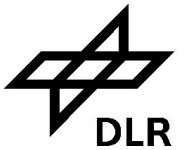

International Workshop

"Renewable Energy: Employment Effects"

- Models, Discussions and Results -

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1. Introduction

The positive impacts of an increasing share of renewable energy on the mitigation of climate change and on decreasing the dependence of energy imports are indisputable. However, the *full economic* impacts of supporting renewable energy technologies are controversial and have been frequently disputed. The debate lies in whether the beneficial effects on the renewable energy industries might be offset by the economic burden of financing the additional costs that still are incurred by supporting renewable energy technologies. The effects on the labor market are of especially great concern to policy makers and other stakeholders.

With the increasing proportion of renewable energy in the overall energy mix, employment effects become more and more relevant. The scientific community has responded by publishing a substantial body of literature in the last several years. A variety of approaches and models has been used and has led to many different and sometimes contradicting results.

An international workshop was organized by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) in order to get a comprehensive overview over the existing results by means of presenting and discussing the most recent studies from various countries and regions. Most participants were researchers working on employment effects studies. The workshop took place in Berlin on April 23rd & 24th, 2007 (cf. appendix 1).

This paper gives a brief summery of the findings from the workshop. It is aimed towards politicians and other stakeholders and should provide detailed insight into different approaches to analyzing employment effects and the comparability of existing results. The discussion which took place in the workshop is resumed in order to show the advantages and disadvantages of the respective methods used.

2. Overview

What are the impacts of supporting and promoting renewable energy technologies on the labor market? How is employment affected if a country tries to raise the share of renewable energy in its energy portfolio? What are the important influencing factors? What development is expected within the next 10, 20 or 30 years? These are some of the questions the discussion around employment effects of renewable energy tries to answer.

The complexity of examining employment effects is reflected in the various macroeconomic impacts that have to be taken into account (cf. Figure 1).

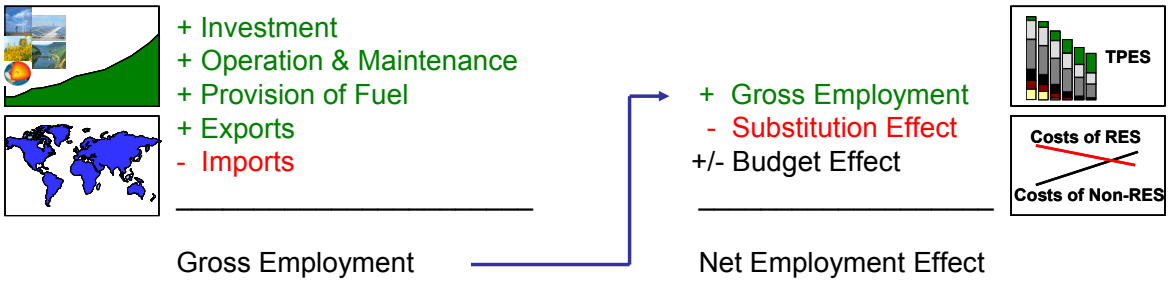


Figure 1: Representation of the correlation between gross and net employment effects

Firstly, Investment, operation and maintenance, and the provision of fuel create direct employment in the renewable energy industry. In addition, goods and services are required from other industries thereby indirectly providing employment via subcontractors and suppliers.

Secondly, foreign trade plays a role. Employment will not necessarily be created in the country of system installation. Wind turbines installed in France might come from a production site in Denmark or Germany, just as PV-modules installed in Germany might originate in the United States or Japan. Similarly, biomass pellets used in Italy could originate in Austria. Foreign trade undoubtedly introduces a challenge to the employment effect analyses. This issue of foreign trade is expected to become increasingly prevalent in the future as the number of large renewable energy companies expanding to international status increases.

Gross employment therefore results from the sum of direct and indirect employment derived from the national and international turnover of domestic companies. While this figure is always positive, there are counterbalancing effects and the total - net - employment effect can be positive or negative. The net employment effect additionally takes the effects of the expanding use of renewable energy on other economic sectors into account.

Total employment will be negatively affected by the so-called substitution effect. This effect takes into consideration that a growing amount of renewable power and heat leads to less new conventional power capacity being needed. Therefore, less employment is generated by investments in conventional power and in their operation and maintenance than without the expansion of the use of renewable energy sources (RES). Although this effect is currently of little importance in most countries, with expanding plans for the use of RES in many countries and regions it could play an important role in the future.

The so-called budget effect derives from the additional costs of renewable energy technologies. This cost difference is borne by the economy as a whole. Therefore, parts of the private and / or public budgets will be spent on energy from renewable sources and cannot be spent on other goods. The reduced expenditures on other goods lead to reduced turnover and therefore to a reduction in employment. Currently it has a negative influence on employment in other sectors. In the future, should renewable energy become cheaper than conventional energy, this effect might be reversed in the favor of renewable energy.

Often, the goal of employment effect analyses is to determine how employment may change under certain support policies compared to others or to business as usual. Therefore, the

gross and net effects have to be calculated for different realistic scenarios. The balances of these scenarios lead to the total overall net and gross effect.

To compare the results of different studies the methodologies, assumptions and available data must be carefully examined. Various studies on the labor market effects of the use of renewable energy have been published in different countries in the last years. Eight of the latest publications from different countries were presented and discussed at the workshop. The methodologies, results and political background of these studies are presented below.

To facilitate comparison, a classification scheme was developed presenting the renewable energy sources discussed and the employment effects included in the individual studies (cf. Table 1). However, this classification scheme cannot yield a direct comparison and/ or ranking of the studies presented as underlying data and procedures differ markedly.

Table 1: Classification scheme

RES for	Gross Employment Effects				Net Employment Effects	
	Direct Employment	Indirect Employment	Export	Import	Budget Effect	Substitution Effect
Electricity						
Heat						
Transport						

The employment effect investigations range widely in their goals. They may aim to provide a quick and easy-to-handle indicator number that is easily understood and easy to communicate or to create a complex analysis of all the above mentioned effects with the help of different models based on a multitude of equations. Each approach has its benefits and its applications.

Different methodological approaches can be used to estimate gross employment: One frequently applied approach generates a ratio of employment per unit capacity installed or money spent – in the following called the analytical approach. For a wider analysis of the economy, Input-Output-Tables can be taken into consideration, often implemented in more complex macro-economic models. Though equilibrium models find frequent applications in energy and climate change modeling, they have not yet been employed to questions concerning renewable energy. Therefore, these models were not represented at the workshop. The studies are presented according on the methodology used.

3. *Analytical approach*

The analytical approach leads to an easily communicable result, usually the employment per amount invested, per capacity installed or per unit of energy produced. As the summary of presentations of studies using this approach shows, it can either focus on direct employment [Kammen04 or Moreno/López07] or on gross employment, thereby also taking indirect employment into account [DTI04]. Results are of indicator type and different future development paths can easily be outlined proportional to the changes in capacity, investment or energy produced. If the work attributed to respective technologies is distinctly modeled, different compositions of the renewable energy portfolio lead to different employment effects. This approach is often chosen when data requirements for a more complete economic analysis cannot be met for countries or regions in question or when the object of investigation is the production sector rather than the whole economy. Three examples of this approach are presented showing the scope of its contributions.

The effects of renewable energy on employment - the case of Asturias

Table 2: Effects included in the study "The effects of renewable energy on employment – the case of Asturias"

RES for	Gross Employment Effects				Net Employment Effects	
	Direct Employment	Indirect Employment	Export	Import	Budget Effect	Substitution Effect
Electricity						
Heat						
Transport						

The study "The effects of renewable energy on employment – the case of Asturias" by Moreno and Lopez of the University of Oviedo was published in 2006 [Moreno/Lopez07]. It was supported by the Government of the Principality of Asturias (Industry and Employment Council), the Asturian Energy Foundation (FAEN) and the Foundation of the University of Oviedo (FUO) with the goal to estimate the impact of renewable energies and new energy technologies on energy employment in Asturias, a northern region of Spain. The regional focus of the study leads to some very interesting methodological challenges.

The interest in energy sector employment results from the industrial structure in Asturias. Coal mining and steel production have been major drivers of the region's economy, which has recently been undergoing structural changes. With decreasing activities of the mining industry, energy sector employment has also declined. Today, employment in the conven-

tional energy sector is only one third of what it was 20 years ago, grabbing the attention of policy makers. Renewable energy currently contributes 4% of the energy consumption in Asturias; half of which comes from hydro energy. There is no manufacture of renewable energy systems in the region; all employment comes from installation, operation and maintenance.

An analytical approach is sensible for a regional investigation because input-output-tables; national accounts and other macro-economic data are not available on a disaggregate level so as to make the information appropriate for a regional study.

Based on information on the renewable energy industry in Asturias by FAEN, employment per capacity installed was calculated for each technology. Similar ratios have been calculated for several countries before. Although the range of ratios internationally is quite wide, the ratios obtained for Asturias compare well with several other studies. From the ratios presented, possible developments of jobs in Asturias across three scenarios were derived for the period 2005-2010.

For construction and installation of renewable technologies in the electricity sector, the ratios are between 4 (Biomass) and 34.6 (Photovoltaic) jobs per installed MW. Operation and maintenance account for another 0.14 to 2.7 jobs per MW. Overall about 8,000 to 15,000 jobs are expected to be created in Asturias between 2005 and 2010, with most in the construction sector. 200 to 700 jobs are expected to be created in the energy sector (the main focus of the study) primarily in operations and maintenance. This compensates for the gradual loss of employment in the conventional energy sector. An overall employment of 10,198 to 10,707 people is expected in 2010.

In addition to the total number of jobs, the qualification of the regional workforce to fill these upcoming positions is important for future development. The main results and recommendations of the study are given as follows:

- Most job creation in the region is related to solar thermal, photovoltaic and wind energy. The development of RES will have an outstanding effect on employment, thus compensating the gradual losses in employment in the traditional mining industries.
- Renewable energies are expected to create more jobs in construction and installation than in operation and maintenance.
- The skill requirement analysis shows two levels of specialization: 1) technical and engineering skills 2) installers of for example thermal and photovoltaic solar panels.
- Asturias must adapt its energy sector to the new framework characterized by changes in the energy supply and demand, and also in the regulation of the sector.

The regional focus of the study calls for a special approach different from that for larger national studies due to data limitations and regional specifications. Few regional studies to date have taken all economic effects into account. The huge effort that is required for such analyses would be substantiated only if there were enough productive structures within a region and adequate data for a regional input-output-table. Without these conditions, the indicator

type approach can give a good estimate of the future development, although it excludes exports, imports and off-setting effects from consideration.

Putting renewables to work

Table 3: Effects included in the study "Putting renewables to work"

RES for	Gross Employment Effects				Net Employment Effects	
	Direct Employment	Indirect Employment	Export	Import	Budget Effect	Substitution Effect
Electricity						
Heat						
Transport						

"Putting renewables to work" is a study of a team from Berkeley University in California, published in April 2004 [Kammen04], with the goal of comparing indicative employment figures across energy technologies in terms of average employment over the lifetime of facilities. The aim was to provide stakeholders with transparent numbers for comparing employment effects of different energy technologies in the electricity sector. This then would push the discussion on this issue in the United States (U.S.).

This study is a review and a meta-analysis of existing results on employment effects. 13 studies from the United States and Europe were examined in terms of gross employment effects differentiated by technologies. Three of these studies with adequately detailed information were chosen upon which to base the analysis despite the fact that they were not necessarily U.S.-based. In order to analyze and average existing results, two steps were necessary: Firstly, employment was not related to the capacity installed but to the energy output, for two reasons: 1. most often political goals for expanding renewable energy are set as a percentage of energy provision. Therefore, the ratio of jobs per produced GWh was more relevant for the purpose of the study than an examination into jobs per installed capacity. 2. Using energy output as a reference makes an easier comparison between different technologies. Energy output of the capacity installed may differ widely between technologies, for example between solar photovoltaics and wind energy. Secondly, employment was averaged over the lifetime of the individual systems. In other words, one-time employment was combined with ongoing employment. Averaging the labor required to install the first batch of equipment and to replace that batch at the end of its life reflects a sustained commitment to each technology and shows the ongoing employment in maintenance and fuel preparation,

according to the authors. The resulting figures were used to show the employment effects of different energy scenarios for electricity in the United States.

A possible range of 176,444 to 240,850 jobs in the electricity sector with a share of 20 % of renewable energy by 2020 was shown. For coal and gas scenarios employment was recorded only between 84,000 and 86,000. Therefore, the results demonstrate that the use of renewable energy is more work intensive per output than the use of conventional energy. The sectoral employment pattern in the 20% renewable scenario is markedly different from the conventional energy scenario. Manufacturing, construction and agriculture, those sectors marked by high unemployment in the US, could grow significantly in a 20% renewable scenario. The comparison between different scenarios of electricity generation in the US against employment figures of the whole sector provided a straight-forward demonstration of the substitution effect of renewable energy generation (cf. Table 4).

Despite the lack of an own empirical basis in this study, it provides a straight-forward comparison between the employment effects of different energy technologies. This methodology can be easily understood and communicated outside of the scientific community.

Employment in the renewable industry in the UK

Table 4: Effects included in the study "Renewable supply chain gap analysis"

RES for	Gross Employment Effects				Net Employment Effects	
	Direct Employment	Indirect Employment	Export	Import	Budget Effect	Substitution Effect
Electricity						
Heat						
Transport						

Labor market effects are highly relevant in the political discussion in the United Kingdom (U.K.). In January 2004, the Department for Business, Enterprise & Regulatory Reform's Energy Group (dti) published "Renewable supply chain gap analysis" prepared by Mott MacDonald in association with the Bourton Group [DTI04]. It aimed to examine the current status of the U.K. renewable energy industry and its value chain in a comprehensive assessment and to assess its future potential. Employment effects are therefore a byproduct of the analysis per se.

The analytical approach yields ratios of jobs per capacity. While the Asturias study focused on the direct effects of installation, operation and maintenance, this study expanded its focus to analyze the complete value chain. The production chain is broken into steps. For each

step the material and labor inputs are derived. Jobs are calculated and associated with each tier in the supply chain for each technology. The study considers wind (onshore and off-shore), wave and tidal, hydro, biomass, waste to energy, landfill to energy and photovoltaic technologies. The monetary value in each template project is determined and broken down into components in technology trees. Each component is further subdivided at each tier in the supply chain. The monetary value is translated into jobs based proportion of material, overhead and profit. The material content is determined based on the manufacturing processes involved. Industry appropriate profit margins were applied. These profit margins are not translated into jobs in the industry as they go directly to the company shareholders. The remaining “payroll and overhead” includes all services and in-house labor. The labor input was calculated by a division by typical labor costs.

Employment is given in terms of jobs per MW at the time of the survey. This ratio was used to express the development of employment under various energy scenarios based on the Energy White Paper of DTI.

Overall, 2,000 companies were contacted with questionnaires concerning the flow of goods, interdependencies of their business and associated employment including the full range of developers, system and component suppliers, as well as research and trade associations. The response of more than 550 companies provided a detailed picture of the renewable energy industry in the UK, including foreign trade. At the time of the survey, renewable energy contributed to approximately 8,000 jobs. An average 10 jobs per MW was derived for the MW capacity under development at that time. By 2020, approximately £15 billion to £19 billion are expected to be invested in renewable energy sustaining about 17,000 to 35,000 jobs in the UK. These numbers account for the case if the ratio of employment per MW stays the same.

Due to this detailed analysis of renewable energy and its associated industry in the UK, it was possible to identify gaps in and therefore future growth potential along the supply chain. On this basis valuable information was provided to politicians on where and how to set the focus on support should they wish to support development in the industry.

The study is unique in its comprehensiveness and technology orientation along the supply chain in the renewable energy sector. It was possible to measure the full range of effects associated with gross employment (cf. Table 4).

4. Input-Output-Modeling

Input-Output-Tables have the advantage of a rather complete picture of the production and service sectors of the economy. Often tables are amended with additional tables on employment and consumption. Input-Output-Analyses consider the complete value chain and the interdependence of the different economic sectors. For the analysis of the aspects of gross and net employment, Input-Output-Analysis provides a very comprehensive tool. To improve the modeling of the behavior of the economy over time, Input-Output-tables can be combined with macro-economic and macro-econometric models. Within these models, labor models, tax models and other macroeconomic aspects are incorporated.

A common tool for macroeconomic analyses, Input-Output-Tables are available for most countries on a national level, and on rare occasion on regional scales. The following five studies used Input-Output-Models in their analyses.

Employment effects of the Austrian RES sector

Table 5: Effects included in the study "The economic relevance of RES in Austria"

RES for	Gross Employment Effects				Net Employment Effects	
	Direct Employment	Indirect Employment	Export	Import	Budget Effect	Substitution Effect
Electricity						
Heat					only biomass	
Transport						

Austria generates more than half of its electricity from hydro energy and has a strong tradition for and a large market of biomass applications. Therefore, several studies have been done on the implications of the growth of renewable energy for the Austrian economy. The Energy Group of the TU-Vienna has done three studies since 2002 related to this topic, two with a focus on Biomass applications ("Analysis of the overall economic relevance of bioenergy for heating applications in Austria, 2002" and "Economic analysis of the Austrian bioenergy sector" 2007) and one on the overall "Economic relevance of RES in Austria", 2005 [EEG06]. The biomass studies encompassed all employment effects, while the study on all RES was focused on gross employment effects. Each study is discussed below.

The Austrian biomass sector includes the entire value chain from the development of biomass heating systems to the manufacture of boilers, to fuel production and processing. Biomass applications, initially more expensive than fossil fuel systems and supported by public expenditures, are shown to have positive net employment effects in most regions considered in the 2002 study. The study concludes that "the promotion of bioenergy in periods of low oil price shows strongly positive impacts in periods of high oil price and that the negative impacts (public and private budget effects, substitution effects) do not over-compensate the positive impacts even in case of long-term low oil-price". The regional analysis shows the strongest positive employment impacts in agricultural and rural areas due to the provision and processing of fuels. Additionally, some positive impacts stem from the construction of district heating facilities in small towns. Some negative impacts may occur in cities due to additional costs of RES.

An update of this study, scheduled to be completed in the fall of 2007, incorporates relevant developments since 2002 such as the change in oil-prices, an increased demand for bio-

mass and strengthened system exports. In addition, it complements the Input-Output-Multiplier analysis with primary data from relevant industries. The first conclusions for the heating sector are: “1. Positive employment effects are increasing with rising oil price. 2. Increases in biomass demand must be accompanied by steady increases in resource mobilisation in order to avoid price shocks. 3. In contrast to other RES, a considerable share of the employment impact of bioenergy systems occurs in operation. 4. The strong tradition of bioenergy in Austria leads to export activities with related positive impact on domestic employment.”

The 2005 study on the effects of all RES considers fewer effects and focuses on the direct and indirect components of gross employment. The direct employment effects were derived with a bottom up approach including a market investigation as well as a variety of interviews with various stakeholders. Indirect employment effects were calculated using multipliers derived from Input-Output-Analysis. Due to fuel provision and operation for biomass applications, a majority of the total 32,700 jobs in 2004 were linked to biomass energy generation.

Macroeconomic Effects of promoting Green Electricity in Austria

Table 6: Effects included in the evaluation of the Austrian promotion of green electricity

RES for	Gross Employment Effects				Net Employment Effects	
	Direct Employment	Indirect Employment	Export	Import	Budget Effect	Substitution Effect
Electricity						
Heat						
Transport						

An evaluation of the macroeconomic effects of the promotion of green electricity in Austria by the Institute for Advanced Studies Carinthia was published in July 2004. The study was commissioned by E-Control, the Austrian regulatory authority for the electricity and gas market, which is also responsible for the Feed-in tariff System of Austria. Due to this responsibility, the focus of this study was placed upon the net effects of the policy. (cf. Table 6).

Gross employment for each renewable technology was calculated according to the Input-Output-Table of Austria. The gross effects of investment, operation and maintenance over a 30-year period were totalled for small hydro power and over a 20-year period for all other technologies. The reduction of disposable income (budget effect) was summed over the 13-year support period. A market price of €3 ct/kWh was assumed to calculate the value of electricity from renewable sources. For wind power and solar photovoltaics a deduction of 40% was included to account for fluctuations in source. CO_2 reduction was considered with a

value of €0.3 ct/kWh (10 €/t CO_2). The sum of these three components resulted in a negative total employment effect for 2 GWh of wind and photovoltaic power (-1.2 and -73.2 person years, respectively). This is mainly due to the lack of wind turbine or photovoltaics manufacturing industries in Austria; the positive employment effects from installation and maintenance alone are comparatively small. System components are imported, thereby giving rise to employment effects in the exporting countries. Employment effects were positive for liquid biomass (94.4 person years) and biogas (92.4 person years), with a lesser positive effect for small scale hydro power (22.8 person years), solid biomass (16.8 person years) and landfill gas (4.9 person years).

Following the implementation of a new promotion scheme in autumn 2006, a new simulation of net effects was done at the beginning of 2007. For this simulation changes in input included technology specific remuneration, length of support (12 years), and a new market price for electricity of €5 ct/kWh which reflects the development of the last years. The results of all renewable technologies employment effects are positive for 2 GWh: the highest, liquid biomass (71.9 person years) and biogas (66.4 person years), followed by photovoltaic (25.4 person years), solid biomass (24.1 person years), landfill gas (14.3 person years) and wind (1.8 person years).

When drawing conclusions on a comparison of the two different support schemes, it is important to consider other aspects which may have also been changed. For example, the market price for electricity or the value of renewable electricity typically has a very strong influence on the outcome of net effects.

Employment effects of Photovoltaics - theory and practical experience

Table 7: Effects included in the study on employment effects of photovoltaics in Germany

RES for	Gross Employment Effects				Net Employment Effects	
	Direct Employment	Indirect Employment	Export	Import	Budget Effect	Substitution Effect
Electricity						
Heat						
Transport						

In September 2006 EuPD Research published a study on the German photovoltaic market in cooperation with the German Solar Industry Federation (BSW) and the German Confederation of Skilled Crafts (ZDH) [EuPD06]. The study was initiated in response to the enormous growth of the market since the amendment of the German Renewable Energy Sources Act in 2004.

The methodological approach is twofold. Firstly, an Input-Output-Analysis was carried out with data more strongly focused on installation than on production. Exports from photovoltaic industries are accounted for; imports enter only as complete modules and systems. There is little attention given to the imports of components. However, installation, maintenance and budget effects are included and net employment shows to be positive. Secondly data on employment was sourced from a comprehensive database of the institute. The empirically measured employment is less than that which was calculated from Input-Output-Analyses. The study concludes that the gross employment of photovoltaics in Germany increased from around 4,000 jobs at the end of year 2002 to around 36,000 jobs at the end of 2006. The study shows that this amount is driven mainly by installed photovoltaic capacity in Germany and successful exports, also driven by rising profit margins, though the trade balance remained negative. Primary and secondary statistics showed that 31,000 people were employed in photovoltaics at the end of 2006. This study assumes a high likelihood of at least 35,000 employees with some regional assessment included. While production facilities and their contribution to employment are mainly based in East Germany, the labor market in West Germany is also stimulated by additional employment in several trades. Primary and secondary statistics underline the results of input-output-analyses. For a comprehensive picture, a combination of the two approaches is recommended.

Impact of the expansion of renewable energy on the German labor market

Table 8: Effects included in the study "Renewable energy: Employment effects"

RES for	Gross Employment Effects				Net Employment Effects	
	Direct Employment	Indirect Employment	Export	Import	Budget Effect	Substitution Effect
Electricity						
Heat						
Transport						

In September 2006, the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) published the study "Renewable energy: Employment effects". The study was prepared by a consortium of the Center of Solar and Hydrogen Research Baden-Württemberg (ZSW), the German Aerospace Center (DLR), the German Institute for Economic Research (DIW) and the Institute for Economic Structure Research (GWS). At the time it was commissioned, unemployment in Germany was at a peak. Political decisions including those for the support of renewable energy were assessed with respect to their effects

on employment. The aim of the study was therefore to take all possible macroeconomic effects into account (cf. Table 8) thereby if possible reaching a consensus in the discussion.

Gross employment was determined based on an Input-Output-Table provided by the Federal Statistical Office of Germany. Because the renewable energy industry in the I/O tables is subsumed in other sectors of the German industry, an input-output-vector was developed for each renewable technology in order to take the specific circumstances of this sector into account. The new vector was included in the existing table and enabled the identification of gross employment including foreign trade. Net employment effects were determined by means of the macro-econometric model PANTA RHEI for Germany on the basis of the aforementioned Input-Output-Table.

The results from more than 1,100 interviews with companies including suppliers of systems and components, developers as well as wholesale merchants are the database for the new Input-Output-Vector. The analysis came to an overall employment of 157,000 people in Germany in 2004. A follow-up study published in September 2007 gave an estimate of about 231.00 jobs in 2006. This figure includes all jobs related to investment in plants for the use of renewable energy and its operation. Jobs related to public support such as research and development were not included. The possible development of employment in the renewable sector was calculated alongside a number of export scenarios. In 2020 a possible range of €17 billion to €36 billion of total revenue for the German industry was reported accounting for a range of 257,000 to 400,000 jobs due to the expansion of renewable energy. Current net employment effects in Germany were found to be positive and are expected to remain positive to 2030. A sensitivity analysis included in the study showed that these positive effects are not guaranteed. The development of energy prices and the progression of foreign trade greatly influence the results. Therefore, the German government is asked to continue its efforts to provide a stable and secure investment climate by which to further the expansion of renewable energy.

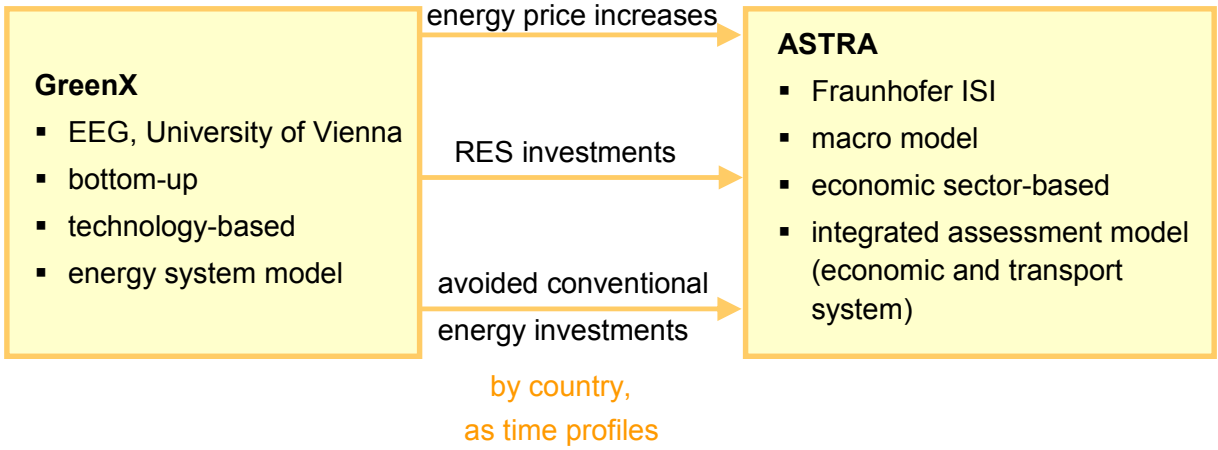
The chosen approach has similar elements to the UK analysis. Both studies base their findings on an extensive survey of the renewable industry. The major difference lies in the depth of the surveys along the supply chain. The UK study looked at the whole supply chain to the greatest extent possible whereas the German study only investigated the supply chain to the point of the plant components. The German Input-Output-Table was used for multiplier effects.

Macroeconomic impacts of proposed European renewables policy

The study “Impact analyses on social and economic aspects of RES-E, Contribution to the impact assessments on the future on the financing of sustainable energies” [PWC/IWW/IIP05] broadens the scope of the analysis from individual countries to the EU-25. It combines two models: the bottom-up analysis of the GreenX model and the macroeconomic model ASTRA. Fig. 2 shows the basic features of the different models and the interaction scheme. While GreenX is a technology based, bottom-up energy system model,

the origins of ASTRA lie in macro-economic modelling. Due to its use for the analysis of transport system, ASTRA has a strong special component, which enables also regional analyses. However, the integration of energy systems and the renewable energy sector is the object of ongoing research.

Figure 2: Linkages between GreenX and Astra



The study was developed with GreenX model scenarios for increasing investments in renewable energy technologies in electricity generation, heat generation and the transport sector for all EU25 countries until 2020. The "disinvestment" in the conventional sector was also modeled. Fed into the ASTRA model, the macro economic implications of these scenarios were derived. The assumed development of RES led to an increase in overall GDP of 5% and an increase in employment of 0.3 % or 650,000 jobs. Exports are not included in these results.

Table 9 Effects included in the ASTRA model

RES for	Gross Employment Effects				Net Employment Effects	
	Direct Employment	Indirect Employment	Export	Import	Budget Effect	Substitution Effect
Electricity						
Heat						
Transport						

5. Discussion and Conclusions

The studies presented at the workshop gave insight into the on-going research on employment effects as renewable energy increases. However, the investigations to date are far from comprehensive. Approaches range from meta-analytical work, which relies on the review of existing works, to various degrees of surveys, to modeling-based studies combined with official data and/or private surveys. Time horizons varied across the studies discussed, primarily due to individual project mandates. Studies aimed either to provide a detailed picture of the current status, or to forecast plausible future developments. Employment is especially sensitive to future developments as RE technologies become more competitive and additional costs decrease.

The more an analysis leans towards modeling the more crucial the role of the initial assumptions becomes. Assumptions regarding the development of oil prices and of learning curves within the renewable energy technologies, the development of permit prices and the true value of electricity from intermittent sources were discussed controversially among the participants. These assumptions are crucial and therefore a transparent declaration of these factors is critical in any scientific study.

The different methods, assumptions, time horizons and unique countries of focus make it difficult if not impossible to accurately compare the results of the different studies. The workshop discussion was surprisingly often focused on understanding different support systems and their influence on cost development, installation and employment.

As agreed by all participants, in the rapidly changing renewable energy industry as in many others, researchers are often faced with a challenge in acquiring adequate data. Although surveys are essential to provide a good data base, they are expensive and often out of budget. The bottom line is that one model will never be able to answer all questions – so models are often tailored to answer specific queries.

Workshop participants recognized a need for future research especially in the following areas:

- The bioenergy sector should be given more attention as it is rapidly changing with diverse developments in different countries.
- International trade will be crucial for the RES industry in the future. Specialization is expected as it would be redundant for every country to try and sell replicated copies of the same technology. An investigation into exactly how the market leaders will develop would be of benefit.
- The development of conventional energy prices has a very strong influence on the net employment effects. Due to the uncertainty of the development of these figures, the discussion on the positive or negative sign of the net employment effects will continue.
- The RES industry has already begun to suffer from a lack of skilled workers. Job qualifications and skills should be investigated and quantified. A forecast of such skills is rec-

ommended in order to be able to meet market requirements. Otherwise companies might start to pull out of certain areas.

- The approaches combining bottom-up and top-down models seem very promising for future research. For such an approach one needs:
- a good Database.

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Appendix 1: Employment Effects of RES - Workshop Agenda

23. April

from	to	Duration	Issue	Referee
09:30	10:00	0:30	Registration	
10:00	10:15	0:15	Introduction	Michael van Mark (BMU)
Session I				
10:15	10:45	0:30	Approaching the effects of renewable energy on Employment in the Spanish regions. The case of Asturias	Blanca Moreno Cuartas, Ana Jesus Lopez (University Orviedo), Spain
10:45	11:15	0:30	Discussion	
11:15	11:45	0:30	Macroeconomic Effects of promoting Green Electricity in Austria	Klaus Weyerstraß (Institute for Advanced Studies), Austria
11:45	12:15	0:30	Discussion	
12:15	13:15	1:00	Lunch	
Session II				
13:15	13:45	0:30	Impact of the expansion of Renewable energy on the German labour market	Ulrike Lehr (German Aerospace Center), Germany
13:45	14:15	0:30	Discussion	
14:15	14:45	0:30	Employment effects of photovoltaics - theory and practical experience	Volker Ruhl (EUPD Research), Germany
14:45	15:15	0:30	Discussion	
15:15	16:00	0:45	Coffee Break	
16:00	16:30	0:30	Employment in the renewable industry in the UK	Isabel Boira Segarra (Mott McDonald), UK
16:30	17:00	0:30	Discussion	
17:00	17:30	0:30	Employment effects of the Austrian RES sector with a special focus on biomass	Lukas Kranzl (Energy Economics Group), Austria
17:30	18:00	0:30	Discussion	
18:00	18:15	0:15	Conclusions	Michael van Mark (BMU)
19:00			Dinner	

24. April

from	to	Duration	Issue	Referee
9:00	9:15	0:15	Introduction	Michael van Mark (BMU)
Session IV				
9:15	9:45	0:30	Putting renewables to work	Matthias Fripp (Berkeley), USA
9:45	10:15	0:30	Discussion	
10:15	10:45	0:30	Coffee Break	
10:45	11:15	0:30	Macroeconomic impacts of proposed European renewables policy	Wolfgang Schade (Fraunhofer Institute for Systems and Innovation Research), Germany
11:15	11:45	0:30	Discussion	
11:45	12:15	0:30	Conclusions	Michael van Mark (BMU)
12:15			Lunch	