RENEWABLE ENERGY POLICIES IN PORTUGAL

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Abstract

Policies chosen to promote renewables can vary significantly and determine different levels of deployment, efficiency and technological innovation. Instruments in this sector have been mostly directed towards electricity generation and are usually divided into two main types: feed-in tariffs and quota obligations. The former is more frequent in the European Union and is associated with higher levels of deployment, as well as higher policy costs. However, support schemes can be adjusted in order to minimize their shortcomings. Tariffs can be reduced progressively as deployment targets are reached and quota obligation schemes can be designed to recognize different technological development stages.

Policies in Portugal have initially been based on investment grants to promote the switch from fuel oil, an attempt to reduce energy dependence and keep the industrial sector competitive after the two oil shocks of the 70s. This approach continued after the accession to the European Union and feed-in tariffs *per se* were only introduced in 1999. However, it would only be with the introduction of technology premiums in the pricing mechanism in 2001 that significant renewable deployment was to be seen. This thesis describes the policy evolution and includes a detailed analysis of the bioenergy sector, where the combined heat and power feed-in tariff has successfully triggered new power capacity promoted mostly by industrial companies in the wood sector, particularly pulp and paper. Incentives for heat production have been scarce but the sector has fought back its troubles by making good use of strong support policies in other Member States.

Keywords: Renewable energy; feed-in tariffs; quota obligation; bioenergy

JEL Codes: Q42; N74

Resumo

As políticas para a promoção de energias renováveis podem variar significativamente e determinar diferentes níveis de desenvolvimento, eficiência e inovação tecnológica. Os instrumentos neste sector têm sido maioritariamente direccionados para a produção de electricidade e são geralmente divididos em dois tipos principais: tarifas de aquisição e quotas. O primeiro é mais frequente na União Europeia e associado a níveis mais elevados de desenvolvimento, apesar de o serem também os custos de política. Os esquemas de apoio podem ser ajustados por forma a minimizar as suas desvantagens. As tarifas podem ser progressivamente reduzidas à medida que as metas de desenvolvimento são atingidas e os esquemas baseados em quotas podem ser desenhados para acomodar os diferentes estádios de desenvolvimento tecnológico.

As políticas em Portugal estiveram inicialmente suportadas em ajudas ao investimento para promover a substituição de fuelóleo, uma tentativa de reduzir a dependência energética e manter o sector industrial competitivo depois dos choques petrolíferos da década de 70. Esta abordagem prosseguiu após a entrada na União Europeia e as tarifas de aquisição *per se* foram apenas introduzidas em 1999. Contudo, apenas com a introdução de um prémio tecnológico no mecanismo de preço em 2001 foi possível registar um desenvolvimento significativo das renováveis.

No sector da bioenergia, a tarifa para a cogeração conseguiu activar com sucesso a construção de nova capacidade, promovida principalmente pela indústria do sector da madeira, especialmente da pasta e papel. Os incentivos para a produção de calor têm sido reduzidos mas o sector soube aproveitar o forte apoio às renováveis noutros Estados-membros.

Palavras-chave: Energias renováveis; tarifas de aquisição; quotas; bioenergia;

Códigos JEL: Q42; N74

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1. Introduction

Energy is essential to economies everywhere and - along with education, financing or well-functioning institutions - it is central to economic development. It was abundant and cheap coal, together with the steam engine, that allowed the rapid increase of standards of living in Great Britain in the 19th century. In the United States, it was oil that proved to be a boon for growth, military power and innovation.

However, since the 70s environmental concerns over major global problems such as acid rain, ozone layer depletion, and, later, climate change, induced a substantial drive for change towards cleaner energy models. Excluding hydro, significant deployment of renewable energy sources was only visible during the late 90s. Change was only possible with a first wave of support to research and development of new and improved technologies. It was then followed by active support policies to production itself, mainly through feed-in tariffs.

Renewable energy policies are intended to internalize environmental benefits, in particular a reduction of greenhouse gas emissions compared to fossil fuel-based energy systems. These policies put an additional cost on energy, even if they are well designed (which has not always been the case). In the past five years serious deficiencies have surfaced as a result of financial and economic crisis that began in 2007-2008. For instance, the power sector in Portugal has now over 3 600 million euros of cumulative debt (ERSE, 2012a), a substantial part of it originating from renewable policy costs, especially wind energy. Efforts to reduce policy costs have accompanied the financial assistance programme backed by the International Monetary Fund and the European Central Bank.

The main objective of this work is to present how renewable energy policies in Portugal changed over the years starting with the oil crisis in the 70s. It will try to show how the country benefitted from the accession to the European Union and how support schemes, namely feed-in tariffs, evolved up until the current model. A comparison with policies in other countries of the European Union (EU) is sought in order to understand the differences and similarities, and what mechanisms have been implemented to control policy costs.

The document is divided into five chapters, the first of which is this Introduction. Chapter 2 presents the theoretical background of policy instruments used in the renewable energy sector, with particular focus on the differences between price-based and quantity-based support schemes in the power sector. Chapter 3 gives an overview of the policy instruments used by EU Member States and presents in greater detail the policy framework in Germany, Spain, Sweden and the United Kingdom. An exhaustive analysis of the renewable policies used in Portugal since 1976 is presented in Chapter 4. Finally, Chapter 5 focuses on bioenergy to present a storyline of its development and the influence of support schemes on actual deployment.

The renewable energy sector is a very intricate and complex research area due to the multiple sources and uses (i.e., power, biofuels, heating, among other). This work tries to mention all relevant policy areas within the sector but it is acknowledged that there is a strong bias towards support schemes for electricity generation, which have dominated discussions in the scientific community.

2. Types of renewable energy policy instruments

1. The rationale for renewable energy policy

Various social benefits arise from the production of energy from renewable sources, and many of these which are not dealt with appropriately by the market mechanisms, thus producing market failures. The most important externality associated with renewable energy is lower greenhouse gas (GHG) emissions compared to fossil fuels and its ensuing contribution to tackle the issue of climate change. Even if renewable energy is not CO_2-neutral, life-cycle analyses, albeit debatable, still point out to substantial GHG emissions savings compared to fossil fuels (Evans *et al*, 2009; Varun & Prakash, 2009).

Renewable energy can also help reduce exposure to volatility in international commodity markets, particularly oil, by diversifying the sources of energy (Olz *et al*, 2007). Schmalensee (2012) raises an important point by stating that oil has a marginal role nowadays in the power sector of the majority of advanced economies and that variable renewable energy sources, e.g. wind and solar, require standby power capacity based on gas and coal (at a cost, too). However, electricity is only a part of a wider energy system that includes heating and transportation fuels. In both these sectors fossil fuels, notably oil, can be displaced by solar thermal, biomass or geothermal technologies for heating, and by biofuels and renewable electricity for transportation (Fischer & Preonas, 2010).

Several renewable sources also have a better environmental performance than fossil fuels or nuclear. Solar thermal panels and wind turbines, for instance, have no SO_2 or NO_x emissions while operating. Impacts and environmental risk on water resources are also negligible when compared to the long supply-chains of oil and coal, or the new extraction methods used to extract shale gas. Renewables still have environmental impacts that must be considered and not all are alike: without the right abatement technologies biomass can cause serious air quality issues; wind turbines and large-scale solar power have a disputed visual impact; and hydropower may irrevocably compromise the use of large swathes of land and impact significantly on biodiversity.

The fourth commonly mentioned reason for specific policy support to renewables is their contribution to green growth (Couture *et al*, 2010; Schmalensee, 2012). However, it is hard to pinpoint where exactly non-market benefits are: if it is about being “green” then we are talking about the same environmental externalities already described above; if it is about "growth" then there seems to be a bias against other businesses. Closely linked to this motive for renewable energy support is industrial policy. Some countries have backed the development of specific renewable technologies – wind and solar are usually the most popular – as industrial strategies fostering national champions and technology leadership (Fischer & Preonas, 2010). Non-market benefits are spilled over in the long-run as a consequence but these externalities are the direct result of an intended government option for an industrial sector in particular, and hence are closer to industrial policy analysis rather than energy policy. Hence these will not be discussed further in the present work.

Other externalities that are not energy-specific (e.g. reduced forest fire risk due to biomass use, development in rural areas) require an appropriate and broader framework in order to include all possible providers of benefits.

2. Renewable energy policy instruments

The Pigouvian school of thought argues that governments should, if they so wish, correct these externalities using, as Pigou himself put it, "*extraordinary encouragements or extraordinary restraints*" (Pigou, 1932). Taxes and subsidies are the most widespread instruments governments have at their disposal to internalize social costs or benefits. Although some externalities could be addressed by bilateral negotiation as Coase (1960) proposes, that is not the case where there are numerous agents, non-excludability issues, diffuse property rights or uncertain and long-term impacts (such conditions occur for example in climate change). Moreover, government intervention does not rely solely on taxes and subsidies. This chapter addresses several other instruments implemented to support renewable energy, each with their own advantages and shortcomings.

While the advantages of renewable energy are clear, an additional issue is how to define support policies. Klein *et al*. (2010) mention two possible methods to set support levels. One is based on the avoided external costs. Mitigation and adaptation costs of climate change or energy security risk can be offered to renewable energy producers as a premium over the market. From an environmental standpoint, this is the most reasonable method. Yet most support schemes are based on generation costs. Subsidies to renewable energy then have to cover capital and operational expenditure, capital cost and allow a return on invested capital. The reason policymakers prefer this method may lie not only on the difficulty of correctly determining environmental benefits, but also on the fact that these may not be sufficiently large to allow for a significant deployment of renewable energy.Though the rationale for renewable energy policy may appear simple, several problems arise during its design and implementation. First, even though externalities are the main reason behind specific instruments, their design has generally been directed toward covering generation costs. This approach suffers from a misconception as to the concrete goals the policy should achieve – namely, GHG emissions reductions and energy security – and those it is actually defending (renewable energy *per se*). Such policies may result in higher costs for consumers as other alternatives are excluded (e.g. energy efficiency, nuclear or conversion of coal power stations to natural gas). Overlapping policy instruments such as emission trading schemes and tradable green certificates can be acceptable if renewables have externalities other than CO_2 reduction, but coordination and a clear understanding of possible interactions are required (González, 2007).

Secondly, some policies may inadvertently promote some technologies over others. "Picking winners" has been an expression frequently used to describe certain policy instruments providing greater, or exclusive, incentives to specific technologies. Using the UK as an example, Lipp (2007) shows how setting up a level playing field for renewable technologies is no easy task. Furthermore, technological lock-in can add to this problem when incentives are given for long periods (e.g. feed-in tariffs for 20 years) and selected technologies gain increased cost-advantage from innovation and learning-by-doing.

Renewable energy also has its own, intrinsic, drawbacks. Electricity from wind and solar is variable and demands standby capacity to make up for sudden drops in power generation. Thus, these two renewable sources have additional costs that are not usually considered. Bioenergy has also been in the spotlight due to indirect land use changes that can have net CO_2 emissions, while the debate over food versus fuel is far from over. Chakravorty *et al* (2009) argue that biofuels targets in Europe will lead to increasing imports from countries where land availability and productivity is greatest, thus increasing prices already under pressure from population dynamics, higher income per capita and dietary changes. While the sustainability criteria proposed alongside incentives to bioenergy address environmental concerns, competition for land still goes largely unattended.

Figure 2.1 classifies renewable policy instruments into two categories: 1) incentive-based instruments; and 2) command and control instruments. Both types of instruments aim to increase generation from renewable sources but the crucial distinction is that the former are mandatory to target agents while the latter intend to influence their decisions.

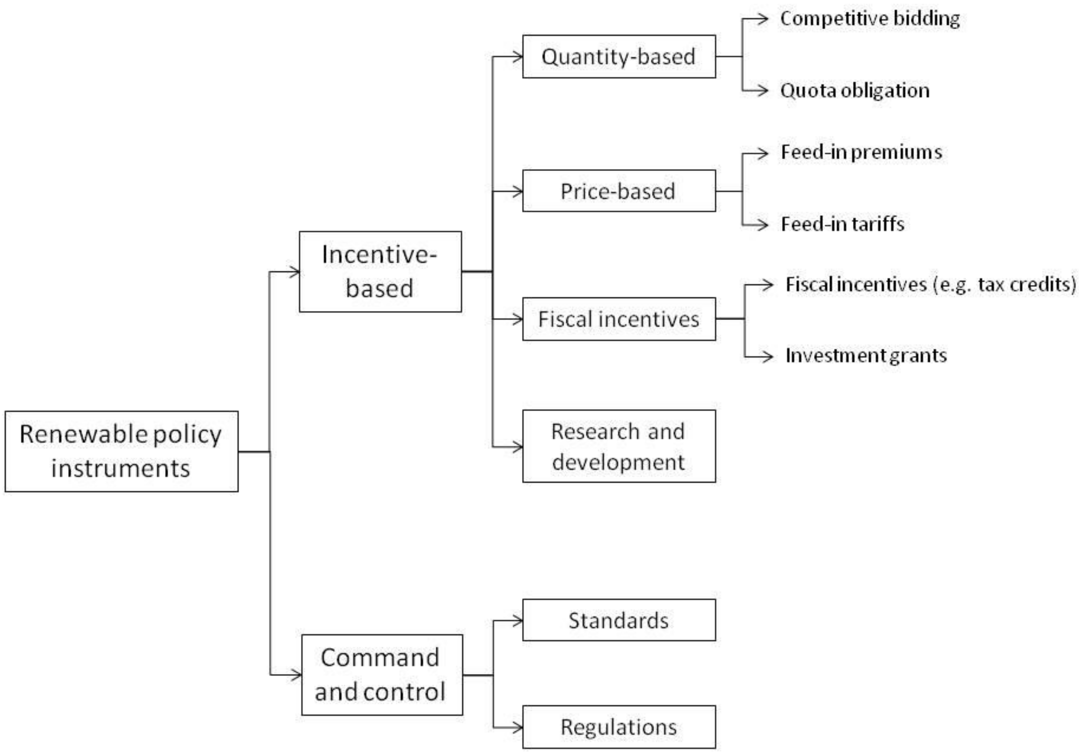

Figure 2.1. A classification system for renewable energy policy instruments.

Regulations and standards can be implemented by governments and usually express their highest ambitions. However, increasing renewable energy production cannot be achieved by government fiat as costs are generally higher than conventional sources. Thus, some sort of incentive must be in place for policies to be effective and for this reason we will focus exclusively on incentive-based instruments. The scope of the analysis will be primarily concentrated on national, supply-side policies. Other instruments such as voluntary schemes, though increasingly important for a variety of businesses, will also be excluded from analysis.

One major distinction in market-based instruments refers to whether they are implemented as investment support, i.e. a one-off, up-front incentive such as capital grants, or as an operating support for a defined period of years. The latter can further be divided into quantity-based and price-based instruments.

i. Quantity-based instruments

Quantity-based instruments are strongly connected to national targets since they define an amount of renewable energy to be generated. They also take greater consideration of resource assessments and grid connection constraints than price-based instruments and thus may avoid future regulatory issues. Bids for quotas can be competitive, through technology-specific public tenders working under a reverse auction system where bidders asking the lowest energy price win the contract and it is set as a guaranteed price for a given period of time (IEA, 2004). The guaranteed price is paid by utilities and the premium – the price above wholesale market price – is passed on either to all electricity consumers, the utilities' clients, taxpayers or a combination of these (Menanteau *et al*, 2003). Each tender is launched for a particular technology (e.g. wind, concentrated-solar power, etc.) and specifies one or several connecting points to the power grid.

Quota obligations require utilities to incorporate a certain share of renewable energy in their energy mix. Non-compliance has a penalty, the revenues of which are distributed among complying producers. A parallel system of green certificates is usually implemented making renewable energy a tradable product in the sector. Utilities, then, have three options under a quota obligation system: 1) they develop and operate their own renewable energy production units, using the green certificates for themselves; 2) they enter into a long-term contract with renewable producers for their green certificates; or 3) they trade green certificates in the spot market (Menanteau *et al*, 2003). Renewable energy producers' revenues come from the wholesale market price and the green certificates they sell in the market to utilities. A quota system favors the most cost-efficient technologies and is technology-neutral, though certain mechanisms can be devised to consider some degree of technology specificity (e.g. banding) (IEA, 2008). Technology is not the only driver of the energy mix; location will also determine both capital investment and operating costs. Wind turbines will first and foremost be deployed where it blows stronger and more frequently, but as the best sites are taken other technologies will become cheaper in comparison.

ii. Price-based instruments

The second major class of instruments concerns those setting a guaranteed price for renewable energy for a fixed period of time, usually 15 to 20 years (Couture *et al*, 2010). These feed-in tariffs are differentiated according to technology, installed capacity, location and other project-specific variables (Klein, *et al*., 2010; Mendonça, 2007). Price-based instruments can be distinguished between market-dependent and market-independent feed-in tariff models (Couture & Gagnon, 2010). A market-independent tariff is not influenced by conditions such as electricity price, inflation or fossil fuel prices (Figure 2.2). On the other hand, in a market-dependent model producers are paid a tariff which can be linked to one or several market conditions.

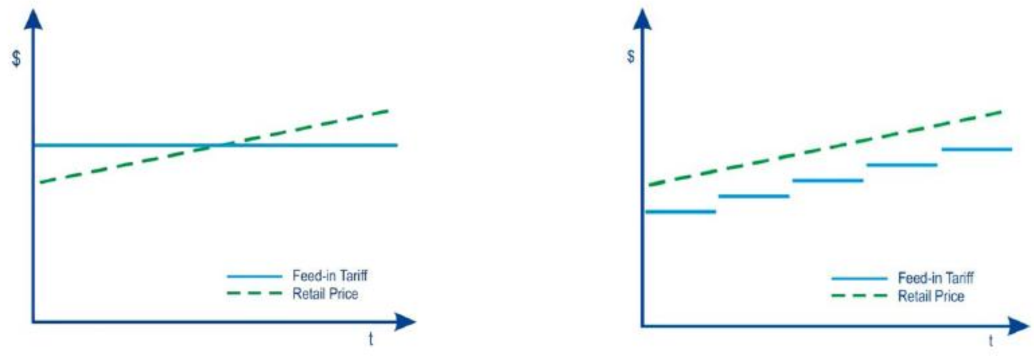

Figure 2.2. Market-independent (left) and market-dependent feed-in tariffs (Couture & Gagnon, 2010).

Most support schemes are not linked to electricity prices although a few may consider a premium option (Klein *et al*, 2010). Premium options allow producers to choose between a pure feed-in tariff or a subsidy level on top of the electricity price, in which case the typical purchase obligation ceases. Premiums can be constant or variable according to market price. In the latter case, a premium is lowered if electricity prices exceed a certain level, as well as raised when prices drop too low (Figure 2.3). Alternatively, a percentage-based premium can also be introduced, though this may lead to windfall profits in case spot prices soar.

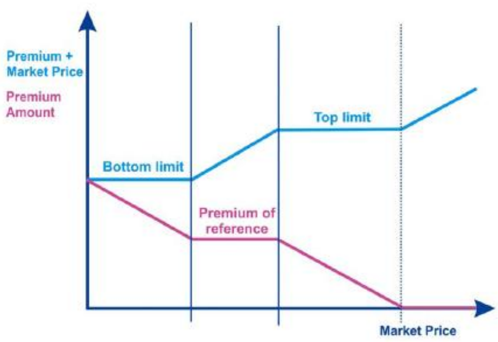

Figure 2.3. Example of a sliding premium (Couture & Gagnon, 2010).

Klein *et al* (2010), from which this section draws extensively, have done one of the most wide-ranging and up-to-date analysis on feed-in policy design options in the EU. Analysis of feed-in tariff schemes needs to consider several dimensions and their options. Although most schemes are independent of electricity prices, tariffs can be adjusted to consider technological developments or inflation. Suppliers are constantly innovating and bringing to market more competitive products, from cheaper turbines to more efficient photovoltaic cells. These improvements allow investors to sweep higher profits, hence in an effort to curb overcompensation, tariffs need to be adjusted downward. Periodical adjustments of the tariff in order to incorporate inflation are also important to maintain the profitability of the investments. Tariffs can be adjusted to inflation in full, partially or with a revenue cap (Couture & Gagnon, 2010).

However, some tariffs are not inflation-adjusted as an incentive to technological development. In this case, the higher feed-in tariffs at the start of the support scheme are an incentive to producers and equipment suppliers to feed know-how and accumulated experience into new plants and to lower long-term generation costs. Other support schemes consider learning effects by lowering tariffs as capacity is increased, an alternative which also helps keep policy costs under control. Technology development or inflation are not the sole reasons for tariff revision. Since in most support schemes tariffs are initially set in accordance to both capital and operating expenditures, changes to input materials, e.g. silicon, iron, copper, that influence any of them can lead to tariff revisions.

Tariffs are not only technology-specific but can also vary according to location, capacity and type of fuel. Producers can benefit from tariffs for a fixed period (15-20 years) but some schemes acknowledge location as a factor affecting profit levels and include a clause for load hours. In these schemes, a tariff is paid up to a certain level of load hours, after which it is reduced or completely withdrawn. This clause is especially targeted to highly variable sources such as wind. A second possible element of a stepped tariff is plant capacity. Larger plants enjoy economies of scale and need a lower tariff to achieve the same profit level as a smaller plant. More distributed energy production can also reduce transportation and distribution losses, although grid management costs may rise. A stepped tariff can also be designed for biomass power plants. The type of fuel used in the power plant – e.g. solid biomass, animal waste, energy crops, etc. – or a blend of these, will determine the overall tariff.

Some systems make it mandatory for producers to forecast production. This is important to improve grid management as electricity cannot be stored and variable renewable sources like wind can pose serious challenges to efficient management. Also related, dispatchable sources like bioenergy and hydropower can be encouraged to produce electricity in peak time, thus being demand-oriented and closer to market needs. A miscellaneous set of tariff bonuses can also be introduced and targeted to specific investments: combined heat and power plants, which are more efficient; producers replacing older equipment with more efficient technology; or pre-commercial technologies, in an attempt to spur innovation and accelerate market development.

Who pays for the policy costs varies from country to country, as noted in the previous section. Klein *et al* (2010) state that most countries distribute policy costs equally among electricity consumers (equal burden-sharing), though some may exempt specific energy-intensive industries as a means to keep competitiveness levels.

Net metering is a particular case of a feed-in tariff. Households and other small electricity consumers can be producers by setting up a solar PV on the rooftop or a small wind turbine. A tariff is earned on all the electricity produced or just the excess over self-consumption. Tariffs in these cases tend to be much higher than for other, larger producers due to higher investment costs and avoided grid losses. A different type of scheme, commonly applied in the United States, uses a reversible meter for when production is fed into the grid, in which case there is only a reduction of the household's bill with electricity.

Concessions, though they are public tenders, are considered a price-based instrument as long as the price to be paid to bidders is determined from the onset. The advantage of concessions is that regulation and permit costs can be reduced since there are fixed timeframes and power capacities for private agents to bid for, while also improving market stability if there is competition for a resource. Thus, concessions can allow better management of the power grid.

iii. Financial incentives

The policy instruments presented so far form the core of renewable-energy support schemes. However, other types of instruments are often used to help overcome barriers to renewable energy development. Financial incentives are mostly used as supplementary measures in combination with feed-in tariffs and quota obligations, since they are seldom sufficiently strong to determine investor decisions by themselves (EC, 2008).

Investment grants are upfront subsidies reducing the total capital expenditure of a renewable project. A distinction can be made between buy-down grants, mainly used to support demonstration projects which are not yet market-ready, and development grants, which are aimed at capital-intensive projects and used mostly in developing countries or regions (World Bank, 2008). Governments may also set up specific loan facilities to support renewable projects with lower-than-market interest rates (soft loans), longer terms or less demanding conditions relative to collateral.

Fiscal incentives, whether reductions or exemptions, are applicable to several taxes: excise duty, corporate tax, income tax, property tax, etc. (Azuela & Barroso, 2011). These incentives are simple to implement and can reduce both investment and operational costs. Some special taxes related to environmental protection (e.g. pollution tax) can also be lifted for renewable projects (World Bank, 2008). Companies producing renewable energy are not the exclusive beneficiaries of pro-renewable policies; equipment suppliers such as wind turbine or boiler manufacturers can also be exempted from taxes such as the value added tax.

iv. Research and development

Another supplementary instrument is funding for research and development in the area of renewable energy. Both quantity- and price-based instruments are designed to promote cheaper solutions in the long-term, but this may not be enough to promote innovation efficiently. Technology lock-in occurs when mature technologies adopted from the onset reduce generation costs through learning-by-doing and crowd out other technologies (Unruh, 2000). This problem happens not only between fossil fuels and renewable energy but also within the latter. The power sector is especially influenced by technology lock-in as electricity has very good substitutability (Kalkuhl *et al*, 2011).

Research and development activities also provide positive knowledge spillovers and thus, in themselves, warrant a level of support. They are the first stage in the process of bringing new technologies to the market. They help break technology lock-in, driving generation costs down in the long-term. Furthermore, research and development can also focus on untapped energy sources and bring them to market, thus increasing the potential of renewable sources in the global energy mix. However, although technology policy aims to unlock the positive externalities linked to innovation, it must complement, and integrate with, environmental policy (Jaffe *et al*, 2005).

3. Climate and energy policy

So far only instruments related to renewable energy have been mentioned. The policy context, however, is much wider and also encompasses other areas such as energy efficiency and carbon emissions. Integration with these other policies is important in order to control overcompensation, unfair treatment with other sectors of the economy and conflicting measures.

Energy efficiency measures can give a substantial contribution to meet GHG emission targets and, depending on previous actions, can be more cost-effective than deploying renewables. Their effect on energy prices, however, can be adverse to renewable energy projects as demand tends to decrease. Instruments such as quota obligations and feed-in premiums are more prone to this problem since they are linked directly to market prices.

Climate policy includes instruments such as taxes on CO_2 and cap-and-trade that address GHG emissions directly. Both instruments are theoretically cost-effective, although the latter allows greater control over total emissions (Perman *et al*, 2003). Under a cap-and-trade system, firms are allocated a number of emission rights and may choose between selling them in the market and implementing abatement measures to reduce GHG emissions. If the ultimate policy objective is to control GHG emissions, then these instruments are more cost-effective than renewable energy policies, as the latter increase compliance costs (Fischer & Preonas, 2010).

As with energy efficiency, it is important to understand the effect of overlapping climate and renewable energy policies. Bohringer and Rosendahl (2009) argue that having both a cap-and-trade scheme and tradable green certificates will increase emissions from the highest polluting technologies (e.g. coal). Energy production is increased by implementing a green-certificate system. As the profitability of fossil-based producers is lowered and output is reduced, so will the price of emissions rights fall. The cap on emissions is kept constant, or else the price of emissions falls even further, and there is a shift towards the dirtiest technologies, which have lower generation costs. This does not mean emissions break the cap; the effect is a shift from nuclear and gas technologies to coal.

Boeters and Koornneef (2011) have estimated that the EU renewable energy target of 20% by 2020 comes at an excess cost of €4 billion or 6% of total costs with climate policy if compared to the emission-reduction policy alone. Böhringer *et al* (2009), too, have shown that not only the 20% emissions reduction target for 2020 has a welfare loss of 0,5-2% but also that second-best policies (e.g. different Emissions Trading Scheme (ETS) and non-ETS carbon prices, renewables standard) may lead to overall cost that is 100-125% too high.

4. Best practice in policy design

Policy design and evaluation must necessarily consider the objectives and targets one intends to achieve, and some degree of specificity will always be present so as to incorporate market, institutional and administrative conditions (Azuela & Barroso, 2008; Lipp, 2007). If tackling climate change and reducing carbon emissions is the single policy objective, then instruments such as emissions trading or a CO_2 tax are the most efficient and any other measure will lead to unnecessary compliance costs (Boeters & Koornneef, 2011; Fischer & Preonas, 2010;

González, 2007). However, if other objectives are pursued (e.g. energy security, green jobs, innovation), other supplementary instruments should be in place. Policies are not to be considered static. They need to be periodically evaluated to take into account several changing conditions and progressively improve them to better fit stated objectives.

Stability is one major, cross-cutting element to all instruments presented above. Investors need a clear, long-term policy framework to assess risk and commit their resources to investment in renewable energy (Klein *et al*, 2010; Couture *et al*, 2010). Without the assurance that measures are kept for a period of at least ten years and no changes will occur in the meantime, renewable energy penetration will suffer.

Much of the debate in renewable policy evaluation concerns effectiveness and efficiency in the sense of cost-effectiveness. Effectiveness refers to the impact on market growth of renewable energy, while efficiency is assessed through the cost incurred with the implementation of a support scheme (IEA, 2008). Both price-based and quantity-based instruments have shortcomings that, though not possible to eradicate in full, must be acknowledged and mitigated. Competitive bidding and tradable green certificates are more efficient than feed-in tariffs: the former will attract bids equal to the producer's marginal costs; the latter will progressively deploy the cheapest options out of a range of technologies and locations (Azuela & Barroso, 2011; Menanteau *et al*, 2003; World Bank, 2008). These instruments also allow a greater control over full policy costs.

On the other hand, countries with feed-in tariffs have been able to promote renewable energy to a greater extent. Feed-in tariffs have a tendency to overpay for renewable energy but as a result they provide greater incentives to invest. Complex feed-in tariff schemes can, nevertheless, consider decreasing payments over time. That is the case in market-independent tariffs (no adjustment to inflation) and degressive tariffs (Klein, *et al*., 2010; World Bank, 2008). The fact that tariffs are reduced over a period of years saves on producers' differential rents and keeps compliance costs in check (Menanteau *et al*, 2003). Moreover, this type of support scheme can be based on a concession system where windows of power capacity are bid for, though price is fixed. This procedure allows policy effectiveness to be monitored more closely and avoids larger budget overshoots. Another alternative is to opt for feed-in premiums which, if well designed, have the advantage of being closely linked to avoided social costs and market conditions.

In practice, there is evidence that feed-in tariffs can not only be more effective in deploying renewable energy but also more cost-effective than quantity-based instruments. Fouquet & Johansson (2008) state that the UK Non-Fossil Fuel Obligation Programme (NFFO) attracted such low prices under a bidding system that eventually firms were unable to meet the fixed prices or went bankrupt. The same authors also mention a significant price disparity between the UK quota obligation and the German feed-in tariff schemes: in 2008, prices for the former ranged between 12 to 14 eurocents/kWh while the latter were in the range of 5,3 to 8,4 eurocents/kWh. Even though, theoretically, tradable green certificates are more cost-effective than feed-in tariffs, in practice that is not always the case (Fischer & Preonas, 2010).

Another level of comparison between tradable green certificates and feed-in tariffs is innovation. Quota obligations are technology-neutral and favor the cheaper technologies. The presence of competition drives innovation for better technologies but producers need to generate and allocate profits to R&D. Menanteau *et al* (2003) argue that because feed-in tariff schemes allow producers to reap greater surpluses, it gives them a greater incentive to innovate, especially with degressive tariffs. A quota obligation system, too, is more prone to technology lock-in than feed-in tariffs or competitive bidding since the latter have some sort of technology specificity, although banding is an effort to circumvent this issue.

Although both systems can be perfected, currently feed-in tariffs are seen as the best support scheme for renewable energy. Couture *et al* (2010) provide some guidelines on feed-in tariff policy design which are intended to overcome the known disadvantages. Stepped tariffs are important as they acknowledge the fact that technologies, fuels and siting influence generation costs. By considering these factors, a feed-in tariff system can adjust remuneration levels to actual generation costs, which should be revisited periodically. Degression, as we have seen, is also crucial to promote better technologies and cut policy costs. Feed-in tariffs could also be linked to the energy market and thus deliver energy when it is most needed. Demand orientation is more applicable to dispatchable technologies such as bioenergy or hydro. In the case of feed-in premiums, tariffs should preferably be sliding as this makes them more market-oriented and helps avoid under- and over-compensation. All these design options must be taken together with other important "add-ons" (guaranteed grid access, purchase obligation, generation forecast, etc.).

Finally, it should be noted that so far we have focused primarily on the power sector since it is where most of the instruments described in the previous sections have been implemented. But bioenergy can give important contributions to other sectors, namely heating and transportation.

This poses a great challenge to policymakers as instruments for the power sector can significantly distort markets. Biomass can be used in combined heat and power (CHP) units, boilers or converted into biofuels. There are many countries where there are feed-in tariffs for CHP plants but little or no integration with policies for other uses, which by themselves also provide externalities such as GHG emissions reductions or increased energy security. Other uses of biomass can stand at a disadvantage against supported uses such as power production. With bioenergy, it is thus important to consider the entire supply chain and possible uses and avoid significant market distortions. There is a need to support not one specific use of biomass but all those uses that produce particular social benefits that should be internalized. Another, more difficult matter is policy integration for a renewable source that can have extensive transboundary impacts on land-use and affects a crucial segment of the economy, the food system.

5. Conclusion

Market failures such as externalities call for government intervention, generally through taxes or subsidies. This chapter presented the main instruments used in the renewable energy sector. Quota obligations and feed-in tariffs, the two principal instruments used to promote renewable electricity, each have their drawbacks. The former may be more efficient than the latter, but it implies greater risk to promoters and deployment of renewable capacity may suffer as a consequence. On the other hand, feed-in tariffs usually lead to higher levels of deployment. Compared to quantity-based instruments, policy costs with feed-in tariffs are higher although mechanisms such as degressive or deployment-dependent tariffs may keep these in check.

Policy design in this sector needs to be coordinated with instruments with a potential to overlap. In particular, climate change and renewable energy policies go hand-in-hand as both try to reduce greenhouse gas emissions. However, there is a real risk of policy overlap and higher costs. Designing policies also needs to consider the specific technologies. Biomass, for instance, has several uses and incentives in one sector (e.g. renewable energy) which may distort the regular functioning of other sectors (e.g. wood industry).

3. Overview of renewable energy instruments in the European Union

1. Introduction

The first section of this chapter gives an overview of the main renewable energy policy instruments used in Member States. Energy and climate policy in Member States is largely determined by commitments at European level and its directives. This chapter thus starts with a brief presentation of the main directives affecting national policies in the sector, as well as a general view of the instruments used in Member States across the European Union.

The remaining section of the chapter focuses specifically on four Member States: Germany, Sweden, Spain and the United Kingdom. This analysis, done in greater detail, is intended to present how similar policy instruments are effectively applied in countries that have taken the lead in renewable energy. The selection was done in such a way as to include two examples of each of the two main instruments to promote renewable energy in the power sector and presented in the previous chapter: quota obligations and feed-in tariffs. A second criterion for the selection relates to the high importance of renewable energy relative to other Member States.

2. European Union

The European Union has had a leading role in developing the renewable energy sector and tackling climate change. It has been one of the strongest proponents for tougher GHG emissions reduction targets. This stance is visible in the Europe 2020 strategy where one of the five headline targets, broken down into three, relates to energy and climate policy: a 20% reduction of GHG emissions compared to 1990 levels, an increase in the share of renewable energy in final energy consumption to 20% and an increase of 20% in energy efficiency (EC, 2013).

Directive 2009/68/EC (EU Renewable Energy Directive) sets the overall national targets for renewable energy in each Member State. It is then up to countries to define how they will reach the mandatory target by specifying sectoral targets (electricity, heating & cooling, transport and energy efficiency). Member States presented their strategies in National Renewable Energy Action Plans in 2009, along with evidence of the instruments (e.g. regulatory, financial, etc.) in place to meet targets by 2020.

Significant EU-level policies concerning climate change started already with the Community's ratification of the Kyoto protocol in 1993 and its approval in 2002 (Decision 2002/358/EC), which established a binding greenhouse gas emissions reduction target of 8% between 2008 and 2012 to be achieved collectively. Directive 2003/87/EC, later amended by Directive 2009/29/EC, defined the implementation of an emissions trading scheme, adding to other Kyoto instruments such as the Clean Development Mechanism and Joint Implementation.

In the power sector most Member States have opted for feed-in tariff support schemes (Table 3.1). All countries that opted for quota obligations have, nevertheless, introduced changes to include also feed-in tariffs for specific technologies or power capacity goals (Ragwitz *et al*, 2012a). Belgium has also set minimum prices, giving investors greater investment security, and tax deductions on investment are available at the federal level. On the other hand, only in the Swedish quota system is the ratio of certificates to MWh equal for all technologies.

Feed-in systems also vary greatly from country to country. There is currently a trend towards feed-in premiums (e.g. Denmark, Germany and Spain), including price caps and floors to address investment risk and overcompensation (Ragwitz *et al*, 2012b). Tariff degression, which can be defined by law or subject to future revisions of financial incentives, is present in Germany, Greece, Slovenia and Spain. This suggests that, if no provisions are in place to control excess deployment of renewables, the likely increase in policy costs may trigger changes to those support schemes. Some countries (The Netherlands, Germany and Denmark) have addressed overcompensation by introducing stepped tariffs which are subject to the potential of the site (Ragwitz *et al*, 2012a). The Netherlands has implemented a system whereby five tenders are opened during the year limited to a previously agreed budget, thus giving generators the incentive to apply in the first calls and at competitive prices (Ragwitz *et al*, 2012a).

Table 3.1 shows that for the heating and cooling sector, most countries use several complementary instruments. Countries usually introduce tax incentives, such as the possibility of investment cost deduction, and incentives to investment in the form of grants or soft loans. There is a strong link with the support scheme for power since combined heat and power is eligible for higher tariffs or more certificates per output. Only three countries (The Netherlands, France and the UK) have introduced market-based instruments such as feed-in tariffs or premiums in this sector.

The transport sector has more modest targets and is also more homogeneous regarding instruments. Nearly all countries use a blend obligation coupled with tax exemptions on biofuels. Sweden is the only country relying solely on tax incentives to meet its target. Greece also provides additional support through investment grants.

Directive 2003/96/EC established an EU framework for the taxation of energy products and electricity. The Directive, currently under reform, will in the future tax products for their CO_2 emissions and energy content. A proposal under discussion pushes for a minimum taxation of €20/tCO_2 and €1,27/GJ for natural gas used for heating (EC, 2011). Such taxation levels, if introduced, could prove to be a significant boost to the use of renewable fuels in Europe.

Table 3.1. Overall and sectoral targets from National Renewable Energy Action Plans and main types of policy instruments used (EC, nd(a), Sturk, 2012)

Country	Overall final energy consumption		Electricity			Heating & Cooling			Transport		
	EU 2020 Target (%)	% RES in 2009	Instrument	EU 2020 Target (%)	% RES in 2009	Instrument	EU 2020 Target (%)	% RES in 2009	Instrument	EU 2020 Target (%)	% RES in 2009
Austria	34,0	31,0	FIT	70,6	68,0	CHP; IG; TAX	32,6	31.2	QO; TAX	11,4	6,5
Belgium	13,0	4,5	TGC; TAX	20,9	5.8	CHP; TAX	11,9	5,1	QO; TAX	10,1	3,3
Denmark	30,0	20,2	FIP	51,9	28,3	TAX	39,8	30,8	QO; TAX	10,1	0,2
Finland	38,0	31,1	FIP; IG (R&D)	33,0	27,2	CHP; IG; TAX	47,0	43,3	QO; TAX	20,0	4,1
France	23,0	12,3	FIP	27,0	15,0	FIP; LIL; TAX	33,0	15,4	QO	10,5	6,1
Germany	19,6	9,5	FIT	38,6	17,2	IG; LIL	15,5	8,5	QO; TAX	13,2	5,3
Greece	18,0	8,1	FIT	39,8	10,5	OBL; TAX; IG	19,7	15,9	QO; IG	10,1	1,1
Ireland	16,0	5,1	FIT	42,5	13,7	IG	12,0	3,9	QO	10,0	1,9
Italy	17,0	8,9	TGC; FIT	26,4	18,8	OBL; TAX;	17,1	8,2	QO; TAX	10,1	3,8
Luxembourg	11,0	2,8	FIT	11,8	4,1	IG	8,5	4,6	QO; TAX	10,0	2,2
Netherlands	14,5	4,1	FIP	37,0	9,1	FIP; CHP; IG	8,7	3,1	QO	10,3	4,2
Portugal	31,0	24,6	FIT	55,3	38,2	CHP; IG	30,6	37,9	QO	10,0	3,9
Spain	22,7	12,8	FIT; FIP	40,0	27,8	CHP: OBL	18,9	12,8	QO	13,6	3,5
Sweden	50,2	48,1	TGC	62,9	58,3	TAX; IG; OBL	62,1	68,1	TAX	13,8	7,3
UK	15,0	2,9	TGC; FIT	31	6,6	FIT; CHP; TAX; IG	12,0	1,7	QO; TAX	10,3	2,6

CHP – combined heat and power premium; FIP – feed-in premium; FIT – feed-in tariff; IG – investment grants; OBL – mandatory regulation; QO – quota obligation; TAX – tax; TGC – tradable green certificates;

EU-level grants are available to support R&D and demonstration projects. A major financial instrument is the 7th Framework Programme (FP7) for research projects. In general terms, these projects require a minimum of three participating member states and are financed up to 75%. Linking academia and business is also an important characteristic of FP7. Some calls required that a certain percentage of the budget is allocated to small and medium enterprises. The Competitiveness and Innovation Framework, through the Intelligent Energy Europe and Eco-Innovation Programmes, co-finances projects focusing on non-market barriers to renewable energies and in bringing to market new and innovative products. Preliminary data on total commitments with FP7 amount to €55 806 million, of which €2 225 million were allocated to the Energy theme (EC, nd(b)). Horizon 2020, the R&D programme covering 2014-2020, will have a budget of nearly €88 000 million.

The European Union has several bodies to devise strategies and instruments on how to promote the development of low-carbon technologies, such as the SET-Plan, SETIS and the European Technology Platforms. Demonstration projects can be supported by specific grants from the European Commission and the European Investment Bank through the NER300 programme. The programmes consists of two calls – the first of which was in opened in 2011 – and is available for a given set of technologies and capacities for biomass-related and carbon capture and storage.

3. Germany

Germany's renewable energy policy is currently framed by the *Energiewende* (energy transition) programme established in 2010 and magnified in importance in 2011 due to the Fukushima accident. Nuclear phase-out has been reactivated on the back of an international discussion on operational safety. Gas-fired power stations are expected to become the major energy source in the power sector, though renewable sources have strong policy support.

The EU Renewable Directive set a share of renewables of 18% in gross final energy consumption by 2020 but the latest version of the National Action Plan estimates reaching 19,6%. This would be accomplished with a share of 38,6% in the electricity sector, 15,5% in the heating and cooling sector, and 13,2% in the transport sector. Interestingly, the Renewable Energy Sources Act (Erneuerbare-EnergienGesetz – EEG) of 2012 sets a less demanding target for the share of renewable electricity by 2020 – 35% – than the National Renewable Energy Action Plan.

The EEG 2012 amends the previous act of 2009 and is the backbone of financial support by setting feed-in tariffs to renewable energy sources. It has four stated objectives: 1) reducing energy supply costs; 2) protecting the environment; 3) conserving fossil fuels; and 4) promoting the development of renewable energy technologies.

Under this Act, renewable power has priority regarding grid connection and purchase by operators. Feed-in tariffs are paid to renewable generators for 20 years, plus the commissioning year, except for hydro which are given for a period of 15 years. Tariffs are set according to power capacity thresholds and power output (i.e. tariffs are reduced as actual power output increases), and technology used. A comparison between 2009 and 2012 feed-in tariffs is presented in Table 3.2.

Tariffs have degression rates in two ways. On the one hand, there are fixed degression rates set for each technology, some of which with set trigger dates (e.g. 7% per year tariff reduction for offshore wind from 2018 onwards). On the other hand, rates for solar photovoltaic are validated annually to keep deployment on track and avoid policy cost overshoots. Thus, rates are decreased if installed capacity reaches a set threshold, but increased if they fall under different thresholds. For instance, tariffs are lowered by 6% if capacity reaches 4,5 GW and are increased by 2,5% if it falls below 2,5 GW.

Major changes were introduced in the EEG 2012 relative to its 2009 version. The technology premium, which aimed at promoting innovative technologies, is now kept only for combined heat and power (CHP) units (up to 20 MW) and petrothermal geothermics. In the case of biomass, the CHP premium was merged with the energy crops premium, and the EEG widened the scope for other feedstocks eligible for an increased tariff. The EEG 2012 links to the Biomass Ordinance of 2011 which defines several feedstock types (Annexes I and II of the Act), technical specifications and sustainability criteria. The guarantee of origin, besides validating that generators are effectively producing power eligible under the EEG 2012, is also a means to check how the Biomass Ordinance is applied in biomass procurement. The 2012 amendment to the EEG significantly reduced tariffs paid to solar photovoltaic generators as it triggered degression rates linked to capacity thresholds.

Table 3.2. Comparison of the 2009 and 2012 Renewable Energy Sources Act.

Technology	Power capacity	Power output (average annual capacity)	EEG 2009		EEG 2012	
			FIT – 2009 (c€/kWh)	Degression rate (%/year)	FIT – (c€/kWh)	Degression rate (%/year)
Hydro	> 5 MW	< 500 kW	7.29	1	12.7	1
		0.5 – 2 MW	6.32		8.3	
		2 – 5 MW	6.32		6.3	
		5 – 10 MW	6.32		5.5	
		10 – 20 MW	5.8		5.3	
		20 – 50 MW	4.34		4.2	
		> 50 MW	3.5		3.4	
Landfill gas	< 5 MW	< 500 kW	9.0	1,5	8.6	1.5
		0.5 – 5 MW	6.16		5.89	
Biomass	< 20 MW	< 150 kW	11.67	1	14.3	2
		150 – 500 kW	91.8		12.3	
		0.5 – 5 MW	8.25		11.0	
		5 – 20 MW	7.79		6.00	
		CHP bonus	3.00			
Geothermal	All	<10 MW	16.0	1	25	5
		> 10 MW	10.5		25	
		Prior 2016 bonus	4.0		-	
		CHP bonus	3.0		-	
		Petrothermal	4.0		5	
Onshore Wind	All	Initial tariff (first 5 years)	9.2	1	8.93	1.5
		Basic tariff (Year 5 onwards)	5.02		4.87	
		Repowering bonus	0.5		0.5	
Offshore wind	All	Initial tariff (first 12 years)	13.0	5 (2015 onwards)	15	7 (2018 onwards)
		Basic tariff (Year 12 onwards)	3.5			
Solar PV	Standalone	-	31.94	11 (2010)	21.1	9 (2012 onwards)
	Attached or on top of buildings	< 30 kW	43.01	9 (2011 onwards)	28.74	
		30 – 100 kW	40.91		27.33	
		0,1 – 1 MW	39.58		25.86	
		> 1 MW	33.0		21.56	

A second piece of legislation concerns heating and cooling. The Act on the Promotion of Renewable Energies in the Heat Sector (Erneuerbare-Energien-Wärmegesetz) was approved in 2008 and aims at increasing the share of renewables in final energy consumption for heating and cooling to 14% by 2020. New buildings with over 50 sq meters have to reach a mandatory target of renewable energy according to the technology used. Obligations under the Heat Act are met if new buildings fulfill their heating and cooling demand with a minimum percentage share according to the technology used. The following minimum percentages apply as defined by the 2011 amendment to the Act:

- Solar radiation – 15%
- Gaseous biomass – 30%
- Solid or liquid biomass – 50%
- Geothermal and ambient heat – 50%

Among other changes to the Act, the 2011 amendment defines strict rules for public buildings, thus acknowledging their exemplary role. Financial instruments are provided by the Federal Government in order to comply with the requirements of the Act. These include capital grants and low-interest loans, as well as redemption grants for larger installations such as district heating plants.

4. Spain

Deployment of renewable energy in Spain has long been associated with energy security. This is one the three arguments, along with sustainability and enhancement of competitiveness, in favor of its renewable energy policy as stated in the National Renewable Energy Action Plan. Under the Renewables Directive the country needs to reach a 20% share of renewable energy in final energy consumption. The sectoral targets for electricity, heating and cooling, and transport are 40%, 18,9% and 13,6%, respectively.

The current support scheme for the power sector in Spain is established by the Royal Decree 661/2007. The scheme includes not only all renewable technologies but also fossil-fuelled CHP units. Generators may opt between a feed-in tariff or a feed-in premium. In the latter case, the decree sets a reference tariff added to the market price but with both ceiling and floor prices in order to attract investment and avoid overcompensation. Generators can switch from one option to the other after one year. Table 3 below presents the feed-in tariffs, premiums, and top and bottom limit prices.

Duration of the support differs between feed-in tariffs and premiums. The former is given for a period of 15 years to most technologies, after which tariffs are reduced. On the other hand, premiums are only given for the initial period of 15 years, then removed entirely (except for hydro, geothermal and solar thermal power). Tariffs for CHP are updated quarterly with the Retail Price Index and a fuel price index, although not to the full extent of changes in the indices used, thus keeping policy costs in check. For renewable technologies and dedicated biomass power stations, the method used to updat the support level is based on RPI minus 0,25% until 2012 and minus 0,5% from 2012 onwards.

Cossent *et al* (2011) state that most generators choose the feed-in premium, although initially there was a larger share of feed-in tariff generators. Wind, concentrated solar power and medium hydro units (10-50 MW) have opted for feed-in premiums, while thermal technologies and solar photovoltaic generally choose feed-in tariffs.

Alongside feed-in tariffs and premiums, generators can also claim bonuses depending on the efficiency and reactive energy of the plant. For biomass and hydro, generators may opt for a different tariff in peak and trough hours. Large power stations (>50 MW) have support levels that are capped or levelised according to capacity up to 100 MW. Co-firing of biomass is possible within a case-by-case analysis of capital and operating costs and the level of support determined by the authorities. Biomass power stations have different tariffs according to whether they use agri-residues, forest residues or energy crops.

The Royal Decree n. 1578/2008 has defined new support measures for the solar photovoltaic sector due to massive investment and deployment. In order to meet investor expectations but still avoid excess costs, the regime is based on successive public tenders in which tariffs are reduced from previous final tender prices. The country has also produced several pieces of legislation since 2009 with the aim of curbing the tariff deficit existing in the power sector by 2013 (Royal Decree 9/2009). As deployment of renewables has contributed to enlarge this deficit and the country is on track to meet its National Renewable Energy Action Plan targets, the government has decided to cut support to renewable electricity from January 2012 (Royal Decree 1/2012).

Table 3.3. Tariff levels considered under the Royal Decree 661/2007.

Technology	Capacity	Duration	Feed-in tariff (c€/kWh)	Premium (c€/kWh)	Ceiling price (c€/kWh)	Floor price (c€/kWh)
b) 1.1 Solar photovoltaic	< 100 kW	First 25 yrs	44,04	-	-	-
		Afterwards	35,23	-	-	-
	100 kW < P < 10 MW	First 25 yrs	41,75	-	-	-
		Afterwards	33,4	-	-	-
	10 MW < P < 50 MW	First 25 yrs	22,98	-	-	-
		Afterwards	18,38	-	-	-
b) 2.1 Onshore wind	-	First 20 yrs	7,32	2,93	8,49	7,13
		Afterwards	6,12			
b) 4 Hydro	< 10 MW	First 25 yrs	7,8	2,50	8,52	6,52
		Afterwards	7,02	1,34		
b) 6.1 Biomass – Energy crops	< 2 MW	First 15 yrs	15,89	11,53	16.63	15,41
		Afterwards	11,79	-	-	-
	> 2 MW	First 15 yrs	14,66	10,10	15,09	14,27
		Afterwards	12.35	-	-	-
b) 6.1 Biomass – Forest waste	< 2 MW	First 15 yrs	12,57	8,21	13,31	12,09
		Afterwards	8,48	-	-	-
b) 6.1 Biomass – Forest waste	>2 MW	First 15 yrs	10,75	6,19	11,19	10,38
		Afterwards	8,07	-	-	-

González (2008) provides some relevant insight regarding the historical background that led to Royal Decree 661/2007 and some improvements that could still be introduced. The current scheme is a reform of a previous, effectiveness-focused scheme. The scheme brought about a huge increase in renewable capacity and the 2007 reform defines measures to reduce overcompensation and uncontrolled policy costs. Some improvements to further reduce producer surplus, namely a stepped tariff, could be introduced in future reforms although the author refers to an increase in administration costs and potential reduction of effectiveness as drawbacks.

In the heating and cooling sector, a combination of investment grants channeled to the Autonomous Communities and low interest rate loans (e.g. BIOMCASA programme) are available to support investment in heating with renewable sources.

5. Sweden

Sweden has a long tradition of renewable energy generation since it committed to change its energy sector after the 70s oil crisis. Current policy targets are highly ambitious: 50,2% share of renewables in final energy consumption by 2020, 1,2% above its mandatory target under the EU Renewables Directive. A staggering target of 62,1% and 62,9% for heating and cooling and electricity sectors by 2020 makes Sweden one of the most pro-renewables countries in the EU.

The power sector is supported by a mandatory green certificate scheme created in 2003 (Act 2003:113) in which electricity suppliers and some electricity users must meet the quota obligation for any given year by presenting the necessary number of certificates. These are issued by the Svenska kraftnät at a ratio of one certificate per MWh, hence the scheme is technology-neutral. If compliance by suppliers is not met until the reporting deadline (31st March), a payment of 150% of the volume-weighted average of the certificate price for the respective year is due.

The scheme is operated jointly by Sweden and Norway since 1st January 2012. Quota obligations for Norway have started low at 3% but will increase by 2020 to 18,3%. Certificates are guaranteed for 15 years and units commissioned before 2003 are eligible until 2012 or 2014. In 2013 there will be a reduction of the overall quota due to legacy units that will reach their allowed eligibility period. Power-intensive industries are partly or wholly exempted from the obligation, thus not supporting the additional costs of renewable generation.

Table 3.4. Quota obligation for Sweden and Norway for 2011 to 2017 (SEA, 2012).

Year	Sweden	Norway
2011	17,9	-
2012	17,9	3,0
2013	13,5	4,9
2014	14,2	6,9
2015	14,3	8,8
2016	14,4	10,8
2017	15,2	12,7

The power sector consists mainly of three different technologies: bioenergy, especially CHP plants used for district heating, which accounts for over 50% of all certificates issued; wind energy with a 30% share; and hydro with nearly 14%. Bergek and Jacobsson (2010) have pointed to high consumer costs and rents to producers, and failure to drive technological change.

Several other policy instruments are in place to help complement the electricity scheme in achieving the renewable targets. Sweden has a two-level (households and industry) carbon tax since 1991 which does not overlap with the later Emissions Trading Scheme. In 2011 the tax was €114/tCO2 for households and €34/tCO2 for installations outside the ETS. Investment aid and grants are also available for solar heating systems, wind power pilot projects and retrofitting from electrical to district heating, biomass and heat pumps.

6. UK

Under the Directive 2009/68/EC the UK has a mandatory target of 15% share of renewable energy by 2020. In 2011 the share of renewable energy accounted for 3,8% of energy consumption, up from 3,2% in 2010 (DEEC, 2012a). This is in line with the first interim target of 4% for 2011/2012. The UK strategy to decarbonize the economy includes renewable energy, nuclear and carbon capture and storage, while it is recognized that energy security, new skills and investment opportunities are also strategic drivers. Adding to the legally binding target set by the Renewable Energy Directive, the National Renewable Energy Action Plan further specifies the share of renewables for three different sectors: 30% for electricity demand, 12% of heat demand and 10% transport demand (DECC, 2012a). One stated and important characteristic of this target split is that it is not mandatory but adjustable as circumstances change. The UK Renewable Energy Roadmap presents the analysis and actions to tackle non-financial barriers and to develop emerging technologies (DEEC, 2012a). It focuses mainly on improving grid access, reducing planning process delays, improving supply chains and infrastructure, and spurring innovation in the renewable energy sector. The Energy Security Strategy and the Heat Strategy complement the framework of the strategic options set out by the Coalition Government.

Overall and sectoral targets are translated into a complex and wide-ranging group of policy measures. Among the several regulatory and financial instruments employed, the Renewables Obligation, the Feed-in Tariffs Scheme, the Renewable Heat Initiative and the Renewable Transport Fuel Obligation Scheme are the backbone of renewable policy in the UK.

The Renewable Obligations scheme was introduced in England and Wales in April 2002. It sets the obligation for electricity suppliers to present evidence in the form of Renewable Obligation Certificates (ROCs) that a fixed amount of renewable electricity was delivered in a given obligation period (1st April to 31st March). In 2012/2013 suppliers will need to present 0,124 ROCs for each MWh supplied in Great Britain. Suppliers can generate renewable electricity themselves or buy ROCs from renewable energy generating stations. Suppliers can be discharged of the renewables obligation by paying a buyout price (£37,19/MWh for 2009/2010 and updated for each obligation period according to the Retail Price Index). Payments are collected into a buyout fund, which is then distributed among electricity suppliers on a pro-rata basis according to their share of ROCs. The Gas and Electricity Markets Authority is responsible for monitoring implementation of the scheme, including accreditation of generating stations, issuing ROCs and managing the buyout fund.

The scheme is only available for renewable electricity supplied to consumers in Great Britain, although Northern Ireland generating stations are eligible suppliers. Large hydro generating stations (>20 MW) commissioned after 1st April 2002 and any generating station commissioned and not renewed since 31st December 1989 are not eligible suppliers. Power from CHP co-firing stations is eligible as long as biomass or waste is burned in separate boilers or engines and, for both CHP and non-CHP units, fossil fuel use (e.g. for start-up) must be under 10% of the total renewable energy content.

Several changes have been inserted to the scheme. In 2009 banding was introduced to reflect the level of development and costs of the several renewable technologies. Banding sets the ratio of ROCs per MWh for each technology, thus reducing technological lock-in. The support level for each accredited station is fixed for 20 years and cannot be changed with future revisions of the banding levels, a provision known as grandfathering.

Another relevant feature of the RO 2009 Order is how the renewable obligation is determined. The target is the greater of two values: 1) the fixed target set in Schedule 1 for each obligation period; 2) an estimate of renewable electricity for the obligation period as notified by electricity suppliers increased by 8%[1]. The latter is known as headroom and considers the potential new build for the next obligation period. The 2009 Order capped the obligation to 20% total electricity output, but it has been removed with the 2010 Order.

The 2009 Order has much greater detail on what is a renewable source, especially regarding waste and biomass. It also caps co-firing without CHP to 12,5% of total renewable electricity but on the other hand, excludes the 2002 provision of 75% co-firing of energy crops for the 2006/2007 obligation period, certainly a late adaptation of the text to the development of the sector since the scheme was first published.

The 2010 revision makes some minor changes to the scheme. It increases support to offshore wind and introduces clauses for suppliers to choose between the RO and feed-in tariffs scheme. On the other hand, the 2011 Order, though not changing the workings of the scheme, introduces articles addressing the issues set out in the EU Renewables Directive, namely the sustainability criteria for bioliquids and biomass (e.g. no biomass from primary forests or high biodiversity sites).

In 2013 a new amendment revised the 2009 Order. This amendment introduced new bands, removed existing bands and amended others (Table 3.5), as well as removing the minimum calorific value for liquid fuels and the limit on the number of ROCs issued for co-firing that suppliers can submit.

Policy costs are borne solely by electricity consumers and amount to 5% of the energy bill of an average household (DECC, 2012b). The Levy Control Framework is responsible for guaranteeing that policy is effective and as efficient as possible, while also controlling how electricity suppliers pass costs to consumers.

Generators are paid tariffs for a period of 20 years according to their technology and power capacity bands. All electricity produced is supported regardless of it being used by the generator itself, although an export tariff exists for energy supplied to the grid. Tariffs defined in 2010 were indexed to the retail price index for every technology except for wind and solar PV tariffs which were reduced over time. However, from 2014 onwards all technologies will have a minimum degression rate of 2,5%. The

[1] The percentage increase was changed to 10% with the RO Order 2010.

degression rate is set according to how renewable energy is being deployed and real technology costs, thus providing a mechanism for effective policy cost control and an incentive for innovation.

Table 3.5. Renewable obligation certificates per MWh produced for each generation type according to the 2013 amendment to the Renewables Obligation.

Generation type	ROCs per MWh
Landfill gas	0.25
Sewage gas **Low-range co-firing**	0.5
Onshore wind **Hydro** **Standard gasification/pyrolysis**	1
Dedicated biomass	1.5
Tidal **Wave** **Solar photovoltaic** **Offshore wind** **Dedicated energy crops** **Geothermal**	2

Feed-in tariffs regulations are set under the Energy Act 2008 (Sections 41 to 43), the Standard License Condition 33 and the Feed-in Tariffs Order 2010, the latter amended twice in 2011. The scheme is applicable only to installations with a maximum capacity of 5 MW and to five technologies: anaerobic digestion, wind, solar photovoltaic and hydro. Combined heat and power is also eligible up to 2 kW capacity and a total of 30 000 units under a pilot scheme basis.

Table 3.6. Support levels for non-PV technologies under the feed-in tariffs scheme (DECC, 2012c).

Technology	Band (kW)	Final tariffs from 1 Dec 2012 (p/kWh, 2012 prices)
Hydro	< 15	21,00
	15 – 100	19,60
	100 – 500	15,50
	500 - 2000	12,10
	2000 – 5000	4,48
Wind	< 1,5	21,00
	1,5 – 15	21,00
	15 – 100	21,00
	100 – 500	17,50
	500 – 1500	9,50

	1500 - 5000	4,48
Anaerobic digestion	< 250 250 – 500 500 – 5000	14,70 13,60 8,96
Micro CHP	< 2	12,5

The Renewable Heat Initiative is a scheme designed to address the targets set out in the National Renewable Energy Action Plan and the Heat Strategy, namely an indicative target of 12% in the heating sector by 2020 and zero carbon heating by 2050. It was firstly implemented in November 2011 and consists of a tariff based on metered heat produced from technologies such as geothermal, heat pumps, solar thermal, biomass and biogas. District heating is included as well as combined heat and power with biomass, although in the latter case generators must choose between having the Renewable Obligation uplift of 0,5 ROCs/MWh or the heat tariff. Currently only non-domestic renewable heat generators are eligible but the government is preparing the extension of the scheme to the domestic sector by mid-2013.

Tariffs were calculated according to the levelised cost methodology. The European Commission argued the initial tariff of 2,7p per kWh would over-compensate investors (DECC, 2011a). As with feed-in tariffs, heat tariffs are linked to inflation and are likely to change subject to actual deployment of renewable heat capacity. Degression will be introduced in Phase 2 as a means to ensure a cost-effective policy.

Biomass tariffs for large generators were initially higher than those ultimately agreed. Generators of over 1 MWh per year are required to supply information on quantity, origin and form of biomass, and if whether it has any environmental accreditation.

Table 3.7. Renewable Heat Incentive tariffs levels by type of technology (DECC, 2011b).

Tariff name	Eligible technology	Eligible sizes	Tariff rate (p/kWh)	Tariff duration (years)	Support calculation
Small commercial biomass	Solid biomass including solid biomass contained in MSW and CHP	Less than 200 kWth	Tier 1: 8,3 Tier 2: 2,1	20	Metering. Tier 1 applies annually up to the Tier Break, Tier 2 above the Tier Break. The Tier Break is : installed capacity x 1,314 peak load hours
Medium commercial biomass		200 kWth and above; less than 1000 kWth	Tier 1: 5,1 Tier 2: 2,1		
Large commercial biomass		1000 kWth and above	1,0		Metering
Small commercial heat	Ground-source heat pumps;	Less than 100 kWth	4,7		

pumps	water-source heat pumps; deep geothermal				
Large commercial heat pumps		100 kWth and above	3,4		
Solar collectors	Solar collectors	Less than 200 kWth	8,9		
Biomethane and biogas combustion	Biomethane injection and biogas combustion	Biomethane all scales, biogas less than 200 kWth	7,1		

The energy sector in the UK is under intense and constant change. Contracts for difference, introduced with the Electricity Sector Reform, will replace the Renewable Obligation scheme from 2017 onwards. Moreover, a strong package of incentives for the domestic heating sector, named Green Deal, has also been approved recently.

7. Conclusion

In this chapter a brief overview of policies across Member States was presented along with the main drivers coming from the European Union. Most Member States use feed-in tariffs to promote renewable electricity, clearly the most developed niche in the energy sector. The heating and cooling sector is dominated by additional incentives for combined heat and power production, and the domestic and commercial sectors still lack stronger incentives. In what concerns biofuels, practically all Member States use a quota obligation and tax exemptions.

Four countries were scrutinized in greater detail regarding their particular policies and instruments. Spain and Germany have feed-in tariff schemes with clearly set support levels. Tariffs vary according to the technology used and have mechanisms in place to avoid policy overcosts (e.g. degression rates, tariff increases below inflation, among other). Spain has been a strong supporter of greater market integration with generators allowed to opt for feed-in premiums.

The UK and Sweden have similar support schemes based on quota obligations. Two significant distinctions can be made when comparing the two systems. First, Sweden and Norway have an integrated market and some large electricity users also need to fulfill the obligation. The second important difference is the consideration of technology in each system. While the Swedish and Norwegian scheme supports technologies equally, the UK gives a different number of certificates according to technology costs.

The UK will also change its quota obligation scheme into contracts for difference starting in 2017. Both countries have strong incentives for heat production through CHP plants, although the UK has also given very high support for the domestic and commercial markets.

4. Renewable energy policies in Portugal

1. Introduction

The previous two chapters gave an overview of policy instruments used in the renewable energy sector and how they have actually been used in the European Union. This chapter presents the development of Portuguese policies in the sector since the 70s. It is focused on the power sector since that is where policy makers have been more active and support is more significant. Support to hydro power, namely large dams, is not covered as instruments are different from those presented previously and the pricing mechanisms differ significantly[2].

This chapter makes reference to numerous Portuguese legislative acts, mainly Decretos-lei and Portarias (Ordinances), and we have chosen to use the abbreviations DL and Ord. for reading sake. All relevant acts, whether mentioned or not, are organized by year and available at this link http://goo.gl/mNqk1. It is supposed to be an extensive database, although there may be a few missing acts.

2. The 70s and the 80s

With neither oil nor significant coal resources, Portugal was seriously affected by the two oil crises of the 70s. Already in 1976, a support scheme was implemented to help industrial fuel-oil consumers cope with higher prices by providing bonuses, promoting energy efficiency and encouraging the switch to other sources (Despacho Ministerial, DR. n. 78, April 1st 1976). This scheme was successively changed in 1978, 1980, 1981 and 1984, cumulatively achieving an estimated savings of 312 ktep/year (Ferreira, 1998). Since the scheme supported industrial users, its impact on renewables was limited mostly to biomass and biogas for heat production (Table 4.1). Users were entitled to a 30% non-reimbursable grant for energy efficiency and renewable energy investments generating fossil-fuel savings. The 1984 scheme also included independent energy generation to reflect changes introduced by Law n. 21/82 to allow this activity.

[2] Hydroelectric units fall under the Energy Purchasing Contracts (CAE) and Costs of Maintenance of Contractual Equilibrium (CMEC).

Table 4.1. Number of projects, total investment and energy savings for each support scheme (MIE, 1989).

Support scheme	Biomass			Biogas		
	Nr. of projects	Investment (10^3 PTE)	Savings (tep/year)	Nr. of projects	Investment (10^3 PTE)	Savings (tep/year)
1976	1	31	1 728			
1978	4	191	7 277			
1980	33	4 359	80 490	1	14	229
1981	35	17 355	35 550	5	134	1 247
1984	39	1 668	33 531	6	109	757
Total	112	23 604	158 576	12	257	2 233

These early support schemes were a quick fix to the problems Portugal was facing in the energy sector. Medium to long-term energy planning started with the National Energy Plan of 1982 (PEN 82), an inter-ministerial effort to define the objectives, policies and major outlines for the energy sector up to 2010. Previous strategic documents covered a time horizon of 6-10 years, while PEN 82 brought a longer-term approach more suitable to the large time lags of investments in the sector. The 70s oil crises were clearly the major driver of the effort to reduce energy dependence and control its side effects on the balance of payments. Indeed, it is possible to read that "our excessive dependence on imported oil is the major weakness of our energy system" (DGE, 1982:25).

Two strategies were set forth in the plan: 1) a Reference Strategy (ER) was built around the ultimate objective of minimizing energy costs, with coal, natural gas and nuclear arising as major future investments; and 2) a Security of Supply Strategy (ESA), which accepted higher costs in order to achieve higher energy independence and resilience levels.

The plan acknowledged the importance in the energy sector of hydro and firewood, which in 1980 represented 10% and 11,6% of primary energy consumption. The PEN 82 was divided into eight development programmes for the energy system, including one for the development of renewable energies where priority actions focused on hydro, biomass and solar thermal for low-temperature heating.

Two other programmes – the Programme for National Energy Resources Assessment and the Programme for Research, Development and Demonstration in Energy –

contained measures to contribute to the development of renewable energy. At the time, knowledge regarding renewable energy potential was clearly deficient. Solar, geothermal, hydro, biomass, wind and municipal solid waste were the renewable sources the Plan intended to evaluate: forest energy crops and use of forest and sawmill waste; national wind map; hydro potential inventory; among others. Technological development and demonstration covered not only energy efficiency, nuclear and coal, but also renewable technologies such as photovoltaic panels, digestors and small-scale hydro.

The plan pinned high hopes on a couple of game-changing technologies, namely coal- and biomass-to-liquids. This was probably connected with the need to find alternatives to oil-based fuels and the devastating effect of price volatility in the 70s. Oddly enough, biomass-to-power, a mature technology by then, was not taken seriously as an opportunity to improve biomass efficiency (from open fireplaces to large-scale boilers) and add renewable-based power to the electric grid.

The PEN 82 was never approved. It was submitted to public discussion in 1983 but the country's difficult financial situation led not only to an IMF-backed economic programme but also to political change. The IX Constitutional Government revised the 1982 version of the Plan in 1984. Most changes concerned the macroeconomic background, with growth and discount rates revised according to the harsher environment, and two price scenarios were considered. Although strategic changes are not very visible, a stronger support for renewable energy can be understood from a decision by the Council of Ministers demanding investment in hydro to be done at the maximum possible rate to achieve the levels established in the Security of Supply Strategy and raising the possibility of a government override of the minimum cost objective to directly support deployment of renewable energies such as biomass, wind and solar.

Prospects for nuclear energy generation in Portugal were definitely put off after the Chernobyl accident in 1986. Coal and natural gas would have to be the two major sources to help achieve greater security of supply. Regarding renewable energy, two factors would determine its development in the late 80s. Firstly, Portugal became a member of the European Communities in 1986 and thereby an important source of funding from the EC VALOREN programme (1987-1991), established by Regulation n. 3301/86 and with the objective of developing local energy sources and promoting new technologies, was made available to businesses. Ten million PTE were channeled to Portugal during the five-year programme (Ferreira, 1998). The national support scheme established by Decree-Law (DL) n.250/86 and Ordinance (Ord.) n.464/86 considered investment grants between 15-30%, according to the level of innovation, economic value and currency savings. Eligible costs for a given project were limited to the cumulative fuel and power savings or the economic value of the energy produced for a period of 6 to 20 years, depending on the technology. In 1988, DL n.188/88 and Ord. n.334/88 introduced some changes to the scheme by allowing more eligible expenses, namely viability studies and costs with human resources, and providing higher grant levels to less developed regions.

The second factor affecting renewable deployment concerns support to power production as defined by DL n.189/88. This piece of legislation revised the prior special regime of power production established by DL n.29/1981, which included serious limitations to the effective deployment of renewable generation stations. The new regime not only aimed to fast-track licensing procedures but, more importantly, softened the limits to the amount of power that could be delivered to the public grid and allowed generators to claim the same subsidy fuel-oil power plants were entitled to. Moreover, risk was largely mitigated due to a State guarantee that provided a tariff floor for a period of 8 years of 90% of the tariff at the start of the contract. This gave investment security since minimum future revenues could be determined. Table 4.2 compares the two pieces of legislation.

Table 4.2. Comparison of the 1981 and 1988 legislation concerning renewable electricity production.

DL n.20/1981	DL n.189/1988
• Renewable sources and coal (if sourced domestically) • Limited to installations that complementarily produce electricity (later changed by Decree-Law 149/1986 to allow installations with the sole aim of power production); • Installations could only deliver up to their own contracted power; • Electricity paid according to fixed tariffs of the next higher tension level;	• Renewable generation units up to 10 MW and CHP (no capacity limit); • Electricity paid according to fixed tariffs of the next higher tension level, but State guarantees 90% of the revenue at the start of operation for the following 8 years; • Extra revenue from fuel-oil subsidy also paid to other thermal power plants;

Renewable electricity production was highly dependent on hydro before 1980. It was during the 80s that not only a significant number of fossil fuel based units came online but also renewable sources other than hydro grew at a pace of 11% annually compared to just 3% in the preceding decade (see Annex I). Despite the high growth rate, those sources accounted for 2% of total electricity production. Hydro, on the other hand, kept its importance with landmark dams during the 70s and 80s, namely Valeira in 1976 (240 MW), Aguieira in 1981 (270 MW) and Pocinho in 1982 (186 MW).

3. The 90s: the awakening of renewable energy

The Social Democratic Party ran the country since 1987. Entering a second mandate (1991-1995), its energy policy was directed toward the liberalization of the electricity and fuel sectors (Portuguese Government, 1991). Electricidade de Portugal (EDP), the power-sector monopolist from production to commercialization, was dismantled and private initiative was further promoted.

The Energy 1995-2015 strategy brought the second generation of planning frameworks after PEN 82- and 84. Its global objective was "to guarantee energy supply and availability to the country, in the amount required, within price conditions that contribute to the competitiveness of the national economy and with respect for the environmental constraints" (MIE, 1995:16). The five specific objectives focus on the same issues as past strategies: energy independence, diversification of sources of supply, energy efficiency and environmental impact. Much priority was given to market liberalization, the forthcoming introduction of natural gas in the country and power production from coal (the Pego power station, with a capacity of 628 MW, was due in 1995). The push towards renewable energy was now based not only on the same reasons as in the past, such as energy dependence, but also on environmental worries, which were spurred by the Rio Conference in 1992 and were better understood and supported. Curbing emissions, namely through fuel specifications, and the possible implementation of a CO_2 tax are mentioned in the document.

There is also a clear acknowledgement of the difficulty in promoting costlier technologies, noting the need for additional R&D to make them competitive. However, as stated, "if, on the other hand, external costs with fossil fuels are taken into account and supported by society, the balance would be different and it would make penetration easier. It is the State's role to acknowledge the long-term interest of that development and intervene in the market" (MIE, 1995).

The strategy sets several measures to promote renewables, including:

- Maintaining a scheme of financial incentives, subject to periodic reviews to address technology competitiveness;
- Support the national production of equipment and machinery (hydro, solar and wind)
- Supporting actions such as dissemination of funding (e.g. Altener), fiscal incentives and the creation of a renewables observatory.

The objectives and measures presented in Energy 1995-2015 were in practice pursued through the Energy Programme (DL n.195/94) and SIURE (DL n.35/95), both using structural funds made available under the second Community support framework (Decision 94/170/CE) covering the period 1994-1999. The Energy Programme was divided into four key areas, including the use of endogenous energy sources. Support in the latter includes a wide range of energy sources (solar, wind, biomass, hydro, geothermal) and uses (fuels, CHP, heat, electricity up to 10 MW capacity). Eligible projects could benefit from capital grants of up to 50% of eligible costs, provided they did not exceed 50 million PTE or 150 million PTE for power stations. Demonstration and dissemination projects were also supported at 60% of eligible costs, including human resources. For both types of projects the support levels could be increased according to their location, thus directing funding to rural areas in need of employment and development.

An extensive reform of the electricity sector was also undertaken in 1995. Within a legislative package approved to define the new structure of production, distribution and transport of electricity, the renewables and CHP regime was also separated. The reasons for this breakup are not only linked to the specificity of CHP but also as a means to introduce different support levels for each. Though the structure of the support scheme does not differ substantially from the previous regime defined by DL n.189/88, there are still some important changes introduced by DL n.186/95 (CHP) and DL n.313/95 (renewables). Firstly, the support level now had a cut-off power capacity of 10 MW. Thus, for the first 10 MW, electricity was paid according to tariffs of the next tension level in the case of CHP, or, for renewables, according to the tariffs of the tension level in which electricity was produced. Above 10 MW, both CHP and renewable generators were paid the avoided costs for a period of 15 years. Secondly, the State guarantee is also different for CHP or renewables. The State guaranteed CHP generators 90% of the inflation-adjusted revenue at the start of operation for a period of five years or during the investment payback period. Revenue for renewable generators, on the other hand, was guaranteed for eight years.

The Portuguese Government ratified the Kyoto Protocol in April 1998. This was possibly the most important driver leading to a new design of the support scheme for renewables and CHP in 1999. The new legal framework for renewable energy production, established by DL n.168/99, excludes non-renewable fuels from the regime (e.g. coal) and provides a clear rationale for the support scheme, namely that it is intended to include avoided costs (both investment in new power stations and operational costs) and the environmental externalities delivered by renewable energy suppliers. The price mechanism clearly reflects this rationale (Figure 4.1). The price formula, applied monthly, is composed of six main components:

1. **KMHO:** an optional, demand-oriented coefficient which lifts prices by 25% during peak hours, and decreases it by 35% for off-peak hours;
2. **PF:** a fixed component that covers capital expenditure and assumes a reference cost per kWh of 1090 PTE. It also takes into account the benefits to security of supply by including a coefficient based on the power station's availability (80% being equal to one);
3. **PV:** A variable component intended to cover operational costs and set at 5,00 PTE/kWh;
4. **PA**: an environmental payment due to avoided CO_2 emissions, which assumes a reference emission intensity of 370 g CO_2/kWh and a price of 0,015 PTE/gCO_2;
5. A consumer price index (CPI) coefficient to adjust prices to inflation on a monthly basis;
6. **LEV**: a factor to adjust for avoided power losses in the transport grid.

$$VRD = KMHO \times [PF + PV + PA] \times \frac{CPI_n}{CPI_{n-1}} \times \frac{1}{(1 - LEV)}$$

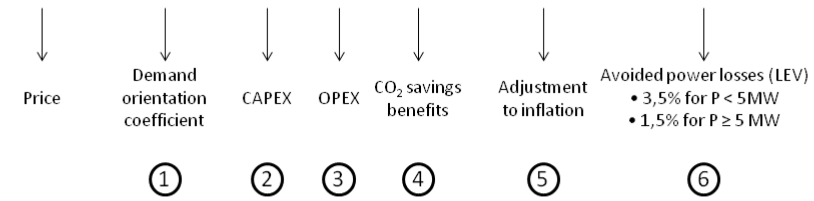

Figure 4.1 – Pricing mechanism for renewable electricity generators according to DL n.168/99.

Support is given to generators for a period of 12 years, after which the PA component is cut by 75% until the end of license and ceases to be adjusted to inflation. Electricity produced within a second licensing period will be paid at market prices.

The CHP support scheme follows the same cost-based, rationale for electricity prices. The pricing mechanism is set by Ord. n.30/2000 (<10 MW) and Ord. n.31/2000 (≥10 MW), and, although similar to the one applied to renewable energy, is more complex. CHP price is the sum of three components:

1. **PF:** an inflation-adjusted fixed component based on a reference value (PF_{ref}), a coefficient expressing the availability of the power station and the power supplied;
2. **PV:** representing all variable costs, including fuel, transport and other costs. Fuel costs are calculated with a reference value (PVC_{ref}), an inflation coefficient that considers oil prices (55%) and consumer prices (45%), and an optional demand orientation coefficient, KMHO (raises price by 25% in peak hours; reduces price by 27,5% during off-peak hours);
3. **PA:** an environmental component taking into account the CO_2 price, the emissions intensity of the power station of reference and the effective electrical efficiency[3] of the unit.

The pricing mechanism for power capacities below or over 10 MW is very similar, with the reference values for each component – namely, investment (PF_{ref}), fuel costs (PVC_{ref}), other costs (PVO_{ref}), and the CO_2 price (PA_{ref}) – set periodically by ministerial order. The mechanism also includes a LEV factor as above, which equals 2% and 4%

[3] Computed as η = Electrical output / (Thermal Input – Useful Thermal Output /α), where α is the efficiency of a conventional unit.

for stations above or equal to 5 MW and for the opposite case, respectively. Support is given for a period of 10 years.

In the 90s the country started to collect data on the deployment of renewable energy with greater regularity and reliability. For all the policy changes that occurred, much renewable capacity had already been built before the 1995 and 1998 support schemes. A major event was the construction of the Alto Lindoso dam with a 630 MW power capacity, which started operating in 1992 and alone increased renewable capacity by over 10%. Biomass capacity was already at 359 MW in 1995 as the wood industry converted fuel oil to forest waste, black liquor and other by-products. Wind was practically non-existent in 1995 with only 8 MW but ended the decade at an astonishing 57 MW, a breakneck average growth rate of 68% per year.

4. From 2000 onwards: the boom of renewable energy

The last period of analysis, covering 2000 until the present day, has been prolific in strategic plans. The pillars of those plans generally revolve around the same directions presented almost two decades before: security of supply, energy independence and environmental concerns. Nevertheless, the new decade also set market liberalization and integration, especially with Spain, as a major objective. It started out in 2001 with the "E4 Programme" (Council of Ministers Resolution (RCM) n.154/2001) and continued throughout the decade. Regarding the renewable energy sector, this programme also set the foundations for legislation to come, namely the introduction of technology-specific support levels and a support scheme for microgeneration. Transportation and energy in buildings have gained particular attention, and in the latter case a strategy to increase renewables penetration was partially implemented through a nationwide programme for solar water heating which, among others, was supported by investment grants and tax deductions.

The energy strategy presented in 2003 (RCM n.63/2003) stressed the importance of energy costs in promoting national competiveness. The document, in addition to setting a target area of 1 million m^2 for solar thermal systems by 2010, specified measurable targets for each renewable source (Table 4.3). There was a clear ambition, perhaps somewhat disconnected from the technology status at the time, in energy sources such as wave and solar photovoltaic. The target for wind was also highly ambitious but the rapid technology development together with existing support measures facilitated its penetration in the market. Except for wind, not one of the objectives was accomplished.

Table 4.3. Installed capacity in 2001 and 2010, and capacity targets for 2010 set in the 2003 strategy (Source: DGGE, 2012; RCM 63/2003).

Energy source	Capacity in 2001 (MW)	Target for 2010 (MW)in 2003	Actual values in 2010 (MW)
Hydro	4 209	5 000	4 497
Small Hydro	215	400	340
Biomass	10	150	106
Biogas	1	50	28
Wind	101	3 750	3 863
Solar PV	1	150	123
MSW	66	130	88
Wave	0	50	0

Climate change and the associated emission reduction thresholds, resulting from international agreements and set in the EU by Directive 2003/87/CE, were taken into account within the National Programme for Climate Change (RCM n.119/2004). For the period between 2008 and 2012 Portugal was not to exceed by 27% its 1990 greenhouse gas emissions levels. The international mechanisms available to reduce emissions comprised of emissions trading in the European Union, Joint Implementation and the Clean Development Mechanism. The first of these mechanisms, the Emissions Trading Scheme, began operating in 2005 and it was meant to provide an incentive for efficiency and greater renewable energy penetration, though it encompasses only those industrial sectors from which emissions are most significant.

Energy policy as defined in 2005 by the XVII Government was one of the most ambitious regarding renewables (RCM 169/2005). The overall objective for the power sector was to reach a 39% share of renewable energy in electricity production, as established in Directive 2001/77/EC. It acknowledged the need to reduce costs by increasing competition in the sector and placed a strong bet on hydro and wind energy. For the former, a national programme would be produced in 2007 which set a target of 7

000 MW by 2020, to be attained by building ten new hydro stations with a total capacity of 2 000 MW (IA, 2007). For wind energy, on the other hand, a target of 5 100 MW by 2012 was set, an astounding goal considering the installed capacity of around 1 050 MW at the time.

In 2010 energy policy for the next 10 years was presented in the National Renewable Energy Action Plan following the requirement set under Article 4 of Directive 2009/28/EC. The Plan sets a 31% objective for the share of renewable energy in final energy consumption by 2020, though this was also an outcome of the above-mentioned directive. Table 4.4 shows the interim and ultimate targets up to 2020 broken down by each of the three relevant sectors (electricity, heating and cooling, and transportation). Most of the effort to push renewable energy further is concentrated in the power sector (from 41,4% to 55,3%) and transportation (from 5% to 10%), the latter strongly reliant on the strategic option for electric vehicles. Regarding heating and cooling, the Plan forecasts a reduction of the share of renewables in the sector mainly due to the increasing deployment of natural gas and a reduction of firewood in inefficient fireplaces. Nevertheless, this trend is slightly countered by increasing penetration of solar thermal panels and pellet-burning stoves.

Table 4.4. Interim and ultimate targets set under the National Renewable Action Plan in 2010 (EC, nd(a))

Sector	2010	2015	2020
Heating & cooling	30,7	31,9	30,6
Electricity	41,4	50,5	55,3
Transportation	5	8,0	10,0
Global target	24,1	28,4	31,0

The Plan brings greater focus to the important role of employment and the development of national clusters in the energy sector, not least due to the straining financial and economic conditions triggered by the subprime crisis in 2007/2008. To this regard, the Plan considered that renewable electricity could contribute with 100 thousand new jobs and 3 800 million Euros in gross value added. In spite of all the investment put into energy efficiency and renewable energy, the Plan expects a decrease of only 9% in energy dependency in 10 years, a sign that structural conditions are hard to counter and need longer time horizons.

The Plan uses the LEAP and PRIMES models to forecast energy demand and evaluate the impacts of policy measures in different scenarios. The 2010 version includes the expected impact of Stability and Growth Pact measures for 2010-2013 on energy demand. By 2013, however, a need to address even harsher financial and economic conditions led to a revision. The revised Plan was approved by RCM n.20/2013 in April 2013, which also revises the National Plan for Energy Efficiency. It uses new macroeconomic forecasts (e.g. reduction of GDP by 8% in 2020) to determine the expected reduction in energy consumption and how targets will be met. In spite of an estimated reduction of 18% in renewable power capacity investment, the share of renewables in the power sector is expected to increase 4,3 percentage points compared to the previous version of the Plan. Sectoral and overall targets all edge higher in the revised Plan, despite its strong focus on controlling incentives to renewable energy.

Table 4.5. Energy consumption and targets by sector under the 2010 and 2013 versions of National Renewable Energy Action Plan (EU, nd(a), RCM n.20/2013).

	Energy consumption in 2020 (ktep)			**Renewables share target by 2020**		**Renewable share in 2010 (%)**
	NREAP (2010)	**NREAP (2013)**	**Reduction (%)**	**NREAP 2010 (%)**	**NREAP 2013 (%)**	
Heating & cooling	8 371	6 998	16	30,6	35,9	34,5
Electricity	5 721	5 603	2	55,3	59,6	41,1
Transportation	6 010	5 435	10	10,0	11,3	5,5
Gross final energy consumption	20 082	17 905	11	31,0	34,5	24,6

The support scheme for renewable energy and CHP maintained the same structure in this decade but a few changes were introduced. For renewables, a technology coefficient (Z) was introduced early in the decade with the DL n.339C/2001 (Table 4.6). This coefficient applies only to the environmental component (PA) of the pricing mechanism. Wind, solar, hydro and wave had different coefficients other than 1, the default value. The coefficient for wind adjusted down with increasing availability, i.e., as the number of hours per year overcame fixed thresholds then revenue would be progressively reduced, thus keeping policy costs in check. National targets were already used in 2001 for wave energy (i.e. 20MW) but it was with the 2005 revision that they became widely used. For instance, solar energy and landfill biogas had national targets of 150 MW and 50 MW respectively. In 2007 these national targets were increased for forest and animal waste (from 150 MW to 250 MW). Coefficients changed individually through specific legislation. For example, geothermal energy had a coefficient of 1, along with all other technologies not mentioned specifically, until in 2009 Ord. n.865/2009 set it to 29,4 for projects with total capacity of 3 MW and up to a national target of 6 MW.

These feed-in tariffs are available to generators for a period of 12 (non-specified technologies) to 25 years (biomass). Production limits are also in place for wind (first 33 GWh/MW), solar (first (21 GWh/MW) and hydro generators (52 GWh/MW).

Table 4.6. Comparison of technology-specific coefficient (Z) for the DL n.339C/2001, DL n.33A/2005 and DL n.225/2007.

	DL 339C/2001	**DL 33A/2005**	**DL 225/2007**
Wind	< 2000 h – 1,7 2000 – 2200 h – 1,3 2200 – 2400 h – 0,95 2400 – 2600 h – 0,65 >2600 h – 0,4	4,6	
Solar	> 5 kW – 6,55 ≤ 5 kW - 12	Up to 150 MW > 5 kW – 35 ≤ 5 kW - 52	Up to 150 MW > 5 kW – 35 ≤ 5 kW – 52 Thermoelectric ≤ 10 MW – 29,3 > 10 MW – 15-20
Hydro	1,2	≤ 10 MW – 4,5 > 10 MW – less 0,075/MW over 10 MW	
Wave	6,35 (< 20 MW national capacity)	1	Demonstration - up to 20 MW national capacity and 4 MW installed capacity – 28,4 Pre-commercial - up to 100 MW national capacity and 20 MW installed capacity – 16-22
Biomass	1	Up to 150 MW Forest waste – 8,2 Animal waste – 7,5	Up to 250 MW Forest waste – 8,2 Animal waste – 7,5 Landfill biogas: ≤ 20 MW national capacity – 7,5

		Up to 50 MW Landfill biogas – 7,5	Up to 50 MW – 3,8
Waste	1	3,8	Up to 150 MW MSW – 1 RDF – 3,8
Geothermal	1	1	1

New areas were developed in the sector, namely with the regimes of lower capacity generation. The microgeneration regime was first established by DL n.68/2002 and Ord. n.764/2002. Generators with capacity up to 150 kW were paid according to the low tension retail price and a coefficient dependent on the technology used (e.g. solar PV and fuel cells - €0,20/kWh; Stirling motors equals - €0,02/kWh). Support levels were given for the first ten years after which the technology coefficient was cut to half. The regime changed in 2007 with DL n.363/2007 for generators with capacity up to 5,75 kW. Support levels were strictly based on retail prices, although smaller generators (up to 3,68 kW) could opt for a fixed feed-in tariff of €650/MWh multiplied by a percentage related to the energy source. For this sub-regime, maximum eligible power sold was defined to 2,4 MWh per year for solar and 4 MWh per year for the other energy sources. Capacity was limited to 10 MW in 2007 with successive annual increases of 20%. In 2010 new changes to the premium sub-regime were undertaken with DL 118A/2010.

In 2011 another piece of legislation completed the final transformation of lower capacity generation by creating the minigeneration regime, applicable to capacities up to 250 kW. This was established along the same lines as the 2007 regime of microgeneration (general and premium sub-regimes). In the general sub-regime payments are done at market prices. On the other hand, the premium sub-regime considers a €250/MWh tariff, degressive by 7% on a yearly basis, and available for 15 years. Tariffs are multiplied by an energy source coefficient: 100% for solar PV; 80% for wind; 60% for biogas and biomass; and 50% for hydro.

Table 4.7. Comparison the microgeneration and minigeneration regimes.

	Microgeneration - 2002	**Microgeneration (premium sub-regime) - 2007**	**Microgeneration (premium sub-regime) - 2010**	**Minigeneration (premium sub-regime) - 2011**
Power capacity	≤150 kW	≤ 3,68 kW	≤ 3,68 kW	≤ 250 kW
Tariff	Equal to the regulated tariff for special lower tension level	First 10 MW capacity - €650/MWh For each subsequent 10 MW – reduction of 5%	First 8 years – €400/MWh Last 7 years – €240/MWh Annual reduction of €20/MWh	€250/MWh Annual degression rate of 7%
Coefficient	• Otto engines - €0,01/kWh • Gas microturbines - €0,015/kWh • Sterling engines - €0,02/kWh • Fuel cells - €0,2/kWh • Solar PV – €0,2/kWh • Other autonomous equipment – €0,015/kWh	• Solar – 100% • Wind– 70% • Hydro – 30% • Biomass CHP – 30%	• Solar – 100% • Wind– 80% • Hydro – 40% • Biomass CHP – 70% • Non-renewable CHP – 40%	• Solar – 100% • Wind– 80% • Hydro – 50% • Biomass and biogas – 60% • Non-renewable CHP – 40%
Duration	10 years	15 years	15 years	15 years
Deployment limits	Not applicable	Solar - 2,4 MWh/kW.yr All other – 4 MWh/kW.yr Max capacity – 10 MW in 2007 and annual increases of 20%	Solar and wind - 2,4 MWh/kW.yr All other – 4 MWh/kW.yr Max capacity – 25 MW	Solar and wind - 2,6 MWh/kW.yr All other – 5 MWh/kW.yr Max capacity – 50 MW

Environmental concerns were also subject of consideration in a different way, other than just the benefits from renewable energy, with legislation on impact assessment.

Annex I of DL n.69/2000, later changed by DL n.197/2005, sets the thresholds above which projects require an environmental impact assessment. For instance, a wind farm with 20 or more turbines, or closer than 2 km from another farm, would need an impact assessment if it is not set within a protected area. Power stations with a capacity equal or above 50 MW fall under this obligation, while for protected areas the threshold is 20 MW. Impact assessment has also moved up to the strategic level with DL n.232/2007, altered by DL n.58/2011, which applies to programmes and plans.

The share of renewable energy, excluding hydro, was stable at around 3% before 2000 (Annex I). The support schemes approved in the first half of the following decade had an enormous effect in production. Renewable production increased at an annual pace of 19% between 2000 and 2012. Wind energy alone reached an impressive annual growth of 43% and was the main cause for reaching a share of renewable energy in 2012 of 26% (DGGE, 2012).

Legislation on biofuels was first published 2006 with DL n.62/2006 transposing Directive 2003/30/EC and establishing a framework for the production of biofuels and its promotion. Support was given through a partial or total (for small producers) tax exemption through Ord. 1391-A/2006 and Ord. 3-A/2007. Later legislation enlarged the scope of biofuels to bioethanol (Ord. n.1554-A/2007) and procedures regarding supply chain certification and sustainability criteria (DL n.49/2009 and DL n.117/2010). Exemptions were given for a maximum quota of biofuels. This considered initially a target of 5,75% of biofuel incorporation by 2010, later increased by RCM n.21/2008 to 10%. The actual share of biofuels in 2010 was 7,56% (APPB, nd).

Sectors such as heating and cooling have had less attention from policy makers. Support to install solar panels has been given through investment grants and fiscal incentives (e.g. Solar Thermal Programmes in 2009 and 2010), actions are being taken to introduce biomethane in the natural gas grid, and fiscal incentives also given to investment in biomass boilers.

5. Policy costs of renewable energy

Control of policy costs with renewable energy became the main concern of the PSD/CDS government since the most recent elections in June 2011, following a request for a financial assistance programme to the European Commission and the International Monetary Fund by the preceding government led by the Socialist Party, PS. In order to keep electricity prices in check, sector regulators and governments postponed part of the costs with renewable energy and CHP - which account for around 25-30% of overall policy costs - increasing debt in the power sector which is currently over €3 600 million (ERSE, 2012a). Figure 4.2 shows which sources of renewable energy have been contributing most to policy costs. It is clear that renewable production (excluding hydro) and costs explode after 2004 and that the main driver is wind energy. Biomass, solar photovoltaic and CHP collectively contribute with nearly 30% since 2011 to the total policy costs. The additional cost due to renewable energy policies alone and incurred by consumers with power capacity lower or equal to 20,7 kVA accounts for 2,8% of the electricity price (ERSE, 2013).

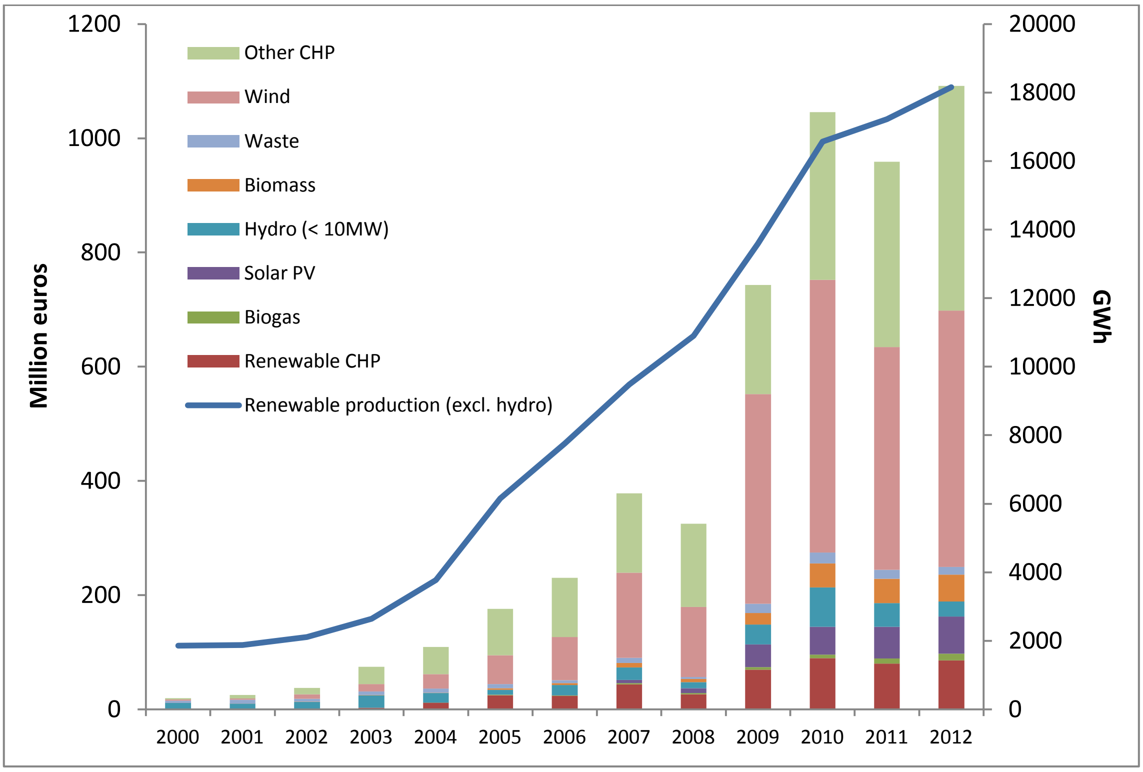

Figure 4.2. Renewable energy production (excluding hydro) and policy over costs by technology (ERSE, 2012b).

It is important to understand in particular what has happened in 2004 and afterwards. Licensed and installed wind energy capacity increased significantly since 2002 as a reaction to strong stimulus induced by DL n.339C/2001 (Figure 4.3). This first peak waned, reaching a trough in 2005 as PS took over and new legislation was under preparation. Licensed capacity in 2005 and afterwards was progressively lower and was driven by public tenders (Phases A, B and C in 2005, 2007 and 2008 with capacities of 800 MW, 400 MW and 200 MW, respectively). Figure 4.3 below suggests tenders, licensed capacity and installed capacity have a time lag of approximately one year.

Although the peak of new installed capacity is in 2006 this is actually the result of licensed capacity in the previous two years. The average feed-in tariff starts to stabilize as new capacity with reduced tariffs as a result of public tenders counters the costlier pre-2005 wind farms.

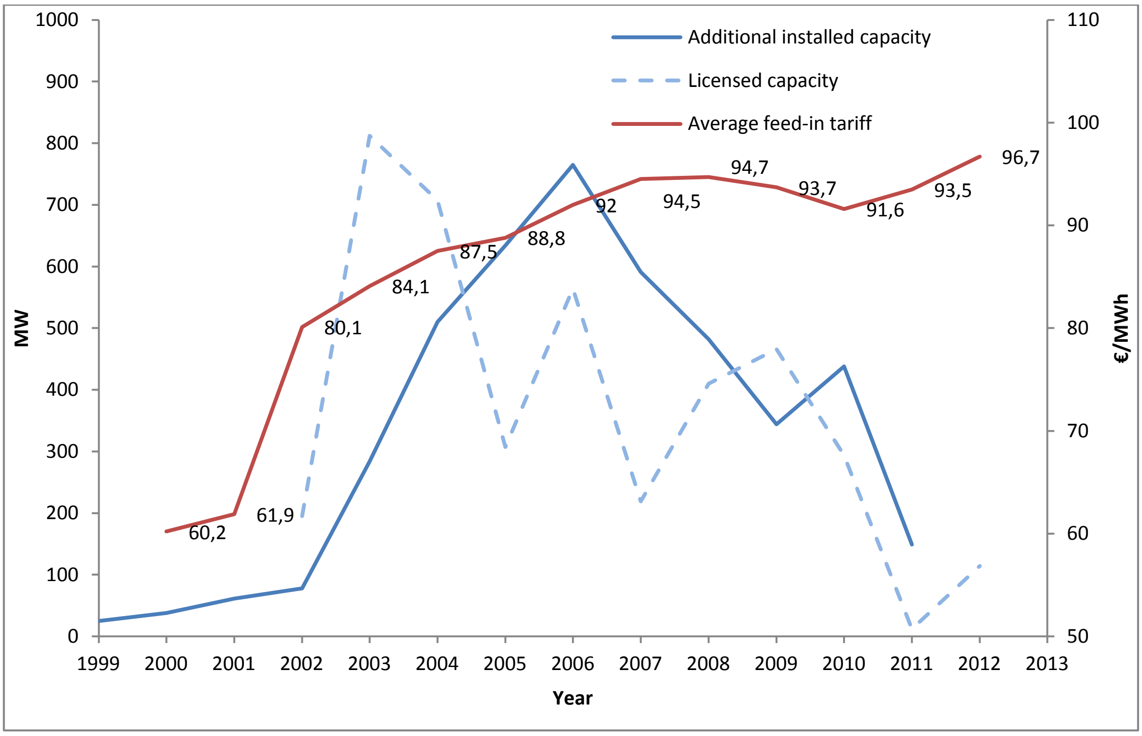

Figure 4.3. Licensed and additional installed capacity, and average feed-in tariff for wind energy (DGGE, 2012; ERSE, 2012b).

Though already in 2007 high debt levels gathered attention (e.g. RCM n.50/2007), the fact is that only in 2012 has legislation been passed to control policy costs in the renewable energy sector. That is the case with DL n.25/2012, which brought to a halt licensing of new renewable capacity, and Ord. n.325/2012 and DL n.35/2013 which decrease support to CHP and wind technologies. In the latter case, wind generators licensed before DL n.33-A/2005 which have completed 15 years of operation, may opt between being paid either the market price with a floor and cap of €74/MWh and €98/MWh, or the market price with a floor of €60/MWh. Further, soon after entry into force of the financial assistance programme, licensing of renewable energy capacity came to a halt.

6. Conclusion

This chapter presented the development of renewable energy policy in Portugal since the 70s. The years before the accession to the European Union in 1986 were dominated by the two oil crises in the 70s and financial rescue to the country by the IMF. All actions in the renewable energy sector were intended to increase energy independence but little fire power was available. After Portugal become member of the European Union, financial support was made poured in to drive investment, growth, employment and transform the energy sector as a whole. Renewables benefitted moderately through investment grants and financial support would need to be set up internally to achieve strategic energy and environmental goals. Feed-in tariffs, which progressively became more relevant at the turn of the century, drove renewable production to very significant increases. This seemingly apparent story of success created in the sector a heavy financial burden. The next decade will most likely see a strong effort to control policy costs in the power sector as recent legislation has shown.

5. Case study: the bioenergy sector in Portugal

1. Introduction

Biomass can be defined as any material of biological origin excluding material embedded in geological formations and transformed to fossil (CEN, 2003). The biomass sector is thus highly diversified and this brings greater difficulties in policy design compared to other sources.

This brief chapter is intended to provide insight into the particular case of biomass development and policy in Portugal. The focus is limited to the forest sector which has by far been most active when compared to biogas or agricultural residues.

2. Feedstocks, technologies and end-products

The extreme diversity of the bioenergy sector comes from the multiple raw materials, which is the origin of the numerous technologies and applications available (Figure 5.1). In practice, biomass encompasses forest (e.g. wood, bark, leaves) and agricultural (e.g. straw, vegetable oils) products, industrial by-products (e.g. sawdust, methane, manure) and the biological fraction of waste (e.g. food leftovers, landfill biogas, sludge). Another increasingly important biomass stream is that from energy crops, i.e. species grown purposefully for energy. These include, among other, poplar, salix and miscanthus.

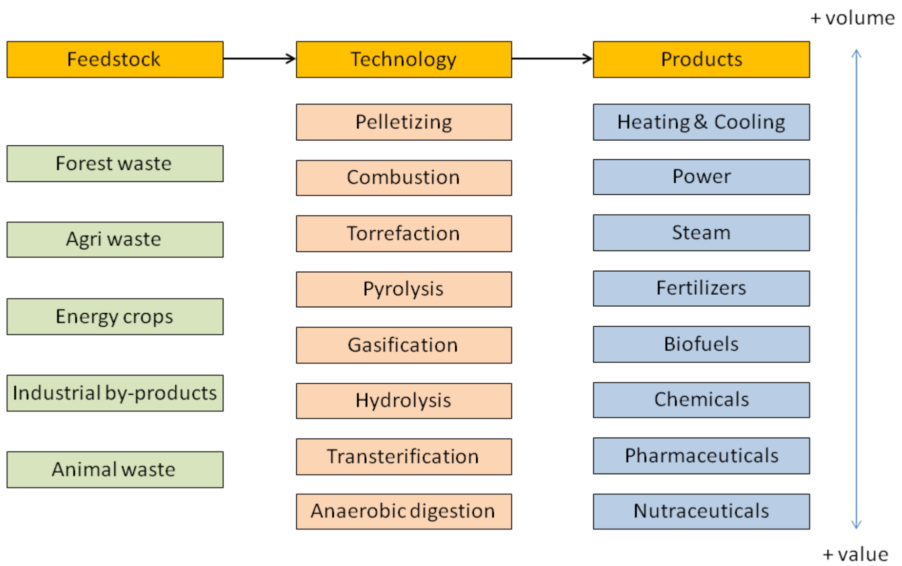

Figure 5.1. Types of feedstock, technologies and products of the biomass sector.

Technologies are determined by the type of feedstock to be processed and the desired end product. They are divided into chemical and biological, where the former are generally used for feedstocks with low moisture content (e.g. combustion for wood) and the latter for wetter raw-materials (e.g. anaerobic digestion for manure). Historically, combustion is the most used, researched and mature technology in the sector. However, the last decades have been prolific in developing new technologies, or adapting existing ones, to biomass. Some technologies (e.g. pelletizing, torrefaction, pyrolysis) are employed to improve efficiency within along the supply chain. For instance, pelletizing increases energy density significantly and reduces transportation costs.

Applications range from energy products, namely and most importantly, heat and power, to chemical compounds, fertilizers and pharmaceutical substances. Product value and market size are two factors influencing a business model, along with maturity of the technologies available and type of feedstock.

3. Environmental services

Converting biomass into useful energy, such as heat or power, has positive environmental externalities which need to be recognized and dealt with in policy design. One of the most important externalities is the reduction of greenhouse gas emissions due to fossil fuel substitution. Biomass use is generally considered carbon neutral in spite of the fossil fuel use in the production, supply chain and transformation of raw-materials. Although lately a controversially topic, there is evidence that biomass supply chains are largely positive compared to fossil-based energy systems (Wihersaari, 2005; Yoshioka *et al*, 2005).

There are other externalities which biomass systems provide. Forestry, and to some extent agriculture, provide important environmental services such water flow regulation, pollution buffer zones, soil retention, or species conservation. Evidently, biomass production must follow best practice guidelines and management models should address these services as part of its objectives.

The problem arising from the rationale of payment for positive externalities arises when several uses are concurrent to the same sources. Biomass is a very particular case within the renewable energy sector since it has different uses within and outside the energy market. Biomass is the only renewable source that can be transported and transformed into useful energy in another location other than the one where it was produced. This poses several problems such as cross-national policy impacts and a two-level market distortion despite the fact they may supply similar positive externalities: 1) within the energy sector, where some energy uses are supported by policy while others are not (e.g. power versus heating & cooling); and 2) with other market applications for biomass (e.g. energy versus furniture industry).

4. Biomass in Portugal

Mainland Portugal has over 3,15 million hectares of forest land, which represents around 35,4% of total surface area (ICNF, 2013). Forest cover – dominated by eucalyptus, cork oak and maritime pine, which together account for 72% of total forest land – has diminished over at least the last 15 years as a consequence of urbanization and abandonment. Since 1995 nearly 21 000 hectares per year were converted to pasture and shrub land.

Estimates on total biomass availability from forest resources are relatively scarce compared to research in other European countries. The first estimate was produced within the framework of resource assessments supported by PEN 82 and PEN 84 programmes and actions. In 1985 the Portuguese Government hired two consultancies with the objective of quantifying the production of biomass from forest resources and the wood industry. The outcome was an estimated annual production of 3,54 million fresh tons (A.D. Little & Tecninvest, 1985). This was a pioneering study which also provided the first biomass equations to be used for similar estimates.

A new estimate published in 2001 pointed to around 2 million dry tons per year from forest resources alone, while the wood industry could contribute with an additional 200 thousand dry tons per year (ADENE & INETI, 2001). A more recent estimate from Campilho (2006) points to a figure of 5,1 million fresh tons annually.

Although still important, firewood was extensively used in the country before other forms of energy (e.g. electricity, natural gas, heating oil) became widely available to households. In the industrial sector, biomass started replacing fuel oil in pulp and paper companies' boilers. The five support schemes from 1976 to 1985 were an important mechanism to induce change in the sector and help counter the price spikes of the 70s. Later, with the EU Valoren Programme, investment grants were also made available to continue this process of retrofitting from fuel oil to biomass. Queiroz & Figueiredo (1989) report that Portucel Viana had already converted one boiler to bark and sawdust in 1974, Celtejo in Vila Velha de Ródão had a converted boiler in 1986 and Soporcel in Setúbal would start using biomass in 1989. It was also around this time, in 1988, supported by PEN 84, that the Biomass Centre for Energy (CBE) was created with the aim of being the reference research organization and promoter of biomass in the country.

Dedicated biomass power stations were first constructed at the end of the century. In 1997 Centroliva, a 3 MW power station, was created in Vila Velha de Ródão and designed to use both forest and olive waste. However, the landmark would be the 9 MW unit in Mortágua, which first started operating in 1999. Supply chain and design issues are well-known in the sector but its importance to future developments is also acknowledged.

While pulp and paper companies continued switching to biomass and developing the supply chain, a public tender for 100 MW distributed among 15 dedicated biomass power stations was launched in 2006. One of the main triggers of the tender were the two years of catastrophic forest fires, 2003 and 2005, since it was expectated that new biomass capacity could promote better and more active forest management. The last awarding decision was made public only in 2009 showing how such bidding processes can slow deployment significantly.

The tender had several mandatory requirements, namely that 60% of the raw-material used be forest waste and no more than 5% of fuel requirements be fulfilled by fossil fuels (DGGE, 2006). Additionally, the evaluation process considered four criteria:

1. Description of the fuel;
2. Solidness and sustainability of supply, including contractual links and guarantees;
3. Technology and energy efficiency (i.e., electrical efficiency and use of heat);
4. Innovation and stimulation of the sector.

Bidders were required to present a resource assessment which included an analysis of the forest cover, species and biomass production, as well as estimates on the expected contribution of by-products from the wood industry. The first two criteria had a weight of 75%, a clear sign of the importance of feedstock supply and management in this type of investments.

Winning consortia were faced with extreme difficulties with project development, particularly financing due to the severe financial crisis that started in the second half of

2008. In order to improve the attractiveness of investments, a strong lobbying effort to increase the feed-in tariff was initiated. After much pressure, the Z coefficient was raised from 8,2 to 9,6 with DL n.5/2011, and the feed-in tariff increased to €116-118/MWh (Table 5.1). This increase was partially supported on the argument that other existing biomass power generators benefitted from annual feed-in tariff revisions as a result of inflation, while for developers the initial tariff would start to be updated after connection to the grid.

Table 5.1. Forest biomass feed-in tariff (€/MWh) comparison between DL n. 33-A/2005 and DL n. 5/2011.

Power capacity	DL n. 33-A/2005	DL n.5/2011
< 5 MW	108	118
>= 5 MW	106	116

DL n.5/2011 also provides some evidence on the conflicts within the sector. Discussions regarding the use of biomass for energy production are not recent in Portugal. Already in the 80s it was clear from both National Energy Plans – PEN 82 and 84 – that land-use change associated with energy crops should be carefully studied regarding its impacts on the industry. This time, however, the conflict was for the resource itself, with the sawmilling industry pitched against biomass power generators. Even within generators, incumbents felt their control over the feedstock was threatened and lobbied against regulatory change. In the legislative act in particular one can see that only waste and energy crops are admitted for use in the power stations, an attempt to avoid competition for roundwood, primarily used by sawmills.

Biomass capacity has increased from 350 MW to 472 MW from 1998 to 2012 – a pace of 2,3% annually – and it has largely been determined by investments from pulp and paper companies, in particular the new biomass boilers from Portucel and Altri that came online in 2009 (DGGE, 2012). Power production has increased steadily and according to capacity increases over the years showing a sustainable supply of feedstock to power stations (Figure 5.2). Feed-in tariffs for non-CHP units have moved in line with regulatory changes, namely the new regime and the Z coefficient change in 2011, and inflation.

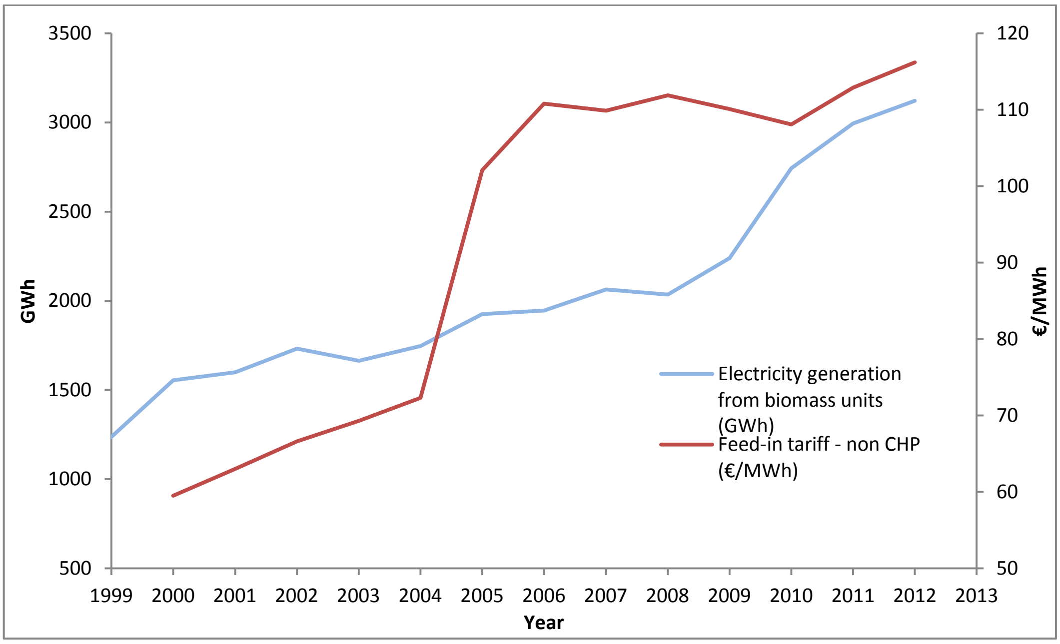

Figure 5.2. Biomass power production (CHP and non-CHP) and average feed-in tariff for non-CHP units (DGGE, 2012; ERSE, 2012b).

At the same time the 2006 public tender was launched, the first wood pellet production units began to operate. Technology development in European countries, alongside strong policy support to biomass, has led to significant investment in pellet production capacity since then. This intense development was also a result of ever harsher restrictions on biomass trade, already occurring through the ports of Aveiro and Leixões, due to pine wilt disease. This forest disease was introduced in Portugal in 1999 through the port of Sines and a buffer zone was set in the region to control its spead (Mota & Vieira, 2008). The methods were unsuccessful and eventually the whole country had pine-based products severely restricted. Today, Portugal has an installed capacity of over one million tons per year (Patrão, 2011), although effective production is much lower, in the region of 50-60%. Pellets are mainly exported to northern European countries such as Sweden, Denmark, Belgium or the UK. With the economic downturn and the shift to lower heating fuels, domestic consumption has also increased, although data is inexistent. New installations have benefitted from tax rebates, although financial support is considerably less important than feed-in tariffs for dedicated power stations or CHP units.

5. Conclusion

Biomass in Portugal developed gradually over the last four decades from open fireplaces to industrial boilers as support in the form of investment grants started after the oil crisis and the country received financial aid from the European Union. The feed-in support scheme has been very successful in the case of CHP units, but dedicated biomass power stations included in the 2006 public tender were hardly hit by the financial and economic crisis after 2008. Nevertheless, the sector has shown strong developments in other areas such as pellet production, exploiting stronger renewable policies in northern Europe.

6. Conclusion

The design of renewable energy policies is a complex process that needs to take into consideration deployment levels, technology lock-in and overcompensation, among other. Though support schemes can be perfected over time and incorporate lessons learned, instruments inevitably have shortcomings. Striking the right balance of support in order to stimulate innovation, accomplish deployment targets, and internalizing social costs while avoiding overcompensation is a difficult task. Moreover, risk of overlap with other areas such as climate policy or policies in other countries lead to a design process where coordinated policy making is required.

Renewable energy policies in Portugal were first directed to staving off the destructive effects of soaring oil prices in the 70s. A support scheme based on investment grants, running from 1976 to 1985, helped industrial users improve energy efficiency and switch from fuel oil. A feed-in tariff was introduced in 1999 but it was only in 2001, with addition of technologic coefficient (Z), that installed capacity began to visibly increase. Wind energy was the champion among all sources, an extraordinary growth path that led to serious policy costs.

While other EU countries have better control over policy costs through mechanisms of tariff degression, market-oriented tariffs or quota obligations, Portugal has been held hostage of an overcapacity in renewable energy which holds back competitiveness through higher energy prices. In 2012 and 2013 legislation has been passed to renegotiate feed-in tariffs, while licensing has come to a halt.

Support in the bioenergy sector has been readily used by CHP units linked mainly to the pulp and paper industry. Dedicated biomass power stations have had a difficult time to reach its full potential, although other lines have developed in the meantime. For instance, the wood pellet industry has grown considerably since 2006 and has been using to its advantage the strong support schemes of northern European countries.

This dissertation was meant to cover the renewable energy sector equally. However, it is clear that the focus has been on the power sector, much like policy makers' preferences. A much needed follow-up of this work should address in greater detail policies on heating & cooling, and biofuels.

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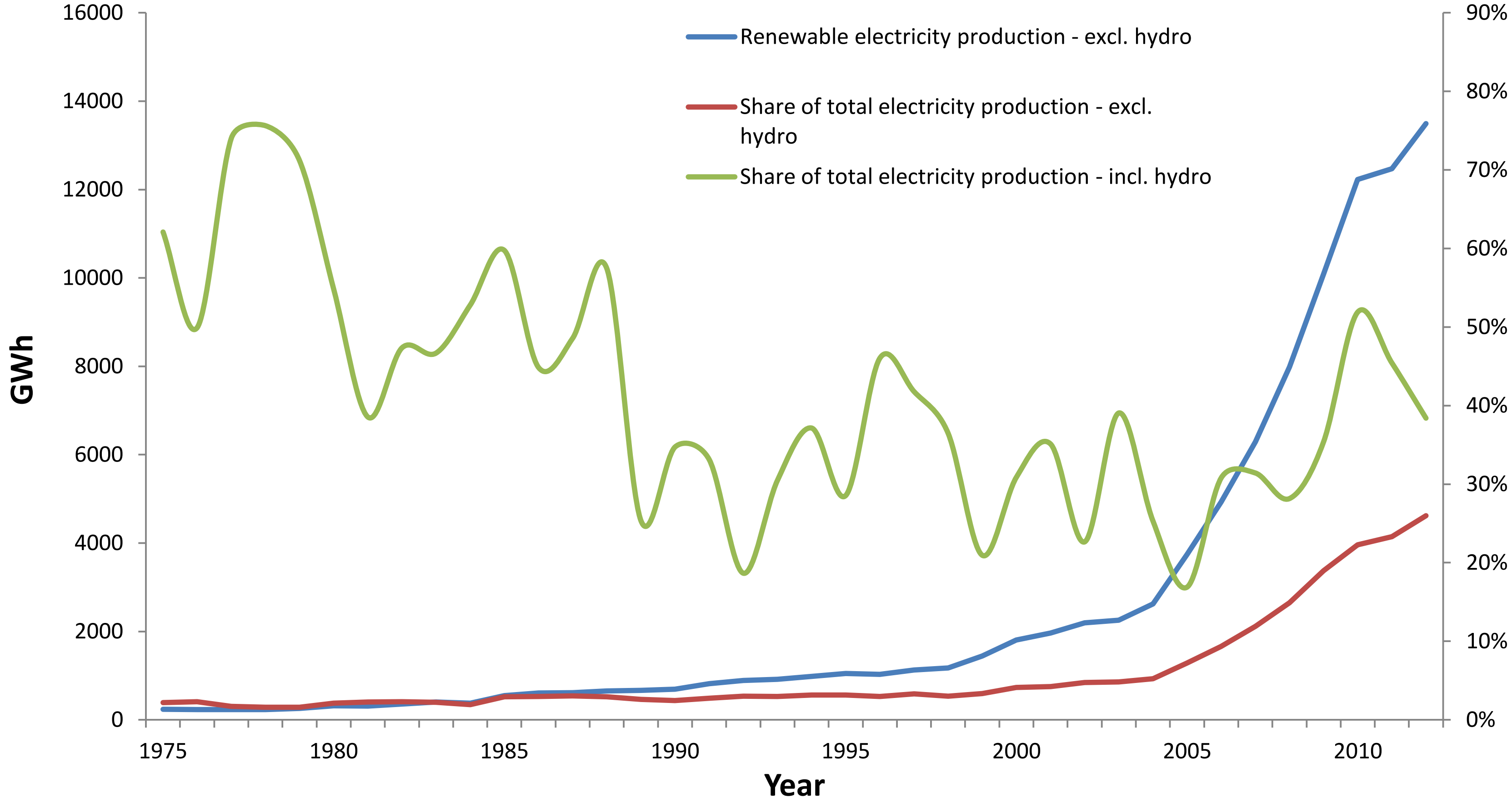
Annex I - Renewable electricity production and share of total electricity production from 1975 to 2012



Source: 1975-1994: World Bank (http://data.worldbank.org); 1995-2003: Direcção Geral de Energia e Geologia – Produção de Energia Eléctrica a partir de FER (http://www.dgeg.pt?cr=8582); 2004-2012: Direcção Geral de Energia e Geologia - Estatísticas Rápidas (2012).