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Employment Impact of Renewable Energy Systems Deployment – Assessment Approaches and Portuguese Case Study

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UNIVERSIDADE DE COIMBRA

ENERGIA PARA A SUSTENTABILIDADE
ENERGY FOR SUSTAINABILITY · EFS

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Employment Impact of Renewable Energy Systems Deployment – Assessment Approaches and Portugal Case Study

Master Dissertation in Energy for Sustainability -Energy Systems and Policy specialization branch - presented to the Faculty of Science and Technology of the University of Coimbra, as part of requirements for award of Master Degree.

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Abstract

Large-scale deployment of renewable energy systems (RES) for electricity production has entered the global mainstream during the last twenty-five years. International and national renewable energy deployment targets, legislation and support measures have been instrumental in securing wide-scale renewable energy technology (RET) applications, and are most commonly justified by the threefold benefit of RES deployment, namely climate change mitigation, improvement of security of energy supply and employment creation.

Within this framework, this thesis aims to examine the employment creation potential of RES deployment in Portugal. Firstly, an overview of methodologies for measuring and estimating the employment impact of RES deployment is presented. Thereafter, results of several studies carried out, of diverse detail and scope of analysis, at national and international levels, by international organizations, national governments and academic researchers, for the purpose of determining the employment impact of RES are discussed.

An online survey was developed and sent, in cooperation with the Portuguese Renewable Energy Association (APREN), to more than 500 entities active in the renewable energy industry, in order to assess the direct job creation impact of RET deployment in Portugal as well as to determine the types of jobs eventually created. Due to the low survey reply rate no statistical inference was made, however a number of country specific conclusions could be drawn according to the sample data.

There was a slight increase (3%) in domestic RES industry employment between 2010 and 2012. Although during the same period small enterprises suffered a decline in employment (10%), many are optimistic in terms of employment creation in their companies in the next 3 to 5 years. Utility companies have stated that feed-in tariffs (FiT) are key for economic viability of RES electricity production, but they plan to continue those activities after their FiT contracts expire. A large proportion of RES jobs are held by university graduates (75%), mostly engineers.

Keywords: European Union, job creation, Portugal, renewable energy legislation, renewable energy systems, RES employment impact, RES deployment support policies.

Resumo

A exploração, em grande escala, de fontes de energia renovável (FER) destinadas à produção de eletricidade teve o seu início mais significativo durante os últimos vinte e cinco anos. Os objectivos internacionais e nacionais de implementação de energia renovável, legislação e medidas de incentivo têm sido decisivos para alcançar em grande escala asaplicações tecnológicas de energia renovável (TER), e são mais comummente justificados com a tripla vantagem de implementação de FER, nomeadamente, mitigação de alterações climáticas, melhoria da segurança de fornecimento de energia e criação de emprego.

Neste contexto, esta dissertação tem como objectivo examinar o potencial de criação de emprego com a implementação de FER em Portugal. Primeiramente, apresenta-se uma revisão das metodologias de mensuração e de estimação dos impactos da exploração de FER no emprego. Apresenta-se, ainda, uma análise aos resultados de um conjunto de estudos que divergequer no seu foco e nos métodos de análise empregues, quer pelo facto de ou terem sido conduzidos por organizações internacionais, ou por governos ou, ainda, por investigadores académicos, com o objetivo de determinar o impacto na criação de emprego de tecnologias associadas à indústria de energias renováveis.

Foi desenvolvido e enviado um questionário online, em cooperação com a Associação Portuguesa de energia renovável (APREN), para mais de 500 entidades activas na indústria de energia renovável, para avaliar o impacto direito da implementação de TER em Portugal na criação de emprego e, ainda, com o propósito de determinar os tipos de empregos eventualmente criados. Devido àbaixa taxa de resposta a pesquisa não permite realizar interferências estatísticas. Todavia, é possível esboçar algumas conclusões específicas para o país de acordo com os dados das amostra.

Registou-se um ligeiro aumento (3%) do emprego em indústria doméstica de FER entre 2010 e 2012. Embora durante o mesmo período as pequenas empresas tenham sofrido uma queda no emprego (10%), muitos dos respondentes mostraram-se otimistas em termos de criação de emprego nas suas empresas nos próximos 3 até 5 anos. A empresas de serviços públicos declararam que tarifas feed-in (FiT) são fundamentais para a viabilidade económicade FER de produção de eletricidade. Foi possível, ainda, aferir que uma grande parte do emprego criado pelas FER é realizados por diplomados das universidades (75%), sobretudo da área da engenharia.

Palavras-chave: criação de emprego, fontes de energia renovável, FER impacto no emprego, legislação de energias renováveis, políticas de exploração de FER, Portugal, União Europeia.

Sažetak

Primena sistema za proizvodnju električne energije iz obnovljivih izvora (SPEOI) je u poslednjih dvadeset i pet godina postala uobičajena širom sveta. Međunarodni i nacionalni ciljevi obima primene SPEOI, zakonski okviri i zakonodavne mere za promociju SPEOI su bili od ključnog značaja za današnju široku rasprostranjenost primene tih tehnologija i najčešće su obrazlagani trostrukom koristi koja se postiže primenom SPEOI, u vidu sprečavanja klimatskih promena, unapređenja energetske bezbednosti i stvaranja radnih mesta.

U tom smislu, cilj ove disertacije je da ispita uticaj primene SPEOI na stvaranje novih radnih mesta u Portugaliji.Disertcija prvo daje pregled metodologija koje se koriste pri merenju ili vršenju procena uticaja primene SPEOI na stvaranje radnih mesta.Nakon toga je predstavljeno nekoliko istraživanja, različitih obima i detaljnosti analize, sprovedenih na nacionalnim i međunarodnim nivoima od strane međunarodnih organizacija, nacionalnih institucija i akademskih istraživača, sa ciljem merenja uticaja primene SPEOI na stvaranje radnijh mesta.

Kako bi se izvršila procena uticaja SPEOI na stvaranje radnih mesta u Portugaliji, pripremnjeno je i sprovedenoistraživanje, u saradnji sa Portugalskom asocijacijom za obnovljive izvore energije (APREN), u kojem je učestvovalo više od 500 preduzeća aktivnih u industriji SPEOI Portugalije.Preduzećima je putem interneta poslat upitnik čiji je cilj bio da izmeri uticaj na stvaranje direktnih radnih mesta primenom SPEOI i da utvrdi vrste radnih mesta koje nastaju primenom tih tehnologija.Usled nedovoljnog odziva predstavnika industrije, nije bilo moguće razviti statistički validne parametre i zaključke, međutim, na osnovu pristiglih podataka utvrđeno je nekoliko činjenica u vezi sa uticajem primene SPEOI na otvaranje radnij mesta u Portugaliji.

U period 2010-2012, došlo je do manjeg rasta (3%) ukupnog broja radnih mesta u industriji SPEOI u Portugaliji. Iako su mala preduzeća pretrpela gubitak radnih mesta (10%) u istom period, mnoga od njih očekuju da će otvoriti nova radna mesta u narednih 3-5 godina. Komunalna preduzeća tvrde da su "fid-in" tarife ključne za ekonmsku isplativost primene SPEOI, ali takođe su naznačila da će nastaviti proizvodnju struje iz obnovljivih izvora nakon isteka "fid-in" ugovora. Značajna proporcija zaposlenih u industriji je fakultetski obrazovana (75%), a većinu njih čine inženjeri.

Ključne reči: Evropska unija, stvaranje radnih mesta, Portugalija, zakonski okvir za obnovljive izvore energije, sistemi za proizvodnju energije iz obnovljivih izvora (SPEOI), uticaj primene SPEOI na stvaranje radnih mesta, zakonodavne mere za promociju primene SPEOI.

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Abbreviations & Acronyms	Explanation
APREN	Associação Portuguesa de Energias Renováveis
BAU	Business as Usual
BF	Biofuels
BM	Biomass
CIE	Concrete Institutional Economics
CIM	Construction, Installation and Manufacturing
EBED	Energy Based Economic Development
EC	European Commission
EE	Energy Efficiency
EfS	Energy for Sustainability initiative
EH	Energy Harvesting
EID	Economic and Industrial Development
EP	European Parliament
EU	European Union
EWEA	European Wind Energy Association
FiP	Feed-in Premiums
FiT	Feed-in Tariffs
GT	Geothermal
GWh	Giga Watt hours
HY	Hydropower
IEA-RETD	International Energy Agency – Renewable Energy Technology Deployment
ILO	International Labor Organization
INESC	Institute for Systems Engineering and Computers
I-O	Input-Output
IPCC	Intergovernmental Panel on Climate Change
IRENA	International Renewable Energy Agency
M€	Million Euro
MWa	Mega Watt average output
MWh	Mega Watt hour
MWp	Mega Watt installed power (capacity)
N/A	No information or data available
NREAP	National Renewable Energy Action Plan

NUTS	Nomenclature of Territorial Units for statistics
O&M	Operations and Maintenance
PNAER	Portuguese National Renewable Energy Action Plan
PV	Photovoltaic
R&D	Research and Development
RE	Renewable Energy
REN	Renewable Energy Network
RES	Renewable Energy Systems
RES3E	Renewable Energy Systems and Energy Efficiency Employment
RES-E	Renewable Energy Systems for Electricity production
RET	Renewable Energy Technologies
RPS	Renewable Portfolio Standard
SMEs	Small and Medium Enterprises
SNP	Strengthened National Policies
ST	Solar Thermal
TGC	Tradable Green Certificates
UN	United Nations
UNEP	United Nations Environment Program
WA	Wave energy
WB	World Bank
WI	Wind power

1. INTRODUCTION

Worldwide jobs in renewable energy industries exceeded 3.5 million in 2010 (REN21, 2011). In many countries job creation is seen as one of the main benefits of investing in renewable energy (RE) technology deployment (REN21, 2011), a kind of win-win solution to dual challenge of stimulating employment and mitigating climate change. Participants of the *United Nations High Level Dialogue on Energy in the Post-2015 Development Agenda* (Oslo, 9 April, 2013) emphasized that energy is a driver of economic prosperity and that successful deployment of renewable energy creates jobs and improves livelihoods (IISD, 2013). Many national green growth strategies have stressed the deployment of RE as an important contribution to job creation (IPCC, 2012). It is expressed as one of the three main goals in European Union (EU) legislation (EC, 1997, 2007, 2011,) (EP, 2009) and in Portuguese policy documents (PNAER, 2010) addressing renewable energy systems deployment. Governments worldwide have included substantial spending on clean energy technologies in their stimulus packages that were mobilized in response to the financial and economic crisis. As of 2011, 119 countries have some form of national renewable energy policy target or renewables support policy in the shape of feed-in tariffs, quota obligations, favorable tax treatment and public loans or grants. One the other hand, many claim that "green jobs" are a myth (Álvarez et al. 2009; Lesser, 2010) and there is no universally accepted methodology to assess the net job creation from renewable energy sources (Lambert and Silva, 2012).

Due to the emphasized employment creation benefits and considerable public expenditures for renewable energy systems (RES) deployment, the employment impact of renewables deployment has come under scrutiny in attempts to corroborate, disprove, or simply analyze its effect on national economies in this regard, though research conducted by academia, contracted by international organizations and the EU itself. Employment impact assessment studies of renewable energy systems deployment are carried out because it is important to determine the results of significant government expenditures incurring through various renewable energy support schemes for the purpose of achieving legislative renewable energy deployment goals (Silva et al. 2013).

The main objective of this thesis is to develop a RES industry survey for assessing the employment impact of renewable energy systems deployment in Portugal; namely to measure the direct industry jobs created as a result of the promotion of renewable energy technologies for electricity production. Towards realizing this goal, extensive research of methodologies applied in RES deployment employment impact studies was carried out in order to determine the appropriate employment impact assessment approach to be exercised in the case of Portugal, taking into consideration the circumstances within which the study is being implemented. The structure of the thesis follows the step-by-step process of preparing and carrying out such a study.

Firstly, chapter 2 describes RE deployment context, i.e. the legislative background for RES deployment in the EU and Portugal, the current RES shares in the electricity generation mix and future targets, and the most typical technology deployment support measures implemented.

Chapter 3 defines RES employment, describes the types of jobs created as a result, and illustrates the available methodologies for assessing the employment impact of RES deployment. Researchers will select the methodology to implement based on their study goals, with respect to the type (direct; indirect; induced) and the scope (gross; net) of employment impact to be measured, as well as based on the capacities of the individuals or team (expertise; material and human resources; timeframe) engaged in the effort.

Chapter 4 includes an extensive overview of RES employment impact studies carried out in the USA, the EU, the individual member states and their regions, assessing employment impact of all renewable energy technologies (RET) in the study area, or of individual RET. Examples and results of studies measuring different types of employment created and scopes of RES employment impact, and using all methodologies described in the previous chapter, are shown. Furthermore, the chapter provides a detailed overview of two studies that utilized industry surveys as the primary data acquisition tools, and upon which the Portugal industry survey was modeled.

Chapter 5 discusses the development, implementation and results of the *Renewable Energy Systems and Energy Efficiency Employment* (RES3E) project. The chapter outlines the survey creation process, its structure and cooperation of stakeholders on the project. It describes the survey deployment method and presents acquired data and results, providing comparisons with outcomes of selected studies described in the previous chapters. Finally, this section emphasizes some strengths and weaknesses of the survey development and deployment process, providing recommendations for future RES employment impact assessments that will use surveys as a data acquisition tool.

The concluding chapter summarizes the main findings of the research carried out within the scope of this thesis, and suggests future steps in monitoring employment impact of renewable energy systems deployment in Portugal.

2. RES EMPLOYMENT IMPACT ASSESSMENT CONTEXT

To begin with the analysis of RES employment impact in Portugal, an overview of European Union and Portuguese renewable energy legislation, corresponding renewable energy support policies in the EU and Portugal, and the renewable energy systems deployment structure in electricity production (RES-E) in these territories are provided.

2.1 EU legislative background

The application of renewable energy (RE) technologies for generation and supply of electricity to industrial and household consumers has been on a constant increase in the past two decades. The absolute increase in renewable energy deployment in electricity generation in the European Union between 1992 and 2010 was 104% *(Table 2.1)*.

Table 2.1: Electricity production trends in the European Union (source: own elaboration based on EIA, 2014)

EU 27	Total Generation	Hydro	Non Hydro Renewable	All Renewables	Conventional Thermal	Nuclear
1992	100%	13%	1%	14%	54.5%	31.5%
2010[1]	100%	12%	10%	22%	50.5%	27.5%
Absolute Increase 1992-2010	28%	18%	1038%	104%	19%	10%

The main drivers of this trend are national policies and international agreements which are designed for, on the one hand, developing energy supply alternatives in face of depletion the of existing fossil fuel reserves and the uncertain economic feasibility of exploitation thereof, while, on the other hand, to set targets for climate change prevention, adaptation and mitigation.

National RES deployment targets, which represent commitments to shares of electricity production typically between 10% and 30%, now exist in many countries (REN21, 2011). The *Renewable Energy Directive for 2020* (EP, 2009) adopted by the European Parliament and the European Council sets targets for each Member State with the aim of achieving a 20% share of renewable energy in Europe's final energy consumption by 2020.

[1] The year 2010 is the most recent year for which information on electricity generation is available online for all individual EU member states. More recent calculations would be lacking data from some countries.

As stated in the *EU Commission Communication 'An energy policy for Europe'*, the motivations for a European energy policy are: "combating climate change, limiting the EU's external vulnerability to imported hydrocarbons, and promoting growth and jobs" (EC, 2007, p.5), therein defining the main goals of energy policies as climate change mitigation, security of energy supply and employment stimulation.

The job creation benefit of application of renewable energy systems has been continuously highlighted in official European Commission and European Parliament documents and legislation concerning renewable energy and energy systems in general. As early as 1986 the European Commission (EC, 1986) listed the promotion of renewable energy sources among its energy objectives. Particular emphasis has been placed on the potential of RES to contribute to "job creation, predominantly among the small and medium sized enterprises" and "in the regional development with the aim of achieving greater social and economic cohesion within the Community" (EC, 1997, p. 4). Estimates on the employment potential of RES deployment were projecting that by 2010 the net employment induced by the renewable energy sector would reach 500,000 jobs in the EU15[2], while the "jobs to be created in 2010 by the wind sector will be between 190,000 and 320,000, if 40 GW of wind power is installed" and "3 GWp installed power in 2010 will create approximately 100,000 jobs in the PV sector" (EC, 1997, p.12).

Furthermore, it has been pointed out that „Action on renewables and energy efficiency...could also create many high-quality jobs in Europe and maintain Europe's technological leadership in a rapidly growing global sector" (EC, 2006). In 2006 specific data was published stating that „The EU's renewable energy market...employs some 300,000 people" (EC, 2006).

The *EC Directive on the promtion of use of energy from renewable sources* (EC, 2009) states that the increased use of energy from renewable sources will be very important for pomoting technological development and innovation and providing opportunities for employment and regional develompent, especially in rural and isolated areas. Furthermore, it emphasizes that opportunities are present for growth and employment that investment in regional and local production of energy from renewable sources brings about in Member States and their regions, and that the positive impact on regional and local development opportunities, export prospects,

[2] The 15 EU member states before the 2004 enlargement.

social cohesion and employment opportunities particularly concern SME's and independent energy producers.

The *European Commission Energy Roadmap 2050* (EC, 2011) explains that in the longer run, high value-added low-carbon technologies will positively affect growth and employment. It claims that the transition to a low carbon economy will affect employment and jobs, requiring education and training and a more vigorous social dialogue and that the design of mechanisms that help workers confronted with job transitions to develop their employability is needed.

The *European Parliament Resolution on the 2050 Energy Roadmap* (EP, 2013) explains that the transition to a low-carbon and energy-efficient economy is an opportunity for small and medium enterprises (SMEs) in the EU operating on the renewable energy market, giving an excellent impulse to the development of entrepreneurship and innovation and possibly providing a prime source of job creation, and employment, in both rural and non-rural areas. Furthermore, the document warns that it is important to obtain an early indication of whether the challenging goals of the Roadmap can be achieved and to review its impact on the EU's economy, not least as regards global competitiveness, employment and social security. It paves the way for establishing a practice of regular monitoring of employment impact of renewable energy systems deployment, stating that the EP requests that the EC provide by the end of 2013 more information on the impact of the transition to low carbon energy generation technologies on employment in the energy, industrial and service sectors, and to develop concrete mechanisms to assist workers and the sectors concerned to promote measures for adjusting education, retraining and requalification in order to help the Member States bring about a highly skilled workforce ready to play its part in the energy transition.

2.2 Renewable energy policy support mechanisms in the European Union

European Union policy documents, directives and strategies serve as umbrella documents for developing national operational legislative solutions for achieving their goals and targets, one of which as explained above is employment creation. In accordance with the *Renewables Directive* (EP, 2009), Member States were obliged to prepare and submit national renewable energy action plans (NREAP) to the European Commission by 30 June 2010. In these documents the countries set out the sectoral targets, the technology mix they expect to use, the trajectory they will follow and the measures and reforms they will undertake to overcome the barriers to developing renewable energy (EC, 2013). As described in *table 2.2* below, there are four main categories of policies and measures for the promotion of renewables deployment (IRENA, 2012).

Table 2.2: Policies for the support of RES deployment (sources: IRENA 2012; Jenner et al. 2013)

Policy	**Definition**
Fiscal incentives	
Grant	Monetary assistance that does not have to be repaid and that is bestowed by a government for specified purposes to an eligible recipient. Usually conditional upon certain qualifications as to the use, maintenance of specified standards, or a proportional contribution by the grantee or other grantor(s). Grants (and rebates) help reduce system investment costs associated with preparation, purchase or construction of renewable energy (RE) equipment or related infrastructure. In some cases, grants are used to create concessional financing instruments (e.g., allowing banks to offer low-interest loans for RE systems).
Energy production payment	Direct payment from the government per unit of RE produced.
Rebate	One-time direct payment from the government to a private party to cover a percentage or specified amount of the investment cost of a RE system or service. Typically offered automatically to eligible projects after completion, not requiring detailed application procedures.
Tax credit (production or investment)	Provides the investor or owner of qualifying property with an annual income tax credit based on the amount of money invested in that facility or the amount of energy that it generates during the relevant year. Allows investments in RE to be fully or partially deducted from tax obligations or income generated.
Tax reduction/ exemption	Reduction in tax—including but not limited to sales, value-added, energy or carbon tax—applicable to the purchase (or production) of RE or RE technologies.
Public Finance	
Investment	Financing provided in return for an equity ownership interest in a RE company or project. Usually delivered as a government-managed fund that directly invests equity in projects and companies, or as a funder of privately managed funds (fund of funds).

<table>
<tr><th>Policy</th><th>Definition</th></tr>
<tr><td>Guarantee</td><td>Risk-sharing mechanism aimed at mobilizing domestic lending from commercial banks for RE companies and projects that have high perceived credit (i.e., repayment) risk.

Typically a guarantee is partial, that is, it covers a portion of the outstanding loan principal with 50 - 80% being common.</td></tr>
<tr><td>Loan</td><td>Financing provided to a RE company or project in return for a debt (i.e., repayment) obligation. It can be provided by governments, development banks or investment authorities, usually on concessional terms (e.g., lower interest rates or with lower security requirements).</td></tr>
<tr><td>Public Procurement</td><td>Public entities preferentially purchase RE services (such as electricity) and/or RE equipment.</td></tr>
<tr><td colspan="2">Regulations</td></tr>
<tr><td colspan="2">Quantity-driven</td></tr>
<tr><td>Renewable Portfolio Standard/Quota obligation or mandate</td><td>Obligates designated parties (generators, suppliers, consumers) to meet minimum (often gradually increasing) renewable energy deployment targets, generally expressed as percentages of total supplies or as an amount of RE capacity, with costs borne by consumers.

Building codes or obligations requiring installation of RE heat or power technologies often combined with efficiency investments RE heating purchase mandates.

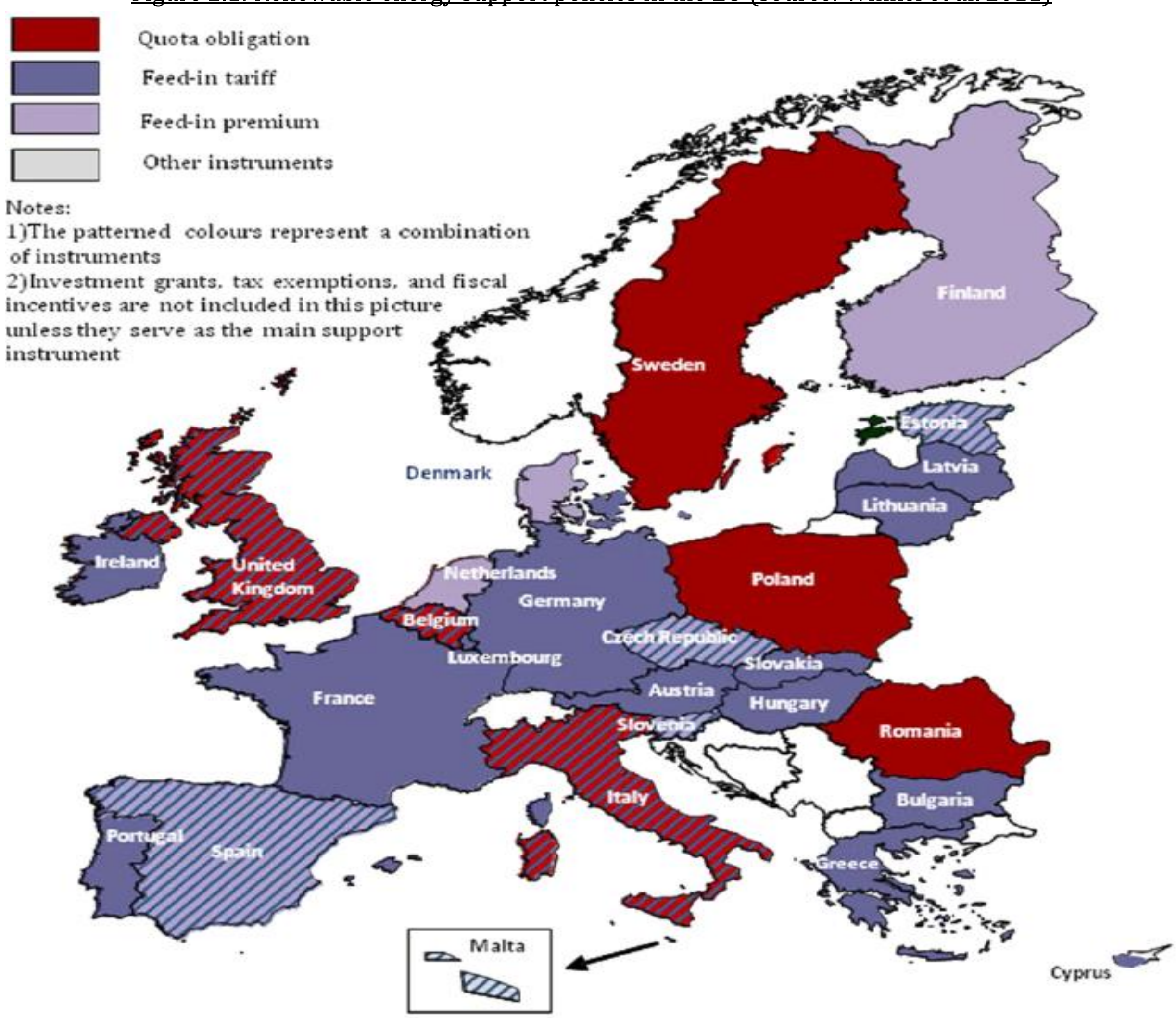
Mandates for blending biofuels into total transportation fuel in percent or specific quantity.</td></tr>
<tr><td>Tendering/ Bidding</td><td>Public authorities organize tenders for given quota of RE supplies or supply capacities, and remunerate winning bids at prices mostly above standard market levels.</td></tr>
<tr><td colspan="2">Price-driven</td></tr>
<tr><td>Fixed payment feed-in tariff (FiT)</td><td>Feed-in premium payment (FiP)</td></tr>
<tr><td>Guarantees RE supplies with priority access and dispatch, and sets a fixed price varying by technology per unit delivered during a specified number of years.</td><td>Guarantees RE supplies an additional payment on top of their energy market price or end-use value (Only Denmark and Cyprus in the EU).</td></tr>
<tr><td colspan="2">Individual fixed-price or premium tariffs may differ in the following:

• Cost allocation: Under a FiT, the generator signs a contract that entitles it to feed electricity into the grid prior to any other conventional source. The difference between the tariff and the</td></tr>
</table>

Policy	Definition
	actual market price is re-distributed among end-users or paid from state budgets in most countries. • Cost containment: Some countries cap the total capacity that may be installed or total tariffs that may be awarded under a FiT policy each year. In the EU, Cyprus, Estonia, Ireland, Latvia, Portugal, and Spain have employed capacity limits while only Austria and the Netherlands have used total cost limits. • Contract duration: The duration over which the FiT is paid to the generator varies between policies. There is often a tradeoff between duration and magnitude. Some countries provide a relatively high tariff for short contract durations of 10 years, while others provides a lower tariff for up to 25 years. • Tariff amount: The tariff received by generators may differ in size between countries and energy technologies. Factors that influence the size of the tariff provided by a policy include generation cost, location, system size, receiving party, and the purpose of the host building. • Digression rate: Many FiT policies have a built-in digression rate; a mechanism for gradually reducing the tariff value according to the number of years after policy enactment the contract is signed. The goal is to slowly adjust the incentive provided by the FiT to adapt to increasing economic viability of RES-E technologies over time.
Quality-driven	
Green energy purchasing	Regulates the supply of voluntary RE purchases by consumers, beyond existing RE obligations.
Green labeling	Government-sponsored labeling that guarantees that energy products meet certain sustainability criteria to facilitate voluntary green energy purchasing. Some governments require labeling on consumer bills, with full disclosure of the energy mix (or share of RE).
Access	
Net metering (and net billing)	Allows a two-way flow of electricity between the electricity distribution grid and customers with their own generation. The meter flows backwards when power is fed into the grid, with power compensated at the retail rate during the 'netting' cycle regardless of whether instantaneous customer generation exceeds customer demand.
Priority/guaranteed network access	Provides RE supplies with unhindered access to established energy networks.
Priority dispatch	Mandates that RE supplies are integrated into energy systems before supplies from other sources.

Two of the globally most popular policy types for promoting RES-E are FiT's and Quotas, or renewable portfolio standards (RPS). As described in *table 2.2* above national FiT's can be designed as unique in structure and in investment incentives they provide. RPS or Quotas require utilities to generate a certain proportion of energy from renewable sources. As utilities can choose from a variety of technologies to produce energy for meeting the Quotas, RPS tend to promote lowest cost RET. On the other hand, FiT's provide a technology specific subsidy to improve the competitiveness of RES-E generation compared to traditional sources, in order to equalize the attractiveness of energy technologies with different production costs (Jenner et al. 2013). FiT's are the common RES-E support scheme in the EU, while 29 US states apply the dominant RPS RES-E support approach in North America. *Figure 2.1* below shows the application of RES support policies in the EU.

Figure 2.1: Renewable energy support policies in the EU (source: Winkel et al. 2011)



FiT's, FiP's and quota obligation systems and combinations are the major policy support programs applied in the EU. FiP's are applied in Belgium (BE), Italy (IT), Sweden, the United Kingdom (UK), Poland and Romania, often in combination with FiT for small-scale projects or specific technologies (BE, IT, UK). Belgium offers minimum tariffs for each technology as an alternative to the revenues from the Tradable Green Certificates (TGC) trade and the electricity market price. Italy offers feed-in tariffs for small-scale applications below 1 MW and the United Kingdom introduced feed-in tariffs for small-scale applications in spring 2010. Tender schemes are not used any longer as the dominating policy scheme in any EU member state, but they are used in certain ones for specific projects/technologies (e.g. wind offshore in Denmark). Other policy measures such as production tax incentives and investment grants represent the dominating policy measure in Malta. In some other countries they are used as supplementary support which in some cases (e.g. tax incentives in the Netherlands) fundamentally contributes to the economic viability of projects (Winkel et al. 2011).

An important question for policy makers is whether FiT policies have succeeded in increasing RES-E generation capacity beyond what would have happened in their absence. Some researchers find that policies, incentives and subsidies including FiT's prove to be significant drivers of RE deployment in the EU (Marques et al. 2012). Others find that while FiT's have driven PV deployment growth, there is not such a clear link between this type of deployment support and wind energy in the EU, except when combined with tendering schemes (Jenner et. al. 2013).

There is also no lack of research strongly criticizing and opposing public financing of renewable energy deployment, such as a study finding that more than 110,000 jobs were lost due to the opportunity cost of 28.67 billion Euro that was spent on RES-E support schemes in Spain since their introduction, and electricity prices would need to increase by 31% in order to repay the public debt accumulated as a result of the cost of these investments (Álvarez et al. 2009). Furthermore, a study assessing the effectiveness of the FIT system in Germany (Frondel et al. 2010) finds that the mechanism imposes high cost without any of the publically promoted positive impacts on emissions reduction, employment, security of energy supply or technological innovation, emphasizing the lack of coordination and "crowding-out" effect of simultaneous implementation of support policies based in the German Renewable Energy Sources Act and the

European Emissions Trading scheme, and describing the German RES-E deployment experience as a “cautionary tale” of extremely expensive environmental and energy policy application, devoid of environmental or economic benefits. The authors conclude that it is more cost-effective to invest in research and development in order to improve technological efficiency of RET, rather than to promote their large scale production and distribution reaching market parity with traditional technologies, which is especially relevant for PV systems.

A critical success factor for RES-E deployment, more important than policy design alone, is the interaction of country specific policies, electricity prices and production costs, i.e. market context and policy design are important, and no policy is better than implementing a poorly designed one (Jenner et al. 2013). Furthermore, although policies have a crucial role in promoting RES-E generation, their effectiveness is subject to diminishing returns as the number of policies applied in one territory increases, due to the “crowding out” effect. Governments should assess the compatibility between RE policies and other regulatory mechanisms, and make the necessary adjustments to reduce policy overlapping and incoherence and improve overall policy complementarities, effectiveness, and coordination (Zhao et al. 2013;Frondel et al. 2010).

Five criteria are commonly used to evaluate policies targeting promotion of renewable energy production (IRENA, 2012). *Table 2.3* below is a brief overview of the five criteria and some proposed indicators for their performance:

Table 2.3: Criteria and indicators for evaluating RE deployment policies (source: adapted from IRENA, 2012)

Criteria	**Indicators**
Effectiveness: The extent to which the predefined objectives are achieved, i.e. the RES-E output, or share of RES-E in total generation.	• Projected vs. realized capacity and/or generation increases within the defined time frame;
Efficiency: Cost effectiveness, or ratio of RES-E targets achieved thanks to economic resources spent.	• Total expenditures per installed unit of capacity/generation vs. price of generation; • Government spending per unit of private investment
Equity: Consequences of policy implementation in terms of fairness, justice and respect of rights of population.	• Change in spending on electricity as a percentage of total household spending, broken down by income groups; • Participation of stakeholders;

Criteria	Indicators
Institutional feasibility: Legitimacy, public acceptance and potential of its provisions to be operationally implemented.	• Policy complexity, clear and appropriate ownership and institutional commitment; • Existence of required institutions and their human resource capacities for policy implementation;
Replicability: If and to what extent can the policy be implemented in another country.	• Analysis of factors that made the policy successful, and verification of their existence in other countries where it will be implemented, as well as the analysis of possible impediments to its implementation in the recipient territory.

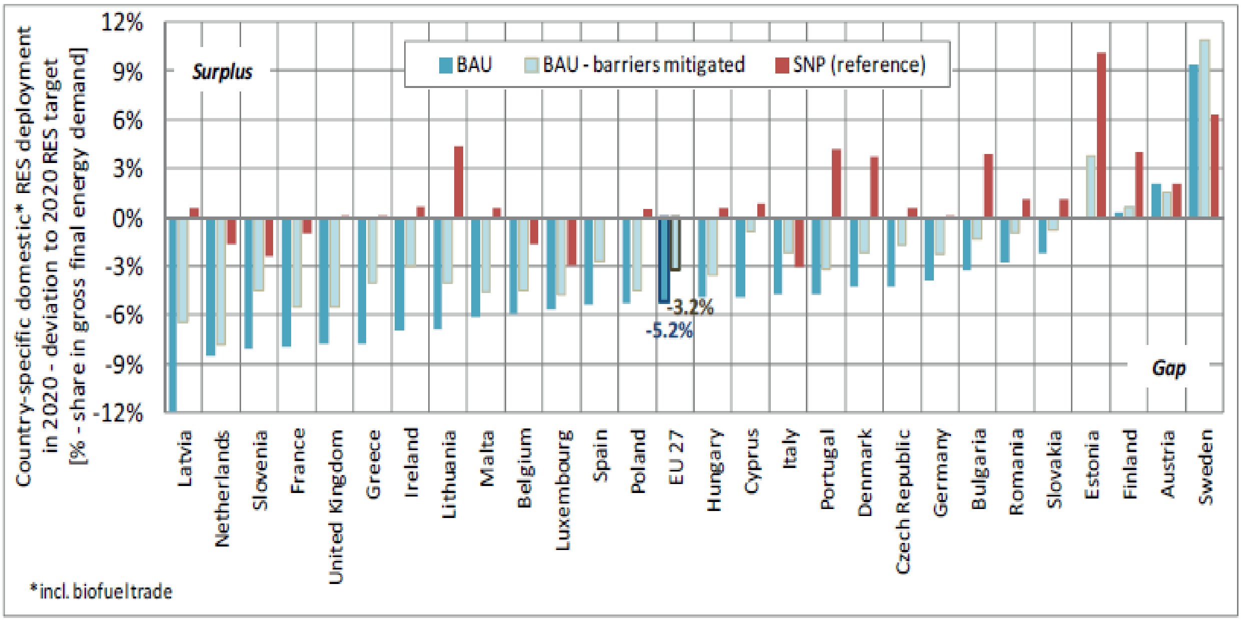
As mentioned above, evaluating the experiences of implementing policies for the support of RES in practice is crucial to continuously improve the design of such policies. The RE-Shaping (Ragwitz et al. 2011; Winkel et al. 2011) project has carried out such an analysis of success of RET support policies by applying the policy effectiveness and efficiency criteria. In their research, the effectiveness of the policies measures the degree of target achievement, while the efficiency indicator measures the costs for society resulting from the support of renewable energies. In addition the authors carry out a comparison of the economic incentives provided for a certain RE technology and the average generation costs for that technology, which facilitates monitoring whether financial support levels are well suited to the actual support requirements of a technology. The report provided data on efficiency and effectiveness of RET deployment policies in the EU during the first decade of the 21st century and projections for achievement of the EU 20-20-20 RE goals[3].

According to the report, the majority of EU Member States will fail to deliver the required RES deployment in 2020 if no further measures or adaptations are undertaken, while only four out of 27 countries may succeed in meeting their 2020 RES targets with RES policies in place under the current framework conditions, i.e. BAU scenario. According to the authors, conditions which are endangering the achievements of the EU 20-20-20 targets are non-economic barriers (building permit procedures, grid access, traditional energy industry lobbies, etc.) and recent decreases in funding available across the Union for renewables support schemes. *Figure 2.2* below, represents the outcome of the assessment, and represents each EU state' projected achievement towards the

[3] Key 20-20-20 objectives: 20% of EU final energy consumption secured from renewable energy sources; GHG emissions decrease by 20% from 1990 levels and energy efficiency improvements of 20% are achieved (Climate Action, 2014).

20-20-20 objectives in the three evaluated scenarios: (1) BAU, (2) BAU + mitigation of non-economic barriers, (3) Strengthened national policies (SNP).

Figure 2.2: EU 20-20-20 goals achievement perspective under scenario modeling (source: Winkel et al. 2011)



According to the results, if non-economic barriers are mitigated, the gap towards achieving 2020 goals then decreases to 3% from the target. Removing these obstacles leads to a significant improvement in the effectiveness of RES support in the majority of Member States, while in a few countries (Netherlands, Malta, Belgium, Luxembourg, Hungary and Portugal) changes arising from the removal of non-economic barriers are less pronounced.

The SNP scenario will require improvement of design and implementation of RES supports instruments, as well as strengthening financial support. According to the report, in order to achieve the 2020 targets, EU annual consumer expenditures for RES-E will have to be increased by 5 billion EURO (10% annually), achieving Union wide gross electricity demand share of 35.4%.Furthermore the authors emphasize that cooperation is a key necessity for several Member States, if they aim for an economically efficient 2020 RES target fulfillment.

As a result of their analysis, the authors recommend a set of renewables support policy recommendations, summarized here in *table 2.4*:

Table 2.4 RE-Shaping project renewables support policy design recommendations (source: Ragwitz et al. 2011)

• Apply appropriate support levels	To increase the capacity of a technology, support levels should be aligned with generation costs, based on realistic assumptions for investment cost and cost of capital in case of price-based support schemes such as feed-in systems. In quota systems, the remuneration level may also be adapted indirectly by changing the quota, banding factors or penalties.
• Reduce barriers, apply best practice support system design and reduce investor risk	Reduce barriers, apply best practice support system design and reduce investor risk. The support level required highly depends on the existing non-economic barriers to projects, the design of the support system, and the risk involved for investors. Removal of certain barriers is useful to reduce support costs and to allow any new projects to be realized.
• Learn from best practice	Countries with immature or intermediate market deployment status for a given technology can rapidly increase policy performance by learning from the best-practice support policy designs and organization of administrative processes of other countries.
• Apply technology-specific support	Policy makers should ensure that a balance is found between developing higher-cost technologies (progressing on the learning curve) on the one hand and deploying low-cost technology potentials at an adequate speed on the other, through providing specific technology-targeted support.

2.3 Portuguese RES legislative background and RET support policies

The Portuguese government has since 1988 adopted policies directed at the promotion and support of renewable energy deployment. *Table 2.5* provides an overview of Portuguese RES legislation chronology since 1988, according to its nature and scope.

Table 2.5: Portuguese Renewable Energy Legislation 1988 – 2013 (adapted from: Ministerio Publico, 2013; RES Legal, 2013; Global Renewable Energy, 2013[4]

Title	Year	Policy Type	Policy Target
Independent Power Production (IPP) Decree-Law no.189/88	1988	Guaranteed prices, feed-in tariffs	All renewables
Decree-Law no.445/88	1988	Licensing procedures	Small-hydro
Decree-Law no.87/90 and Decree-Law no.90/90	1990	Procedures and licensing	Geothermal
ENERGIA Program	1994	Capital grants / voluntary program /	All renewables

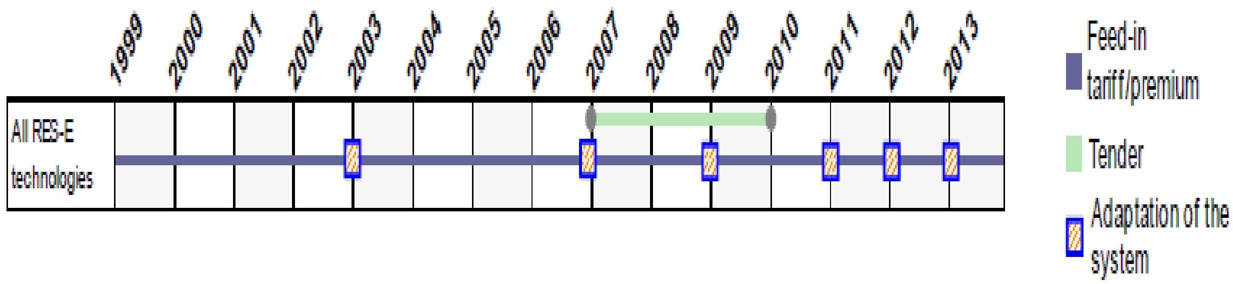
[4] Unless otherwise referenced, all Portuguese policy documents mentioned in the text have been retrieved from one of these three sources

Title	Year	Policy Type	Policy Target
Decree-Law no.195/94 DespachoNormativo no.681/94 DespachoNormativo no.11-B/95 DespachoNormativo no.11-E/95	1995	third-party finance	
Action Plan for Municipalities	1996	Public Awareness	All renewables
Tax reductions for renewables equipment	1999	VAT/Sales tax	All renewables
Electricity Generation Efficiency	1999	Regulatory and administrative rules	All renewables
Decree-Law no.254/99	1999	Regulatory and administrative rules	Ocean Energy
Decree-Law no.69/2000 (05/05/00); Despacho no.11091/2001 (25/05/01); Despacho no.12006/2001 (06/06/01); DespachoConjuncto no.583/2001 (03/07/01)	2000	Regulatory and administrative rules	Hydro, Offshore and Onshore wind
Revision of Energy Program and PEDIP, SIME	2000	Research, Development and Deployment (RD&D), Demonstration project	All renewables
Portaria no. 383/2002 (MAPE/POE Program)	2000	Capital grants	All renewables
Energy Efficiency and Endogenous Energies (E4) Program	2001	Regulatory Instruments, Economic Instruments, Fiscal/financial incentives, Feed-in tariffs/premiums, Regulatory Instruments, Obligation schemes	Hydro, Offshore and Onshore Wind, Solar PV
Decree-Law no. 339-C/2001	2001	Feed-in tariffs/Guaranteed prices	All renewables
New Tariffs for Renewables	2001	Feed-in tariffs/ Guaranteed prices	All renewables
Decree-Law no. 312/2001	2001	Regulatory and administrative rules	All renewables
Decree-Law no. 68/2002	2002	Regulatory and administrative rules	All renewables
Tax Incentives	2002	Tax exemptions	All renewables
Resolution of the Council of Ministries - 63/2003	2003	General energy policy	All renewables
Resolution of the Council of Ministries - 171/2004	2004	A significant increase of the production of Energy from Renewable sources and the liberalization of energy markets.	All renewables
New feed in tariffs for Renewables - DL 33-A/2005	2005	Formula and scope of feed-in tariffs	All renewables
National Energy Strategy	2005	Policy Support, Strategic planning, Policy Support	Multiple RE Sources
Biofuels Law (in relation to Directive 2003/30/EC)	2006 (amended 2008)	Policy Support, Strategic planning, Economic Instruments, Fiscal/financial incentives, Tax relief	Bio-energy, Biofuels for transport

Title	Year	Policy Type	Policy Target
Modified feed-in tariffs for renewables	2007	Economic Instruments, Fiscal/financial incentives, Feed-in tariffs/premiums	Multiple RE Sources, Power
Wave Energy Pilot Zone	2008	Regulatory Instruments, Research, Development and Deployment (RD&D), Research program, Technology deployment and diffusion, Research, Development and Deployment (RD&D), Research program , Technology development	Ocean, Wave
Biodiesel blending requirement	2009	Regulatory Instruments, Obligation schemes , Regulatory Instruments, Monitoring	Bio-energy, Biofuels for transport
Biodiesel tax exemption	2009	Economic Instruments, Fiscal/financial incentives, Tax relief	Bio-energy, Biofuels for transport
Solar thermal incentive scheme 2009	2009	Economic Instruments, Fiscal/financial incentives, Grants and subsidies, Economic Instruments, Fiscal/financial incentives, Loans	Solar Thermal
National Energy Strategy 2020 (ENE 2020)	2010	Policy Support, Strategic planning	Multiple RE Sources
Micro-generation Law (Application Decree Law 118-A/2010)	2010	Economic Instruments, Fiscal/financial incentives, Feed-in tariffs/premiums	Multiple RE Sources, Power
Implementation of the CHP Directive	2010	Regulatory Instruments, Codes and standards, Economic Instruments, Fiscal/financial incentives, Grants and subsidies	Multiple RE Sources, CHP
National Renewable Energy action Plan (PNAER)	2010	Policy Support, Strategic planning	Multiple RE Sources
Mini Production Law amendment (Decree Law 34/2011)	2011	Economic Instruments, Fiscal/financial incentives, Feed-in tariffs/premiums	Multiple RE Sources
Feed-in tariffs for micro and mini generation for 2013 (Portarias 430/2012 and 431 /2012)	2013	Economic Instruments, Fiscal/financial incentives, Feed-in tariffs/premiums	Solar, Solar photovoltaic

Financial instruments to support the introduction of renewable energy systems in electricity production were first established in 1999 through the Electricity Generation Efficiency legislation, and have been modified, broadened or otherwise changed numerous times since then as scheduled in *Figure 2.3* below.

Figure 2.3: Evolution of Portuguese RET deployment support policies (source: adapted and updated from Winkel et al 2011)

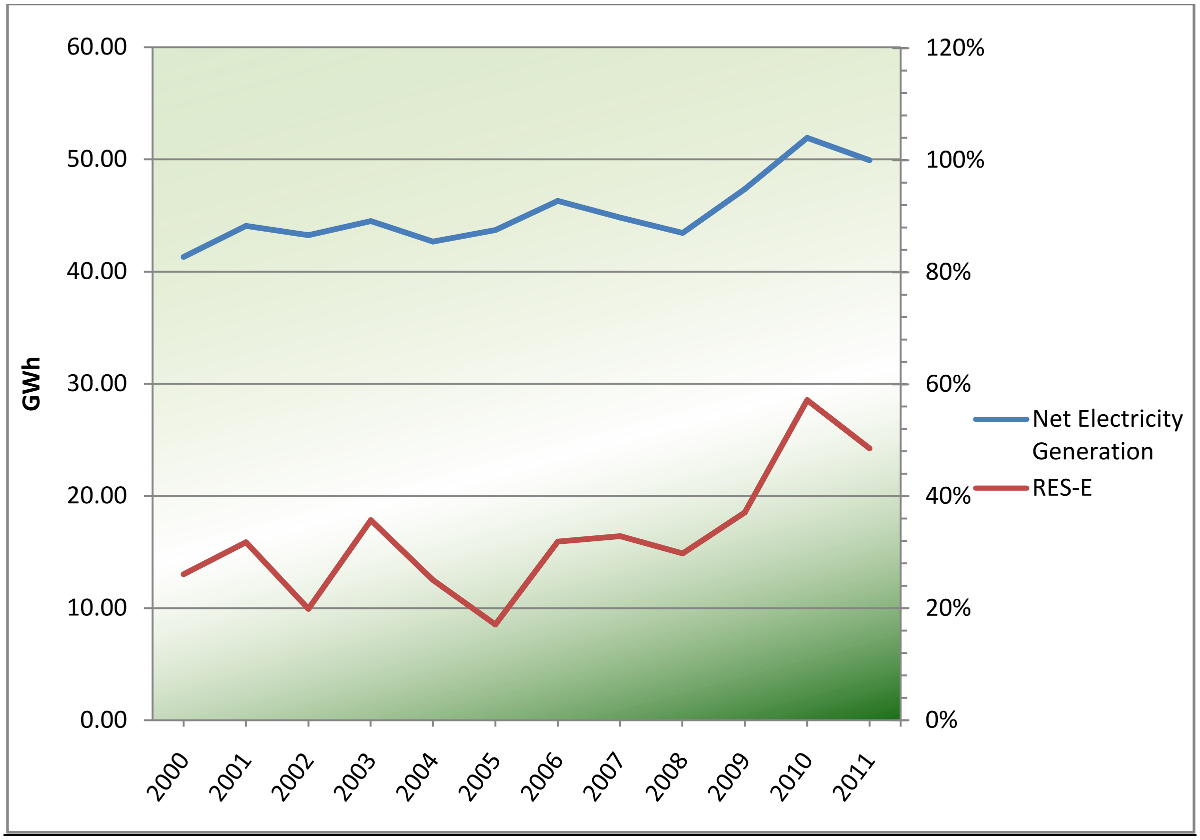


According to the RE-Shaping project report (Ragwitz et al, 2011) policy effectiveness indicator described in the previous section, Portuguese renewable energy promotion policies have been particularly successful and achieved above average EU results in onshore wind deployment (3rd), above average in solid and liquid biomass, while below-par in terms of PV, small-hydro, wind offshore and biogas deployment.

As a result of the policy and financial support of the Portuguese government, the growth in renewable energies deployment in electricity production since the year 2000 has been notable, growing from 13.01 GWh in 2000, to 20.4GWh in 2012. This growth was predominantly driven by the increase of non-hydro renewables in the energy generation mix, the installed capacity of which started at 1.8 GWh in 2000, increasing to 14.25GWh in 2012. *Chart 2.1*on the next page show the total net electricity generation and the share of RES-E in GWh and the pertaining percentages between 2000 and 2011.

The *Portuguese National Renewable Energy Action Plan* (PNAER, 2010) is the most recent strategic policy document designed to guide development in the sector through the year 2020. It states that the RES sector represented 0.8% of the national GDP in 2009, and that it is expected to increase to 1.3% of GDP in 2020, through meeting the PNAER target of 31% of gross final energy consumption coming from renewables. To achieve the 2020 target, Portugal aims to reach a share of 60% of renewable energy in the electricity sector, 10% in road transport sector and 30% in the heating and cooling sector. The document estimates that the renewable energy sector could generate a gross added value of approximately 3.8 billion Euros.

Chart 2.1: Total net and RES-e electricity production in Portugal 2000 – 2011 (source: own elaboration based on data from EIA 2014)



The PNAER emphasizes that the decentralized nature of renewable energy makes it possible to ensure a more balanced territorial distribution for investments in RES, thus contributing towards a greater regional and local development.

In terms of employment generated in the sector, the document concludes that achieving the adopted RES deployment targets will require an investment of 17.8 billion Euros. This will result in the direct or indirect creation of 100,000 new jobs, thereby achieving an annual average renewables employment growth rate of 11.2% by 2020, bearing in mind that the sector currently already employs approximately 35,000 people, including the electricity, heating and cooling and transport sectors.

Table 2.6 presents the PNAER in target figures for installed capacity for electricity production from renewables and current installed capacities.

Table 2.6: RES-E installed capacities 2013 and PNAER targets 2020 (sources: own elaboration based on data from APREN 2013; EIA 2014; PNAER 2010).

RES	**Installed capacity 2013 MW**	**PNAER 2020 installed capacity target MW**
Hydro	4,046	9,548
Wind	4,270	6,875
Solar (thermal and PV)	244	1,500
Geothermal	29	75
Wave	300 (KW)	250
Biomass and Waste	209	400
Total	**8,798.30**	**18,648**

Unfortunately, Portugal did not evade the aftermath of the 2007-08 global economic crisis. The country's GDP declined 3 percent in 2012; unemployment reached 16% in the same year, nearly doubling from 2008 levels (EUROSTAT 2014a), while debt had increased sharply compared to the gross domestic product and is forecasted to peak at 124% in 2014. A €78 billion bailout package for Portugal was approved by euro-zone leaders in 2011. The austerity measures which Portugal has agreed to as a result will be an obstacle in achieving PNAER set goals.

As a consequence of the agreements with the European Commission and the International Monetary Fund, Portugal committed to ensure that the promotion of renewable energies is made in a way that limits the additional costs associated with the production of electricity and to review the efficiency of support schemes for co-generation, the efficiency of support schemes for renewables, in terms of their rationale, their levels, and other relevant design elements. For new contracts in renewables the government has accepted to revise downward the feed-in tariffs and ensure that the tariffs do not over-compensate producers for their costs, as well as to continue to provide an incentive to reduce costs further, through digressive tariffs. For more mature technologies an alternative is seen in developing alternative mechanisms such as feed-in premiums (Ragwitz et al. 2011)

The most recent legislation amendments in 2013 included lowering feed-in tariff rates for micro and mini generation. Another effect is the decision to increase VAT for renewable energy equipment from the rate of 13%, to 23% and to eliminate the fiscal deductions applicable to the buying of renewable energy or energy saving equipment such as solar thermal panels or double glazed windows (Ragwitz et al. 2011). Therefore, in light of recent austerity measures and the projections of the RE-Shaping 2011 report summarized in the previous section, Portugal will face a difficult challenge in trying to minimize renewables deployment support costs and at the same time stay on course to meet PNAER targets for 2020.

2.4 Monitoring socio-economic impact or RE legislation and promotion policies

The successful role of renewable energy technology deployment and policies for their promotion in achieving energy security and mitigating climate change is widely accepted (Lambert and Silva, 2012), but there is a broad debate whether RES policies actually contribute to job growth, as promoted in legislative documents described in the beginning of this chapter. As during the past couple of decades there has been strong growth in the renewable energy industry, and future targeted renewable shares in final energy consumption will require continued RES deployment, there is public interest in monitoring its economic development and its impact on employment.

Thorough analysis is continuously needed to determine the economic costs carried by efforts towards achieving these dividends with RE deployment in individual countries such as Portugal, as well as in the global context. In order to realize economic growth targets, it is important to gain further understanding and awareness of the employment benefits of RE. Many academic reviews and studies, which will be discussed in chapters 3 and 4 of this thesis, address the relationship between RE deployment and employment in the EU, the individual member states or their regions, as well as in other countries such as the USA, Turkey, Japan and China, estimating its impact on job creation. The next section presents a brief overview of the research focus, scope and methodologies utilized in RES employment impact assessment studies. Before going there, we need to define what categories fall into the so-called “green jobs” those studies are analyzing.

3. RES EMPLOYMENT IMPACT ASSESSMENT – DEFINITIONS, SCOPE AND METHODOLOGIES

Before discussing RES employment impact study scopes and respective methodologies, it is important to set the context as to how RES jobs are defined. Renewable energy jobs belong to the broader category of what is defined in relevant literature and studies as "green employment" or "clean energy jobs". While there is no unique definition, in general "green" jobs can be regarded as those associated with environmental objectives and policies (Silva et al. 2013).

3.1 RES Employment within the "green jobs" context

Clean Tech Job Trends 2009 (Pernick et al. 2009) defines clean-energy jobs as "jobs in renewable energy, energy efficiency, environmentally friendly production, conservation and pollution mitigation, plus related training and support". The same study also gives a more specific definition of clean-tech jobs as those that are a direct result of the development, production, and/or deployment of technologies that harness renewable materials and energy sources; reduce the use of natural resources by using them more efficiently and productively; and cut or eliminate pollution and toxic wastes.

U.S. Metro Economics – Current and Potential Green Jobs in the U.S. Economy (United States Conference of Mayors, 2008) speaks of green activities as any activity that generates electricity using renewable or nuclear fuels, agriculture jobs supplying corn or soy for transportation fuel, manufacturing jobs producing goods used in renewable power generation, equipment dealers and wholesalers specializing in renewable energy or energy efficiency products, construction and installation of energy and pollution management systems, government administration of environmental programs, and supporting jobs in the engineering, legal, research and consulting fields. Although outside the scope of this thesis topic, it is interesting to note that this definition also incorporates nuclear fuels as part of green activities.

Apart from identifying the sectors in which green employment belongs to, literature also provides an overview of the vocations and qualifications that are seen as necessary to carry out those tasks. The Environment Institute of Australia and New Zealand defines "green collar workers" as "managers, professionals and technicians who work in green organizations or who have *green skills* and responsibilities within other organizations that may not be considered as green" and "service, clerical, sales and semi-skilled workers who work in green organizations" (Ehmcke et al. 2009). The International Labor Organization (ILO) and the United Nations Environment Program (UNEP), which are both part of the UN system, in their *Green Jobs: Towards decent work in a sustainable, low-carbon world* (UNEP/ILO/IOE/UTUC, 2008),within defining green jobs provide a more specific, and for this thesis more relevant, overview of personnel and skills needed in the wind power industry, including in their list meteorologists, wind potential surveyors, anemometry specialists, structural, electrical, and mechanical engineers who design turbines, generators, and other equipment and to supervise their assembly, quality-control personnel to monitor machining, casting, and forging processes, computer operators and software specialists to monitor the system and mechanics and technicians to keep it in good working order.

The available definitions of green jobs are often quite broad and sometimes seem to be vague. Nevertheless, it is certainly clear from the above examples that the renewable energy sector jobs do fall under the broad green jobs category. In order to establish a structured framework for employment impact assessment, literature classifies employment created as a result of renewable energy deployment as follows (Caldés et al. 2009):

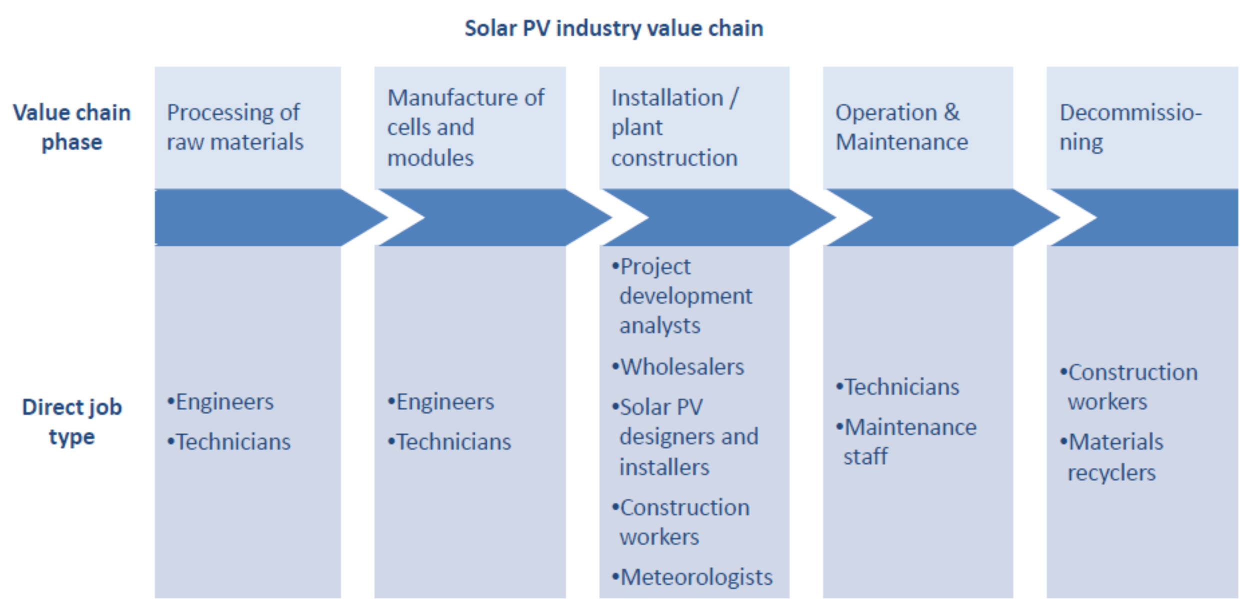
- Direct effects –employment in those industries that directly provide goods and services required to construct, operate, maintain and dismantle a power plant;
- Indirect effects – new investment effect on purchases or sales among other productive sectors in the economy, or provision of secondary inputs of goods (steel for a wind tower) or services necessary for the RES lifecycle;
- Induced effects – as a result of expansion of private expenditure (transportation, food, health services, etc.) due to wealth created by the direct or indirect effect of RES project activities.

The World Bank report *Issues in estimating the employment generated by energy sector activities* (Bacon and Kojima, 2011) distinguishes direct employment on RE projects, indirect employment on activities supplying inputs, and induced employment resulting from supply of goods and services to meet consumption demand of additional directly or indirectly employed workers.

3.2 RES Employment Types

Direct jobs can be measured in a relatively straightforward way. These are the jobs related to the sectors core activities. The exact structure of direct jobs depends on the value chain of technology in question. From a value chain perspective we can consider two broad groups of direct jobs, namely fuel-free technologies such as solar PV or wind power, and fuel-based technologies like biomass based electricity generation and liquid biofuels for transport (IRENA 2011). In fuel-free technologies direct jobs would include product development, design, manufacturing, site preparation, product delivery and installation of equipment, as well as systems operations and maintenance and finally decommissioning and dismantling (although this last phase is not considered as RES employment by some researchers such as Çetin and Eğrican (2011), or Kammen et al. (2004)). As for fuel-based technologies direct jobs would also include production and collection of feedstock, their processing into fuels and its' distribution. *Figure 3.1* below represents a breakdown of direct jobs in the solar PV value chain.

Figure 3.1: Direct jobs across the PV value chain (source: adapted from IRENA, 2011)



In an example of another RE technology, the European Wind Energy Association defines direct jobs in the wind industry as (Blanco and Kjaer, 2009):

- Employment within wind turbine manufacturing companies and manufacturers, whose main activity is the supply of wind turbine components;
- Wind energy project developers, including installation, operation and maintenance;

- Utilities selling electricity from wind energy;
- Major research and development;
- Engineering and specialized wind energy services.

Indirect jobs include all those involved in supplying the renewable energy industry. These are the jobs in the industrial input sectors in the production and operation and maintenance phase of renewable energy technologies (Oliveira et al. 2013) the labor required to extract and process raw materials, such as steel for wind turbine towers, positions in government ministries, regulatory bodies, consultancy firms and research organizations working partly in the renewable energies field and companies that sporadically carry out work in renewable related activities (Dalton and Lewis, 2011).

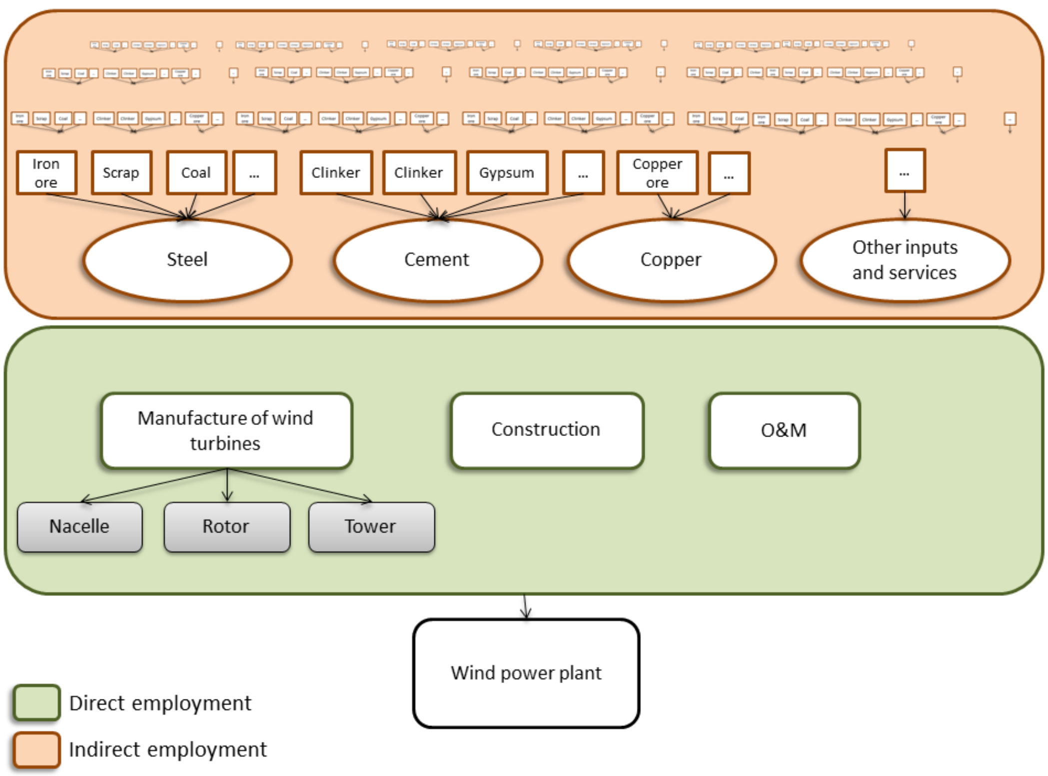
Induced jobs are established when the wealth created by the renewable energy industry, is directly and indirectly spent elsewhere in the economy, thus stimulating demand in industries that may be unrelated. A wind energy power plant staff may for instance spend part of their wages on a holiday, thus inducing jobs in the tourism industry.

The definitions of direct, indirect and induced jobs can substantially vary across different RES employment impact studies (Wei et al. 2010). Confusion occurs in with the exact definition of "direct jobs", which sometimes refers to manufacturing only, but mostly also includes installation, operation and maintenance and pertaining finance and legal activities. The definition of "indirect jobs" sometimes includes, while it sometimes excludes RES components made outside of the main RES assembly factory, such as a wind turbine gear box that may be procured from contractors (Dalton and Lewis, 2011). Most studies consider site preparation and access roads for wind power plants as indirect employment effects, while others consider it direct employment (such as IRENA, 2011). Also, the boundary between direct, indirect and induced employment effects is not always straightforward in studies assessing employment impact of renewables, and depends on the technology under analysis, the scope of the study and the system boundary of the renewable energy industry that has been set in order to achieve the goals of a particular research effort (Breitschopf et al. 2011).

Nevertheless, as indicated in many academic articles on the subject, in order to carry out employment impact assessment, the system boundary needs to be drawn somewhere. According to the more elaborate definition found in *Methodological guidelines for estimating the employment impact of using renewable energies for electricity generation* (Breitschopf et al. 2012), direct job effects are only those within the RE industry, i.e. construction and machine manufacturing, operation and maintenance or biofuels provision, while indirect jobs are a result of the RE industry impact on upstream industries, like steel processing or chemicals production for use as intermediate products (steel for wind towers is produced by outside contractors and can very well be used for any other construction requiring steel). Induced jobs are created outside of the RE industry and upstream industries, and occur as a result of income and power prices effecting general production and consumption patterns (Breitschopf et al. 2012).

Based on relevant literature review and their authors' comments, it seems that it would be very useful for future impact assessment studies if a standardization of direct and indirect jobs for each renewable energy technology would be defined by a perceived and interested authority (institute, international organization, inter-governmental organization, etc). *Figure 3.2* is an example of the proposed system boundary for direct and indirect employment effects in case of a wind power employment impact study.

Figure 3.2: System boundaries: Wind power plant lifecycle direct and indirect jobs (source: Simas and Pacca, 2014)



As mentioned above, determining the system boundaries of the RET industry and clearly defining the boundaries between direct and indirect employment in various renewable energy technologies considered in employment impact studies is important because it is the starting point that determines which data will be analyzed as a result of the desired research focus and scope of the study, and the consequent selection of appropriate methodologies.

3.3 Measuring RES employment – Scope

In order to carry out renewable energy deployment impact assessment, more specific research aims must be defined first, namely whether the study is going to count the number of jobs created in the RE industry, or whether the goal is to assess the broader impact on national, or regional employment as a result of renewable energy policy goals and deployment support measures.

Employment impact assessment studies can be defined and/or grouped on a number of levels, but first of all according to the research question(s) under consideration. There are two principal types of employment impact assessment studies:

- Gross Employment impact studies assess the number of jobs created in the RE industry.
- Net Employment impact studies analyze the employment changes in the entire economy due to renewable energy technology deployment.

Gross employment impact studies estimate the size and relevance of the renewable energy industry as a job creator in region or country; the total number of people employed directly in manufacturing, operation or maintenance of renewable energy facilities or the supply of fuel to them, as well as persons indirectly employed as a result of demand from those activities for supplies of goods and services (O'Sullivan et al. 2011). These studies assess employment in industries that are related to the use of RE. They define the system boundaries of the RE industry and take into consideration only the lifecycle of RE projects and direct and indirect jobs created, as a result presenting only positive employment effects. Direct employment in the RE industry as well as indirect employment in upstream industries is considered. The relevance (with respect to employment) of the RE industry (and its upstream industry) within the economy of a country is highlighted. To emphasize the perspective, in the fossil fuel industry, if we consider thermoelectric power plants, gross employment would take into account employment in the coal mining sector and the building, operation and maintenance of those facilities (Lehr et al. 2012).

RES Gross employment impact studies can also be applied as a tool for a structural analysis of the RE industry, by for example highlighting the importance of the different technologies (solar, wind, etc.), or the relevance of domestic RES manufacturing versus imports as drivers of the RE industry's level of employment. This approach allows specific strengths and weaknesses of the RE industry to be assessed and suitable policy support options to be suggested. Apart from the current RET deployment status, the development of the RE industry as a consequence of continued and increased RET deployment can be monitored or forecast with the help of evaluating different future scenarios for RES deployment (Breitschopf et al. 2012).

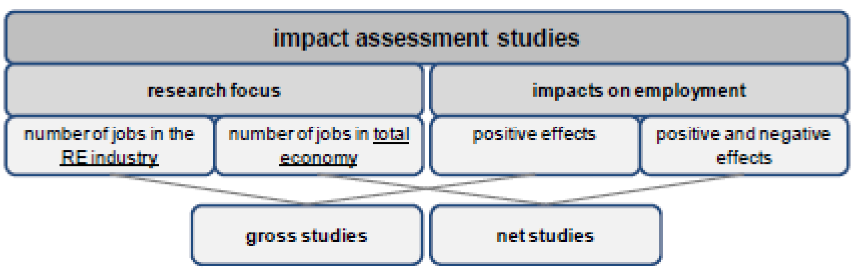
As stated in the previous section, deployment of renewable energy systems for power generation is a result of inter-industry cooperation and it needs therefore to be observed from the point of view of all economic activities participating in the lifecycle of RES. Each of the lifecycle phases is supported by a supply chain of activities, such as civil engineering in the construction of a dam, or wind turbine foundation, or manufacturing of parts and components of a turbine or photovoltaic cell. Obviously, if there is a renewable energy promotion policy and government subsidies to back it, there will be a certain amount of job creation due to investments in the sector. Nevertheless, gross employment impact studies are only partial assessments because they include only the positive employment impact of renewable energy technologies (Breitschopf et al. 2012).

Inclusion of renewables into the local energy mix may raise electricity prices and reduce demand in other sectors (Hillebrand et al. 2006), thus also job growth within them. In order to assess the full economic impact of renewable energy deployment it is necessary to carry out a net employment impact study that takes all relevant impact mechanisms into account, such as potential negative impacts related to displacement of conventional energy technologies, opportunity cost of forgone investments in other industries (expenditures for subsidizing the renewable sector may have prevented stronger job creation opportunities elsewhere in the economy from being realized) or reduced household disposable incomes as a result of higher energy prices (Breitschopf et al. 2012).

To measure these and other consequences, net employment impact studies explore effects on the whole economy showing both positive and negative effects, comparing the situation as a result of different scopes of RE deployment through time, including the above indicated issues. Analysis requires implementation of more complex tools in order to provide a holistic impact assessment on employment throughout an economy. Estimation of net job impact can be expensive and highly sensitive to modeling assumptions (IRENA, 2011). Gross employment impact studies are usually more technology specific and more detailed than net impact studies. As such they can be helpful in evaluating the overall employment impacts of renewable energy promotion and deployment, and can serve to validate the results of net impact studies (Breitschopf et al. 2011).

Figure 3.3 represents a graphic representation on study classifications.

Figure 3.3: Impact assessment studies classification (source: Breitschopf et al. 2011)



3.4 Methodologies for RES employment impact assessment

There are a number of methodologies found in relevant literature, whose main focus is quantitative assessment of employment impact of renewables deployment. The most common ones are explained briefly in this section, while the main focus will be on the analytical or employment factor approach and enterprise survey as its data acquisition method, because it is the selected methodology for the Portugal RES employment impact study that was carried out as part of this thesis. Apart from the count of jobs, quantitative assessment addresses, in terms of direct employment impacts, the duration of jobs in lifecycle phases (manufacturing, construction, operations and maintenance) of RES deployment. On the other hand, the qualitative component of RES employment impact assessment in literature focuses on location of the work carried out (local or aboard) and the level of expertise and education of employees within various tasks in the deployment efforts.

Although academic articles list and analyze methodologies for employment impact assessment, similarly to literature examples and definitions of types of jobs within the renewable energy sector, there are a number of issues that are outstanding in terms of harmonization and comparability of employment data across RES value chain phases and between geographic areas in which the research is carried out. An overview of these issues will be discussed in the following sections. First of all, the methodologies and their utility are presented, starting with the graphic overview below.

Table 3.1: Employment impact assessment methodologies based on scope and defined research question (source: own elaboration)

<table>
<tr><th>Employment Effects</th><th colspan="2">Gross Employment</th><th>Net Employment</th></tr>
<tr><td rowspan="2">Direct</td><td>Analytical Model / EF Approach</td><td colspan="2" rowspan="4">Input-Output Models / Full Economic Modeling</td></tr>
<tr><td></td></tr>
<tr><td>Indirect</td><td></td></tr>
<tr><td>Induced</td><td></td></tr>
</table>

Analytical methods are commonly used for regional or provincial studies to calculate gross employment effect, direct jobs creation in the RE industry. These studies are found in literature for a specific RE technology or for a range of technologies in a certain territory. The method commonly relies on extensive surveys (often followed up by interviews) for acquisition of data, on territorial statistical databases or industry statistics, energy agencies, industry associations and frequently on more than one available source (Llera et al. 2010). While the analytical method may not be able to determine indirect jobs (only direct jobs), it can be a more transparent model, easily understood by other authors and able to have sensitivity evaluated (Lambert and Silva, 2012).

These models use the employment factor approach to estimate the average number of jobs per unit associated with energy production (e.g. jobs per MW of installed capacity or MWh of energy produced) and multiply this figure by the total of these units. Factors are specific for technologies and stages in the value chain. This method is usually only used to estimate direct jobs created as a result of activities in the RE supply chain that have a clear link to renewable energy use. For example, the direct jobs in PV installations would include designing and engineering, silicon production, manufacturing solar cells and solar modules, manufacturing of electronic components and inverters, installation of the final PV system and O&M (Llera et al. 2013).

Two different ratios are typically used in studies to estimate employment impacts – job-years per installed MW for the manufacturing, construction and installation phase (and decommissioning) (CIM), and number of jobs per MW of installed capacity for the operations and maintenance phase (O&M). The distinction is because the first is a temporary phase while the second is continuous employment through the duration of the operational life of the power plant. In this distinction lies the problem of comparing the employment ratios of the two assessment phases. A conversion of the ratios can solve this issue, firstly by converting the CIM job-years per MW to the average jobs per MW over the lifetime of the facility. In this way the two ratios can be added to calculate the total jobs per MW for a plant.

Furthermore, in order to provide a meaningful comparison of employment impact of various technologies, the total number of per MW installed capacity, or peak MW (MWp) is normalized to total jobs per average MW (MWa), by dividing jobs per MWp by the capacity factor, i.e. the fraction of the year that the facility is in operation (Kammen et al. 2004; Wei et al. 2010; Croucher, 2011). Normalized job-years per GWh of output can also be calculated using these steps, and used as multipliers for estimating future RES deployment employment impact based on country specific RES-E deployment targets or various scenarios (Wei et al. 2010).

There is a drawback in this technique if researchers are interested in assessing the location where employment takes place. Namely, manufacturing of components for RES is usually carried out away from the location of the power plant. In order to analyze the extent to which RES jobs are locally generated, the manufacturing phase should be assessed separately, while construction and installation jobs should be added to the O&M jobs (as done in Lehr et al. 2008; Llera et al.

2010). This issue also gives rise to statistically unrealistic high job rates (Dalton and Lewis, 2011) for countries in which much of the RES manufacturing is intended for export, such as Denmark. Therefore, in some studies, which are dubbed by authors as the "value-chain" or "supply chain" approach, (Llera et al. 2010, 2013) the stages in RES development and deployment are grouped a bit differently, introducing the "Technological Development" stage to include research and development (R&D), and manufacturing, the second being "Installation & Dismantling", while the final one is "Operation and Maintenance". The graph below is an example of how the authors reasoned the introduction of the three stages and the information which can be processed from employment impact assessment within them:

Table 3.2: Supply chain quantitative and qualitative employment impact assessment approach (source: adapted from Llera et al. 2013)

Phase	**Employment generation potential**	**Location of work**	**Duration of work**	**Education / Specialization**
Technological development	Medium	Mostly foreign	Long term	Very high
Installation and decommissioning	High	Mostly local	Temporary	High
Operation and Maintenance	Low	Local	Long term	Medium

The employment factor approach has the potential to be accurate and technology specific if the data sources for the employment factors are accurate and reliable (Breitschopf et al. 2011). No country in Europe possesses statistical data with a level of detail that would allow employment directly attributable to the renewable energy industry to be quantified (Blanco and Rodrigues 2009). When an official register is used to acquire employment data its' reliability, accuracy and comprehensiveness need to be considered (Lambert and Silva, 2012). The accuracy of data is related to the objective of the agents involved. For example industrial associations are more likely to have current employment information than energy agencies, where the accuracy of employment data is secondary to other information (Llera et al. 2010).

Analytical studies determining the number of direct jobs created through the promotion of renewable energies should rely on first-hand information collected through an extensive survey; a technique that can provide the most reliable data on direct employment impact (Lambert and Silva, 2012). The main objective of an enterprise survey is to obtain first hand data on employment from the enterprises in the RE industry. Furthermore it is possible to obtain additional information, e.g. on enterprise characteristics, field of activity, economic variables such as turnover, exports or value added, job qualification or R&D activities. As survey is the selected methodology for research that is carried out as part of this thesis, special attention has been given to studies which apply surveys for data acquisition, and results of two of such will be presented in chapter 4.

The first step in carrying out such a survey is identification of enterprises active in the renewable energy field in the study area in question. One approach for identifying the appropriate companies to survey is examining the membership lists of renewable energy industry associations. Furthermore, an important requirement is that the survey is designed appropriately in order to acquire all the relevant data. The questions in the survey need to avoid unbiased answers. No less important is the length of the survey because of the strain on workload that it requires from representatives of the RE industry in completing it. Survey data can, therefore, only be considered reliable if relevant data is acquired from a representative sample of the industry, if not from all industry representatives of the region in which the study is carried out. For this reason surveys are a more appropriate tool for direct employment impact measurement in country regions or in smaller countries, or where RE industry has limited presence. Otherwise, direct impact on employment can be estimated through using input-output tables. An industry survey can be an important foundation on which to build accurate projections of employment (Lambert and Silva, 2012).

The analytical model can supply detailed and authentic statistics regarding technologies impact on employment. This model has much clearer assumptions and level of transparency and is better at solving direct job issues. The input-output (I-O) model, as described below, can on the other hand capture the relations between different sectors within one economy, and depict the employment multiplier effect and estimate indirect employment. However, it requires a large amount of data and therefore increases the workload and level of uncertainty (Wang et al. 2011).

Input-Output methodology– Indirect and induced employment effects of RES deployment might be greater than direct employment effects but they are more difficult to calculate and require more advanced methodologies, namely I-O tables that can link the output of the project sector to all the supply sectors, both immediate and indirect. I-O models can be used to estimate gross and net employment effects of renewable energy deployment. Wassily Leontief first introduced the input-output methodology in the 1930s (Blanco et al. 2009b). These models predict macro-economic outcomes based on tracking linkages across the entire economy, enabling estimation of direct, indirect and induced jobs in all sectors[5]. They are widely used to estimate the economic and employment impacts of renewable energy systems deployment.

An input-output model contains data on the flow of goods and services between the industries of a national economy and from the industries to final demand. They allow capturing multiplier effects and macroeconomic shifts between sectors, and can account for losses incurred in one sector due to growth created in another (Oliveira et al. 2013; Wei et al. 2010). Each column of the I-O table contains the amount of inputs provided from each sector to the rest of the sectors in the economy. The matrix of technical coefficients, constructed based on the I-O table, summarizes the interdependencies between production sectors (Caldés et al. 2009).

A limitation of this approach is the uncertainty if industries included in I-O models are adequate proxies for the companies in the RES industry and its value chain. This aggregation bias can be reduced by including estimation of direct employment data from enterprise surveys (Breitschopf et al. 2012). When a specific sector like the RES sector or a particular RES technology like wind energy or solar PV is to be studied, the I-O tables must be adapted by adding a new vector to the model, or by adding new elements into the coefficients of the technical coefficient table for the economy (Blanco and Rodrigues, 2009). In this framework, the structure of the new sectors defined by the input coming from all other sectors, and the output going to those, imports and the added value created by the new sector. Inputs go into a new column, while outputs from the sector are added in a new row of the table (Lehr et al. 2008).

When I-O methodology is applied to estimate the number of RES related jobs, a number of possible RES deployment scenarios are used to evaluate its resulting employment impact. Scenarios provide a structured description of possible future developments depending on current and future policies and circumstances in the industry (Lehr et al. 2008). Most commonly the scenarios calculate future employment effects based on government policy targets for RES deployment by a certain year, as well as the employment impacts of exceeding or missing those

[5] Portuguese I-O tables consist of 64 sectors in Silva et al. 2013 study, while the German ones consist of 59 sectors in Lehr et al. 2008.

targets, thereafter providing analysis of the different impacts of these possible scenarios. Also, scenarios are created to model this target RES deployment impact on job creation taking into account the location of manufacturing of the RES systems and components, thereby evaluating resulting job creation in “import” or “export” scenarios[6]

This methodology is more suited for national and international analysis. Countries, as a national statistical requirement, compile I-O tables for their economies at regular time intervals to provide detailed databases for policy analysis (Silva et al. 2013). Their application to regional studies is limited because the creation of an I-O model requires a lot of information (Llera et al. 2010).

Although the I-O approach can provide a detailed analysis of sectoral impacts and examine net employment effects as a result of RES deployment, however if not specifically designed to, it may neglect the resulting positive externalities such as decrease in pollution, protection of resources, and positive health impacts (Breitschopf et al. 2012).

Full Economic modeling is a comprehensive methodology, mainly used for assessment of future employment impacts, which takes into account all positive and negative potential effects of RES deployment. It captures all present and future employment effects in all sectors and industries, the behavior of all economic stakeholders such as the reactions of households and industries to changes in prices and depicts several interdependencies or feedback loops and multiplier effects. In order to implement such an analysis, specific knowledge, significant financial resources and a large amount of high quality data are required. Econometric models, applied general equilibrium models and system dynamic models can be used (Breitschopf et al. 2012). An example of such a study is found in “*EmployRES - The impact of renewable energy policy on economic growth and employment in the European Union”* (Ragwitz et al. 2009).

3.5 Setting a methodological framework for RES employment impact assessment

Studies assessing economic impacts of large-scale deployment of RE technologies vary in scope, depth, methodology, complexity and data quality, making it difficult for their results to be compared. In an attempt to facilitate a more structural approach, which will contribute to reliable and consistent insights of employment effects from deployment of renewable energy

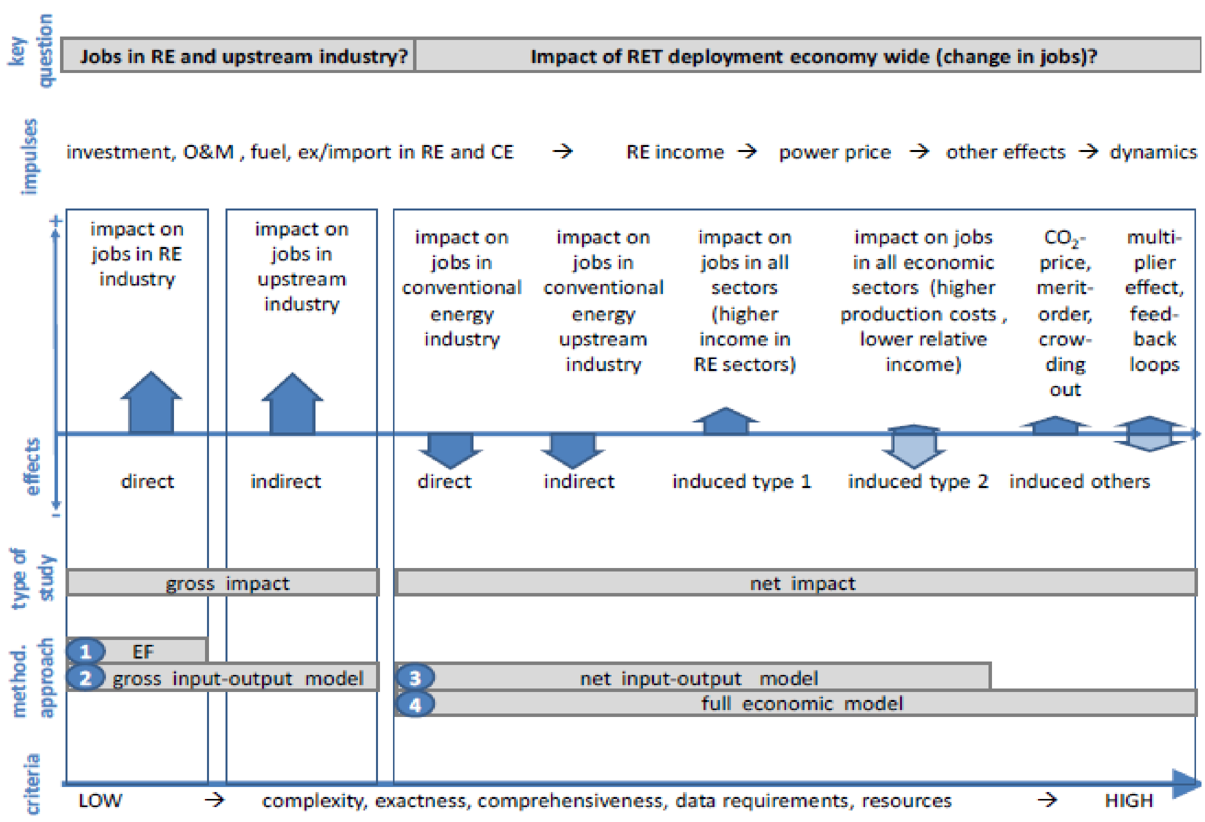
[6] Examples of such studies are P. Silva et al. 2012; U. Lehr et al. 2008; Oliveira et al. 2013.

technologies, the International Energy Agency's Implementing Agreement on Renewable Energy Technology Deployment (IEA-RETD) initiated and funded the Economic and Industrial Development (EID)-Employ project.

The objective of the EID-Employ project was to review employment impact studies and elaborate methodological guidelines for estimating employment impacts of RES-e deployment. The purpose of these guidelines is to provide policy makers and analysts with a tool to obtain comparable results based on a consistent and homogenous approach and to define impacts and types of impact study[7].

Upon the authors' extensive research into RES employment impact practices, four methodologies were proposed and instructions for their implementation are standardized in IEA-RETD 2012 (Breitschopf et al. 2012). Figure *3.4* represents the scope, utility and data requirements for the four proposed employment assessment approaches.

Figure 3.4: RES employment impact assessment impact, scope and measurement methogologies (source: Breitschopf et al. 2012)



7 http://www.isi.fraunhofer.de/isi-en/x/projekte/employ_314927_bf.php (last accessed 26.12.2013)

As the purpose of the survey carried out as part of this thesis, and described in chapter 5, is to measure gross employment creation from direct renewable energy jobs, based on the relevant literature review, direct RE employment will for the purpose of the study be defined as: Full time, part time, permanent and temporary employment existing within companies that manufacture and construct RES, facilities or their components, produce energy from RES, carry out equipment operation, maintenance and various services in the field of RET, and trade in renewable energy.

Within this definition, the survey will attempt to determine the labor intensity that goes into those RES jobs, through calculating employment factors for the different lifecycle phases of the various RE technologies deployed in Portugal for electricity production, the education level of employees, the duration of employment and the gender distribution.

Before presenting and discussing the *RES3E (Renewable Energy Systems and Energy Efficiency) project* survey deployment and results, the next chapter presents application of the above discussed methodologies for RES employment impact assessment in other countries and regions, and some relevant results, observations and conclusions of authors' efforts.

4. RES DEPLOYMENT EMPLOYMENT IMPACT STUDIES –EXAMPLES, FINDINGS AND RESULTS

The previous chapter discussed the renewable energy jobs' concepts, and provided an overview of the RES employment impact assessment methodologies that can be found in literature, as well as their application based on the scope of impact.

This chapter will, consequently, present the results of selected employment impact assessment studies, and provides a closer look at two studies that utilized industry surveys as a method to acquire employment data within the RES sector, and were used as a model for the development of the Portuguese RES employment impact survey questionnaires.

4.1 An overview of studies and findings

The results of studies utilizing employment factor, I-O and macroeconomic modeling are summarized in the *table 4.1* below. Thereafter, their conclusions and interpretations about RES employment effects are discussed and the most common findings are singled out. Finally, a number of alternative approaches for analyzing socio-economic effects of RES deployment found in literature are presented.

Table: 4.1 Employment impact studies, methodologies and results (source: own elaboration based on the review of listed publications)

Country/Region	Technology	Author-Institution, year of publication	Study title	Method	Scenarios and Results
Multi-country	PV, wind, biomass	Kammen et al. – University of California, Berkley 2004;	Putting renewables to work – how many jobs can the clean energy industry generate?	Meta analysis of 13 renewable energy job creation studies. Normalization of job creation by average power over lifetime of plant to calculate employment multipliers for 2020 scenarios direct employment estimates.	Comparison of average employment from five electricity generation scenarios for 2020: - 20% renewable portfolio standard and three pertaining technology ratios - Two fossil fuel 2020 scenarios
USA	All RES	Wei et al. 2010;	Putting renewables to work – how many jobs can the clean energy industry generate in the US?	Analytical model, employment factor approach, net job creation. Meta-analysis of 15 studies - normalization of job creation to average employment per unit energy output over lifetime of plant to determine technology employment factors.	Scenarios of RES deployment impact on employment based on assumptions for 2030: - Energy efficiency improvements - Renewables portfolio standard percentage and pertaining technology ratios - Low carbon percentage and portfolio contributions. Net effect modeled with projected job losses in the coal and gas industries.

Country/Region	Technology	Author-Institution, year of publication	Study title	Method	Scenarios and Results
Germany	All RES	O'Sullivan et al. - Ministry of the Environment, Nature Conservation and Nuclear Safety 2010;	Gross Employment from Renewable Energy in Germany	I-O model, RE sector data from survey.	Total gross employment in RES sector in Germany in 2010 was 367,400, an increase of 27,900 from 2009. Major industries: - Wind 89,200, (decline 6,400 from previous year) - PV 107,800 (increase 43,100 from previous year) Since 2004, gross employment increased by 129%.
Germany	All RES	Lehr et al. 2008;	Renewable energy and Employment in Germany	Full Macroeconomic model; PANTHA RHEI. Net and gross impacts of RES deployment. Source data gathered from survey.	Modeling scenarios included effects of: - 2 German 2030 RES deployment and 2050 CO_2 emissions reduction paths - 2 International RES deployment goals (BAU and dynamic - 4 German export scenarios Gross employment effect is estimated at 200,000-400,000 employed in the RES industry in 2030, depending on scenario. Net effect positive in all scenarios.
Germany	All RES	Blazejczak et al. - German Institurte for Economic Research 2011;	Economic Effects of Renewable Energy Expansion: A Model-Based Analysis for Germany	Full Macroeconomic model; SEEEM. Net and gross impacts of RES deployment.	Renewable energy expansion scenario based on official German Government RES deployment plans by 2030 compared to a no deployment scenario, tested for sensitivity based on alternative cost effects and labor market conditions.

Country/Region	Technology	Author-Institution, year of publication	Study title	Method	Scenarios and Results
Germany	All RES	Lehr et al. 2012;	Green Jobs? Economic Impacts of Renewable Energy in Germany	Full Macroeconomic model; PANTHA RHEI. Net and gross impacts of RES deployment.	Scenarios of RES deployment impact on employment based on assumptions for future: - Fossil fuel market prices - Domestic RET investment - German RET exports
Aragon, Spain	Wind; Solar Thermal; PV.	Llera et al 2010;	Local Impact of Renewables on Employment: Assessment Methodology and Case Study	Analytical model-value chain approach. Employment factor approach to present direct job creation. Qualitative assessment of existing jobs via "Quality Factor"	2007 RES employment: 1500–Wind (0.86/MW) 450–Solar thermal (43/MW) 350-PV (38/MW) 2500-total (1.38/MW)
Spain	PV	Llera et al. 2013;	Forecasting Job Creation from Renewable Energy Deployment Through a Value Chain Approach	Analytical model-value chain approach; employment factor approach; direct job creation. Survey was one of the methods used for data collection.	For a 1MW installed capacity of a PV power plant 29.46 jobs are contracted across the value chain. Taking into account its' 25 year life time, a 1MW PV power plant generates 2.76 jobs per year.
Asturias, Spain	All RES	Moreno et al. 2008;	The Effect of Renewable Energy on Employment. The Case of Asturias (Spain).	Analytical model, employment factor approach. Data for calculation of employment ratios was obtained from Spanish Renewable Energy Foundation	Three scenarios are considered: - Baseline, according to the outcome of the Spanish Renewable Energy Development Plan - Optimistic, surpassing the plan - Pessimistic, falling short of the plan

Country/Region	Technology	Author-Institution, year of publication	Study title	Method	Scenarios and Results
Portugal	All RES	Oliveira et al. 2013;	How Many Jobs can the RES-E Sectors generate in the Portuguese Context?	MOLP I-O model; direct and indirect jobs. RES-E production targets according to National Energy Strategy 2020.	Baseline 2008 BAU scenario and 3 others in terms of ratios of different RES technology percentage in total generation. Additional scenario with basic RES-E equipment produced domestically.
Portugal	All RES	Silva et al. 2013;	Employment Effects and Renewable Energy Policies: Applying I-O Methodology to Portugal	I-O model, gross job creation – direct, indirect and induced jobs. Employment factor results elaboration. Data based on national statistics, prior research and reports.	Employment impact of 2020 RES deployment targets of Portuguese National RES Action Plan, two modeled scenarios: - Basic RES equipment domestically produced - Basic RES equipment imported Local RES production maximizes employment impact.
EU 28	Wind	Blanco and Kjaer, 2009;	Direct Employment in the Wind Energy Sector: An EU Study	Analytical model, employment factor approach. Estimation of direct job creation.	104,350 direct wind energy industry jobs in the EU 28 in 2008, 72% of which were in Denmark, Germany and Spain. 50,434 direct jobs were recorded in survey responses; the final amount obtained was estimated based on survey response rate (30%) and secondary sources.

Country/Region	Technology	Author-Institution, year of publication	Study title	Method	Scenarios and Results
EU 28	Wind	Blanco and Rodrigues, 2009; – European Wind Energy Association (EWEA).	Wind at Work – Wind Energy and Job Creation in the EU	Analytical model for direct job creation survey using survey as a data acquisition tool, supplemented by industry reports, country studies and national wind energy associations data I-O model for indirect job estimation.	EWEA baseline scenario - 300 GW of wind energy installed in EU 28 by 2030 154,106 direct and indirect jobs in the EU wind industry in 2008; 377,244 direct and indirect jobs in EU wind industry in 2030, of which 215,000 off-shore[8].

[8] In their estimation, the authors consider that the jobs/MW ratio in new deployed wind farms will decrease from 15.1 in 2008 to 11 in 2030, due to learning curve effects within the industry.

Kammen et al. (2004), carry out a meta-analysis of past employment studies. The main results are that the renewable energy sector generates more jobs per MW of power installed, per unit of energy produced and per US$ of investment than the fossil fuel based energy sector. They find that the distribution of employment benefits across regions can vary considerably. In the US, a 20% RE share by 2020 could create between 163,669 and 188,018 new jobs, as compared with a figure of 86,369 in the business as usual scenario. The jobs/MW (normalized to technology capacity factor) ratio for wind power ranges between 0.71 and 2.79, for PV it is 7.14-10.56, while for biomass the range is 0.78-2.84. The authors also describe that the decline in fossil fuel industry jobs is not related to, environmental regulations and increasing deployment of RES in electricity production. They conclude that the opportunity exists for establishing retraining programs for employees that lose jobs in the fossil fuel industry; hence providing them the necessary skills to work in the clean energy industry should be considered by authorities.

In their 2010 Aragon RES and 2013 Spanish PV employment impact studies Llera et al. estimate job creation in utilizing a value chain approach (described in chapter 3.3.1). They assess the quantity of jobs created and the influence of value chain stages on the volume and quality of employment (graph 3.2, chapter 3.3.1). In order to obtain data for the 2010 Aragon case study, the researchers carried out a survey and consulted regional statistics. The results provided a count of 2500 jobs (2007) in the RES sector in Aragon. A large proportion of the RES jobs in Aragon are in the technological development value chain stage of the wind power industry (90% of wind total, and 55% of total), and the authors conclude that local technological development and manufacturing is key to providing sustainable and highly qualified RES jobs in a particular region. Other Spanish regional studies (Faulin et al. 2006), agree with this conclusion, stating that manufacturing opportunities at the local level have provided a strong motivation for regional governments to promote the production and use of renewable energies. New manufacturing is being effective in reviving sluggish local economies through the creation of direct and indirect employment.

In their 2013 Spanish PV analysis, they take into account the economies of scale and technological development influences on human resource needs in the Spanish PV sector value chain stages as well as the effects of trade balance on local employment generation, although the latter is not reflected in the model job creation results. The estimated 29.46 jobs generated in the construction and operating of a one MWp PV power plants, however, is a figure that does not discriminate in terms of the location of jobs, and as the authors also noted, it is highly probable that 14 of those jobs created in the manufacture of silicon, the PV sells and other components are not to be considered as local job gains. The final ratio also contains 6.37 jobs per MW of installed power for manufacturing of solar tracking systems, which are not always used in PV power plants. Unfortunately the study does not normalize jobs created in terms of power output generated from 1MW of installed PV capacity. Normalizing with a 20% capacity factor would yield 1.5 jobs per GWh of energy produced.

Moreno et al. (2008), find that in 2010 RES jobs in Asturias would amount to 10,200-10,700. They state that further development of RES industry can be a possible alternative employment strategy to counter the job losses in the declining coal mining sector, and can contribute to reducing coal imports in the past coal exporting region of Asturias. The authors also caution that educational planners must take into account the necessary skill development for activities within the RES sector in order for the region to secure qualified personnel for industry employment.

In Oliveira et al. (2013), the MOLP I-O model assesses environmental, social and economic impacts of RES-E deployment. It concludes that in the model solutions where RES-E production is maximized, the level of GDP and employment suffer a negative impact. However, in solutions that optimize GDP the consequent levels of CO_2 reach the highest levels. Maximization of RES-E production obtains the lowest CO_2 levels as well as secondary energy imports. Local manufacturing of RES components is emphasized as a key factor in achieving national positive net employment effects of RES-E deployment; however such a scenario would neither secure lower CO_2 emissions nor lower levels of primary energy imports due to high energy intensity of RES-E systems and component manufacturing.

Lehr et al.(2012), in their macroeconomic model conclude that positive net employment effects will strongly depend on growth of global markets and German RET exports, with the highest net employment projected within the maximum export and high PV expansion scenarios. Gross employment will not grow as fast as in the past due to increased labor productivity and learning curve effects with maturing of the RET industry. The study also concludes that accounting for additional RE deployment benefits in impact studies, such as climate change mitigation, decreasing of local air pollution and damage resulting from fossil fuel extraction, would strengthen positive deployment effect forecasts.

Blazejczak et al. (2011), utilize the SEEEM (sectoral energy-economy econometric model), a complete representation of the economy, which takes into account production, government activities, income generation and consumption, prices, wages, exchange rates and international financial and trade flows. The model application concludes that in the exponential scenario there is a moderate gain in net employment in the RES industry as compared to the no deployment scenario. The authors explain that only a moderate net employment gain is a result of labor productivity improvements and the industry learning curve, while GDP growth is more significant (1%-2.9% by 2030). Furthermore, the study finds that in a more flexible labor market scenario, where labor market activation policies such as retraining schemes are applied, net employment created in the RES sector is more significant than in the exponential scenario (and 270.000 jobs more than in the no deployment scenario are created). The study restates the importance of the RES facility manufacturing sector in Germany, naming it the main winner in terms of employment creation, and reiterating the crucial contribution of exports for the German RES job creation potential. The authors conclude that the primary aims of transition towards RES, namely the reduction of environmental impacts and long-term improvement of security of energy supply can be obtained without sacrifices to income and net employment.

Wei et al. (2010), find that an increasing number of studies identify that RES deployment secures job creation and improves security of energy supply. The authors used data from 15 studies to assess 6 RES technologies and coal, natural gas, nuclear, energy efficiency and carbon capture & storage potential for job creation and calculate employment multipliers to use in their own analytical model. In order to combine the construction, installation and manufacturing (CIM) and the operations, maintenance and fuel processing (O&M) job creation data from the analyzed studies, having in mind that the respective jobs take place in different time periods, and their duration is different, the job creation data for CIM is converted from the original job-years per MWp to average jobs per MWp over the lifetime of the plant. This figure is then adjusted for the capacity factor, and converted to job-years per GWh of energy produced to average the employment multipliers for different technologies observed. The authors calculate that the applied 30% renewables portfolio standard, coupled with a 0.37% annual reduction in energy consumption, can create 4 million jobs more than in BAU scenario by 2030, and conclude that higher employment benefits can be achieved in countries that develop strong export markets as well as in developing nations that lack resources for large centralized power plants.

The presented studies share a number of common conclusions, regardless of their country or region of analysis, or the methodology applied to estimate employment impact data:

- Renewable energy deployment has a strong job creation potential at the national and regional level;
- Future RES deployment will be highly dependent on fossil fuel prices, support mechanisms (policy, monetary, fiscal) and electricity prices;
- Employment in the CIM stage of RES deployment generates the majority of sector jobs;
- CIM jobs are usually displaced from the country or region of the RES installation (except in German studies);
- Employment factors are not reliable when modeling employment impact of RES in one country with a set of ratios coming from a different country, because of contextual differences (production and manufacturing of RES systems, technology development stage, learning curves, employee productivity, etc.)
- Renewable energy deployment creates more jobs in countries and regions that have developed technological and industrial capacities for production and manufacturing of RES;
- Studies that model future RES deployment scenarios find that higher national job creation would be achieved as a result of locally producing basic RES equipment;
- Studies analyzing the employment impact of RES in Germany unanimously conclude that export related manufacturing of components is the single most relevant factor for future scenario net positive employment impact effects;
- Development of educational programs for qualification of skilled workers is necessary to secure personnel for RES facilities, locally and national;
- Employment in the RES industry requires an array of skills, including highly trained engineers (mechanical, electrical, chemical), lawyers, economists, project managers, engineering technicians, etc; and
- As RES deployment increases, the retraining of workers from traditional energy industries for tasks in the clean energy industry can alleviate job losses incurred, although there is no

clear link between job losses in the traditional energy industry and the proliferation of environmental legislation and increasing RES deployment.

Although outside of the scope of this thesis, there are a number of broader approaches for assessing socio-economic impact of RES, including employment impacts, worth mentioning. Del Río et al. (2009), develop a slightly different theoretical framework for analysis of RES deployment on local sustainability, including the employment effects. In their "Substantive and Procedural Sustainability" analysis in the RES deployment context they define substantive sustainability as the impact or contribution of RES project in achieving the triple bottom line (environmental, social and economic sustainability), while procedural sustainability is explained as the need for such projects to be scrutinized by public debate, and that all local stakeholder interests and opinions need to be observed and respected in order for project outcomes to be successful. Similarly to other researchers, the authors emphasize that the development of endogenous resources are crucial in achieving positive quantitative and appropriate qualitative impacts on employment from local RES deployment.

Another example is the Irish study of Dalton and Lewis (2011), in which the authors suggest MW installed per million person and RES jobs created per 1000 persons as additional national statistic to provide more detail in monitoring of RES deployment and its relative employment benefits in an economy.

Danish authors Lund and Hvelplund (2012), promote the Concrete Institutional Economics (CIE) concept as a tool and methodology of designing strategies for how to use the present economic crisis and investments in sustainable energy as a driver of industrial development and economic growth. As part of the concept they define three phases of RES deployment in an economy; the introduction phase (high RES energy prices), the transition period (high investment to move away from traditional energy production), consolidation phase (net positive future employment impact with modest direct employment but high indirect employment due to lower energy prices of maturing technologies and increased international competitiveness from exploitation of a higher proportion of domestic resources). The steps to be taken in order to plan RES deployment within the CIE concept are: (1) carrying out feasibility studies of energy scenarios and evaluate the effects of different technical scenarios on employment and public finances; (2) analyze the present institutional and political contexts and hindrances to best technical scenarios; and (3) design the needed institutional scenarios in order to implement the most favorable technical scenario determined in point (1).

Finally, Carley et al.(2011), coin the term Energy Based Economic Development (EBED) in their attempt to strengthen the link they find in literature between the areas of energy policy and economic development and establish a broader understanding of the interaction between activities of the two fields, and discuss the technical approaches to measure EBED impact. They define EBED as "a process by which economic developers, energy policymakers and planners, government officials, industry, utility and business leaders and other stakeholders in a given region strive to increase energy efficiency or diversify energy resources in ways that contribute to job creation, job retention and regional wealth creation". EBED goals are defined as (1) increasing energy self-sufficiency, (2) energy diversification, (3) economic growth and (4) economic development. The authors promote an EBED planning process which includes all regional or national project stakeholder engagement, identification of goals and objectives, assessment of assets and gaps that enable or constrain goals and objectives, comparison and selection of alternative interventions, implementation and evaluation. In their review of RES impact assessment studies, the authors criticize the fact that most of the research is composed of scenario based modeling of employment impact estimates performed prior to actual RES deployment, rather than assessment of effects after implementation. They conclude their analysis by emphasizing that sound EBED solutions require understanding of global circumstances, accompanied by local action and efficient production of local energy-based resources and the role of public-private partnerships, economic development practitioners, energy users and coordination of all stakeholders in encouraging sustainability as a part of community economic development.

4.2 Models studies for Portugal survey

As introduced in the previous chapter, the survey method has a number of strengths:

- Data on the RE industry has high validity, since it is directly acquired and industry specific;
- There is no need (or very little need) to work with larger industry average data such as in modeling approaches; and
- Firms in the RE field are identified. Their type of activity or technology field is known.

This information is important to assess the potential of the RE industry of a country and to tailor industry support strategies.

On the other hand, the limitations of this method include the following:

- It is difficult to identify companies that supply dual use goods and to clearly allocate them to the RE industry. These are goods that can be used for RE technologies but also for other technologies (e.g. generators, pumps). The dual-use-problem mainly relates to components of RE technologies, while to a very limited extent to the final products.
- The resources needed for enterprise surveys are larger than for the other approaches.

Such a survey was used to gather data in the study *Direct Employment in the Wind Energy Sector: An EU study,* carried out by Maria Isabel Blanco and Gloria Rodrigues of the Department of Economic Analysis of the University of Alcala de Henares in Spain in 2008, the first of its kind in the EU (Blanco and Rodrigues, 2009). The results of this survey were also presented in the EWEA Wind at Work report (Blanco and Kjaer, 2009). The survey was carried out through questionnaire comprised of three groups of questions. The first group aimed to collect data on the company field of activity, including choosing one or more of the following sectors:

- Wind turbine manufacturer;
- Component manufacturer;
- Developer;
- Independent power producer, utility;
- Installation, repair, operation & maintenance;
- Consultancy, engineering, legal services, certification;
- R&D centre, laboratory, university;
- Financial institution, insurance company;
- Energy agency, energy association, other lobby organization, or;
- Other (please explain).

The second group addressed the number and gender of employees of companies engaged on activities in the wind energy sector, providing a clarification that if worker is not 100% dedicated to wind-related activities, companies should give the most accurate estimate of how much time he/she spends on that work; e.g. if approx. 25% of a worker's time is spent on wind-related activities, he/she should be counted as 0.25. The third group of questions aimed at acquiring understanding of labor force scarcity in the wind energy sector, employee profiles that were lacking and the prospects of wind energy companies in terms of future employment levels and profiles, and assessed the following:

- Executive, top managers, directors
- Engineers
- Commercial, marketing, sales managers
- Operation & Maintenance technician
- Low-skilled workers
- Others (field with requested clarification)

The authors' questionnaire was sent to all European Wind Energy Association members and all members of the EU-27 national wind energy associations. Data obtained through the questionnaire was supplemented by reviewing annual reports of major wind energy companies in the EU and by assessing the data from national studies compiled by national wind energy associations. The results of the survey showed that the number of jobs in the wind energy sector in the EU-27 in 2008 was 104,350. The breakdown per country is as detailed in *Table 4.2* below.

Table 4.2: Wind energy sector jobs in Europe (source: own elaboration based on Blanco and Rodrigues, 2009)

Country	No. of direct jobs	Country	No. of direct jobs
Austria	750	Hungary	100
Belgium	2,000	Ireland	1,500
Bulgaria	100	Italy	3,000
Czech Republic	100	The Netherlands	2,000
Denmark	17,000	Poland	800
Finland	800	Portugal	3,000
France	6,000	Spain	20,500
Germany	38,000	Sweden	2,000
Greece	1,800	UK	4,500
Rest of EU	400		
TOTAL NO. OF DIRECT JOBS IN EU		**104,350**	

The results of this survey can be compared with the results of a survey carried out by the European Wind Energy Association (EWEA, 2003) which concluded that in 2003 there were 46,000 jobs in the wind energy sector. This growth in jobs between 2003 and 2007 of 226% is consistent with the increase in wind power installed capacity in (MW) in Europe during the same period, which was 276% (EWEA, 2007).

Some of the key findings of the survey were:

- Wind energy represents an attractive source of employment in the EU;
- Jobs in the wind energy sector are more widely spread across the EU than 5 years prior;
- There is a clear link between the number of MW of installed capacity and the number of jobs. However, the types of jobs are not evenly distributed as for example development and O&M tend to be provided by local companies, while manufacturing was carried out mostly in the three wind sector leaders at the time, Denmark, Germany and Spain;
- Manufacturing companies are responsible for 59% of the direct wind energy jobs, leading the way in terms of share of employment, followed by service companies and developers;
- Policy measures that encourage the transfer of workers from general energy to the wind energy sector will be highly beneficial from the social and economic perspective, as the general sector employment is declining and the wind energy sector is on the increase.

This research aimed at collecting and analyzing data on the employment impact of the European wind energy sector. Further examples of using surveys as a research methodology are German Federal Ministry for the Environment Nature Conservation and Nuclear Safety publications assessing 2008 and 2009 gross RES employment impact (BMU, 2009b; BMU, 2009a). The research behind the 2010 publication *Renewably employed! Short and long-term impacts of the expansion of renewable energy on the German labor market* (BMU, 2010)[9], intended to measure the impact of the deployment of various renewable energy technologies on employment in Germany and scenario based projections of future RES employment levels. This extensive survey was carried out three times, in 2004 and 2008 and in 2013, and it was also the main data source for the above-mentioned report by Lehr et al. (2008).

In 2004 (2008), this very comprehensive survey was sent to 1100 (1200) companies in order to acquire data to measure the direct employment impact of RES deployment in Germany and to

[9] It is interesting to note that since 2004 the German Ministry for Environment, Nature Conservation and Nuclear Safety has been annually (except in 2005) publishing a report on the gross employment creation in their national RES industry, the only such national example I have come across in my research (other countries are possibly doing the same, but not publishing in English).

amend the country I-O tables. Information about the inputs in different production processes was obtained thanks to a comprehensive component list of the important inputs in the intermediary goods for the respective production. The survey was co-authored and carried out in cooperation with a number of research institutes in Germany. The questionnaires were sent to system manufacturers, suppliers, developers, planners and operators, financiers, insurers and retailers.

The survey consisted of 57 questions in total; however no company was required to answer all of them as respondents were automatically referred to questions or sections depending on their previous answers. The first survey section aimed at assessing the location, employment generation and the main activity of the enterprise. Companies with having less than 20 employees were redirected to a short version of the questionnaire, adapted to their size.

In this section the questionnaire distinguishes between:

- a company for the manufacture of production facilities in the area of RE;
- a company producing RE;
- a service provider in the field of RE;
- trading company in the field or RE; or
- manufacturers of bio-fuels.

Thereafter RES equipment manufacturers and bio-fuel manufacturers would proceed to respective specific questionnaire sections, while the others would answer the same, slightly modified for each type, questions about:

- The sector in which they operate (PV, wind, geothermal, etc);
- Domestic market share in the respective market of operation;
- Turnover, revenue, sales national and international per RES sector applicable;
- Which types of clients buy their product or services, (Service provider, wholesales, retail trades, end customers industries) and respective sales revenues from each group.

Apart from those, special questions addressed to RES manufacturing companies were:

- Proportion of revenue spent for purchasing production inputs;
- Proportion of imported goods or services for production inputs;
- Investments incurred to raise capacities in the previous year.

The following section contained questions concerning company personnel, assessing the extent of employment, the composition of staff according to education, gender and job location, companies' demands on the job market, success or lack thereof hiring qualified staff and their expectations for the future development in terms of employee quantity and quality. The survey resulted in counting 26,400 RES manufacturing related jobs in 2004, in an industry dominated by SME's; 84% of companies employ less than 250 persons. The final gross employment results for the 2004 and 2007 are shown in *table 4.3* below.

Table 4.3: Gross employment from RES in Germany 2004/2007 (source: own elaboration based on data from Lehr et al. 2008; BMU, 2010)

	2004		2007	
RET	**Employees**	**In %**	**Employees**	**In %**
Wind	63,944	39.85%	85,700	30.91%
Photovoltaic	17,397	10.84%	38,300	13.81%
Solar thermal	7,666	4.78%	10,900	3.93%
Hydro	9,515	5.93%	8,100	2.92%
Biomass	51,745	32.24%	48,300	17.42%
Biomass fuels	/	/	28,200	10.17%
Biofuels for trans.	/	/	23,900	8.62%
Biogas	5,035	3.14%	19,100	6.89%
Geothermal	1,773	1.10%	10,300	3.71%
Public funding	3,400	2.12%	4,500	1.62%
Total RES	160,475	100%	277,300	100.00%

In the Lehr et al. (2008) study, data from the 2004 survey was combined with technical data to amend the I-O tables and to derive direct and indirect employment for the newly created sector. The researchers then applied scenarios for the development of technological parameters, costs and capacities installed in order to estimate the development of employment until 2030. As mentioned in *table 4.1*, gross employment (direct and indirect) effect is estimated at 200,000-400,000 employed in the RES industry in 2030, depending on scenario in question.

As many others, the authors of this study conclude that exports are key for employment generation in the RES sector in Germany and that growth within it cannot be expected without a strong international market. The diffusion of the German RES legislation and particularly of the feed-in tariff system into other national legislations has given Germany a lead market position in terms of price and cost of technology advantages. Germany started developing RES technologies earlier than other countries, and as other countries have incorporated support mechanisms for RES deployment into their legislation when the technology development was already far under way, German companies found new markets and compete there with success.

As the goal of the survey is also to assess the qualitative impact of RES on employment, the 2008 survey provided findings on the type of employment created in the RET industrial sectors, as summarized in the *table 4.4*, and concluded that a prominent feature of companies in the renewable energy sector is their high proportion of skilled employees (BMU, 2010).

Table 4.4: Qualitative assessment of RES employment in Germany in 2008 (source: BMU, 2010)

	Without vocational qualifications	With vocational qualifications	With a university degree
Photovoltaics	5.8 %	81.7 %	34.7 %
Hydro	1.7 %	93.8 %	57.0 %
Wind	0.9 %	79.7 %	27.1 %
Solar thermal	9.5 %	80.3 %	24.4 %
Solar thermal power plants	6.7 %	84.8 %	44.1 %
Deep geothermal	2.1 %	85.6 %	50.4 %
Near-surface geothermal	6.6 %	81.1 %	15.3 %
Biogas	2.5 %	82.5 %	33.1 %
Liquid biomass	0.0 %	92.2 %	57.3 %
Solid biomass	3.1 %	86.5 %	29.7 %
RE overall	**4.1 %**	**82.1 %**	**32.1 %**
Manufacturing jobs	22.7 %	63.2 %	0.6 %
Technical jobs	4.0 %	88.3 %	37.7 %
Total	**15.0 %**	**69.5 %**	**9.9 %**

The two above described questionnaires were used as a model for this thesis empirical research, the Portugal RES deployment employment impact survey. As presented in the next chapter, the developed survey basically included elements of both examples. It is a bit more detailed than the EWEA survey (Blanco and Kjaer, 2009), although significantly less demanding on respondents than the German example, while retaining all questions designed to provide key information necessary for a valid estimation of the quantity and quality of RES employment in Portugal.

5. RES EMPLOYMENT IMPACT - PORTUGAL SURVEY

This chapter describes the development of the applied methodology and the results of the employment impact assessment of renewable energy deployment in Portugal; a study carried out between October and December 2013. The purpose of the study is to acquire better understanding as to the extent of RES deployment job creation impact in Portugal, in the context of legislative and strategic Portuguese government and European Union documents expressing job creations as one of the three main effects of increased RET deployment, and the significant dedication of public financing towards this end, as described in chapter 2 of this thesis. The survey is designed to measure direct employment effects of RES deployment, calculate employment factors for the lifecycle phases of RES-E technologies, and assess quality of jobs created, i.e. gender distribution, education levels of employees and industry staff needs and requirements projected in the short to mid-term.

The RES employment impact assessment was carried out as part of the "RES3E" (renewable energy systems and energy efficiency employment) Project, which aimed at measuring impacts of RES and energy efficiency (EE) on job creation in Portugal. It was prepared and carried out in cooperation with Mr. Guillermo Pereira, a colleague from the Energy for Sustainability M.Sc. degree program, whose main focus was on measuring job impacts of energy efficiency initiatives in Portugal. The full roster of participants in study development and deployment is as follows:

- M.Sc. students of the Energy for Sustainability Initiative (EfS) of the University of Coimbra:
  - Guillermo Pereira
  - Nikola Šahović;
- EfS Faculty Member:
  - Professor Patrícia Pereira da Silva Ph. D;
- Institute for Systems Engineering and Computers(INESC) at Coimbra researcher:
  - Professor Carla Oliveria Ph. D.;
- The Portuguese Association of Renewable Energy (APREN) Collaboration:
  - Ms Lara Ferreira M. Sc.;

5.1 Study development

The first step in the development of the described RES impact assessment project was the analysis of existing studies, the applied methodologies and achieved results. The goal was to identify best practices in development and delivery of studies applying the survey methodology for acquiring relevant input for measuring RE deployment impact on direct employment. The outcome of this phase is the literature review presented in chapters 3 and 4 of this thesis.

The next step of the process was to contact researchers, organizations and government institutions identified in the literature review, which had published studies that applied the survey methodology for the purpose of obtaining the original questionnaire that they used.

The majority of contacted authors throughout the Spring of 2013 replied, however the responses were mostly that the questionnaires were no longer available or aren't kept in their records any longer (which is reasonable in some cases as some of the studies published were done in 2003, 2005, 2006), while some others did not forward their questionnaire, replying that they thought their questionnaires would not be a useful example for the study in development.

The most relevant and detailed survey was received from the German Ministry of Environment, Nature Conservation and Nuclear Safety. The Ministry commissioned drafting of the survey in 2004. Its drafting, deployment and results elaboration was the result of the Ministries cooperation with 6 other research institutions in Germany[10].The second survey used as a reference was available in the annex of the *"Wind at Work"* EWEA study on EU wind energy employment impact (Blanco and Kjaer, 2009) described in the previous chapter.

The questionnaire used in the survey was designed to enable the assessment of the existing number of direct jobs in the RES-E sector, the quality of jobs currently available, and the short to mid-term quantitative and qualitative employment outlook based on the opinion of the companies that would take part. Therefore, similarly to the EWEA survey described above, it consists of three sets of questions.

[10]GWS - Institute of Economic Structures Research; DIW - German Institute for Economic Research; DLR - German Aerospace Center; Frauhofer ISI; Center for Solar Energy and Hydrogen Research Baden Wurttemberg; Bielefeld Institute for Social Research and Communications;

Section 1 – General questions providing specific information on the entity, its location, market presence, revenue and industry activity.

Section 2 – RES-E industry and sector specific questions providing data on specific field of activity, products and personnel of entities in the industry.

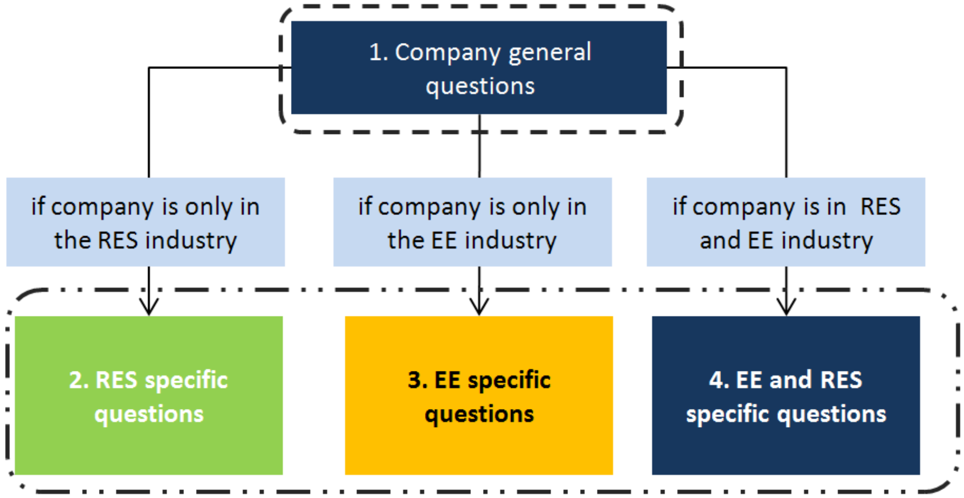
Section 3 – Qualitative RES-E sector employment and short to mid-term employment outlook based on the projections of business entities active in the sector.

Apart from these three sections, as mentioned, the survey also included a section containing questions to assess the employment impact of EE initiatives by enterprises in Portugal, in order to acquire data necessary for both this study and the M.Sc. thesis - *Connecting energy efficiency progress and job creation potential* - developed by my colleague, Mr. Guillermo Pereira.

While maintaining its basic composition, in that the RES and EE questionnaire sections were mirror images in terms of structure, the specific questions within the two sections were adapted to suit the industry relevant aspects and the specific data needs of the two research areas.

Furthermore, the survey contained an additional section, which allowed firms active in both the RES and the EE sector to streamline their survey completion efforts by completing one section to provide both data sets simultaneously, instead of filling out one by one. *Figure 5.1* below illustrates the structure of the questionnaire. The full questionnaire can be reviewed in annex A1 of this dissertation.

Figure 5.1:Draft RES&EE survey structure



The survey was carried out in collaboration with the Portuguese Renewable Energy Association (APREN - Associação Portuguesa de Energias Renováveis), in order to reach as many companies active in the sector as possible. The cooperation with APREN has been established as a result of efforts of Prof. Patricia Pereira da Silva. Securing the participation of APREN in the effort was a crucial milestone, as its membership is diverse and includes a range of associated members, from renewable energy generation companies, to individuals and entities that promote and prioritize the development of renewable energies in Portugal. Furthermore, the Association has established relationships with several key industry players that focus on the issue of sustainable energy systems and energy efficiency, hence the importance of their support reaching this market segment to understand the job creation deriving from both renewable energy systems deployment and energy efficiency efforts.

The research, survey development, rollout and results analysis depicted in *figure 5.2* and *table 5.1* below:

Figure 5.2: RES3E project development timeline

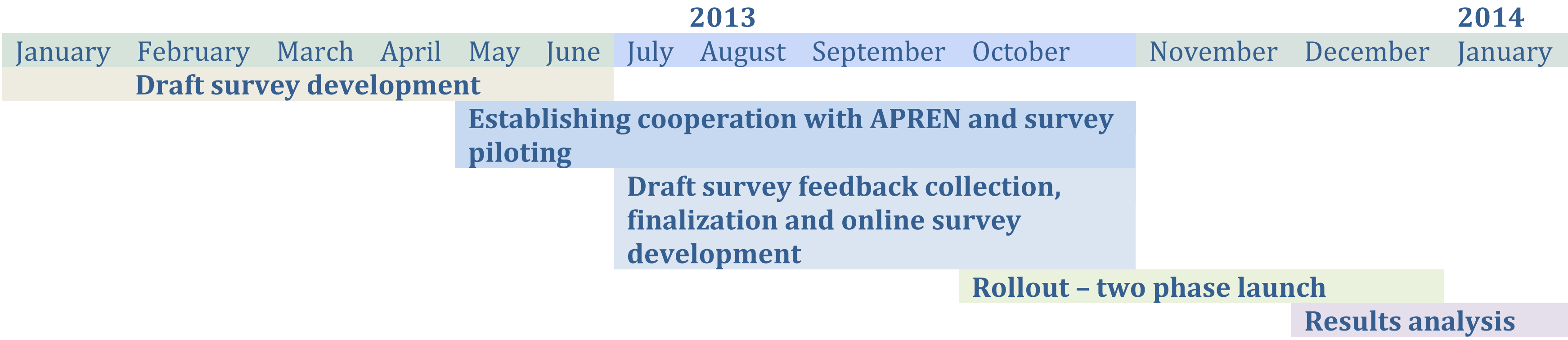


Table 5.1: RES3E project development phases

• **Draft survey development**
- Literature review based on material received from Prof. Patricia Pereira da Silva, and additional relevant sources identified during the research; - Selection of appropriate research methodology in consultation with Prof. Patricia Pereira da Silva; - Identification of surveys carried out in European countries and regions; - Contacting researchers in order to request their surveys implemented in studies and review of received surveys; - Development of questionnaire based on contacted researcher responses and the literature review; - Submitting the draft survey to the thesis supervisor, Prof. Patricia Pereira da Silva.
• **Establishing cooperation with APREN and survey piloting**
- Meeting in Lisbon with Ms. Lara Ferreira of APREN on June 25th2013, in order to define the terms of cooperation; - Submitting of first draft survey to APREN for comments and suggestions; - Participation at the Conference celebrating the 25th anniversary of APREN in Estoril on October 21st 2013, taking the opportunity to personally notify association members' representatives of the upcoming RES3E survey.
• **Draft survey feedback collection, finalization and online survey development**
- Analysis of available internet based survey platforms and selection of most appropriate solution; - Drafting of the online version of the survey on the "Qualtrics[11]" internet based survey tool;

[11] www.qualtrics.com

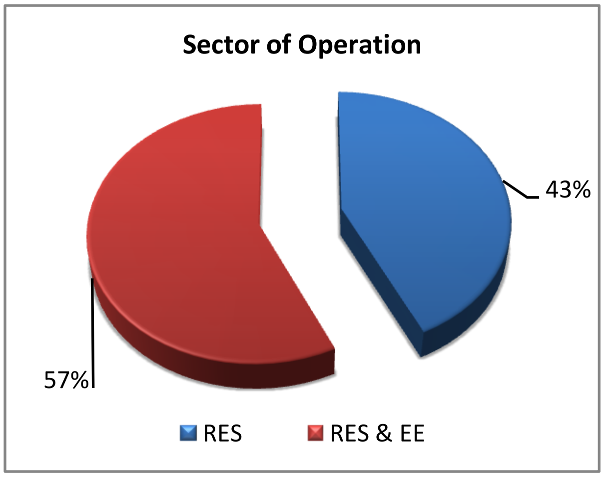
- Finalization of survey based on feedback from APREN and consultations with Prof. Patricia Pereira da Silva and Prof. Carla Oliveira; - Finalizing online Qualtrics survey version.
• **Survey rollout – two phase launch**
- The first survey was launched on October 10th, 2013, with e-mails sent to approximately 370 entities, from a data base compiled by Mr. Guillermo Pereira, consisting of: 1. Energy Service Companies certified by the General Directorate for Energy and Geology of the Portuguese Ministry of Environment, Spatial Planning and Energy; 2. Energy for Sustainability Initiative External Council Companies; 3. Local and the National Agency on Energy and Environment, the Association of Agencies for Energy and Environment, and their members and RNAE Associates; 4. Other RES-E and EE companies. - Final survey rollout by APREN to their members was on October 22, 2013. A 10 day deadline for survey completion was proposed in the follow up email. As in the first rollout, companies received a link which would take them directly to the survey. The responses were recorded on the Qualtrics platform for post-survey analysis. A follow up was sent by APREN to companies to remind them of the survey on the 27th of October; - Separate cover letters to accompany the survey Qualtrics link were drafted for each distinct target group of entities described above, in order to clearly emphasize the potential contribution of their responses to the better understanding of RES and EE deployment impact on employment; - Regardless of the proposed survey completion deadlines, the surveys were kept active online for the full 100 day duration offered by the Qualtrics platform.
• **Survey results analysis**
- Results were analyzed in December 2013, and January 2014; - 100 entities from Phase 1 rollout accessed the online survey, while 34 logs were recorded from Phase 2 launch; - Total of 21 fully completed questionnaires for the RES-E sector, containing all relevant entity employment data; - Further internet research of data of entities that have opted to disclose their names; - Survey data analysis was carried out in Excel. Although the initial intention was to carry out a thorough analysis and calculation of indicators in SPSS, due to the low response rate and lack of quality of received data this preference was forgone.

5.2 Survey results analysis[12]

As mentioned in the *table 5.1* above, a total of 21 valid questionnaires were recorded from more than 500 entities invited to take part in the RES3E Project survey. This represents less than a 5% rate of return of valid responses, and therefore the data gathered on the number and quality of jobs in the RES industry in Portugal does not constitute a representative sample as a result of which valid conclusions can be drawn. Nevertheless, this section will present a summary of the data that has been received according to the three groups of questions within the scope of the survey.

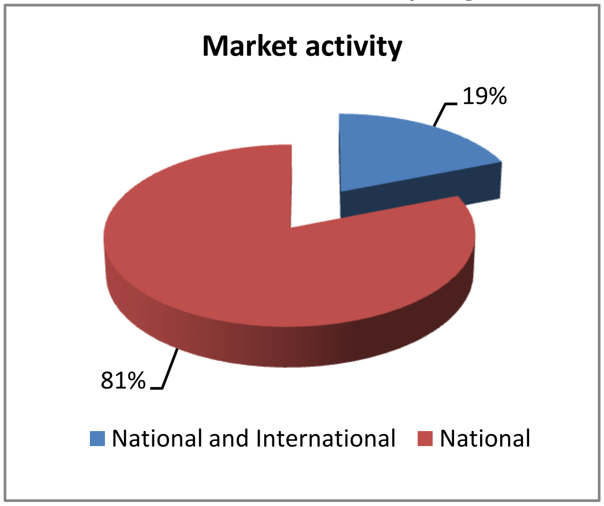
5.2.1 Entity background data

Chart 5.1: Sector of operation of survey respondents



Slightly more than half of the entities that responded to the survey, 12 of them are active only in the RES sector, while 9 are active in both RES and EE sectors.

Chart 5.2: Market reach of survey respondents

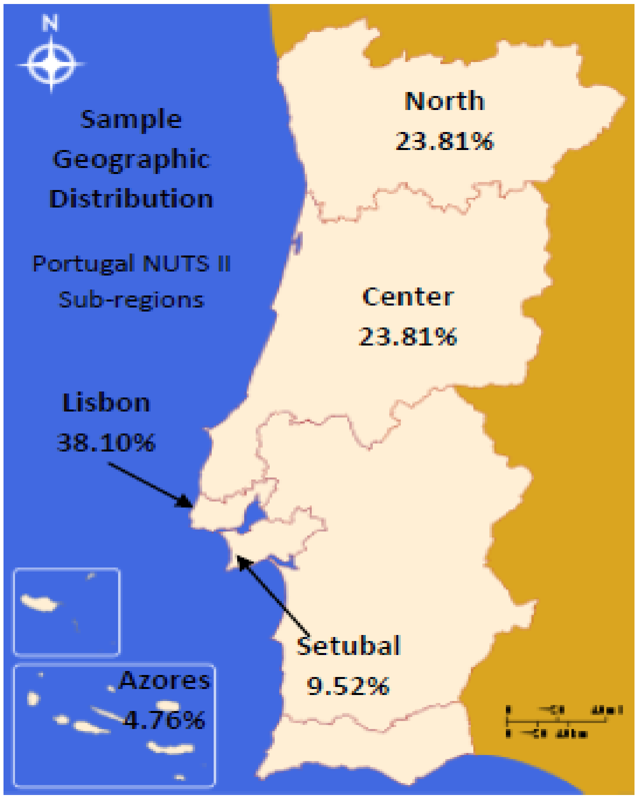


Only 4 of the 21 respondents carry out operations in both the domestic Portuguese and the international market. Naturally, those are also the 4 largest companies that responded to the survey in terms of both revenue and employment.

[12] All charts, tables or figures used in this section are created based on feedback of entities participating in the RES3E Project survey.

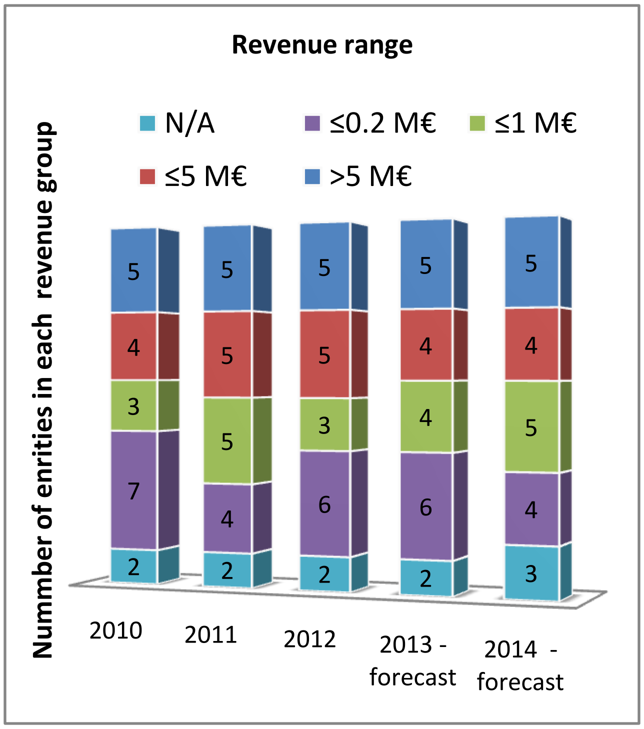
The survey required participants to identify their location based on the type III Nomenclature of territorial units for statistics (NUTS)[14], however for practical purposes, and due to the low survey reply rate, the headquarters of respondents are presented according to the NUTS II nomenclature in *figure 5.3.* Unfortunately, no valid survey responses were received from the regions of *Alentejo*, *Algarve* and *Madeira.* The Lisbon region with 8 entities was most represented in the survey, while North and Center produced valid results from 5 respectively.

Figure 5.3: Territorial study results map of NUTS II regions[13]



Two options were given to respondents in the survey for providing revenue data. They could either provide exact revenue or indicate a range; the majority selected the latter option. The received data, as presented in *Chart 5.3,* shows a consistency of large enterprises in annual revenue rates of above 5 million Euros, as well as a relatively even distribution of respondents' revenue levels in the available categories. The results of this question indicate that entities of all sizes were equally represented in the sample.

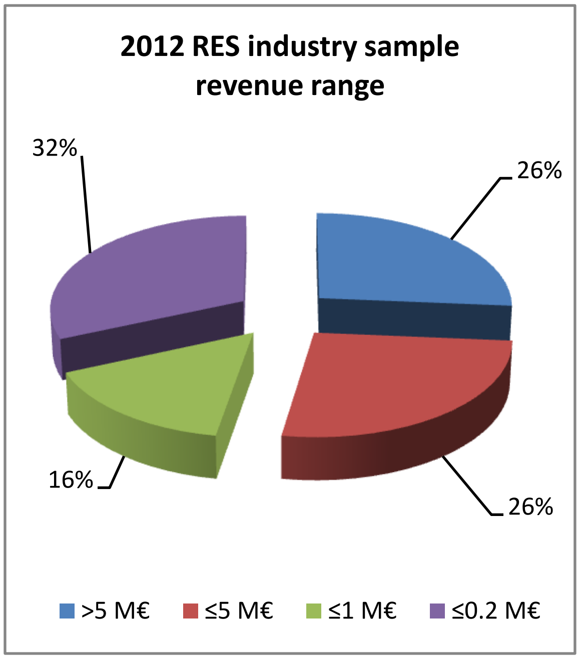
Chart 5.3: Revenue ranges of sample respondents



[13]Map source: http://en.wikipedia.org/wiki/Administrative_divisions_of_Portugal
[14]Source: http://epp.eurostat.ec.europa.eu/portal/page/portal/nuts_nomenclature/introduction

Based on the data, it is clear that the highest fluctuation of entity revenue is present between the <0.2M€ and <1M€ groups, indicating that a considerable number of sampled entities (at least having in mind the size of the sample) are, or expect to be, hovering around annual revenues of 0.2M€. Chart 5.4 displays the proportion of entities that have provided data in the available revenue groups. Unfortunately, the data is not consistent with other studies finding (Llera et al. 2010), which find a higher proportion SME's in terms of revenue in the overall RES markets.

Chart 5.4: 2012 RES industry revenue breakdown

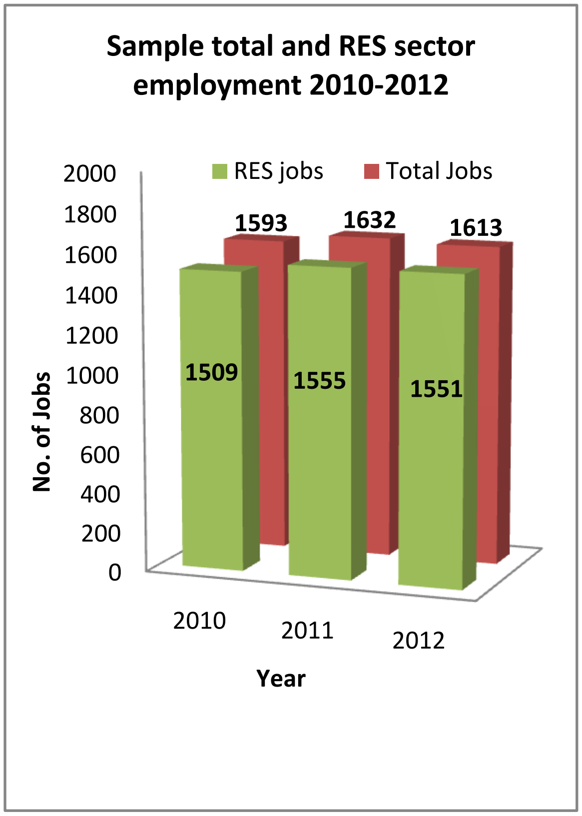


5.2.2 RES Sector, employment and field of activity

The entities that completed the survey reported a total of 2.460 jobs in 2012. Unfortunately, the second biggest employer that took part in the survey, EDA - Electricidade dos Açores S.A, did not designate which proportion or amount of the total jobs reported are pertaining to the RES part of their enterprise. This existing data could not be supplemented by online sources; therefore the jobs reported by this company were not included in the following analysis.

Chart 5.5 is an overview of total employment reported by entities that took part in the survey. Evidently, most of the employment created by these companies pertains to the RES sector,

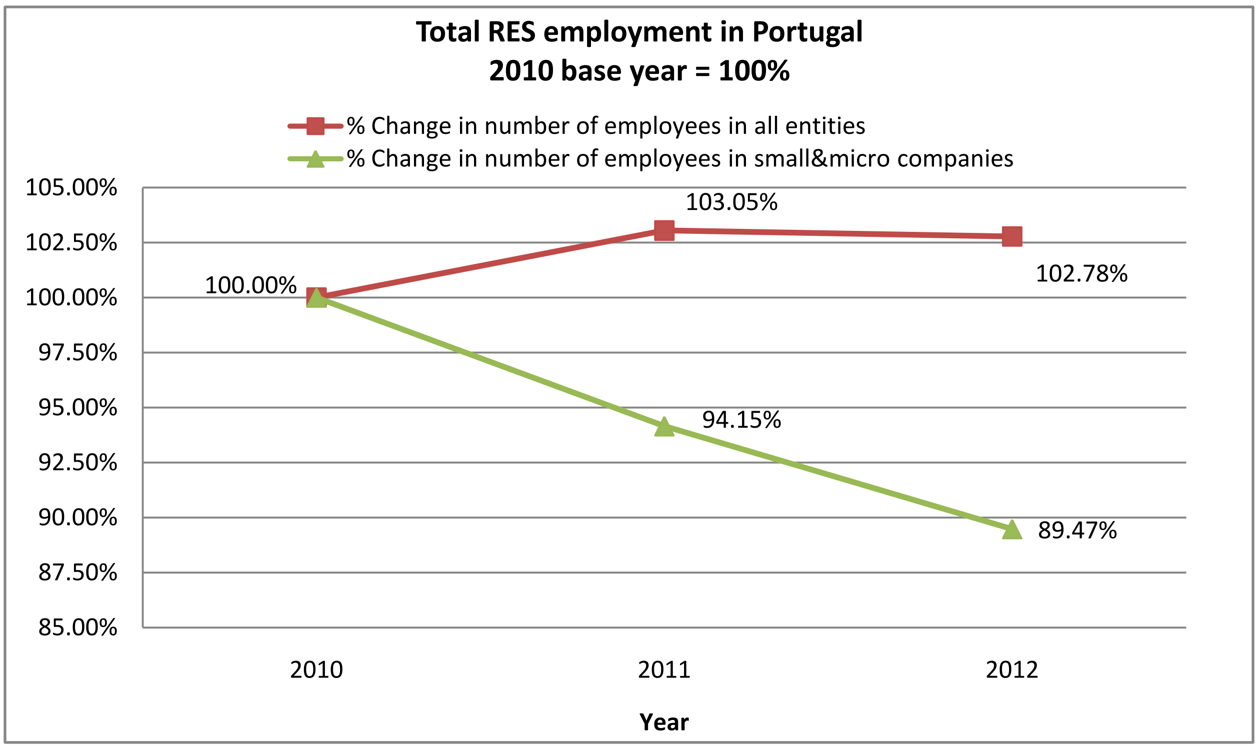
Chart 5.5: Number of employees, complete sample



especially as concerns the larger employers in the sample. Only a few small companies, those also active in the EE sector, reported employment other than RES activity related.

Changes in the number of jobs across the three studied years, as shown in *chart 5.6*, can be interpreted in two ways as a result of the distribution of sample data. There is slight increase in RES employment within the sample entities between 2010 and 2012, amounting to 1.4%. However, as *chart 5.7* below demonstrates, the increase in employment is actually the result of larger enterprises requiring an increase in staff, while sample small and micro-companies[15] are facing a significant workforce reduction of 10% during the same period, following a nearly perfect average 5% annual rate of job losses.

Chart 5.6: Employment evolution in RES sector, total sample and small and micro-companies



The sample survey respondents included representatives of all sectors of the RES industry and RES technologies. Most of the entities were either involved in more than one sector of the industry, and/or carried out activities related to more than one renewable technology. *Table 5.8* presents this aspect of the complexity of the RES industry sector entities. Unfortunately,

[15] Source of definition of medium, small and micro companies: http://ec.europa.eu/enterprise/policies/sme/facts-figures-analysis/sme-definition/index_en.htm

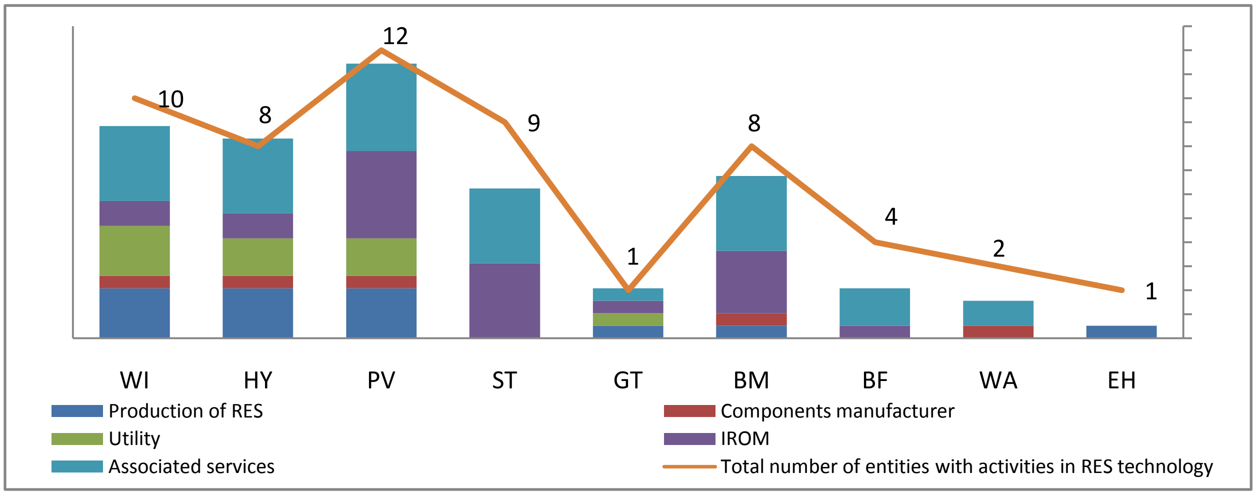
although the questionnaire was designed to provide an option for such entities to indicate the number of employees dedicated to each sector of operation, none of the respondents took the opportunity to do so. Therefore, there is no clear data on the exact number of jobs per sector and per technology generated by the sample entities. There's neither an indication in relevant literature on how to assess this type of aggregated data, nor were there described experiences or proposed solutions for this issue in the surveys that were used as models for the RES3E Project survey. To provide a better overview, *table 5.2* and *chart 5.7* count the number of companies per sector and per technology.

Table 5.2: RES sector and RES technology activities of sample entities[16]

<table>
<tr><th>Sector
Entity</th><th>Utility</th><th>Production of RES systems</th><th>IROM[17]</th><th>Associated Services</th><th>Component Manufacturing</th></tr>
<tr><td>1</td><td></td><td colspan="5">HYDRO; WIND; SOLAR THERMAL; PV; BIOMASS; WAVE</td></tr>
<tr><td>2</td><td>HYDRO</td><td></td><td></td><td></td><td></td></tr>
<tr><td>3</td><td></td><td></td><td></td><td>HY; WI; ST; PV; BM; BF</td><td></td></tr>
<tr><td>4</td><td></td><td>WIND</td><td></td><td></td><td></td></tr>
<tr><td>5</td><td></td><td></td><td>ST; PV; BF</td><td></td><td></td></tr>
<tr><td>6</td><td></td><td></td><td></td><td>HYDRO</td><td></td></tr>
<tr><td>7</td><td></td><td>HYDRO</td><td></td><td></td><td></td></tr>
<tr><td>8</td><td></td><td></td><td colspan="2">PV</td><td></td></tr>
<tr><td>9</td><td>WIND</td><td></td><td></td><td></td><td></td></tr>
<tr><td>10</td><td></td><td></td><td></td><td>HY; WI; ST; PV; BM; BF; WA</td><td></td></tr>
<tr><td>11</td><td></td><td></td><td>ST; PV; BM</td><td></td><td></td></tr>
<tr><td>12</td><td></td><td></td><td></td><td>HYDRO; WIND</td><td></td></tr>
<tr><td>13</td><td></td><td>EH</td><td></td><td></td><td></td></tr>
<tr><td>14</td><td></td><td></td><td colspan="2">ST; PV; BM</td><td></td></tr>
<tr><td>15</td><td colspan="2">HYDRO; PV</td><td></td><td></td><td></td></tr>
<tr><td>16</td><td></td><td></td><td></td><td>WI; ST; PV; BM; BF</td><td></td></tr>
<tr><td>17</td><td></td><td></td><td>ST; PV; BM</td><td></td><td></td></tr>
<tr><td>18</td><td>WIND</td><td></td><td></td><td></td><td></td></tr>
<tr><td>19</td><td></td><td></td><td colspan="2">ST; GT; BM</td><td></td></tr>
<tr><td>20</td><td colspan="2">WIND; PV</td><td></td><td></td><td></td></tr>
<tr><td>21</td><td colspan="4">HYDRO; WIND; PV; GEOTHERMAL</td><td></td></tr>
</table>

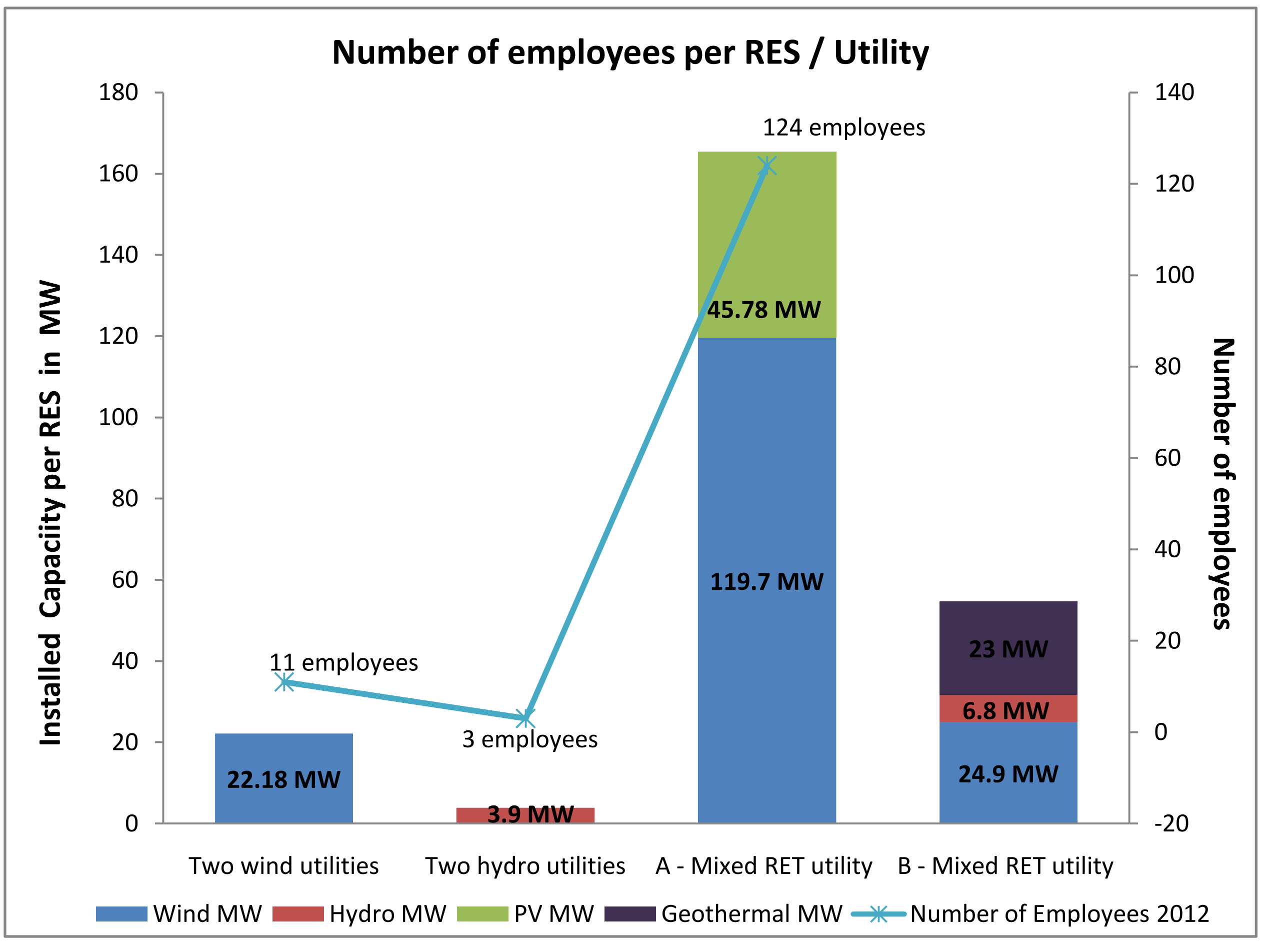
[16] Wind-WI; Hydro-HY; Photovoltaic-PV; Biomass-BM; Biofuels-BF; Wave-WA; Geothermal-GT; Solar Thermal-ST; Energy harvesting-EH.
[17] Installation, Reparation, Operations and Maintenance.

Chart 5.7: RES technologies represented in sample by sector activity, 2012 data



Six utility companies are represented in the sample survey. Two are hydropower plants and two are wind power plants, while the remaining two are larger utility companies producing electricity from (A) wind and PV, and (B) wind, geothermal and hydropower respectively.

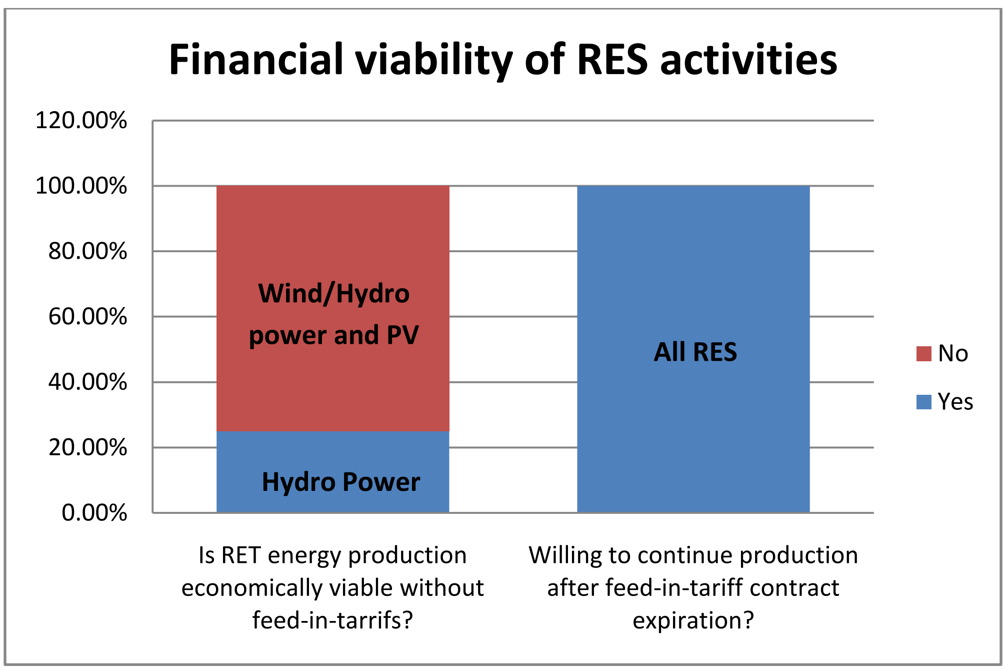
Chart 5.8: Sample utility companies installed capacity per RES technology and employment, 2012 data



The same aggregation of jobs data, as mentioned above, does not allow estimating the number of jobs per RES technology created in the two utility companies producing electricity from more than one source, due to the fact that the respondents did not choose to indicate the technology specific employment data in the survey. The small data sample of wind and hydro utilities cannot be considered a sound source for calculating reliable employment factors for operations and maintenance in Portuguese wind and small-hydro power sectors. The 0.77 jobs/MWp for hydro, and 0.49 jobs/MWp for wind calculated from the above data (methodology source: M. Wei et al. 2010; Breitschopf et al. 2012), do not correspond with ranges of employment factors for O&M in hydro and wind power presented in literature (M. Wei et al. 2010; Moreno et al. 2008)

Five of the six sample utility companies stated in the survey that they are benefiting from feed-in-tariffs for the production of RES-E offered by the Portuguese government. They assess the financial viability of RES-E production without feed-in tariff support as shown in *chart 5.9.*

Chart 5.9: Feed-in tariff benefits and outlook of sample utility companies

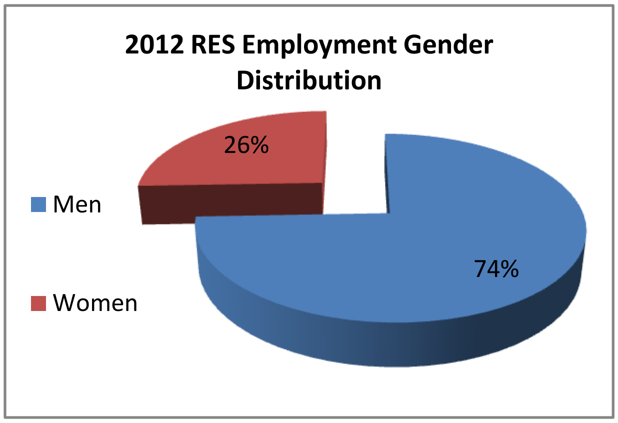


Only the smallest hydro power plant participating in the survey, with an installed capacity of 0.085 MW, stated that production would be economically viable without feed-in-tariff support, however they are themselves benefiting from the measure. With their feed-in tariffs due to expire in 2025 and 2028 for hydro power, and 2022 for wind power, the utilities plan to continue production beyond these years.

5.2.3 Employment quality and future outlook

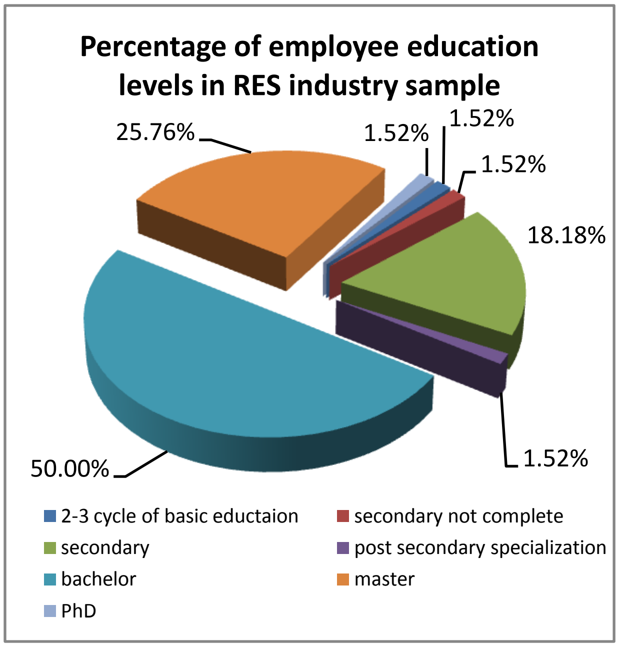
This section of the survey provided interesting data on trends in RES entities sample on employment quality, gender distribution and short to mid-term outlook of the respondents. Out of the 21 entities that completed the survey, 16 provided detailed data on gender distribution, education levels and background. The three largest employers (Utilities, and RES manufacturing) in the sample and two small companies (IROM, production of components and provision of services) did not provide this data, bringing the total number of jobs evaluated in terms of gender and education down to 66. The 5 companies did however provide short to-mid term projections; therefore the complete sample is represented in that regard.

Chart 5.10: RES 2012 employment gender distribution



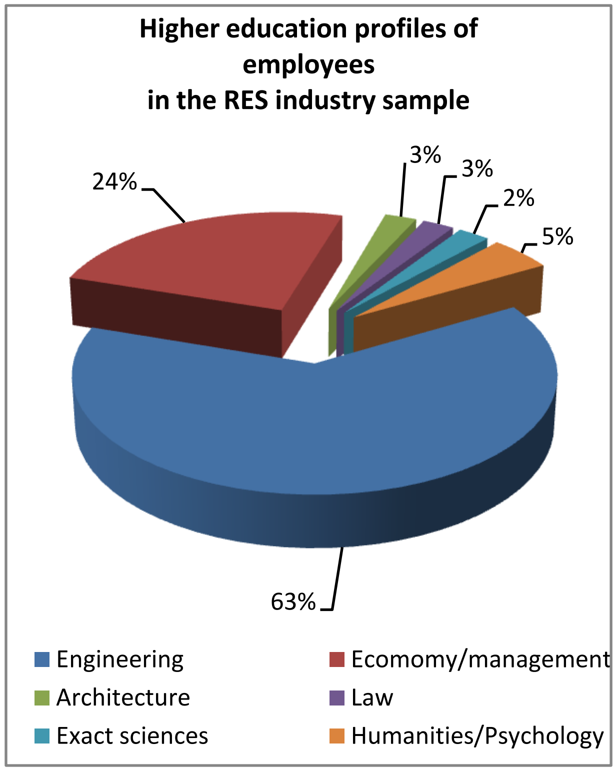
The gender distribution in *chart 5.10* demonstrates that, according to the available data, in 2012 RES was a predominantly “male industry”, showing that they hold 48 of the jobs counted. This figure is consistent with similar studies, which show an average of 78% of male employees in the RES sector (Blanco and Rodrigues, 2009; IRENA, 2012).

Chart 5.11: RES 2012 employment education profiles



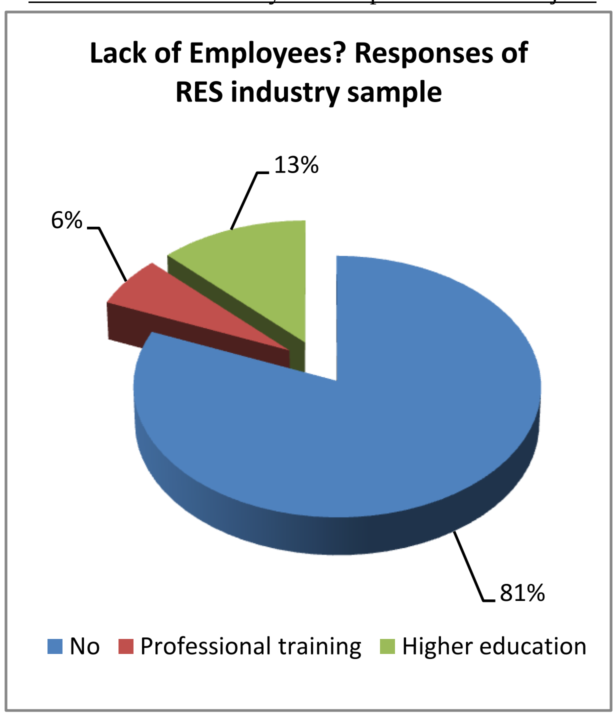
A high proportion of employees in small RES entities hold university degrees Less than a quarter are not university graduates, while bachelor and masters degree graduates represent more than 75% of the employees of evaluated entities. This is a remarkable proportion, although probably not a valid statistic having in mind that only smaller firms completed this part of the survey. Other studies have shown that between 40-50% of the employees in the RES sector are university graduates (Llera et al. 2010; BMU, 2010).

Chart 5.12: Education profiles of RES sector employees



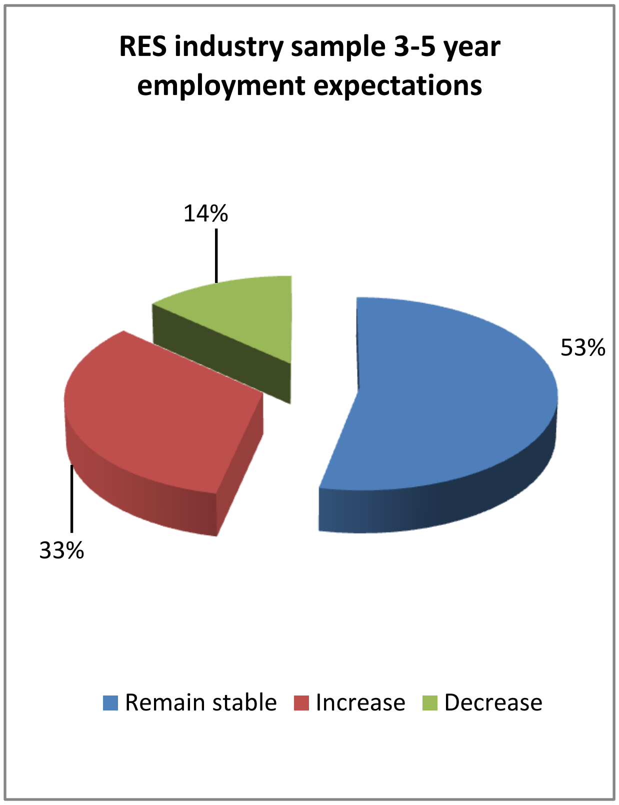
As expected, the conclusion that is drawn from the sample data is that the employees holding a higher education degree, as seen in *chart 5.12*, are mostly engineers (mechanical, electrical or chemical, as the survey question did not require more specific data), representing 63%. Economics or management graduates make up one quarter of the RES staff, while the remaining positions are filled by lawyers, scientists, architects and humanities or psychology graduates. These conclusions are complementary with RES industry skill requirements identified in studies (B. Moreno et al. 2008; Blanco and Kjaer, 2009).

Chart 5.13: Availability of skill profiles for RES jobs



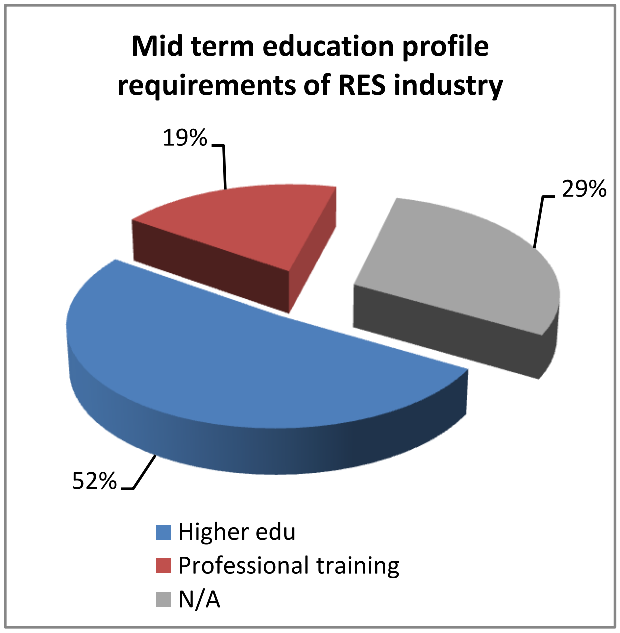
Portuguese RES entities report a comparatively lower rate of lack of specialized individuals than other similar studies in the EU (Blanco and Rodrigues, 2009; U. Lehr et al. 2008). 81% of entities are not facing a lack of employees, while 13% require staff with university degrees and 6% would need workers with specialist training. The reason for the discrepancy with other European studies may be the general economic downturn currently experienced in the country inhibiting expansion of activities, or possibly the success of Portuguese education institutions in adapting study programs to suit the needs of contemporary industry. Unfortunately the small sample size does not allow further analysis of this matter, or provide conclusive insight.

Chart 5.14: RES industry employment expectations



More than half of surveyed entities expect a stable 3-5 year employment outlook, as shown in *chart 5.14* .The trend that can be observed is that companies facing employment cuts in the recent past are more pessimistic and expect further decreases in job numbers. Larger companies expect the situation to be stable in the next 3-5 years, while a number of small entities are very optimistic, some even expecting 50-100% growth in their employment in the short term. According to the recorded response no RES sector is more optimistic or pessimistic than others, as all three answers were equally distributed among all participating sectors and technologies.

Chart 5.15: RES entities mid-term employment outlook



Almost 30% of the RES entities that provided data for the third part of the survey did not reply to this question. There is no indication as to the reasons why this one was not replied to as all entities that replied to at least one, replied consistently to all questions in this section. This again may be indicative of the uncertainty of the general economic outlook the industry members may be facing. Those that have answered stated that they will be searching for one form or another of specialized personnel. More than half of the sample indicated that their primary focus will be to recruit university graduates, while the remaining 19% stipulated an expected need for workers trained for specific tasks.

5.3 RES3E project outcome

Although the RES3E survey deployment was not successful in mobilizing a representative sample of Portuguese entities active in the renewable energy sector, and therefore valid conclusions about the sector quantitative and qualitative employment impact could not be drawn, there are a number of lessons learned for future employment impact assessment endeavors using the survey methodology.

- One of the apparent weaknesses in the project was the issue of ownership of the survey deployment process, in terms of communication between the researchers and the target group, especially with regard to the 2nd phase of survey rollout, which was facilitated thanks to the partnership established with APREN. The association directly forwarded by e-mail the survey cover letter, including the link for the online survey prepared by the researcher, to their members. As a result of not being involved in the deployment, the researchers were not aware of any potential e-mail responses, doubts or clarification requests from APREN members to the initial e-mail survey invitation. Furthermore, the researchers were not aware of the exact number of APREN associates that were invited to complete the survey, because of which the exact response rate cannot be calculated. Therefore, it is imperative in such studies that the researcher team is involved in all aspects of the process form "A to Z" if a satisfactory quality and quantity of data is to be expected (also indicated as a prerequisite of survey success in Blanco and Rodrigues, 2009).

- The decision to provide survey respondents the opportunity to remain anonymous was seen as a potential strength of survey design, as it was expected that a larger proportion of entities would be more comfortable with sharing data, which could be perceived as sensitive, with the researchers if they would not need to disclose their name and organization details. However, there were many incomplete questionnaires that could have been supplemented with direct interview information, improving the response rate and possibly, if cooperation would have been received by a substantial proportion of such entities, securing a valid sample of data for acquiring insight on employment trends in the Portuguese RES sector. Unfortunately, the majority of incomplete survey responses were from anonymous participants so follow up contacts could not be established.

- The academic character of survey deployment, combined with the length of the survey, may not have provided sufficient motivation for participants to devote their time and carefully provide all of the requested information. However, deployment of a less detailed and shorter survey would only compromise the quality data that can be acquired. Most of the complete survey responses were submitted by small and micro enterprises. The data requested in the survey was quite broad, and in a larger enterprise it could not have been completed by a single individual without consulting in-house registries, databases or perhaps initiating an inter-departmental cooperation for its completion. More successful survey examples in literature do not discuss in detail the circumstances of their study deployment; however, they were either government backed, as in the case of the surveys carried out in Germany and the Spanish region of Aragon, or strongly supported by international associations, as in the case of the EWEA survey. Therefore, it appears that entities would need to be lobbied more persistently to participate in such endeavors, or motivated otherwise.

- As mentioned in chapters 3 and 4, the reviewed literature on survey deployment rightfully so states that successful RES employment impact survey deployment requires a significant amount of time and resources, primarily in terms of staff for carrying out the project. In terms of material resources, although the Qualtrics online platform is excellent in terms of the quality of a survey that could be built without charge, certainly the best such online platform available, for pay solutions offer significantly more sophisticated question design and data analysis tools as part of the subscription packages. In terms of manpower, all surveys presented in literature were followed up by telephone or personal interviews with representatives of the target group. Unfortunately, the scope of the RES3E project and the survey design itself were not envisaged so as to facilitate a strong survey deployment follow-up.

In summary, the experience of the RES3E project suggests that in order to carry out a successful RES employment impact survey, the following conditions need to be met:

- Researchers must have full ownership of the survey process;
- The survey target group needs to be strongly motivated to provide the required data. This could be either government backing, stronger industry lobbying or other forms of incentives to RES entities for their participation;
- Strong follow up in the form of post survey interviews is imperative to successful data acquisition from industry representatives;
- Strong human resources capacities are necessary to achieve successful survey deployment, post-survey follow-up and data analysis.

Nevertheless, the RES3E survey project did establish a framework and added experience for carrying out RES employment impact analysis surveys in Portugal:

- Partnership between the Energy for Sustainability initiative of the University of Coimbra and APREN resulted in cooperation on a joint project to deploy the first RES employment impact survey in Portugal.
- A comprehensive survey has been created. If updated, redesigned and upgraded, and with stronger awareness raising and support within the industry on the merits of carrying out such a comprehensive study, improved results can be reached.

6. Conclusion

The goal of this dissertation was to assess the employment impact of renewable energy deployment in Portugal. First of all, to set contextual framework of assessing employment impact of RES deployment, the development of the renewable energy legislative framework and support measures, as a result of which countries are incurring significant financial expenditures, in the EU and Portugal was presented, along with the respective progress in achieving set RE deployment targets for the year 2020. Secondly, an extensive literature review of RES employment impact studies was provided in chapters 3 and 4, for the purpose of identifying the appropriate course of action for developing and carrying out a RES employment impact study in Portugal. Finally, the results and outcome of the Portugal RES employment impact study were described in chapter 5.

Key conclusions drawn from the renewable energy deployment context, legislation and policy measures overview in the EU and Portugal are the following:

- Regardless of the renewable energy deployment support policies in effect, the majority of EU member states are on course to fall short of the target 2020 final energy consumption share of RE. Mitigation of non-economic RET deployment barriers would significantly improve the outlook for reaching the 2020 targets Union wide;
- Renewable energy policy support measures should be devised so as to secure reduced barriers and investor risk for RET deployment, application of best practice support system design, and allocation of technology-specific support. In terms of the repeatedly underlined threefold benefit of renewable energy deployment in EU and Portuguese legislation (climate change mitigation, improved security of energy supply and employment creation), adopted policy support measures need to be consistently monitored for their effectiveness, efficiency, equity and institutional feasibility, through establishing specific impact success indicators to monitor the adherence of the measures to the set criteria;
- As employment creation is one of the legislative goals of promotion of renewable energy deployment, the success of policy support measures in achieving job creation targets in the industry should be measured and monitored equally as RET deployment contribution to climate change mitigation and security of energy supply are;

Researchers intending to carry out studies assessing the employment impact of renewable energy systems deployment should follow a sequence of steps to select the appropriate methodology for their project, based on the specific research goal and capacities to accomplish the task at hand:

- Identify the type(s) of jobs (direct, indirect, and induced) that will be assessed in the study. Therein it is important to determine the system boundary of the renewable energy technology(ies) job type(s) which will be studied, i.e. to specifically define which jobs for which technologies constitute what will be considered direct and indirect employment effects;
- In accordance with the prior step, select the scope; whether the gross or net impact on employment is to be assessed and measured;
- Select the appropriate methodology and apply the specific tools which can be used to estimate the employment impact of the type and scope of employment identified as the research topic according to the prior two steps; and
- Specific knowledge and expertise of researchers, and resources are required for applying the different RES employment impact assessment methodologies, therefore the capacities of the research team in this regard need to be taken into account prior to setting the goals of the research project.

The numerous RES employment impact studies reviewed within this thesis sometimes apply slightly different standards in drawing the line between direct and indirect employment creation effects of renewable energy deployment in assessing job creation potentials of the same technology, making it difficult to compare these effects across countries and regions. Furthermore, different employment factors (MW/jobs, MW/job-years, MWp/jobs, MWa/job-years, etc.) are used to estimate the job creation potential of RES in its various lifecycle phases (CIM, O&M, also sometimes elaborated differently), again creating obstacles in evaluating the different employment creation prospective of the technologies across territories. Guidelines or a proposal for standardization of these matters coming from a recognized authority (EU, international organization, institute, etc.) would facilitate easier cross-country RES employment effects comparison, creating a baseline for improved international comparison of national RES policy deployment support measures impact in terms of employment creation, therein allowing better identification of best practices in this regard and their implementation in other countries (in accordance with their existing socio-economic conditions).

In accordance with recommendations drawn from the literature review, the *RES3E*survey for assessing employment impact of renewables deployment in Portugal was developed and defined the research focus and scope as follows:

- The aim of the survey was to acquire data to measure the gross employment impact, number of direct jobs existing in the renewable energy industry in Portugal.
- Direct employment was for the purpose of the survey defined as full time, part time, permanent and temporary employment existing within companies that manufacture and construct RES, facilities or their components, produce energy from RES, carry out equipment operation, maintenance and various services in the field of RET, and trade in renewable energy.
- Within this definition, the survey attempted to measure the qualitative and quantitative RES employment impact in Portugal; the labor intensity that goes into those RES jobs, through calculating employment factors for the different lifecycle phases of the various RE technologies deployed in Portugal for electricity production, the education level of employees, the duration of employment and the gender distribution.

As described in the previous chapter, the low survey response rate did not allow valid conclusions to be drawn about the sector quantitative and qualitative employment impact. Nevertheless, the process provided a number of lessons learned, for future RES employment impact assessment projects using the survey methodology:

- Researchers ownership of the survey deployment process;
- Motivated survey target group;
- Strong post survey follow-up;
- Sufficient material and human resources for project execution.

The conditions contributing to the shortcomings of the *RES3E* survey outcome were in fact potential weaknesses and risks of a survey deployment process identified in literature. In terms of possible future research, these are the exact issues that should be corrected upon deployment of a new survey.

This future research can build on the framework and experience for carrying out RES employment impact analysis surveys in Portugal that created by the *RES3E* project, including the established cooperation of the EfS Initiative with APREN, and the representatives of companies that have provided their contacts in the survey. The *RES3E* survey should be updated, redesigned and upgraded for this purpose. With stronger awareness raising and support within the industry (and possibly the Government of Portugal or its relevant bodies as well) on the merits of carrying out such a comprehensive study, improved results and assessment of employment impact of RES deployment can be achieved.

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