priority should be given to remove administrative barriers and improve grid connection for renewable energy producers.

Commission analysis has also been undertaken to examine some of the administrative procedures that are considered to be potential barriers to the development of renewable electricity. An examination of the permit regimes for building renewable electricity plants highlighted a wide variety of practices across Member States. On average, over nine different authorities needed to be contacted. This amount varied according to the Member State, the technology in question and sometimes the size of the installation.

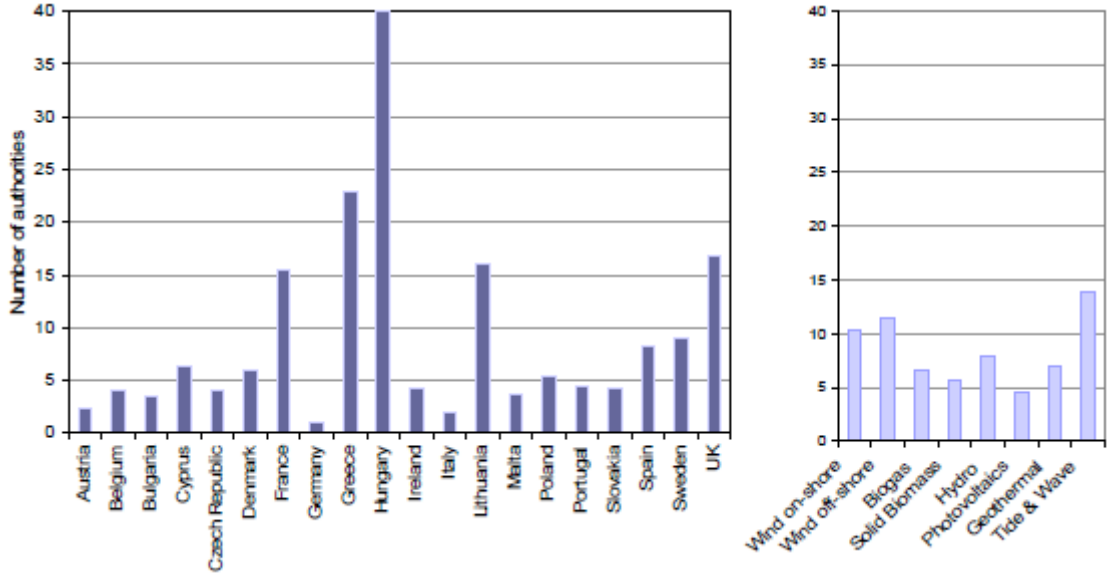


Figure 3.11. Average number of authorities involved in the permission procedure [56].

There have been some reforms to the authorisation process in recent years. For example, the UK revised its legislation on planning permission for projects of national interest and the Greek government has begun to streamline environmental permission procedures by setting up two central bodies to coordinate procedures and has limited the time authorities have to grant or deny permits to 6 months.

National practices differ, and whilst most informed, potential renewable electricity producers believe that the procedures for licensing are clear; a common complaint is the lack of time limits for responses. This problem appears to have been exacerbated by the introduction of tiers of regional government working in conjunction with support schemes or authorising bodies at a national level. Examining the duration of permit planning also reveals differences according to Member States and technologies (Figure 3.12).

In general, average lead times for grid connection were very high representing a significant bottleneck. Exceptionally high authorisation procedure lead times were reported for offshore wind developments.

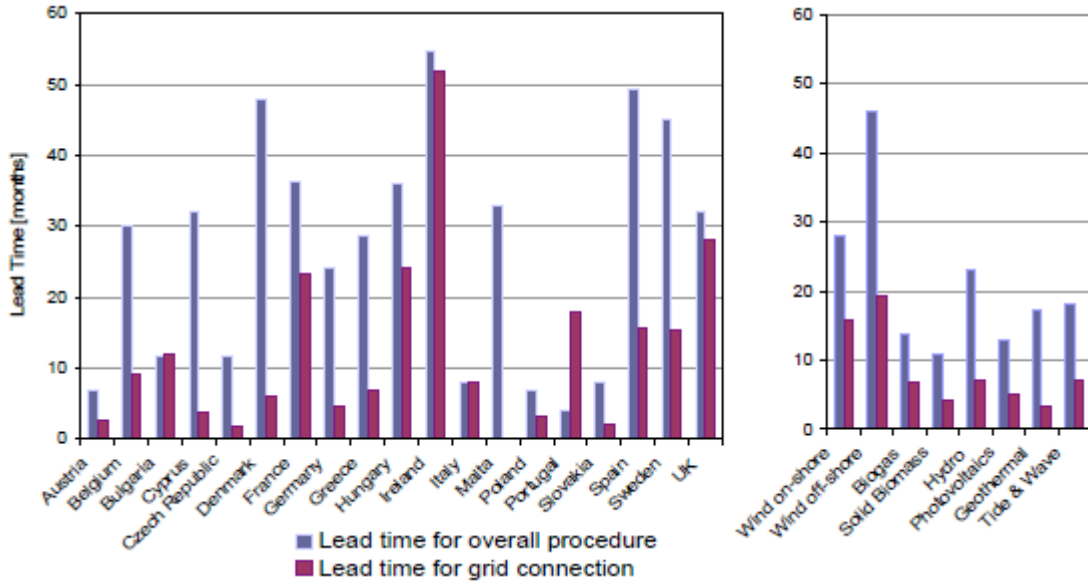


Figure 3.12. Average lead time in months for overall procedure and grid connection [56].

The uncertainty of the procedure and the time it takes to complete the process compound the uncertainty of the overall acceptance or rejection of an application. On this point there is wide variation across Member States but less variation according to technology. The average rate of permit rejection is 30% but in some cases (reflecting ad hoc moratoriums on certain technologies in certain regions or countries) the rate is much higher.

In many cases, a lack of grid capacity represents a crucial factor for rejection. This and other reasons (such as an excess of applications) suggest that better structured administrative procedures, further administrative resources and coordination with grid planning is necessary. For instance, in countries with a high rate of successful planning appeals, an increase in resources for initial applications could speed up the treatment of applications, increase the rate of initial approvals and reduce the administrative costs associated with appeals.

Analysis of the planning process reveals that problems relating to grid connection and capacity are a major obstacle which is more often generated by limits on administrative and other resources than technological constraints.

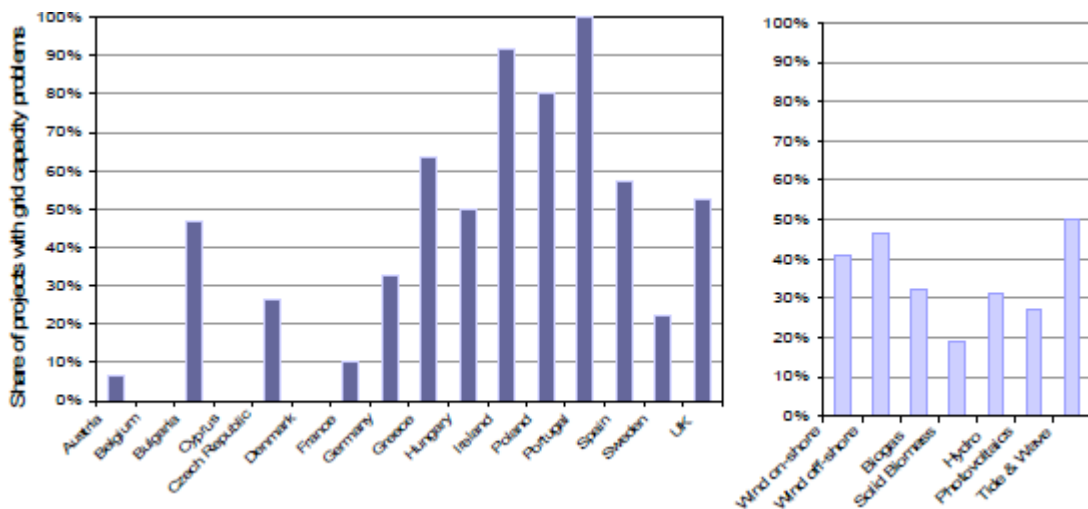
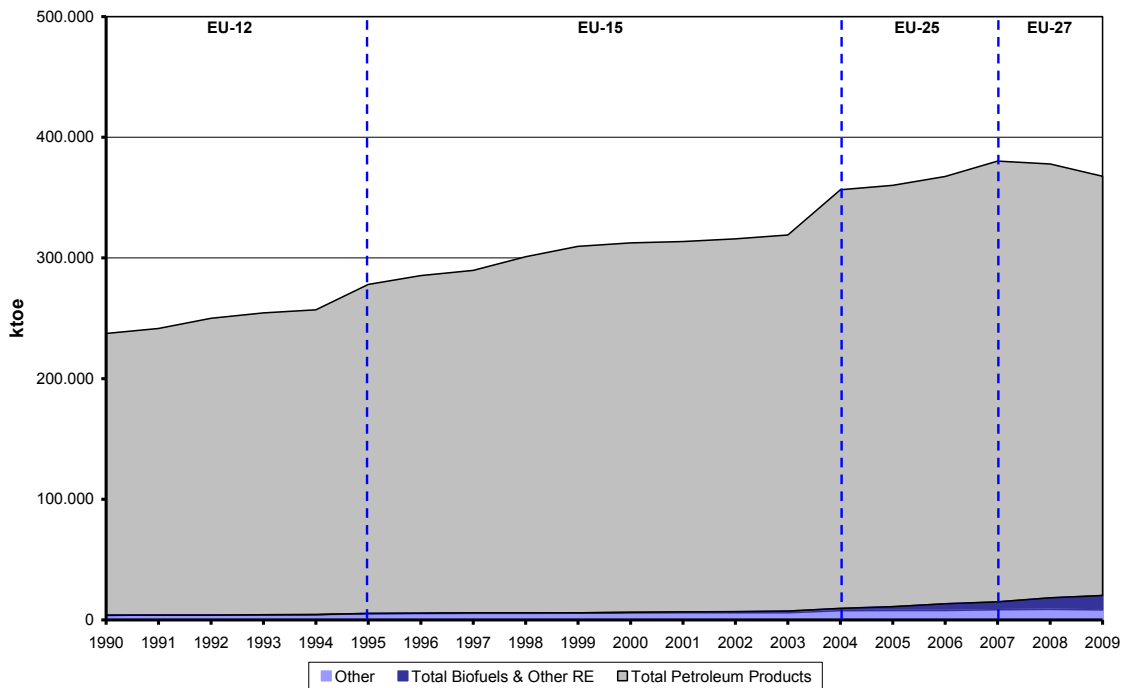


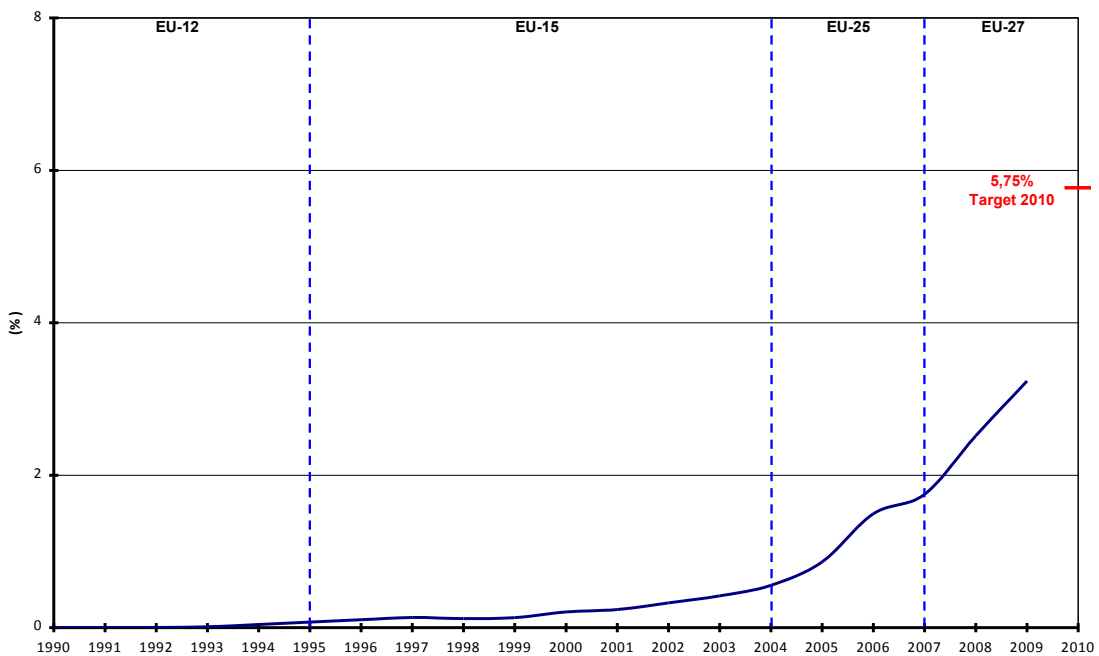
Figure 3.13. Share of planned projects for which insufficient grid capacity represents a major problem [56].

### 3.3. Transport (RES-T)

The Directive 2003 on renewable energy in transport required Member States to set targets for the share of renewable energy replacing petrol and diesel in transport in 2005 and 2010, taking as their starting point reference values of 2% and 5,75% respectively. It is known as the "Biofuels Directive" since in practice, biofuels were expected to be the sole contributor in this sector up to 2010.



**Figure 3.14.** Fuels in final energy consumption in transport.  
Data Source: [10]



**Figure 3.15.** Share of RES in final consumption in transport.  
Data Source: [10]

In 2005, biofuels achieved a share of 0,86% in the EU, with only Germany and Sweden reaching the reference targets and the interim target of 2% in 2005 was missed. Biofuels production progressed much faster in 2006 and 2007 than in earlier years. In 2007 the use of biofuels in road transport was 1,75% (6,7 Mtoe). Biofuels contribution in final energy consumption grew by 113% between 2005 and 2007, and by 134% between 2003 and 2005. An overall 800% increase occurred after the implementation of the 2003 biofuel directive while the increase was 240% between 1997 and 2003.

In 2008 four countries – Austria, Germany, Slovakia and Sweden – had already met their 2010 transport targets with France being almost certain to join this group of countries in 2009. With the exception of Slovakia, all of these countries, as well as Finland and Portugal state in their NREAPs their intention to exceed the 5,75% target for renewable energy use in transport in 2010.

According to MEMO 11/54, nine Member States are about to meet their 2010 targets in 2010 with EU reaching 5,1% instead of 5,75% RES share in transport sector.

The more rapid development of biofuels since 2005 reflects the widespread development of support systems at Member State level (see Appendix A3). Tax relief and biofuels obligations remain the two most common instruments used by Member States to promote biofuels. In 2005-2006 all Member States, except Finland, used excise tax exemptions as the main support measure, while biofuels obligations were only used by 3 countries. Since 2007 more than half of Member States have adopted obligations to blend, in most cases combined with partial but increasing levels of taxation. Some countries use a quota mechanism and tender. This mechanism allows Governments to decide the amount of biofuels that has to be supplied each year, thus creating some regulation of the market.

The good progress resulting from tax exemptions and new measures such as biofuels obligations are still in evidence today. The Member States which saw above-average progress in biofuels use between 2005 and 2007 (Figure 3.16) reflect this. It can also be seen from the figure that nine Member States are making little or no progress towards their national targets, raising concern about whether those targets will in fact be achieved.

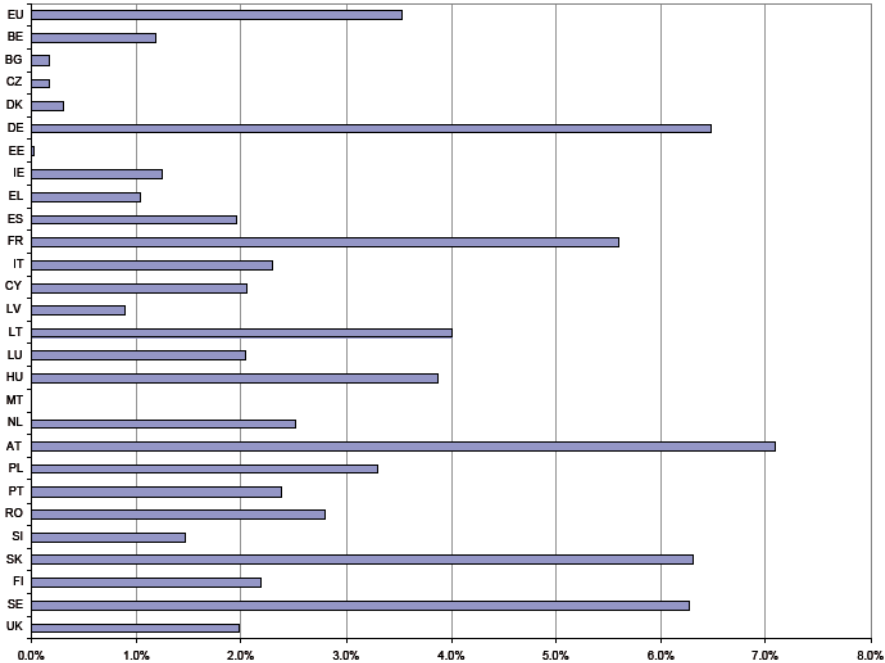


Figure 3.16. Progress of Member States towards 2010 RES-T Targets in 2008 [58].

Since 2005, the Commission has started 62 legal proceedings against Member States for noncompliance with the Directive 2003/30, many of which were for failure to comply with reporting obligations or failure to set national objectives in compliance with the reference values of the Directive. Of these cases Italy, Greece and Finland have had the most with 5 each, followed by France, Denmark and Ireland with 4 and Hungary, Austria, Luxembourg, Portugal and the Slovak Republic with 3. These cases have been successfully resolved. The EC will continue to monitor Member States' progress towards their targets [58].

In the next paragraphs the development of consumption in the EU between 2000 and 2009 is presented [17]. Of the 2009 total, an estimated 11 Mt (75% by mass) was biodiesel and 3,5 Mt was ethanol. Biodiesel accounted for an estimated 5,4% of the approximately 230 billion litres EU road diesel market on a volume basis in 2009. Ethanol accounted for an estimated 3,4% of the approximately 130 billion litre gasoline market, again on a volume basis.

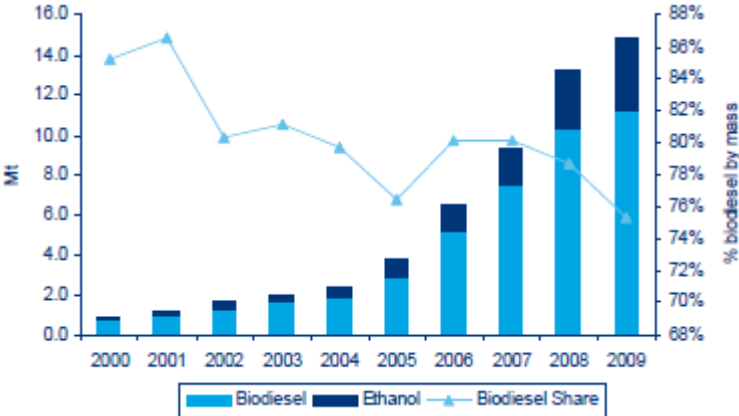


Figure 3.17. Biofuels consumption in EU [59].

Overall, biofuels accounted for 3,3% of energy use in road transport; up from 0,9% in 2005. Biodiesel production grew more than six-fold between 2003 and 2009 to 9 Mt (Figure 3.18). Its Production capacity started to dramatically outpace actual production from around 2007.

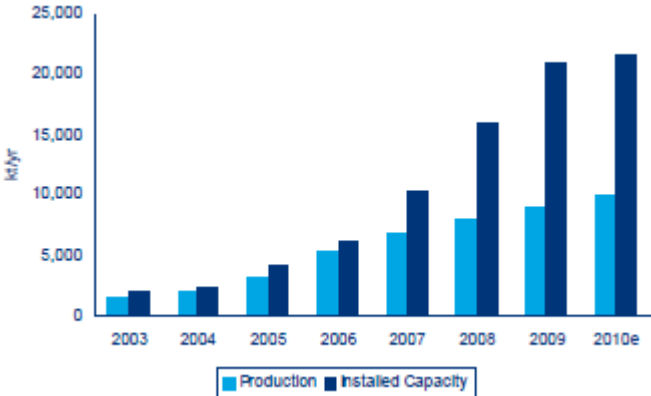


Figure 3.18. Biodiesel production & installed capacity [59].

The relatively low barriers to entry in terms of capital requirements and technology for esterification of vegetable oils, combined with a rising oil price and an apparently supportive regulatory environment led to a surge in investment in biodiesel production plants in the EU. As of July 2009, installed biodiesel production capacity is estimated to have totalled 22 million

tonnes per year. With production of only just over 9 million tonnes in 2009, the average industry utilisation rate for the region was around 40%. A lot of biodiesel production capacity is currently lying idle and many European biodiesel producers are finding themselves in financial difficulties, which were exacerbated by the recent credit crunch. Rationalisation of existing capacity seems inevitable.

Figure 3.19 shows the development of fuel ethanol production in the EU between 2004 and 2009. Production grew more than seven-fold over this period to reach 2,9 Mt. Production is estimated to be growing rapidly in 2010 and could reach close to 4 Mt. Installed fuel ethanol production capacity in Greater Europe as of mid- 2010 is estimated at 5,7 Mt. A further 1,4 Mt of capacity is under construction, potentially raising total capacity to 7,1 Mt over the next couple of years.

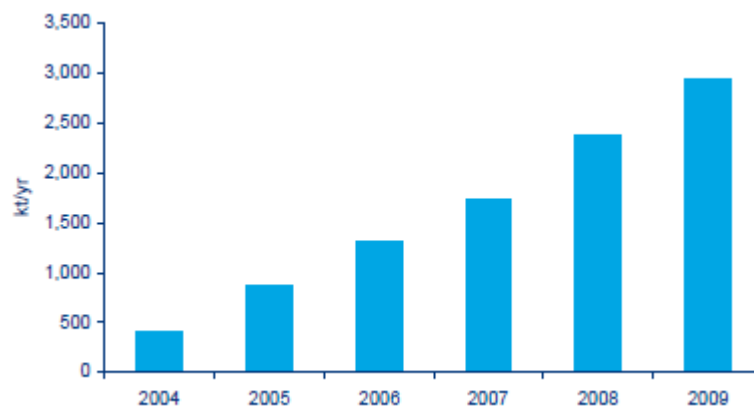


Figure 3.19. Bioethanol production in EU [59].

Overall, it is obvious that biofuels started to play their role in the energy mix at the end of 90s and both their production and consumption skyrocketed after the Directive 2003/30. The 2010 target was missed only slightly and considering their rapid growth and the 10% target for 2020, sustainability criteria were introduced with the RES Directive 2009/28.

### 3.4. Heating & Cooling (RES-H)

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Despite the fact that the RES-H is the dominant sector in RES contribution to final energy (Figures 3.4 & 3.5), its growth has been the least rapid, compared to the RES-E and RES-T sectors. In previous years it had received little political attention and in most EU Member States there is not yet a comprehensive approach to support RES-H. The last directive on RES (Directive 28/2009) finally closed the legislative gap which existed so far for this sector and a more rapid growth is expected in the next years.

The EU renewables based heating market is dominated by domestic decentralised heating appliances using biomass. The use of biomass in centralised heating plants or CHP-plants also plays an important role in Nordic countries, Germany and Italy. Solar thermal heating technologies account for a low share of the total amount of heat generated from renewable energy. Similarly, ground source heat pumps and geothermal heating technologies represent a relatively limited share of renewables based heat production but are expected to experience some growth in the future [60].

In 2008 the share of renewable heating and cooling was 11,9%, compared to 11,5% in 2007 and 10,3% in 2006. The direct use of biomass, covering wood and wood waste, renewable municipal wastes and biogas, contributed 55,1 Mtoe and liquid biofuels used for heating contributed 0,6 Mtoe. Also in 2008, derived heat, produced from heating and CHP plants using biomass, contributed 7,8 Mtoe of renewable energy, solar thermal energy contributed 1,1 Mtoe and low enthalpy geothermal energy 0,7 Mtoe. The direct use of liquid biofuels for heat production in industry and households, the services sector and in agriculture increased significantly, from 128 ktoe in 2006 to 617 ktoe in 2008 [61].

Despite the low contribution of solar thermal in the total share of RES-H sector, it would be interesting to focus on the solar thermal markets trends and development. According to ESTIF, in 2010, the European solar thermal market totalled 2.586 MW<sub>th</sub> (3.694.940 m<sup>2</sup>) of newly installed capacity.

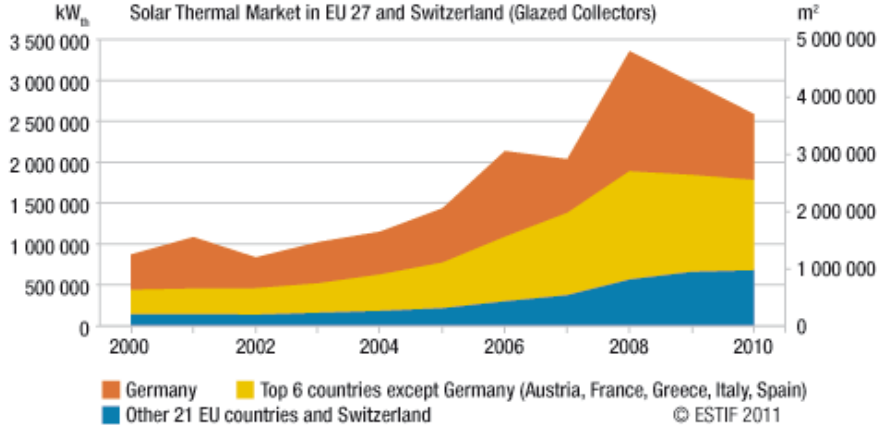


Figure 3.20. Trend of newly installed capacity in EU & Switzerland [62].

ESTIF has adopted three categories for the European solar thermal markets. These groups are: 50 to 200.000m<sup>2</sup>, above 200.000 to 500.000m<sup>2</sup>, and above 500.000m<sup>2</sup> of newly installed capacity of glazed collectors [62].

The only country above 500.000m<sup>2</sup> of newly installed capacity is Germany which is the leading European market.



Figure 3.21. Trend of newly installed capacity in Germany [62].

The solar thermal markets above 200.000 to 500.000m<sup>2</sup> consists of the Italian, Spanish, Austrian, French and Greek markets which behaved very differently in 2010. While the Italian market confirmed its 2009 level (around 500.000m<sup>2</sup>), the Spanish market continued to decline, increasing the gap between the second and third European markets in terms of newly installed capacity. In previous years, Austria managed to successfully overcome the market downturn but is now following the trend set by its northern neighbour, with a significant



decrease of 21%. France also experienced a second year of decline, though more modest than in Spain (-3,4%). Finally, the Greek market recovered after a bad performance in 2009, in spite of the difficult situation faced by the country.

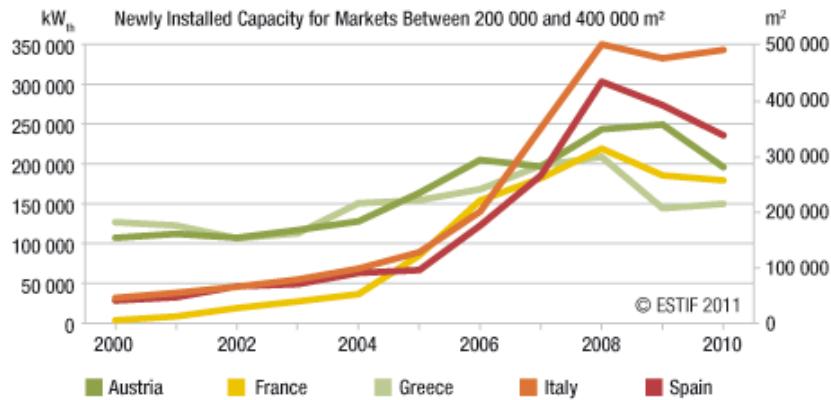


Figure 3.22. Trend of newly installed capacity in Austria, France, Greece, Italy & Spain [62].

Overall, markets below 200.000m<sup>2</sup> and above 50.000m<sup>2</sup> grew by 8,8%. Their combined increase of 40.000m<sup>2</sup> does not quite compensate for the decrease recorded in larger markets. However, it illustrates a different dynamic, triggered by new support schemes in some cases or possibly an increased awareness of solar thermal.

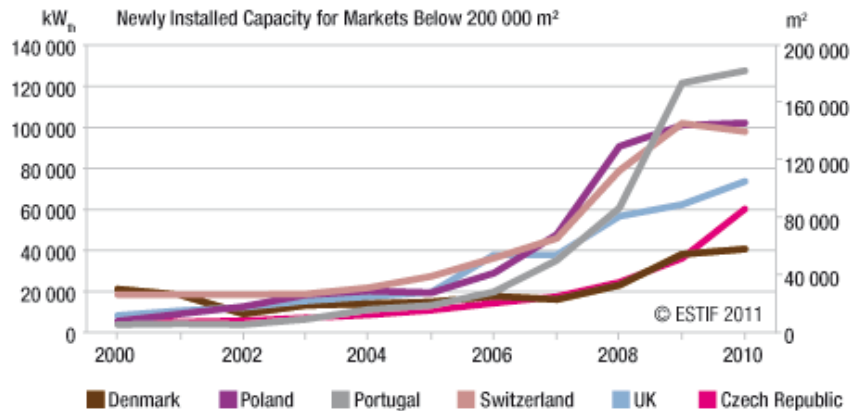


Figure 3.23. Trend of newly installed capacity in Denmark, Poland, Portugal, Switzerland, UK & Czech R. [62].

**Note:** In the third chapter the source of the data is Eurostat. Details about the methodology, for the calculation of the RES share for every sector, can be found in the Renewable Energy Directive 2009/28/EC, the Energy Statistics Regulation 1099/2008 and on DG ENERGY's transparency platform: [http://ec.europa.eu/energy/renewables/index\\_en.htm](http://ec.europa.eu/energy/renewables/index_en.htm). For the RES-H sector the proposed methodology couldn't be followed and that is why there are no graphs for its contribution through time. Final percentages calculated differ from the percentages in Commission's progress reports, something that indicates the difficulty to handle and ensure the consistency of the necessary data.

# 4

## Projections for RES Share in 2020

As mentioned in the third chapter, the second phase –towards 2020 targets– has started in the middle of a political and financial tough period not only for the EU, but also for the global economic and political environment. It is obvious that following the existing strategy is currently unlikely to meet all the 2020 targets and deal with the longer-term challenges, provided that none of the 2010 targets were accomplished. Exception consist only few Member States that have reached their quotas (e.g. Germany, Sweden)

In order to deal with this challenge, EU has introduced stricter policies through new and updated legislation with unambiguous and mandatory targets for the upcoming decade. Energy and climate goals have been incorporated in Europe's 2020 strategy for smart, sustainable and inclusive growth. The formal adoption of this strategy has been ratified by the European Council in June 2010.

In this section we will try to assess if the 2020 target of 20%, for the overall RES share in total gross final energy consumption, is about to be accomplished. Our study employs annual time series data for the share of RES in total gross final energy consumption for the period 1995 to 2009. As mentioned in the third chapter, the source of the data is Eurostat and details about the methodology can be found in the European legislation (Directive 2009/28/EC, Regulation 1099/2008).

Five different regression specifications will be implemented in order to end up to the most appropriate which will be used in order to perform a long-run forecast. Starting from the most simple up to the most complex, the regression specifications are the following:

- Autoregressive (AR) specification
- Polynomial regression specification
- Gompertz regression specification
- Multiple regression specification
- Logistic regression specification

## 4.1. Autoregressive Specification

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An autoregressive specification is a very common specification for time series in which past values are used as feedback and therefore the system can generate internal dynamics. The general specification is provided in equation (1) below:

$$y_t = c_0 + \sum_{i=1}^N c_i y_{t-i} + e_t \quad (1)$$

where,  $c_i$  are weights or alternatively autoregression coefficients to be estimated,  $y_t$  is the share of RES in total gross final energy consumption and  $N$  is the lag order (length) which is generally for annual observations pretty limited (e.g. 3 to 5 lags). The noise or error term,  $e_t$  above, is assumed to be Gaussian white noise (normally distributed with zero mean and constant variance).

The problem in the case of the AR specification is to derive the optimal lag length. The  $y_t$  series is assumed to be stationary. By convention the series  $y_t$  is assumed to be zero mean. If not, this is simply another term  $c_0$  in front of the summation in the equation (1).

Running the third order of equation (1), AR(3), we get the output of the Table 4.1:

Variable	Coefficient	Std. Error	t-Statistic	Prob.
$c_0$	-2,009431	0,931391	-2,157451	0,0630
$y(-1)$	1,314914	0,289923	4,535389	0,0019
$y(-2)$	-0,095574	0,497687	-0,192036	0,8525
$y(-3)$	0,285297	0,467470	0,610299	0,5586
R-squared	0,978028	Mean dependent var	4,582500	
Adjusted R-squared	0,969789	S.D. dependent var	0,678958	
S.E. of regression	0,118012	Akaike info criterion	-1,174866	
Sum squared resid	0,111414	Schwarz criterion	-1,013230	
Log likelihood	11,04920	F-statistic	118,7024	
Durbin-Watson stat	1,891986	Prob(F-statistic)	0,000001	

**Table 4.1.** Output of the AR(3) regression.

As shown in Table 4.1, the only statistically significant variable, at the conventional level of 0,05, is the  $y(-1)$ . The approximately 97% fit (Adjusted R-squared) shows that past values explain to a great extent the variability of the dependent variable. However, due to the model's simplicity<sup>12</sup> it is expected high inaccuracy for future estimation, thus, it is not proper for long run forecast.

<sup>1</sup> By construction the specification may provide diffusion values that lie well above the theoretical maximum.

<sup>2</sup> The y variable is probably not stationary at that stage of diffusion (despite the fact that is a bounded variable).

After completing the estimation of our adopted specification, we continue by executing a pseudo-forecasting exercise in order to evaluate the model's forecasting performance. In particular, we adjust our sample to a smaller size by removing some of the last observations. In our case the time period to forecast extends from 2005 to 2009. Then, by choosing the static forecasting method, the forecasted values for the desired period are obtained. Hence, we can compare the real values with the forecasted values as it is shown in Figure 4.1.

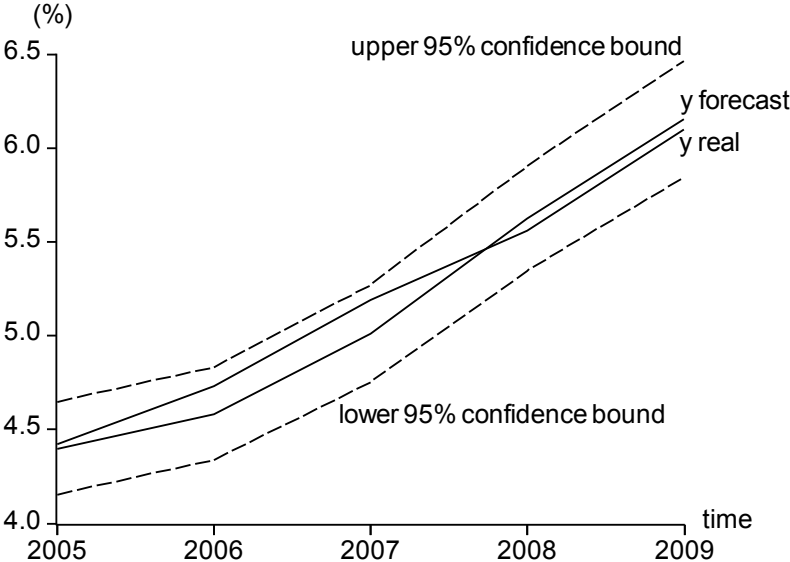


Figure 4.1. Actual and forecasted values based on the AR(3) specification.

Visual inspection of Figure 4.1 reveals a very good forecasting performance with the estimated and actual values to be very close. Both of them are moving within the 95% confidence bounds which are formed by the  $\pm 2$  times the standard error (assumed normally distributed) of the forecasted values.

## 4.2. Polynomial Regression Specification

Polynomial regression is a form of linear regression in which the relationship between the independent variable and the dependent variable is modeled as a  $k^{\text{th}}$  order polynomial. The general specification is provided by the equation (2):

$$y_t = c_0 + c_1 y_t + c_2 y_t^2 + \dots + c_k y_t^k + e_t \tag{2}$$

Where,  $y_t$  is the predicted outcome value for the polynomial specification with regression coefficients  $c_1, c_2, \dots, c_k$  for each degree of  $y_t$  and finally  $c_0$  is the intercept. A second order ( $k=2$ ) polynomial forms a quadratic expression (parabolic curve), a third order ( $k=3$ ) polynomial forms a cubic expression and a fourth order ( $k=4$ ) polynomial forms a quadric expression. More complex expressions involving polynomials of more than one predictor can be achieved by using the general linear regression function.

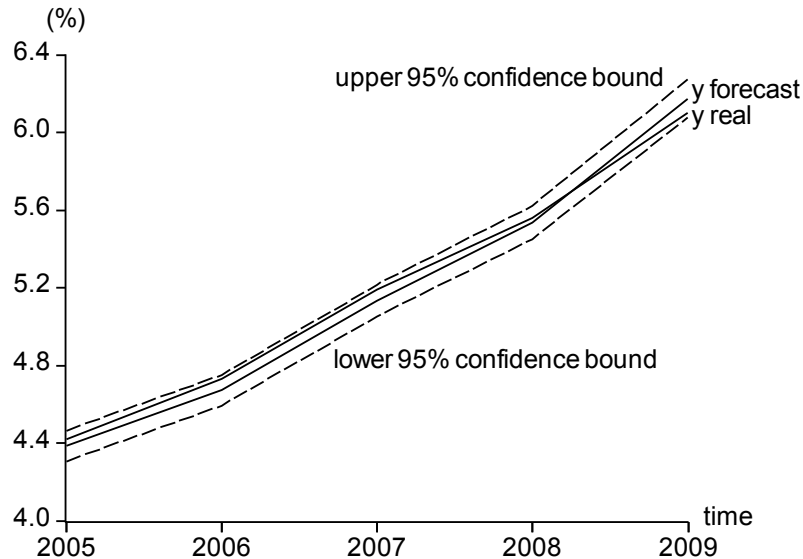
Estimating the second order polynomial regression we get the output of Table 4.2:

Variable	Coefficient	Std. Error	t-Statistic	Prob.
$c_0$	2,403842	0,033905	70,89977	0,0000
$y_t^2$	0,101339	0,001597	63,47471	0,0000
R-squared	0,996784	Mean dependent var	4,461333	
Adjusted R-squared	0,996536	S.D. dependent var	0,654270	
S.E. of regression	0,038505	Akaike info criterion	-3,552474	
Sum squared resid	0,019275	Schwarz criterion	-3,458067	
Log likelihood	28,64355	F-statistic	4029,038	
Durbin-Watson stat	0,742349	Prob(F-statistic)	0,000000	

**Table 4.2.** Output of the second order polynomial regression.

As shown from the results, the success of the regression in predicting the values of the dependent variable within the sample is excellent since the fit is 99,6%. Both variables  $y_t^2$  and  $c_0$  are statistically significant with  $y_t^2$  having a positive coefficient. The statistical noise in the estimates is very low as we can see from the standard errors which assumed to be normally distributed.

After completing the estimation of the specification we perform the pseudo-forecasting exercise described in the previous section. As we can see the actual and forecasted values are very close with the 95% confidence bounds being very narrow since the fit is almost perfect.



**Figure 4.2.** Actual and forecasted values based on the second order polynomial specification.

However, this specification is not as ideal as it seems at first sight. One reason is that it is based on a small number of observations, something that might affect the fit. Another and very important reason is that the value of the Durbin-Watson statistic is less than 1. This indicates strong positive first-order serial correlation in the residuals which means that the estimated specification is not proper for further statistical inference.

### 4.3. Gompertz Regression Model

The Gompertz curve is a sigmoid curve. It is a type of mathematic specification for a time series, where growth is slowest at the start and at the end of a time period. The right-hand or future value asymptote of the function is approached much more gradually by the curve than the left-hand or lower valued asymptote, in contrast to the logistic function in which both asymptotes are approached by the curve symmetrically.

The Gompertz curve is given by the equation:

$$y_t = a \exp(-b(\exp(-ct))) \tag{3}$$

Where  $y_t$  is the variable representing the diffusion process of RES share in the total gross final energy consumption in time  $t$  (time trend) and  $a, b$  and  $c$  are positive parameters subject to estimation. Then by adding the stochastic term  $e_t$  and after some algebra in equation (3), we get the following specification:

$$\ln(\Delta \ln y_t) = -ct + \ln(b \exp(c) - b) + e_t \tag{4}$$

In equation (4), only  $b$  and  $c$  out of three initial parameters are subject to estimation. The third parameter  $a$  (saturation level or upper bound of the regression) is assumed to be time-varying. The advantage of time-varying assumption is that it permits the identification of possible structural breaks that took place during the diffusion process [63]. The series of  $a$  is obtained exogenously through the following expression:

$$\hat{a}_t = \exp(\ln y_t + \hat{b} \exp(-\hat{c}t)) \tag{5}$$

Running the Gompertz equation as it is shown in equation (4) by means of a non-linear least squares, we get the output of the Table 4.3:

Parameter	Coefficient	Std. Error	t-Statistic	Prob.
$b$	-0,406545	0,064832	-6,270746	0,0001
$c$	-0,002646	0,001572	-1,682378	0,1234
R-squared	0,797252	Mean dependent var	-4,388793	
Adjusted R-squared	0,776977	S.D. dependent var	1,641659	
S.E. of regression	0,775279	Akaike info criterion	2,479824	
Sum squared resid	6,010571	Schwarz criterion	2,560641	
Log likelihood	-12,87894	Durbin-Watson stat	1,061091	

**Table 4.3.** Output of the Gompertz regression.

The results show that the fit of the estimated curve to the data is quite satisfactory but the standard error of the regression is high. From the parameters, only  $b$  is statistically significant and both of them have negative signs while they were expected to be positive. The pseudo-forecasting exercise shows the actual and forecasted values lie within the 95% confidence bounds (Figure 4.3.) while the Durbin-Watson statistic shows a strong positive first-order serial correlation in the residuals. From all these facts mentioned, our model doesn't seem reliable for long term forecasting.

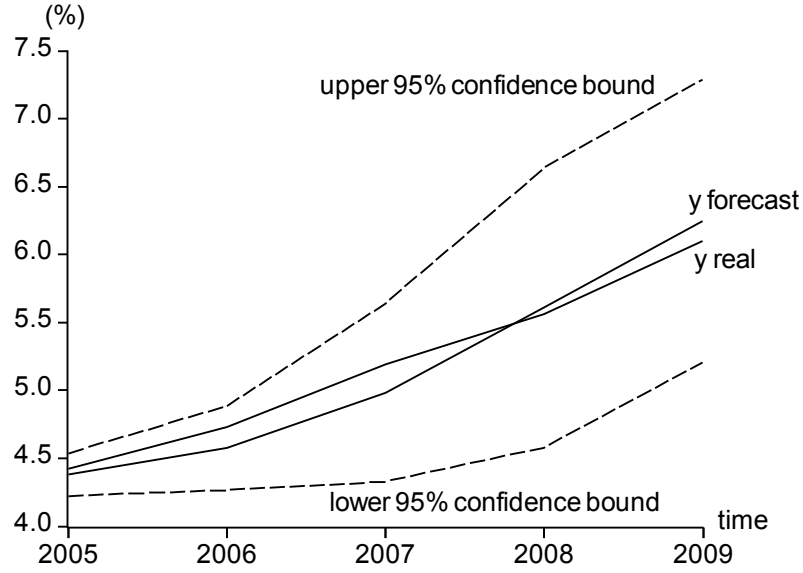


Figure 4.3. Actual and forecasted values based on the Gompertz specification.

#### 4.4. Multiple Regression Specification

The multiple linear regression specification and its estimation using ordinary least squares (OLS) is doubtless the most widely used tool in econometrics. It allows to assess the relation between a dependent variable and a set of explanatory variables. The dependent variable is an interval variable, i.e. its values represent a natural order and differences of two values are meaningful. The dependent variable can, in principle, take any real value between  $-\infty$  and  $+\infty$ . In practice, this means that the variable needs to be observed with some precision and that all the observed values are far from ranges which are theoretically excluded.

The multiple linear regression specification assumes a linear (in parameters) relationship between a dependent variable  $y_i$  and a set of explanatory variables  $x_i' = (x_{i0}, x_{i1}, \dots, x_{iK})$ ;  $x_{iK}$  is also called an independent variable, a covariate or a regressor. The first regressor  $x_{i0} = 1$  is a constant unless otherwise specified. So:

$$y_i = x_i' \beta + u_i = \beta_0 + \beta_1 x_{i1} + \dots + \beta_K x_{iK} + u_i \quad (6)$$

where  $\beta$  is a  $(K+1)$ -dimensional column vector of parameters,  $x_i'$  is a  $(K+1)$ -dimensional row vector and  $u_i$  is the error term.

The OLS approach minimizes the squared distances between the observed and the predicted dependent values for the variable  $y$ :

$$S(\beta) = \sum_{i=1}^N (y_i - x_i' \beta)^2 = (y - X\beta)' (y - X\beta) \rightarrow \min_{\beta} \quad (7)$$

The resulting OLS estimator for  $\beta$  is:

$$\hat{\beta} = (X'X)^{-1} X'y$$

Given the OLS estimator we can predict the dependent variable by  $\hat{y}_i = x_i' \hat{\beta}$  and the error term by  $\hat{u}_i = y_i - x_i' \hat{\beta}$ ;  $\hat{u}_i$  is called the residual.

Some of the parameters affecting the diffusion of the RES share in total gross final energy consumption, as suggested by the relevant literature, are: the energy balance ( $x_1$ ) which is the ratio imports/exports, the final energy consumption ( $x_2$ ), the R&D as annual percentage of GDP ( $x_3$ ) and the oil prices ( $x_4$ ) which is the dominant fossil fuel.

Estimating the equation (6) we get the output of the Table 4.4:

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-8,482980	5,012412	-1,662543	0,1274
$x_1$	3,354270	1,353239	2,478698	0,0326
$x_2$	-6,33E-06	2,00E-06	-3,170906	0,0100
$x_3$	5,197726	1,146141	4,534978	0,0011
$x_4$	0,013051	0,004461	2,925708	0,0152
R-squared	0,936609	Mean dependent var	4,461333	
Adjusted R-squared	0,911253	S.D. dependent var	0,654270	
S.E. of regression	0,194910	Akaike info criterion	-0,171360	
Sum squared resid	0,379898	Schwarz criterion	0,064657	
Log likelihood	6,285196	F-statistic	36,93806	
Durbin-Watson stat	2,150833	Prob(F-statistic)	0,000006	

**Table 4.4.** Output of the Multiple regression.

In general, the estimated sign for every single parameter is theoretically meaningful. Four out of the five parameters appear to be statistically significant at the conventional level of 0,05 and finally, the model seems to fit the data very well.

In more detail and in relation to the expected signs we stress the following: One of the most important factors that affect the penetration of RES in the final energy mix is the need for security of energy supply. As energy imports and prices are steadily increasing, especially for fossil fuels which are lacking in the European Union, the penetration of renewable energy seems one of the most important factors to offset the increasing trend of EU's energy dependency. Thus, the signs of the energy balance and oil prices parameters were expected to be positive, as they are in our model. The penetration of RES technologies in the market is the result of R&D like any other new technology. EU has many programs of R&D (see chapter 2.10), funded with quite significant amounts (see Appendix A2) and R&D is considered a top priority policy sector. So, we would expect the sign of the R&D parameter to be positive, as it happens in our case. The disadvantages of renewable energy are that it is a diffuse and not constant form of energy. This means that RE technologies don't assure a constant outcome and might not be able to meet the demand needs in case of an excess demand period, something that would lead to more conventional fuels consumption. On the other hand when there is a shortfall in energy demand, the percentage of RES in the final energy consumption would increase since less fossil fuels would be used. Thus the sign of the final energy consumption parameter could be negative, as it is in our case, or positive. Overall, the signs of the estimated coefficients are theoretically meaningful. This indicates that our model could be considered as pretty satisfactory.



Among the independent variables used, only the constant (C) doesn't appear to be statistically significant at the conventional level of 0,05. The significance for a coefficient can be affirmed by the corresponding *t*-statistic or alternatively by the associated *p*-value. The *t*-statistic is calculated by the ratio of the estimated coefficient (column two) to the associated standard error (column three). If the absolute value of the *t*-statistic is greater than 2, then we may say that the coefficient is significant at the 0,05 significance level (but this is a rule of thumb). More accurate information with respect to the significance can be derived from the *p*-value. Hence, if the *p*-value is lower than the selected level of significance (e.g. 0,01), then the coefficient is considered significant at that particular level of significance.

As it can be inferred by the value of the adjusted R-square (corrected with the degrees of freedom), which is 0,911, the included into the model independent variables explain more than the 9/10 of the RES penetration in total gross final energy consumption. The fit seems excellent as it can be seen by the following Figure 4.4. Both the actual and forecasted values are within the 95% confidence bounds.

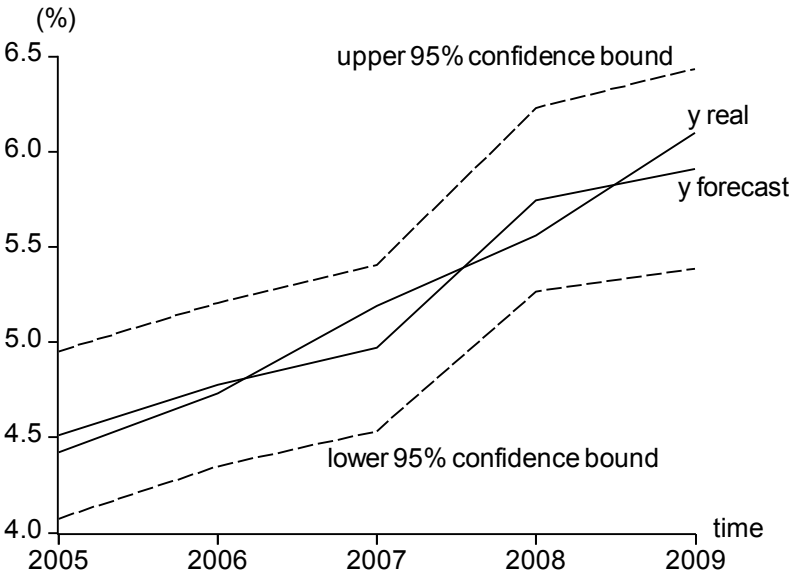


Figure 4.4. Actual and forecasted values based on the Multiple specification.

Despite the fact that our model seems to be well specified, it wouldn't be safe to use it for future estimations. The multiple regression specification assumes the stationarity of the parameters. The parameters we have used are not stationary something that would result to misleading inference.

### 4.5. Logistic Regression Specification

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The functional form of the Logistic curve is given by the next equation:

$$y_t = a(1 + b \exp(-ct))^{-1} \tag{8}$$

Where  $y_t$  is the variable measuring the diffusion process in period  $t$  (RES share in total gross final energy consumption) and  $a, b$  and  $c$  are positive parameters for estimation. Investigating

the meaning of these parameters it turns out that: the parameter  $a$  represents the upper limiting value of the output, the parameter  $b$  is the number of times that the initial output  $y_0$  must grow to reach  $a$  and since the parameter  $c$  is much harder to interpret exactly, we will simply mention that if it is positive, the logistic function will always increase, while if it is negative, the function will always decrease.

One way to work with the Logistic equation is to apply the same methodology as applied to the Gompertz regression in paragraph 4.3. The other way and the one we use for our model, is to replace the independent variable  $t$  in the equation (8) with a set of explanatory variables, like the OLS model. So, equation (8) is formed to the next specification:

$$y_i = a(1 + b \exp(-\beta X))^{-1} \quad (9)$$

Where,  $X$  is a  $(N \times K)$  matrix containing the independent variables affecting the diffusion of the dependent variable  $y_i$  (the energy balance ( $x_1$ ) which is the ratio imports to exports, the final energy consumption ( $x_2$ ), the R&D as annual percentage of GDP ( $x_3$ ) and the oil prices ( $x_4$ ) which is the dominant fossil fuel), while  $\beta$  is the vector of the parameters. The parameter  $a$  represents the upper limit, as mentioned above, and for the estimation of the regression it will be equal to its theoretical maximum value which is 1.

Estimating the Logistic regression (2) we get the output of the Table 4.5:

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-5,859490	1,124450	-5,21100	0,00039
$x_1$	0,690840	0,298223	2,31650	0,04303
$x_2$	-1,20E-06	4,40E-07	-2,72820	0,02126
$x_3$	1,066180	0,252583	4,22110	0,00177
$x_4$	0,002945	0,000983	2,99590	0,01344
R-squared	0,934456	Mean dependent var	4,461333	
Adjusted R-squared	0,908243	S.D. dependent var	0,654270	
S.E. of regression	0,042954	Akaike info criterion	-47,94288	
Sum squared resid	0,018450	Schwarz criterion	-44,40263	
Log likelihood	28,97144	F-statistic	35,64412	
Durbin-Watson stat	2,079205	Prob(F-statistic)	6,86E-06	

**Table 4.5.** Output of the Logistic regression.

In general, the estimated sign for every single coefficient is theoretically meaningful. All five variables appear to be statistically significant at the conventional level of 0,05 and finally, the specification seems to fit the data very well.

In more detail and in relation to the expected signs we stress the following: As mentioned in the multiple regression model, penetration of renewable energy seems one of the most important factors to offset the increasing trend of EU's energy dependency. Thus, the signs of the energy balance and oil prices coefficients were expected to be positive, as they are in our model. R&D is considered a top priority policy sector in the EU with many programs and significant amounts invested. This accelerates the penetration of RES technologies, so we would expect the sign of the R&D coefficient to be positive, as it happens in our case. RES,

due to their nature, might not be able to meet the demand needs in case of an excess demand period, something that would lead to the use of more conventional fuels. On the other hand when there is a shortfall in energy demand, the percentage of RES in the final energy consumption would increase since less fossil fuels would be used. Thus the sign of the final energy consumption coefficient could be negative, as it is in our case, or positive. Overall, since the signs of the estimated coefficients are theoretically meaningful, we reach the conclusion that our model could be considered as pretty satisfactory from this point of view.

Among the independent variables used, all of them appear to be statistically significant at the conventional level of 0,05. As mentioned in section 4.4, the significance for a coefficient can be affirmed by the corresponding *t*-statistic or alternatively by the associated *p*-value. If the absolute value of the *t*-statistic is greater than 2, then we may say that the coefficient is significant at the 0,05 significance level (but this is a rule of thumb). More accurate information with respect to the significance can be derived from the *p*-value. Hence, if the *p*-value is lower than the selected level of significance (e.g. 0,01), then the coefficient is considered significant at that particular level of significance.

As it can be inferred by the value of the adjusted R-square (corrected with the degrees of freedom), which is almost 91%, the included into the model independent variables explain more than the 9/10 of the RES penetration in total gross final energy consumption. The fit seems excellent with pretty low standard error. After the pseudo-forecasting exercise we get the next figure which shows both the actual and forecasted values within the 95% confidence bounds (standard errors assumed normally distributed).

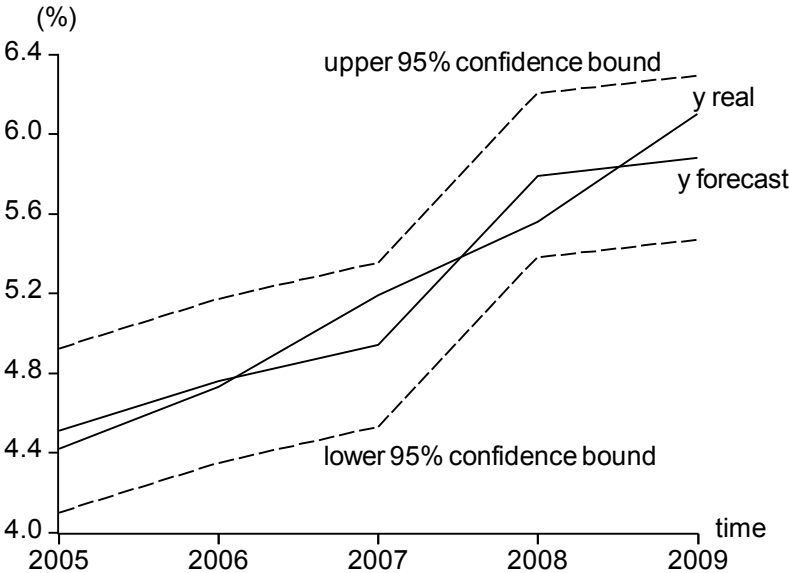


Figure 4.5. Actual and forecasted values based on the Logistic specification.

### 4.6. Model Comparison

The next table (Table 4.6) presents the in-sample criteria as well as the forecast evaluation criteria for each one of the previously estimated specifications.

	AR(3)	Polynomial	Gompertz	Multiple	Logistic
<b>Equation Estimation</b>					
R-squared	0,978028	0,996784	0,797252	0,936609	0,934456
Adjusted R-squared	0,969789	0,996536	0,776977	0,911253	0,908243
S.E. of regression	0,118012	0,038505	0,775279	0,194910	0,042954
Sum squared resid	0,111414	0,019275	6,010571	0,379898	0,018450
Log likelihood	11,049200	28,643550	-12,878940	6,285196	28,971440
Durbin-Watson stat	1,891986	0,742349	1,061091	2,150833	2,079205
Mean dependent var	4,582500	4,461333	-4,388793	4,461333	4,461333
S.D. dependent var	0,678958	0,654270	1,641659	0,654270	0,654270
Akaike info criterion	-1,174866	-3,552474	2,479824	-0,171360	-47,942880
Schwarz criterion	-1,013230	-3,458067	2,560641	0,064657	-44,402630
<b>Forecast Evaluation</b>					
Root Mean Squared Error	0,111361	0,053113	0,136566	0,162090	0,186030
Mean Absolute Error	0,093767	0,049962	0,119809	0,147543	0,163690
Mean Absolute % Error	1,828450	0,960221	2,298972	2,763333	0,360530
Theil Inequality Coefficient	0,010678	0,005081	0,013085	0,015519	0,470580
Bias Proportion	0,172350	0,143126	0,098692	0,012419	0,019424
Variance Proportion	0,286037	0,553590	0,459690	0,080871	0,002826
Covariance Proportion	0,541613	0,303284	0,441618	0,906710	0,977750

**Table 4.6.** Data summarization for all regression specifications.

The R-squared Statistic measures the success of the regression in predicting the values of the dependent variable within the sample. In standard settings, may be interpreted as the fraction of the variance of the dependent variable explained by the independent variables. The Statistic will equal one if the regression fits perfectly, and zero if it fits no better than the simple mean of the dependent variable. One problem with using R-squared as a measure of goodness of fit is that it will never decrease as you add more regressors. The adjusted R-squared penalizes the R-squared for the addition of regressors which do not contribute to the explanatory power of the model. So, according to adjusted R-squared, the *Polynomial regression model* is ideal with the lowest standard error of regression.

The Durbin-Watson statistic is a test for first-order serial correlation. More formally, the DW Statistic assesses the linear association in the residuals. This serial correlation violates the standard assumption of regression theory that disturbances are not correlated with their past values. The primary problem associated with the serial correlation is: OLS is no longer efficient among linear estimators; standard errors computed are not correct and are generally understated. If there is no serial correlation, the DW statistic will be around 2. The DW statistic will fall below 2 if there is positive serial correlation (in the worst case, it will be near zero). If there is negative correlation, the statistic will lie somewhere between 2 and 4. So, according to the DW statistic, the *Logistic regression specification* is the selected one.

The information criteria, in our case Akaike and Schwarz, are often used as a guide in model selection. The notion of an information criterion is to provide a measure of information that strikes a balance between this measure of goodness of fit and parsimonious specification of the model. The various information criteria differ in how to strike this balance.

The Akaike Information Criterion (AIC) is given by:  $AIC = -2(l/T) + 2(k/T)$ , while the Schwarz Criterion (SC) is given by:  $SC = -2(l/T) + k \log(T)/T$ . Where,  $l$  is the value of the log of the likelihood function with the  $k$  parameters estimated using  $T$  observations. The various

information criteria are all based on -2 times the average log likelihood function, adjusted by a penalty function. The selected model is the one with the smallest value criterion. So, according to the AIC and SC the ideal model is the *Logistic regression model*.

The first two forecast error statistics (Root Mean Squared Error & Mean Absolute Error) depend on the scale of the dependent variable. These should be used as relative measures to compare forecasts for the same series across different models; the smaller the error, the better the forecasting ability of that model according to that criterion. So, the best model seems to be the *Polynomial regression model*. The remaining two statistics (Mean Absolute Percentage Error & Theil Inequality Coefficient) are scale invariant. The Theil inequality coefficient always lies between zero and one, where zero indicates a perfect fit. Thus, according to the mean absolute percentage error the selected model is the *Logistic*, while the *Polynomial* is the selected according to Theil inequality coefficient.

Finally, the bias, variance and covariance proportions add up to one in the Theil inequality coefficient. The bias proportion informs us how far the mean of the forecast is from the mean of the actual series – In the *Multiple regression specification* the mean of the forecasts does the best job of tracking the mean of the dependent variable. The variance proportion tells us how far the variation of the forecast is from the variation of the actual series – In the *Logistic* the variation of the forecast and the actual series is the closest. The covariance proportion measures the remaining unsystematic forecasting errors with the least of them being in the *Polynomial regression specification*.

Overall, from the comparison above and having in mind the drawbacks for each model, mentioned in the previous paragraphs of the chapter, we draw the conclusion that the most consistent, valid and proper regression model for long term forecasting is the *Logistic*.

## 4.7. The Overall RES Share in 2020

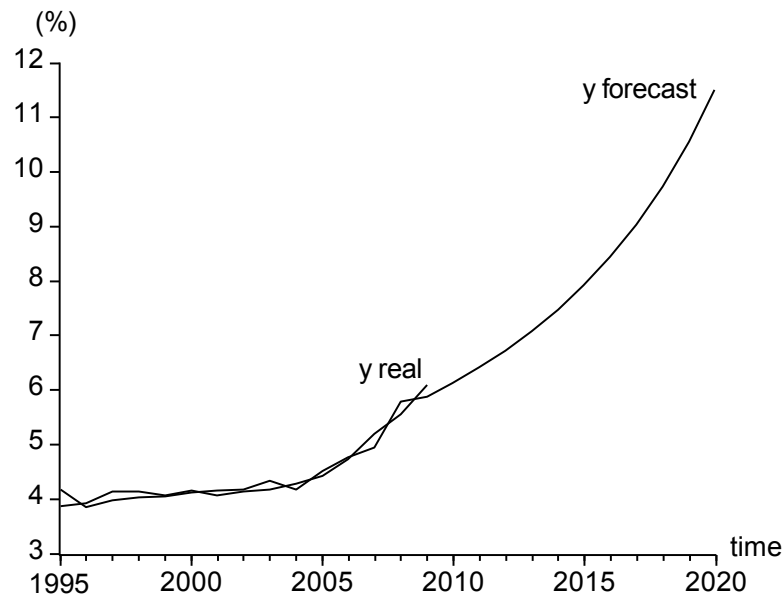
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In the previous paragraph we ended up to the Logistic regression model as the most proper model for the long term forecasting (up to 2020). In this theoretical approach, in order to perform future projection, a decisive assumption must be made.

We assume that the independent variables (the energy balance – ratio imports to exports, the final energy consumption, the R&D as annual percentage of the GDP and the oil prices) affecting the diffusion process of RES share in the total gross final energy consumption ( $y$ ), have a stable growth rate for the years 2010-2020 equal to their average growth rate of the last fifteen years (1995-2009).

At first sight this assumption seems rather simplistic; however, the average growth rate from the last fifteen years is a quite accurate and safe approach which leads to rather expected results. So, performing the forecast for the years 2010-2020 we receive Figure 4.6.

As it is shown in Figure 4.6, the share of RES in total gross final energy consumption, grew from 6,1% (2009) to 11,51% (2020). It is an *88,7% increase from the current levels*, a result that can be considered as pretty satisfactory. However, the target share for 2020 is 20%, so, there is a lack of 8,5% between the targeted and the forecasted value.



**Figure 4.6.** Actual and forecasted values up to 2020 based on the Logistic specification.

According to the derived forecast, the 2020 target will not be met. As mentioned before, the values of the independent variables (energy balance, final energy consumption, R&D as % of GDP and oil prices) were assumed to evolve linearly. This assumption implies that the projected values of the parameters, for the period 2010-2020, reflect the past policies' effectiveness (policies implemented in the late 90's and early 00's).

From the mid 00's European Commission had already realized that the 2010 targets would not be met due to the loose framework established from the first RES directives (2001/77/EC and 2003/30/EC). As a reaction to this prospect many directives and regulations were recasted and developed. In 2009 and 2010 updated legislation on RES, energy efficiency, internal market reforming and energy & environment protection was ratified (e.g. the RES directive 28/2009, the EPBD 31/2010, the CCS directive 31/2009). Stricter and more aggressive policies were introduced in the last couple of years from which there will be results in the years to come. Hopefully, these results are expected to have positive impact on the acceleration of RES share increase in final energy mix, increase of energy efficiency and environmental protection. This stricter framework is expected to help EU achieve its 2020 targets.

**Note:** all the calculations and estimations of this chapter were made with the software EViews & Gretl

# 5

## Conclusions

Increasing dependence on fossil fuels, growing imports and rising energy costs are making societies and economies vulnerable. EU and the whole world are called to face these challenges and proceed towards a sustainable energy development.

From a world energy review it is clear that the total energy consumption increases at a rate of 2,3% annually over the last 25 years. Since 80's the fossil fuels count for about 80% of the worlds final energy mix. Consistent with the surge in energy consumption, CO<sub>2</sub> emissions have an increasing trend and from 270ppm, before the Industrial Revolution, have reached the 393ppm in 2011. So, with certainty it can be said that current energy sources and patterns of energy use are unsustainable. They lead to major problems related to climate change, environmental pollution, inequity, source depletion, higher energy costs and security of supply.

A sustainable energy future is possible through much greater energy efficiency and much greater reliance on RES compared to current energy patterns and trends. Greater energy efficiency would reduce growth in energy consumption, decrease investment requirements and improve energy services in poorer households and nations. Shifting from fossil fuels to RES in the coming decades would address all the problems associated with a business as usual energy future.

Despite the fact that RES could provide all of the energy consumed in the world, according to many studies, a wide range of barriers limit their diffusion in final energy mix. The significance of these barriers varies among sectors, institutions and regions. In order to overcome them, different types of policies must be implemented. The policy options can be classified into 13 categories: R&D, financing, financial incentives, pricing, voluntary agreements, regulations, information & training, procurement, market reforms, market obligations, capacity building, planning techniques and supporting tools.

The role of each of the above energy policy options depends on the maturity level of the RE technology. For example, R&D is important in the very early stage of the technology. Then with financial incentives and information & training policies this technology will increase its share in the market. Afterwards, while the technology starts to mature, regulations and codes will contribute towards the maximization of its share in the market and the final energy mix.

EU's energy policy aims at addressing growing environmental concerns associated with the energy sector, such as global climate change, and to transform this growing concern for sustainability into opportunities for global economic and technological leadership. This overarching goal is supported by activities in three main energy policy areas market liberalisation, energy security, and protection of the environment and climate. The EU's energy policies can be classified into 8 broad categories:

- Renewable Energy
- Energy Efficiency & Savings
- Internal Energy Markets
- Security of Energy Supply
- Environmental Protection
- Nuclear Energy
- R&D
- External Energy Relations

EU is recognized as a global leader in creating sustainable energy policy. As a consequence of this ambition, and the realisation of the responsibilities thrust upon it, the Commission has developed some energy policies that are at the cutting edge of global energy policy development. In particular with integrating energy into the broader sustainability objectives and approaching policy issues in an integrated way, by drawing together energy security, cost, and environmental policies into a comprehensive framework.

An indicative example of a “cutting-edge” policy is the EU ETS which is the first and biggest international scheme for the trading of greenhouse gas emission allowances. Its aim is to encourage the emissions reduction and energy efficiency increase by reducing the number of emission allowances and making fines heavier year by year. In the short term though, it works as a mechanism of statistical transfer between industries. The EU ETS will be a model for energy markets around the world.

Important milestones on RE policy's evolution are: the White Paper of 1997, which sets an indicative target of a 12% share of renewable energy sources in total gross final energy consumption by 2010. The biofuels Directive 2003/30/EC, which sets an indicative target of 5,75% of renewable fuels share in the final energy consumption for transport by 2010. The RES Directive 2001/77/EC, which sets an indicative target of 21% RES share, in the gross final energy consumption of electricity, by 2010. Finally, the last RES Directive 28/2009/EC which sets stricter policies on RE penetration like the binding target of 20% RES share in total gross final energy consumption by 2020.

Although significant progress has been made towards increasing the RE penetration in the final energy mix, the targets of 2010 were not met. That is mainly due to the loose framework established by the policies ratified in late 90's – early 00's. For example the policy of setting targets for RE share in the final energy mix was disruptive in early 00's, however, these targets were indicative. However, the overall progress can be considered as pretty satisfactory since: the RE share in primary energy production increases with an average rate of 9% over the last 7 years; The RE share in electricity sector increased by 21% from 1997 levels and in



transport sector by 240% in the period 1997-2003 and by 800% in the period 2003-2009 (in final energy consumption).

From the mid 00's European Commission had already realized that the 2010 targets would not be met. As a reaction to this prospect many directives and regulations were recasted and developed. In 2009 and 2010 updated legislation on RES, energy efficiency, internal market reforming and energy & environment protection was ratified (e.g. the RES directive 28/2009, the EPBD 31/2010, the CCS directive 31/2009). Stricter and more aggressive policies were introduced in the last couple of years from which there will be results in the years to come.

Examples of latest and stricter policies in RE are the binding RES share targets for 2020, cooperation mechanisms like statistical transfers and joint projects between Member States and Member States with Third countries, NREAPs and indicative intermediate targets for better monitoring of the progress towards 2020, the close of the legislative gap for heating and cooling sector etc.

In an attempt to forecast the RES share in the total gross final energy consumption, in 2020, five different regression specifications were implemented and compared in order to end up to the most appropriate for long-run forecast. The parameters involved (energy balance, final energy consumption, R&D as % of GDP and oil prices) in the selected specification (Logistic regression specification) were assumed to evolve linearly up to 2020. A simplistic approach but quite accurate and safe for the elementary level of this attempt.

The forecasted value for 2020 is 11,51% which is much lower than the targeted value of 20%. However, the previous assumption implies that the projected values (up to 2020) of the involved parameters reflect the past policies' effectiveness.

Finally, it must be made clear that RE penetration progress isn't affected only by the four parameters mentioned above. The phase towards 2020 targets has started in the middle of a political and financial tough period not only for the EU, but also for the global economic and political environment. Economic recession affects every aspect of our lives and none knows for sure its impacts on the EU's effort towards the sustainable energy development. For example someone could say that since economic recession will lead to energy consumption decrease this would also lead to fossil fuels consumption decrease, thus increase the RES share in final energy consumption. On the other hand, economic recession could lead to a significant drop of amounts for RE investments and cause major delay in the RES penetration progress.

EU always set the bar high and hopefully through the extensive reporting from the Member States and monitoring from the European Commission it will manage to accelerate the increase of RE use and energy efficiency and achieve the 2020 targets.

# Appendix

## *A1. RE Sources & Technologies Overview*

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Renewable energy is any form of energy from solar, geophysical or biological sources that is replenished by natural processes at a rate that equals or exceeds its rate of use. RE is obtained from the continuing or repetitive flows of energy occurring in the natural environment and includes resources such as:

- Biomass
- Solar energy
- Geothermal heat
- Hydropower
- Tide/waves/ocean energy and
- Wind energy

However, it is possible to utilize biomass at a greater rate than it can grow, or to draw heat from a geothermal field at a faster rate than heat flows can replenish it. On the other hand, the rate of utilization of direct solar energy has no bearing on the rate at which it reaches the Earth. Fossil fuels (coal, oil, natural gas) do not fall under this definition, as they are not replenished within a time frame that is short relative to their rate of utilization.

There is a multi-step process whereby primary energy is converted into an energy carrier (heat, electricity or mechanical work), and then into an energy service. RE technologies are diverse and can serve the full range of energy service needs. Various types of RE can supply electricity, thermal energy and mechanical energy, as well as produce fuels that are able to satisfy multiple energy service needs.

Since it is energy services and not energy that people need, the goal is to meet those needs in an efficient manner that requires less primary energy consumption with low-carbon technologies that minimize CO<sub>2</sub> emissions.

Thermal conversion processes to produce electricity (including from biomass and geothermal) suffer losses of approximately 40 to 90%, and losses of around 80% occur when supplying the mechanical energy needed for transport based on internal combustion engines. These conversion losses raise the share of primary energy from fossil fuels, and the primary energy required from fossil fuels to produce electricity and mechanical energy from heat.

Direct energy conversions from solar PV, hydro, ocean, and wind energy to electricity do not suffer thermodynamic power cycle (heat to work) losses although they do experience other conversion inefficiencies in extracting energy from natural energy flows that may also be relatively large and irreducible.

Some RE technologies can be deployed at the point of use (decentralized) in rural and urban environments, whereas others are primarily employed within large (centralized) energy networks. Though many RE technologies are technically mature and are being deployed at significant scale, others are in an earlier phase of technical maturity and commercial deployment.

The overview of RE technologies and applications in the next tables provides an abbreviated list of the major renewable primary energy sources and technologies, the status of their development and the typical or primary distribution method (centralized network/grid required or decentralized, local standalone supply) [2].

<b>RES</b>	<b>RES Technology</b>	<b>Primary Energy Sector</b>
<b>Bioenergy</b>	Traditional Use of Fuelwood/Charcoal	Thermal
	Cook stoves (Primitive and Advanced)	Thermal
	Domestic Heating Systems (pellet based)	Thermal
	Small- and Large-Scale Boilers	Thermal
	Anaerobic Digestion for Biogas Production	Electricity/Thermal/Transport
	Combined Heat and Power (CHP)	Electricity/Thermal
	Co-firing in Fossil Fuel Power Plant	Electricity
	Combustion-based Power Plant	Electricity
	Gasification-based Power Plant	Electricity
	Sugar & Starch-Based Crop Ethanol	Transport
	Plant & Seed Oil-Based Biodiesel	Transport
	Lignocellulose Sugar-Based Biofuels	Transport
	Lignocellulose Syngas-Based Biofuels	Transport
	Pyrolysis-Based Biofuels	Transport
	Aquatic Plant-Derived Fuels	Transport
Gaseous Biofuels	Thermal	
<b>Solar</b>	Photovoltaic (PV)	Electricity
	Concentrating PV (CPV)	Electricity
	Concentrating Solar Thermal Power (CSP)	Electricity
	Low Temperature Solar Thermal	Thermal
	Solar Cooling	Thermal
	Passive Solar Architecture	Thermal
	Solar Cooking	Thermal
	Solar Fuels	Transport
<b>Geothermal</b>	Hydrothermal, Condensing Flash	Electricity
	Hydrothermal, Binary Cycle	Electricity
	Engineered Geothermal Systems (EGS)	Electricity
	Submarine Geothermal	Electricity
	Direct Use Applications	Thermal
	Geothermal Heat Pumps (GHP)	Thermal
<b>Hydropower</b>	Run-of-River	Electricity/Mechanical
	Reservoirs	Electricity
	Pumped Storage	Electricity
	Hydrokinetic Turbines	Electricity/Mechanical
<b>Ocean</b>	Wave	Electricity
	Tidal Range	Electricity
	Tidal Currents	Electricity
	Ocean Currents	Electricity
	Ocean Thermal Energy Conversion	Electricity/Thermal
	Salinity Gradients	Electricity
<b>Wind</b>	Onshore, Large Turbines	Electricity
	Offshore, Large Turbines	Electricity
	Distributed, Small Turbines	Electricity
	Turbines for Water Pumping / Other Mechanical	Mechanical
	Wind Kites	Transport
	Higher-Altitude Wind Generators	Electricity

**Table A1:** RE Technologies overview (part 1) [2].

RES	RES Technology	Technology Maturity				Distribution Method	
		R&D	Demo/ Pilot	Early Stage	Later Stage	Centr alized	Decent ralized
<b>Bioenergy</b>	Traditional Use of Fuelwood/Charcoal				X		X
	Cook stoves (Primitive and Advanced)				X		X
	Domestic Heating Systems (pellet based)				X		X
	Small & Large-Scale Boilers				X	X	X
	Anaerobic Digestion for Biogas Production				X	X	X
	Combined Heat and Power (CHP)				X	X	X
	Co-firing in Fossil Fuel Power Plant				X	X	
	Combustion-based Power Plant				X	X	X
	Gasification-based Power Plant			X		X	X
	Sugar & Starch-Based Crop Ethanol				X	X	
	Plant & Seed Oil-Based Biodiesel				X	X	
	Lignocellulose Sugar-Based Biofuels		X			X	
	Lignocellulose Syngas-Based Biofuels			X		X	
	Pyrolysis-Based Biofuels		X			X	
	Aquatic Plant-Derived Fuels	X				X	
Gaseous Biofuels				X	X		
<b>Solar</b>	Photovoltaic (PV)				X	X	X
	Concentrating PV (CPV)			X		X	X
	Concentrating Solar Thermal Power (CSP)			X		X	X
	Low Temperature Solar Thermal				X		X
	Solar Cooling		X				X
	Passive Solar Architecture				X		X
	Solar Cooking			X			X
	Solar Fuels	X				X	
<b>Geothermal</b>	Hydrothermal, Condensing Flash				X	X	
	Hydrothermal, Binary Cycle				X	X	
	Engineered Geothermal Systems (EGS)		X			X	
	Submarine Geothermal	X				X	
	Direct Use Applications				X	X	X
	Geothermal Heat Pumps (GHP)				X		X
<b>Hydropower</b>	Run-of-River				X	X	X
	Reservoirs				X	X	X
	Pumped Storage				X	X	
	Hydrokinetic Turbines		X			X	X
<b>Ocean</b>	Wave		X			X	
	Tidal Range				X	X	
	Tidal Currents		X			X	
	Ocean Currents	X				X	
	Ocean Thermal Energy Conversion		X			X	
	Salinity Gradients		X			X	
<b>Wind</b>	Onshore, Large Turbines				X	X	
	Offshore, Large Turbines			X		X	
	Distributed, Small Turbines				X		X
	Turbines for Water Pumping				X		X
	Wind Kites		X				X
	Higher-Altitude Wind Generators	X				X	

Table A2: RE Technologies overview (part 2) [2].

The economic performance of a specific energy source determines its future market penetration. Economic conditions of the various RES technologies are based on both economic and technical specifications, varying across the EU countries. We can have an overview for each technology through the next tables:

RES-E sub-category	Plant specification	Investment costs	O&M costs	Efficiency (electricity)	Efficiency (heat)	Lifetime (average)	Typical plant size
		[€/kW <sub>el</sub> ]	[€/kW <sub>el</sub> * year]	[1]	[1]	[years]	[MW <sub>el</sub> ]
Biogas	Agricultural biogas plant	2550 - 4290	115 - 140	0.28 - 0.34	-	25	0.1 - 0.5
	Agricultural biogas plant - CHP	2765 - 4525	120 - 145	0.27 - 0.33	0.55 - 0.59	25	0.1 - 0.5
	Landfill gas plant	1350 - 1950	50 - 80	0.32 - 0.36	-	25	0.75 - 8
	Landfill gas plant - CHP	1500 - 2100	55 - 85	0.31 - 0.35	0.5 - 0.54	25	0.75 - 8
	Sewage gas plant	2300 - 3400	115 - 165	0.28 - 0.32	-	25	0.1 - 0.6
	Sewage gas plant - CHP	2400 - 3550	125 - 175	0.26 - 0.3	0.54 - 0.58	25	0.1 - 0.6
Biomass	Biomass plant	2225 - 2995	84 - 146	0.26 - 0.3	-	30	1 - 25
	Cofiring	450 - 650	65 - 95	0.37	-	30	-
	Biomass plant - CHP	2600 - 4375	86 - 176	0.22 - 0.27	0.63 - 0.66	30	1 - 25
	Cofiring - CHP	450 - 650	85 - 125	0.2	0.6	30	-
Biowaste	Waste incineration plant	5500 - 7125	145 - 249	0.18 - 0.22	-	30	2 - 50
	Waste incineration plant - CHP	5800 - 7425	172 - 258	0.14 - 0.16	0.64 - 0.66	30	2 - 50
Geothermal Electricity	Geothermal power plant	2575 - 6750	113 - 185	0.11 - 0.14	-	30	5 - 50
Hydro large-scale	Large-scale unit	850 - 3650	35	-	-	50	250
	Medium-scale unit	1125 - 4875	35	-	-	50	75
	Small-scale unit	1450 - 5750	35	-	-	50	20
	Upgrading	800 - 3600	35	-	-	50	-
Hydro small-scale	Large-scale unit	975 - 1600	40	-	-	50	9.5
	Medium-scale unit	1275 - 5025	40	-	-	50	2
	Small-scale unit	1550 - 6050	40	-	-	50	0.25
	Upgrading	900 - 3700	40	-	-	50	-
Photovoltaics	PV plant	2950 - 4750	30 - 42	-	-	25	0.005 - 0.05
Solar thermal electricity	Concentrating solar power plant	3600 - 5025	150 - 200	0.33 - 0.38	-	30	2 - 50
Tidal stream energy	Tidal (stream) power plant - shoreline	5650	145	-	-	25	0.5
	Tidal (stream) power plant - nearshore	6825	150	-	-	25	1
	Tidal (stream) power plant - offshore	8000	160	-	-	25	2
Wave energy	Wave power plant - shoreline	4750	140	-	-	25	0.5
	Wave power plant - nearshore	6125	145	-	-	25	1
	Wave power plant - offshore	7500	155	-	-	25	2
Wind onshore	Wind power plant	1125 - 1525	35 - 45	-	-	25	2
Wind offshore	Wind power plant - nearshore	2450 - 2850	90	-	-	25	5
	Wind power plant - offshore: 5...30km	2750 - 3150	100	-	-	25	5
	Wind power plant - offshore: 30...50km	3100 - 3350	110	-	-	25	5
	Wind power plant - offshore: 50km...	3350 - 3500	120	-	-	25	5

**Table A3:** Economic & technical specifications for new RES-E plants [12].

Generally speaking, the cost of RE technologies drops as they gain more and more share in the market. For example, in 2009 typical PV system costs were in the range 2950 €/kWe to 4750 €/kWe. These cost levels were reached after strong cost declines in the years 2008 and 2009. This reduction in investment cost marks an important departure from the trend of the years 2005 to 2007, during which costs remained flat, as rapidly expanding global PV markets and a shortage of silicon feedstock put upward pressure on both module prices and non-module costs. Before this period of stagnation PV systems had experienced a continuous decline in cost since the start of commercial manufacture in the mid 1970's following a typical learning curve. The new dynamic began to shift in 2008, as expansions on the supply-side

coupled with the financial crisis led to a relaxation of the PV markets and the cost reductions achieved on the learning curve in the meantime factored in again. Furthermore, the cost decrease has been stimulated by the increasing globalization of the PV market, especially the stronger market appearance of Asian manufacturers.

RES-H sub-category	Plant specification	Investment costs	O&M costs	Efficiency (heat) <sup>1</sup>	Lifetime (average)	Typical plant size
		[€/kW <sub>heat</sub> ] <sup>2</sup>	[€/kW <sub>heat</sub> *yr] <sup>2</sup>	[1]	[years]	[MW <sub>heat</sub> ] <sup>2</sup>
<b>Grid-connected heating systems</b>						
Biomass - district heat	Large-scale unit	350 - 380	16 - 17	0.89	30	10
	Medium-scale unit	390 - 420	17 - 19	0.87	30	5
	Small-scale unit	475 - 550	20 - 22	0.85	30	0.5 - 1
Geothermal - district heat	Large-scale unit	800	50	0.9	30	10
	Medium-scale unit	1200 - 1500	55	0.88	30	5
	Small-scale unit	2000 - 2200	57 - 60	0.87	30	0.5 - 1
<b>Non-grid heating systems</b>						
Biomass non-grid heat	log wood	255 - 340	6 - 10	0.75 - 0.85*	20	0.015 - 0.04
	wood chips	340 - 610	6 - 10	0.78 - 0.85*	20	0.02 - 0.3
	Pellets	390 - 530	6 - 10	0.85 - 0.9*	20	0.01 - 0.25
Heat pumps	ground coupled	900 - 1100	5.5 - 7.5	3 - 4 <sup>1</sup>	20	0.015 - 0.03
	earth water	650 - 1050	10.5 - 18	3.5 - 4.5 <sup>1</sup>	20	0.015 - 0.03
Solar thermal heating & hot water supply	Large-scale unit	400 - 420 <sup>2</sup>	5 - 7 <sup>2</sup>	-	20	100 - 200
	Medium-scale unit	540 - 560 <sup>2</sup>	7 - 9 <sup>2</sup>	-	20	50
	Small-scale unit	900 - 930 <sup>2</sup>	13 - 15 <sup>2</sup>	-	20	5 - 10

**Remarks:** <sup>1</sup> In case of heat pumps we specify under the terminology "efficiency (heat)" the *seasonal performance factor* - i.e. the output in terms of produced heat per unit of electricity input

<sup>2</sup> In case of solar thermal heating & hot water supply we specify under the investment and O&M cost per unit of m<sup>2</sup> collector surface (instead of kW). Accordingly, expressed figures with regard to plant sizes are also expressed in m<sup>2</sup> (instead of MW).

**Table A4:** Economic & technical specifications for new RES-H plants [12].

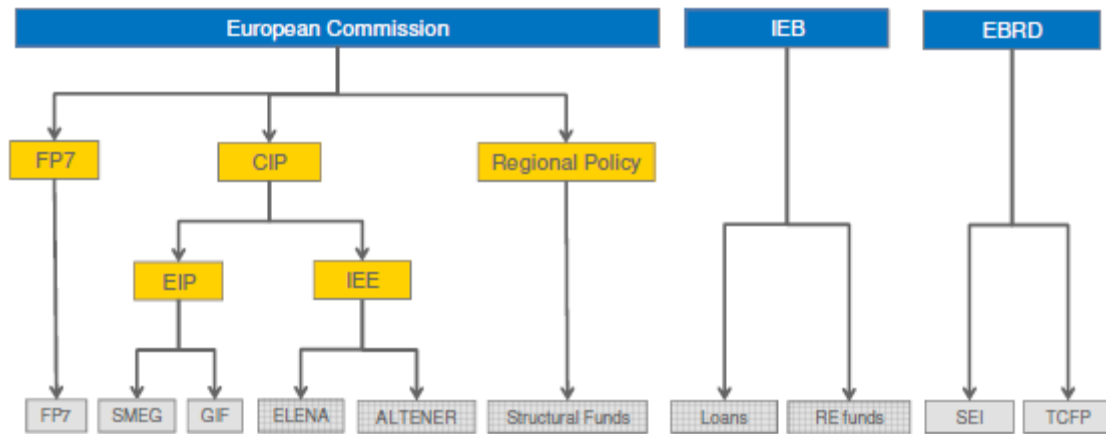
RES-T sub-category	Fuel input	Investment costs	O&M costs	Efficiency (transport)	Efficiency (electricity)	Lifetime (average)	Typical plant size
		[€/kW <sub>trans</sub> ]	[€/kW <sub>trans</sub> *y ear]	[1]	[1]	[years]	[MW <sub>trans</sub> ]
Biodiesel plant (FAME)	rape and sunflower seed	210 - 860	10.5 - 45	0.66	-	20	5 - 25
Bio ethanol plant (EtOH)	energy crops (i.e. sorghum and corn from maize, triticale, wheat)	640 - 2200	32 - 110	0.57 0.65	- -	20	5 - 25
Advanced bio ethanol plant (EtOH+)	energy crops (i.e. sorghum and whole plants of maize, triticale, wheat)	1130 1510 <sup>1</sup>	- 57 - 76 <sup>1</sup>	0.58 0.65 <sup>1</sup>	- 0.05 0.12 <sup>1</sup>	- 20	5 - 25
BtL (from gasifier)	energy crops (i.e. SRC, miscanthus, red canary grass, switchgrass, giant red), selected waste streams (e.g. straw) and forestry	750 - 5600 <sup>1</sup>	38 - 280 <sup>1</sup>	0.36 0.43 <sup>1</sup>	- 0.02 0.09 <sup>1</sup>	- 20	50 - 750

**Remarks:** <sup>1</sup> In case of Advanced bio ethanol and BtL cost and performance data refer to 2015 - the year of possible market entrance with regard to both novel technology options.

**Table A5:** Economic & technical specifications for new biofuel refineries [12].

## A2. Funding RES & Current Investment Dynamics

The following paragraphs present an overview on the different European bodies involved in financing RES employment and list specific funding programmes, pointing out the type of financial support, financial volumes, as well as eligible beneficiaries [12].



**Figure A1:** Organization of the financing of RE in EU [12].

Figure A1 depicts the organisation of the RES financing programmes within the EU. As will be seen in the following paragraphs, the main portion of the available funding is dedicated to large scale investments through the European Funds funds (particularly ERDF and CF) of the EC and the European banks: IEB and EBRD.

### 1. FP7

The Seventh Framework Programme bundles all research-related EU initiatives together under a common programme. The FP7 is playing a critical role in reaching the goals of growth, competitiveness and employment. It is one of the tools to reach the European Union's Lisbon objective to become the "most dynamic competitive knowledge-based economy in the world". The programme will last for seven years from 2007 until 2013 and has a total budget of over € 50 billion. It is divided in 4 main specific programmes:

- The Cooperation Programmes: € 32.413 million;
- The Ideas Programmes: € 7.513 million;
- The People Programmes: € 4.750 million;
- The Capacity Programmes: € 4.097 million.

The Cooperation programmes will be devoted to supporting cooperation between universities, industry, research centres and public authorities throughout the EU and beyond. The Cooperation programme is sub-divided into ten distinct themes, one of them is Energy (2.300 million €). The Energy theme covers: hydrogen and fuel cells, renewable electricity generation, renewable fuel production, renewables for heating and cooling, CO<sub>2</sub> capture and storage technologies for zero emission power generation, clean coal technologies, smart energy networks, energy efficiency and savings, knowledge for energy policy making.

It is expected that renewable energies will cover 45% of the energy sector total budget: around € 1.035 million between 2007 and 2013 (€ 150 million per year on average) and 11% of the total funding Energy Efficiency projects. At the end of 2009, second generation fuel from biomass and photovoltaics were the most subsidized technologies.

There is a huge financing need during the early-stage of RE technology development that EC only partially covers. Indeed, the demand for grant under the FP7 Energy Theme of the



renewable energy activities is between six and eight times higher than the EC contribution according to the statistical overview of the implementation of the FP7 Energy Theme.

## **2. CIP**

With small and medium-sized enterprises (SMEs) as its main target, the Competitiveness and Innovation Programme supports innovation activities (including eco-innovation), provides better access to finance and delivers business support services in the regions. Among others it promotes the increased use of renewable energies and energy efficiency and it runs from 2007 to 2013 with an overall budget of € 3621 million.

The Entrepreneurship and Innovation Programme (**EIP**) is one part of the CIP. Two financial instruments have been developed by the EIP:

- High Growth and Innovative SME Facility (GIF 1&2) and
- SME Guarantee Facility (SMEG).

GIF 1 and 2 are capital risk instruments, while SMEG is a guarantee instrument. The budget for 2007-2013 of the former is €550 million, and €506 millions for the latter. Those CIP financial instruments are not directly available to SMEs but implemented by the European Investment Fund (EIF) and selected financial institutions. For GIF, EIF invests in funds focused on early and expansion stage of specialized sectors, particularly eco-innovation. In this “eco-innovation” group, some companies are likely to be in one of the renewable energy technologies. The total amount dedicated to renewable energies can not be estimated; however it should not be very significant. Concerning the SMEG scheme, around 5% of the total budget would be allocated to “eco-innovation” (including some renewable energy companies). Similarly to GIF, the total amount dedicated to renewable energies can not be estimated, but it should not be very significant.

The Intelligent Energy Europe (**IEE**) Programme is the other part of the CIP. It aims at being a catalyst for innovation and new market opportunities. It is therefore aiming at market development and capacity building and not hardware investment or R&D. IEE Programme raises awareness on new market transformations. The 2009 funding areas of IEE are the following:

- Energy Efficiency;
- RE sources (“ALTENER” priority);
- Mobility;
- Local Leadership;
- Special initiatives.

The IEE Program is implemented largely by means of two main instruments:

- Grants : Grant agreements / Direct Grant;
- Procurement.

The IEE Programme finances different initiatives: usual projects, and specific initiatives such as “Covenant of Mayors”, ELENA and Mangenergy.

Usual projects aim at raising awareness in European territories (e.g. developing a target-group-specific financial scheme with experts overcoming financial barriers in geothermal projects; enhancing proactive land valorisation policies within a strategic eco-sustainable approach to local developments, promotion of Renewable Energy for Water production through Desalination ...). The average size of a usual project is €1 million. Financed projects have to involve a minimum of 3 different countries per project and the average number of countries involved in one project is around 7 or 8.

## **3. Regional Policy**

The European cohesion policy supports the regions through the financial instruments called the European Funds: the European Regional Development Fund (ERDF) and the Cohesion Fund (CF). The European Funds are often simply called the Structural Funds.

The regulation on the ERDF defines its role and fields of interventions as the promotion of public and private investments to help reduce regional disparities across the Union. The detailed management of programmes which receive support from the Structural Funds is the Member States' responsibility. For every programme, they designate a managing authority (at national, regional or other levels) which will inform potential beneficiaries, select the projects and generally monitor implementation. The expenditure planned by ERDF and CF on RE for the 2007-2013 period amounts 4.760 million €. This represents a total of 680 million €/year.

The European Parliament passed the €5 billion European Union (EU) Economic Recovery Plan on 6 May 2009, which will see investment in energy projects, broadband internet infrastructure and rural development. In the energy sector three activities are concerned:

- Gas and electricity infrastructure (€2,365bn);
- Offshore wind energy (€565 million);
- Carbon capture and storage (CCS) projects (€1,05bn).

The budget was allocated in 2009 and 2010 for the selected projects. For the Offshore wind energy, 9 projects representing €565 million have been selected. These projects will be implemented in Germany, Sweden, Denmark, The Netherlands, Denmark, United Kingdom and Belgium.

#### **4. EIB**

Since 2006, EIB spending on RE has strongly increased (from € 0,5 billion to 2,8 billion in 2009). Renewables represent about a third of EIB's total energy spending (11 billion within Europe in 2009). The rest is conventional energy capacities, transmission, etc.

Key words of EIB's intervention in the sector are "clean, secure, competitive". Their goal also includes setting the trend to decrease the cost curves of emerging technologies. The EIB has also provided credit lines to banks and financial institutions to help them provide finance to small and medium-sized enterprises or public institutions active on various RE projects, including wind, solar PV and biomass.

Other minor investment sectors are EIB carbon fund of 50 million € (purchase of carbon credits) and a 185 million € loan attributed to Acciona's Research, Development and Innovation programme.

90% of spending of EIB on RE is done within EU. The main beneficiaries were Spain, UK, Belgium, Italy and Ireland benefiting from almost three quarters of EIB expenditures in 2009.

The EIB normally finances projects up to 50% of investment costs; however, exceptionally the EIB is willing to provide a larger percentage for renewable energy projects and projects making a significant contribution to energy efficiency. Financing may be combined with EU grants depending on the scope and definition of the individual project. Debt tenors are usually 12-15 years. Other financing instruments include infrastructure investment funds through which the EIB indirectly participates in companies and projects promoting EU priority objectives in energy and renewable energy projects.

EIB's Corporate Operational Plan for the years 2010-2012 highlights two key objectives:

- 25% of total lending should be related to Climate Change (RE, EE, Transport, etc.);
- 20% of all energy financing should be dedicated to renewables (already achieved).

Currently the EIB plays a strong role on the market as the credit market is holding back RE projects, but the EIB is not inexhaustible. State-owned banks should also do the effort to get more involved in RE financing. The EIB on its side could also contribute to catalyzing private equity. The EIB encourages the Commission to support the risk-sharing facility. It can be a very good multiplier of money invested in this facility.

#### **5. EBRD**

The EBRD supports Renewable Energy projects from Central Europe to Central Asia mostly through the Sustainable Energy Initiative (SEI). The SEI, launched in 2006, responds to

specific needs of the energy transition in the EBRD countries of operation: regulatory frameworks not in place in many countries, preferential tariffs not always adequate, problematic grid access, technical and financial skills gaps.

The first phase of SEI ended up in 2008 with an amount of investments of € 2,7 billion (above its original targets) in the following categories:

- SEI 1 : Industrial energy efficiency;
- SEI 2 : Sustainable Energy credit lines;
- SEI 3 : Cleaner energy production;
- SEI 4 : Renewable energy;
- SEI 5 : Municipal infrastructure energy efficiency.

SEI 2 and SEI 4 fall under the scope of renewable energy financing. During the first period of SEI implementation (2006-2008), 10% of investments were signed in the Renewable Energy sector that is to say €277 million over 3 years.

Building on this first experience, SEI phase two objectives for the period 2009-11 include:

- EBRD SEI financing target range of €3 to 5 billion for total project value of €9 to 15 billion: the same rate of investments in the RE sector as during the first period can be expected, that is to say €500 million over the 3 years;
- Technical assistance grant funding of €100 million and investment grant funding target of €250 million for EE and RE projects.

After having a picture of the funding structure for RES, the next paragraphs will show an estimation of investments in RES projects in the EU according to the RE-Shaping D8 report (January 2011) [22].

Investments in RE projects represent investments in tangible fixed assets and are financed by equity, debts and in some cases by grants. These three capital types differ with respect to their source and subordination. In general, subordinated capital shows a higher exposure to risks and hence requires a higher risk premium. To analyze the current RES investment situation, the investments in RES projects are estimated via two approaches:

- RES investments are based on the number and volume of transactions in the corresponding year (Database of BNEF 2010).
- RES investments rely on the estimation of the monetary value of the installed RES capacities in the EU, based upon average capital costs per capacity (Held 2010) and capacities installed (EUROSTAT 2010). These investments reflect the capacities of the installations completed in the corresponding year.

## **1. Investments in RES based on financial transactions**

The database of BNEF (Bloomberg New Energy Finance) applied in the first approach reflects asset financing related to the generation of electricity, heat or fuel from RES. The estimation includes RES investments within the EU, differentiated into RES sectors and types of transactions, such as acquisitions, refinancing or financing of RES projects by debts and equity. The financial transactions are marked with the status “announced” or “completed”. This status refers to the transaction status and not to the project development status. A completed or announced financing could coincide with different project development phases, e.g. project planning or construction, while refinancing or acquisitions can also take place during the operation phase.

The analysis of the data refers to the number of transactions and the transaction volume. The transaction volume – if disclosed - either comprises total capital (equity and debt) invested, debt or equity only. Not disclosed values on transaction volumes have been supplemented. Since the transaction volume only reflects partial investments – in several cases just equity or

debt – total investments in RES tend to be underestimated. Furthermore, small individual investments, grants or investment subsidies provided by states, governmental organizations or NGOs are not listed in the dataset. However, this approach reveals current investment trends and activities, and allows a differentiation of investments with respect to financing instruments.

The results of the first approach show that asset financing of RES projects in the EU has significantly increased in number and transaction volume during the last decade. The number of planned, announced or completed transactions in RES projects encompassing biomass, solar energy, wind power, small hydropower, tidal power and geothermal plants reached the zenith with around 750 activities in 2008 and decreased slightly in 2009. Data on activities in 2010 are still incomplete and hence not fully usable. However, first publications of BNEF (2011) reveal even a further increase in RES investments in 2010. Regarding the type of transaction, financing of new RES installations dominates by number and volume and strongly determines the growth in RES financing activities.

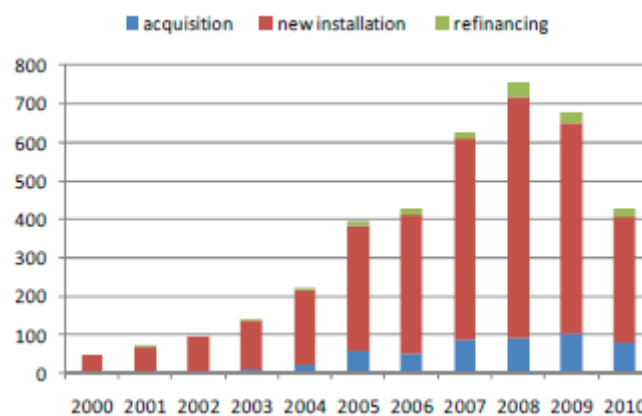


Figure A2: Number of transactions in the EU in 2000-2010 [22].

For further analysis, the completed transactions - and not announced or planned transactions - are of interest. The development pattern of completed transactions is similar to the pattern of total RES asset financing. In numbers and financed volume, investments peak in 2008 and 2009, respectively. The total volume of investments in RES projects in 2009 is estimated between € 20 and 53 billion.

The range of uncertainty in the estimation based on the existing data is indicated in Figure A3. The large uncertainty is due to the fact that the total transaction volume is not disclosed for many projects in the database. The upper range refers to the assumption that the average transaction volume of all disclosed transactions is used for the non-disclosed ones. The lower range reflects the transaction volume if non-disclosed transactions are set to zero.

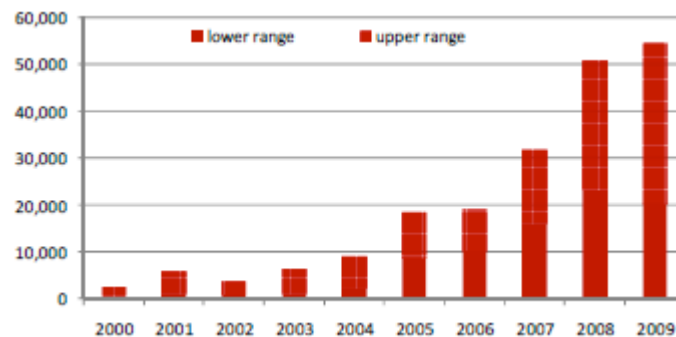


Figure A3: Estimated volume of transactions in million € [22].

In the last years, the investment in RES has been dominated by wind and solar power. Most of the transactions take place in Spain, the United Kingdom, Germany, France and Italy (2008 and 2009), where mainly PV and wind power projects are developed.

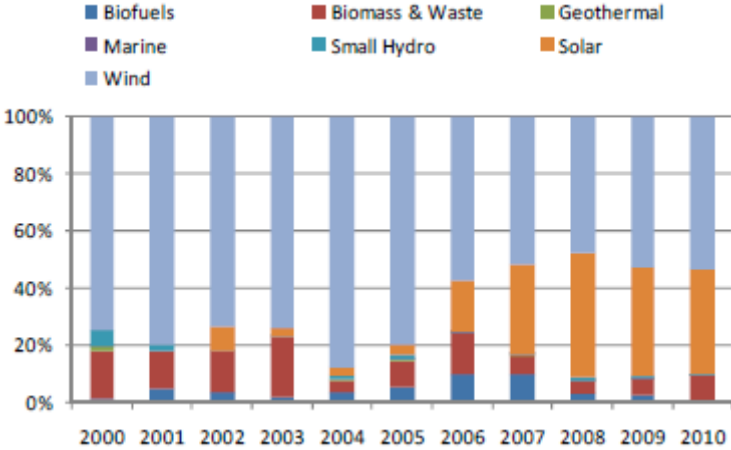


Figure A4: Share of financed new RES projects in the EU from 2000 – 2010 by sector [22].

Regarding the type of finance, balance sheet financing is still dominating the financial activities, but with decreasing importance. In turn, loans – construction loans, syndicated bank loans – gain in importance.

The growth of loans and public capital in RES financing signals an increasingly maturing market and decreasing risks, both also probably influenced by the increasing use of RES policy support mechanisms with guaranteed off-take prices.

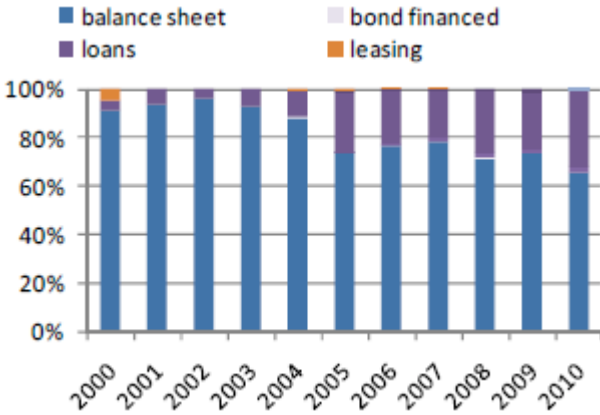


Figure A5: Shares of financing instruments based on number of transactions, EU 2000 – 2010 [22].

**2. Investments based on RES installations**

A second approach, based on installations in RES power generation plants, was pursued. The investments are estimated based on the growth of installed RES generation capacities weighted with the average investment per capacity.

The data on capacity installations relies on statistical data from EUROSTAT, where current data for 2010 or 2009 is not available yet. Therefore, the values for 2009 are projected and not based on statistics about actual installations, as in the preceding years. The data for the average capital costs per installed capacity is applied as gathered in Held (2010). The investments enter the statistical database in the year the generation plant starts operation.

The results depicted in Figure A6 show a steadily increasing investment in RES projects reaching around € 40 billion in 2009. Regarding RES installations with respect to RES technology and country, PV and wind power have dominated the RES projects in recent years, and Spain, Germany, Italy, the United Kingdom and France are also the leading countries in RES investments.

Compared to the first approach, this method reveals an investment volume that is significantly lower than the estimated investment volume based on financial transactions. Furthermore, it allows no conclusions on the financial instruments used to finance RES investments to be drawn, but it shows the capital funds needed.

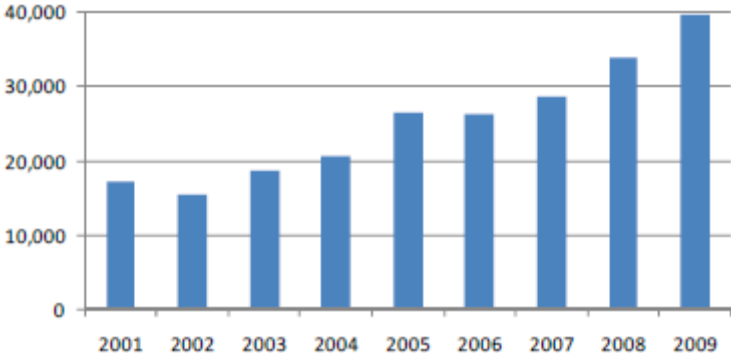


Figure A6: Investments of new RES projects in the EU from 2001 – 2009 in million € [22].

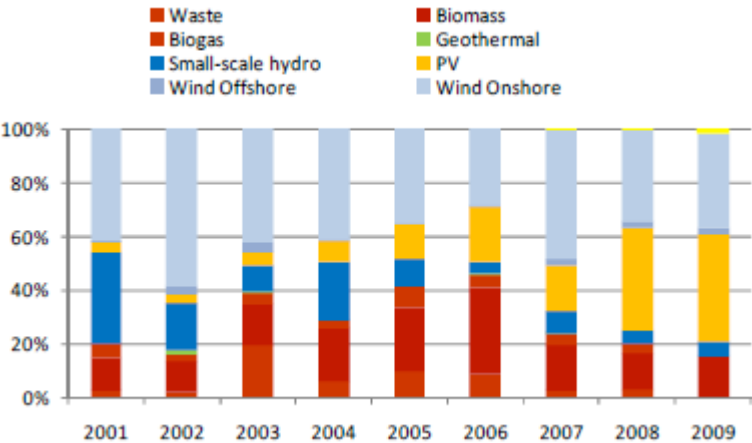
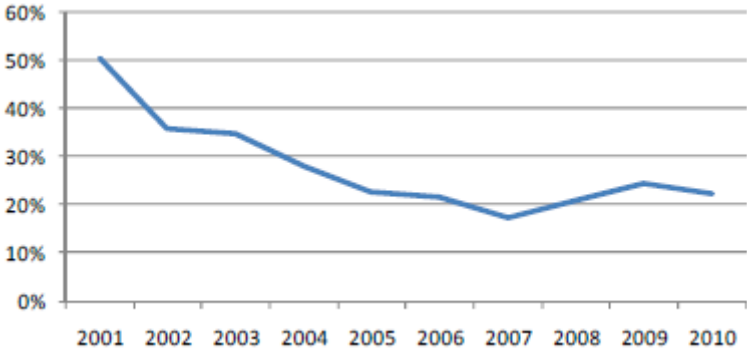


Figure A7: RES investments 2001 – 2009 in the EU by technology [22].

The estimated investments based on financial transactions show a similar level to those based on capacity of around € 40 billion in 2009, whereas the estimate based on completed transactions is subject to substantial uncertainty.

In both approaches, most investments were carried out in wind power and PV and take predominant place in the same five countries, but with a slightly different order. One of the main reasons for the differences in investment volume is likely to be the time gap between financial transactions and installed capacity. The first takes place during planning, development and construction of the generation plant, while the latter occurs with the completed installation or operation of the plant. Further, financial transactions include all RES projects (power and fuel, possibly heat) while installed capacities include only plants for electric power generation, but no fuel refineries. Additionally, data on financial transactions are most likely rather incomplete for the earlier years of the last decade. Finally, in 2000, markets for RES investments were less mature than in 2010, therefore probably less financing deals were concluded in the market.

The decreasing equity share in RES investments (Figure A8) shows changes in financing patterns that could be explained by technology and market development, resulting in a reduction of risks. Furthermore, from the viewpoint of investors and lenders, the strong political commitment for RES might also contribute to a reduction and/or shift of risks.



**Figure A8:** Average equity-debt ratio of RES investments in the EU from 2001 – 2010  
 Transactions with 100% share of equity or debt are ignored [22].

Overall, in the EU, financial transactions – and hence investments - in RES projects have strongly increased over the last years and range between € 55 and 62 billion (US\$ 60 and 70 billion in 2008 and 2009, respectively).

The estimated investments exceed those indicated by REN21 for Europe, the Middle East and Africa (US\$ 42 billion in 2009). Capital expenditures needed to achieve the EU deployment objectives are estimated at € 70 billion per year, which is still quite above the current actual investments; but they tend to get closer.

Furthermore, capacity-based installation was relatively high at the beginning of the decade, but grew at a slower pace than financial transactions. The dominance of capacity-based investment in 2000-2006 can be explained by rather immature markets for RES investments, in line with a strong political commitment.

While at the beginning of the decade balance sheet financing (with equity) strongly dominated the financial instruments, in recent years debts or loans are growing in number, revealing an increasing confidence of lenders and other investors in the RES business/market.

### *A3. Evaluation of Support Schemes in Key RES Technologies*

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Evaluating the experiences made with policies for the support of renewable energy technologies (RET) in practice is crucial to continuously improve the design of renewable policies. To do so, reliable evaluation criteria covering various aspects of renewable support policies have to be defined. These aspects include the effectiveness of the policies used to measure the degree of target achievement and the costs for society resulting from the support of renewable energies, expressed by the static efficiency. In addition, a comparison of the economic incentives provided for a certain RET and the average generation costs, helps to monitor whether financial support levels are well suited to the actual support requirements of a technology.

To assess the described issues, this analysis [22] relies on the *policy performance indicators* that have already been developed in the context of the EIE-funded research project OPTRES and applied for EC's monitoring process of renewable support schemes as well as for an analysis of the International energy agency.

The *Policy Effectiveness Indicator*, has formerly be used to evaluate RET exclusively in the electricity sector, to monitor the effectiveness of support policies in the heating and cooling sector as well as in the transport sector. In principle the effectiveness of a policy instrument serves as a measurement for the degree to which a predefined goal could be achieved.

Nevertheless, this definition of the effectiveness complicates a cross-country comparison of the effectiveness, as the setting of objectives and their ambition level might vary significantly among countries. A less ambitious objective is easier to attain than a more ambitious one. In this case, the degree of achievement does not serve as an appropriate indication for the quality of a support scheme. Consequently, the effectiveness of a policy scheme for the promotion of renewable electricity is understood as the increase in the supply of renewable final energy due to this policy compared to a suitable reference quantity. Such a reference quantity could be the additional available renewable electricity generation potential or the gross electricity consumption.

The renewable final energy provided may show some volatility from year to year which cannot be attributed to changes in policy support, but rather to weather-related factors. This means, that hydro or wind power electricity generation may vary from year to year as a result of changing precipitation or wind speed conditions. In case of renewables-based heating system, it shall be considered that the space heating demand may also vary according to the average temperatures. To exclude the influence of changes in the supply of renewable final energy due to weather conditions and other external and un-predictable circumstances, the energy provided shall be corrected by these factors. Using real generation figures would lead to a biased picture of policy effectiveness, as for instance a successful policy in the wind sector would be underestimated, if the wind conditions were especially bad in the observed time frame.

In order to take into account additional factors that may influence the attractiveness of RET investments information about the deployment status of a certain RET will be provided in terms of the *Deployment Status Indicator*. The *RET (Renewable Energy Technology) Deployment Status Indicator* aims to quantify how advanced the market for a specific RET is in a specific Member State: the higher the value, the higher the maturity of that specific technology market in that country. The indicator shall be applicable to the key RE Technologies in 27 EU Member States based on existing statistical data.



Based on earlier RET market surveys, we differentiate three types of deployment status, well aware that these categorization is somewhat rough and generalizing.

**Immature RET markets** are characterized by small market sizes, few market players and low growth rates. Local, regional and national administrations have little experience with the use and the promotion of that RET. Also local banks needed for financing, energy companies and local project developers have little experience with that RET. This goes along with the typical market entry barriers for the RET, e.g. long and in transparent permitting procedures, grid access barriers, low or unreliable financial support etc.

**Intermediate RET markets** are characterized by increased market sizes, typically accompanied by strong market growth and the interest of many market players. The increased market size reflects that the energy sector, the administration and parties involved in financing have gained growing experience with the RET. In case of fast market growth, growth related market barriers may occur, e.g. infrastructural (rather local) and supply chain bottlenecks (both local and global). Not all intermediate markets show fast market growth, however; in some countries this status reflects that the market has stopped growing at intermediate level, e.g. due to a stopped support policy; in other countries the potential for a specific RET is so limited that the market cannot reach advanced deployment status.

**Advanced RET markets** are characterized by established market players and fully mature technology. Market growth may start to slow down at this advanced stage. Market players may encounter typical high-end barriers: competition for scarce sites and resources as the most cost effective RES potential is increasingly exploited, power system limitations like curtailment, etc.

In addition to the effectiveness of policy support the level of financial support paid to the supplier of renewable final energy is another core characteristic of a support policy. Besides its direct influences on the policy cost, it influences also the policy effectiveness. In general, one can expect that a high support level induces more capacity growth than a lower support level, provided that the remaining framework conditions are equal. Evidently, a higher support level does not necessarily lead to an accelerated market development of RET, if e.g. the framework conditions for permitting procedures are not favourable or if risk considerations are taken into account. Nevertheless, a high support level involves higher policy costs to be borne by the society. Hence, the support level should be sufficient to stimulate capacity growth of RES by offering a certain profitability level to potential investors but should also avoid windfall profits caused by high support levels exceeding the requirements of the RES technology.

Comparing the support level available for the different technologies in each MS contributes to the identification of best policy practices that have been the most successful in encouraging market growth at preferably low costs. However, the actual support levels are not comparable, since significant criteria including in particular the duration of support payments are not considered. For this reason the available remuneration level during the whole lifetime of a RET plant has to be taken into account. The remuneration level contains the final energy price if the support payments expire after a certain time horizon, but the RET plant continues in operation. To make the remuneration level comparable, time series of the expected support payments or final energy prices respectively are created and the net present value is calculated. The remuneration level under each instrument was normalised to a common duration of 15 years based on the assumption of discount rate of 6.5 %. The discount rate is assumed to reflect weighted average costs of capital (WACC) consisting of costs for equity and debt. Support payments with a duration of 20 years lead to a higher annualised remuneration level than the same payments available only for 15 years. In case of a certificate scheme, it was assumed that remuneration level is composed of the conventional electricity price and the average value of the tradable green certificate. It is supposed that the elements of the time series remain constant during the time certificate trading is allowed.

## 1. Wind Onshore (RES-E)

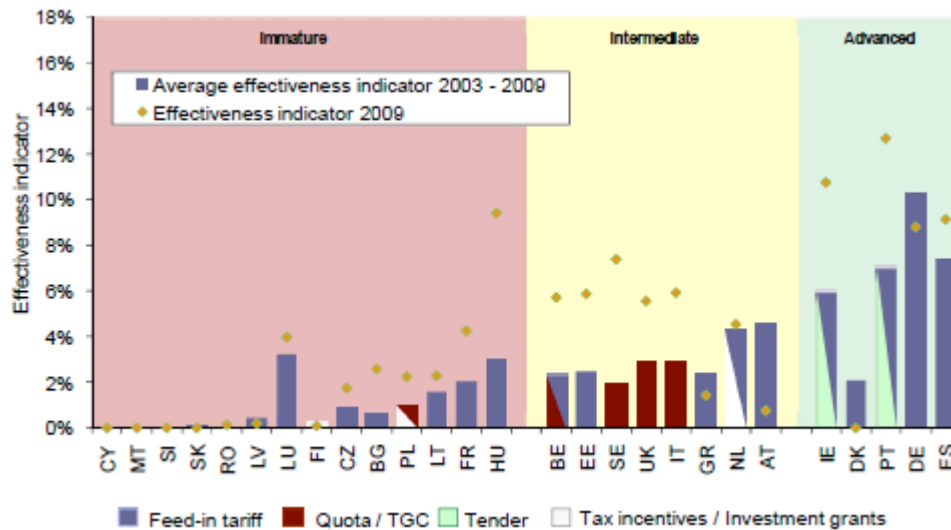


Figure A9: Policy effectiveness indicator in the period 2003-2009 [21].

Figure A9 displays the *Policy Effectiveness Indicator* for wind onshore power plants. The columns depict the average indicator of the observation period 2003 to 2009. To get an idea of the current trends of the policy effectiveness, the effectiveness indicator is also shown for 2009, the last year where statistical data is available. The colour of the columns indicates the policy instrument prevalingly applied in the respective country to support wind onshore power plants.

Observing Figure A9, it becomes evident that the countries with the highest average effectiveness during the last seven years (Germany, Spain, Portugal and Ireland) apply feed-in tariffs to promote electricity produced by wind power plants (onshore). Whilst Germany and Spain already supported effectively wind onshore electricity before 2003, the wind onshore development in Ireland and Portugal caught up after 2004. Regarding Ireland the change from the tendering system to a feed-in tariff, which took place in 2006, helped to speed-up the development of wind onshore energy.

The trend of the policy effectiveness in 2009 observed in a group of countries with a reasonable average policy effectiveness including Belgium, Estonia, Hungary, Italy, Sweden and UK is clearly upward. Despite existing grid-capacity problems in Estonia, wind onshore capacity increased from 77 MW to 150 MW in 2009. The accelerated growth in 2009 appears to be a result of the government's decision to increase the cap for electricity from wind power plants that receives the feed-in tariff support from 400 GWh to 500 GWh. Although the grid capacity still appears to be a limiting factor in Italy wind power plants experienced strong growth in Italy during the last five years, achieving a total of almost 4,8 GW of wind power plants at the end of 2009. To tackle the grid-integration problems obliged curtailment of wind power production was already required and realised in Italy. After comparatively moderate capacity development of wind onshore energy in Sweden until 2008, Sweden shows a strong policy performance in 2009, corresponding to a doubling of the installed capacity to a total installed capacity of 1.4 GW. The example of Hungary – that showed the third-highest policy effectiveness in 2009 while it has the 15th rank in deployment status - shows that strong growth can be achieved also in Member States starting from a low deployment level.

Looking at the situation in France, the effectiveness of policy support has been improving in recent years. However, given the vast wind energy potential, more growth than the additionally installed 1 GW of wind turbines in 2009 could be expected. Despite a favourable

feed-in tariff system, problems with permission procedures and an active anti-wind lobby are still obstacles to higher growth rates.

Policy effectiveness in the Netherlands appears to be on a reasonable level on average. The capacity growth achieved in 2009 is mainly due to the repowering of old turbines. In the Czech Republic a reasonable capacity growth of wind onshore power plants is hampered by a very strong growth of solar PV power plants. The extraordinary growth of Solar PV in the Czech Republic may have involved some difficulties for wind projects to get permissions for connecting to the electricity grid which again may have hampered stronger growth of wind energy.

In general, the progress in the support of wind onshore energy is low in Finland, Latvia, Romania and Slovakia. Hardly any capacity growth has been observed in Cyprus, Malta and Slovenia.

Comparing the policy effectiveness of wind onshore electricity with previous analysis (European Commission 2005; European Commission 2008), it becomes clear, that countries using quota obligations such as Italy, Sweden and the United Kingdom have caught up in terms of policy effectiveness in particular in 2009. However, their performance still lags behind policy effectiveness in the group of effective feed-in tariff countries Spain, Germany, Portugal and Ireland.

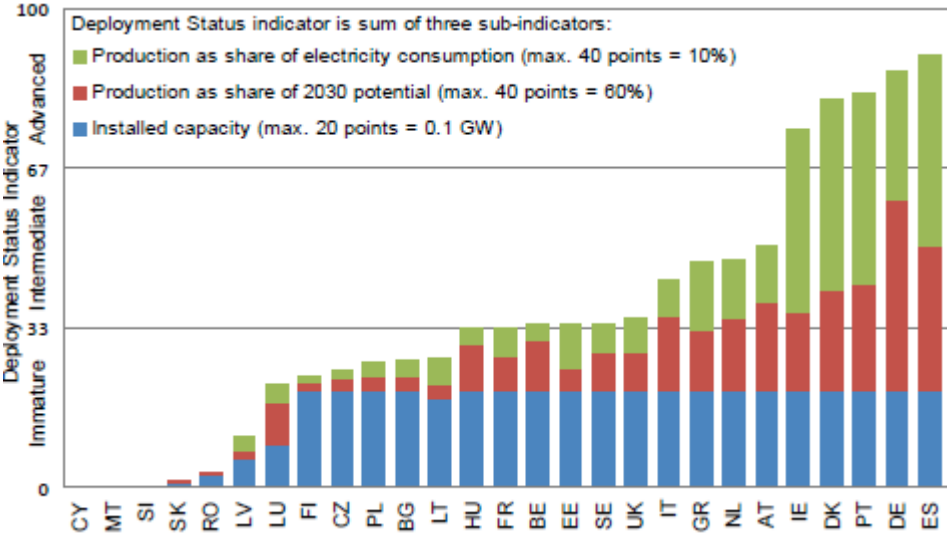
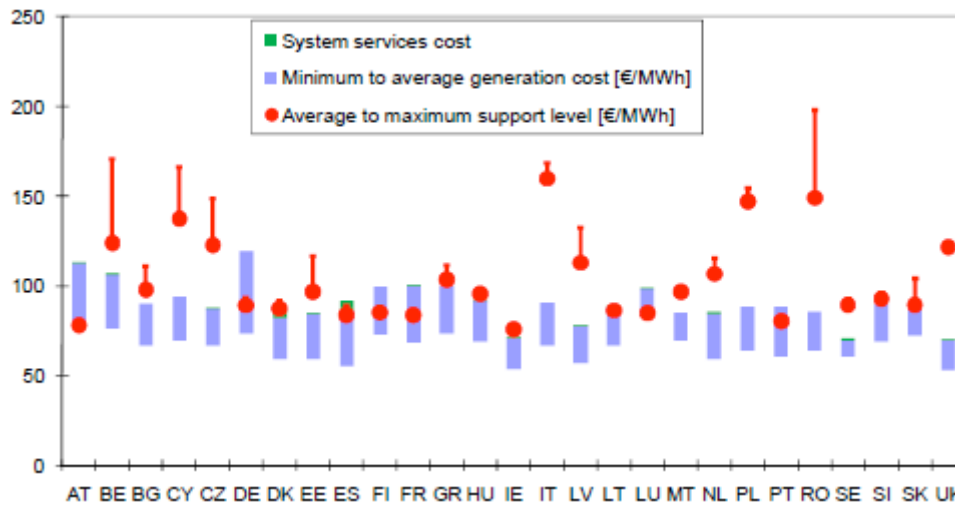


Figure A10: Deployment status indicator for 2009 [21].

Wind onshore is one of the more advanced technologies (Figure A10). The majority of MS meets (or exceeds) the 100 MW installation threshold. 15 MS reach the deployment status intermediate or higher. The results for the five advanced countries illustrate how the sub-indicators balance each other: The absolute market size and the share of exploited potential is in the medium range for Portugal, Denmark and Ireland (all < 4 GW installed capacity, 25-32% exploited potential), but wind energy already plays an advanced role in their electricity sector (10 or more percent of sector consumption). Germany has developed the largest wind onshore market and exploited 57% of its on-shore potential, but the contribution to the electricity sector is with 6% not as high as in the other frontrunner countries. Spain is the only country that scores high on all sub-indicators.

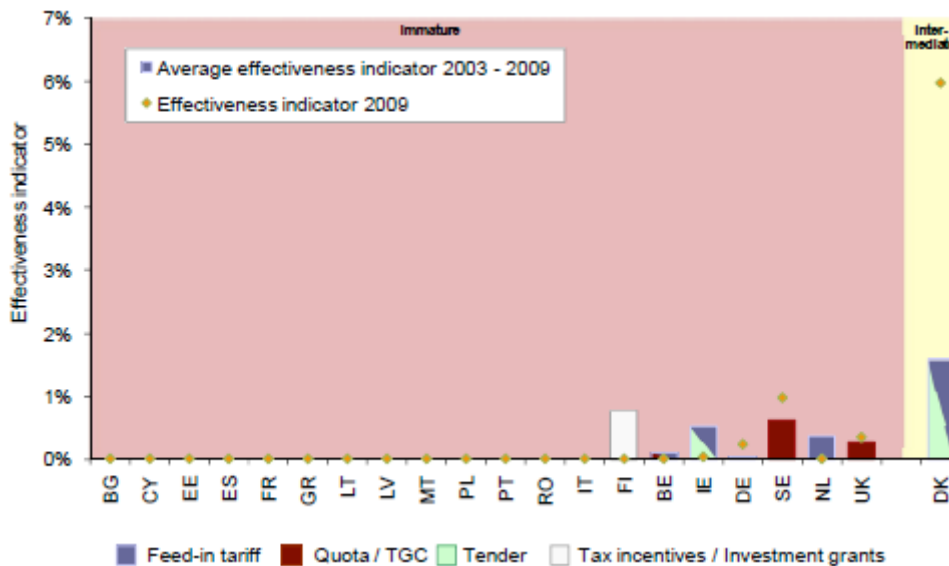
Figure A11 shows the range for the support level paid for electricity generated by onshore power plants and compares it with the minimum to average electricity generation costs.



**Figure A11:** Support level ranges (average to maximum support) in 2009 (average tariffs are indicative) compared to the long term marginal generation costs (minimum to average costs) [21].

Electricity generation costs of wind onshore power plants have increased during the last few years as a result of increasing steel prices and a strong demand for wind turbines. In general, almost all EU Member States appear to provide a sufficiently high support level for wind onshore electricity. Only in Austria and Luxemburg, the support level is just high enough to cover the lower limit of electricity generation costs. In contrast, countries applying a quota obligation with tradable green certificates such as Belgium, Italy, Poland, Romania and the UK provide a support level which clearly exceeds the average level of generation costs. Likewise, the feed-in tariff in Cyprus leads to a rather high support level of roughly 166 €/MWh at the maximum. In the figure, the system services costs are displayed. They notably contribute to the generation costs in Denmark, Spain and the Netherlands.

## 2. Wind Offshore (RES-E)



**Figure A12:** Policy effectiveness indicator in the period 2003-2009 [21].

Due to the fact that the development of wind offshore is still in its initial phase, the *Policy Effectiveness Indicator* is still on a considerably lower level than in case of wind onshore. Comparing the policy effectiveness in the EU Member States reveals that Denmark is the

most successful country in supporting the market diffusion of wind off-shore technologies so far. Both, the average effectiveness as well as the trend in 2009 shows higher values than in other European countries. Finland, Sweden, Ireland, the Netherlands and the United Kingdom begin to achieve capacity growth of wind offshore power plants. Due to differences in the overall wind offshore potential, the effectiveness in Finland, where one offshore wind park (Kemi Ajos I & II) of 24 MW was installed between 2007 and 2008, was higher than in the United Kingdom, where a total of 688 MW have been installed until 2009.

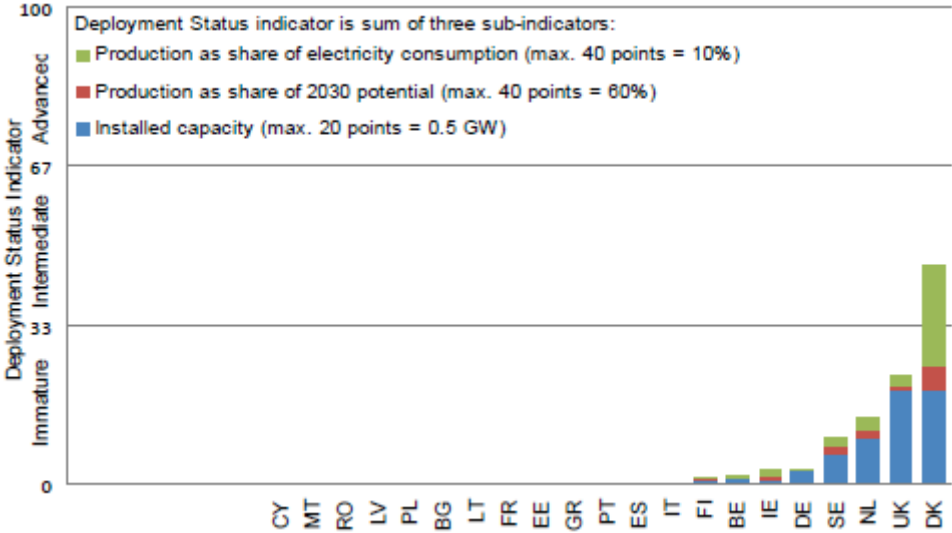


Figure A13: Deployment status indicator for 2009 [21].

Only eight MS deploy wind offshore so far (Figure A13). The deployment status is still immature in all countries except Denmark, where wind offshore contributes with 5,3% to electricity consumption. Besides Denmark, also the UK exceeds the 0,5 GW threshold. The UK is currently clearly the most dynamic market in terms of projects under development, but as explained earlier this indicator does by purpose not include dynamic elements.

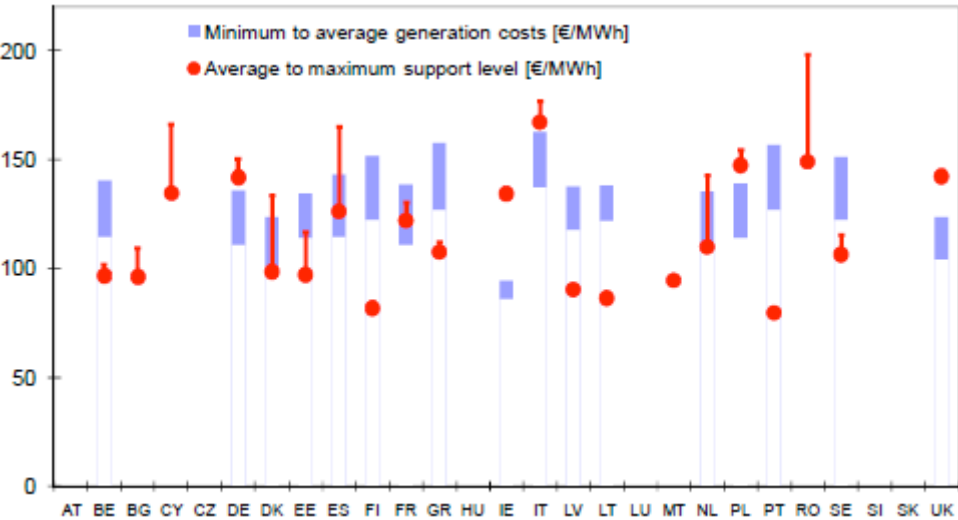


Figure A14: Support level ranges (average to maximum support) in 2009 (average tariffs are indicative) compared to the long term marginal generation costs (minimum to average costs) [21].

Figure A14 indicates cost ranges for electricity production in wind offshore power plants and the available support level. Electricity generation costs of wind offshore power plants are mainly characterised by the water depth, the distance to coast and finally by the local wind

conditions. Germany, Italy, Poland and the United Kingdom apparently provide a support level above average electricity generation costs. Given the fact that less experience with commercial wind offshore installations is available than in case of wind onshore, offshore electricity generation costs are characterised by higher uncertainties. In countries such as Denmark, Spain, France and the Netherlands the support granted for wind offshore appears to be sufficient for the lower cost potentials. In contrast, the support level available for wind offshore in Belgium, Estonia, Finland, Greece, Latvia, Lithuania, Portugal and Sweden is clearly beyond the economic requirements in the respective countries.

### 3. Solar Photovoltaics (RES-E)

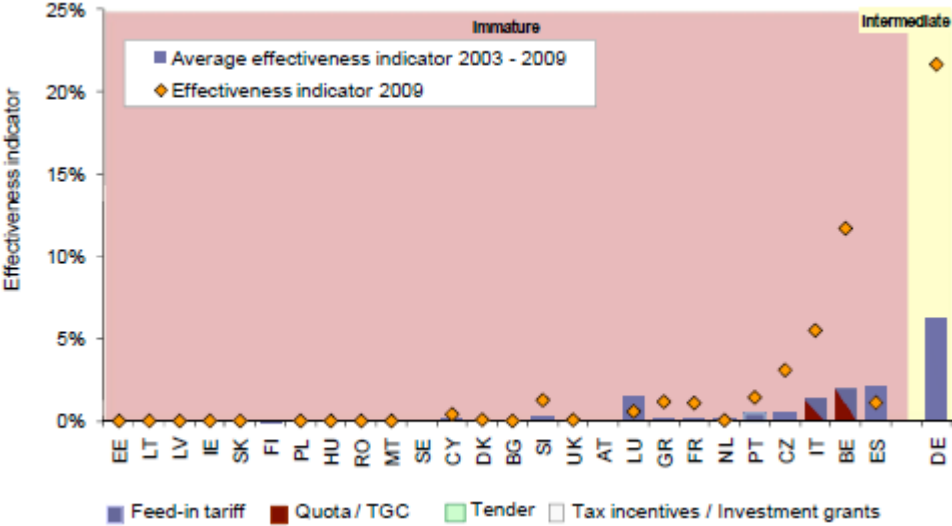


Figure A15: Policy effectiveness indicator in the period 2003-2009 [21].

Similar to the case of wind onshore, statistical data for solar PV required to calculate the effectiveness indicator as shown in Figure A15 is available until 2009. However, it was necessary to estimate electricity generation in the year 2009, as only capacity data is available. Therefore, 2009 capacity data is multiplied with the ratio of electricity generation and capacity data in 2008.

In general the Policy Effectiveness Indicator for PV is on a lower level than in case of wind onshore energy and the same goes for the Deployment Status (Figure A16). This is partly due to still comparatively high electricity generation costs and many markets still being in their infancy. In addition this fact can be explained by the large PV potentials available in most Member States, which means that only smaller shares of the potential can be realised in a year compared to technologies with a limited total potential. However, the deployment of solar PV in the EU has increased impressively during the last decade, increasing from merely 180 MW in 2000 to 15,7 GW in 2009.

Looking at the development in the individual MS, it becomes evident that Germany clearly dominates the PV deployment in recent years. With roughly 9,8 GW of totally installed PV capacity by the end of 2009, more than 60% of PV capacity installed in Europe is located in Germany. But other countries such as Spain, Belgium, Luxembourg and Italy also show a considerable market development of PV. Whilst in Spain PV capacity nearly stagnated in 2009 as a result of cuts in feed-in tariffs and the limitation to support only 500 MW of additional PV capacity, Belgium and Italy show considerable average policy effectiveness due to an outstanding development in 2008 and 2009.

According to the effectiveness indicator in 2009 further growing PV markets are the Czech Republic and Portugal. In particular the Czech Republic experienced an exceptional boom of solar PV development in 2009 with an additionally installed capacity of more than 400 MW.

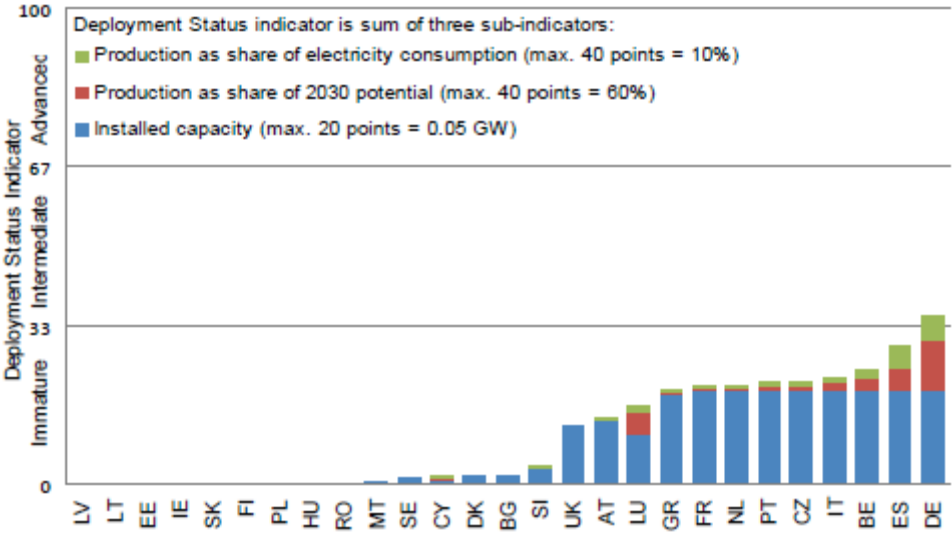


Figure A16: Deployment status indicator for 2009 [21].

The deployment status of photovoltaics is still immature in all MS except for Germany. Seven further countries pass the 50 MW threshold (Spain, Belgium, Italy, Czech Republic, Portugal, the Netherlands and France). Compared to other RET, the untapped PV potential is huge. Only three countries exploit more than 5% of their mid-term PV potential: Germany (16%), Spain and Luxemburg (both 7%).

The German PV market is currently by far the most important one in terms of installed capacity and market dynamics. This is not fully reflected by the indicator, because the indicator does not reflect absolute market size only to a limited extent in order to be able to compare larger and smaller Member States. The indicator gives strong weight to production as share of consumption and potential, and in that respect even the German market is still rather small with 1,3% contribution to electricity consumption and 16% of the mid-term potential being exploited.

In contrast to the case of wind onshore electricity, Figure A16 shows that the support level paid for electricity from Solar PV power plants is far below electricity generation costs in some countries. These countries include some Northern European countries with less favourable solar conditions such as Denmark, Estonia, Finland, Ireland, Poland, Sweden and the UK. However, also Southern European countries including Hungary, Malta and Romania provide a support level significantly below the range of electricity generation costs. Belgium and Italy, both countries using a quota obligation as their dominant support scheme offer special feed-in tariffs for Solar PV electricity. In the United Kingdom, the technology-banding option, which provides two certificates for one MWh of Solar PV electricity, implies a support level which is still far below generation costs.

In Bulgaria, Cyprus and Czech Republic tariffs clearly exceed the level of average generation costs, whilst France, Greece, Italy, Portugal and Spain support photovoltaic electricity with stable and technology-specific feed-in tariffs. According to Figure A17 Germany, Latvia, Lithuania, Luxembourg, the Netherlands and Slovenia apparently provide a sufficient support level for the lower-cost potentials of solar PV electricity.

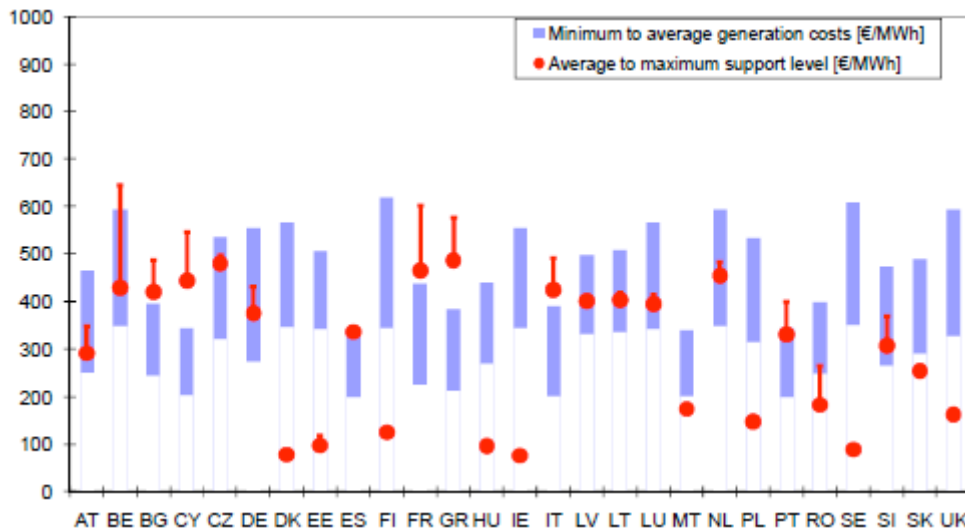


Figure A17: Support level ranges (average to maximum support) in 2009 (average tariffs are indicative) compared to the long term marginal generation costs (minimum to average costs) [21].

#### 4. Solid & Liquid Biomass (RES-E)

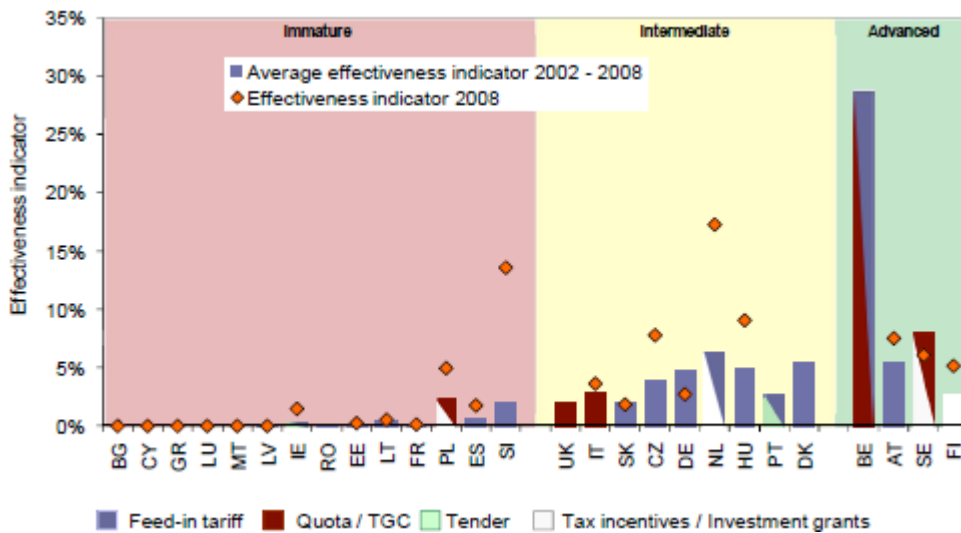


Figure A18: Policy effectiveness indicator in the period 2002-2008 [21].

To calculate the effectiveness indicator for electricity generation based on solid and liquid biomass illustrated in Figure A18, we could resort to statistical data available until the year 2008. The effectiveness indicator for biomass-based electricity generation comprises biomass incineration in pure electricity generation plants and in cogeneration plants. In addition, some countries such as Belgium, Denmark, the Netherlands, Hungary and Sweden, also support co-firing of biomass in coal-fired power plants. It should be noted, that biomass-derived electricity generation comprises domestically available as well as imported biomass resources. Since the realisable potential covers exclusively the domestic biomass potential the effectiveness indicator may be rather high, as it is the case in Belgium.

According to the indicator the country found to be the most effective in supporting electricity from solid and liquid biomass is Belgium, followed by Sweden, the Netherlands, Denmark, Austria, Hungary, Germany and the Czech Republic. It is striking that in case of biomass



electricity the application of different support mechanisms appear to be effective. These include quota obligations in Belgium and Sweden as well as feed-in tariffs or premiums in Germany, Denmark, Hungary and the Netherlands. Due to the comparatively low electricity generation costs in particular in the Scandinavian countries, biomass-derived electricity benefits from technology-uniform renewables support. Given the abundant resource potential and crucial role of the pulp and paper industry, Scandinavian countries (Finland and Sweden) are traditionally characterised by a well-established market of biomass conversion technologies (Figure A19). Looking at the most recent development of policy effectiveness, Austria, Belgium, the Czech Republic and the Netherlands indicate a positive trend in 2008.

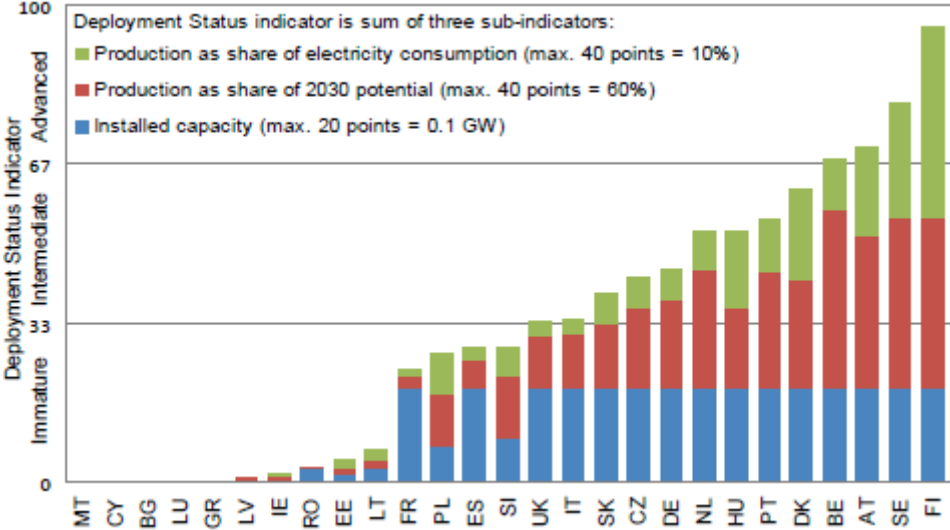


Figure A19: Deployment status indicator for solid biomass in 2008 [21].

Figure A19 shows the deployment status of the solid biomass technology mix. As explained above, solid biomass is a very heterogeneous category as it comprises different technologies (pure biomass plants and co-firing) and both domestic and imported biomass. This limits comparability between countries: co-firing in existing fossil fuel plants is by definition a more advanced market than the use of pure biomass power plants; the exploitation of domestic biomass resources is not as meaningful as for other RES, as it does not reflect biomass imports and exports.

Despite these limitations, the frontrunners that reach advanced deployment status are obvious: Finland, Sweden and Austria. Also Belgium reaches advanced deployment status due to its high share of exploited potential. Further nine countries reach intermediate Deployment Status, which makes solid biomass the most advanced technology category besides large hydro.

Figure A20 illustrates the current support level and the generation costs of biomass electricity generation. Since both costs and the support level may vary strongly for the many different types of biomass resources, price ranges are shown for electricity production from forestry residues. However, there are considerable differences in generation costs even within this option. This is partly due to the fact that the support systems of countries with comparatively low minimum generation costs allow the application of cost-efficient co-firing. Moreover, it should be added that the generation costs in bio-mass sectors are also heavily dependent on plant size.

The general support situation for biomass-based electricity generation in the EU appears to be rather favourable. Again, the support level in some countries is considerably above generation costs. These countries apply both feed-in tariffs, such as the Czech Republic, Germany,

Spain, the Netherlands and Portugal and quota obligations such as Belgium, Italy, Poland and the United Kingdom.

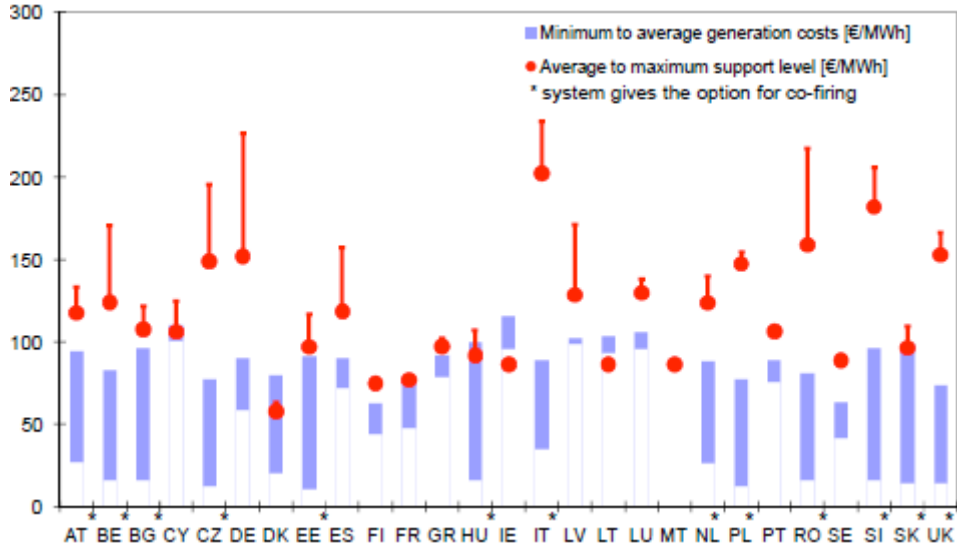


Figure A20: Support level ranges (average to maximum support) in 2008 (average tariffs are indicative) compared to the long term marginal generation costs (minimum to average costs) [21].

5. Small-Scale Hydro (RES-E)

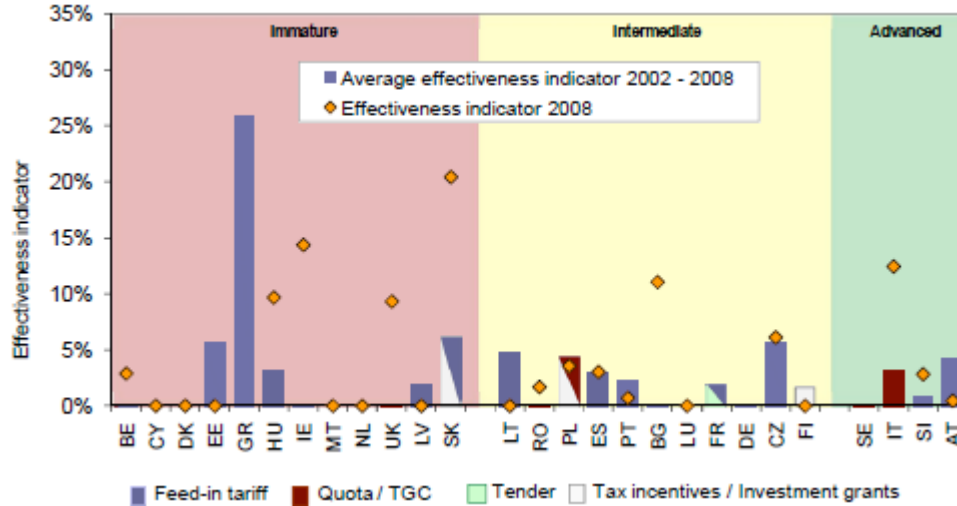


Figure A21: Policy effectiveness indicator in the period 2002-2008 [21].

In most European countries the additional potential for the exploitation of hydropower is small. Greece shows the highest average effectiveness due to several new hydropower installations between 2003 and 2008 and very limited additional exploitation potential. Some Eastern European countries such as the Czech Republic, Estonia, Lithuania, Poland and the Slovak Republic have promoted small-scale hydropower effectively. The market development in these countries is still feasible since there is still some unexploited potential available.

The Deployment Status of small hydro is intermediate for most countries that have hydropower potential. Austria, Slovenia, Italy and Sweden are the only countries that reach advanced Deployment Status. The available potential for small hydro is very limited. 10

countries have very low potential, i.e. lower than 1% of the electricity consumption, and are therefore not shown in the chart. With the exception of Slovakia and Latvia, all other countries already exploit more than 25% of their potential.

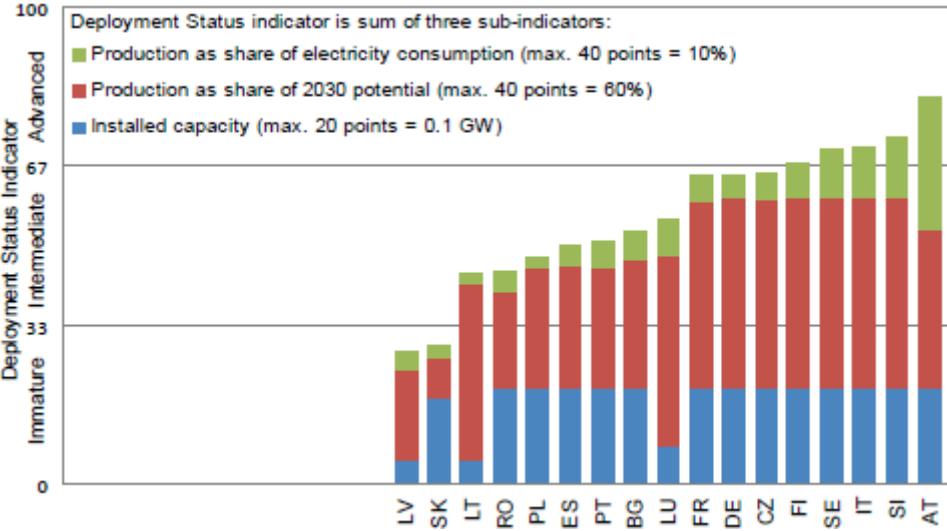


Figure A22: Deployment status indicator in 2009 [21].

In case of small-scale hydropower or hydropower plants with a capacity below 10 MW the country-specific costs show very large differences. It can be seen that the existing feed-in tariffs are quite well adjusted to generation costs. Similar to the case of wind onshore, the support level resulting from the application of a quota obligation appears to exceed clearly electricity generation costs of small-scale hydropower plants in Belgium, Italy, Romania and the United Kingdom. This can be explained by the fact that electricity generation costs of small-scale hydropower are at the lower end of the cost range of renewable electricity. Likewise, the support level resulting from feed-in tariffs are considerably above generation costs in Eastern European countries such as the Czech Republic, Estonia, Latvia, Slovenia and Slovakia. Due to the fact that there is still some unexploited potential available this technology is especially relevant for these new Member States. In contrast, the available potential for the use of small-scale hydropower is already exploited to a large extent.

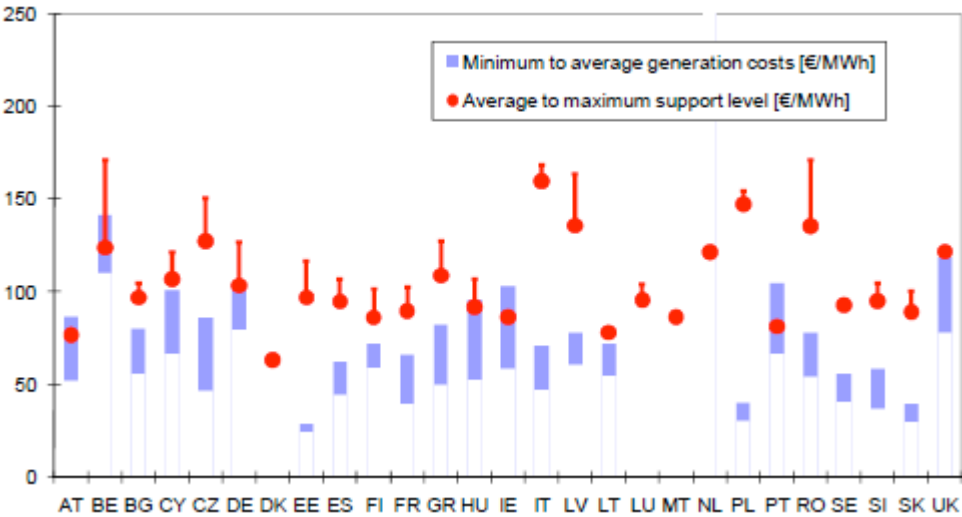


Figure A23: Support level ranges (average to maximum support) for hydro < 10 MW in 2008 (average tariffs are indicative) compared to the long term marginal generation costs (minimum to average costs) [21].

## 6. Biomass Centralized Heating Plants (RES-H)

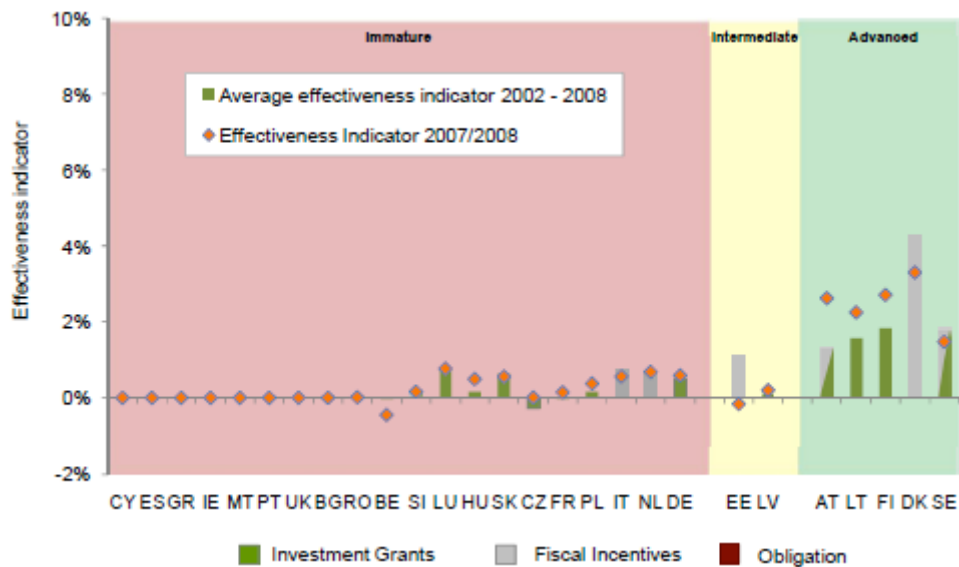


Figure A24: Policy effectiveness indicator in the period 2002-2008 [21].

According to the indicator depicted in Figure A24, in particular Scandinavian (Denmark, Finland and Sweden) and Baltic countries (Estonia and Lithuania) as well as Austria have supported centralised biomass heating plants effectively between 2002 and 2008. Additionally, the ascending trend of the indicator in 2007/2008 points to a continuation of the effective policy support in most of these countries.

Several factors, such as the tradition of Northern European countries to use grid-connected heating systems with an existing infrastructure of district-heating networks, the biomass availability and the sufficiently available heat demand certainly have an effect on the successful support of biomass-derived district heating and CHP-plants. Policy effectiveness in Germany, the Netherlands, Luxembourg, Poland and Slovakia appears to be on the upgrade. Given the low heat demand in Southern European countries, only little effort is made to support heating technologies.

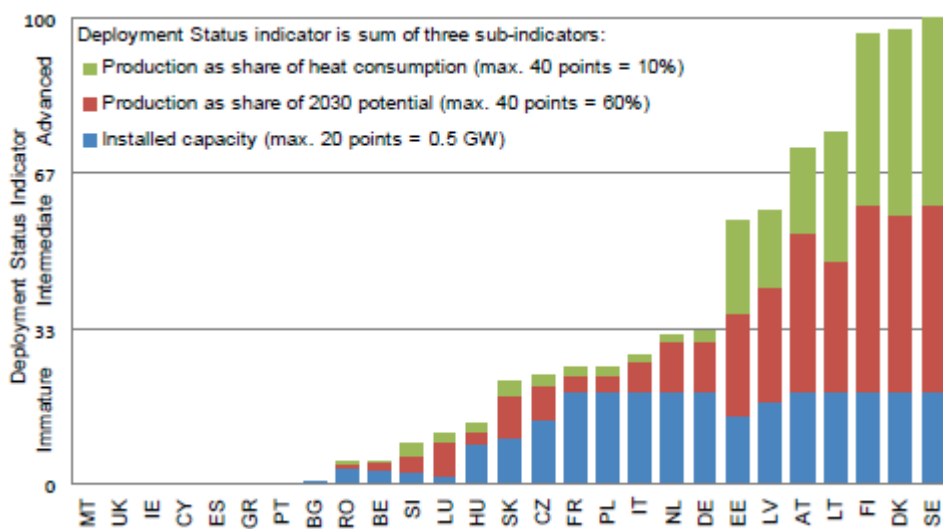
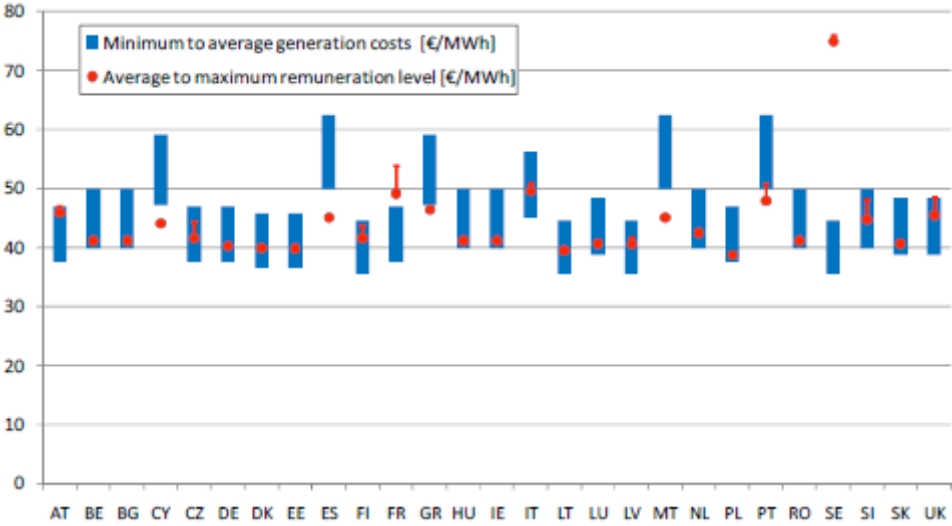


Figure A25: Deployment status indicator in 2008 [21].

Figure A25 shows the deployment status of grid connected biomass heat in the EU-27, which varies considerably. The market is very advanced in the Scandinavian countries (Sweden, Denmark, and Finland) with contributions to heat consumption between 9 and 20% and a potential exploitation between 57 and 72%. They are followed by Lithuania and Austria that also reach advanced deployment status. Latvia and Estonia reach intermediate deployment status. All other countries score immature, even though five of them reach the 500 MW threshold.

Figure A26 shows the range of the remuneration level for heat generated by RES district heating plants and compares it with the minimum to average heat generation costs. District heating by RES in this section typically refers to large biomass plants, which produce centralised heat for a heating grid.



**Figure A26:** Support level ranges (average to maximum support) in 2009 (average remuneration levels are indicative) compared to the long term marginal generation costs (minimum to average costs) [21].

Sweden has the highest level of remuneration. It is comprised of the conventional reference price for grid connected heat and the level of remuneration of RES district heating. The main support instruments applied in Sweden are direct subsidies and exemption from energy, CO<sub>2</sub>, sulphur and the NO<sub>x</sub> taxes. France is ranked second with a maximum remuneration level of 54 €/MWh. Investors in RES-H grid in France benefit from a regional feed-in premium for large-scale installations or from a zero-interest loan for small-scale district heating. Italy and Portugal also have above-average levels of remuneration in the range of 50 €/MWh. In the EU-12 Member States relevant support of district heat is provided in the Czech Republic, in Latvia and Slovenia.

**7. Biomass Decentralized Heating Plants (RES-H)**

When looking at the effectiveness of support for small decentralised biomass heating plants (boilers and stoves) in Figure A27 a different picture emerges. In general, the policy effectiveness on EU-level for small-scale biomass heating plants is higher than for large centralised systems. It is no longer Northern European (except Denmark) countries which are the most effective, as is the case with centralised heating plants, but the Czech Republic Hungary, Belgium, Germany and Romania.

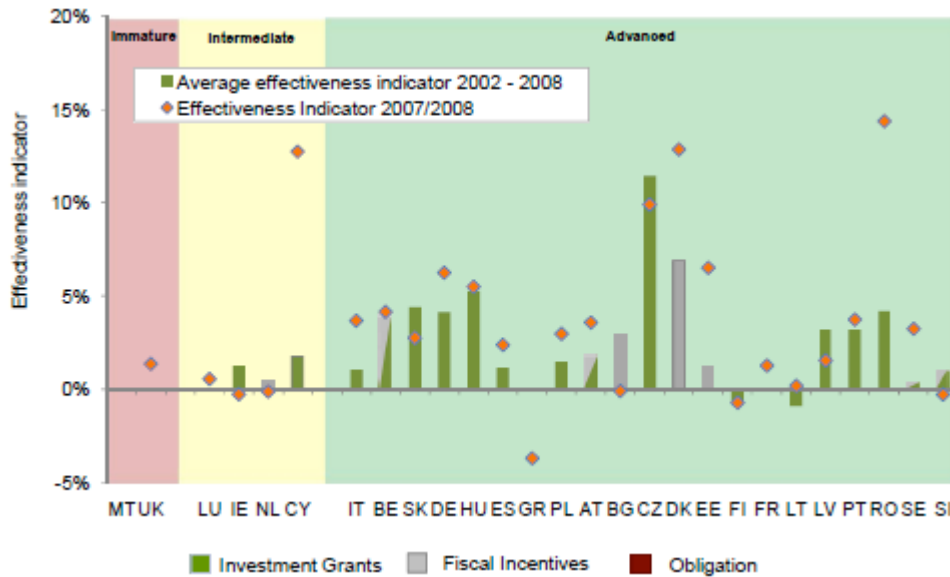


Figure A27: Policy effectiveness indicator in the period 2002-2008 [21].

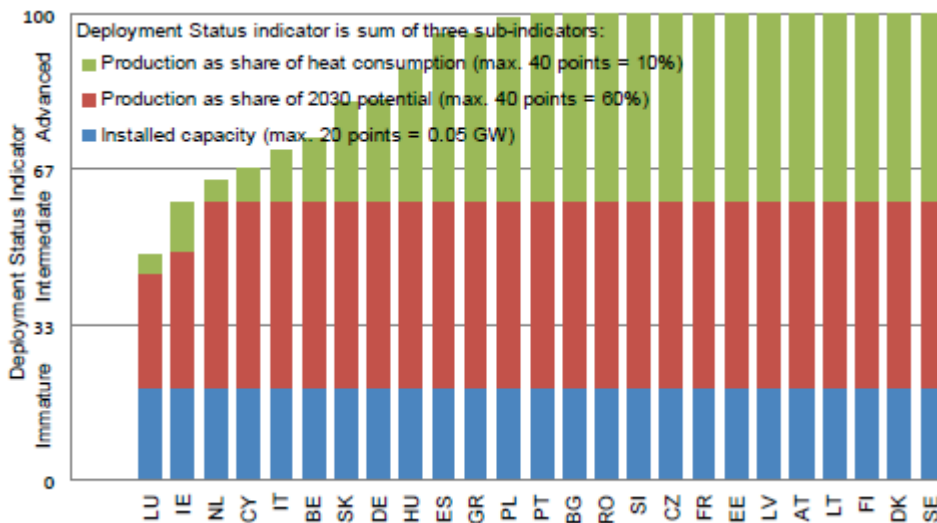
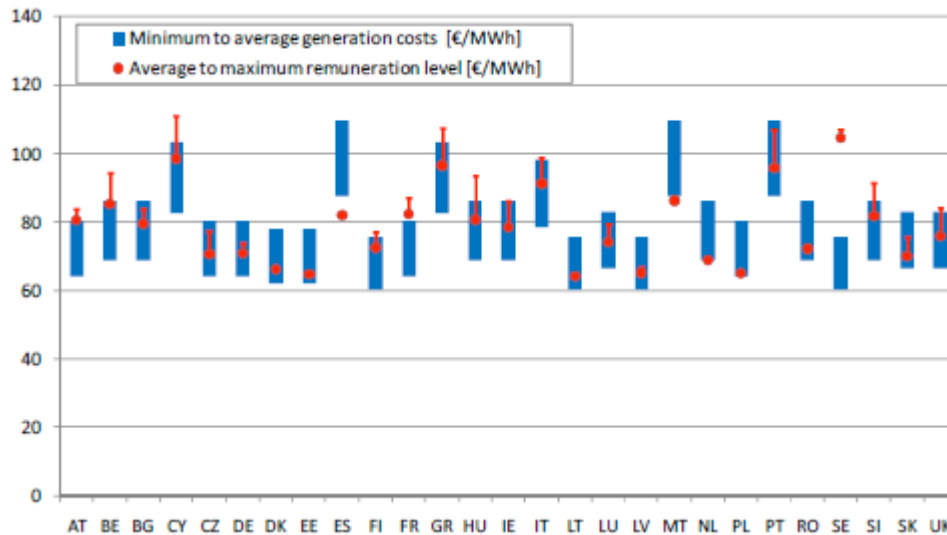


Figure A28: Deployment status indicator in 2008 [21].

Figure A28 shows the Deployment Status of biomass heat installations that are not connected to any heating network, i.e. mainly traditional and modern wood combustion technologies. The Deployment Status is generally mature. 13 countries have reached fully advanced Deployment Status, i.e. they exploit more than 60% of their potential and non-grid biomass covers at least 10% of their heat consumption. The leading countries are the Scandinavian countries, the Baltic States and Austria. Further seven countries score advanced, with high shares in exploited potential, but lower contributions to their heat consumption. The only countries that exploit less than 60% of their solid biomass potential are Ireland and Luxemburg. Malta and the UK are not shown as their potential is assumed to be below 1% of heat consumption.

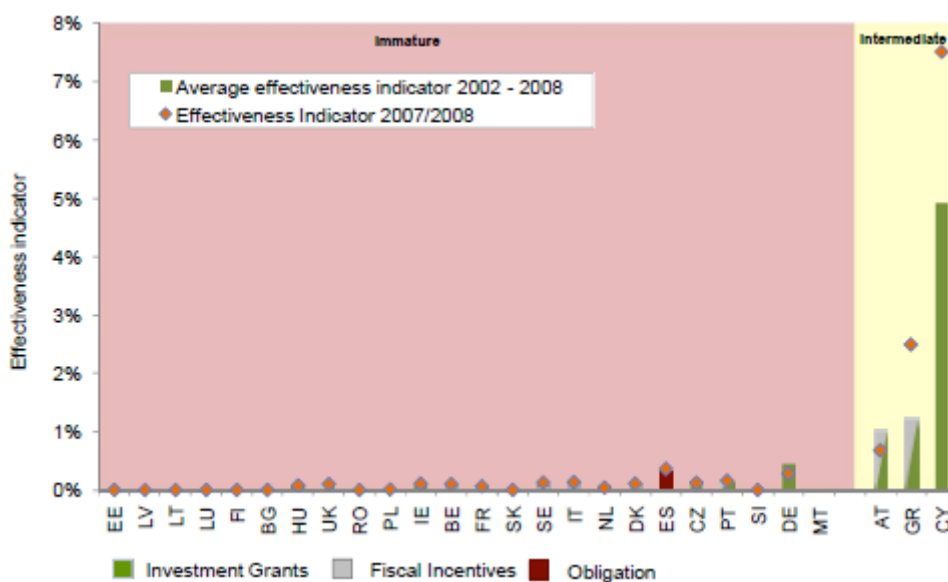
The high scores for exploited biomass potential can be explained by the fact that Europe has only limited additional potential that can be harvested in a sustainable way. In that sense, biomass technologies have a structural advantage when the Deployment Status is calculated compared to RET with vast potential like solar energy.



**Figure A29:** Support level ranges (average to maximum support) in 2009 (average remuneration levels are indicative) compared to the long term marginal generation costs (minimum to average costs) [21].

Cyprus shows the highest remuneration level among all Member States. This is due to a relatively high reference price for heat non-grid and investment subsidies that amount to 55% in Cyprus. In terms of the average remuneration level, Sweden ranks first. Here, biomass heat non-grid is promoted by investment incentives and tax exemption. Furthermore, Greece, Portugal, Italy and Belgium have high remuneration levels. There is no promotion of biomass heat non-grid via investment grants, tax exemption or fiscal incentives for Estonia, Spain, Lithuania, Malta, Poland and Romania.

## 8. Solar Thermal Heat (RES-H)



**Figure A30:** Policy effectiveness indicator in the period 2002-2008 [21].

Figure A30 illustrates the effectiveness indicator for solar thermal heating appliances, including glazed and unglazed solar collectors covering the time horizon from 2002 to 2008. Glazed collectors may be further differentiated in flat plate and vacuum collectors. The market

development of solar thermal heating appliances in the EU was rather moderate until 2005, but started to accelerate in 2006. Given the vast available potential for solar thermal heating the effectiveness indicator in the EU is still on a comparatively low level. But in particular the 2007/2008 trend reflects two years of impressive growth corresponding to an additionally installed capacity of 3,2 GWth. Most of the growth in this year took place in Germany with an annual in-stalled capacity of 1,3 GWth in 2008. However, market development of this sector is expected to contract as a result of budget constraints for the investment incentives provided by the "Marktanreizprogramm" (MAP) as of 2010.

Countries showing a high effectiveness are Austria, Cyprus and Greece, followed by Germany, Spain, Portugal and the Czech Republic. Austria offers stable support conditions for solar thermal heat by providing investment incentives on state level. In addition, Austria is very active in the field of communication campaigns, encouraging therewith the population to invest in solar thermal heating applications. The effective support of solar-based domestic hot water heating systems in Spain stimulated by obligations established in building codes (CTE – Código Técnico de la Edificación) is expected to slow down for the future due to the housing crisis.

Although France and Italy rank among the top five countries in terms of total capacity installed the effectiveness appears to be moderate due to a vast available solar thermal heating potential. The French incentive system for solar thermal heating systems providing a 50% tax credit on equipment costs and additional support from local authorities appears to be one of the most attractive in Europe. Similarly, Italy attained a considerable growth of solar thermal heating between 2006 and 2008 by means of a tax reduction scheme. For the future some of the Italian regions and municipalities are planning the introduction of obligations for newly constructed buildings.

Figure A31 shows the Deployment Status of solar thermal. Only three countries score intermediate: Cyprus, Greece and Austria. Malta is one of the smallest markets in absolute size, but one of the largest markets in relative terms. Germany is by far the largest solar thermal market, but this hardly shows due to the rather low share in potential and consumption.

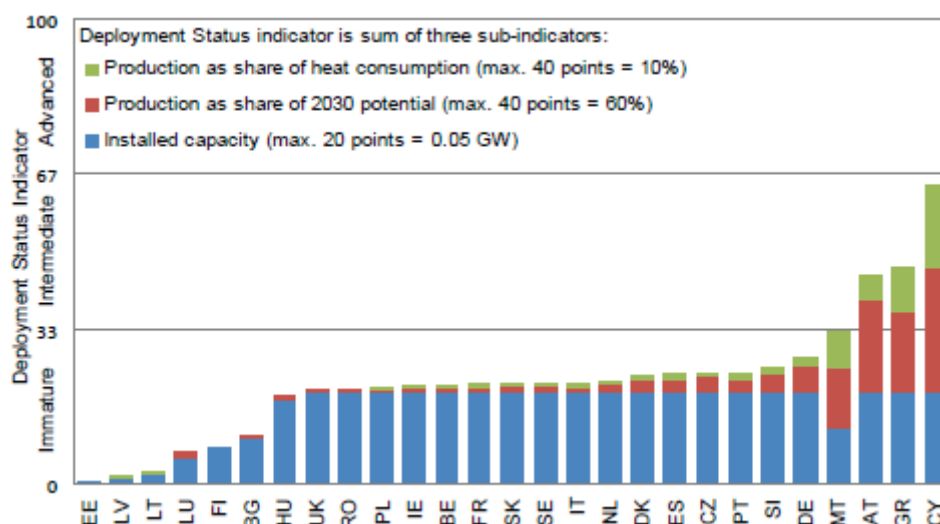
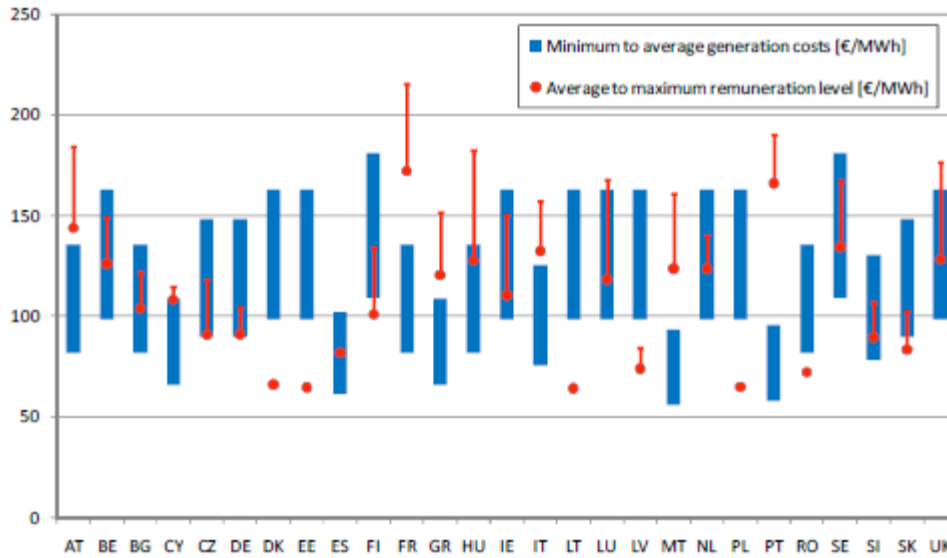


Figure A31: Deployment status indicator in 2009 [21].

Figure A32 shows the range for the remuneration level for solar thermal heat and compares it with the minimum to average heat generation costs.



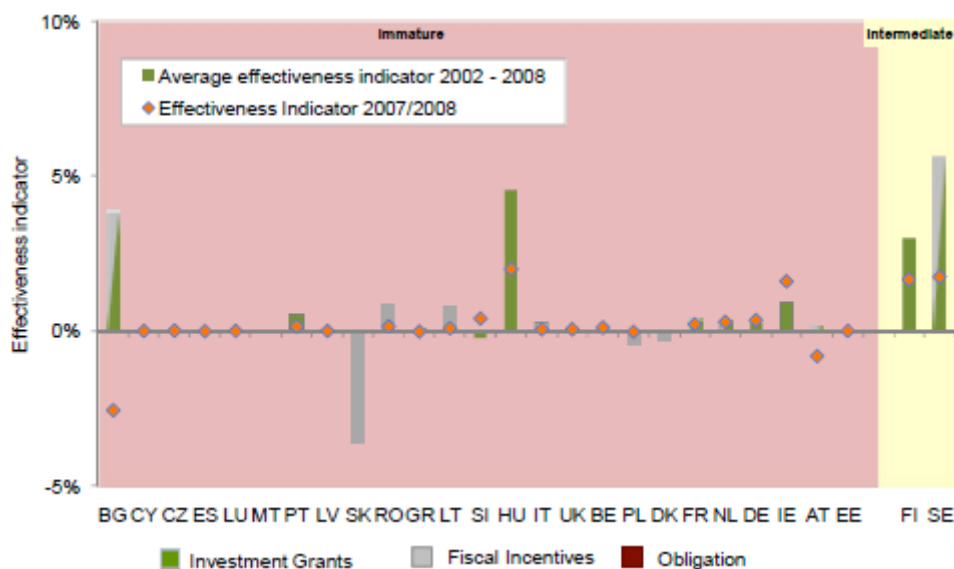


**Figure A32:** Support level ranges (average to maximum support) in 2009 (average remuneration levels are indicative) compared to the long term marginal generation costs (minimum to average costs) [21].

France, Portugal and Austria have the highest maximum remuneration for solar thermal heat with levels of 215 €/MWh, 188 €/MWh and 184 €/MWh respectively. In France, there is a regional feed-in premium in place for large-scale installations and an income tax and VAT reduction and a zero-interest loan for small-scale installations. Besides investment incentives, the promotion consists of a tax credit and a VAT decrease in Portugal. In Austria, solar thermal heat is promoted by a direct investment incentive and an income tax reduction. There is a building obligation for solar thermal heating in Spain that is not accounted for in the efficiency indicator.

There is no support in Denmark, Spain<sup>4</sup>, Estonia, Lithuania and Poland. This leaves those countries at the price level of heat non-grid which is in the range of 64 €/MWh to 82 €/MWh.

## 9. Ground-source Heat Pumps (RES-H)



**Figure A33:** Policy effectiveness indicator in the period 2002-2008 [21].

Figure A33 outlines the effectiveness indicator for ground-source heat pumps covering the time horizon between 2002 and 2008. Given the still immature markets (Figure A34) the average effectiveness is mainly on a level below 5 % with the exception of Sweden. Besides Sweden, countries showing a comparatively high performance are Hungary, Finland and Bulgaria. In general Eastern European countries appear to be quite effective in supporting ground-source heat pumps. To achieve the effective policy support, investment grants and fiscal incentives are predominantly applied.

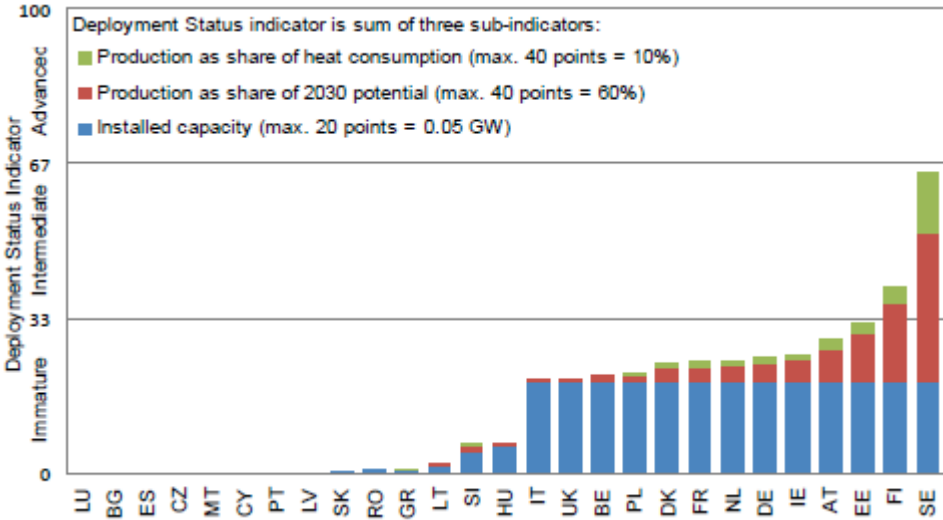


Figure A34: Deployment status indicator in 2008 [21].

The markets for ground source heat pumps are still immature in the vast majority of Member States. The most advanced market is Sweden with 47% of the potential being exploited and 3,3% contribution to heat consumption, which results in intermediate (almost advanced) Deployment Status. Finland follows in some distance. Still, 13 countries meet the 50 MW threshold.

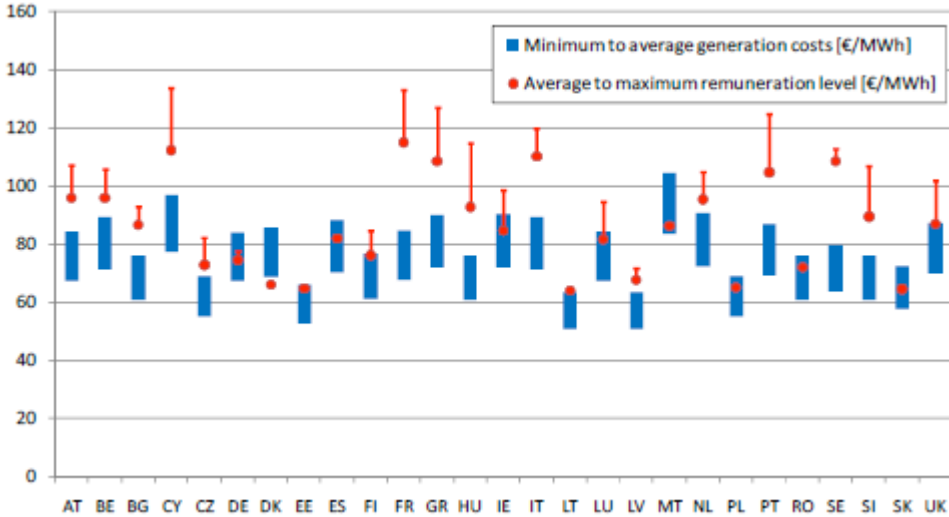


Figure A35: Support level ranges (average to maximum support) in 2009 (average remuneration levels are indicative) compared to the long term marginal generation costs (minimum to average costs) [21].

From the above figure it becomes evident that France has the highest remuneration level in terms of the maximum and the average. Heat pumps are promoted by either a combination of an income tax, a VAT reduction and a zero-interest loan or by a regional feed-premium. The remuneration level in Cyprus, Greece and Portugal is in the same range as France.

No support schemes are in place in Denmark, Spain, Estonia, Lithuania, Malta, Poland, Romania and Slovakia. This leaves those countries at the price level of heat non-grid which is in the range of 64 €/MWh to 86 €/MWh.

### 10. Geothermal Heat (RES-H)

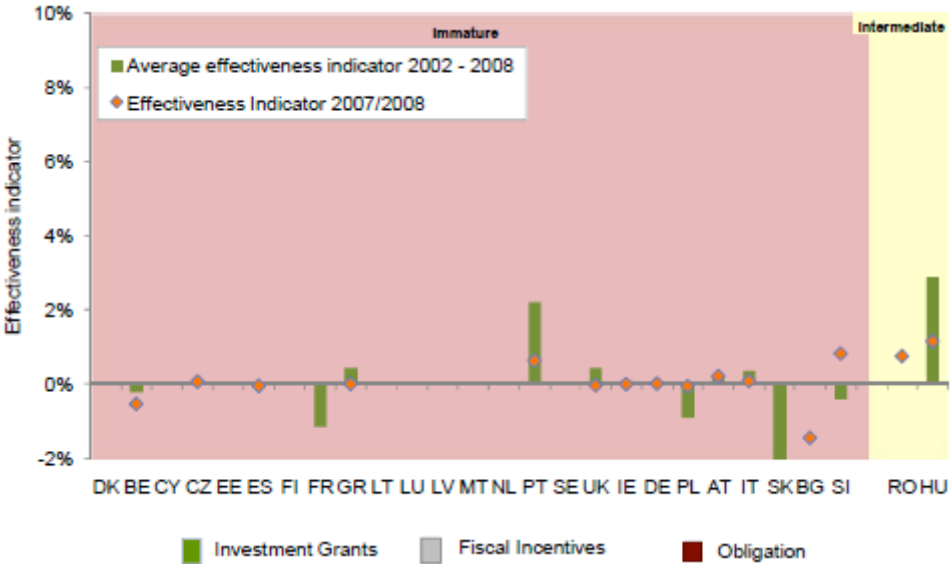


Figure A36: Policy effectiveness indicator in the period 2002-2008 [21].

Geothermal heat shows even a lower effectiveness level than ground-source heat pumps. Hungary and Portugal perform strongest in supporting geo-thermal heat, followed by Greece, Austria, the United Kingdom and Italy, which have achieved at least a positive average effectiveness between 2002 and 2008.

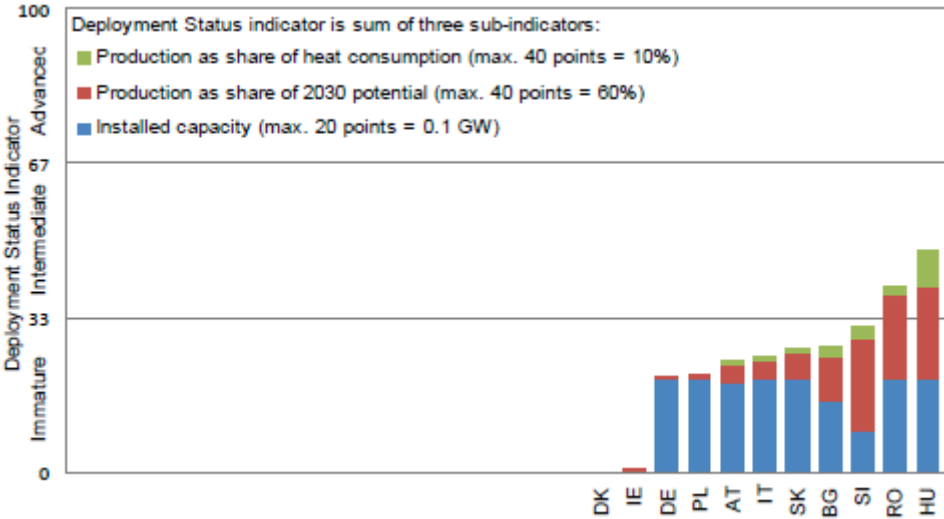


Figure A37: Deployment status indicator in 2008 [21].

The Deployment Status of geothermal heat shows that this RET is still immature in almost all Member States. The most advanced market is Hungary with 2% contribution to heat contribution and a potential exploitation of 30%, followed by Romania.

## 11. Biofuels for Transport (RES-T)

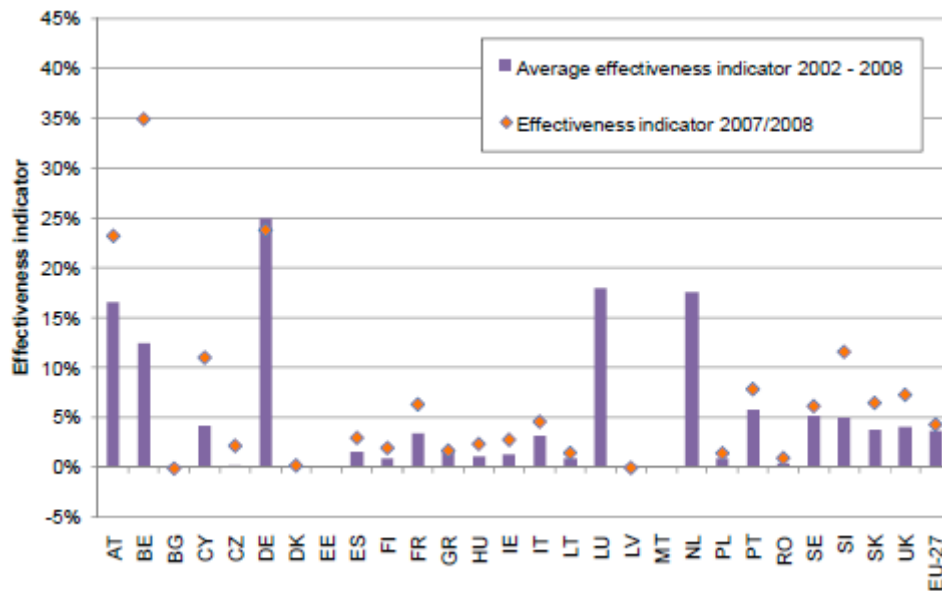


Figure A38: Policy effectiveness indicator in the period 2002-2008 [21].

The policy effectiveness for biofuel consumption appears to be on comparatively high level. According to the effectiveness indicator shown in Figure A38, in particular Germany, Austria and Luxembourg have effectively increased biofuel consumption in their countries. Germany showed a high effectiveness until 2008 but German biofuel consumption started to decrease from 2008 onwards. This effect cannot be observed in Figure A38, since the calculation of moving averages smoothes this effect in 2008. This fact can be explained by the total phase-out of the tax exemption for biofuel blends starting in 2007 and the low quota for biodiesel, which was over-achieved already before 2007. Furthermore the tax reductions for pure biofuels are gradually reduced until 2012. The phase-out of the tax exemption had a stronger impact on the German biodiesel market than on the bioethanol market, due to the different quotas for biodiesel and bioethanol. As depicted in Figure A39, the predominant part of the bio-fuel consumed in the EU is biodiesel, but the share of ethanol and other biofuels shows a slightly increasing trend.

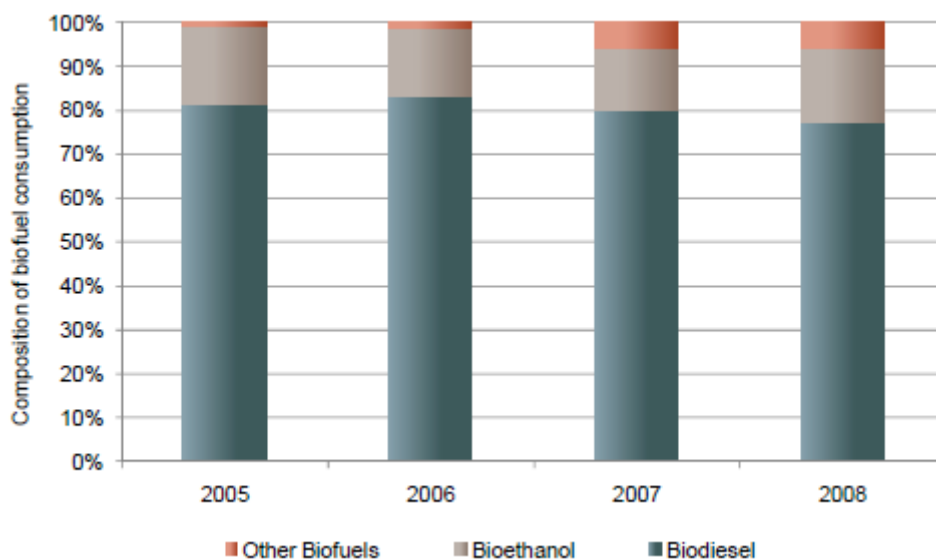


Figure A39: Composition of biofuel consumption 2005-2008 [21].

Since biofuels are assumed to be an internationally traded commodity in this case not the cost levels between Member States are compared with the remuneration / support levels, but only the support levels have been assessed. The support for biofuel consumption in EU Member States is often a combination of an obligation and tax reductions or only one of these two instruments is applied.

In case of biofuel obligations the level of support is very difficult to assess since the prices implied by these obligations are typically not public (different to the case of quota systems in the electricity sector where TGC prices are generally transparent). Therefore we show the level of tax reductions for biofuels in each Member State. This is shown in Figure A40 for the case of biodiesel. For some countries like Bulgaria, Finland and the Netherlands only a quota obligation is applied. Other countries such as Germany apply a mixed support based on quota obligations and tax reductions, whereas tax reductions are subsequently phased out. The overall picture shows a rather homogenous level of support in terms of tax reduction among EU Member States. Figure A41 shows the level of tax reductions for the case of bioethanol.

In addition, any kind of double-support should be avoided, as it happened with bio-diesel imports from the US, benefitting therewith from US as well as from European support schemes.

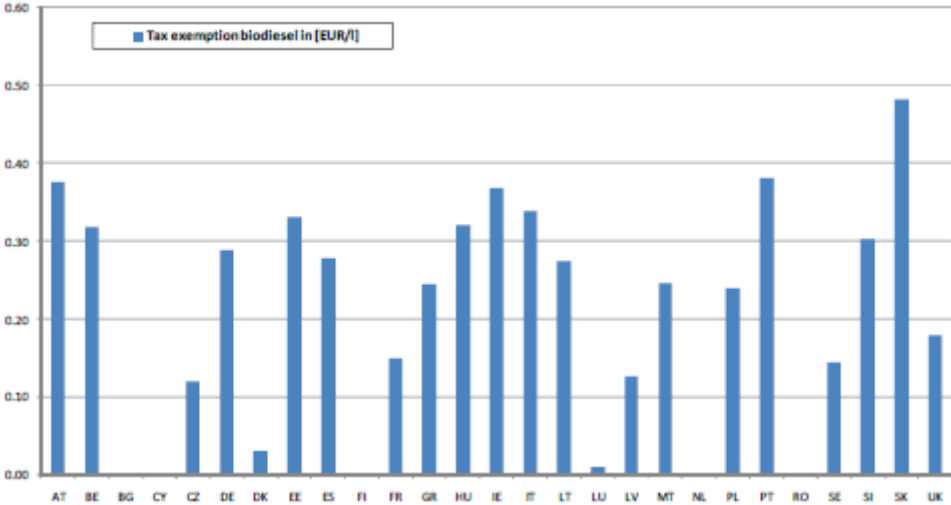


Figure A40: Level of tax reductions for biodiesel in 2009 [21].

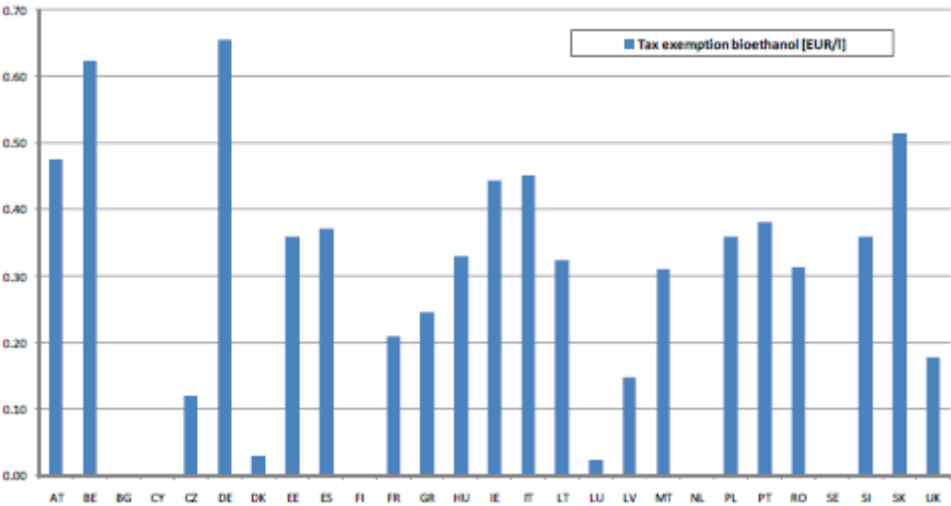


Figure A41: Level of tax reductions for bioethanol in 2009 [21].

## **Overall Support Schemes Policy**

In general, the support policy performance is rather heterogeneous depending on the final energy sector, the renewable energy technology (RET) and the individual Member State. The main messages from the analysis of the policy performance achieved in all EU Member States in recent years are the following:

### *Relationship between support level and generation costs*

If support levels are below generation costs, little or no capacity growth can be observed. There can be exceptions when investments are motivated by other than economic reasons (e.g. ecologic benefits). High support levels compared to generation costs do not in all cases lead to substantial capacity growth. Usually this is due to flaws in the support instrument or non-economic barriers in other parts of the regulatory framework (permitting, grid connection, electricity market structure, etc.). Too high support levels can also lead to unnecessarily high support costs.

### *Relationship between market deployment status and policy effectiveness*

Often a correlation between deployment status and policy effectiveness can be observed: Markets with a higher deployment status tend to grow faster. However, some examples can be found where markets with a low deployment status also grow very quickly as e.g. observed for wind onshore development in Hungary. If adequate policies are applied and non-economic barriers are removed, markets can grow quickly without having an extremely long track-record in the past, partially by using spill-over effects from other markets. If the market development has already achieved a very advanced stage, the effectiveness may decrease due to saturation effects or reduced policy efforts (see e.g. wind onshore in Denmark).

### *Comparison of support in the electricity and heat sector*

Support levels for renewable heat generally appear to provide less profit than the ones provided in the electricity sector, despite the low generation costs of many RES-H technologies. On average, policy effectiveness in the heat sector is also lower than in the electricity sector.

Policy effectiveness of promotion schemes in the electricity sector is comparatively high in several countries, in particular with regard to mature, but still evolving technologies such as wind onshore and biomass conversion. Owing to the existence of a legal framework and sectoral (indicative) targets since 2001 some RES-E technologies including wind onshore have experienced considerable growth in several countries. Therefore, more experience is available for RES-support in the electricity sector than in the heat sector.

## **RES-E Support Schemes Policy**

### *Comparison of support scheme performance*

Compared to previous analyses the policy effectiveness in quota-using countries in the last two years shows improving values for low-cost technologies (wind on-shore and biomass), but in general feed-in systems still appear to be more effective than quota obligations. It should be noted that in the same period e.g. in the UK quota system risk for investors has been reduced substantially – from an investment risk perspective the system evolved in the direction of a less risky feed-in premium system.

### *Relationship between market deployment status and support scheme*

Depending on the deployment status and the maturity of a technology, different support instruments may be more or less suited. For example, technology-uniform quota obligations appear to be more effective in stimulating more mature technologies such as wind onshore or biomass-based renewable power plants than in promoting less mature technologies such as wind offshore or solar PV. Many Member States act accordingly and apply different support

instruments for different technologies. For example very often a feed-in premium or a quota obligation for large-scale and/or mature technologies is combined with a feed-in tariff for small-scale and/or less mature technologies.

#### Support level comparison

The analysis of the economic characteristics of RES-E support and electricity generation costs reveals that the remuneration granted under a FIT-system tends to be lower for lower-cost technologies than under a quota obligation scheme. In contrast, the remuneration level based on electricity price and TGC-price in case of technology-uniform quota obligation schemes is generally lower than under technology-specific support. In most cases this support level is insufficient to incentivise investment for more cost-intensive technologies such as solar PV.

To trigger additional growth of cost-intensive technologies which do not receive sufficient support from technology-uniform quota obligations, some countries offer additional incentives such as technology-specific minimum prices or feed-in tariffs. For example, Belgium offers minimum prices for solar PV electricity, Italy uses an additional feed-in premium for Solar PV and the United Kingdom has introduced feed-in tariffs for small-scale applications with a capacity below 5 MW. Technology-banding within the quota, which is applied in the United Kingdom, can help to support cost-intensive technologies like wind offshore, but is less suitable for small-scale projects than feed-in tariffs.

#### Relationship between potential profit and policy effectiveness

The results have shown that high potential profit opportunities do not necessarily lead to high policy effectiveness. In particular in case of less mature technologies such as wind offshore, an economically attractive profit level – calculated with uniform risk premiums – appears to be insufficient to stimulate capacity growth. Uncertainties related to technological, financial and administrative factors still appear to hamper a faster growth of these technologies. Also political uncertainties about the future development of the support scheme (e.g. price development of TGC-prices) may involve higher risk premium requirements or reduced policy effectiveness.

#### Policy costs

When evaluating policy effectiveness of a support scheme, stimulated capacity growth also may develop faster than envisaged and therewith cause high policy costs. This appears to be a risk of technology-specific support. Thus, the application of feed-in systems carries the risk of involving considerable policy costs for consumers if the market for a cost-intensive technology is booming unexpectedly, as happened with the development of solar PV power plants in Spain, the Czech Republic in 2008/2009 or currently in Germany. This risk exists to a lesser extent also in quota systems with technology-specific banding or minimum prices.

#### Identification of best practice countries

The leading countries in terms of effectively supporting wind onshore energy are Germany, Spain, Portugal and Ireland. At the same time all these countries show an advanced market deployment status. Looking at the effectiveness of policy support for wind offshore, it becomes clear that market development is just starting in a few countries (United Kingdom, Ireland, the Netherlands and Denmark). Examples for an effective promotion of solar PV are Germany, the Czech Republic and Italy. In terms of supporting biomass-based electricity some Member States already have a very advanced deployment status. Of the others, Belgium and the Netherlands have achieved the most effective policy support in 2008. In case of biogas power plants, Austria, Germany and the United Kingdom still apply very effective support schemes.

## **RES-H Support Schemes Policy**

### Policy effectiveness and infrastructure

The existence of district heating grids is crucial for the realisation of renewable-based centralised heating systems. This means that depending on the situation of the gas and district heat grid no short-term structural changes are feasible. Similarly, the competition between gas and district heating grids may have an impact on the effectiveness of policy support for centralised biomass heating applications. For example, the expansion of the gas network in Greece in recent years appears to hamper a stronger development of district heating grids.

### Technology-specific observations

Long reinvestment cycles limit the diffusion rate for the integration of renewable heating systems that are integrated in buildings.

### Burden sharing

The dependence of financial incentives – predominantly in terms of investment grants – on the public budget and a potential stop- and go policy creates stronger uncertainty for investors in the heat sector than common in the electricity sector, since RES-E support is mainly based on long-term commitments. For example the German "Marktanreizprogramm" (MAP) has been suspended due to budgetary reasons and re-launched recently in summer 2010.

### Identification of best practice countries

Austria, Denmark, Finland, Lithuania and Sweden have effectively promoted bio-mass-based centralised heating plants in recent years with an ascending trend in 2008. Several factors, such as the existing infrastructure of district heating net-works in Northern European countries, the biomass availability and the sufficiently available heat demand certainly have an effect on the successful support of bio-mass-derived district heating and large-scale CHP-plants.

In general, the support for decentralised biomass heating plants is on a higher level than that of centralised plants. According to our analysis Belgium, the Czech Republic, Germany and Romania have shown the most effective support policies for decentralised biomass heating in terms of the policy effectiveness indicator.

Owing to a high remaining resource potential the policy effectiveness for the support of solar thermal heating is on rather moderate level. Austria, Greece and Cyprus rank among the group of leading countries in terms of effective support policy. In Austria, communication campaigns and investment incentives have primarily contributed to this positive market development.

Ground-source heat pumps have been effectively promoted by using obligations in Sweden and investment grants and fiscal incentives Hungary and Finland. The transition to the use of heat pumps in Sweden was favoured by a previously high share of electric heating.

## **RES-T Support Schemes Policy**

Despite the uniform European biofuel target, deployment varies significantly across Member States.

The support of biofuels in recent year is characterised by a comparatively high effectiveness. However, the development in one of the leading countries Germany started to decrease from 2008 onwards due to the phase-out of the tax exemption and the low biodiesel quota.

In general a rather homogenous level of support in terms of tax reduction among EU Member States could be observed.



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