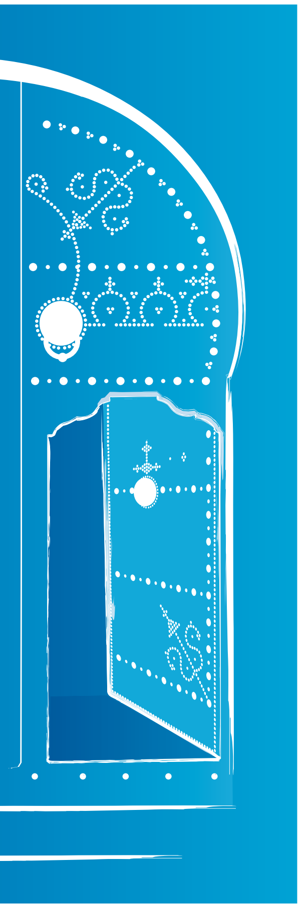
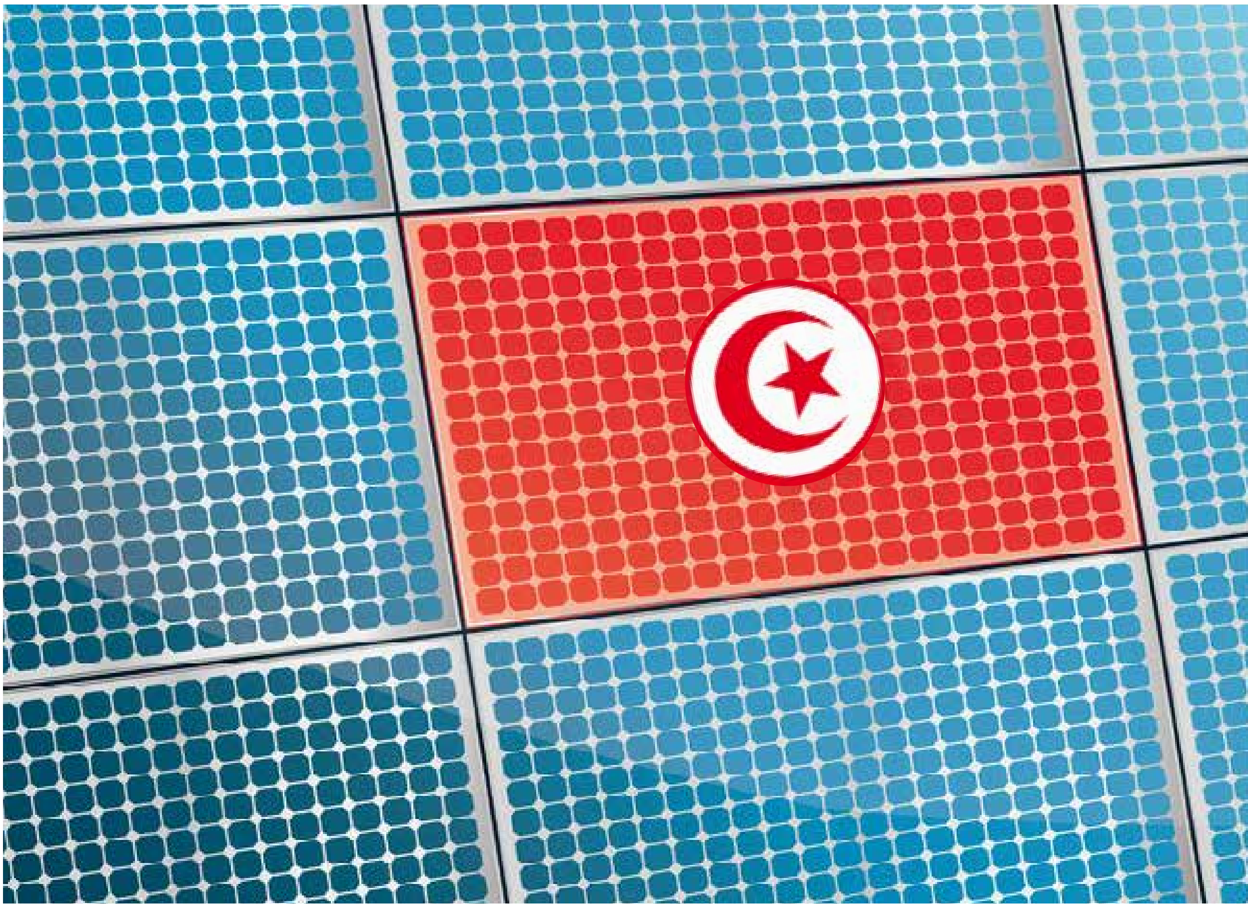




Renewable energy and energy efficiency in Tunisia – employment, qualification and economic effects

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

التعاون الألماني
DEUTSCHE ZUSAMMENARBEIT

ANME

IMPRINT

As a federally owned enterprise, GIZ supports the German Government in achieving its objectives in the field of international cooperation for sustainable development.

Published by:
Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH

Registered offices
Bonn and Eschborn, Germany
T +49 228 44 60-0 (Bonn)
T +49 61 96 79-0 (Eschborn)

Friedrich-Ebert-Allee 40
53113 Bonn, Germany
T +49 228 44 60-0
F +49 228 44 60-17 66
E info@giz.de
I www.giz.de

Dag-Hammarskjöld-Weg 1-5
65760 Eschborn, Germany
T +49 61 96 79-0
F +49 61 96 79-11 15
E info@giz.de
I www.giz.de

Bureau de la GIZ à Tunis
Le Grand Boulevard de la Corniche
Immeuble le Grand Boulevard
Les Berges du Lac II
Tunis
Tunisia
T +216 71 967 220
F +216 71 967 227
E GIZ-Tunesien@giz.de
I www.giz.de

Responsible
Ulrich Laumanns (GIZ)
Project "Promotion of renewable energy and energy efficiency in Tunisia"

Authors
Ulrike Lehr (GWS)
Anke Mönnig (GWS)
Rafik Missaoui (Alcor)
Sami Marrouki (Alcor)

Layout
MediaCompany GmbH

Photos
Front page: Fotolia.com / kotoyamagami
Others: GIZ

Printing
Das Druckhaus GmbH
Printed on 100 % recycled paper,
certified to FSC standards

Place and date of publication
Tunis, December 2012

Renewable energy and energy efficiency in Tunisia – employment, qualification and economic effects

CONTENTS

EXECUTIVE SUMMARY

According to the Tunisian Solar Plan and other sources, renewable energy (RE) and energy efficiency increases in Tunisia will generate additional employment for between **7,000** and **20,000** people until the year 2030. Total investment will be TND [1] **8.28 billion** on renewable energy and TND **1.5 billion** on energy efficiency measures. Total RE capacity installed for electricity generation will be **4,045 MW** and additional capacity from solar water heaters will be **700 MW**. The total energy savings by 2030 will be **120,000 GWh.**

There are currently **3,391 people employed in the renewable energy and energy efficiency** sectors. The largest share, 1,445 people, work in renewable energy, followed by 931 in energy efficiency, and 975 in cross-sectional activities, i.e. research, consulting and the promotion of renewable energy and energy efficiency.

Given the current production structure in Tunisia in the short term, most employment will be generated from the **installation, operation and maintenance of renewable energy capacities** and from **increasing energy efficiency in buildings**. In the long term, **increased integration** of production processes and **exports** of PV and solar water heaters can also contribute to further job creation.

Most **qualifications** in the renewable energy sector are specialisations within already existing qualifications: electricians specialise in photovoltaics (PV), plumbers in solar water heaters, etc. Additional employment, depending on the import/export scenario, is between **0.2% and 0.5%** of today's employment. The largest percentage contribution will come from the construction sector and in the production of machinery and electrical equipment. Taken together, additional **employment will increase the workforce by 1.4%** within these sectors in 2016 in comparison with today.

A comparison of employment generated per investment of TND 100 million suggest that energy **efficiency within buildings generates the most employment**, followed by **solar water heaters** and **PV installations** and finally by wind energy and Concentrated Solar Power (CSP). Though PV production facilities can be easily imported and implemented in any country, new production capacities do not seem recommendable on a large scale under the current consolidation phase in the international PV markets. Tunisia should benefit from falling PV prices and realise the employment opportunities available for installation and in the production of PV system electrical and electronic components.

Wind energy does not contribute as many jobs as the first three technologies mentioned but provides opportunities for **technology development** because component manufacture leads to an additional demand for inputs from other Tunisian production sectors. Additionally, wind energy will provide academic jobs for wind prognosis services.

To become successful in international markets, products need to **maintain high quality standards and be certified**. For certification procedures, new qualifications in the service sector need to be developed according to international standards such as the Solar Keymark Certification. This generates new opportunities for qualification within the service sector.

Next to funding and support from the Tunisian National Fonds for Renewable Energy and Energy Efficiency (Fonds National pour la Maîtrise de l'Energie - FNME), the Solar Plan expects co-financing and support from international finance institutions, the European Union and individual European countries, international carbon-based funds and further international funds. For this reason, we do not analyse the crowding-out effects of alternative investment options.

Solar thermal water heaters, insulation measures and PV installations on private houses pay for themselves within a reasonable timespan (5–10 years). Solar thermal water heaters save costs for other sources of hot water. Insulation and PVcan greatly reduce the costs of air conditioning by means of reducing the need for cooling and producing electricity during peak demand times. However, their attractiveness for electricity consumers depends on future electricity prices. PV electricity generation during peak times (the middle of the day in summer) will also help to balance the load and the burden on the grid. This can create an incentive for the Tunisian Electricity and Gas Company (Société Tunisienne d'Electricité et du Gaz - STEG) to support private PV generation to some extent. These three technologies need support for the initial investment at reasonable terms, such as the PROSOL programme that currently exists for solar heaters or the PROMO-ISOL programme that has been suggested for roof insulation.

1 Tunisian Dinar. 1 TND = 0,49 EUR (october 2012).

Continuous development of the policy towards more renewable energy **supports the employment outlook**. International experience shows that a stable policy framework and transparent support mechanisms are the most important prerequisites for the successful development of renewable energy and the energy efficiency sector. Large infrastructure projects such as wind parks often lead to irregular investment paths. In terms of employment, qualification strategies require continuous development or they become inefficient and lead to disappointment among the well-qualified workforce.

The second column of the Tunisian Solar Plan (Plan Solaire Tunisien – PST), **energy efficiency**, requires **sensibilisation strategies for households, enterprises and services**. The long-term benefits of energy-efficient appliances must be explained to consumers. Energy consulting, labelling and campaigning to advertise energy efficiency are the minimum requirements necessary for a successful promotion of energy efficiency. Future gains from energy efficiency will also depend on the pricing system.

Increasing energy efficiency and capacities of renewable energy to a 30% share of electricity generation as well as increasing solar water heaters to 700 MW will have a positive effect on the economy. **GDP will increase by almost 0.4%** and investment will be 1.4% higher than in the reference case. Although imports will increase, the overall effects will be positive, with **exports increasing by 0.1% and employment by 0.2%.**

INTRODUCTION

Strategies to increase investment in renewable energy and energy efficiency are on the agenda for several countries. Alongside the obvious reasons such as climate change mitigation and resource protection, these activities are linked with hopes for economic development and the creation of employment. Several studies show that given appropriate policy support and a target-oriented policy instrument mix, positive effects on the labour market and on adaptation and innovation can indeed be observed. Such studies have made it possible for industrial countries to calculate the effects of various support policies.

For developing countries, the effects of decentralised applications such as PV in India or energy efficiency in rural areas, such as efficient stoves in Africa, have been analysed. The employment effets of renewable energy and energy efficiency in emerging economies such as Tunisia have not yet been studied in depth. More recently there has been an increased interest in projects such as DESERTEC and the Mediterranean Solar Plan. Moreover, national activities such as the Tunisian Solar Plan harbour development opportunities and prospects for the creation of highly-skilled employment which is of particular interest to national governements, especially against the background of recent changes in the region.

Against this background, the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, in the framework of the project "Promotion of Renewable Energy and Energy Efficiency in Tunisia" which is financed by the German Federal Ministry for Economic Cooperation and Development (BMZ), commissioned a study from the consortium GWS (Osnabrück) and Alcor (Tunis) on the past, present and potential future employment benefits of renewable energies and energy efficiency in Tunisia. The goal of the study is threefold:

- In terms of policy analysis, prerequisites and frameworks for successful implementation of the PST have been derived from international experiences (Part I).
- In terms of macroeconomic labour market analysis, past experiences with Tunisian promotion programmes for renewable energy and energy efficiency (Part II), and future opportunities from the PST and other measures of sustainable energy promotion have been analysed (Part III). The method has been developed so that it can be used by the Tunisian authorities.
- In terms of capacity building, the Tunisian Energy Agency (Agence Nationale pour la Maîtrise de l'Energie – ANME) has been trained on a tool that enables estimates to be adjusted depending on new information and data collection.

PART I: INTERNATIONAL EXPERIENCES IN THE FIELD OF JOB CREATION FROM RENEWABLE ENERGY AND ENERGY EFFICIENCY

1 INTRODUCTION

The increase of RE in the worldwide energy mix has many drivers and motives. Concerns about greenhouse gas emissions from burning fossil fuels and the scarcity of resources, i.e. oil, gas and even coal, are important grounds for a change in attitude towards fossil fuel-based generation of heat, electricity and transport. Equally important are issues of energy security relating to international or national conflicts in resource rich areas in the world, i.e. the Gulf Wars, the Ukrainian/Russian gas crisis or the crisis in Libya during spring and summer 2011.

More recently, the economic impacts of a renewable energy strategy for certain countries and regions have been discussed in great detail. Of special interest for industrialised countries as well as for emerging economies and developing countries are the quantity and quality of so-called 'green jobs' in this new economic sector. However, the numbers reported seem to be based on different measurement concepts and therefore appear contradictory at times. Estimates for the world as a whole seem to be lower than the sum of estimates from Europe and China. Different definitions of 'green jobs' are often contradictory.

Nevertheless, employment is impacted by increased usage of renewable energy and this is arousing greater interest among developing countries and emerging economies. The PST in Tunisia provides a framework for the increase of renewable energy and energy efficiency until 2016 and beyond. Against this background, Section 1 of Part I gives the results of a review of the most important concepts used in other countries as published or from international statistics.

Section 2 develops the basic definitions. Section 3 outlines the main international concepts and illustrates them with case and country study examples. Section 4 explores the employment impact of energy efficiency measures and Section 5 offers a series of conclusions.

2 MEASURING EMPLOYMENT – CONCEPTS AND DEFINITIONS

2.1 Gross, net, direct and indirect employment

To better understand the discussion on the effects of renewable energy and energy efficiency policies on employment, some definitions are needed. In the literature, the terms direct and indirect (induced) employment, gross and net effects are found.

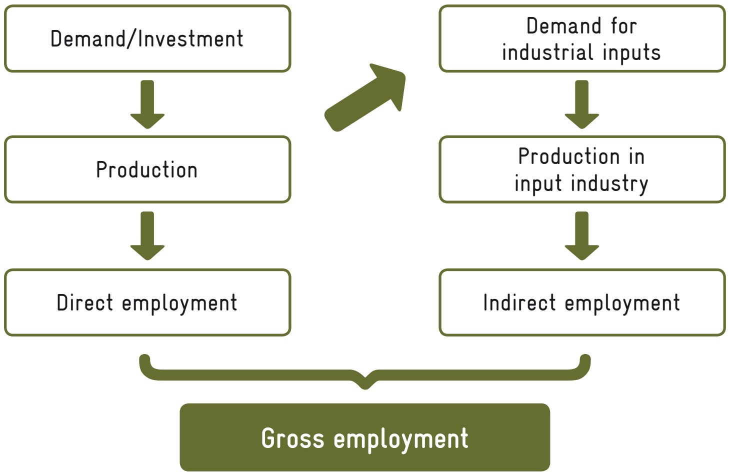
Direct employment is the easiest to measure and understand. Direct employment within an economic sector, e.g. the wind industry, comprises all the people employed in planning, production and the operation and maintenance of RE facilities. The main challenge of this approach lies in the definition of the system to be analysed, i.e. which technologies to include. Wind energy, photovoltaic electricity generation, solar thermal heat and power generation, heat and electricity from modern biomass as well as geothermal and maritime energy belong to the core renewable energy sources. Large hydro energy is disputed, partly because it is not 'new', and partly because of its environmental degradation potential. Hydrogen is usually only considered if the energy requirements for its generation are covered from renewable sources. Energy from waste incineration or landfill gases can be included in the calculation; the definitions differ widely, which often makes cross-country comparison very difficult.

Direct employment depends on a country's RE technology industries for employment in production and/or a country's RE installations for operation and maintenance figures. Germany, for instance, has the largest RE industry in Europe and therefore has high employment in production. Germany also has high wind and solar installation figures and employment in operation and maintenance is increasing.

Indirect employment includes all the people who work in the industrial input sectors, including those who work in production and the operation and maintenance of RE technologies. Any industrial process requires inputs either from other industrial processes or as raw materials. These inputs in turn necessitate other inputs along the value chain. Indirect employment comprises all those employed in the other sectors along the value chain. The advantage of this approach lies in its comprehensiveness. The effects of indirect employment demonstrate the economic impacts of an increase of renewable energy on all economic sectors. Germany, for instance, has more people working along the value chain than in the renewable energy sectors itself, i.e. indirect employment generates greater numbers than direct employment.

Estimates for the effects on indirect employment require knowledge of the value chains in the RE industries. Fortunately, since most of the technologies are new and innovative, the input structure is similar around the world. Additional country-specific information is therefore needed about productivity in different economic sectors (see figure 1).

Figure 1: The elements of gross employment



The sum of all direct and indirect employment in production and the operation and maintenance of RE technologies as well as in the installation and production of efficiency technologies is often called *gross employment*. This term refers to the number of people in a country who find employment in the renewable energy/energy efficiency sector based on a) worldwide demand for renewable energy products and technologies and b) manpower requirements for the installation, operation and maintenance of RE-based systems.

The increasing share of renewable energy in the national energy mix also leads to negative economic effects from job losses in other fossil fuel-based industries, to private budget losses from increasing energy prices and to governmental budget losses, for instance from tax breaks. In order to evaluate the net impact of renewable energies on job creation, we must calculate the effects of two scenarios (see next chapter). One scenario serves as the reference case with business as usual or no support and an increase of renewable energy in the energy mix (baseline). The second scenario illustrates the future development path for renewable energy with an increasing share of renewable energy in the energy mix and a decreasing share of fossil fuel technologies. It may even include exports of renewable energy components to other countries in the region or in Europe. A comparison of economic indicators such as employment between these two scenarios results in the *net impact*. For this type of analysis, models of the entire economy including all economic aspects must be applied.

2.2 Methods

Thus far, there is no comprehensive database for socio-economic effects of an increase in renewable energy and energy efficiency. The International Energy Agency (IEA) is currently supporting a study designed to develop guidelines for future RE employment analysis in IEA member countries. The Renewable Energy Agency (IRENA) will develop a research project proposing guidelines for developing countries. The results of both projects will be presented in 2012/2013 but will not include energy efficiency technologies. Thus far, international experience has been gleaned only from the literature and from policy oriented studies.

Estimating employment in the renewable energy sector is difficult mainly because no international classification system exists for this sector. Parts of it belong to the machinery sector, parts to the semi-conductor industry and parts to the construction sector, amongst others. The only way to obtain information on the sector is through aggregated data on individual companies. Employment in the renewable energy industry is therefore not reported in any of the international statistics from the International Labour Organisation or Eurostat or in any of the national statistics. With the increasing relevance of renewable energy technologies for energy generation around the world, interest in the economic impacts and options for future skilled and high quality jobs increases. For this reason, estimates regarding green jobs must be chosen from one of the methods suggested in the literature.

The three main methodologies are the employment factor approach (EFA), input-output-analyses (IOA) and full models.

The EFA is quite popular due to its seemingly simple applicability. The basic idea is to find employment factors per megawatt (MW) of capacity installed to be able to combine installations with respective employment. Employment factors are usually derived from industry studies, industry information and literature reviews. Employment by MW installed differs according to technology. For example, the construction of a wind turbine requires more workers than the construction of a solar thermal heating system. It also differs by country, because some countries are more productive than others, and it changes over time because of efficiency increases in production due to scale effects or general technological progress.

The literature often illustrates different system definitions for direct and indirect employment effects. Since the EFA is targeted at direct employment, one must be careful not to mix different concepts. Direct employment is often understood as employment 'that is directly connected with installation' such as construction, planning or development. Other definitions are targeted at the manufacturing industries and regard construction as an input and as an indirect effect.

As an example, figure 2 shows how employment factors in manufacturing, construction, operation and maintenance and fuel supply can be calculated. The authors applied this approach to the energy [r]evolution scenarios developed for Greenpeace.

Since most studies thus far have been carried out for developed countries, the employment factor method needs several adjustments to be applicable for developing countries. Labour costs are usually much lower in developing countries, which can result in higher employment per MW – or higher

Figure 2: **The calculation of employment factors**

Methodoloy Overview								
Manufacturing (for domestic use)	=	MW installed per year	X	Manufacturing employment factor	X	Regional job multiplier	X	% of local manufacturing
Manufacturing (for export)	=	MW exported per year	X	Manufacturing employment factor	X	Regional job multiplier		
Construction	=	MW installed per year	X	Construction employment factor	X	Regional job multiplier		
Operation and maintenance	=	Cumulative capacity	X	O&M employment factor	X	Regional job multiplier		
Fuel supply (Nuclear, oil, diesel, biomass)	=	Electricity generation	X	Fuel employment factor	X	Regional job multiplier		
Fuel supply (coal)	=	Electricity generation + net coal imports	X	Regional fuel employment factor	X	Regional job multiplier		
Fuel supply (gas)	=	Electricity generation + net gas imports	X	Fuel employment factor	X	Regional job multiplier	X	% of local production
Jobs in region	=	Manufacturing	+	Construction	+	Operation and maintenance	+	fuel supply
Jobs in region 2010	=	Jobs in region						
Jobs in region 2020	=	Jobs in region X Technology decline factor_10 Number of years after 2010						
Jobs in region 2030	=	Jobs in region X Technology decline factor_20 Number of years after 2020						

Source: Rutovitz and Usher (2009).

profits for firms. Labour productivity varies across countries and is significantly lower in developing countries. Rutovitz and Usher (2009) suggest regional factors to account for these facts.

The renewable industry itself is changing rapidly over time. So-called learning curves can be used to model the cost reductions in renewable energy technologies. However, the speed at which the industries undergo these learning curves are hard to predict: The costs for solar PV fell over the last five years by 50%.

The *economic Input-Output-Analysis* (Eurostat 2008) combines the understanding of economic theory and the development of employment by sector with technology-specific information on renewable energy systems. From economic theory we know how the demand for a certain product or good is 'translated' into the full employment impact on the economy. The demand for more solar thermal water heaters for instance, is met by the producers of water heaters. They produce water heaters with several types of inputs. Obviously one important input is labour, but capital and industrial inputs exist as well. These industrial inputs (and the capital, i.e. machinery) are produced with labour input, and also with capital and further industrial inputs. The impact of any investment on the economy is much larger than merely the first round effect of investment goods production.

One method to account for all first- and second-round effects is input-output analysis. At the core of this method lies the so-called Input-Output-table that connects all industrial sectors with each other. Investment in RE technologies creates additional demand for investment goods, intermediate inputs and for inputs further along the value chain. The latter two are called second-round effects. Knowledge about the production structure of the 10 main RE technologies helps to channel the additional demand into the right economic sectors. Knowledge about labour intensities in the 10 main RE technology production sectors leads to direct employment. Statistical data on labour intensities in all other sectors determines second-round effects and indirect employment.

This method has been developed and applied to Germany; the IO tables for 10 RE technologies are based on industry surveys. Where no such data are available, RE technology industries must be distributed to the existing economic sectors for which statistical data are available (for an example, see EMPLOY-RES, 2009).

The only feasible way to understand the *net economic effects* is to apply a *full model* of the total economy to capture all effects [2]. This type of analysis has been carried out mostly for Europe and for individual European countries. A series of studies for the German Ministry of the Environment follows this approach (see case study on Germany below) and the EMPLOY-RES Project followed it for all of the European member states. The advantage of a full model is that the balancing of positive and negative impact changes in exports, investment, prices, employment, household income and governmental budgets is fully accounted for.

2 Wei et al. (2010) have suggested an employment factor based on a net effects algorithm, but it cannot capture all of the economic effects.

Future developments can be simulated using scenarios, i.e. projections of variables that do not have certain future development. International fossil fuel prices are a good example. Despite the large body of literature about oil price forecasts, their development remains uncertain. But fossil fuel prices are an important driver for economic development, production conditions, cost structures and other economic variables. Therefore, a scenario sets a certain path for fossil fuel price developments and lets the model develop around this scenario. To determine the effects of price changes, the results are compared with a second scenario having different price paths.

The same holds for RE technologies: to determine the overall economic effects of a RE investment path, we must compare model results *with* and *without* RE technologies. This type of analysis is appropriate if different paths of RE support and/or of RE technology increases are problematic for a political body. Often the development of an appropriate model will be too time consuming and expensive for the administrative body to undertake.

2.3 Methodology in this study

The study on the employment effects of an increase in renewable energy and energy efficiency in a developing country/emerging economy has hitherto not been reported in the literature. Employment has been reported either for larger units, for instance for certain world regions such as Africa, the Middle East, Latin America and Asia; or for much smaller units with the analysis of single projects. The latter can be found for rural electrification projects, but neither result is helpful for our task.

In this paper, we apply an adjusted Input-Output-Analysis, embedded in a model of a small country, Tunisia. For this approach we use a combination of technology-specific input-output tables, the respective labour intensities of production, country-specific Input-Output-tables and country-specific statistical data. From the technology-specific tables, we will derive information about the cost structure of 10 different RE technologies, the energy efficiency increase of buildings and in the main industry sectors. Depending on the shares of imported goods and services and domestic production, we can obtain domestic employment figures by combining these tables with the domestic input-output structure. The same applies to the installation of the systems. From international tables we know which sectors contribute to installation and operation and maintenance. The results of these steps will indicate indirect employment figures, which will be the largest share in Tunisia at the beginning of the analysed time period. For those technologies that are produced domestically to be installed in the country or exported, direct employment figures must be added. Those figures can be derived from international labour intensities, because Tunisian industry will be as innovative and productive as their international competitors.

To combine as much knowledge as possible we suggest this two-stage procedure. Demand for renewable energy installations in Tunisia will be modelled according to the PST until 2016. To forecast development beyond 2016 we will use scenarios developed in the context of German-Tunisian cooperation by the Wuppertal Institute. We will provide a tool with a user-friendly interface to handle different scenarios, allowing for the incorporation of other aspects. The most important scenario parameters will be the capacity installed, costs of RE installation and the share of domestic production for domestic and international installation. Since domestic production creates domestic demand for further inputs following the domestic production structure given in the Tunisian Input-Output-tables, this is an important parameter.

We do not need to consider crowding out effects and alternative investment strategies since investment in RE technologies almost everywhere is additional. Moreover, owing to the abundant and qualified workforce and projected future population growth, shortages in labour supply are not expected. Finally, since RE expansion is additional and will not impact consumers' electricity bills, we do not need to analyse the negative effects.

3 INTERNATIONAL RESULTS

The increase in renewable energy installations and the development of the respective industry are a result of political support within all countries. There is a direct link between the support policy and the success of renewable energy in terms of employment and capacities installed. However, it not only the choice of a political support instrument as such that affects the success of renewable energy. International experience has taught us that the way an instrument is implemented, its reliability and stability to the respective industry and the continuity and transparency of support are almost as important as the level of support and the political instrument itself.

Employment can be driven by three developments: high domestic production of RE technologies and the industrial inputs to this production, high domestic installation numbers and qualified people for this type of work and high provision of material inputs, i.e. biomass and biofuel inputs. Germany covers all three aspects; China started with production (wind and PV) and installation followed, and Brazil is driven by biofuel provision and production.

Each of these developments depends on the political framework. Since RE technologies are often still more expensive than fossil fuel-based technologies, installations must be supported by subsidies, funds, tariffs or other types of regulation such as quotas.

Table 1 gives an overview of the most important categories of support schemes. Since the EU has played a very active role in the discussion on the use of renewable energy, costs and benefits as well as policy implications, most literature addressing the right support scheme focuses on Europe. While in the beginning of the 2000s the harmonisation of support schemes across Europe was considered, individual regulation in the member states is now a matter of consensus (COM 2011).

Renewable energy creates positive external effects, but is currently not competitive under market prices. Governments therefore have two options: regulating the quantity, i.e. the share of renewable energy in the energy mix is set, or regulating the price, meaning that electricity from renewable energy sources will be remunerated according to cost. The first solution leads to quantity-based certificate systems, such as the Renewable Portfolio Standard (RPS). The UK, Sweden, Poland and some states in the United States are examples of this solution in practice. The RPS sets binding targets for a percentage share of renewable generation in electricity production. Utility companies can either provide this certified share or buy certificates from other utilities. In the UK, utility companies were allowed to buy themselves out by paying a fine. The minor success of the initial phase of the system can

Table 1: Support schemes for increasing renewable energy

Support scheme	Explanation	Countries	Success
Priority access to the grid	Electricity from renewable energy has guaranteed access and must be purchased from grid-operators		Very important element of a successful support scheme
Feed-in tariff	Guaranteed rate for electricity from renewable energy	All EU-27 Member States except Finland, Netherlands, Poland, Romania and Sweden	Depends on the level of the tariffs, differentiation and duration and on the payment mechanism
Green certificates	Renewable portfolio standards, obligation of electricity providers to fixed shares from RE, tradable	UK, Belgium, Poland, Romania, Sweden	The UK had limited success; a low-cost opt out was allowed
Fiscal incentives	Tax exemptions (e.g. CO_2-tax), tax cuts for investments in RE	Most countries have some kind of tax alleviation, never only an instrument	Depends on the general tax framework; Finland was very successful in biomass
Tendering	Government calls for tenders for large projects and awards project to the most efficient bidder	Netherlands, Denmark, the UK and Spain	Medium success very centralised
Subsidies, Funds	Subsidies and/or subsidised interest rates for credits are given to investors	Most countries use subsidies to develop renewable heating systems	Successful if steady and transparent, otherwise boom-bust cycles

Table 2: Jobs from renewable energy, 2006 and 2010, world and selected countries

Industry	World 2010	World 2006	Selected national estimates 2010	Selected national estimates 2006
Biofuels	› 1,500,000		Brazil: 730,000 for sugarcane and ethanol production	
Wind power	~ 630,000	300,000	China 150,000 / Germany 100,000 United States 85,000 Spain 40,000 / Italy 28,000 Denmark 24,000 / Brazil 14,000 India 10,000	Germany 82,100 United States 36,800 / Spain 35,000; China 22,200 / Denmark 21,000 India 10,000
Solar hot water	~ 300,000	› 624,000	China 250,000 Spain 7,000	China 600,000 / Germany 13,300 Spain 9,142 / United States 1,900
Solar PV	~ 350,000	170,000	China 120,000 / Germany 120,000 Japan 26,000 United States 17,000 Spain 14,000	China 55,000 / Germany 35,000 Spain 26,449 / United States 15,700
Biomass power		1,174,000 (total biomass including fuel and gas)	Germany 120,000 United States 66,000 Spain 5,000	(total biomass including fuel and gas) Brazil 500,000 United States 312,200 China 266,000 / Germany 95,400 Spain 10,349
Hydropower		› 39,000	Europe 20,000 United States 8,000 / Spain 7,000	Europe 20,000 / United States 19,000
Geothermal		25,000	Germany 13,000 United States 9,000	Germany 4,200 / United States 21,000
Biogas			Germany 20,000	
Solar thermal power	~ 15,000		Spain 1,000 / United States 1,000	
Total estimated	› 3,500,000	› 2,332,000		

Source: REN21 (2011), Renewables 2011, Global Status Report, UNEP 2009 for 2006 numbers.

be directly attributed to the low level of the fine. It was less expensive to opt out of the system than to install renewable energy capacities.

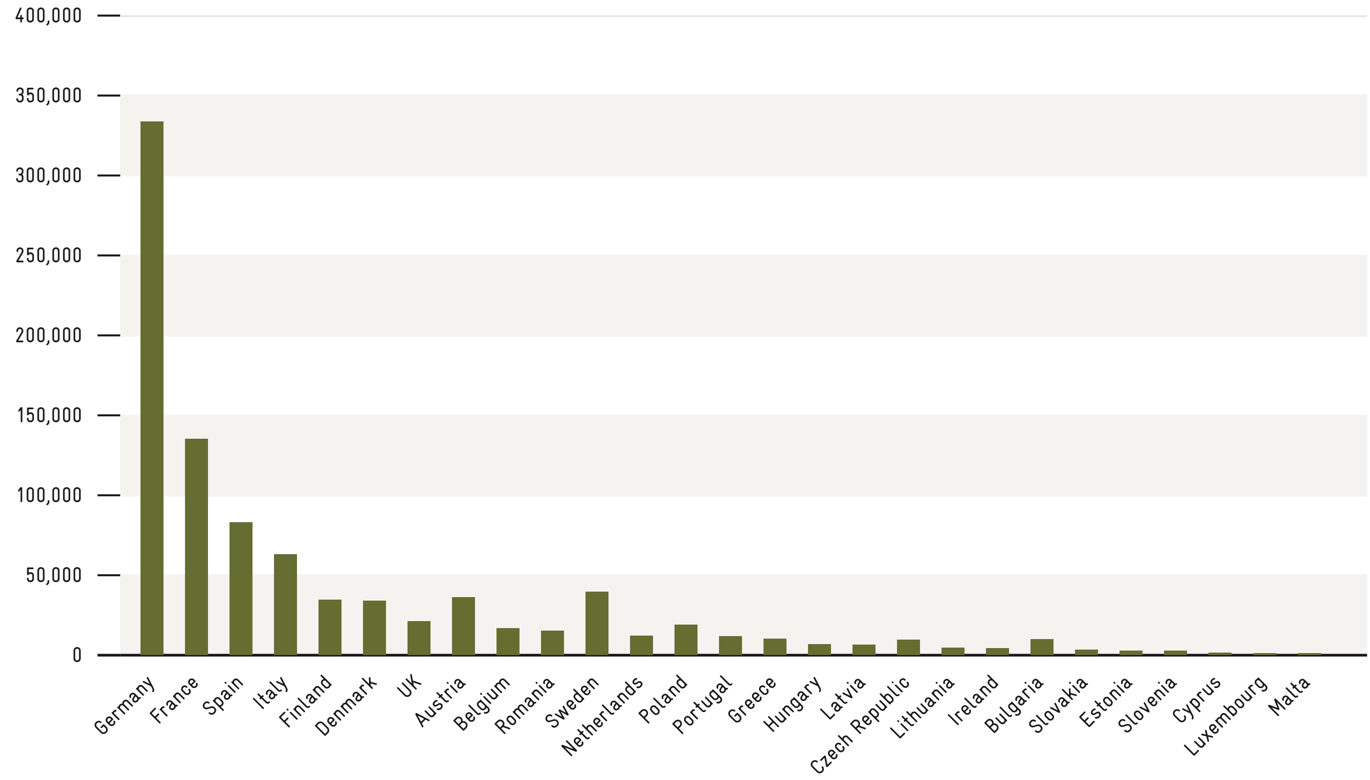
The second solution is a feed-in tariff. The majority of European member states have implemented feed-in tariffs because the annual monitoring reports on the status of renewable energy in the EU showed that price-based instruments were more successful. The investment security of a price-based system such as a feed-in tariff is higher and more attractive to investors. Europe has a rather short history of deregulated energy markets; therefore market price coupled systems such as the Spanish feed-in tariff/premium system turned out to be difficult to implement, because Spain had guaranteed fixed prices for household consumers at the same time (see the Spanish example, below). With increasing market prices, the subsidy for RE increased and the price gap to the guaranteed rate widened and contributed significantly to the Spanish budget deficit.

The EU has set country-specific renewable energy targets to reach an overall target of 20% renewable energy of gross final energy demand by 2020. Success is regularly monitored; beginning in 2010, countries were required to provide National Renewable Energy Action Plans that showed how they will reach their respective targets. Countries with feed-in tariffs have been more successful in reaching their targets.

3.1 WORLDWIDE ESTIMATES

Renewable energy has shown increasing growth rates since the beginning of this century. While the literature was initially very fragmented and scattered, a number of publications have since emerged to become the source for most of the research being done. Regular frameworks have been developed and are annually improved and updated. Owing to their use of physical units, i.e. capacity installed or energy produced,

Figure 3: Employment in the renewable energy sector in the year 2009 in all EU-27 countries (EurObserv'ER 2010)



these statistics can be considered very reliable. In Europe, the EurObserv'ER Reports provide a reliable overview of the state of affairs of the member states in terms of capacities installed and will provide the basis for future evaluation of the National Renewable Energy Action Plans of all the member states. Similar overviews are given at the international level by the REN21 network (REN21, 2011).

Socio-economic indicators, however, still must be developed in a consistent manner. Despite increasing interest in the employment impacts of renewable energy activities, the database on jobs, turnover and profits is still very weak. The above-mentioned publications collect employment estimates around the world from various sources, such as industry associations, individual country studies, etc. Table 2 offers an overview of the worldwide results. Unfortunately, it is not always clear what these employment figures include. The German figures denote gross employment, i.e. they include direct and indirect effects. They are taken from a study that will be described in greater detail in Chapter 3.12.6. Biofuel and biomass estimates use the above-outlined employment factor approach and do not include indirect jobs. Greenpeace (2010) suggested higher employment estimates from the Energy Revolution scenarios based on the EFA of Rutovitz and Usher (2009). They estimated worldwide employment in 2010 at more than 4 million jobs.

3.2 European estimates

European countries monitor their progress of the increase in renewable energy in terms of capacity installed and energy generated because Europe has set targets that must be reached by 2020 and progress must be reported in the National Renewable Energy Action Plans. Employment is not monitored and not reported. Germany and Spain are the only countries in the world to report regularly on employment in the renewable energy sector. Figure 3 offers an overview of employment in the renewable energy sector in all EU-27 countries for the year 2009 as reported in the annual publication,'The State of Renewable Energy in Europe'. The literature for this publication is reviewed annually and the available data are processed. Where no data are available, employment is estimated. Germany has three times as many jobs in the renewable energy sector as the next country in the country ranking (France), and as many people working in the industry as the following five countries in this ranking put together. Germany has the most employment of all EU-27 countries in all single technologies except for geothermal energy and small hydro, for which France has 20% more.

If we analyse the contributions of the different RE technologies, we find that the biomass sector is the largest in terms of employment. From a total of 912,220 people working in RE industries in EU-27 in 2009, 283,750 (30%)

Table 3a: Employment impact of the installation and maintenance of solar thermal heaters, EU-27, 2009

Country	Capacity installed (MW)	Employment	Employment/ MW capacity installed (jobs/MW)	Increase in capacity (MW) in 2009	Employment in installation/MW new capacity (jobs/MW)	Employment in O&M/MW capacity installed (jobs/MW)
Germany	9,029.9	15,900	14.0	1133.9	n.a.	0.6
Spain	1,305.5	3,500	12.4	281.4	3.7	0.3
Denmark	338.9	500	13.1	38.2	7.9	n.a.
Italy	1,410.4	5,000	17.9	280.0	12.5	n.a.
France	1,369.3	6,250	28.2	221.9	7.0	0.5
UK	333.4	900	14.4	62.4	9.4	n.a.
Ireland	84.7	400	13.4	29.8	n.a.	4.7
Poland	356.9	2,000	19.8	101.0	8.9	1.4
Portugal	311.5	1,250	12.8	98.0	n.a.	n.a.
Sweden	295.4	300	9.3	32.4	7.4	n.a.
Belgium	234.5	500	13.0	38.5	10.4	0.2
Austria	3,031	6,200	24.3	255.5	7.3	0.6
Finland	19,9	50	23.8	2.1	n.a.	n.a.
Greece	2,853.3	3,000	20.8	144.2	n.a.	n.a.
Bulgaria	25.6	400	114.3	3.5	45.7	1.6
Estonia	1.5	50	250.0	0.2	n.a.	n.a.
Czech Republic	359.6	350	5.6	63.0	n.a.	n.a.
Netherlands	542	970	19.6	49.5	12.7	n.a.
Lithuania	3.4	50	100.0	0.5	n.a.	n.a.
Hungary	46.7	250	35.7	7.0	23.9	0.9
Romania	80	200	14.3	14.0	n.a.	n.a.
Latvia	5.8	50	45.5	1.1	n.a.	n.a.
Luxembourg	14.1	50	21.7	2.3	n.a.	3.5
Slovenia	110.5	250	15.0	16.7	n.a.	n.a.
Median					**9.1**	**0.8**
Mean					**13.1**	**1.4**

were working in the biomass sector. This figure is the most uncertain in this framework because some countries report employment in the biomass sector including the provision of biomass from the agricultural sector, whilst other countries, e.g. Germany, report these numbers separately. For the next three most important technologies i.e. wind energy, PV and solar heat, the data are more detailed regarding their job impact in Europe. Table 3 a-c shows the capacity installed for the respective technology, the increase in capacity in 2009 and the employment factor for installation and maintenance where this information is available.

Detailed data on operation and maintenance or installation are not available for many countries. The above table shows the employment impacts for large water heaters. The median value and the average (mean) are reported in the table because some countries show rather extreme values. A possible explanation for very high values in countries with low installations such as Bulgaria or Hungary is that employment

Table 3b: Employment impacts of the installation and maintenance of PV, EU-27, 2009

Country	Capacity installed (MW)	Employment	Employment/ MW capacity installed (jobs/MW)	Increase 2009 in capacity (MW)	Employment in installation/MW new capacity (jobs/MW)	Employment in O&M/ MW capacity installed (jobs/MW)
Germany	9,830.3	64,700	17.0	3,811.0	6.79	0.7
Spain	3,520.1	14,000	141.4	99.0	113.1	n.a.
Denmark	4.6	350	269.2	1.3	26.9	7.6
Italy	1,181.7	9,000	12.4	723.1	6.8	1.1
France	33.1	13,200	60.8	217.0	51.7	n.a.
UK	32.6	6,800	673.3	10.1	n.a.	n.a.
Ireland	0.4	50	0	0	n.a.	n.a.
Poland	1	100	0	0	0	25.0
Portugal	102.2	1,500	43.8	34.2	n.a.	n.a.
Sweden	8.8	650	764.7	0,8	n.a.	3.7
Belgium	363	7,000	24.0	292.1	n.a.	n.a.
Austria	52.6	2,500	123.7	20.2	n.a.	26.1
Finland	7.6	100	50.0	2	2.5	n.a.
Greece	55	1,300	35.6	36.5	n.a.	n.a.
Bulgaria	5.7	200	46.6	4.3	9.3	28.1
Estonia	0.1	50	1,000.0	0.05	n.a.	n.a.
Czech Republic	465.9	2,100	5.1	411.2	1.3	3.4
Netherlands	67.5	600	56.2	10.6	n.a.	4.4
Lithuania	0.1	50	0	0	n.a.	n.a.
Hungary	0.7	350	1,750.0	0.2	787.5	275.0
Romania	0.6	100	526.3	0.2	184.2	108.3
Latvia	0	350	0	0	n.a.	n.a.
Luxembourg	26.3	50	28.4	1.8	n.a.	n.a.
Slovenia	8.4	250	29.8	6.4	n.a.	n.a.
Médiane					**9.3**	**7.6**
Moyenne					**108.2**	**44.0**

reported is not full-time employment in person years, but includes all people who spend some part of their working day on the installation of solar heaters. In some countries sales activities are included in the installation category, which increases the employment factor. Similar variations can be observed in the next table, which shows employment in the PV sector (Table 3b).

For the wind industry (Table 3c), the values are much closer together as installation of wind parks is carried out by specialists working full-time on the project. Where planning services are included, it drives the number of jobs upwards because planning offices also offer services for solar power stations, etc.

The table also shows a column of figures for employment per capacity domestically installed. Export-oriented countries show very high values in this column. Germany and Denmark are two examples of this. Finland had fewer installations in 2009, which biases the results.

Table 3c : Employment impacts of the installation and maintenance of wind energy, EU-27, 2009

Country	Capacity installed	Employment	Employment / capacity installed	Increase 2009	Employment in installation / new capacity	Employment in O&M
Germany	25,777	102,100	54.3	1,880	n.a.	0.6
Spain	19,148	45,000	18.3	2,459	7.3	0.7
Denmark	3,482	24,000	75.9	316	n.a.	1.0
Italy	4,850	20,000	18.0	1,114	9.0	1.2
France	4,626	19,700	18.0	1,094	7.2	0.4
UK	4,424	6,800	6.7	1,018	2.7	0.6
Ireland	1,260	3,000	12.9	233	n.a.	n.a.
Poland	705	3,000	11.8	254	1.2	0.6
Portugal	3,326	3,000	6.4	469	n.a.	n.a.
Sweden	1,560	3,000	5.6	539	n.a.	n.a.
Belgium	606	2,800	13.1	214	n.a.	n.a.
Austria	994	2,500	0.0	0	n.a.	0.3
Finland	147	2,000	500.0	4	25.0	n.a.
Greece	1,087	2,000	19.6	102	n.a.	n.a.
Bulgaria	177	1,000	17.5	57	12.3	1.7
Estonia	149	1,000	15.6	64	7.0	3.7
Czech Republic	193	700	16.3	43	n.a.	n.a.
Netherlands	2,222	700	9.6	73	n.a.	n.a.
Lithuania	98	600	13.6	44	n.a.	n.a.
Hungary	201	500	6.8	74	3.0	1.4
Romania	14	100	25.0	4	8.8	4.6
Latvia	28	50	0	0	n.a.	n.a.
Luxembourg	43	50	0	0	n.a.	n.a.
Slovenia	0	0	0	0	n.a.	n.a.
Median					**7.3**	**0.9**
Mean					**8.3**	**1.4**

As there are no data available on the production and turnover of RE companies, no similar calculations for production can be carried out. Production can be for domestic installation or for export purposes and the MW produced can only be surveyed at the level of individual companies. Most of the literature used in this report does not include these data. One exception is the case study for Germany, where employment data are based on a representative survey of the RE industry.

The heterogeneity of the above data is partly due to the methods used for each study taken into consideration. Some values are clearly much too high and there is speculation about the reasons for this. Nevertheless, all data limitations considered, the tables seem to illustrate several interesting facts:

- Countries with similar installation, production and export structures show similar employment factors,

- Countries with little installations have less efficient installation and operation and maintenance routines,
- The three technologies considered show similar employment impacts for the installation of the facilities; they differ strongly in operation and maintenance. Operation and maintenance shows the widest spread between countries for solar thermal energy. The data do not appear accurate because some countries report maintenance and sales activities within this category.

Though the success of renewables in the EU-27 and also in the US and China is impressive (see table 4 for an overview), it does not convey much about the underlying drivers and influences that made RE a success story in some countries while other countries were left behind with respect to employment.

A closer look at different examples at the individual country level is required to obtain more information about these factors. The following case studies show the drivers that led individual countries to be successful in terms of reaching their installation targets and creating a sustainable positive labour market impact.

3.3 Country studies

Our overview is somewhat biased, because the data quality differs across technologies. The wind industry publishes annual statistics on technological and economic variables (GWEC, different years) by country and/or region. Solar energy is not as comprehensively covered and the information on biomass is rather scattered. Electricity generation is much better documented than heat applications, at least for Europe, and the literature on energy efficiency application is very sparse.

3.3.1 Spain

Spain has excellent potential for the use of renewable energy, especially wind and sun. The Spanish company Gamesa is the world's third largest producer of wind turbines. Together with the Spanish power company Iberdrola Renovables, Gamesa has a strategic partnership. Iberdrola Renovables is the largest individual owner of wind parks in the world. The Spanish support system offers two options for remuneration of electricity from solar PV or wind: a feed-in tariff and a bonus system. The latter is paid on top of the market price and favours large suppliers, since they are experienced in accessing the electricity market and can handle sales of electricity from wind energy and large PV installations. The feed-in tariff for solar panels has been subject to a great deal of stop-and-go politics and the Spanish market is currently considered dead. After coupling the feed-in tariff to the market price in 2006, the system instigated large holes in the public budget. Consumer electricity prices were guaranteed, market prices skyrocketed in 2007 and the renewable energy premium came on top of market prices. The government had to cover the difference between the guaranteed rate and the actual prices.

The change of system to a fixed feed-in tariff came with a cap on PV installation. This heated the market up until the cap was reached and afterwards the market subsided. The final blow to the PV industry in Spain, as well as in all of Europe, was the ex post reduction of the amount of hours that would be remunerated. Some electricity providers are considering taking the Spanish government to court because investment that was initiated before conditions changed has now been stranded.

Since 1998, wind power has grown tremendously in Spain, from 723 MW to 20,676 MW. A strong domestic market with a preference for large wind parks operated by sizeable utility companies led to the development of a robust industry with worldwide customers. Since 2003/04 Spain built concentrating solar power plants, first as test and pilot projects and later for commercial use. Large solar PV power generation followed, though neither technology led to significant growth in the Spanish industry; solar PV industries developed faster in countries with a history of strong semi-conductor and electronics industries. Nonetheless, 14,000 people work in the solar power/PV sector, mainly in installation and operation and maintenance. It is the second most important branch of renewable energy in Spain. The third most important branch is the solid biomass sector, although has been a slow developer. With 8,000 jobs it is rather small compared to the numbers in other countries in the European Union. Spain has a total of 82,845 people working in the renewable energy industry and comes in third in the EU-27. The main driver has been support for large scale wind generation. The main difficulties have been observed recently when the feed-in tariff was cut back and the industry lost up to 30% of turnover and up to 50% of employment.

3.3.2 France

France produces more than 70% of its electricity from nuclear power. Nuclear power generally slows the increase of renewable energy electricity generation because it is difficult to combine with fluctuating generation and lowers the pressure on prices from the CO_2-emission trading system. Currently, the main renewable power source in France is large hydro.

According to the nuclear industry, there are 125,000 people directly employed in the nuclear energy sector with a total of 410,000, including indirect employment. Renewable energy creates about 135,000 direct and indirect jobs in France.

The largest share of these jobs lies in the agricultural sector, which produces solid, liquid and gaseous biomass inputs. RE electricity is supported by a feed-in tariff (wind, PV, biogas, hydro and geothermal). The rates are paid for 15 years after installation and they are comparable to the levels set by other European countries.

France does not have a large renewable energy industry. There has been some activity in building integrated PV and some initial successes have been observed in the past few years. France could develop into an example of good practice in this sector: their natural potentials make building integrated PV a potentially useful system and their support policy has been especially designed to develop this niche technology into a growing industry.

Most renewable energy employment in France lies in the installation of wind parks, solar panels and especially in the use of biomass (almost 50%). France is the largest agricultural economy in Europe and solid biomass heaters have been heavily subsidised. There are 60,000 people who work in the biomass sector. With 135,270 RE jobs, France ranks second in the EU (see figure 3), just behind Germany in terms of employment in the renewable energy sector.

The most important driver for the expansion of renewable energy has been the pre-existing agricultural character of the French economy and the natural potentials for building integrated PV and wind, especially in its overseas territories. The most important barrier to the expansion of renewable energy is the dominance of nuclear energy on the French mainland.

Table 4: Overview of RE employment, EU-27 and selected countries, 2009 unless stated otherwise

Country	Employment	Country	Employment
Germany	333,400	Hungary	6,850
France	135,270	Latvia	6,600
Spain	82,845	Czech Republic	9,800
Italy	63,200	Lithuania	4,700
Finland	34,820	Ireland	4,250
Denmark	33,900	Bulgaria	9,885
UK	21,400	Slovakia	3,650
Austria	35,950	Estonia	2,850
Belgium	16,650	Slovenia	2,715
Romania	15,150	Cyprus	700
Sweden	39,400	Luxembourg	270
Netherlands	12,400	Malta	100
Poland	19,115	EU-27	918,220
Portugal	11,950	China (2007)	943,200
Greece	10,400	USA (2006)	427,000

3.3.3 Italy

Italy follows a variety of approaches in the support of renewable energy. Wind energy is supported by quotas and green certificates; PV and other small systems are supported by a feed-in tariff, tax reductions and net metering. Thus far, heat from renewable energy sources is only supported in certain cities and regions, but not on the national level.

Wind energy has picked up speed in Italy in the last few years. A late starter, in 2009 more than one fifth of total wind energy capacity was added within a year. The total is currently 4,850 MW. Italy surpassed Denmark and ranks third within Europe in terms of capacity installed. Employment, however, is mainly in operation and maintenance with only 20% in manufacturing. A total of 20,000 people work directly and indirectly for the wind industry; if installation is counted as indirect employment, the vast majority of the 20,000 jobs are in indirect employment. Italy surpassed the US in terms of solar panel installation. Wafers, cells and modules are produced in the country, though the industry does not yet have a company that ranks among the top ten companies worldwide. The employment statistics differ widely: EurObserv'ER reports employment figures of between 9,000 and 22,000 people in the solar PV sector. Despite the lack of continuous and dedicated public support schemes, heat pump installations have spread widely in Italy. This is reflected in its comparably high employment figures in the geothermal sector. Of 10,000 people reported as working in that sector, 9,000 work in the installation, operation and maintenance of heat pumps. With a total RE employment of 63,200, Italy ranks fourth in Europe in terms of overall employment in the renewable energy sector, after Germany, France and Spain.

Although Italy has excellent wind and solar potential, the electricity sector suffers from an inadequate grid infrastructure (GWEC 2011). Large renewable energy electricity generation suffers from this bottleneck. According to the World Wind Energy Association, in 2009, some wind energy farms operated at only 30% of their normal capacity (average through the course of a year). Grid constraints even led to the shutdown of individual wind farms. The integration of fluctuating energy sources becomes more difficult when the infrastructure is old and outdated. Given the natural potential in the south of Italy, solar heat and heat pumps have been established without major support.

3.3.4 Portugal

Portugal has seen enormous growth rates in renewable energy recently and is one of the leading European countries in terms of wind penetration (GWEC 2011). Portugal supports renewable energy with a wide range of instruments: fixed feed-in tariffs are in place for PV, wave energy, small hydro, wind power, forest biomass, urban waste and biogas. Tendering procedures are used in connection to wind and biomass installations and investment subsidies and tax reductions are also available.

Of benefit to market integration is the combination of large pumped storage and wind energy, which increases off-peak power generation. The economic downturn in Portugal is creating heavy pressure on investments and in renewable energy installations, leading to decelerating investment and attempts to decrease feed-in tariffs in order to keep electricity prices down.

The increase in Portugal's development of renewable energy came very late, given the excellent potential in the country for wind, solar and wave energy. In 2005, the Portuguese government approved an investment plan to increase the share of renewable energy in power generation to 60% by 2020. Portugal will also have the largest solar energy station in the world, being built in the Baldio das Ferrarías Valley, in one of the country's poorest regions. Thus far, most of the country's installations have been imported and employment has primarily been generated in the installation and operation and maintenance sectors. Out of a total of 12,000 jobs, the largest share is found in biomass and biofuels (more than 80%), followed by wind energy and photovoltaic installations. Detailed figures about the distribution of jobs generated by production, installation and operation and maintenance are not available.

The most important driver has been Portugal's desire to replace imported energy with domestic production and an investment plan for large installations. For households and end-customers, a variety of incentives has been created and has proved sufficient.

3.3.5 China

China has become a serious player on the world market for renewable energy technologies in terms of production, and more recently, in terms of installation. The Renewable Energy Law passed in 2005 was a turning point for China's RE development. Since then, wind power capacity has grown 30-fold according to Martinot (2010) and other technologies have started to gain ground. Companies from China's wind and photovoltaic industries have become world leaders. The wind industry started in the late 1990s with small turbine models. International investors and producers were required to use 70% local content. This policy was recently shelved because all wind mills installed in China now come from domestic production. REN21 estimates that there are 150,000 people working in the wind industry. Given industrial output in China and assuming comparable productivity from these new companies, as with companies in Europe or in the US, this figure comprises direct and indirect employment.

China's policy is targeted at a 15% renewable energy share in final energy demand by 2020. Given the natural resources and the growth rates during the last couple of years, this target might be achieved ahead of schedule. At present, China's renewable energy industry is mainly driven by exports, benefiting from favourable conditions and renewable energy targets around the world. With 120,000 jobs, the solar industry has been established to serve international markets. The production facilities had to be imported from Germany and other countries. Meanwhile, China is introducing solar PV to the domestic market but a number of problems must be resolved before the installations can pursue their expansion. Demand for trained personnel and engineers is greater than current supply. Given the fast development of renewable energy industries and installations in China, the institutional infrastructure has not been developed at the same pace. Research institutes, measuring and testing facilities, wind prognosis and potential mapping for the best areas for solar or wind power must be created or extended.

The production and installation of solar heat applications employs 250,000 people. Here, the domestic market plays a significant role for the industry's turnover. China has 64% of the worldwide capacity installed in the country.

During the last five years, China has successfully developed its legislation into a multiple incentive structure with feed-in tariffs, tendering procedures for large projects, portfolio standards for large utilities and investment subsidies for PV and biomass applications. GWEC (2010) stresses the importance of the Clean Development Mechanism (CDM) for the development of wind energy projects and the United Nations has approved 869 Chinese projects as CDM projects. China holds almost 40% of all CDM projects and the income from the CDM has made large impacts on investors' returns. Conflicts have arisen about the CDM condition of 'additionality', meaning that many projects would have been realised even without CDM. The future fate of CDM is currently uncertain the mechanism ends with the expiration of the Kyoto protocol in 2012. The Chinese energy sector has been supported by a large investment from CDM that helped to establish a domestic market which keeps driving up employment. The future financing instrument for large RE projects is currently unknown.

3.3.6 Germany

Germany has developed into the European leader in terms of capacity installed, jobs and companies with successful world trade shares. It is often seen as a role model in terms of legislation, at least in the electricity sector. The German support system originated from a system coupled to electricity prices and developed into a feed-in tariff with cost-oriented rates (20 years lifetime, 8% interest rate on the investment). The rates differ between technologies and within technologies by size. Bonuses are paid for market integration and the provision of services to stabilise the grid and other system-relevant properties (improvement of prognosis, etc.). The tariffs are assessed biannually to reflect market developments and cost curves. PV installations were huge in 2010 (almost 44% of worldwide installations) and the feed-in tariff has been decreased owing to cost reductions in the industry. Prices for PV Modules fell by 50% in the last five years. The adjustment of the feed-in tariff endeavours to account for this price decrease.

Germany has followed an industrial political strategy, not only supporting the installation of wind, solar and biomass technologies but also the development of respective industries with attractive investment conditions and stable regulation. Employment in the renewable energy sector has been analysed since 2004. Staiss et al. 2006 was the first report on the employment effects of an increase in renewable energy in Germany, with an emphasis on the outlook for foreign trade. The study is the first in a series of studies that cover a wide scope of aspects of this issue.

The core contribution of this series is the development of deeper insights into the inter-industrial input-output structures of the renewable energy industry. Since this industry is too young to be included in official industry statistics as a branch of its own, primary statistical data could only be gleaned from industrial surveys. The first survey was carried out in 2005, the second in 2008. Regular surveys are necessary because the renewable energy industry is still young and subject to changes in production processes, cost structures and production portfolios. The surveys provide results on the cost structure, imports, exports, turnover and jobs. The unit of interest is the production company. This is the most feasible approach for Germany, because it has a comparatively large productive sector and a large industry for intermediates. Direct employment can be derived from production in the wind industry, PV industry, and solar thermal industry, etc. Indirect employment comes from the inputs to production and the inputs to these inputs (see chapter on methodology, above).

Since Germany is an export-oriented economy, the chances were that the new renewable energy industry would turn to exports too. Denmark set the example with its wind industry: Denmark was a very early adopter in the field of renewable energy. In the 1980s, Denmark developed the legislation framework with stable political conditions, a feed-in tariff, energy taxes and special zoning laws for wind parks. Nowadays, Vestas is the largest wind technology company in the world; 90% of its turnover comes from exports.

Germany has a large industrial base and has adopted more than one technology. In nearly all of the RE technologies, German companies are among the five leading companies in the world. While exports are an important pillar of production, Germany has also successfully created a large domestic market.

Table 5 shows the top five rankings of the countries with the largest additions for several core technologies in 2010 (REN21 2011). In terms of country size and natural resources, the fact that Germany is present among the top five positions reflects its strategic approach.

Employment has been monitored, as mentioned above, since 2004. For 2004, the study listed 160,500 jobs in the RE sector. By 2009, this number had already more than doubled. In 2010, 367,400 people worked in the production of RE technologies, intermediate goods and in the operation and maintenance of RE facilities, including the provision of fuels.

Export is the driving factor not only of the German economy but also for the renewable energy industry in Germany. Therefore, sectors such as wind and solar electricity generation that are stronger in exports than others, contribute the most to employment in the sector. Biomass heating stoves have the lowest export shares and large hydro the highest, in percentage terms, because the large hydro potential in Germany is exhausted and production is nearly 100% geared to export. Without exports, there would be little employment in the hydro industry.

Operation and maintenance is growing in importance with growing installations. This observation holds especially true for smaller applications such as heat pumps and solar thermal hot water appliances. Larger installations do not increase as much in cost and employment for operation and maintenance because of scale effects. Today's wind parks are larger and have more capacity installed per park. Therefore maintenance works can be carried out in a more concentrated and efficient manner. Heat appliances on private and public buildings, however, are decentralised and employment in operations and maintenance (O&M) increases with the increase in capacity installed.

The industry survey in BMU 2011 also provides data about the quality of additional employment. UNEP (2008) published a comprehensive report on green jobs, with the subtitle, 'Towards decent work in a sustainable, low-carbon world'. The quality of future employment in the green industries will be relevant. Renewable energy can provide employment with fewer health risks and better working conditions compared to mines, oil drilling and uranium extraction. But how do green jobs compare in terms of qualification, gender equality and sustainability?

Table 5: Top five countries, new additions

	New capacity investment	Wind power	Solar power	SWH	Ethanol	Biodiesel
1	China	China	Germany	China	United States	Germany
2	Germany	United States	Italy	Germany	Brazil	Brazil
3	United States	Spain	Czech Republic	Turkey	China	Argentina
4	Italy	Germany	Japan	India	Canada	France
5	Brazil	India	United States	Australia	France	United States

Table 6 shows a number of characteristics of employment in the renewable energy sector. The last column gives average values for the manufacturing industry in Germany, for comparison. On average, jobs in the renewable energy sector require higher skills and better qualifications compared to the rest of the economy. The rate of unskilled labour is much lower than the industrial average and college or university degree rates are higher. The rate of female employees, however, is still rather low; the concept of 'green' employment is not reversing the reluctance of young females to choose a technical education. Temporary staffing is higher than in the rest of the productive sector and this is often a characteristic of new industries. The need for labour is not yet established and so the expansion path of the industry is often staffed with temporary workers to hedge against the risks of future market developments.

Intensive foreign trade relations characterise German economic development. For several years Germany was the worldwide 'export champion', a title that has recently gone to China, although Germany remains the second largest exporter in the world. From its industrial structure and its excellent trade relations worldwide, it seems only natural that it has also become a leading exporter in the renewable energy sector. The 2008 industry survey shows export activities of up to 75% of total turnover for some RE technologies. Not only full equipment is exported, but also components and inputs to the production of that full equipment. In the PV industry and in solar thermal systems production, component exports exceed the exports of full equipment.

Photovoltaic module, cell and wafer production have been particularly supported in East Germany. The so-called 'Solar Valley' (borrowed from the American Silicon Valley), is an East German region with the highest density of solar industries in Europe. The region partly belongs to three German sub-States: Saxony, Saxony Anhalt and Thuringia. It was important for the chemical industry of the former GDR, but after unification, health risks and outdated production technologies led to the closure of the chemical industry in the region. Dedicated investment promotion led to the development of a new industry in this formerly core industrial region. Currently more than 3,000 people work in the solar cluster and the negative migratory trend has come to a halt. Germany has specifically tried to establish renewable energy companies in East German sub states. While full equipment production followed the investment incentives and tax exemptions, production of industrial inputs often remained in the established western industrial centres. This leads to a different distribution pattern of direct and indirect employment. Distelkamp et al. (2011) observed this pattern in the regional distribution of direct and indirect employment in the wind industry. While strong wind potential in the north obviously leads to installations taking place in the north, southern sub states benefit from the demand for intermediate inputs.

Gross employment in the renewable energy sector is increasing with growing domestic installations and exports. German industry and households bear the additional costs of domestic installations. In 2010, these additional costs for electricity, heat and fuel together amounted to almost EUR 10 billion. To cover the additional costs, households and industry pay a surcharge, with exemptions for the energy intensive sector. This contribution rose from 0.2 ct/kWh in 2000 to 3.53 ct/kWh in 2011. Projections show that the peak will be approximately 3.8 ct/kWh in 2015 and will fall afterwards. It is therefore important to analyse the overall net economic impact of the domestic increase of renewable energy in Germany. Assuming that the industry and its success strongly hinges on RE legislation and on stable domestic demand, we can define a counterfactual method without exports and without RE technologies in Germany. The difference between two simulation runs (with RE and without) can then be compared with the difference in employment and be calculated in order to obtain the net employment impact.

3.3.7 Barriers and drivers to the renewable energy sector

Europe's electricity grids were developed in the last century and are often inadequate for modern energy supply and demand (e.g. in Italy). According to a German study (DENA

Table 6: Employment structure in the renewable energy industry (as a percentage of total)

	Total RES	PV	Wind	Heat pumps	Biomass	Industry average
Female	23.6%	30.6%	20.0%	13.8%	18.6%	35.0%
Apprentices	3.8%	3.2%	4.8%	3.0%	4.0%	4.9%
Temporary staffing	7.4%	7.3%	11.3%	7.5%	3.8%	2.5%
Without finished apprenticeship	4.1%	5.8%	0.9%	6.6%	3.1%	15.0%
With finished apprenticeship	49.9%	47.0%	52.6%	65.8%	56.8%	69.5%
With college/university degree	32.1%	34.7%	27.1%	15.3%	29.7%	9.9%

Source: own calculations from 418 companies surveyed, does not necessarily add up to 100.

II), investment of up to €1.6 billion will be necessary up to 2020 to guarantee stable and secure electricity for the German grid. The integration of renewable energy requires new skills and technologies in the fields of wind prognosis, storage capacities, demand side management and demand prediction techniques. Concerning Chinese development, studies point out that the grid will be an important bottleneck, preventing significant increases in shares of renewable energy in the overall energy supply scheme. Another bottleneck will be bringing the skills of the workforce up to par, according to different case studies. Since Germany had a highly skilled workforce in industrial production, training was only necessary for special skills. This situation may vary from country to country and must be analysed in detail. Producers usually prefer in-house training to directly familiarise the workers with their products. Regarding education, special course work in engineering has been developed for solar and wind technologies. Several college and university degree programmes focus on renewable energy, in technical as well as socio-economic studies.

Germany currently has shortages of skilled workers in many sectors because of the economic uptake. The extent to which the companies in the RE sector are affected by this has yet to be seen.

China's increasing need for skilled workers is the result of rapid growth in the industry. Training and education have not kept up with this growth. Since this is the case in several Chinese industries, competition for well-trained workers is high among different sectors.

Worldwide concerns about the investment needs of renewable energy were expressed during the financial crisis. In retrospect, we saw some slowdown, but much less than in other industries and less than expected. In Germany, where the feed-in tariff is not tied to public budgets and the refinancing scheme is clear, there was a strong increase in PV projects, usually mounted on the rooftops of private houses. Wind energy struggled to find capital for large wind parks, but most projects were financed. It represented a 'safe' investment with guaranteed returns, while suddenly, alternative investments did not seem so attractive any more. Large off-shore wind projects suffered because they are still considered more risky and the turnover is not as clear, due to lack of experience.

Legislation and stable political framework conditions can be seen as the most important drivers of a successful renewable energy strategy that leads to sustainable employment. Despite textbook definitions of firms as daring entrepreneurs merely waiting for the best opportunity, in reality, firms are investors that prefer a stable, reliable, predictable political framework. Long-term policies with transparent targets, frequent target control and transparent adaption procedures seem to enjoy most success. German legislation is often cited as a role model (REN21, UNEP 2010). The latest IPCC report on renewable energy (IPCC 2011) highlights the German experience, concluding:

'The German example shows how rapidly RE can advance when supported by ambitious policies that convey clear and consistent signals and that adapt to technical and market changes. RE deployment policies can start with simple incentives, evolving towards stable and predictable policies and frameworks to address the long-term nature of developing and integrating RE into existing energy systems. However, integration of RE remains a constant challenge as indicated by recent limitations of the German electricity network to absorb rising shares of RE, and the cost implications of Germany's programme have also begun to attract concern.'

4 IMPACTS OF ENERGY EFFICIENCY

Energy efficiency is often called the most important energy source for any country. All scenarios that project significant shares of non-fossil energy sources in the overall energy mix are based on significant decreases in primary energy demand for final energy consumption, whether on a regional, country or worldwide basis. All sectors must increase efficiency, otherwise no decoupling of economic growth, energy demand and GHG-emissions will be possible.

Buildings are the largest single energy consumer around the world, and they also represent the largest single potential for energy savings. Efficient buildings are of crucial importance for the future containment of greenhouse gas emissions, because population development and its increasing energy demands will drive household energy consumption sky high otherwise. Average and specific household energy consumption has increased in most regions in the last years. It has recently been driven by economic growth in emerging economies such as China, India and South-East Asia, where more and more people can afford electrical household appliances and cooling devices. In the industrial countries, household energy consumption has been driven up by three developments: first, the average household size has shrunk while the number of households has increased and therefore the number of basic appliances such as washers, driers, refrigerators and dishwashers has grown accordingly. Second, the average size of houses and apartments has increased, increasing the requirements for heating, cooling and lighting, and third, the number of electrical appliances per household has grown. The average energy consumption per household in the IEA member states rose by 29 per cent between 1990 and 2004. Electricity for household appliances grew by 50 per cent during the same time span.

4.1 International experiences

Energy efficiency not only provides vast potential for energy savings, but these savings will be achieved in comparably labour-intensive sectors of the economy. UNEP 2009 introduces international research on energy efficiency and employment. The first studies undertaken for Germany go as far back as 1992. Jochem and Hohmeyer analysed the impacts of a German retrofit programme and found that 100 new jobs per petajoule (PJ) saved have been created. A British Association study from the year 2000 also found large employment increases from an input-output modelling exercise of 44 EU energy saving programmes (up to 13.5 jobs/per EUR million spent).

For the US, several studies have found that close to 300,000 new jobs were created by a programme of combined measures taken in the building sector using efficient cooling, heating and appliances. If all the 'efficiency jobs' of all efficiency related activities in the US are taken together, estimates number eight million direct and indirect jobs. This number, however, includes waste management, water treatment and the production of appliances and electronics of high efficiency standards.

Since the construction sector stands out in the efficiency programmes of most countries, the majority of studies focus on additional employment from programmes targeted at the retrofitting of existing buildings and on the construction of new energy efficient buildings. Studies in the US have identified more than 800,000 people working in this area. The German initiative to retrofit houses has yielded 25,000 jobs for every €1 billion spent.

Overall, there are few detailed studies on the effects of energy efficiency on employment. Apart from construction, employment growth from energy efficiency is hard to determine. In industry, efficient machinery is replaced during usual replacement cycles and new products are produced by the same companies or at least within the same economic sectors from which the replaced equipment came. Efficient refrigerators are produced by the refrigerator industry. Employment effects may be more easily noticed if some of the more efficient products are produced domestically while inefficient products are imported (or vice versa). If the efficiency gap is so large that it leads to a competitive advantage for the industry, additional employment from additional exports could occur.

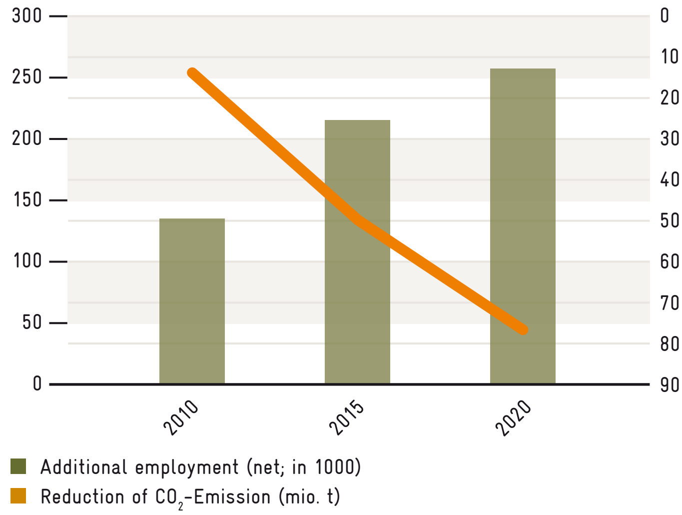
The impact of energy efficiency on the creation of new jobs, e.g. for the production of insulation materials for houses and for more efficient household appliances, must therefore be analysed on a country by country basis.

4.2 The German experience

The German Ministry of the Environment together with the National Climate Initiative supports several programmes for consumers, industry and administrations to reduce energy consumption. The initiative is targeted at efficient buildings (new and refurbished), efficient machinery, efficient heating and cooling and some measures within the transport sector. The programme is financed by the revenues from emissions trading. Parts of the programme are currently evaluated by a consortium of researchers from several research institutes (ifeu, GWS, ISI 2009 and forthcoming). A first evaluation report was published in 2009. The team found great potential for efficiency increases in all sectors. They suggested measures to tap the potentials that are economically viable, i.e. for which the payback time of the investments is shorter than the lifetime of the project. For industry investments, we found quite short payback times in some cases.

A total of 33 different measures in the following sectors have been analysed: household, industry, trade, services and transport. Overall energy reduction compared to base year

Figure 4 : Employment and CO_2 emissions, difference of efficiency and reference



Source: ifeu/ISI/Prognos/GWS 2009 and the sources quoted there.

2007 was 10% and electricity consumption was reduced by 14%. Energy productivity will increase by 90% from these economically viable measures alone and therefore almost reach the German target of doubling its energy efficiency by 2020. CO2 emissions will be decreased by 9% and additional investment in energy efficiency and reduction in energy costs will lead to a nearly 1% increase in GDP and the additional employment of 260,000 people in 2020. At current fossil fuel prices, imports will fall by €6 billion and if prices increase in line with one of the IEA's projections, these savings could rise to €12 billion. Overall savings of up to €19 billion in 2020 would be possible and would create a positive balance to annual investment.

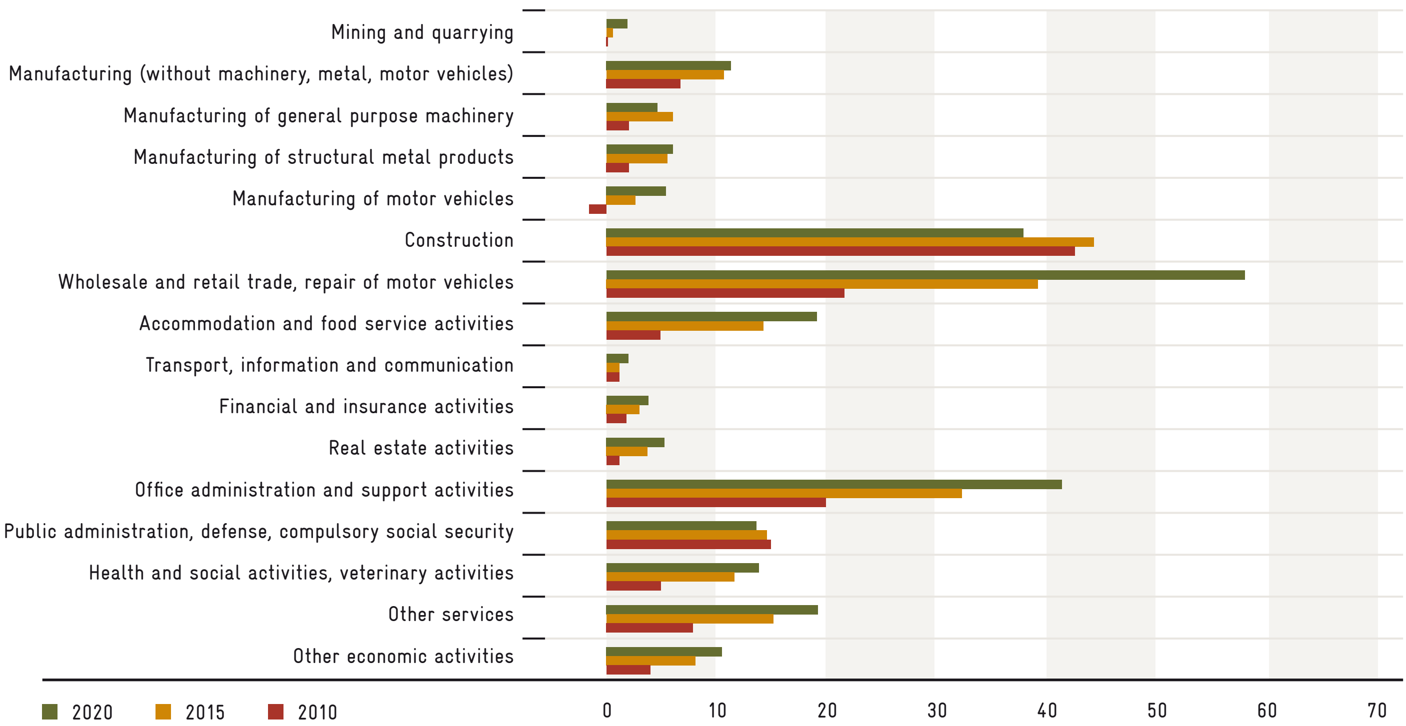
The sum of the net effects is positive. Gross production, GDP and its components, consumption, investment and trade, are higher in the energy efficiency scenario due to efficiency measures taken during the entire simulation period (2009-2020). Higher production does not necessarily translate directly into higher added value, because it is partly imported and increases the imported inputs according to the German trade structure. A considerable share of additional GDP stems from private consumption (€18.3 billion). The direct effect would come from the consumption of energy efficient goods, but there is a large indirect effect that would occur from additional consumption due to energy savings. The reallocation of funds from energy expenditure to consumption would lead to more employment in all sectors. Employment would also rise in the construction and production sectors, adding to the overall consumption effect.

Figure 4 shows the differences between the two simulation runs for two important quantities: CO2 emissions and employment between 2010 and 2020. The efficiency scenario yields considerable CO2 reductions and increases in employment. Additional employment reaches a figure of 257,000, and by adding governmental employees and the self-employed, the number climbs to almost 290,000. At the same time, wages will increase due to the employment increase (+.27% in 2020). The positive employment effects will be the results of these various impacts:

- Additional investment yields, additional production and therefore additional employment,
- Energy will be replaced by capital,
- Imported value added (e.g. crude oil, gas) will be replaced by domestic value added,
- Construction and the tertiary sector will be more labour intensive than the energy industry,
- Energy efficiency will improve economic productivity and thus competitiveness,
- Short term higher demand for (efficient) investment goods and equipment will improve private budgets and induce additional incomes.

The main impact will come from additional investment, especially in the construction sector, where labour intensity is rather high. Given the work necessary for installing insulation, additional employment will mainly be created in small and medium enterprises. The long-term effects go back to energy savings and reductions in the energy bill. Sectoral effects reflect the structure of production in the efficiency scenario and most sectors show increasing employment. Of course, the highest effects will be seen in construction, reflecting the already mentioned labour intensity and the large investment being made in this sector as well as. But employment increases also in other sectors. Efficient appliances and efficient cars

Figure 5: Sectoral employment in comparison to the BAU scenario (in thousands)



Source: ifeu/ISI/Prognos/GWS 2009 and the sources quoted there.

involve major inputs from the tertiary sector. The structural distribution of additional jobs reflects the economic activity within the sectors as well as the concentration of labour. This is especially evident in the large increase in services and rather small increase in industry. While the vehicle industry will witness turnover gains from the sales of more efficient vehicles, the majority of those gains will be seen in car sales, since more turnover there would translate into additional employment rather than in the highly automated vehicle production. The same would hold true for other production sectors. Additional employment in the retail sectors, in gastronomy and in real estate would result from the shift in energy spending to other consumption goods as a consequence of efficiency gains (see figure 5).

5 CONCLUSIONS

In the short history of modern renewable energy generation to date, expectations and targets have often been exceeded. In 2011, targets exist for at least 98 countries (REN21) aiming at shares of 10-30% in electricity generation through the next one or two decades. The year 2010 was a crucial year for former targets and most targets were met, sometimes several years before the deadline. The European target for wind power was surpassed more than twice and the photovoltaic target almost tenfold (29 GW achieved compared to a 3 GW target for 2010). Two countries in the European Union have already surpassed their 2020 targets (Finland and Sweden). Most European countries have adjusted their targets upwards.

When countries studied the employment effects of renewable energy policies, the results were, in most cases, positive. Renewable energy has become a fast growing industry, providing sustainable employment in industrial countries and more recently, also in emerging economies and developing countries.

To measure employment, the specific conditions of each country or region must be carefully analysed. There is no one-size-fits-all approach. Employment factors seem to provide a 'quick and dirty' approach, but since the literature is very scattered and the methodologies vary across studies, there is no way to obtain generic factors from meta-analysis. Recent careful attempts show very unpromising results. Labour per MW installed changes too quickly to provide reasonable estimates. A state-of-the-art 6 MW wind turbine will not require three times as much labour as a state-of-the-art 2 MW wind turbine installed a couple of years back. Also, jobs per MWh of energy generated can be misleading if one translates this number to a region with higher wind speeds. The same wind turbine can generate much greater amounts of electricity but will not require proportionately higher amounts of labour. This is also true for solar power plants.

The best approach in our view is to translate installation scenarios into investment and then use the most recent industry information available on the production of RE technologies. This information is, for a given time period, generic across regions, because in the rather young industry the cost structures are the same across different countries. Country-specific factors come into play in domestic production and cost structures can be translated into domestic employment.

From international experience we have been able to identify the following barriers and drivers of the expansion of renewable energy and, thus, of employment in this sector:

1. Clear targets for a future energy mix are important! Renewable energy has been successful in Europe because there is commitment to the expansion of renewable energy in the form of binding targets. Member states are required to regularly evaluate and report the progress in the installations of renewable energy. This progress signals a stable future path for the RE industry.

2. Policy matters! The right choice of support instrument is important for the development of renewable energy. Even more important than the actual choice of support mechanism is the implementation of the mechanism. Stability, transparency and reliability are essential to the RE industry. Spain, where rapid changes lacking in transparency in legislation have led to massive decreases in employment in the RE sector, offers a negative example. Germany is mentioned in the literature as a positive example, because changes in tariffs were announced well ahead of time and in a comprehensible way.

3. Bottlenecks exist! In most countries the grid was projected and built for fossil fuel-based electricity. It is important to adjust the grid parallel to the expansion of renewable energy. Italy and other European countries, as well as China, cannot take full advantage of the capacity installed due to grid failures.

4. Bottlenecks do not only exist in terms of physical limitations, but also in the labour market. It is important that the workforce is kept abreast of skills and qualifications changes during the expansion of renewable energy sectors. Once more, China is reported to be experiencing considerable problems in establishing a skilled workforce and the required training infrastructure.

PART II: PAST EXPERIENCES IN RENEWABLE ENERGY AND ENERGY EFFICIENCY IN TUNISIA: IMPACTS ON EMPLOYMENT

1 INTRODUCTION

Tunisia is one of the few developing countries to have developed a proactive policy for the promotion of renewable energy and energy efficiency already in the mid-1980s. This policy gained special momentum starting in the mid-2000s, in the context of spiralling international oil prices and the development of a steadily growing energy deficit.

This momentum resulted in the development of ambitious energy efficiency and renewable energy development programmes, designed to meet energy requirements in a cost-effective manner and to reduce the Tunisian economy's vulnerability to rising fossil fuel prices.

The three-year (2005-2007) and four-year (2008-2011) programmes as well as the Tunisian Solar Plan are strong indicators of Tunisia's commitment to a genuine, large-scale sustainable energy policy. They represent a framework for development and investment in renewable energy and energy efficiency in Tunisia.

Sustainable energy has thus emerged as one of the pillars of sustainable development policy in Tunisia, paving the way for:

- a reduction of overall energy intensity and economic vulnerability;
- improvement of the country's energy independence by diversifying its sources of supply;
- contributions to international efforts in the fight against climate change by reducing GHG emissions from the energy sector;
- contributions to the creation of new jobs and the promotion of Tunisia's position as a regional industrial hub with a cluster of expertise in this field.

2 NATIONAL ENERGY SITUATION

2.1 ENERGY DEMAND PROFILE

The country's socio-economic development, combined with economic and social policies based on the subsidisation of nearly all types of energy, has led to the strong growth of energy demand in Tunisia over the last 20 years. As the following graph demonstrates, energy consumption, which was 0.78 tonnes of oil equivalent (toe) per capita in 2010, increased at an average annual rate of 3.3% between 1995 and 2000, compared to an annual rate of 1.4% between 2005 and 2010 (see figure 1).

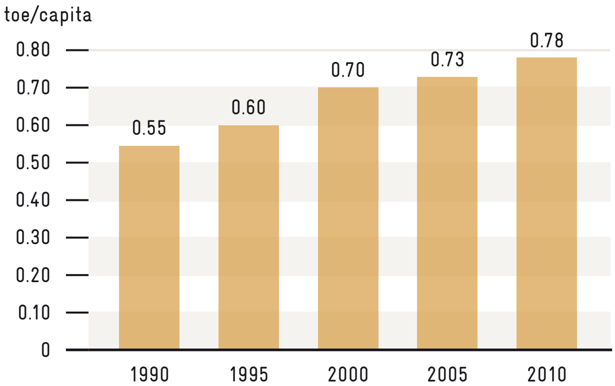
Therefore, at the turn of the century, Tunisia entered an energy deficit phase when resources stagnated at around 7.5 million toe, while demand recorded sustained growth, reaching 8.2 million toe in 2010 (see figure 2).

The industrial sector accounts for the largest share of energy consumption at 36% of overall final consumption, followed by the transportation sector at 31%, buildings at 27% and finally agriculture at 6%. As the sector breakdown of energy consumption is more or less balanced, the level of priority given to each sector in the government's policy is similar. The following graph demonstrates the increasing share of transportation and buildings in the energy consumption breakdown since 1990 (see figure 3).

As demonstrated in the following graph, the energy situation in Tunisia is also characterised by a heavy dependence on natural gas. The share of natural gas in the country's primary energy consumption has become increasingly significant (see figure 4).

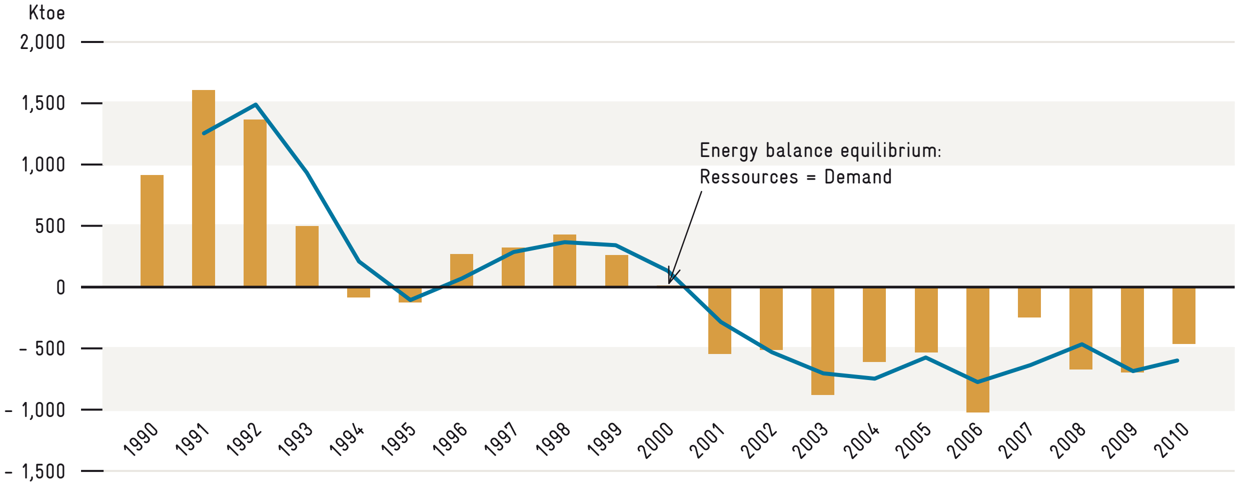
Furthermore, despite Tunisia's efforts to promote renewable energy, as of 2011, its share of national consumption remains insignificant.

Figure 1 : Primary energy consumption per capita



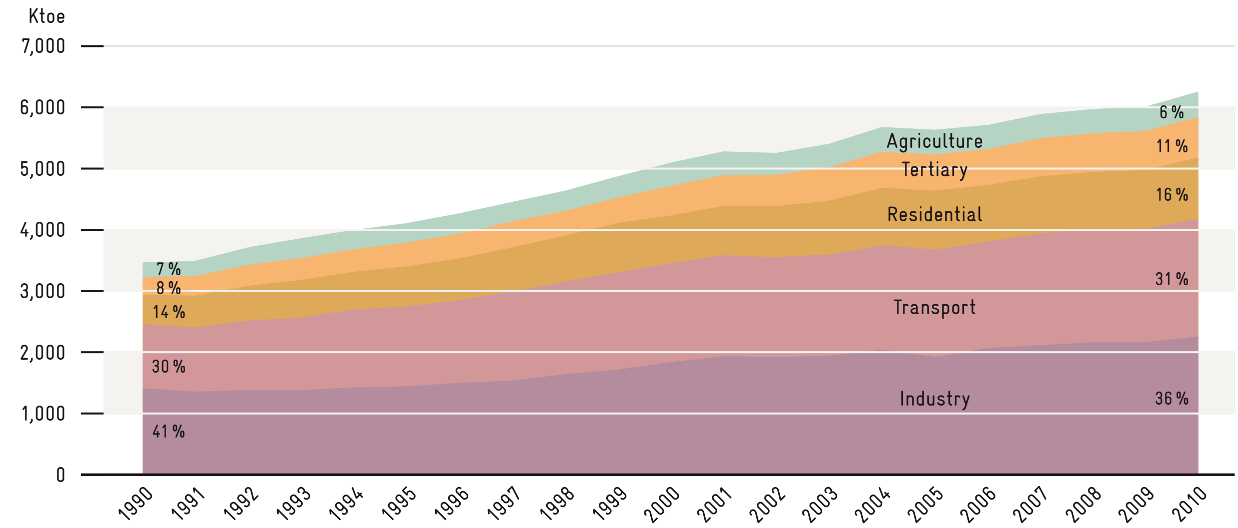
Source: ANME

Figure 2: Evolution of the energy balance



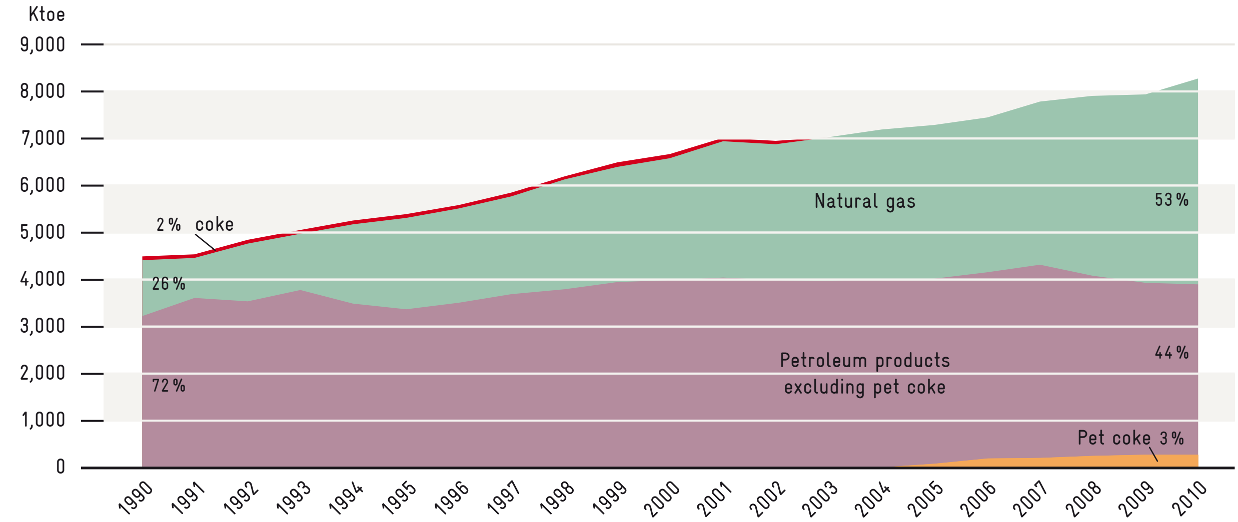
Source: Observatoire National de l'Energie (ONE)

Figure 3: Final energy consumption per sector



Source: Observatoire National de l'Energie (ONE)

Figure 4: Primary energy consumption per type of energy



Source: Observatoire National de l'Energie (ONE)

2.2 TUNISIAN SUSTAINABLE ENERGY POLICY

The main objectives of the national sustainable energy policy are:

- to reduce the country's energy dependence on fossil fuels by managing demand and diversifying the offer by means of alternative resources such as renewable energies;
- to improve energy supply security by reducing the rate of energy dependence currently estimated at around 10% and still rising;
- to improve the competitiveness of the economy and economic operators by reducing their energy bill.

As a result of this policy, supported by a general trend towards the increasing importance of the tertiary sector in the economy, primary energy intensity has clearly improved. Indeed, over the last twenty years, primary energy intensity has been decreasing at an average annual rate of 2.6% (see figure 5).

As a result of this drop in energy intensity, the country also experienced a decrease in carbon intensity, which fell from 1.43 million tonnes of carbon dioxide equivalent per 1,000 Tunisian dinars ($MtCO_2e$/TND 1,000) in 1990 to just 1.09 $MtCO_2e$/TND 1,000 in 2009.

Sustainable energy management is therefore a significant component of Tunisia's sustainable development policy, due to the link with the implementation of low-carbon economic development.

3 SUSTAINABLE ENERGY PROGRAMMES IN TUNISIA

Starting in 1985, Tunisia implemented a proactive and coherent policy to promote renewable energy and the rational use of energy. The 2004 and 2009 laws concerning sustainable energy confirmed the status of this issue as a national priority, particularly with regard to the promotion of renewable energy for electricity generation.

In order to bolster its national policy by scaling up initiatives in favour of sustainable energy, Tunisia implemented a three-year programme (2005-2007) which was then followed by a four-year programme for the 2008-2011 period.

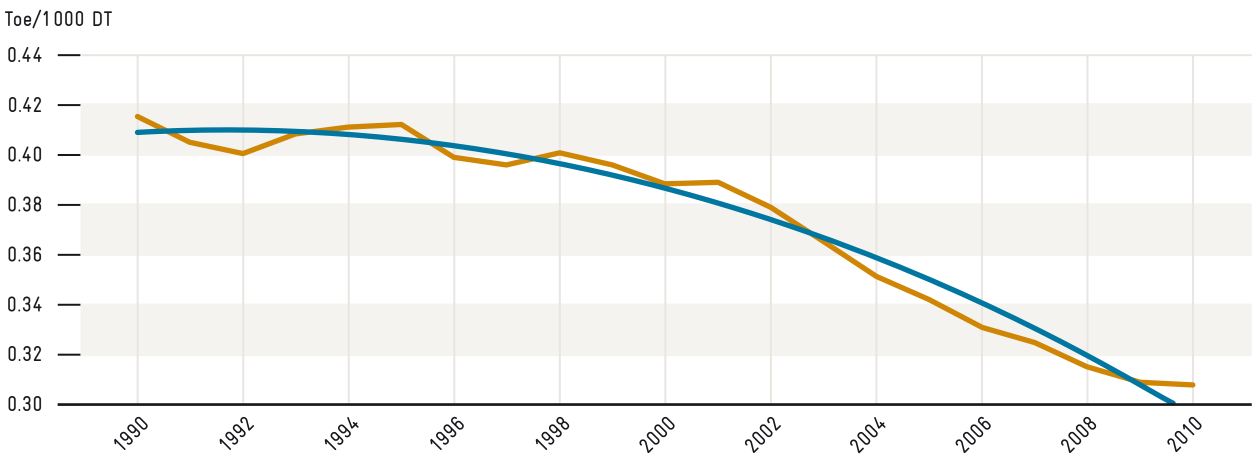
3.1 The three-year programme (2005-2007)

The 2005-2007 three-year programme was established in the context of significant, unexpected increases in the cost of energy on the international market, prompting Tunisia to broaden the scope of the sustainable energy development process by involving all the players and by allocating the necessary public resources.

The three-year programme was mainly focused on priority areas and mature industries for which it was relatively easy to mobilise resources. Among these resources, the following are noteworthy:

- around 230 energy efficiency programme contracts were established between the government and companies in the industrial sector between 2005 and 2007 alone;
- around thirty EE programme contracts were signed in the tertiary sector and around twenty in the transportation sector;

Figure 5: Evolution of primary energy intensity



Source: ANME

Table 1: Results of the three-year plan 2005-2007

Initiatives	Saving achieved ktoe			
Year	2005	2006	2007	Total
Contrats programmes	84.3	129.1	223.2	436.6
Cogénération	0	0	9.2	9.2
Efficacité dans le bâtiment (éclairage public + LBC)	31.0	72.2	119.2	222.4
Efficacité énergétique dans le transport	13.0	14.0	15.0	42.0
Eolien	10.2	10.2	10.2	30.6
Chauffage solaire de l'eau	6.6	9.1	13.4	29.1
Total	145.1	234.6	390.2	769.9

Source: ANME

- the installation of cogeneration facilities producing around 10 MW in the industrial sector;
- the installation of around 120,000 m² of solar water heaters, primarily in the residential sector;
- the development of the use of natural gas, in the industrial and residential sectors in particular;
- the distribution of around 1 million energy-saving lamps in the residential sector.

Investments in RE and EE undertaken in the framework of the 2005-2007 three-year programme are estimated at around TND 250 million (EUR 140 million), of which the government contributed an estimated 10% (TND 25 million). The rest came from private-sector funding.

The achievements of the 2005-2007 three-year sustainable energy programme (see table 1) include accumulated energy savings of around 770 ktoe, representing 8% of national annual consumption. Over the lifespan of these initiatives, energy savings are projected to reach around 2,800 ktoe. These savings resulted in a primary energy intensity decrease from 351 toe/TND million of GDP in 2004 to 323 toe/TND million in 2007, an average annual decrease of 2.8% (the annual growth rate of consumption was 2.2%, and the annual GDP growth rate was 5.1%).

The environmental impacts of the 2005-2007 three-year plan include an estimated 7 $MtCO_2e$ of avoided GHG emissions, for investments totalling around EUR 70 million, which translates to around EUR 10/tCO_2e.

3.2 The four-year programme (2008-2011)

The four-year programme sought to ramp up the sustainable energy policy, with the establishment of institutional and regulatory measures as well as the strengthening of initiatives in favour of the rational use of energy and renewable energy initially scheduled in the 11th development plan (2007-2011).

Programme objectives included the reduction of Tunisia's economic vulnerability to the increasing burden of energy spending in the government budget, estimated at 12% of GDP in 2007.

To that effect, the Tunisian government set a very ambitious goal for the 2008-2011 period, aiming to reduce energy intensity by 3% per year, maintain moderate energy demand growth and bring the share of renewable energy in primary energy consumption up to 4% by 2011.

The following main investments were scheduled in the four-year programme:

- installation of 480,000 m² of solar collectors, of which 90,000 m² for water heating in the tertiary and industrial sectors;
- distribution of 2 million energy-saving lamps per year;
- roof insulation for over 20,000 existing housing units and 1,500 tertiary-sector buildings, in the framework of a pilot programme (PROMO-ISOL);
- installation of a wind farm with a capacity of 120 MW by the national energy company STEG;
- installation of wind power facilities with a 60 MW capacity for electricity generation in energy-intensive industries;
- installation of cogeneration facilities with a capacity of 70 MW, of which 60 MW in the industrial sector and 10 MW in the tertiary sector;
- installation of electricity generation facilities with a capacity of 40 MW using olive residues;

Table 2: Results of the four-year plan 2008-2011

Initiatives	Energy savings in ktoe			Total
Year	2008	2009	2010	
Programme contracts	210.0	298.0	331.0	839.0
Cogeneration	17.2	25.2	30.0	72.4
Energy efficiency in buildings	0	0	8,0	8,0
Energy efficiency in electricity usage	218.0	221.0	283.0	721.0
Energy efficiency in transportation	32.0	35.0	36.0	104.0
Wind power	26.0	26.0	62.0	113.0
Solar water heating	19.1	25.1	31.0	75.0
Photovoltaics (PV)	0	1.0	1.0	1.0
Solar thermal	0	0	0	0
Biogas	0	0	0	0
Biomass energy	0	0	0	0
Total	522.7	630.7	780.0	1,933.6

Source: ANME

- installation of electricity generation facilities with a capacity of 40 MW using household waste;
- consolidation of EE programme contracts in the industrial sector, with a target of 300 new programme contracts;
- signature of 325 new EE programme contracts in the tertiary sector and 75 in the transportation sector.

Expected energy savings are estimated at 3.2 Mtoe for the 2008-2011 period, in other words, around 15 Mtoe over the entire lifespan of the initiatives. As a result of these savings, primary energy intensity should record an average drop of around 3% starting in 2007 (0.32 toe/TND million). It was therefore expected to reach 0.28 toe/TND million by 2011.

Total investment requirements for this programme were in the TND 1.1 billion range, broken down as follows:

- renewable energy: TND 600 million (50% of total investments) for solar water heating, photovoltaics, wind power, biogas and biomass energy;
- energy efficiency: TND 440 million (45% of total investments) for buildings, transportation and industrial sectors (EE programme contracts, cogeneration, etc.);
- energy substitution: TND 60 million (5% of total investments) for the development of natural gas in the industrial and residential sectors.

As of end 2010, accumulated savings made during the 2008-2010 period reached around 1,950 ktoe, of which over 90% can be attributed to four sectors (43% from EE programme contracts, 37% from energy efficiency in electricity usage, 6% from wind power and 5% from energy efficiency in transportation). The following table details the savings achieved.

3.3 OUTLOOK ON SUSTAINABLE ENERGY: THE TUNISIAN SOLAR PLAN

The Tunisian Solar Plan (Plan Solaire Tunisien – PST) for the 2010-2016 period constitutes a framework for Tunisia's integration into the Mediterranean area, confirming Tunisia's goal of becoming a regional hub for industrial and energy production and signalling Tunisia's commitment to energy-efficient and low-carbon socio-economic development.

The PST takes the strengths of the energy policy into account. It is based on the renewable energy and energy efficiency projects that make up and complement the four-year sustainable energy programme (2008-2011).

As per the end-2009 publication, the PST covers the 2010-2016 period and consists of around forty projects, divided into five main areas:

- solar power
- wind power
- energy efficiency
- other projects
- research and implementation of the PST.

The PST provides support for Tunisian sustainable energy policies in order to better address future energy and climate

4 OVERVIEW OF ACHIEVEMENTS 2005-2010

issues. It is intended to promote the large-scale deployment of renewable energy for electricity generation, to enhance energy efficiency in order to manage energy demand and to establish interconnection lines for the purpose of exporting power to Europe.

The PST›s main objectives can be summarised as follows:

- Strong penetration of renewable energy, wind and solar energy in particular, in electricity generation. The additional capacity projected for 2016 is 480 MW, including 140 MW for CSP and 280 MW for wind power.
- Enhancement of energy demand management; energy savings should represent 23% of the primary energy demand by 2016.
- Interconnection with the European power grid would make it possible to export electricity to Europe, as set out in article 9 of the European directive adopted on 17 December 2008. By 2016, export capacity is expected to reach 1,000 MW, including 800 MW from fossil fuels and 200 MW from renewable energy.
- The establishment of a cluster of expertise in order to foster the rapid development of the solar equipment industry in Tunisia.

All the initiatives implemented during the 2005-2010 period have made it possible to achieve accumulated energy savings of around 2,700 ktoe, of which over 90% can be attributed to energy efficiency initiatives and 10% to renewable energy initiatives. Table 3 details the breakdown of savings made during the 2005-2010 period, per type of initiative.

Regarding avoided GHG emissions, the initiatives implemented within the framework of the three-year and four-year programmes led to a reduction of 1,870 ktCO_2e in 2010 and around 6,500 ktCO_2e during the 2005-2010 period. Figure 6 illustrates how the share of EE and RE changed over time for overall emissions avoided.

4.1 ACHIEVEMENTS IN THE FIELD OF RENEWABLE ENERGY

4.1.1 Wind power

STEG began developing wind power in the early 2000s by implementing an initial capacity of 10 MW in Sidi Daoud in 2001, which was extended to 20 MW in 2003. The capacity reached 55 MW in 2008 and was slated to reach 175 MW in 2011 and 245 MW in 2012 (see figure 7).

It should be noted that according to information provided by STEG, the integration rate for wind power in Tunisia is around 40%.

4.1.2 Solar thermal energy

The solar water heater (SWH) market has significantly evolved since the establishment of the 'PROSOL' funding mechanism in 2005. With PROSOL, installed capacity rose from around 7,000 m² in 2004 to over 80,000 m² in 2010. At the end of 2010, the total installed collector surface area had reached around 490,000 m² compared to just 120,000 m² in 2004 (see figure 8).

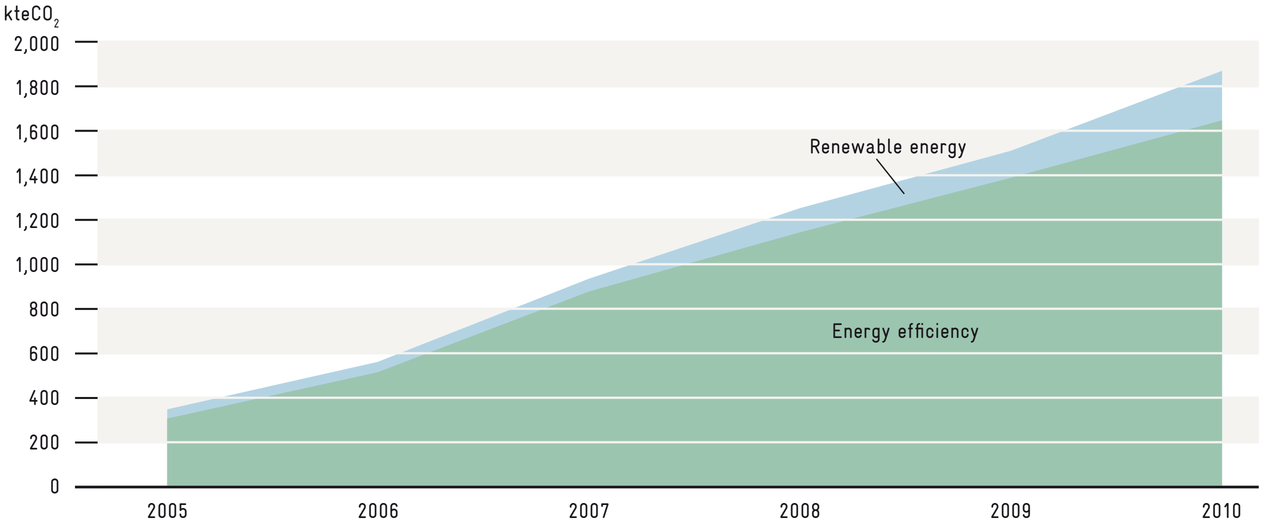
The development of this technology made it possible to create a genuine market for over 50 suppliers, including seven

Table 3: Energy savings between 2005 and 2010 (en ktoe)

	2005	2006	2007	2008	2009	2010	2005-2010
Energy efficiency	128	215	367	478	580	687	2,455
Renewable energy	17	19	24	45	51	93	249
Total	145	235	390	523	631	780	2,704

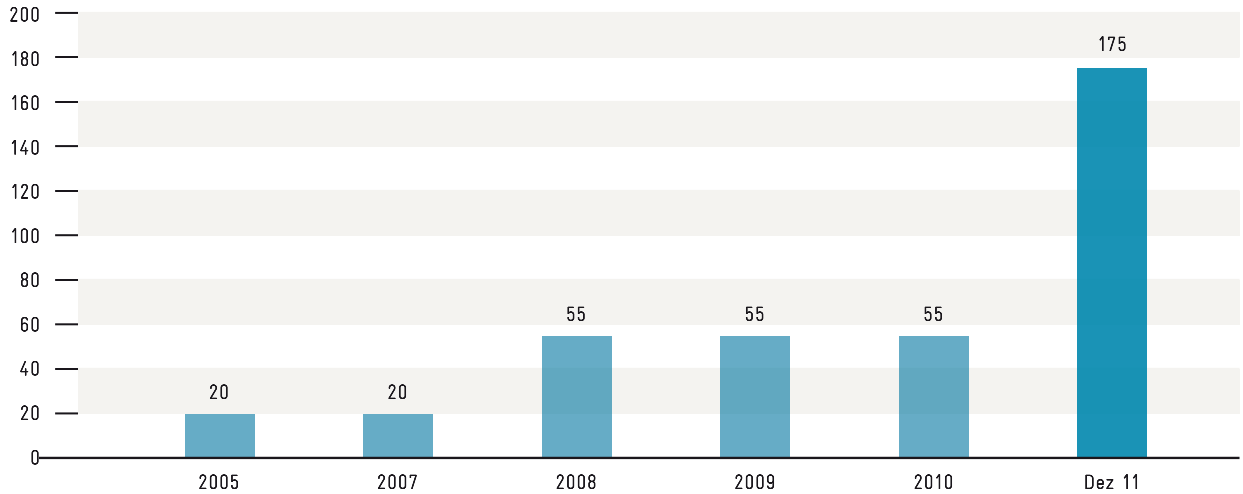
Source: ANME

Figure 6: GHG emissions avoided due to sustainable energy programmes



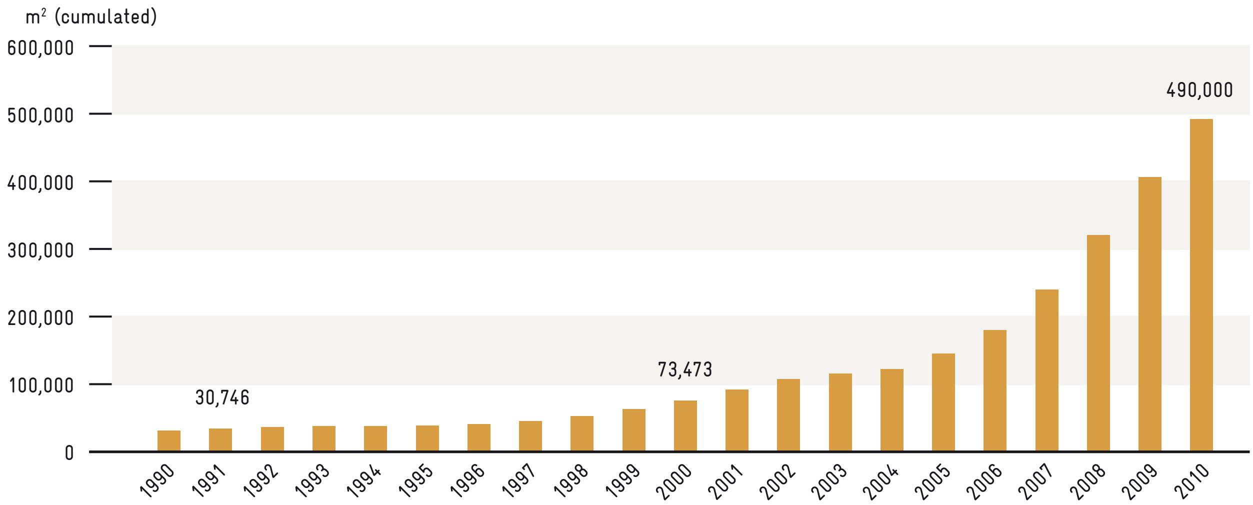
Source: ANME

Figure 7: Installed wind power capacity (MW)



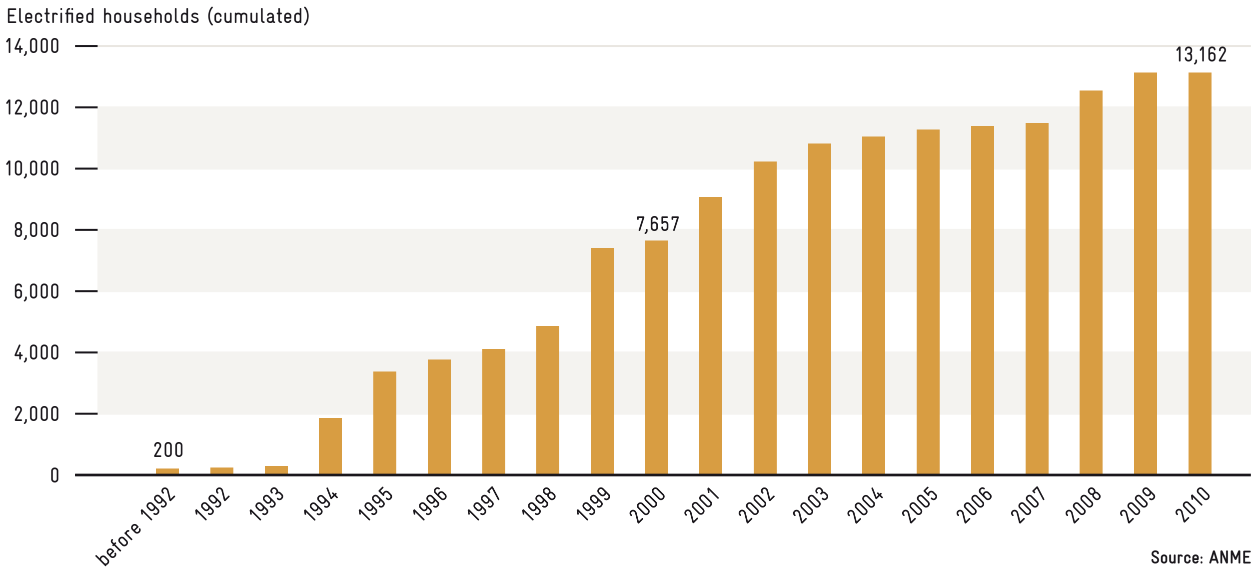
Source: ANME

Figure 8: Installed solar thermal collectors (m^2)



Source: ANME

Figure 9: Solar PV systems installed in the context of rural electrification



Source: ANME

manufacturers, and over 1,200 small installation businesses, of which over 400 are active.

4.1.3 Solar photovoltaics

The use of PV for residential electricity demand has mainly been of interest in the context of rural electrification. A total of 13,000 households had been electrified with PV kits by 2010 compared to 7,600 households in 2000 (see figure 9).

This sector, with an estimated average integration rate of over 50%, made it possible to attract importers, fitters, local accessories suppliers, installers and small maintenance businesses.

In 2010, the PROSOL-Elec programme has been initiated in order to promote grid-connected PV systems.

4.2 ACHIEVEMENTS IN ENERGY EFFICIENCY

4.2.1 Programme contracts

The first results were seen in 2005, with soaring numbers of signed energy efficiency programme contracts (CP), reaching over 900 CPs in 2010 compared to just 200 CPs during the 1987-2004 period. The results of the EE programme in the economic sectors during this period significantly contributed to the overall energy savings potential recorded during the same period (see figure 10).

Beyond the direct impact in energy, economic and environmental terms, the energy audit system made it possible to create employment positions, with the emergence of new professions such as expert auditor, expert consultant and energy manager. Since the establishment of the audit system, the Tunisian National Energy Agency (ANME) has provided nearly 200 certifications to 134 experts and engineering consultancies in the various fields (thermal, electricity, etc.).

As an indication, 50 architects, 74 auditors in the tertiary sector and 66 auditors in the industrial sector were certified as of end 2010.

4.2.2 Cogeneration

The cogeneration potential in Tunisia is estimated at around 606 MW (522 MW in the industrial sector and 84 MW in the tertiary sector). At the end of 2010 installed capacity had reached 32.6 MW, in other words, less than 8% of the industrial sector potential.

Although the Tunisian cogeneration market is not strong enough to establish a local industry, development of this sector requires the supply of accessories and related services, such as engineering, installation and maintenance (see figure 11).

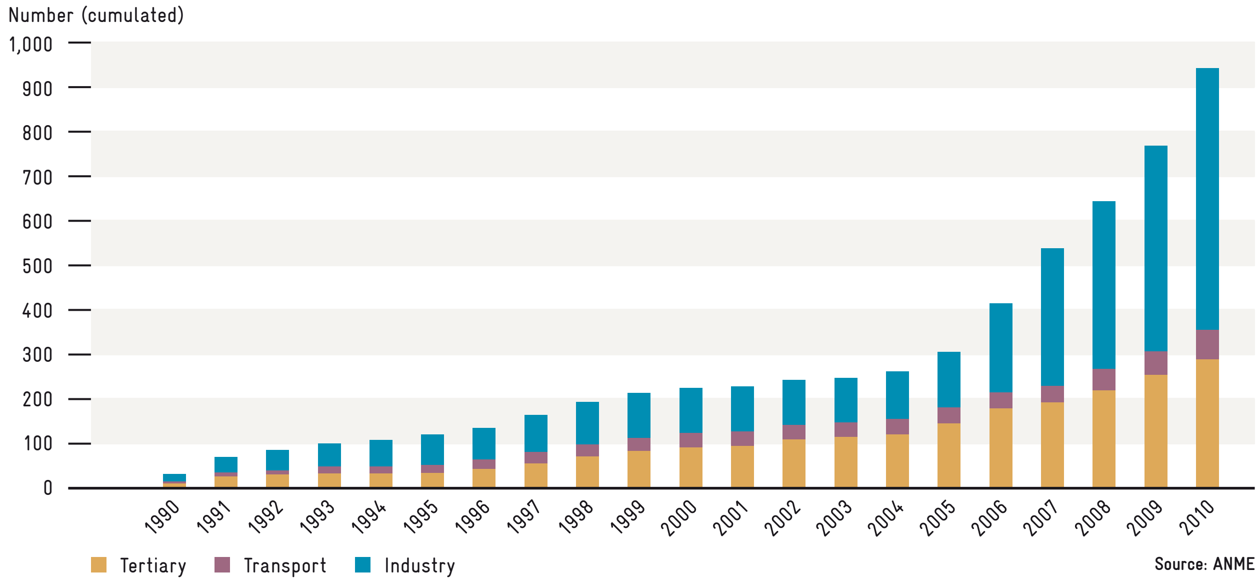
4.2.3 Energy saving lamps

The number of energy-saving lamps (CFL) installed in households and tertiary businesses is now over 11 million lamps compared to just 380,000 lamps in 2004. The CFL market is covered by local manufacturing and imports (see figure 12).

4.2.4 Energy efficiency in buildings

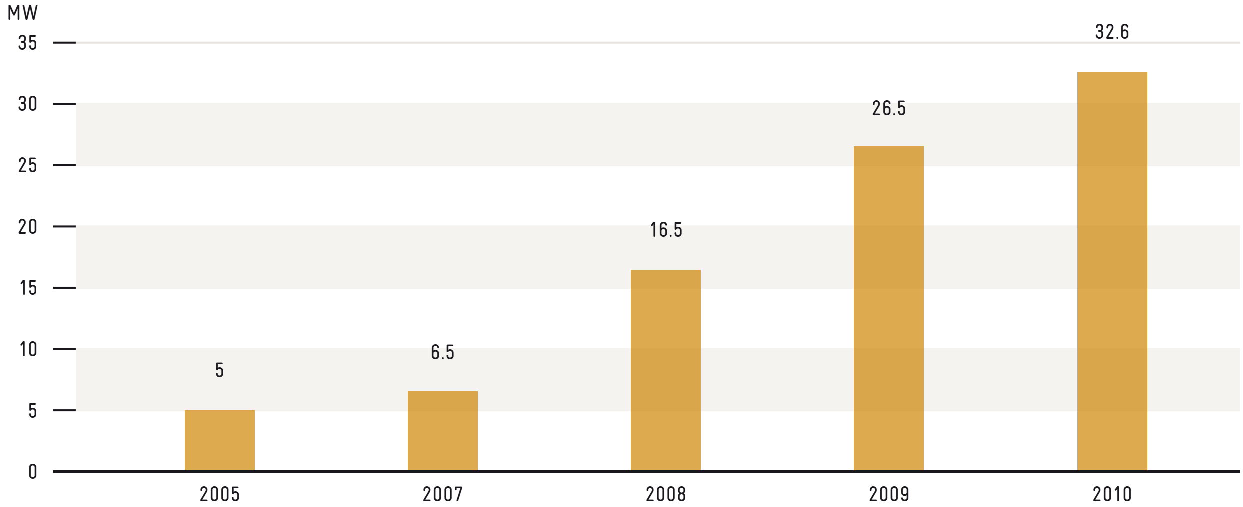
Act 2004-72 dated 2 August 2004 and the corresponding implementation decree dated 2 September 2004 provided for mandatory measures for the thermal performance of new buildings.
Practical measures for the implementation of the decree are promulgated within the framework of joint ministerial orders

Figure 10: Evolution of the number of programme-contracts



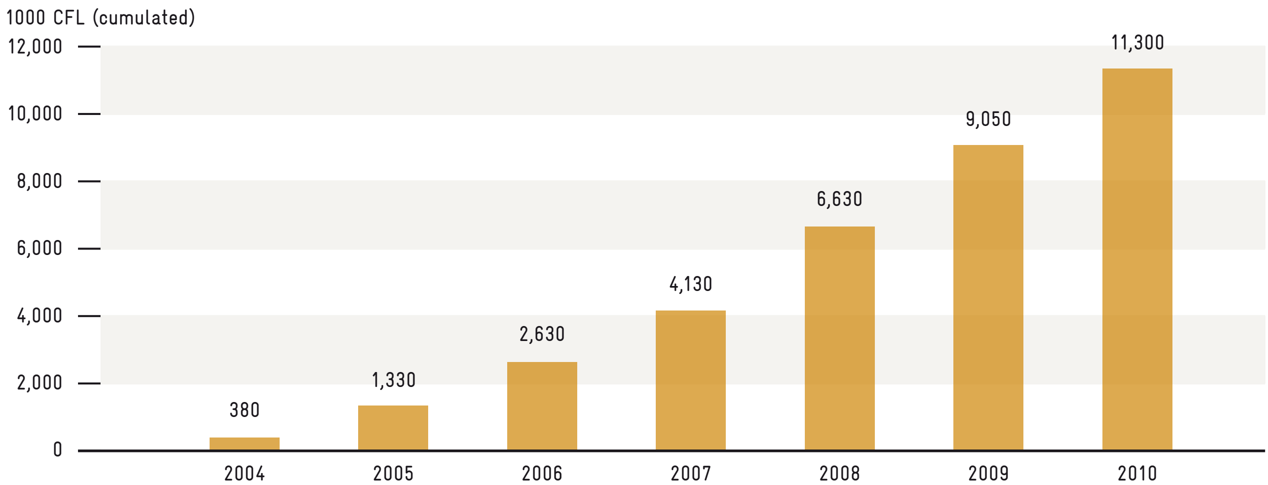
Source: ANME

Figure 11: Cumulative installed capacity of cogeneration (MW)



Source: ANME

Figure 12: Number of compact fluorescent lamps in use



Source: ANME

by the ministry in charge of energy and the ministry in charge of housing. Two orders have already been promulgated:

- an order setting the minimum technical specifications in relation to energy consumption levels for residential construction and extension projects;
- an order setting the minimum technical specifications in relation to energy consumption levels for office construction and extension projects.

Thermal regulations for multi-family residential buildings came into effect as of 1 June 2009. As of end 2010, there were more than 2,000 new buildings in compliance with these regulations, according to the observatory of the ministry in charge of housing.

4.2.5 Energy efficiency in other fields

These include energy efficiency programmes that have not really created any employment positions or were undertaken in addition to scheduled initiatives, such as:

- the refrigeration appliance labelling programme;
- the programme to promote the position of 'energy manager'.

The labelling programme led to the transformation of the refrigerator market in Tunisia, yet did not, on the whole, contribute to the creation of new jobs.

In the 2000s, public institutions and energy-intensive businesses established the position of energy manager. As of end 2010, there were 500 energy managers in the various business sectors, the majority having received specific training.

In addition, the development of renewable energy and energy efficiency in Tunisia has given rise to the establishment of specialised consulting firms in this field. These firms are providing services in both the local and export markets, in light of Tunisia's wealth of experience. As of end 2010, there were around ten consulting firms employing around fifty senior professionals.

5 ASSESSMENT OF THE GOODS AND SERVICES MARKET IN RELATION TO SUSTAINABLE ENERGY PROGRAMMES

With reference to the sustainable energy programmes implemented between 2005 and 2010, we will focus on the relevant goods and services that have undergone development over the last five years, covering only the following sectors:

- the SWH and solar thermal equipment markets
- the photovoltaics market
- the wind energy market
- the auditing and programme contracts market
- the cogeneration market
- the energy efficiency market in buildings
- engine diagnostics stations
- the market for energy-efficient equipment.

5.1 The solar thermal market

The SWH market in Tunisia has been steadily gaining a stronger foothold since the launch of the PROSOL programme. Indeed, the change of scale that was seen beginning in 2005 is the result of a host of measures based on a financial scheme which made it possible to overcome the barrier of initial investment and improve the return on investment in SWHs for end users. Table 4 provides an overview of the main economic data for the SWH sector.

The installed capacity for the 2005-2010 period is around 360,000 m² with a current pace of around 80,000 m²/year. A breakdown shows that 76% of the market is covered by local manufacturers/fitters and 24% by importers.

This trend has made the establishment of an industrial fabric possible, currently consisting of seven local manufacturers and fitters as well as over 1,100 small installation and after-sales service businesses. Industry growth over the 2005-2010 period is detailed below:

- the number of suppliers rose from 12, of which four manufacturers in 2005, to 41 suppliers, of which seven manufacturers in 2010, representing 63% growth per year;
- over 180 models of individual SWHs were available on the market in 2010;
- on average, 78% of suppliers are active in the market;

Table 4: Evolution of the SWH market 2005-2010

Achievements	2005	2006	2007	2008	2009	2010	TOTAL
PROSOL Residential							
Installed surface area (m²)	22,000	33,362	60,000	80,000	82,000	81,000	358,362
% manufacturers	90 %	80 %	80 %	79 %	73 %	67 %	76 %
% manufacturers	10 %	20 %	20 %	21 %	27 %	33 %	24 %
Turnover (TND million)	11.7	16	29	39	40	41	176
Number of equipment suppliers	4	12	21	28	40	46	46
of which manufacturers	3	3	5	6	6	7	7
Number of installers	227	346	564	750	1,045	1,100	1,100

- the number of individual SWH installers (small businesses, two to four people max.) rose from 227 in 2005 to 1,100 in 2010, representing an average increase of 37% per year;
- on average, 50% of installers are active in the market.

Despite a visible increase in the unit cost of SWHs available on the market, total turnover of around 176 TND million was made possible thanks to the PROSOL programme in the residential sector during the 2005-2010 period, with an average increase of 28% per year (see figure 13). This growth attests to the strong competitive dynamics in the Tunisian market. As this market is now mature, the rhythm of achievements beyond 2010 is expected to remain stable at around 100,000 m² per year, with the goal being to reach an installed capacity of 1 million m² by 2015.

With regard to the tertiary sector, the market has not really taken off, as the funding mechanism was only implemented in 2008 (see table 5).

Only 4,100 m² of solar collectors were installed, representing a total turnover of 2.7 million dinars. Nevertheless, a new cluster of expertise has been established, including:

- 20 engineering consultancy firms specialised in the design and sizing of collective solar installations;
- 12 category B2 and higher installers, certified by the Ministry of Infrastructure and specialised in installation and after-sales service for collective solar installations.

Often, these are not newly founded companies, but rather existing companies that are expanding into new niche segments in fields related to their core business.

5.2 The PV market

Thanks to the national rural electrification programme launched in the 1990s, 2,112 systems were installed between 2005 and 2010, representing a total investment of around 3.6 million dinars.

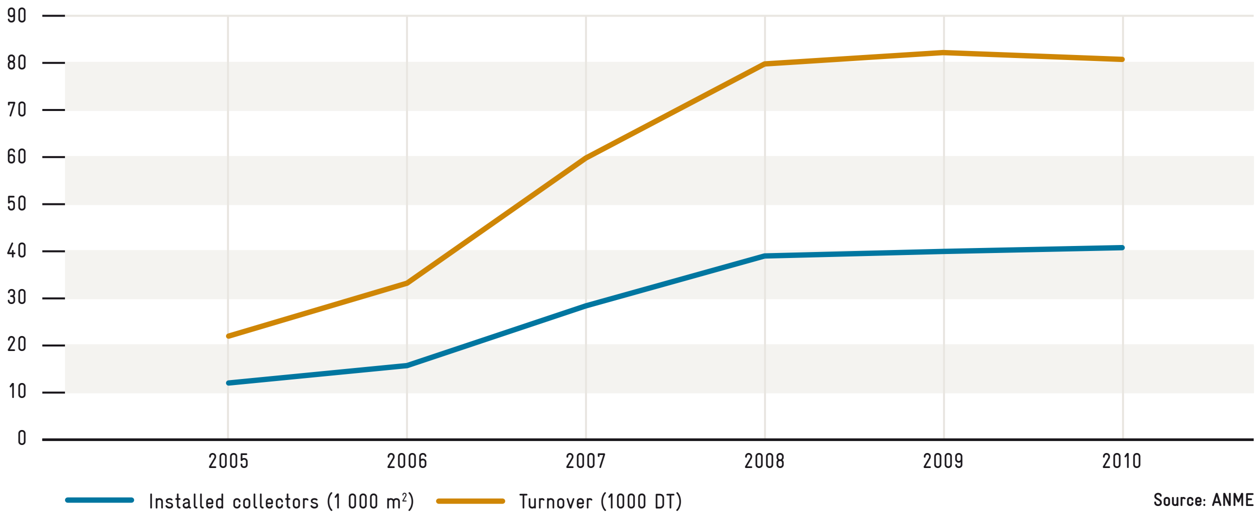
Table 6 illustrates the evolution of the rural electrification market.

New programmes have contributed to the expansion of this market, such as:

- The JBIC project by ANME, consisting of fitting out 63 wells with PV pumping units and/or brackish water desalination units as well as the electrification of 500 new housing units for 2010.
- The PROSOL-Elec or 'solar roofs' programme for the installation of micro photovoltaic plants connected to the STEG grid. The programme provides for the installation of 3 MW between 2010 and 2012 (by end 2010, around 408 kW were installed with a total investment of 3 million dinars).
- The photovoltaic solar pumping programme. Between 2005 and 2007, a total capacity of 152 kW was installed with an investment of around 2.6 million dinars. These facilities are operated and maintained by the regional agriculture development committees (CRDA), under the jurisdiction of the Ministry of Agriculture.

Technological progress in photovoltaic solar energy and steadily improving competitiveness are indicators that the use of this technology will pick up speed in the years to come, which bodes well for the prospects of job creation in this sector.

Figure 13: Evolution of the individual SWH market



Source: ANME

Table 5: Evolution of the SWH market in the tertiary sector

Achievements	2005	2006	2007	2008	2009	2010	TOTAL
PROSOL Tertiary							
Installed surface area (m²)	–	–	–	–	500	3,600	4,100
Turnover (TND million)	–	–	–	–	0.3	2.4	2.7
Number of installers	–	–	–	–	–	12	12
Number of engineering consultancies	–	–	–	–	–	20	20

Table 6: Evolution of the market for decentralised solar PV systems

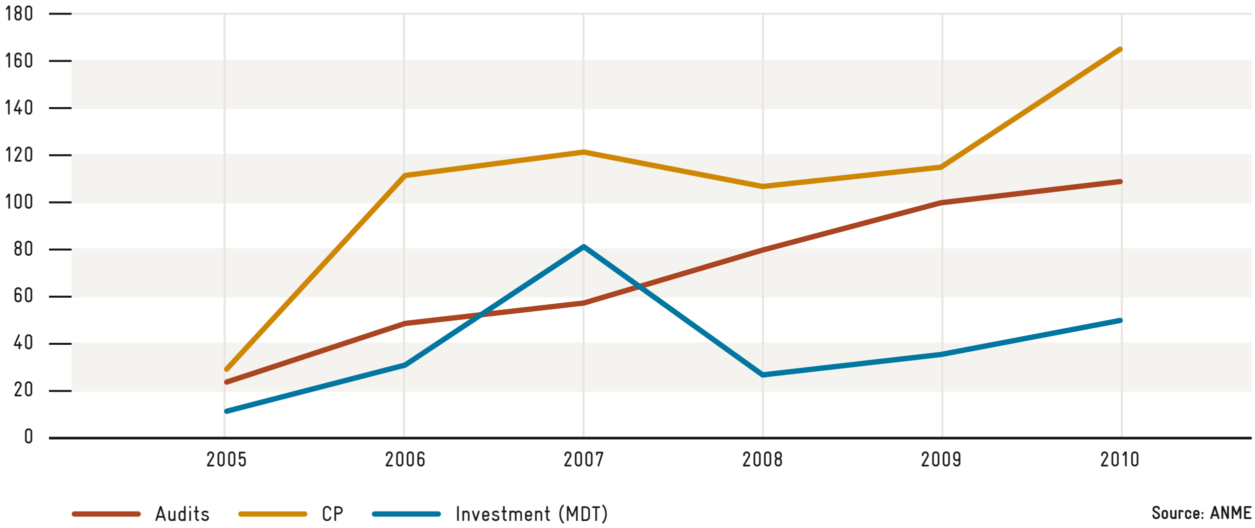
Solar photovoltaics	2005	2006	2007	2008	2009	2010	TOTAL
Rural Electrification Programme							
Number of housing units	235	105	128	1,052	584	8	2,112
Turnover (TND million)	0.4	0.2	0.2	1.8	1	0	3.6
Number of suppliers	3	3	3	3	3	50	50
Number of installers	0	0	0	0	0	50	50

5.3 The wind power market

Wind power has been in use for many years in European countries such as Germany and Denmark, as well as in the United States. Wind power is currently the most mature renewable energy technology, in both technical and commercial terms, making it a competitive alternative to traditional means of energy production.

In Tunisia, despite the rather significant wind power potential, estimated at around 8,000 MW, on account of the rather limited legal framework, it was only possible to achieve a capacity of 54 MW as of end 2010. A 190 MW installation is underway and is expected to be commissioned in 2011/2012, bringing the total installed wind power capacity up to 244 MW by end 2012.

Figure 14: Evolution of the market for energy audits and CPs



Source: ANME

The 34 MW extension at the Sidi Daoud wind farm in 2009 represents a total investment of TND 84 million.

Determining factors for the future development of this sector in Tunisia include the opening of the electricity market to private investors and the possibilities for exporting wind power to Europe.

Indeed, Tunisia has an embryonic local industry that is able to supply various components of wind power facilities (towers, cables, transformers, control panels, etc). The prospects for industrial integration of the wind power sector in Tunisia are therefore promising. The Tunisian market is also capable of handling services related to logistics and construction as well as the operation and maintenance of wind power plants.

5.4 The auditing and programme contracts market

Institutional activities, which generally include initiatives based on auditing and programme contracts, are the cornerstone of Tunisia's policy for the rational use of energy, established in the early 1990s. These programmes aim to strengthen the commitment of public and private economic operators in the field of energy efficiency.

The 2004 regulatory framework bolstered this activity with the organisation and promotion of investments to improve energy efficiency in businesses.

During the 2005-2010 period, over 420 energy audits were carried out in various industrial, tertiary and transportation sectors, over 50% more than the number of audits conducted during the 1987-2003 period. Between 2005 and 2010, 651 programme contracts were established, representing a total investment of TND 239 million (see figure 14).

Assessment of the employment market related to investments in the energy efficiency field in businesses depends on the assessment of investments that were actually undertaken. As no precise figures are available on achievements, our assessment is only an estimate (see table 7).

From the supply-side perspective, energy audits are carried out by expert auditors from consultancy firms or by engineering consultants, certified by ANME. The number of expert auditors has risen sharply over the last five years, with 152 experts as of end 2010.

Although there has been no increase in the number of certified auditors in the transportation sector, where the majority of businesses are in difficulty, the number of experts has more than doubled in the industrial sector and more than tripled in the tertiary sector, mainly as a result of the increasing number of companies subject to energy audits.

In order to complete programme contract projects, expert assistance is increasingly required to help companies implement their energy savings objectives.

5.5 The cogeneration market

Cogeneration development in Tunisia was launched in 2001, with the publication of the December 2002 decree (2002-3232) establishing rules and provisions for the implementation of cogeneration projects.

Despite the high potential of around 606 MW estimated by ANME, the established objectives have yet to be attained. As of end 2010, total installed capacity was only 27.5 MW, with a total investment of around 20 million dinars, representing 39% of the 2011 objective (70 MWe).

Table 8 summarises the cogeneration market trend over the 2005-2010 period.

Table 7: Evolution of the market for energy audits and CPs

SECTOR		2005	2006	2007	2008	2009	2010	TOTAL
Transportation	Number of certified experts	9	9	9	9	9	9	9
	Number of audits	1	1	3	5	3	15	28
	Number of programme contracts	1	1	0	10	5	14	31
	Investment (TND thousand)	0.3	0.4	0.01	3	7	2	13
Industry	Number of certified experts	32	43	53	62	67	68	68
	Number of audits	11	30	37	49	63	48	238
	Number of programme contracts	18	75	108	70	84	128	483
	Number of prior consultations			25	13	7	6	51
	Investment (TND million)	11	25	80	20	24	43	203
Tertiary	Number of certified experts	28	39	49	66	73	75	75
	Number of audits	12	18	18	26	34	46	154
	Number of programme contracts	11	36	14	27	26	23	137
	Investment (TND million)	0.8	5.8	2.0	4.2	4.7	5.3	23
TOTAL	Number of certified experts	69	91	111	137	149	152	152
	Number of audits	24	49	58	80	100	109	420
	Number of programme contracts	30	112	122	107	115	165	651
	Investment (TND million)	12	31	82	27	36	50	239

Table 8: Evolution of the cogeneration market

	2005	2006	2007	2008	2009	2010	TOTAL
Installed MW			1.5	10	10	6	27.5
Total MW			1.5	11.5	21.5	27.5	27.5
Investment (TND million)			1.3	5.9	7.1	5.8	20
Number of suppliers			1	1	2	2	2

5.6 The building energy efficiency market

The energy efficiency programme for buildings aims to improve the thermal performance of residential and tertiary sector buildings, by developing thermal regulations suited to the climate context in Tunisia. The purpose of these regulations is to define the minimal standards to be applied for the design and construction of residential and tertiary sector buildings by:

- developing minimum technical energy-saving specifications for projects to construct or extend office buildings and multi-family residential buildings;
- establishing blueprint auditing for new projects and extension projects in the construction sector;
- defining conditions and methods for carrying out blueprint energy audits in the residential and tertiary sectors, within the framework of specifications approved by ministerial order.

Although the regulatory framework provides for access to benefits and subsidies in accordance with national efforts in favour of energy management, achievements are still somewhat limited, with around 12 blueprint audits and 12 signed programme contracts, representing a total investment of around 0.6 million dinars (see table 9).

Table 9: Evolution of the market for blueprint audits and CPs in buildings

Buildings (blueprint audits)	2005	2006	2007	2008	2009	2010	TOTAL
Number of certified experts	22	22	22	22	22	22	22
Number of blueprint audits	1	0	0	2	4	5	12
Number of programme contracts	1	0	0	2	4	5	12
Investment (TND million)	0.03	–	–	0.11	0.18	0.23	0.6

Table 10: Evolution of the market for engine diagnostic stations

	2005	2006	2007	2008	2009	2010	TOTAL
Number of approved suppliers	0	0	6	8	3	4	21
Number of stations			33	59	2	11	105
Turnover (TND million)	0	0	0.2	1	0.4	0.2	1.6

Table 11: Evolution of the market of supply of RE and EE equipment

	2005	2006	2007	2008	2009	2010
Number of suppliers	35	30	29	33	39	39
Number of certificates	79	73	95	123	199	190
Investment (TND million)	2	4	4	19	12	15

5.7 The engine diagnostics station market

This programme provides for the establishment of a network of engine diagnostics stations so that motorists can have their vehicle engines inspected and tuned up.

Publication of decree 2005-1497 on 11 May 2005 provided impetus for this programme, establishing mandatory engine diagnostics as part of periodic motor vehicle inspections. This measure has not yet been made compulsory by the Ministry of Transportation. Table 10 illustrates the evolution of the engine diagnostics station market.

The acquisition of stations is subject to the requirements set out for the organisation of motor vehicle engine diagnostics practices. A 20% investment aid is available, capped at TND 6,000 per station. In this context, 105 diagnostics stations were acquired during the 2005-2010 period, representing a total investment of around TND 1.6 million. Equipment supply and maintenance is provided by eight local suppliers.

5.8 The market for energy-efficiency equipment

Tunisia has fiscal incentives to encourage the use of products and equipment that contribute to energy efficiency, pursuant to decree 95-744 dated 24 April 1995 which defines the list of raw materials, semi-finished goods and equipment entitled to the below tax breaks:

- VAT exemption on locally purchased raw materials, semi-finished goods and equipment (lists 2 and 4);
- VAT suspension and payment of customs duties at the minimum rate of 10% for imported goods and equipment that have no locally manufactured equivalent (lists 1 and 3).

ANME grants these tax breaks upon presentation of an exemption certificate issued for that purpose.

Many operators in the various sectors (electricity, electronics, construction, etc.) are involved in marketing these products, resulting in the steady growth of investments. The equivalent of TND 56 million was imported by 39 suppliers of energy-efficient equipment during the 2005-2010 period. In the renewable energy field, equipment is mostly supplied by companies operating within the framework of related programmes (PROSOL Thermique, PROSOL Elec, rural electrification, etc.).

Table 11 illustrates the evolution of the market for the supply and marketing of goods and equipment in the field of sustainable energy.

It should be noted that 80% of this market concerns imports of electronic ballasts and energy-saving lamps, which represent 59% and 21% of the total, respectively.

6 ASSESSMENT OF EMPLOYMENT CREATION

6.1 Methodology

In this section we will evaluate direct employment created within the framework of national sustainable energy programmes during the 2005-2010 period. The creation of direct employment in the various fields, sectors and industries is indicated by the number of permanent jobs or intermittent jobs.

The employment evaluation is based on a certain number of hypotheses derived from statistics related to achievements and the evolution of the sustainable energy goods and services market, within the scope of the implementation of the three and four-year programmes.

These hypotheses, some of which are based on targeted surveys of operators, have made it possible to obtain specific indicators for each sector, reflecting employment potential in the sector in terms of economic or physical parameters.

Extrapolation of these ratios to the objectives of the Tunisian Solar Plan then allows us to estimate the number of potential jobs, in the medium and long term.

6.2 Characterisation of direct employment

Analysis of the job market in the sustainable energy management field allows us to identify two types of employment:

- Permanent jobs, considered to be stable and full time, such as institutional activities (ANME, technical centres, etc.), operation of major renewable energy facilities, sustainable markets such as PROSOL, etc.

- Intermittent jobs, considered to be part-time work. This refers to the creation of additional, occasional activity in professions such as engineering consulting, supply and installation. Through the development of sustainable markets, these intermittent jobs may be turned into permanent positions.

In the context of this study, our view is that direct employment, whether permanent or intermittent, depends on the level of investment and/or the turnover of the goods and services market in relation to sustainable energy management. The following market niches in particular are examined below:

- equipment manufacturing (industrialisation and integration)
- engineering and design
- equipment supply and installation
- equipment operation and maintenance
- assistance and promotion (training, financing, insurance, etc.)
- research and development.

Nevertheless, as jobs in the above-mentioned professions often depend on the maturity of the sector or market, the stability of the corresponding jobs may be subject to this factor. Furthermore, as certain markets are still at an embryonic stage, due to the experimental nature of the activities, evaluation of their employment potential presents a challenge. In these cases, we have based our findings on ratios derived from experience in other countries.

Table 12 illustrates the characterisation of the various types of employment per activity.

It should be noted that jobs are also created in relation to programme implementation support in structures such as:

- ANME
- technical centres
- training, education and R&D organisations
- engineering and consulting firms.

6.3 Assessment of direct employment in renewable energy and energy efficiency

6.3.1 The solar thermal sector

First, the impact of the SWH distribution programme is evaluated in the context of the PROSOL Residential programme (see table 13).

The number of jobs created in the solar thermal sector, particularly in the residential sector, is then evaluated using the following hypotheses calculated on the basis of statistical data or targeted surveys (see table 14):

- 1.3 jobs per 100 systems manufactured by local manufacturers, equivalent to 5.2 jobs per 1,000 m² produced;
- 3 jobs per 1,000 m² imported;
- an average of 4.6 jobs per 1,000 m² supplied;
- 13.6 jobs per 1,000 m² of collectors installed;
- 0.8 jobs per 1,000 m² for SWH maintenance and after-sales service;
- representing an overall total of 19 jobs per 1,000 m² of SWHs.

Considering the steady rhythm of installation and the market size, all jobs created in the individual SWH sector can be considered as permanent.

It follows that the total number of jobs created in this sector during the 2005-2010 period is around 1,483 permanent jobs as per the following breakdown:

Table 12: Classification of types of employment per activity

Programme ▾ / Profession ▸	Testing and R&D	Manufacturing	Engineering	Supply and installation	Operation and maintenance
Energy Efficiency					
Energy audits and CPs	I	N	P/I	N	N
EE in buildings	I	N	I	P	N
Cogeneration	N	N	I	I	P
Diagnostics stations	N	N	N	P	P
Renewable Energy					
PROSOL Residential	I	P	N	P	P
PROSOL Tertiary	I	P	I	P	P
PROSOL Elec	I	I	I	P	P
Rural electrification	I	I	N	I	P
Wind power	I	I	I	I	P

P: Permanent I: Intermittent N: Nil

Table 13: Impacts of PROSOL Residential

PROSOL Residential	2005	2006	2007	2008	2009	2010	Cumulated impact 2005-2010	Savings Ktoe-year
m^2	22,000	33,362	60,000	80,000	82,000	81,000	358,362	
Cumulated m^2	22,000	55,362	115,362	195,362	277,362	358,362	358,362	
Cumulated energy savings (ktoe)	2	4	8	14	19	25	72	
Energy savings over lifespan (ktoe)	23	35	63	84	86	85	376	25

- 374 jobs in equipment supply (manufacturing/assembly and imports);
- 1,100 jobs in equipment installation and after-sales service;
- nine jobs in support programmes.

Table 15 illustrates the annual evolution of permanent employment per profession:

Figure 15 illustrates the growth of job creation in the residential solar thermal sector.

Table 16 illustrates the impact of the collective solar thermal sector (PROSOL Tertiary) during the 2005-2010 period.

For this sector, the jobs created are considered permanent, except for the engineering market where the jobs created are considered intermittent.

The following ratios are the basis for the estimation of jobs created in this programme (see table 17).

This represents a total of 4.3 jobs per m^2, and the addition of the supply market, at 3.4, gives a total of 7.7 man-years per 1,000 m^2.

Considering the achievements made during the 2005-2010 period, the number of jobs created in this programme is estimated at around 31 jobs as per the below breakdown:

- engineering and assistance: four intermittent jobs which, in time, as the market grows, should turn into permanent jobs;
- supply and installation: 19 permanent jobs;
- operation and maintenance: four permanent jobs;
- support and programme management: three jobs.

The total number of jobs created in the context of the national SWH promotion programme is 1,515, for a total estimated investment of 178 million dinars.

6.3.2 The solar photovoltaics sector

Table 19 illustrates the impacts of the solar PV promotion programmes during the 2005-2010 period.

The evaluation of jobs created in the solar photovoltaics sector is based on the following statistical hypotheses, derived from surveys of local operators (see table 20).

Taking these employment potential ratios into account, the number of jobs created amounts to around 54 as of end 2010, of which 44 permanent and ten temporary (see table 21).

With the installation of 3 MWp under the PROSOL Elec programme, 205 permanent jobs are projected by 2012.

Table 14: Employment factors for solar thermal systems

Installer		
Installation	3.4	jobs/100 SWHs
	3.3	man-days/m²
	13.6	jobs/1,000 m²
Maintenance	0.5	man-days/SWHs
	0.2	man-days/m²
	0.8	man-years/1,000 m²
Manufacturer		
Production	1.3	jobs/100 SWHs
	1.2	man-days/m²
	5.2	jobs/1,000 m²
Importer		
Supply	0.9	jobs/100 SWHs
	0.8	man-days/m²
	3	jobs/1,000 m²
Supply (Mfr + Imp)		
Supply	1.2	jobs/100 SWHs
	1.1	man-days/m²
	4.6	jobs/1,000 m²
TOTAL	19	jobs/1,000 m²

Source: Alcor survey

Table 15: Evolution of the number of jobs in PROSOL Residential

Sector	Achievements	2005	2006	2007	2008	2009	2010	TOTAL
	Solar Thermal							
PROSOL Residential	m²	22,000	33,362	60,000	80,000	82,000	81,000	358,362
	% manufacturers	90%	80%	80%	79%	73%	67%	76%
	% importers	10%	20%	20%	21%	27%	33%	24%
	m² after-sales service		22,000	55,362	115,362	195,362	277,362	277,362
	Turnover (TND million)	11,7	16	29	39	40	41	176
	of which imports (TND thousand)	990	3,003	5,868	8,803	11,978	14,702	45,343
	of which installation costs (TND thousand)	2	2	4	5	5	5	23
	Average cost (TND/m²)	450	450	489	524	541	550	501
	Number of suppliers	4	12	21	28	40	46	46
	of which active suppliers	4	9	18	21	27	30	30
	of which manufacturers	3	3	5	6	6	7	7
	Number of installers	227	346	564	750	1,045	1,100	1,100
	of which active installers	188	252	395	450	470	440	2,195
	Number of job-years							
	Manufacturing	170	175	180	223	261	282	282
	Imports	4	24	52	60	84	92	92
	Installation + after-sales service	376	504	987	1,125	1,176	1,100	1,100
	Programme management (ANME)	4	4	9	9	9	9	9
	S/TOTAL PROSOL Residential	550	703	1,219	1,408	1,521	1,474	1,483

Source: ANME/PROSOL

Figure 15: Evolution of the number of jobs in the solar thermal sector

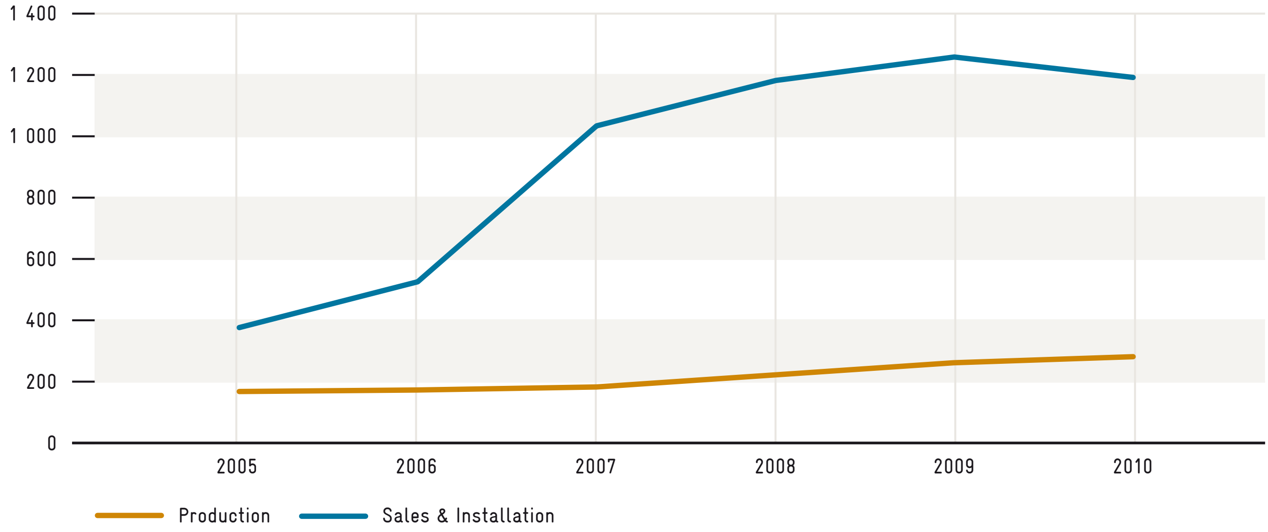


Table 16: Impacts of PROSOL Tertiary

PROSOL Tertiary	2005	2006	2007	2008	2009	2010	Cumulated impact 2005-2010	Savings Ktoe-year
m²					500	3,600	4,100	
Cumulated m²	0	0	0	0	500	4,100	4,100	
Cumulated energy savings (ktoe)	0	0	0	0	0.05	0.41	0.46	
Energy savings over lifespan (ktoe)	0	0	0	0	0.8	5.4	6.2	0.4

Table 17: Employment factors for PROSOL Tertiary

Sector	Installation	Engineering	Operation and maintenance
Unit	Jobs/1,000 m²	Jobs/1,000 m²	Jobs/1,000 m²
Collective SWHs	2	1.2	1.1

Source: ANME/PROSOL

Table 18: Evolution of the number of jobs in PROSOL Tertiary

Sector	Achievements	2005	2006	2007	2008	2009	2010	TOTAL
PROSOL Tertiary	m²					500	3,600	4,100
	Turnover (TND million)					0.3	2.4	2.7
	Number of installers						12	
	Number of engineering consultancies						20	
	Number of job-years							
	Engineering and assistance					1	4	4
	Supply and installation					3	19	19
	Operation and maintenance					1	4	4
	Programme management (ANME)			2	2	2	3	3
	S/TOTAL PROSOL Tertiary			2	2	6	31	31

Table 19: Impacts of the solar PV promotion programmes

Rural Electrification	2005	2006	2007	2008	2009	2010	Cumulated impact 2005-2010	Savings Ktoe-year
Number of housing units	235	105	128	1,052	584	8	2,112	
kWp	26	12	14	116	64	1	232	
Cumulated kWp	26	37	51	167	231	232	232	
Cumulated primary energy savings (ktoe)	0.01	0.02	0.02	0.07	0.10	0.10	0.3	
Energy savings over lifespan (ktoe)	0.2	0.1	0.1	1.0	0.6	0	2	0.1
PROSOL Elec	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**Cumulated impact 2005-2010**	**Savings Ktoe-year**
Number of housing units						235	235	
kWp						408		
Cumulated kWp						408	408	
Cumulated energy savings (ktoe)						0.18	0.18	
Energy savings over lifespan (ktoe)						3.5	4	0.2

Table 20: Employment factors for solar PV promotion programmes

Grid-connected PV		
Average capacity per system		1.7 kW
Supply and installation	20 m-d/sys	12 m-d/kW
		49 m-y/MW
Maintenance	1 m-d/sys	0,6 m-d/kW
		2.5 m-y/MW

Rural electrification		
Average capacity per system		0.11 kW
Supply and installation	2 m-d/sys	18 m-d/kW
		76 m-y/MW
Maintenance	0.18 m-d/sys	1.6 m-d/kW
		7 m-y/MW

m-d: man-days m-y: man-years

Source: Renewable Energy Division, ANME

6.3.3 The wind power sector

The number of jobs created in the wind power field is estimated on the basis of ratios established in the GIZ and ANME [3] study, as no precise statistical data are available in this field.

In this context, wind power is expected to generate 15 job-years (intermittent jobs) per installed MW in turbine manufacturing, component manufacturing, development and installation. Furthermore, operation and maintenance contribute another 0.4 jobs per MW of total installed capacity (see figure 16).

In the case of Tunisia, the number of jobs created in the context of STEG activities is estimated at around 2.9 jobs per MW, as per the following breakdown (see table 22):

- engineering, support and training: 1.3 man-years per MW installed, representing 0.1 job equivalents per MW;
- construction, installation and accessories supply: 3.7 man-years per MW installed, representing 0.2 job equivalents per MW;
- operation and maintenance: 0.4 permanent job equivalents per MW installed.

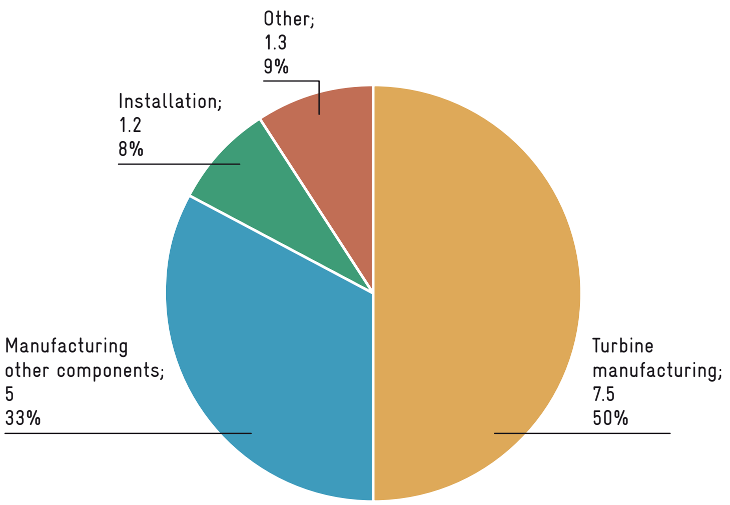
When these ratios are applied to the 54 MW installed by STEG, the number of jobs created can be estimated as follows (see table 23):

3 Production d'électricité renouvelable en Tunisie: Perspectives et Opportunités - Partie 3: Potentiel et scénarios de développement de la production d'électricité renouvelable en Tunisie; ANME-GIZ, February 2011.

Table 21: Evolution of the number of jobs in the photovoltaic sector

Sector	Achievements	2005	2006	2007	2008	2009	2010	TOTAL
Solaire Photovoltaique								
PROSOL Elec	Number of systems						234	234
	kW						408	408
	Turnover (TND million)						3	3
	Number of suppliers						50	50
	Number of installers						50	50
	of which active installers						10	10
	Number of job-years							
	Supply and installation							
	of which permanent jobs						20	20
	of which temp man-years						10	10
	Maintenance						2	2
	S/TOTAL PROSOL Elec	0	0	0	0	0	22	32
Rural Electrification	Number of systems	235	105	128	1,052	584	8	2,112
	Capacity (kW)	26	12	14	116	64	1	232
	After-sales service capacity (kW)	26	52	63	77	193	257	
	Turnover (TND million)	0.4	0.2	0.2	1.8	1.0		3.6
	Number of suppliers	3	3	3	3	3	50	50
	Number of installers						50	
	Number of job-years							
	Supply and installation	2	1	1	9	5	0	18
	Maintenance (warranty)	0.2	0.4	0.4	0.5	1.3	1.8	5
	S/TOTAL Rural Electrification	2	1	1	10	6	2	22
S/Total Solar PV	Investment (TND million)	0	0	0	2	1	3	7
	Number of job-years	2	1	1	10	6	24	42

Figure 16: Employment factors for wind energy (international)



Source: EWEA (2008)

Table 22: Employment factors for wind energy (Tunisia)

	Man-years/MW	Job Equiv./MW
Construction and installation	3.7	0.2
Operation and maintenance	-	0.4
Other (engineerng, training, support, etc.)	1.3	0.1
Total		**0.7**

Source: GIZ/ANME (2010)

Table 23: Evolution of the number of jobs in the wind energy sector

Sector	Achievements	2005	2006	2007	2008	2009	2010	TOTAL
Centralised Wind Power	Cumulated MW	20	20	20	20	54	54	54
	Turnover (TND million)	50				70		120
	Man-year jobs							
	Supply and installation					124	0	124
	Support (education, engineering, funding)					44	0	44
	Operation & maintenance	8	8	8	8	8	8	8
S/Total Wind Power (Job Equivalents)		8	8	8	8	16	8	16

Table 24: Evolution of the number of jobs in the renewable energy sector

	2005	2006	2007	2008	2009	2010	TOTAL
Investment (TND million)	62	16	29	41	111	46	305
Permanent jobs	560	712	1,231	1,427	1,549	1,535	1,558

- eight permanent jobs for the operation and maintenance of wind farms;
- 168 job-years for the implementation phase, representing around eight equivalent permanent jobs.

In 2012, when the installed capacity for wind power will have reached 245 MW, 100 new permanent jobs in operation and maintenance are projected, and around 25 permanent job equivalents in project implementation.

Table 24 illustrates total jobs created in renewable energy sectors.

6.3.4 Energy audits and programme contracts

For institutional activities, those related to mandatory, periodic energy audits and the resulting programme contracts, the number of permanent jobs created in the context of these activities was estimated on the basis of the following ratios, which were defined by taking the entire process into account, in other words, from the establishment of the audit agreement to assistance for the implementation of energy-saving measures:

- 0.4 permanent jobs/audit
- 0.7 permanent jobs/programme contract.

It follows that the number of jobs created during the 2005-2010 period can be estimated at around 154 permanent jobs as per the following breakdown by sector (see table 25):

- 106 permanent jobs in the industrial sector
- 33 permanent jobs in the tertiary sector
- 15 permanent jobs in the transportation sector.

6.3.5 Other energy efficiency programmes

Other energy efficiency measures are related to the construction sector, cogeneration, engine diagnostics stations and energy service companies.

Table 26 illustrates the number of direct jobs created by institutional measures in these sectors.

6.3.5.1 The buildings sector

Regarding the blueprint audit sector, 61 permanent jobs are estimated for the 2005-2010 period.

For the thermal insulation market, there are 31 suppliers in all, with around 560 intermittent employees, broken down as illustrated in the following table 27.

Furthermore, if there is an upscaling of activities, this field has significant potential for the creation of direct employment, particularly for the realisation of works.

6.3.5.2 Energy service companies

It is estimated that nine permanent jobs were created by energy service companies (ESCOs).

6.3.5.3 The diagnostics station programme

A good level of technical expertise and a minimum of experience is necessary for the operation of motor vehicle engine diagnostics stations, so as to carry out tests, inspections and adjustments in accordance with good professional practice.

It is therefore generally necessary to hire technicians who fulfil the requirements set out in the specifications for best practices in motor vehicle engine diagnostics, established by ANME and promulgated by the 10 August 2007 decree.

Table 25: Evolution of the number of jobs in the energy audit and CP sector

Sector	Achievements	2005	2006	2007	2008	2009	2010	TOTAL
Transportation	Number of certified experts	9	9	9	9	9	9	9
	Number of audits	1	1	3	5	3	15	28
	Number of programme contracts	1	1	0	10	5	14	31
	Audit amounts (TND million)	0.008	0.35	0.01	0.03	0.02	0.08	0.50
	Investment (TND million)	0.3	0.04	0.00	2.9	7.4	1.8	12
	Man-year jobs (engineering & development)	**1**	**1**	**1**	**9**	**5**	**15**	**15**
Industry	Number of certified experts	32	43	53	62	67	68	68
	Number of audits	11	30	37	49	63	48	238
	Number of prior consultations			25	13	7	6	51
	Number of programme contracts	18	75	108	70	84	128	483
	Audit amounts (TND million)	4	11	46	11	13	14	100
	Investment (TND million)	11	25	80	20	24	43	203
	Man-year jobs (engineering & development)	**16**	**62**	**91**	**68**	**82**	**106**	**106**
Tertiary	Number of certified experts	28	39	49	66	73	75	75
	Number of audits	12	18	18	26	34	46	154
	Number of prior consultations							0
	Number of programme contracts	11	36	14	27	26	23	137
	Audit amounts (TND million)	0.10	0.16	0.13	0.25	0.95	1.06	2.6
	Investment (TND million)	1	6	2	4	4	4	20
	Job-years (engineering & development)	**12**	**31**	**16**	**28**	**30**	**33**	**33**
TOTAL INSTITUTIONAL ACTIVITIES								
	Investments (TND million)	12	31	82	27	35	49	235
	Analytical approach: Total job-years	29	94	108	105	117	154	154
	Inventory approach: Total jobs	69	91	111	137	149	152	152

In this context, it is estimated that new employment generated by this activity totalled 109 permanent jobs during the 2005-2010 period, on the basis of the following ratios:

- supply, installation and maintenance: three permanent jobs per 100 stations installed;
- operation: one permanent job for each station installed.

6.3.5.4 Cogeneration

Cogeneration is an extremely capital-intensive sector where a significant share of the value chain is located abroad. Indeed, the rate of integration is estimated at 25% maximum.

Average employment potential indicators based on feedback from Tunisia's experience in this area are as follows (see table 28).

Table 26: Evolution of the number of jobs in other energy efficiency sectors

Sector	Achievements	2005	2006	2007	2008	2009	2010	TOTAL
"Buildings (blueprint audits)"	Number of certified experts	22	22	22	22	22	22	22
	Number of audits	1	0	0	2	4	5	12
	Number of programme contracts	1	0	0	2	4	5	12
	Surface area (m²)						200,000	200,000
	Investment (TND million)	0	0	0	0	0	2	2
	Energy savings (ktoe)						0.54	0.54
	Number of direct jobs						61	61
ESCO	No. of energy performance contracts (CPEs)		3	4	7	1	8	23
	Investment (TND million)		0.8	2.2	3.5	0.9	11.4	19
	Number of man-days		417	543	1,051	200	1,996	4,207
	Job-years (engineering & development)		2	2	5	1	9	9
Cogeneration	MW installed			1.5	10	10	6	28
	Number of projects			1	2	2	1	6
	Investment (TND million)	0	0	1.3	5.9	7.1	5.8	20
	Number of suppliers			1	1	2	2	2
	Number of direct jobs							
	Operation /Maintenance			4	8	8	4	
	Job-years							
	Support (engineering, training, funding)			0.07	0.13	0.13	0.07	0.40
	Supply and installation			6	12	12	6	35
	Operation & Maintenance			4	8	8	4	24
	S/Total Cogeneration	0	0	10	20	20	10	60
Diagnostics stations	**Number of approved suppliers**	0	0	6	8	3	4	21
	Number of stations			33	59	2	11	105
	Turnover (TND million)	0	0	0.2	1	0.4	0.2	1.6
	Man-year jobs							
	Supply & installation and maintenance			1	2	0.1	0.4	4
	Operation & Maintenance			33	59	2	11	105
	S/Total Diagnostics	0	0	34	61	2	11	109
Total other energy efficiency programmes								
	Investments (TND million)	0	0	1	7	7	8	42
	Permanent jobs	0	2	47	86	23	91	239

On this basis, at the end of 2010, the number of jobs created can be estimated at around 24 permanent jobs and 500 man-years of occasional employment, which economically speaking, corresponds to around twenty permanent job equivalents.

As of end 2012, the estimated number of jobs created is 60 permanent jobs, broken down as follows:

- 25 for engineering, operation and maintenance;
- 35 for supply and installation.

Table 27: Employment factors for the thermal insulation sector

Designation	I	D	M	Number of companies	Average workforce
Activity/ Service	x			3	50
		x		6	100
	x	x		10	200
	x		x	1	6
		x	x	7	105
	x	x	x	4	100
TOTAL				31	561

I: Installer D: Distributor M: Manufacturer

Table 28: Employment factors for the cogeneration sector

Field	Value	Unit
Engineering and consulting	1	man-years
Engineering	0.5	man-years
Consulting	0.5	man-years
Implementation	88	man-years
Civil engineering	8	man-years
Electricity	40	man-years
Mechanics	40	man-years
Operation	4	jobs

Source: Alcor (2011)

6.3.6 The market for energy efficient household appliances

6.3.6.1 The CFL market

This section focuses on the CFL and thermal insulation markets, both of which have potential for integration and industrialisation. For the CFL market, there are 42 suppliers, of which six local manufacturers, who have a market share of 50%. Overall accumulated turnover for the 2005-2010 period amounts to over TND 27 million, for around 11 million CFLs (see table 29).

As CFL manufacturing represents, in our opinion, a shift in the incandescent bulb market towards CFLs, it will not have any significant impact on the creation of new jobs. Only importers are contributing to creating jobs, at the rate of one job per supplier (average of 42 jobs).

6.3.6.2 Household appliances

Labelling programmes for refrigerators, air conditioners and household appliances represent a mere market shift and, in our opinion, do not have any significant impact on the creation of new jobs.

6.4 Summary of the assessment of direct employment in renewable energy and energy efficiency

In conclusion, sustainable energy programmes have generated over 2,500 direct jobs in the 2005-2010 period, as illustrated in the following chart, of which 60% were generated by the PROSOL programme in the residential sector (see table 30).

Table 29: Evolution of the CFL market

CFL market	2005	2006	2007	2008	2009	2010	TOTAL
Number of importers	7	13	12	20	19	16	36
Number of CFLs imported	257,277	646,243	511,023	1,785,343	1,282,572	1,187,786	5,670,244
Turnover (TND)	739,765	1,593,140	1,126,731	2,670,348	2,429,234	2,868,850	11,428,067
Number of manufacturers	2	2	3	4	5	6	6
Number of local CFLs	690,000	653,750	989,000	715,000	1,138,000	1,062,000	5,247,750
Turnover (TND)	2,070,000	1,961,250	2,967,000	2,145,000	3,414,000	3,186,000	15,743,250
TOTAL							
Suppliers	9	15	15	24	24	22	42
Number of CFLs	947,277	1,299,993	1,500,023	2,500,343	2,420,572	2,249,786	10,917,994
Turnover (TND)	2,809,765	3,554,390	4,093,731	4,815,348	5,843,234	6,054,850	27,171,317

NB: This overview does not include the 2 million lamps imported by the Tunisian Trade Agency (OCT) in 2006 and 2007.

Table 30: Evolution of the number of jobs in the field of RE and EE

<table>
<tr><th>Profession ▸
Programme ▾</th><th>Trials & tests</th><th>Engineering & development</th><th>Supply</th><th>Installation</th><th>Operation & maintenance</th><th>Support & manage-ment</th><th>"Total jobs 2005-2010"</th></tr>
<tr><td>Energy Efficiency</td><td>30</td><td>161</td><td>210</td><td>425</td><td>129</td><td></td><td>956</td></tr>
<tr><td>Energy audits and programme contracts</td><td>-</td><td>152</td><td>-</td><td>-</td><td>-</td><td></td><td>152</td></tr>
<tr><td>Energy efficiency in buildings</td><td>25</td><td>-</td><td>-</td><td>36</td><td>-</td><td></td><td>61</td></tr>
<tr><td>ESCO</td><td></td><td>9</td><td></td><td></td><td></td><td></td><td>9</td></tr>
<tr><td>Cogeneration</td><td>-</td><td>1</td><td>-</td><td>35</td><td>24</td><td></td><td>60</td></tr>
<tr><td>Diagnostics stations</td><td>-</td><td>-</td><td>-</td><td>4</td><td>105</td><td></td><td>109</td></tr>
<tr><td>Energy management equipment</td><td>5</td><td>-</td><td>210</td><td>350</td><td>-</td><td></td><td>565</td></tr>
<tr><td>Renewable Energy</td><td>15</td><td>10</td><td>374</td><td>1,159</td><td>14</td><td>-</td><td>1,572</td></tr>
<tr><td>PROSOL Residential</td><td rowspan="2">15</td><td>-</td><td>374</td><td>1,100</td><td></td><td></td><td>1,489</td></tr>
<tr><td>PROSOL Tertiary</td><td>4</td><td></td><td>19</td><td>4</td><td></td><td>27</td></tr>
<tr><td>PROSOL Elec</td><td>-</td><td>-</td><td rowspan="2"></td><td rowspan="2">38</td><td rowspan="2">2</td><td rowspan="2"></td><td rowspan="2">40</td></tr>
<tr><td>Rural electrification</td><td>-</td><td>-</td></tr>
<tr><td>Wind power</td><td>-</td><td>6</td><td>-</td><td>2</td><td>8</td><td></td><td>16</td></tr>
<tr><td>TOTAL EE & RE</td><td>45</td><td>172</td><td>584</td><td>1,584</td><td>143</td><td>-</td><td>2,528</td></tr>
</table>

7 IDENTIFICATION AND ASSESSMENT OF THE PRIMARY SUPPORTING MEASURES

The most significant share of new jobs in the EE and RE fields is found in extensive programmes, which reach a greater share of the targeted population, resulting in the creation of a fairly significant market which generates interest in certain professions.

Local integration of production for new technologies has a significant impact on the creation of employment, as seen with solar water heaters.

Initiatives in support of renewable energy and energy efficiency apply to areas such as training, education, tests and research & development, as well as promotion and management.

7.1 Education and training

With regard to qualifications and the improvement of skills, the emphasis in Tunisia has been on human resources development, particularly in innovative domains such as information technology. Indeed, over the last two decades, the government has implemented its policy decision to pursue and adapt its efforts in favour of education and professional training, a sector that currently receives 7.5% of GDP and has an average budget increase of 10% each year.

The development of skills in relation to renewable energy and energy efficiency has often been a key component in national sustainable energy programmes. This component has been integrated into various academic and professional courses of study and has also been the focus of targeted initiatives in favour of continuing education and capacity building.

7.1.1 Higher education

Academic institutions launched specialised courses of study (doctorate, professional master's degree, post-graduate degree, etc.) in order to meet the requirements of the business sectors. Tunisia boasts six public and private higher education institutions, including schools of engineering and higher technology institutes (ISETs). These academic institutions train engineers, technologists and technicians who will contribute to the implementation of energy supply and management projects. These skills are also used in advising various institutions (public and professional organisations, businesses, etc.) concerned with energy issues in general, and sustainable energy issues in particular.

The establishment of a specialised academic institution in 2006, 'Institut Supérieur des Sciences et Technologies de l'Energie de Gafsa', attests to the importance of education in the field of sustainable energy. This institution provides training in four specialist areas related to energy efficiency and renewable energy services and techniques.

As of end 2010, around 300 graduates were working in the sector and over 700 students were enrolled at public and private specialised institutions.

7.1.2 Vocational training

From its beginnings in the early 1990s, the MANFORM training update programme has endeavoured to create a new generation of industry-specific vocational training centres for targeted training of specialised, rapidly operational workers in various fields of activity, including energy, mechanics, electricity, plumbing and construction, in order to meet the skills and qualifications requirements of businesses.

The vocational training system consists of around 150 public and private centres with a capacity of around 60,000 training places, of which over 90% in public centres and around 40% in specialised industry-specific centres (four industry-specific centres in the energy sector with around 600 training places and 200 staff members, 50 at each centre).

As the vocational training system plays a significant role in the development of a qualified labour pool, it receives support from the private sector, where the majority of qualified interns are employed. Coordination with public institutions such as ANME is lacking. The only coordination initiative involved SWH installers and aimed to respond to the requirements of the PROSOL programme.

7.1.3 Continuing education and national capacity building

The Tunisian continuing education system is one of the most advanced in the Mediterranean region. With appropriate tools and funding mechanisms, such as the professional training tax (TPF) rebate and priority technology investment (ITP) aid, some 2,000 companies and 120,000 candidates take part in around 20,000 continuing education programmes each year. Due to the specificities of the sector, the training market in the sustainable energy field is not sufficiently organised, which explains why so little data is available on the initiatives carried out.

In fact, ANME carries out many continuing education initiatives as part of its mission, in order to ensure the various sectors have the necessary skills (industry, residential, tertiary and transportation). This training covers renewable energy sectors (solar thermal and photovoltaics, wind power, biomass) as well as energy efficiency. ANME considers that it has a local skill-base capable of supporting national programmes: energy auditors, engineering consultants, architects, liaison experts, equipment installers, energy managers for the various types of establishment, project economists, etc. working in specialised consultancies, energy service companies (ESCOs), financial institutions, insurance companies, technical centres and elsewhere.

All these initiatives have made it possible to build up knowledge, achieve sustained improvements in business competitiveness and foster the emergence of professionals in the energy efficiency and renewable energy fields.

7.2 Tests and research & development

Since the turn of the century, sustainable energy has been the focus of several research and development programmes at various specialised structures in order to master and adapt technologies to the context in Tunisia and especially to enhance cooperation with the economic environment. Particularly noteworthy are the 'Programmes de Recherche Fédérés' (PRF - common research programmes), which aim to improve the organisation of the national R&D system by mobilising skills and establishing partnerships between research establishments and the public and private operators concerned.

With regard to sustainable energy, the PRFs were coordinated by ANME acting as a supporting structure, and a certain number of projects were involved, including solar water heating, the development of solar energy cooling processes, air conditioning using natural gas, the use of wind power in the industrial sector, the development of a wind power system prototype and hydrogen-based energy generation. These projects involved over twenty research teams in cooperation with economic organisations and specialised public structures in addition to over TND 1.5 million in funding.

Among the research establishments, the Borj Cedria technopark is noteworthy for its three centres which are already operational, with test and research facilities and qualified, experienced human resources.

It is the Energy Research and Technology Centre (CRTEn) that is the most involved with energy efficiency and renewable energy. In operation since 2006, this centre is involved in the development of energy technologies and ensuring their integration in the economic and social spheres, as well as scientific and technology monitoring in the energy field. The centre also contributes to training senior managers in this field. So far the centre has focused on the applications of photovoltaic systems for lighting, irrigation and water desalination using renewable energy, the use of solar and wind power as well as research on materials for photovoltaic applications.

Furthermore, a laboratory test and trials system has been developed in light of the need to evaluate the eligibility of energy-efficient products with regard to tax breaks and dedicated programmes, such as PROSOL, PROSOL Elec and PROMO-ISOL, as well as to cater to inspection requirements before products go on the market.

Noteworthy establishments include:

- CETIME for testing on CFLs, refrigerators and air conditioners (around 15 jobs);
- CTMCCV for testing on SWHs and thermal insulation materials (around 15 jobs);
- The Borj Cedria laboratory for testing on SWHs (around 5 jobs);
- The ENIT laboratory for testing on SWHs (around 5 jobs).

7.3 Promotion and management

ANME, STEG and the relevant professional bodies are responsible for the promotion and management of sustainable energy programmes. Since 2005, an estimated 200 jobs have been created by these players:

- ANME has a staff of around 140 people split up among six regions and is responsible for the implementation of government policy in the field of sustainable energy;
- STEG employs around 50 people in the field of sensibilisation programmes and project implementation through its STEG-ER (renewable energy) subsidiary;
- professional bodies including trade associations, professional associations and consumer protection groups, representing around ten jobs.

8 IDENTIFICATION OF COMPANIES INVOLVED IN THE SUSTAINABLE ENERGY FIELD IN TUNISIA

Tunisia has a wealth of industrial experience in several fields, such as mechanics, electricity, electronic components and automotive components. The technological and industrial context in Tunisia is thus very favourable to partnership-type operations between Tunisian promoters and foreign manufacturers, particularly for equipment manufacturing projects for both renewable energy and energy efficiency.

8.1 Renewable energy

The industrial fabric has seen the most growth in the SWH sector where visibility provided by support programmes for the solar thermal market made it possible to encourage Tunisian industrial initiatives and foster partnership operations. Tunisia now has a significant SWH manufacturing and assembly capacity. Six production facilities are already in operation: SOFTEN, SINES, SIER, BSI, Tech-Sol and Soltech. Furthermore, around forty companies are importing SWHs from various countries including Greece, Turkey, Italy and China, and distributing them on the Tunisian market.

With regard to installation, Tunisia has over a thousand small businesses involved in installing individual solar water heaters. These companies are present throughout the entire Tunisian territory. There are also a dozen specialised companies qualified to assemble and install collective systems.

8.1.2 Solar photovoltaics

For this sector, industrial integration projects have been launched in support of local manufacturing and assembly of photovoltaic modules. Construction of two production units is currently underway. One unit is located in Béjà with a production capacity of 20 MWp, at a cost of 4.5 million euros. The other unit is in Manouba with a production capacity of 15 MWp at an investment cost of 4 million euros. Both of these units were expected to be commissioned around end 2010.

Regarding the other components, two Tunisian companies are currently manufacturing the batteries used to store electricity produced by photovoltaic systems. Other components, such as regulators, cables, junction boxes and connectors, are manufactured by over 300 companies in the electrical and electronics industries. Specific equipment, such as inverters, could be manufactured by some of these companies with some adaptation of their production lines.

As for the installation of photovoltaic systems, several new companies have been established in the assembly sector. They import modules from various countries (Japan, Germany, Spain, France and China).

8.1.3 Wind power

This is a promising new sector in terms of industrial integration. Wind turbine towers are currently being manufactured by SOCOMENIN, a company specialised in steel construction.

Tunisia has a local industry capable of supplying various wind farm components (towers, cables, transformers, control panels, display panels, regulators, etc.). The Tunisian manufacturers are in a position to supply these components are involved in the electrical and mechanics industries. The Tunisian industry is also in a position to provide logistics, transportation and construction services as well as services related to the operation and maintenance of wind power plants.

8.2 Energy efficiency

The initiatives implemented thus far have contributed to the development of national skills in the various fields, particularly for energy audits where Tunisia has a number of operational specialists in each sector (industry, tertiary and transportation). ANME has also established a network of liaison experts, relying on them for a large portion of its interventions with economic operators. Furthermore, a network of national consulting companies, engineering consultants and architects is currently involved in the various sustainable energy programmes: strategic studies, solar and wind power development, etc. Tunisian specialists have also accumulated a wealth of experience in fields such as household appliance certification, energy efficiency in buildings and funding mechanisms, including the Clean Development Mechanism (CDM).

CFLs, or energy-saving lamps, are already being manufactured locally, and the industry is expanding in order to meet the growing demand for these products (Tunisia currently boasts four CFL manufacturers).

In addition, household appliance manufacturers have integrated the latest techniques designed to improve the energy efficiency of refrigeration and cooling equipment. In the buildings sector, interest in thermal insulation has been rising, and several operators have started to position themselves on the market. There are also partnerships underway with specialised European companies in order establish production capacities.

These initiatives have made it possible to foster commercial and industrial integration with the emergence of partnerships in various sustainable energy sectors.

9 SUMMARY

Sustainable energy activities in Tunisia during the 2005-2010 period generated around 4,000 job equivalents, of which nearly 90% are permanent jobs (3,500 jobs; see table 31).

Renewable energy contributed to 45% of total direct employment created, followed by horizontal activities (28%) and energy efficiency (27%). Excluding horizontal activities, RE alone represents 60% of employment created.

In order to understand the impact on employment of the various programmes and sectors, we have defined two main indicators as follows:

- the 'energy' employment potential ratio (jobs/ktoe-year) defined as the relationship between jobs created and the annual quantity of energy saved;
- the 'economic' employment potential ratio (jobs/TND million) defined as the relationship between jobs created and capital invested.

In this regard, the renewable energy sector presents the highest energy employment potential ratio with 31 jobs/ktoe-year compared to only two jobs/ktoe-year for energy efficiency and six jobs/ktoe-year for all sectors combined. For renewable energy, the energy employment potential ratios are highest in the solar sector, and for energy efficiency, they are highest in the buildings sector. This attests to the importance of the impact of extensive programmes on the employment potential of sectors with a low energy-savings rate where the cost is higher per toe saved (see figure 17).

Table 31: Evolution of the number of jobs in the field of RE and EE

<table>
<tr><th>Profession ▸
Programme ▾</th><th>Trials & tests</th><th>Engineering & development</th><th>Supply</th><th>Installation</th><th>Operation & maintenance</th><th>Support & manage-ment</th><th>"Total jobs 2005-2010"</th></tr>
<tr><td>**Energy Efficiency**</td><td>30</td><td>162</td><td>210</td><td>425</td><td>129</td><td></td><td>956</td></tr>
<tr><td>Energy audits and programme contracts</td><td>-</td><td>152</td><td>-</td><td>-</td><td>-</td><td></td><td>152</td></tr>
<tr><td>Energy efficiency in buildings</td><td>25</td><td>-</td><td>-</td><td>36</td><td>-</td><td></td><td>61</td></tr>
<tr><td>ESCO</td><td></td><td>9</td><td></td><td></td><td></td><td></td><td>9</td></tr>
<tr><td>Cogeneration</td><td>-</td><td>1</td><td>-</td><td>35</td><td>24</td><td></td><td>60</td></tr>
<tr><td>Diagnostics stations</td><td>-</td><td>-</td><td>-</td><td>4</td><td>105</td><td></td><td>109</td></tr>
<tr><td>Energy management equipment</td><td>5</td><td>-</td><td>210</td><td>350</td><td>-</td><td></td><td>565</td></tr>
<tr><td>**Renewable Energy**</td><td>15</td><td>10</td><td>374</td><td>1,159</td><td>14</td><td>-</td><td>1,572</td></tr>
<tr><td>PROSOL Residential</td><td rowspan="2">15</td><td>-</td><td>374</td><td>1,100</td><td></td><td></td><td>1,489</td></tr>
<tr><td>PROSOL Tertiary</td><td>4</td><td></td><td>19</td><td>4</td><td></td><td>27</td></tr>
<tr><td>PROSOL Elec</td><td>-</td><td>-</td><td rowspan="2"></td><td rowspan="2">38</td><td rowspan="2">2</td><td rowspan="2"></td><td rowspan="2">40</td></tr>
<tr><td>Rural electrification</td><td>-</td><td>-</td></tr>
<tr><td>Wind power</td><td>-</td><td>6</td><td>-</td><td>2</td><td>8</td><td></td><td>16</td></tr>
<tr><td>**Horizontal Activities**</td><td></td><td></td><td></td><td></td><td></td><td>975</td><td>975</td></tr>
<tr><td>Promotion and management</td><td></td><td></td><td></td><td></td><td></td><td>200</td><td>200</td></tr>
<tr><td>Training and education</td><td></td><td></td><td></td><td></td><td></td><td>200</td><td>200</td></tr>
<tr><td>R&D</td><td></td><td></td><td></td><td></td><td></td><td>25</td><td>25</td></tr>
<tr><td>Energy manager</td><td></td><td></td><td></td><td></td><td></td><td>500</td><td>500</td></tr>
<tr><td>Specialised consulting</td><td></td><td></td><td></td><td></td><td></td><td>50</td><td>50</td></tr>
<tr><td>TOTAL</td><td>45</td><td>172</td><td>584</td><td>1,584</td><td>143</td><td>975</td><td>3,503</td></tr>
</table>

Figure 17: 'Energy' employment potential ratio (jobs/ktoe-year)

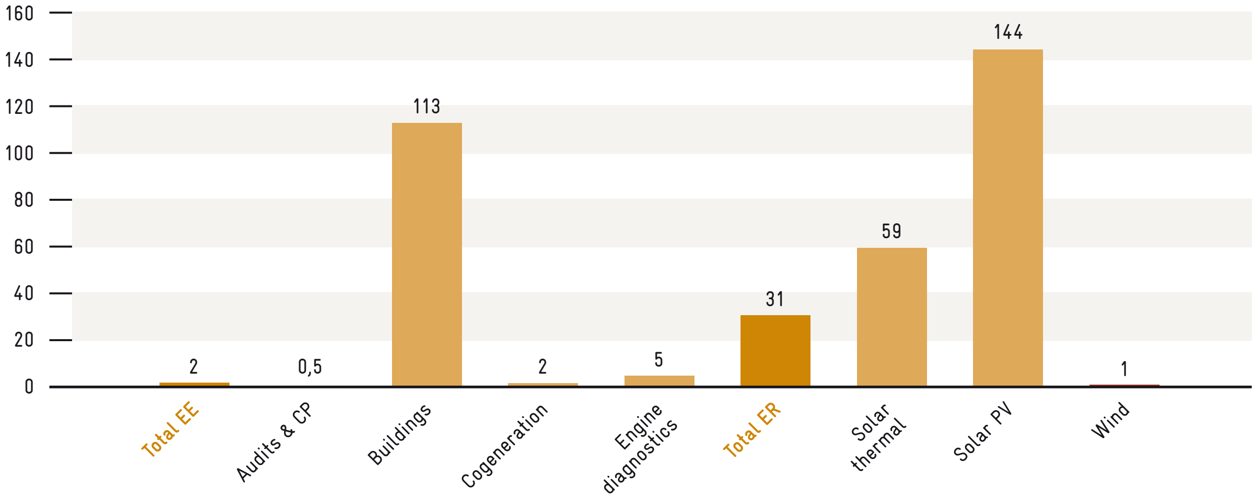
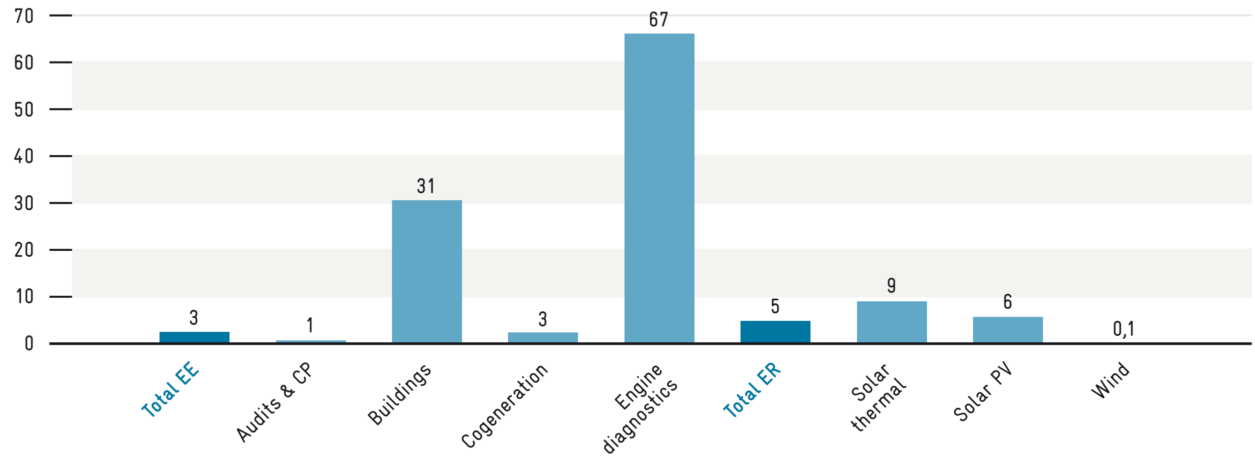


Figure 18: 'Economic' employment potential ratio (jobs/TND million)



With regard to economic employment potential, energy efficiency programmes are the most job-intensive, as illustrated by figure 18, owing mainly to the building energy efficiency sector and the engine diagnostics station sector.

The following lessons can be drawn from this analysis:

- sustainable energy can have a positive social impact, translating into the creation of employment and the development of professions in general;
- the buildings sector has the highest employment potential, and strengthening the building energy efficiency programmes would make it possible to generate more employment;
- employment potential is as good in the RE sector as in the EE sector;
- retrospective analysis demonstrates that employment was considered as a co-benefit and was not a determining factor in the choice of sustainable energy activities;
- permanent job sustainability and stability is related to the sustainability of RE and EE markets for equipment, goods and services;
- in the long term, the employment factor and industrial development may justify public investments in the high value-added sustainable energy sectors.

Therefore, from now on, priorities for the development of sustainable energy sectors should be determined based on a multi-criteria analysis that takes into account factors such as the sector's capacity to save energy, employment potential, the amount of public subsidies per job created, etc.

In conclusion, it is our opinion that employment generated by sustainable energy in Tunisia is still fragile, as it depends on markets that are still fluctuating and unstable (except for programmes based on regulatory frameworks such as PROSOL, the energy audit market and cogeneration). It is therefore up to the government to ensure the sustainability of employment by implementing mechanisms to support the maturation of these markets in the medium and long term.

PART III: PERSPECTIVES FOR JOB CREATION IN THE FIELD OF RENEWABLE ENERGY AND ENERGY EFFICIENCY IN TUNISIA

1 OVERALL APPROACH

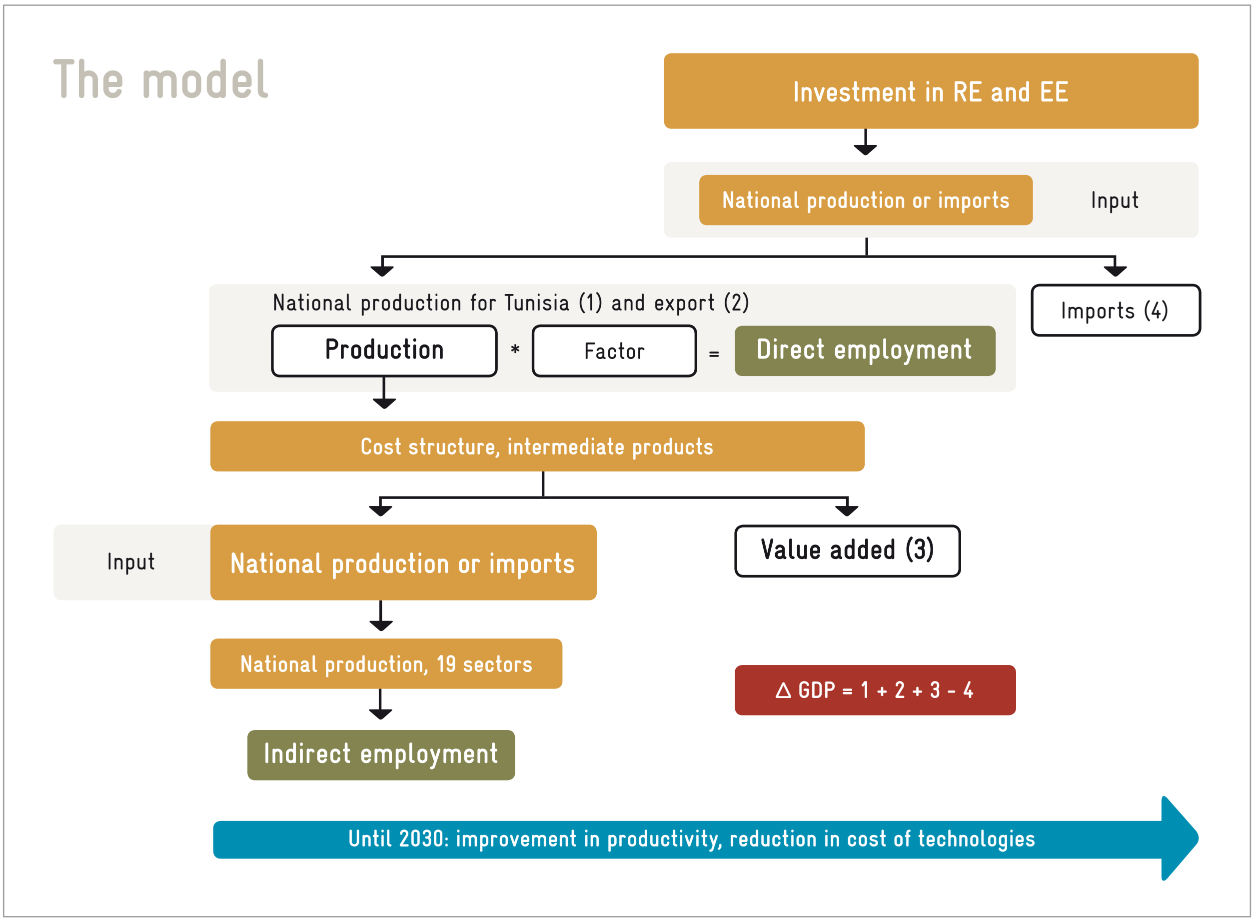
1.1 Employment along the value chain

The first part of this report offered an overview of the different methods that can be applied to measure the employment effects of renewable energy and energy efficiency increases. Some approaches are more useful for developing countries than others. The approach chosen should rely on the country-specific data available, because employment impacts hinge on the production structure of the respective country, the capacity level and skills of the workforce and the available natural resources for renewable energy.

Here, we will propose an adjusted input-output approach embedded in a small model of the country Tunisia. Our approach is a combination of technology-specific input-output tables, labour intensities of the respective production, country-specific input-output tables and country-specific statistical data. Using technology-specific tables we derive information about the cost structure of five different renewable energy technologies and on the increase in energy efficiency of buildings and within the main industry sectors. Depending on the shares of imported goods and services and domestic production we can obtain domestic employment figures by combining these tables with the domestic input-output structure. This method is also recommended in the RETND-IEA guidelines for measuring employment effects from renewable energy (forthcoming).

To combine as much knowledge as possible we suggest a two-stage procedure. The demand for renewable energy installations in Tunisia is modelled according to the Tunisian Solar Plan (PST) until 2016. As mentioned above, for the development of renewable energy (RE) for electricity generation beyond 2016, we use scenarios developed in the context of German-Tunisian cooperation by Wuppertal Institute/Alcor. For the other RE and energy efficiency (EE) measures,

Figure 1: Employment creation along the value chain



2 SCENARIO FOR RENEWABLE ENERGY AND ENERGY EFFICIENCY IN TUNISIA

Tunisia does not yet have an official, detailed long-term RE and EE plan [4].The authors have therefore proposed their own long-term investment plan based on their knowledge of the Tunisian context and the perspectives of EE and RE development in the country. The most important scenario parameters are investment in RE and EE as well as the share of domestic production for domestic and international installation. Domestic production creates domestic demand for further inputs, following the domestic production structure given in the Tunisian input-output tables, while imports will create jobs and value added for the producer countries. Figure 1 shows the drivers of employment creation along the value chain. Renewable energy and energy efficiency technologies can be produced nationally or can be imported. For the domestic production of these technologies, employment is the first step of the value chain created within the production facility. Indirect effects come from inputs (materials, planning, services and technical components) if they are domestically produced. If the products are competitive on international markets, exports will add to this production and create additional value and employment. Total employment is the sum of direct and indirect employment and this holds true for the production of wind turbines, solar panels, solar water heaters and other energy efficiency technologies as well as for their operation and maintenance.

Because of the abundant qualified workforce and projected future population growth, shortages in labour supply are not expected.

The employment effects of the PST can be obtained by comparing employment in a reference scenario without renewable energy and energy efficiency increases with a scenario that includes these new investment paths. All other assumptions and relations will be equal across the scenarios.

4 Two studies are ongoing concerning RE strategy and EE strategy, but the results will not be ready before the end of 2012.

2.1 Quantification of capacity installed, energy saved and investment

The future development path of renewable energy and energy efficiency in Tunisia is still subject to much discussion. The most recent contributions considered in this study are:

1. The PST (2009) on energy efficiency and renewable energy for electricity and heat.
2. 'Renewable energy production in Tunisia, perspectives and opportunities until 2030' (Production d'électricité renouvelable en Tunisie – Perspectives et opportunités a l'horizon 2030) GIZ/ANME), October 2010.
3. The strategic study on the energy mix for electricity production in Tunisia, Part 5, 'Models and scenarios', Wuppertal Institute and Alcor, January 2012.

The latter two studies focus on electricity generation.

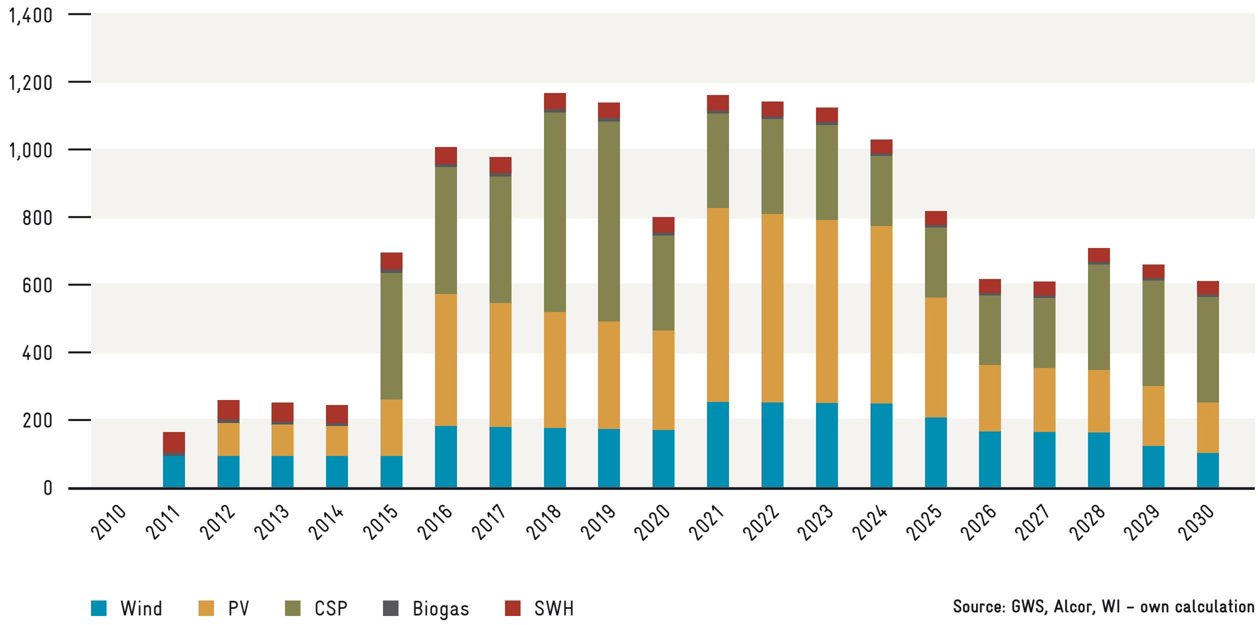
The targets for renewable energy and energy efficiency in the PST are set for 2016 and 2030. For renewable energy, the PST sets targets of 1,000 MW capacity installed by 2016 and 4,600 MW capacity installed by 2030. The conventional capacity development would reach 5,100 MW by 2016 and 7,000 MW by 2030. Therefore, renewable energy is projected to reach a 16% share of total capacity installed by 2016 and the respective share by 2030 would be up to 40%. Comparing these target values with the scenario suggested below, one must keep in mind that the share of renewable energy in electricity production will be less, since conventional energy has a much higher production/capacity ratio.

GIZ/ANME 2010 elaborates on the PST and gives the perspectives for three electricity generating technologies (wind, PV, concentrating solar power generation [CSP]) in greater detail until 2030. Two scenarios are presented: a high RE penetration scenario that reaches 30% renewable energy in electricity generation or 40% in capacity installed as foreseen in the PST and a low RE penetration scenario with 15% renewables in electricity generation. Neither study gives cost estimates for an electricity generation mix. Further, GIZ/ANME 2010 focuses on electricity generation; water heaters and energy efficiency are not considered.

This study adopts the suggestions made in the most recent study on electricity generation strategies for Tunisia carried out by the Wuppertal Institute (Germany), together with Alcor (Tunisia) [5], which developed five scenarios for future energy generation in Tunisia. The authors suggest a moderate

5 Etude Stratégique du Mix Energétique pour la Production d'Electricité en Tunisie, Modélisation et Scenarios, Wuppertal Institut, Alcor, January 2012.

Figure 2: Investment path for renewable energy systems, in TND2011 million



Source: GWS, Alcor, WI – own calculation

scenario regarding demand, with a 1.1% increase in energy efficiency per year. This leads to total electricity consumption of 33.2 TWh in 2030, up from 12.9 TWh in 2009 (GIZ/ANME 2010). Compared to earlier estimates by STEG (2010), this projection is at the higher end. This is mainly due to more economic growth in WI/Alcor 2012.

This electricity demand can be met with different energy mixes. WI/Alcor (2012) suggests a business as usual scenario and four more advanced scenarios and compares them in terms of costs, marketable benefits and non-market benefits. Since the goal of this study is the estimate of employment possibilities from the PST and beyond, we consider the DivRen (renewable diversification) scenario with a 30% penetration rate for renewable energy in the electricity sector. This scenario sets a path to reach 1520 MW capacity of wind energy installed, 1930 MW capacity PV installed and 595 MW capacity installed of CSP. For PV installations, we assume a mix between individual PV installed on residential homes, tertiary buildings and large power plants. Investment reflects the costs of this mix. A total of 11,335 GWh electricity will be generated from renewable sources. Between now and 2030, TND 7.1 billion be spent on purchasing and installing these facilities. A total of TND 343 million will must be spent on operating and maintaining these facilities.

The DivRen scenario is supplemented by a development path for solar water heaters, biogas and waste electricity generation. From our analysis in Part 2 we know that a total of 358,000 square metres of solar water heaters have been installed since 2005. During the last three years an additional annual capacity of 25 MW has been installed. An industrial sector that employs up to 270 people in the production of solar water heaters has been developed and a total of almost 1,500 people were employed between 2005 and 2010 in the production, operation and installation of solar water heaters. Our scenario anticipates continued development with annual installation of 37 MW and a total additional capacity of 700 MW installed by 2030.

Biogas and landfill gas generation occupy the fifth renewable energy column of our scenario. An annual increase of capacities by 3 MW is anticipated.

Capacities installed are reflected in monetary terms by scenario investment paths. The investment path in electricity generation follows the results of WI/Alcor (2012). The model used there calculates investment for large projects at typical sites that are characterised by different wind speeds or levels of solar radiation; therefore, the results show an irregular investment path. A smoother investment path would lead to smoother development of employment.

All in all, investment in renewable energy will be dominated by PV after 2020, when the competitiveness of PV will be fully reached. Before then, large investment sums will go into wind energy and CSP will start later, as already mentioned. The PROSOL support programme led to a successful launch of solar thermal water heaters (SWH) in Tunisia and this success story continues in the scenario. A total of more than 8.3 billion DT will be spent altogether on all RE technologies until 2030 (see figure 2).

All investment and other monetary information in the scenarios are given in TND2011. Changes to the grid are not contained in this exercise because of the difficulty of separating grid expansion costs caused by renewable energy expansion from necessary grid expansion caused by higher electricity consumption as a result of economic growth. Following current knowledge gleaned from international studies, additional grid expansion costs due to RE are rather marginal.

The total investment in technology and capacity installed until 2030 is given in Table 1.

Energy efficiency measures were taken from a variety of sources:

1. The PST foresees a decrease in primary energy use by 40% until 2030.
2. 'KfW Programme of Activities Project Idea Note', (PoA-PIN), (PROMO-ISOL), Date of Submission: 19.11.2010 (Version 02).
3. 'Climate Change and Energy in the Mediterranean', Plan Bleu, EIB 2008.
4. Financial Mechanism for the Development of Energy Efficiency and Renewable Energies in the Southern and Eastern Mediterranean Countries.

The energy efficiency scenario was developed from these sources. It includes energy efficiency measures in both the residential and the industrial sectors. Households can save energy by installing thermal insulation in their homes, replacing conventional light bulbs with energy efficient lamps and buying energy efficient appliances such as refrigerators, stoves, washers, TVs and computers. Industry can improve energy efficiency by using efficient equipment. The energy efficiency section of our scenarios also contains diagnostics stations for vehicles and cogeneration processes.

The distribution of energy savings from households and industry is shown in table 2.

Plan Bleu (2008) estimates the costs of one TOE saved with, on average, €40, which converts into 7740 TND2011/GWh. Our scenario anticipates technology-specific cost reductions until 2030.

Figure 3 shows the investment paths for energy efficiency increases. Investment in energy efficiency is more homogeneous over time compared with the investment data from WI/Alcor (2012). Cogeneration has a large share, in monetary units; insulation for residential and public homes comes second and investment in efficient appliances comes third. An average of TND2011 80 million per year is invested in energy efficiency, summing up to a total of more than TND2011 1.5 billion investments by 2030.

Table 1: Total investment in technology in TND2011 million

Technology	Total additional capacity installed in MW	Total investment (TND 2011 billion)
Wind	1,570	1.65
PV	1,930	2.87
CSP	595	2.65
SWH	700	0.93
Biogas	50	0.18
Total	4,845	8.28

Source: WI/Alcor; GWS/Alcor

Table 2: Energy savings from energy efficiency measures in GWh

		2016	2030
Residential	56 %	-20,279	-67,596
Industry	44 %	-16,007	-53,356

Source: Plan Bleu and own calculation

2.2 Operation and maintenance

Investment in O&M is derived from this scenario. International experience shows that the costs of O&M vary with the investment costs in installation, i.e. cost decreases in RE technologies will be reflected in cost decreases for O&M (see figure 4).

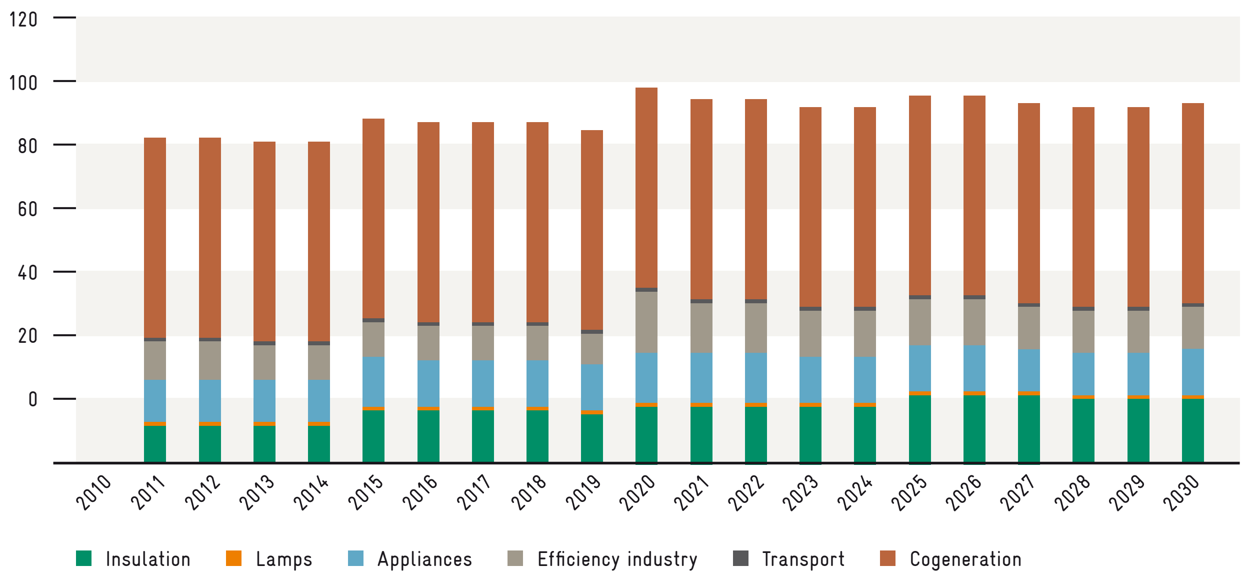
2.3 Further assumptions

Apart from the monetary and physical quantitative framework data, the scenario on renewable energy and energy efficiency must also integrate further hypotheses on industrial integration and opportunities for export to regional and international markets of the relevant Tunisian industries.

2.3.1 Imports

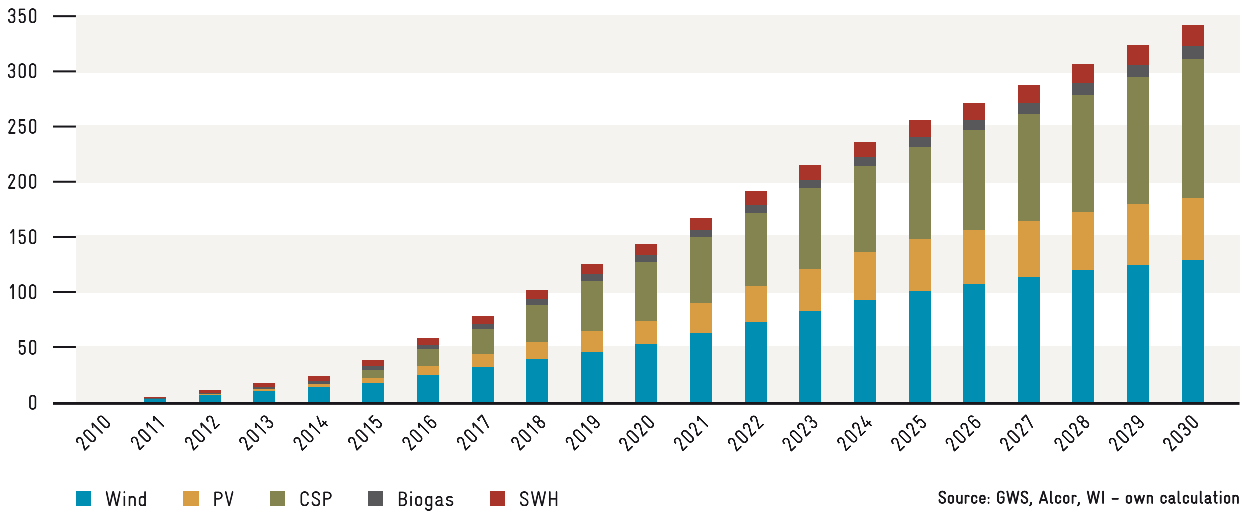
To determine the domestic value added and imports, our analysis starts with a renewable energy system already installed and producing electricity or heat or, respectively, an energy saving appliance or an insulated building ready to save energy. This is the product that corresponds to our investment data. From this point we look back and analyse what is required to get the system ready to work, i.e. material inputs, labour input in intermediate products, installation and planning. We then look forward and determine the requirements to keep

Figure 3: Investment path for energy efficiency applications, in TND2011 million



Source: GWS, Alcor, WI – own calculation

Figure 4: Investment in O&M, in TND2011 million



Source: GWS, Alcor, WI – own calculation

the system operating, i.e. we determine material inputs and labour for O&M.

For this analysis we start with an example from the renewable energy technologies, to determine which share of all wind turbines in a planned wind park are imported and which components can be produced in Tunisia. Going back along the economic value chain, we look closely at the inputs for the wind park in terms of materials, planning and installation. Again, we must ask: what proportion of these inputs can be produced in Tunisia? Information was taken from international studies, the PST, the 'Renewable energy production in Tunisia, perspectives and opportunities until 2030' study (GIZ/ANME 2010) study and from discussions with Tunisian experts.

For the wind energy estimates, GIZ and ANME (2010) selected an employment factor approach (EFA) based on the data for 2008 from the European Wind Association. The shares of turbine production, installation and production of other components were determined in terms of employment and integration rates were set for each share. The integration rates used are not mentioned in the study. The PST derives an integration rate of 43% of the installation of a wind park at Bizerte. In our study, we use the share of domestic value added in the production of windmills plus the share of domestic value added in all input sectors. The actual setting of these shares has been discussed with Tunisian experts. Table 3 gives an overview of the context used for import quotas for all RE technologies.

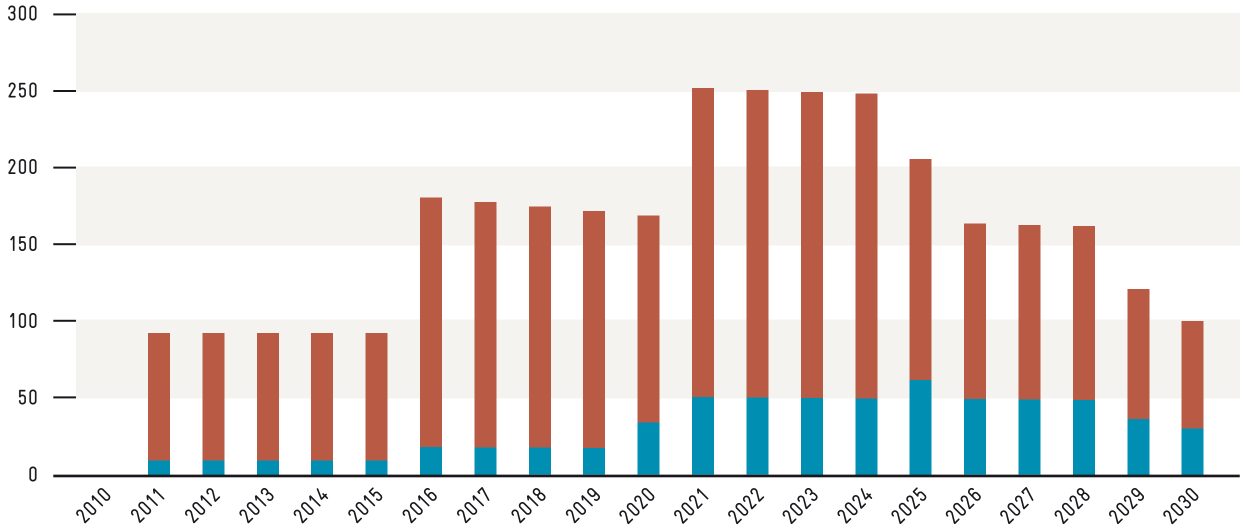
Table 3: Import quota of selected industrial sectors

	Ceramics/ glass	Machinery	Electrical appliances	Systems for measurement and control	Cranes	Construc-tion site preparation	Installation and other construction	Trade	Realty, services	Planning services
Wind										
2010	n.a	100 %	30 %	75 %	100 %	20 %	20 %	70 %		0 %
2015	n.a	100 %	20 %	50 %	100 %	10 %	10 %	60 %		0 %
2020	n.a	100 %	20 %	40 %	0 %	0 %	0 %	50 %		0 %
2025	n.a	100 %	10 %	30 %	0 %	0 %	0 %	50 %		0 %
2030	n.a	100 %	10 %	20 %	0 %	0 %	0 %	50 %		0 %
PV										
2010	50 %		30 %				20 %			0 %
2015	50 %		20 %				10 %			0 %
2020	50 %		20 %				0 %			0 %
2025	50 %		10 %				0 %			0 %
2030	50 %		10 %				0 %			0 %
CSP										
2010	n.a		30 %					70 %	0 %	100 %
2015	n.a		20 %					60 %	0 %	50 %
2020	n.a		20 %					50 %	0 %	0 %
2025	n.a		10 %					50 %	0 %	0 %
2030	n.a		10 %					50 %	0 %	0 %
SWH										
2010	n.a	70 %		100 %			0 %	0 %		0 %
2015	n.a	60 %		100 %			0 %	0 %		0 %
2020	n.a	50 %		100 %			0 %	0 %		0 %
2025	n.a	40 %		100 %			0 %	0 %		0 %
2030	n.a	40 %		100 %			0 %	0 %		0 %

Table 4: Import of whole systems for RE and EE, in % of total investments

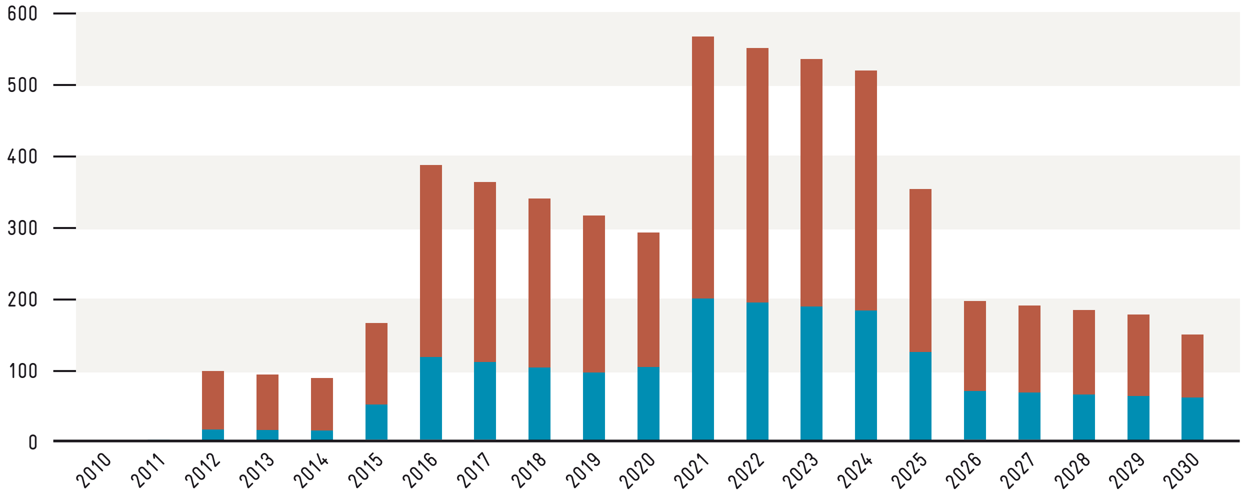
	Wind	PV	CSP	Biogas	SWH	Isolation	CFL	Efficient house-hold appliances	Efficient equipment (industry)
2010	90 %	85 %	90 %	85 %	40 %	75 %	50 %	50 %	90 %
2015	90 %	70 %	90 %	85 %	40 %	65 %	40 %	40 %	90 %
2020	80 %	65 %	80 %	85 %	30 %	60 %	40 %	30 %	80 %
2025	70 %	65 %	70 %	85 %	20 %	50 %	30 %	30 %	80 %
2030	70 %	60 %	70 %	85 %	10 %	50 %	30 %	20 %	80 %

Figure 5: Relation between imports and domestic production, wind energy, in TND2011 million



Source: GWS, Alcor, WI – own calculation

Figure 6: Relation between imports and domestic production of PV in TND2011 million



Source: GWS, Alcor, WI – own calculation

The intermediate input structure is the result of a survey done in international RE industries. The results are extensively documented in Lehr et al, (2012).

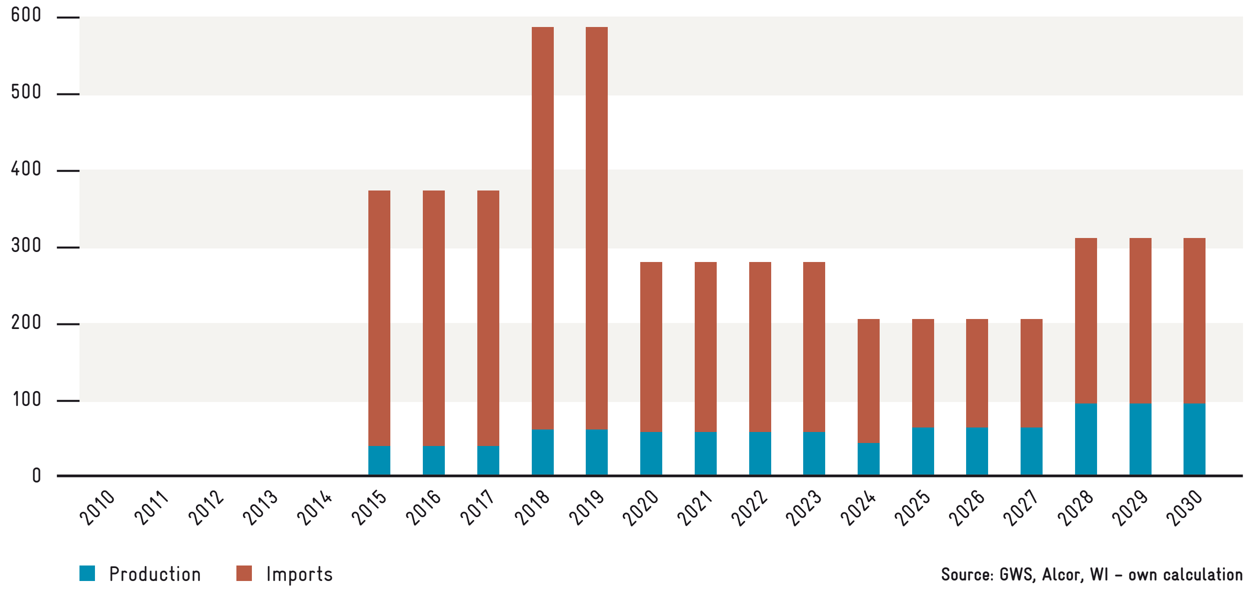
The O&M sector is treated separately in this exercise. It is anticipated that operation and maintenance services will be fully conducted by domestic professionals and will therefore not be a service imported from outside of Tunisia.

For the finished product (RE as well as energy efficiency), quotas are given in table 4. We find a higher integration rate for energy efficiency products compared to the RE sector, except for efficient equipment for industry, and for solar water heaters, which already start at a rather low import rate of 40%.

The following figures illustrate the underlying assumptions.

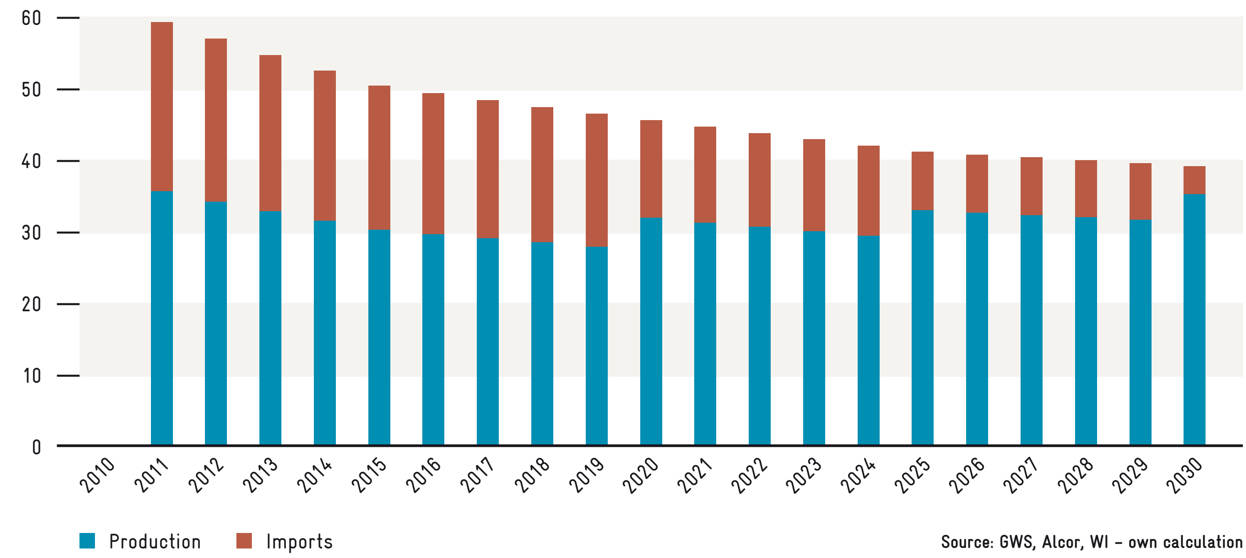
Wind turbines are currently imported from one of the large international producers. Domestic contributions consist of planning and administration as well as generic construction works such as towers and electrical devices. Overtime, more inputs in terms of planning, wind forecast and all services as well as certain components can be provided by Tunisian industry. If conditions are very favourable, Tunisia could attract

Figure 7: Relation between imports and domestic production of CSP in TND^{2011} million



Source: GWS, Alcor, WI – own calculation

Figure 8: Relation between imports and domestic production of SWH in TND^{2011} million



Source: GWS, Alcor, WI – own calculation

an affiliate of the international producers to produce for the whole region. However, this is not currently included in the scenario in order to avoid undue optimism (see figure 5).

Domestic inputs in the installation and planning of PV are assumed to be higher because the skills necessary for installation already exist in Tunisia. The skills necessary for installation of PV power plants will be easily acquired with some additional training.

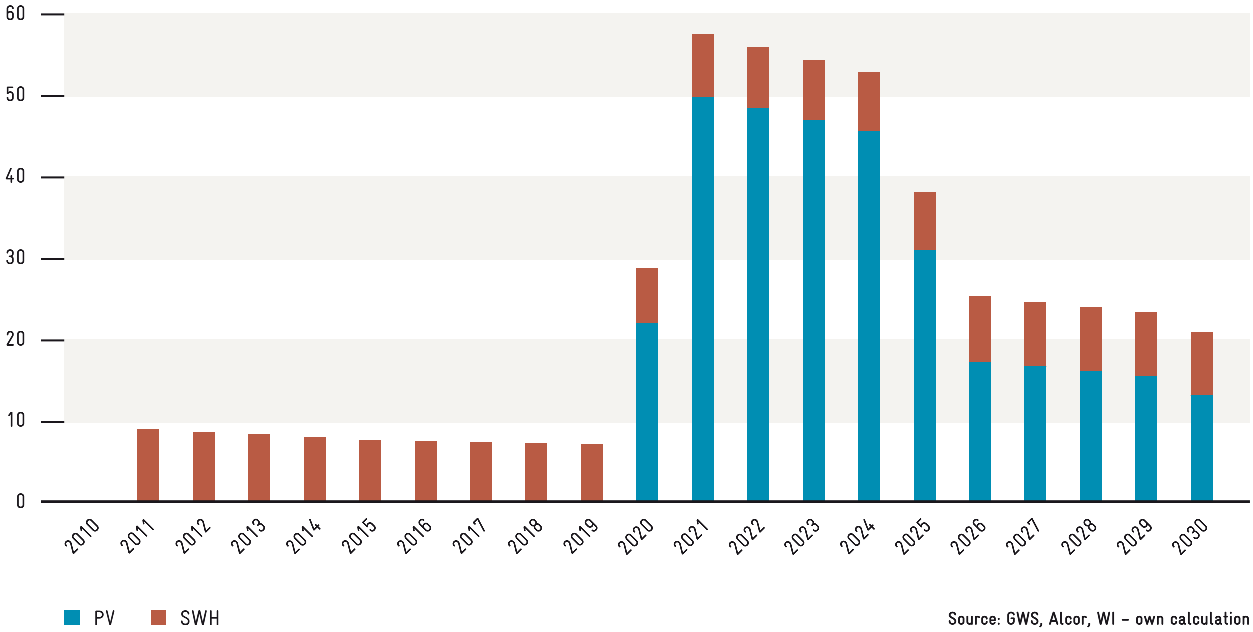
PV offers the fastest potential of developing a domestic industry: production facilities for PV modules can be bought almost ready-made on the international market and can then be set up in the country. While these facilities do not require a large workforce, the raw material inputs (PV cells) will still have to be imported (see figure 6).

CSP comes into play a little later in the scenarios. The development of CSP hinges on the success of the DESERTEC Initiative and/or the Mediterranean Solar Plan, among other factors. If the installations anticipated for this scenario occur, large parts will initially be imported. In comparison to other technologies, more inputs will later be produced domestically (see figure 7).

Table 5: Export RE, in % of total investments

	Wind	PV	CSP	Biogas	SWH
2010	0 %	0 %	0 %	0 %	0 %
2015	0 %	0 %	0 %	0 %	7.6 %
2020	0 %	22.2 %	0 %	0 %	6.9 %
2025	0 %	31.3 %	0 %	0 %	7.2 %
2030	0 %	13.1 %	0 %	0 %	7.9 %

Figure 9: Total exports by technologies, in TND[2011] million



Source: GWS, Alcor, WI – own calculation

Solar power water heaters (SWH) are quite successful in Tunisia and domestic production already exists. Though most of the production is assembly work, this will increase over the years. Some further inputs will be produced domestically (see figure 8).

2.3.2 Exports

A number of international success stories were analysed in Part I of this report. One important driver of the success of the renewable energy and energy efficiency industries lies with international market opportunities, which result in exports to other countries. Thus far in Tunisia, solar water heater exports have been observed. Given the large numbers of PV installations anticipated in the DivRen scenario, we also included PV exports in our analysis. Other exports can develop from component production for the wind industry and can be adjusted in the tool[6].

The exports included in our scenario analysis are shown in table 5 and figure 9.

6 Discussion with Tunisian experts also focused on possible export for the wind industry. If more data become available from an ongoing study, they can be used to create a new scenario. We are currently including higher exports in a separate sensitivity analysis.

2.4 An overview of the scenario

Table 6: Scenario inputs; investments by different RE and EE activities

	Renewable energy					Energy Efficiency					
	Wind	PV	CSP	Biogas	SWH	Building material	Efficient lightbulbs	Efficient household appliances	Efficient equipment (industry)	Transport	Co-generation
Installation											
	[mnTD]	[mnTD]	[mnTD]	[mnTD]	[mnTD]	[mnTD]	[mnTD]	[mnTD]	[mnTD]	[mnTD]	[mnTD]
2011	92	0	0	11	60	41	2	23	98	1	52
2015	92	167	376	10	51	40	2	21	90	1	52
2020	169	296	282	9	46	38	2	19	82	1	52
2025	205	357	206	8	41	36	2	17	59	1	52
2030	100	150	313	8	39	34	1	15	53	1	52
Operation & Maintenance											
	[mnTD]	[mnTD]	[mnTD]	[mnTD]	[mnTD]	[mnTD]	[mnTD]	[mnTD]	[mnTD]	[mnTD]	[mnTD]
2011	4	0	0	1	1	–	–	–	–	1	2
2015	18	4	8	3	6	–	–	–	–	1	2
2020	53	22	53	6	10	–	–	–	–	1	2
2025	101	47	84	9	15	–	–	–	–	1	2
2030	130	56	127	12	19	–	–	–	–	1	2
Imports of whole systems											
	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2011	90	85	90	85	40	75	50	50	90	–	–
2015	90	70	90	85	40	65	40	40	90	–	–
2020	80	65	80	85	30	60	40	40	80	–	–
2025	70	65	70	85	20	50	30	30	80	–	–
2030	70	60	70	85	10	50	30	20	80	–	–
Imports of production inputs: services											
	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2011	50	–	80	–	–	–	–	–	–	–	–
2015	50	–	80	–	–	–	–	–	–	–	–
2020	40	–	50	–	–	–	–	–	–	–	–
2025	40	–	50	–	–	–	–	–	–	–	–
2030	40	–	50	–	–	–	–	–	–	–	–
Exports											
	[mnTD]	[mnTD]	[mnTD]	[mnTD]	[mnTD]	[mnTD]	[mnTD]	[mnTD]	[mnTD]	[mnTD]	[mnTD]
2011	–	0	–	–	9	–	–	–	–	–	–
2015	–	0	–	–	7	–	–	–	–	–	–
2020	–	22	–	–	7	–	–	–	–	–	–
2025	–	31	–	–	7	–	–	–	–	–	–
2030	–	13	–	–	8	–	–	–	–	–	–

3 EMPLOYMENT EFFECTS – DRIVERS AND CHALLENGES

Apart from the contribution of renewable energy technologies to energy security, a decrease in import dependence and climate change mitigation, an increase in employment and economic benefits are expected. These hopes are supported by international success stories based on the examples of Germany, Portugal and China.

For a very rough first estimate of the employment expected from the PST and beyond, it pays to look at the experiences of other countries. Part I of the report in this study gave an overview of international experience. Germany ranks highest in Europe in terms of employment and in terms of capacity installed. The German economy is an export-oriented economy with a strong focus on the production of machinery, electrical appliances and optical and electrical instruments. Germany has used its strength to develop this new sector and RE technologies worth more than €120 billion were installed in the country before 2011. In comparison, the scenario analysed in this framework for Tunisia comprises a total of €7.2 billion between now and 2020. Initially, most of the German PV systems had to be imported from Japan and most wind installations from Vestas in Denmark. Since then, large PV companies have evolved and are currently in a consolidation phase as the market now anticipates immense competition from China. But there is more than the direct employment in the wind turbine or PV module production sectors. Due to the industrial structure of Germany, more than half the 382,000 jobs in the renewable energy sector are hidden in the intermediary and inputs production sectors.

For Tunisia, the starting point is different. Tunisia's industrial structure is not as highly developed and a large share of the renewable energy systems will be imported during the initial phase. If Tunisia had the same per capita installation output as Germany, the same production structure and the same export opportunities, roughly 35,000 jobs would be created. Estimates for future job creation in Tunisia will lie somewhere between this number and the 3,500 jobs created over the last five years.

A smaller, less industrialised country might provide a better benchmark. Portugal has 11,950 people working in the RE industry. It has 2,857 MW of wind energy installed, roughly as much as the RE scenario predicts for Tunisia. There are 3,000 people working in the wind industry; 34,153 MW of photovoltaic power have been installed and 1,500 people work in that industry. Portugal has no CSP as of yet, so there are no comparable numbers. It supports renewable energy technologies with a combination of feed-in tariffs, fiscal support and a tendering procedure for wind energy. While at the beginning of the support mechanisms in 2004 most products had to be imported, the country now boasts several companies that produce technology inputs for the wind industry and in particular, for the solar industry. Efacec provided inverters, transformers and switchboards for €5.3 million to the Czech Republic in 2010 and 2011 and €11.2 million to a project in Greece. Service companies plan and implement projects worldwide.
The following factors have proved to be important:

- Stable framework
- RE and energy efficiency development plan
- (Successful) attempts at integrating the value chain
- Capacity building to obtain the necessary workforce (GIZ/Action 2011)
- Capacity building for services and planning (GIZ/Action 2011)
- Exploration of export markets

Since this is a complex and highly interdependent field, we have developed a tool that enables the user to change some of these factors and look at the results in terms of GDP and employment.

4 STUDY RESULTS

As we have seen, the employment effects of renewable energy and energy efficiency increases depend on investment and domestic production structures. Our baseline scenario does not include any additional renewable energy or energy efficiency investments. The model suggested allows for changes in investment and for adjustments in the production capabilities of Tunisia. Experts from Germany and Tunisia have developed a scenario that forecasts certain investment paths and production structures (cf. Chapter 3). If Tunisia releases local content requirements for international investors as China has done, or includes these in a tendering procedure for wind installations as Portugal has done, the import quota will be less than currently anticipated.

With the given structure, the PST would lead to more than 10,000 additional jobs in Tunisia. In figure 10, this scenario is called S1 RE+EE (renewable energy + energy efficiency).

The shape of the curve reflects investment paths and productivity growths. The employment effect is initially rather small since large portions of the new systems will be imported. Only small inputs are locally produced.

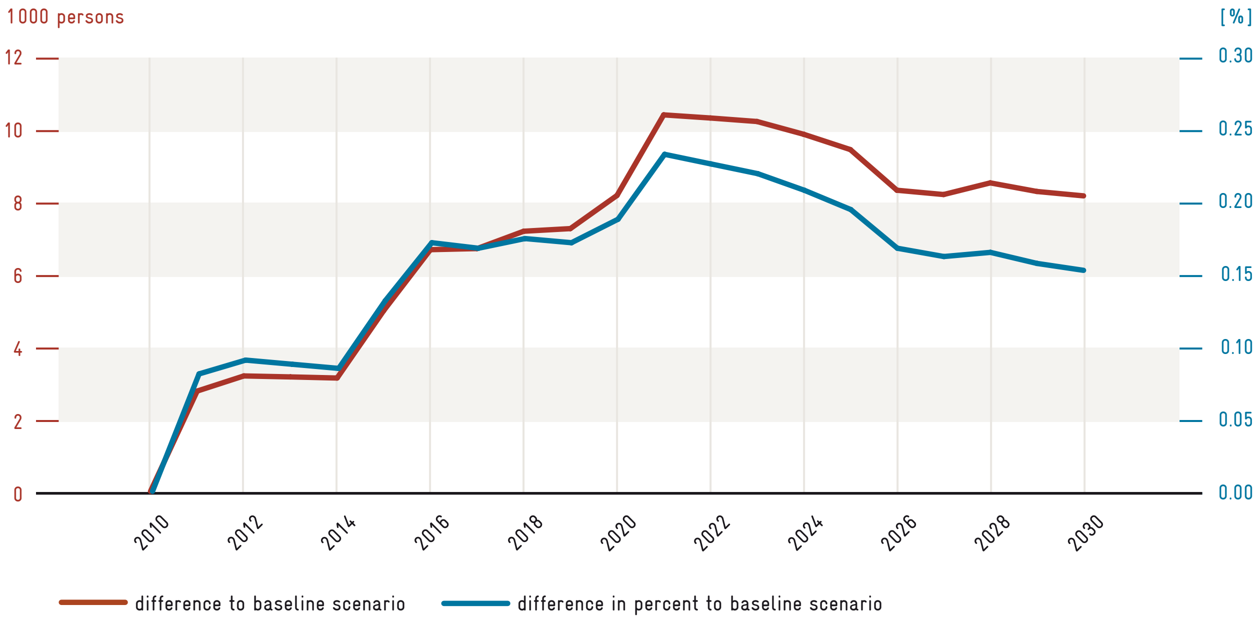
Employment figures could rise to over 20,000 people or more than 0.6% of overall employment if imports were lowered to only 10% on average (Scenario S2 RE+EE integration; figure 11). Given the investment path, this would be considered the maximum attainable employment figures. Again, towards the end of the simulation horizon, productivity gains and RE cost decreases would lead to less employment from the same investment impacts.

The shape of the employment curve in this scenario more accurately reflects the investment structure since the investment path is no longer smoothed by imports, but strikes the economy with full force. Investments in CSP are especially irregular with time.

The PST gives an estimate for domestic integration of production for the wind industry. If we simulate employment effects using the suggested 43% of integration starting in 2011, the results shift from the original 10,000 jobs to a new total of more than 12,000 jobs (S3 RE+EE with integration of windpower; figure 12). This shows the possible benefits of a successful integration strategy.

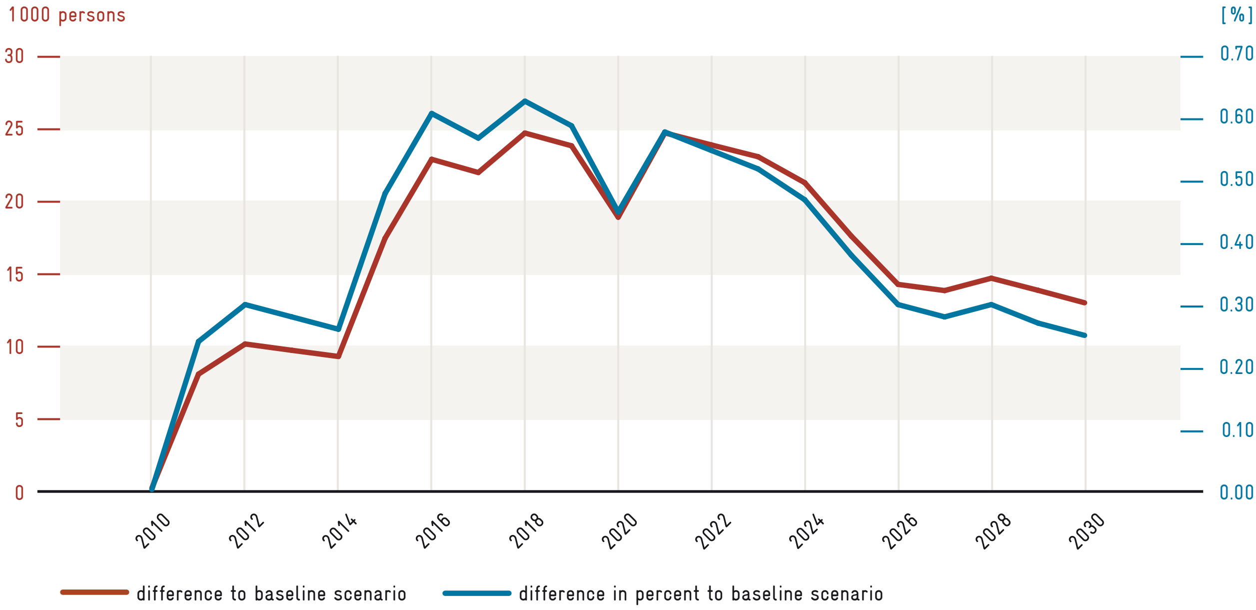
Employment can be analysed by economic sector and also by technology. Figure 13 shows the overall growth tendency of all sectors, i.e. the underlying growth path and investment going into the productive sectors.

Figure 10: Additional employment from the PST (S1 RE+EE)



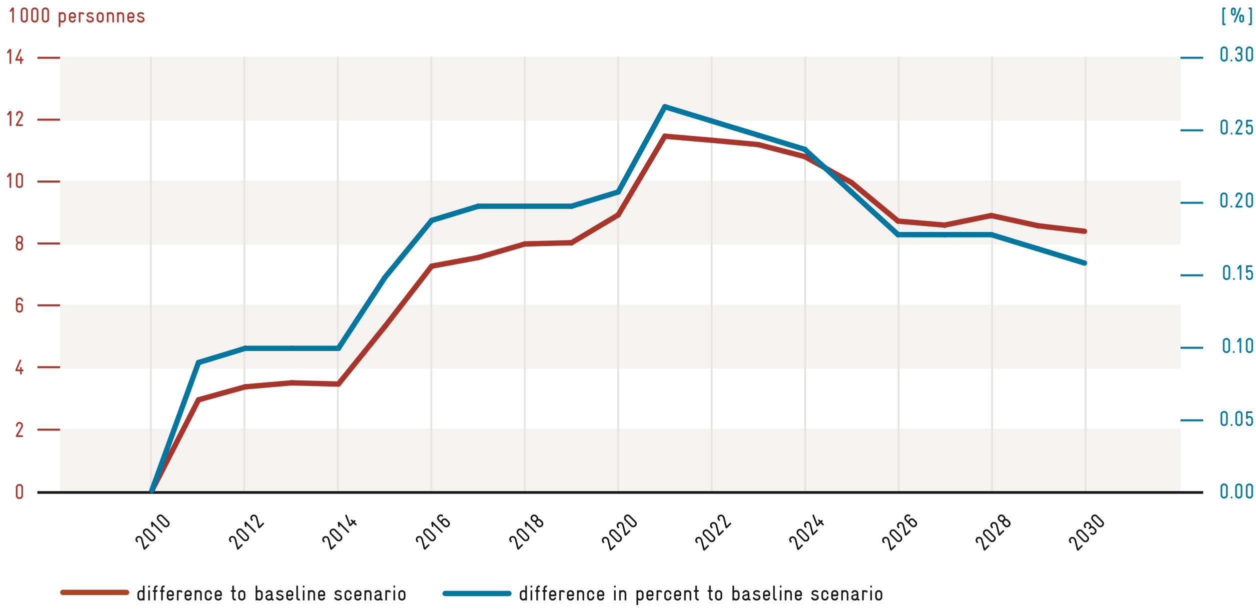
Source: GWS, Alcor, WI – own calculation

Figure 11: Employment effects with high domestic integration (S2 RE+EE integration)



Source: GWS, Alcor, WI – own calculation

Figure 12: Employment effects with high domestic integration for wind energy (S3 RE+EE with integration of windpower)

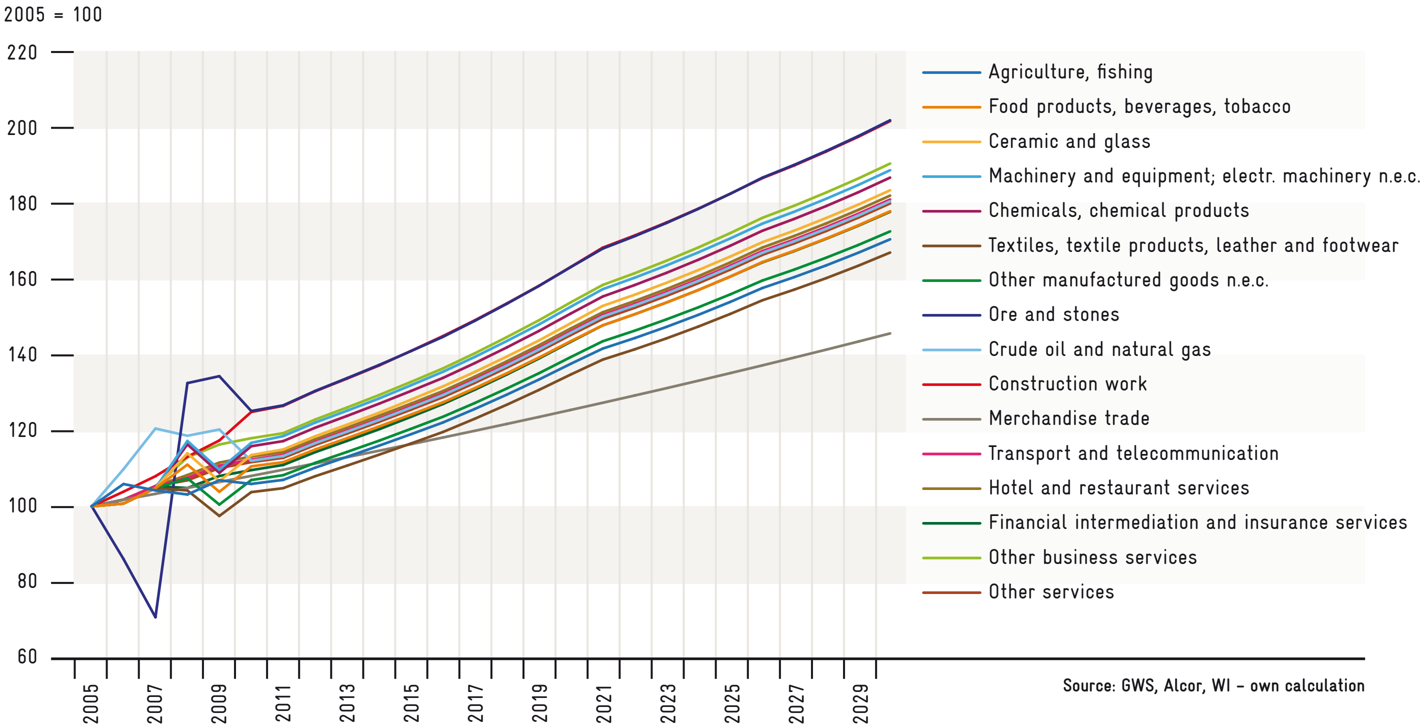


Source: GWS, Alcor, WI – own calculation

As outlined in the scenario comparison, a large part of overall investment in the PST goes into renewable energy. This is reflected in figure 14. A large part of overall additional employment comes from the increase in renewable energy. SWH provides a small but constant share in this employment development. All other technologies will require large (foreign) investment and depend on the rigour with which the PST is implemented.

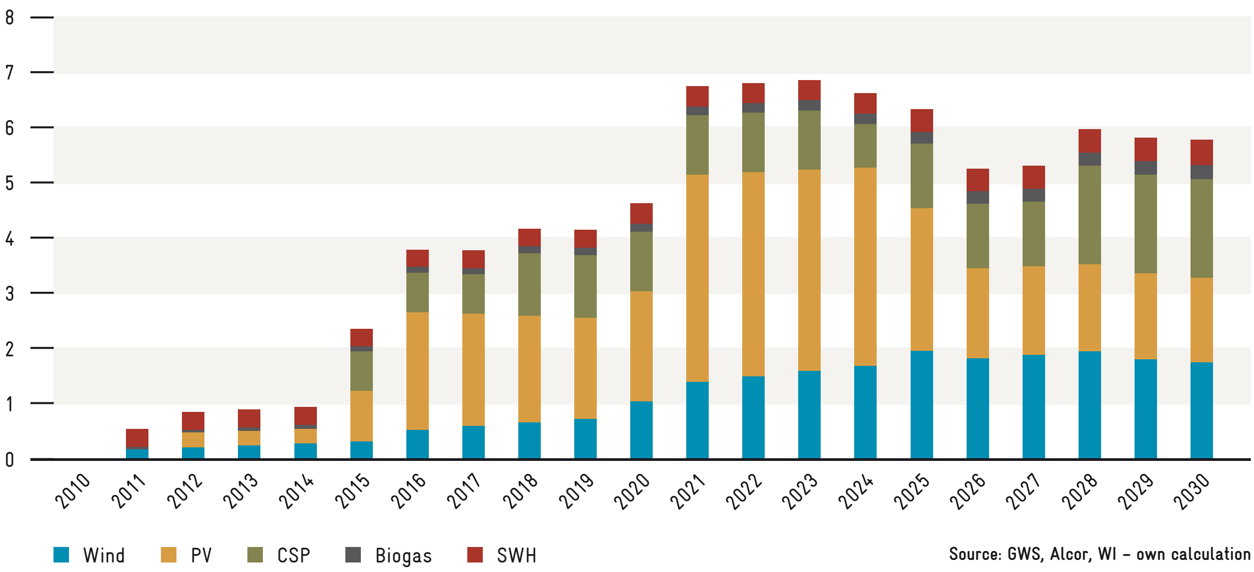
The overall GDP effects are positive throughout the scenarios analysed. As we have seen, no financing mechanism has been built into the partial model. Investment in the Solar Plan is considered additional to the economy. The Solar Plan does not include information on a burden-sharing process such as a feed-in tariff or other instruments. If such an analysis is necessary, the model must be supplemented by new modules (see figure 15).

Figure 13: Employment by sector in the S1 RE+EE



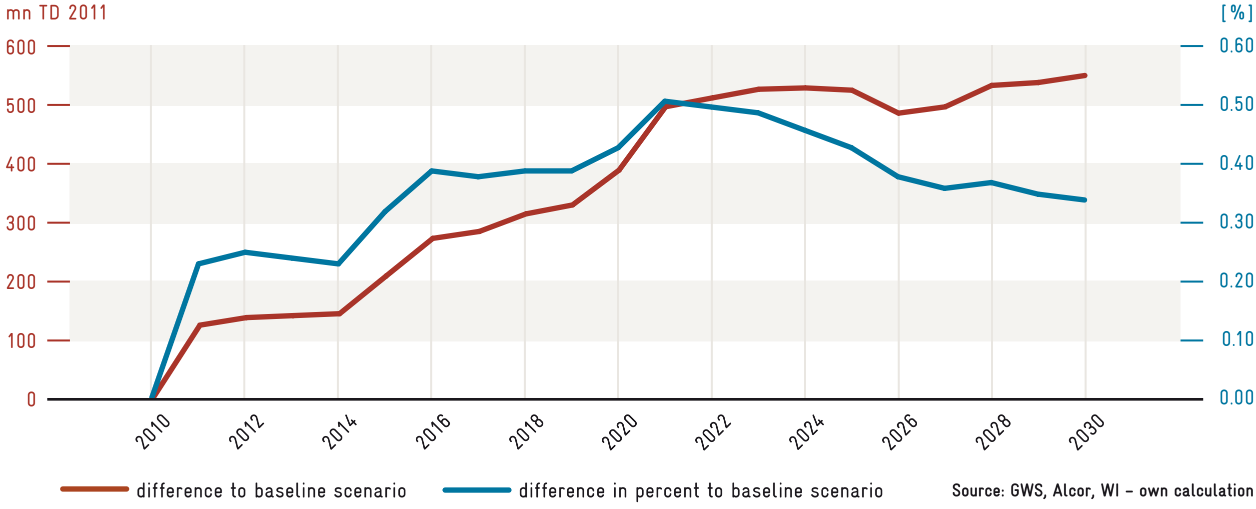
Source: GWS, Alcor, WI – own calculation

Figure 14: Total employment by RE technologies (S1: RE+EE), in thousands jobs



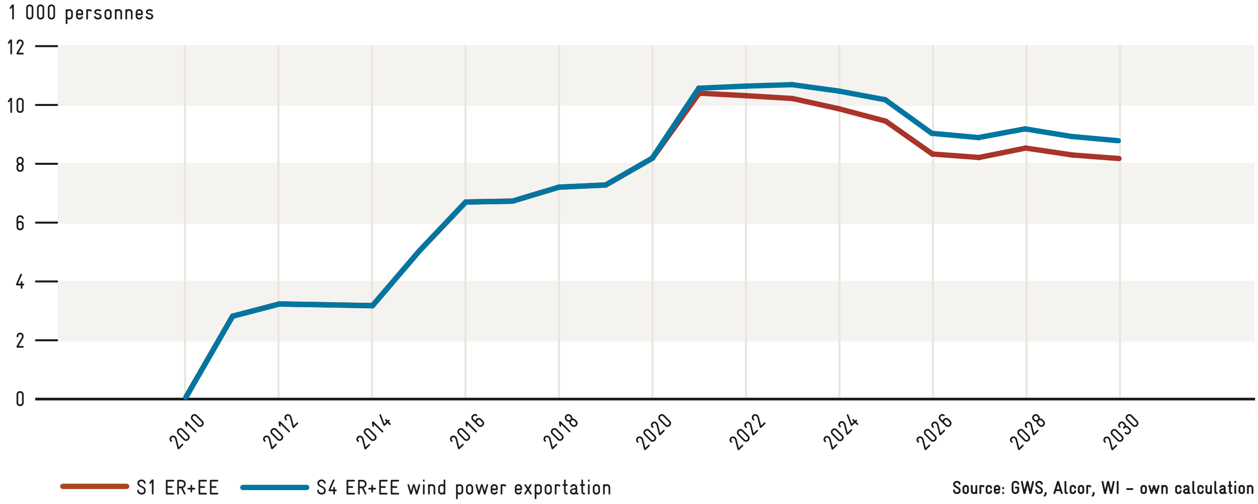
Source: GWS, Alcor, WI – own calculation

Figure 15: Development of real GDP, difference from baseline scenario in absolute and percentage terms (S1 RE+EE)



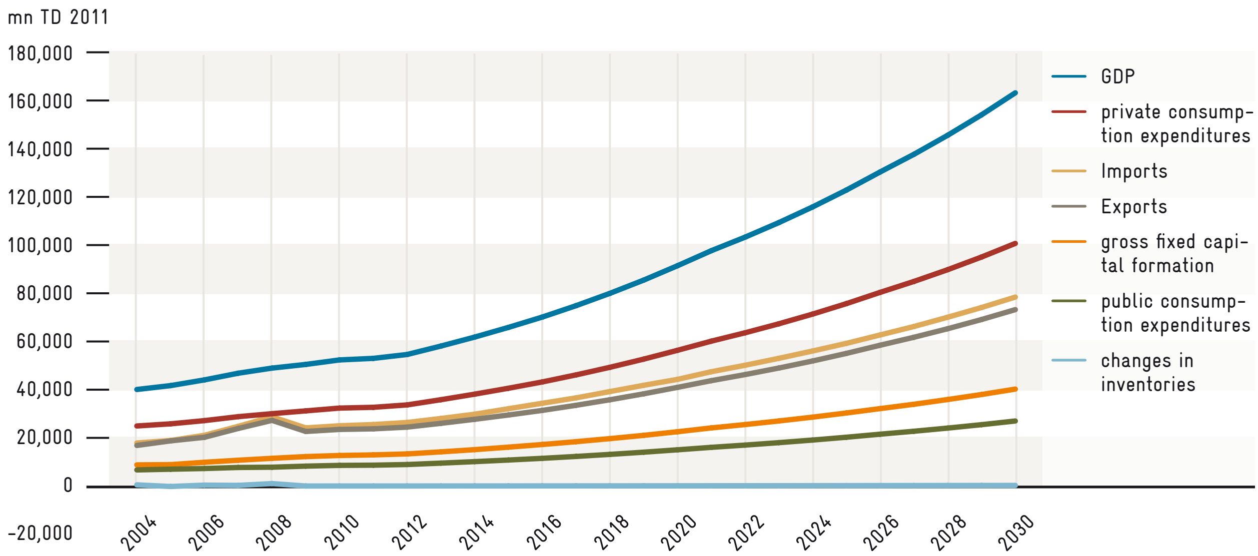
Source: GWS, Alcor, WI – own calculation

Figure 16: Employment from additional exports in the wind sector, difference to baseline scenario (S1 RE+EE and S4 RE+EE wind power exportation)



Source: GWS, Alcor, WI – own calculation

Figure 17: Development of GDP and its components (S1 RE+EE), in TND million



Source: GWS, Alcor, WI – own calculation

If we consider exports in the wind sector and anticipate that Tunisian exports from 2021 until 2030 will total around TND 800 million, we find aggregate employment even further increased. The new scenario shows that employment will be further stimulated, gaining around 200 more jobs (see figure 16).

The real GDP will differ from the base run by up to TND 375 million or 0.4%. Figure 17 shows real GDP and its components for the scenario S1 RE+EE. The real GDP shows an average growth rate of around 5.8% for the years between 2010 and 2030. The economic improvement in this scenario is mainly driven by the development of gross fixed capital formation and exports. Gross fixed capital formation will determine roughly one quarter of real GDP by the end of the projection horizon. Exports will also constantly increase compared to the baseline scenario. However, the negative trade balance will remain the same until 2030 due to increasing import flows.

5 SENSITIVITY ANALYSIS – HOW MUCH EMPLOYMENT CAN 100 MILLION TUNISIAN DINARS GENERATE?

To shed some light on the details of the employment mechanisms, we conducted a sensitivity analysis to look at the results of TND 100 million spent entirely on either of the technologies shown in the above scenario.[7] This helped us to understand the effects and evaluate the dependence of the results on:

- the technology,
- the capacity of the industries,
- the capacity of the workforce, and
- the opportunities in regional and global markets.

This exercise helps us to understand the different drivers of employment along the value chain and the working of our model.

5.1.1 Employment from investment in wind energy

The first example is employment from a TND2011 100 million investment in wind energy between 2012 and 2016. This investment represents similar investments made in projects that are either already in place in Tunisia or that have been recently planned, respectively. For a wind park with approximately 50 MW capacity installed, the investment is around TND 100 million. A study from GIZ and ANME (2011) estimates that employment generated from a 54 MW wind park would be 27 permanent jobs.

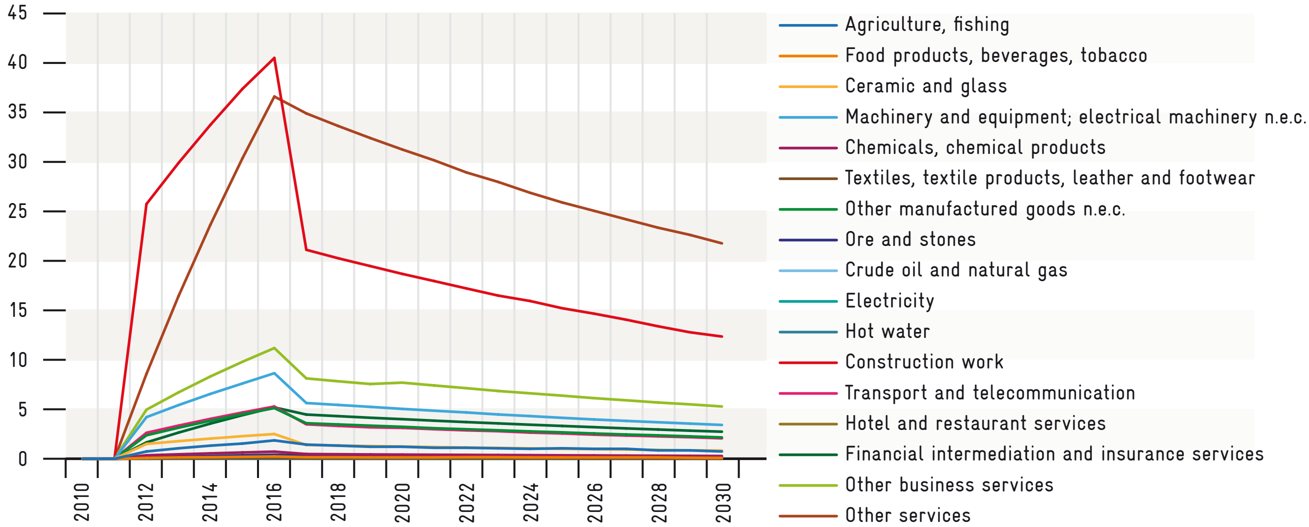
Our analysis shows the following results: A large share of the TND 100 million investment will go into imported products. In the wind energy sector, the estimates for domestically produced components and services vary between 30% and 40%. Here we assume that almost all complete systems will be imported, but 32% of components (turbines, electronics) will be produced within the country. 80% of construction works (including towers) will be provided domestically, and 50% of the planning will be done within Tunisia. Overall we find that additional employment from the TND 100 million investment in a wind park during the five-year construction and building phase will result in jobs for 122 people; afterwards we find that, on average, 50 permanent jobs will be added in O&M.

The difference to the GIZ and ANME calculations is in their consideration of direct and indirect jobs. Given a certain amount of integration within the Tunisian production sector, we find economic impacts from the TND 100 million investment in all economic sectors. Total indirect employment makes up a little more than half of direct employment (31 person years) during the construction phase. Much of the

7 Biogas is not factored into this exercise, because it does not figure prominently in the scenario.

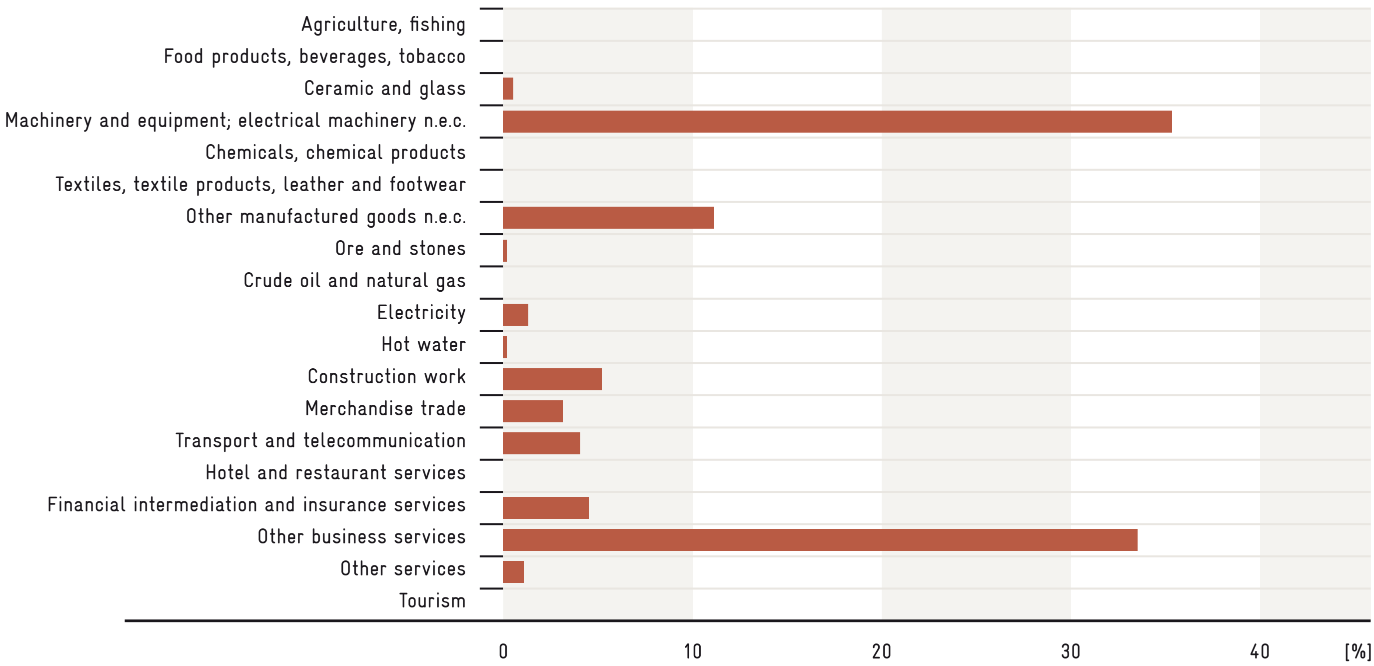
Figure 18: Employment effects and value added from wind energy

(a) Employment by sector (persons)



Source: GWS, Alcor – own calculation

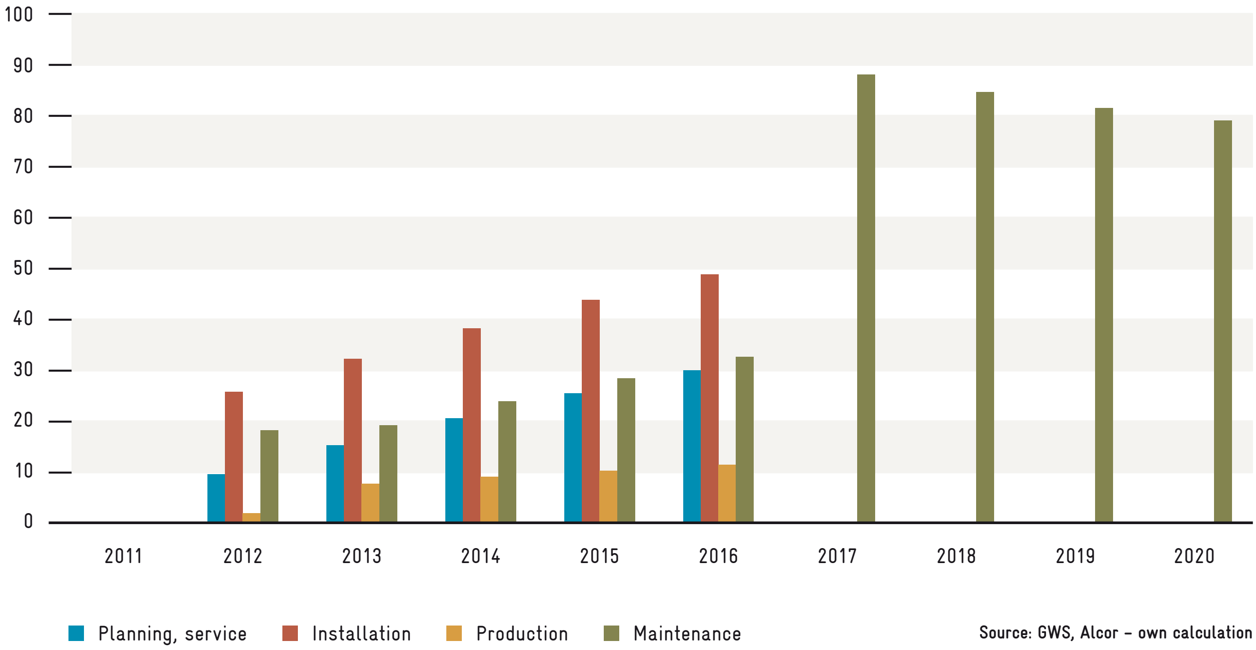
(b) Value added by sector, 2012



Source: GWS, Alcor – own calculation

(c) Employment within the technological value chain (persons)

Employment wind



Source: GWS, Alcor – own calculation

impact will come from construction works, financial services, energy generation and industrial services.

Figure 18 (a) shows the distribution of total employment (direct and indirect) on all economic sectors concerned. Figure 18 (b) gives the distribution of input sectors for the wind energy sector from international data. Figure 18 (c) shows employment created along the technical value chain.

5.1.2 Employment from investment in photovoltaic electricity generation

The second example focuses on employment generated from a TND 100 million investment in PV between 2012 and 2016. Until now, less investment went into PV installations, but the DivRen scenario projects a total PV investment of more than TND 2.6 billion before 2030. Approximately 30 MW could be installed at today's prices.

Our analysis shows the following results: From an investment of TND 100 million, a large share will go into imported products. In the PV sector, the estimates of domestically produced components and services vary between 85% and 30%. Here we assume that almost all complete systems will be imported, but glass products and electric components will increasingly be produced within the country (90% by 2030). Up to 90% of all construction works will be provided domestically and 50% of the planning will be done within Tunisia. The overall additional employment generated from the TND 100 million investment in PV during the five-year construction and building phase will initially provide jobs for 70 people. During the last year of the five-year period, when imports decrease, that figure will increase to 130 people. Afterwards, in operation and maintenance, we find eight permanent jobs. Figure 19 (a) shows the distribution of total employment (direct and indirect) on all economic sectors concerned. Part (b) shows employment along the technological value chain.

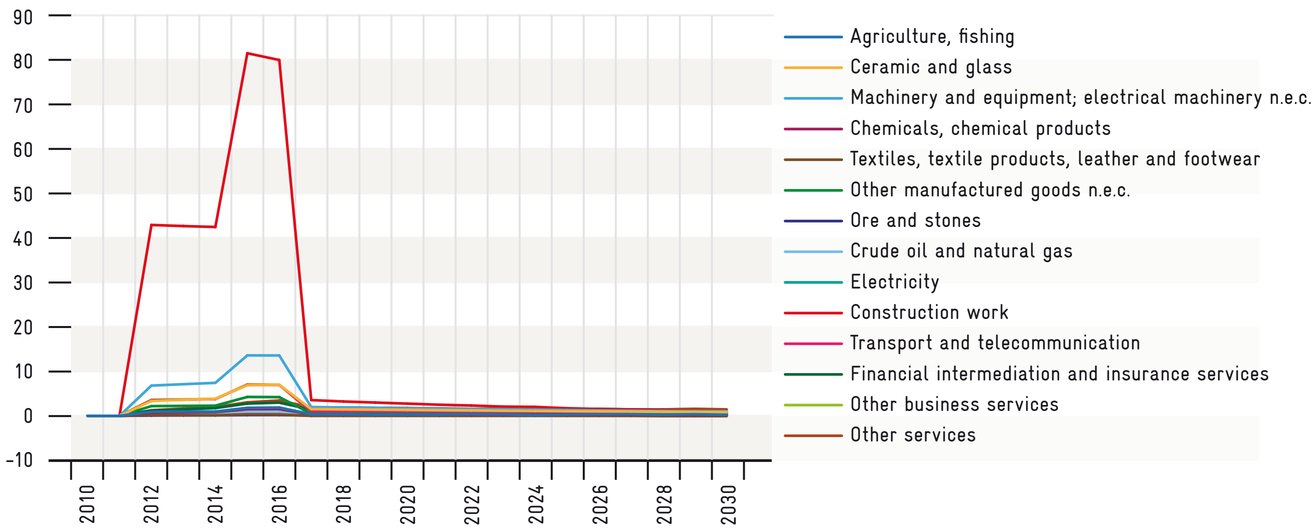
5.1.3 Employment from investment in CSP electricity generation

The third example focuses on employment from a TND 100 million investment in CSP between 2015 and 2019, since this technology could be implemented in the framework of the Desertec initiative or the Mediterranean Solar Plan, both expected to start around 2015. However, this is a little contrived, because TND 100 million will not cover the costs for a reasonably sized CSP installation. Recent publications (GTM research, 2012) have found that the most usable size for CSP installation is around 150 MW. Currently, prices are still between EUR 3.6/W and EUR 8.72/W. CSP is facing considerable problems in competing with rapidly falling PV prices. However, the overnight storage of daytime heat and electricity generation during the evening peak will be an advantage for CSP.

Our analysis shows the following results: From an initial investment of TND 100 million, the largest share among all technologies used in the DivRen scenario will go into imported products. In CSP, the estimates of domestically produced components and services vary between 85% and 30%. Here we expect that almost all complete systems will be imported, but glass products and electric components will increasingly be produced within the country (90% by 2030). Up to 90% of construction works will be provided

Figure 19: Employment effects and value added from PV

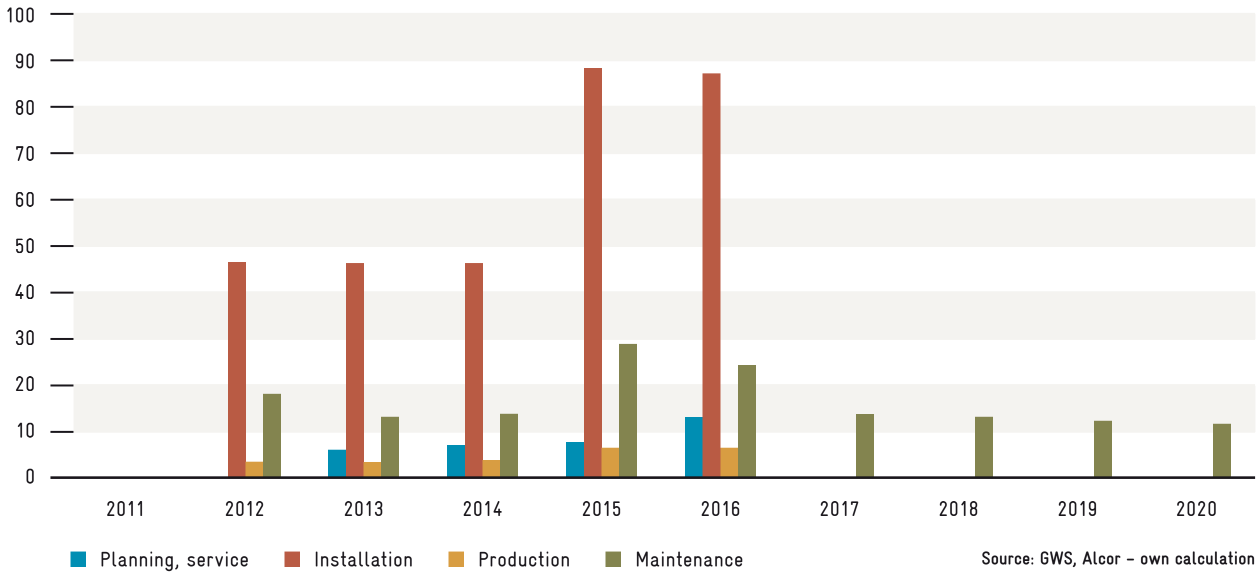
(a) Employment by sector (persons)



Source: GWS, Alcor – own calculation

(b) Employment within the technological value chain (persons)

Employment PV



Source: GWS, Alcor – own calculation

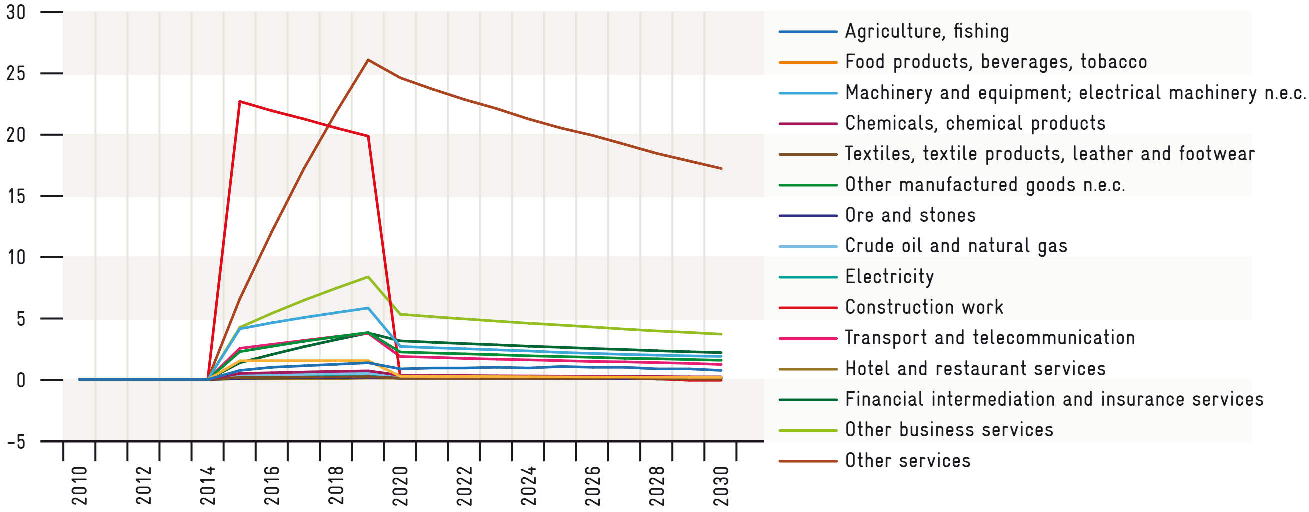
domestically and 50% of planning will be done within Tunisia. The overall additional employment generated from the TND 100 million investment in a CSP park during the five-year construction and building phase will provide 76 jobs, mostly due to large employment impacts in the construction sector. Afterwards, in operation and maintenance, an additional 30 permanent jobs will be generated. Figure 20 (a) shows the distribution of total employment (direct and indirect) on all economic sectors concerned. Part (b) gives the distribution of input sectors for CSP from international data.

5.1.4 Employment from investment in solar thermal water heaters

The last sensitivity analysis for RE sectors focuses on a TND 100 million investment in solar thermal water heaters be-

Figure 20: Employment effects and value chain from CSP

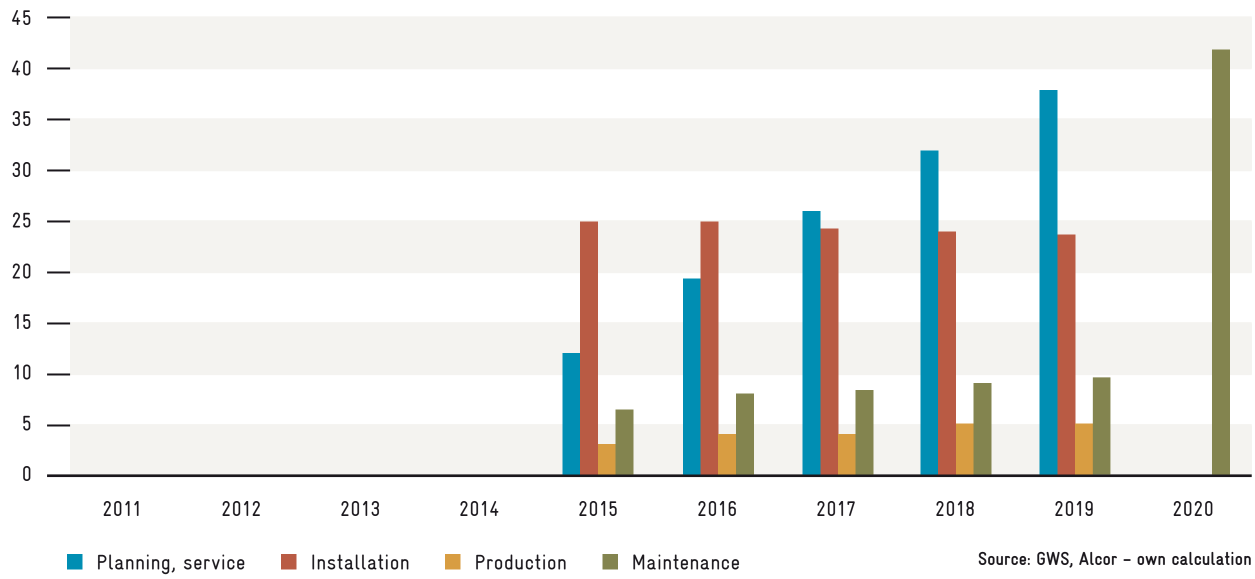
(a) Employment by sector (persons)



Source: GWS, Alcor – own calculation

(b) Employment within the technological value chain (persons)

Employment CSP



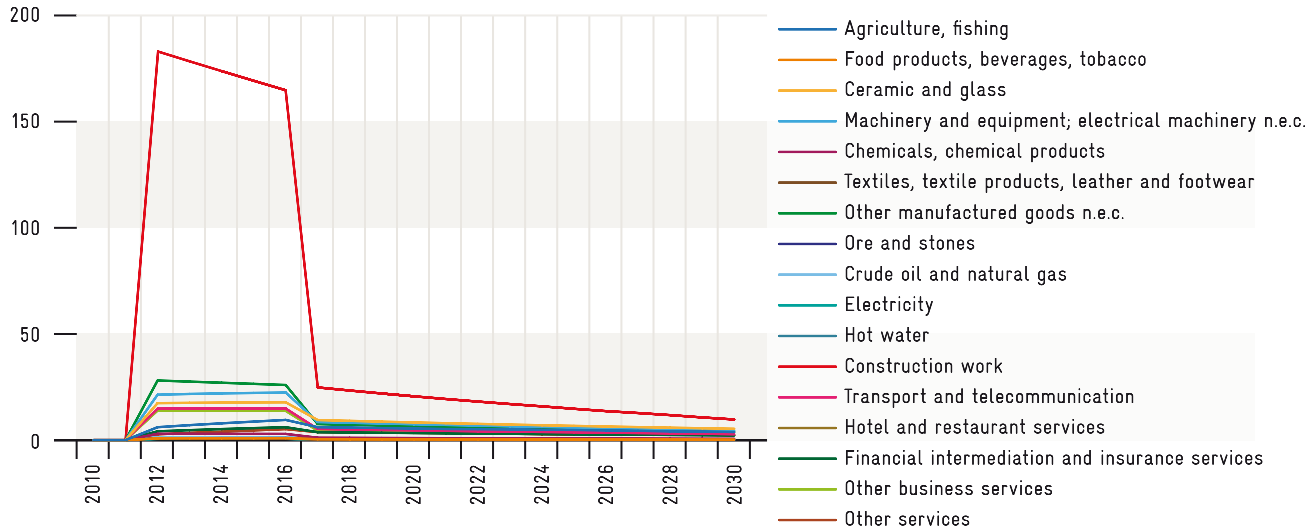
Source: GWS, Alcor – own calculation

tween 2012 and 2016. Between 2009 and 2010 roughly the same amount was spent in the PROSOL programme (Alcor 2011).

Our analysis shows the following results: To a large extent, solar water heaters are assembled in Tunisia. By 2010, there were seven companies doing their own production and 1,100 microenterprises capable of installation and O&M. A large share of the TND 100 million investment will stay in the country and impact the local economy. In this sector, the estimates of domestically produced components and services vary between 85% and 50%. We anticipate that a majority of the solar water heaters will at least be assembled within the country; installation and operation and maintenance will largely be done by Tunisian workers. Up to 90% of construction works will be provided domestically and 90% of the planning will be done within Tunisia. The overall additional employment gen-

Figure 21: Employment effects and value added from solar water heaters

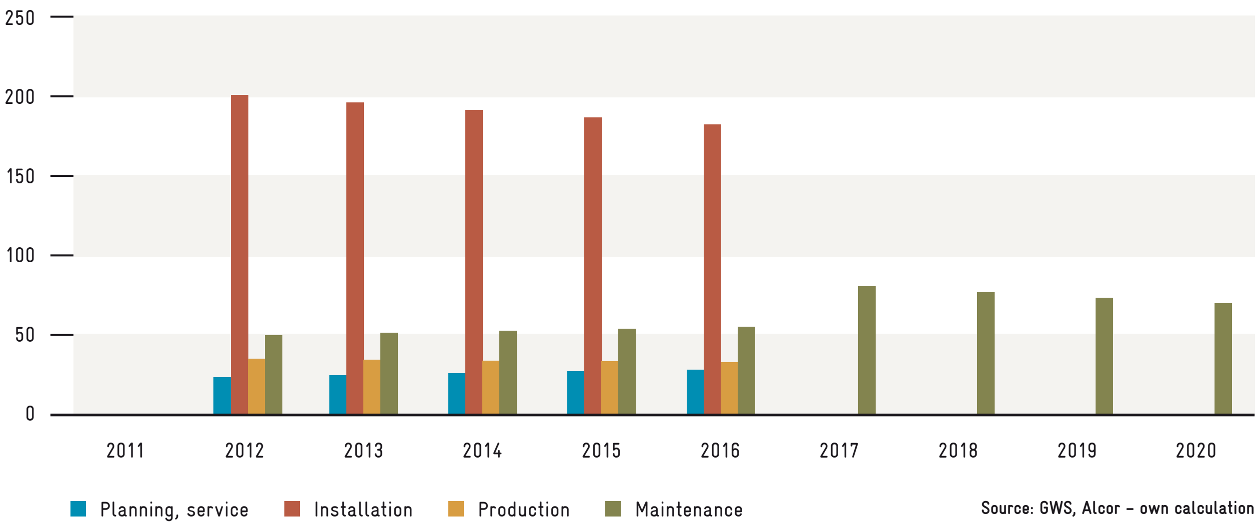
(a) Employment by sector (persons)



Source: GWS, Alcor – own calculation

(b) Employment within the technological value chain (persons)

Employment SWH



Source: GWS, Alcor – own calculation

erated from the TND 100 million investment in solar water heaters during the five-year construction and building phase will provide jobs for 300 people. As solar water heaters require little maintenance, after the investment phase only 50 people will remain in O&M. Figure 21 (a) shows the distribution of total employment (direct and indirect) on all economic sectors concerned. Part (b) gives the distribution of input sectors for solar water heaters from international data.

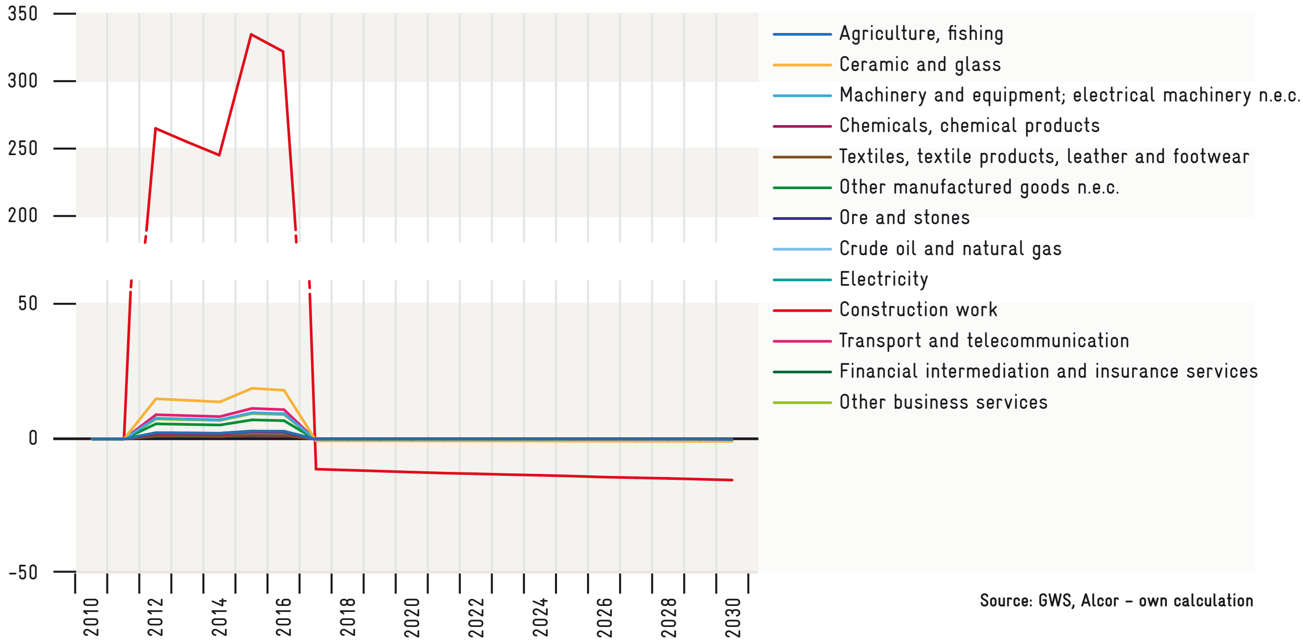
5.1.5 Employment from investment in efficient buildings

To show the impacts in the energy efficiency sector we are simulating an example where TND 100 million will be spent on the thermal insulation of buildings between 2012 and 2016.

Our analysis shows the following results: Thermal insulation can be largely provided with domestic products, though

Figure 22: Employment effects and value added from thermal insulation

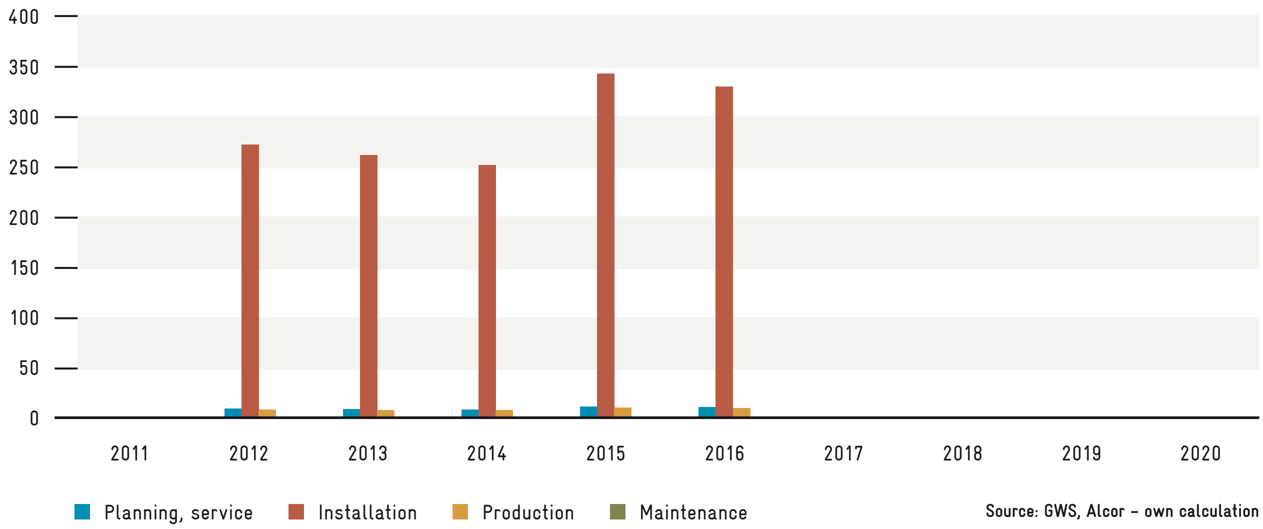
(a) Employment by sector (persons)



Source: GWS, Alcor – own calculation

(b) Employment within the technological value chain (persons)

Emploiyment thermal insulation



Source: GWS, Alcor – own calculation

some components and materials will need to be imported. The overall additional employment generated from the TND 100 million investment in thermal insulation during the five-year construction and building phase will provide jobs for 394 people. It thus exhibits the highest employment yield per TND spent. Thermal insulation is very efficient in terms of energy saved per TND spent and will pay for itself over a rather short time span through energy savings from reduced heating and cooling demand of buildings. Thus, a programme to support initial investment as suggested by KfW (2009) is recommended (see chapter recommendations towards the end of this document). The performance of operation and maintenance is not necessary with energy efficiency measures. Figure 22 shows the distribution of total employment (direct and indirect) on all economic sectors concerned.

5.2 Sensitivity with higher exports

Exports can smooth production and lead to better use of existing capacities. In this sensitivity, we show the effects of exports of components within the wind sector. If an additional export of TND 100 million can be realised, employment will rise by 1,200. The machinery sector, in particular, benefits from additional export. The construction sector, which has been the main contributor to employment from domestic investment, will not benefit from demand in neighbouring countries since construction will be provided abroad. Services can be exported with components to a small extent, but according to Tunisian experts, there have been no energy efficiency technology exports thus far.

6 SUMMARY AND RECOMMENDATIONS

Our analysis shows that under the right framework conditions, investing in renewable energy and energy efficiency in Tunisia will lead to an increase in qualified, sustainable jobs. Ambitious targets for renewable energy and energy efficiency are a necessary condition for employment creation in these sectors. Any investor, whether national or international, will want reliable and stable framework conditions to obtain returns on their investment. Electricity generated from renewable sources must have priority access to the grid so that it can be marketed by the producer. Grids and infrastructure need to be capable of handling increasing amounts of fluctuating energy inputs. The regulatory framework for this must be put into place.

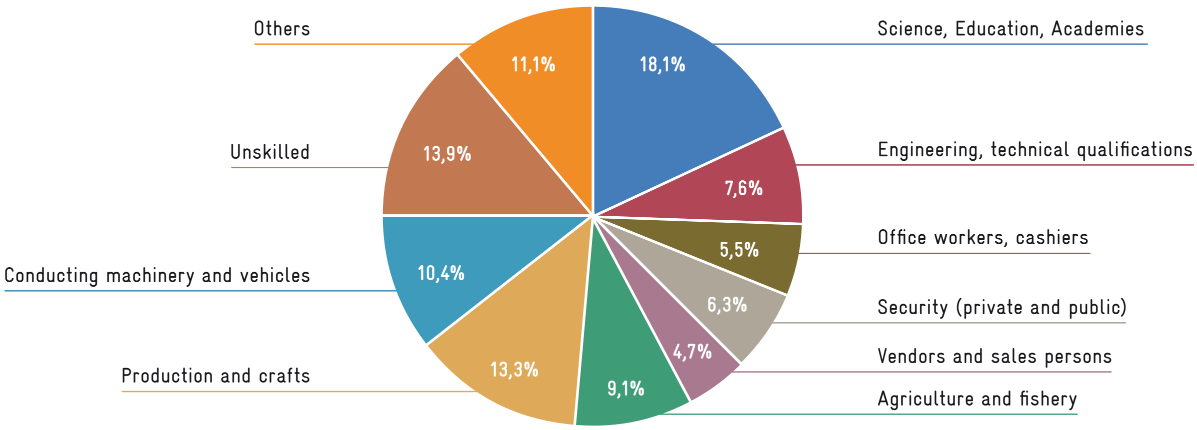
Grants and credits must be secure over time. This holds for companies and private households who must bear upfront additional costs, especially with energy efficiency technologies. Over their lifetime, these technologies then 'pay for themselves' through decreased energy consumption.

Before any other measures can be taken, e.g. stepped-up qualification measures, the future renewable energy mix must be decided politically.

6.1 Overview

Renewable energy and energy efficiency increases in Tunisia according to the Solar Plan and others will contribute to the additional employment of between 7,000 and 20,000 people. Different scenarios have been elaborated to analyse the impact of local integration and exports on employment. An additional sensitivity analysis has been provided to show which sectors are the most promising from an employment perspective. The answer to this question is not as straightforward as one might hope, since it depends on a variety of factors. By comparing the employment generated per TND 100 million investment, we can conclude that energy efficiency in buildings generates the most employment, followed by solar water heaters and PV installations. Wind energy and CSP follow. These results were obtained given a certain import structure of the respective industries. Solar water heaters have been successfully implemented in the PROSOL framework and lead to the second largest employment figure per TND 100 million invested. PV generates the third largest figure for employment, though sizeable Tunisian production of solar modules is not anticipated. New production capacities do not seem feasible under the current consolidation phase in international PV markets although production facilities can be easily imported and implemented in any country, as shown by the example of China during the past few years. Tunisia should benefit from falling PV prices and realise the employment opportunities available in the installation and production of electric and electronic components of PV systems. A more detailed analysis of

Figure 23: Employment by occupation, in percent, 2010



Source: Ministry of Vocational Training and Employment, own calculation

production possibilities within this sector would make the requirements for industrial policies more specific.

Wind energy does not contribute as many jobs as the first three technologies but provides opportunities for technology development. Thus far, expert judgments and experience from projects built before 2010 have been included in our analysis. Opportunities for ambitious technological development and for exports are very significant within the wind industry, since component manufacturing will lead to additional demand for inputs from other Tunisian production sectors.

6.2 Qualification

Does the renewable energy sector and additional energy efficiency require a specialised workforce? How can a country prevent shortages of appropriately trained personnel and prepare for changes in the energy sector?

Even a country such as Germany, which is highly successful in the RE sector, struggles with these questions. GIZ has supported a comprehensive review of the requirements for the different technology sectors in Tunisia. Most qualifications required for the renewable energy sector are specialisations within already existing qualifications: electricians specialised in PV, plumbers in solar water heaters, etc.

Data on employment by economic activities, educational levels or occupational fields and for the required level of qualification can be obtained by the Ministry of Vocational Training and Employment in Tunisia (Ministère de la Formation Professionelle et de l'Emploi, http://www.emploi.gov.tn; see figure 23). A quantitative analysis of qualification needs could be performed and has already been conducted by FEMISE (2010); they investigated the main determinants of integration into the labour market. A comparison of the current sectoral employment distribution in Tunisia with the sectoral distribution of additional employment from the DivRen scenario presents a promising picture.

Additional employment on the national level is estimated at between 0.2% and 0.5%, depending on the import/export scenario. The largest percentage sectoral contribution in the ER+ scenario will be in the construction sector and in the production of machinery and electrical equipment. In these sectors together, additional employment will increase the workforce by 1.4% in 2016, compared to today. This can be easily attained with the scope of training that is suggested in GIZ/Action (2011).

However, further research is suggested. For instance, the distribution of employment by economic activities and the required qualification by energy technologies have to be elaborated. In the case for future manpower requirements, it is also essential to learn more about the demographic structure and changes as well as about the perspectives for the educational system in Tunisia.

If the targets of the DivRen scenario are politically accepted and can be agreed upon, such a study should be carried out. No qualification programme can be suggested without more specific information about the currently existing supply of qualified labour and potentials for development in the future. The technological progress of Tunisia and of the industrial sectors which are only indirectly connected with the promotion of renewable energy and energy efficiency will need qualified personnel in all economic sectors.

To be successful in the international market, products must meet and maintain high quality standards. For certification procedures, new qualifications in the service sector need to be developed according to international standards. This will open new opportunities for qualification in the service sector. Training together with international companies according to international certificates is recommended. Exchange programmes could be developed and created with respective institutions in other European countries.

Greater shares of wind energy will represent greater needs for services such as wind prognosis. The qualifications necessary to supply these services range from university graduates with degrees in meteorology to statisticians and technicians. Experiences of European countries and close cooperation with European companies will be valuable for developing the respective programmes.

6.3 Support policy and financing requirements

The PST is not very detailed on financing aspects, especially for the years beyond 2016. Next to funding and support from the FNME (Fonds National pour la Maîtrise de l'Energie), co-financing and support is expected from the World Bank, the European Union and individual European countries, carbon financing and other international funds. Our approach does not therefore analyse the crowding out effects of alternative investment purposes.

Solar thermal water heaters, thermal insulation measures and PV installations on private houses can pay for themselves within a reasonable timespan (5–10 years). Solar thermal water heaters save costs for other sources for hot water; insulation and PV can greatly bring down air conditioning costs. The former, because cooling needs would decrease, and the latter, because electricity generation peaks occur during times of higher needs for cooling. However, the incentive depends on future electricity prices. PV electricity generation during peak time (around the middle of the day) will also help to decrease the load and the burden on the grid. This could create an incentive for STEG to support individual PV generation, to some extent. These three technologies only require credits at reasonable conditions for the initial investment, such as the PROSOL programme that exists for solar heaters, PROSOL Elec for PV or the PROMO-ISOL programme that has been suggested for roof insulation.

Opportunities on the international markets will be improved by high quality and the certification of products. On markets with strong competition from China and other Asian countries, either certification by some international standard or the development of certificates especially tailored to the needs of a certain region will contribute to successful market penetration. For example, solar water heaters in the MENA region might require different technical standards due to climate conditions as compared to SWH in Germany or China.

Experience from production in countries with local content requirements shows that investors need to rely on quality standards within the respective country. In China, the automotive production industry spends large amounts on securing quality standards with Chinese producers of inputs. If European or international standards were implemented, local content requirements would become much more feasible. More analysis must be done on the existing technology-specific certificates and the respective qualifications of the control authorities.

Continuous development towards more renewable energy supports the employment outlook. Large infrastructure projects such as wind parks often lead to irregular investment paths. In terms of employment, qualification strategies need continuous development or they will be inefficient and lead to disappointment within the well-qualified workforce.

The second column of the PST, energy efficiency, needs information strategies for households, enterprises and services. The long-term benefits of energy efficient appliances must be explained to consumers. Energy consulting, labelling and campaigns to advertise energy efficiency are the minimum requirements for the success of energy efficiency. Again, future gains from energy efficiency depend on the pricing system.

REFERENCES

Agama, 2003. *Employment Potential of Renewable Energy in South Africa*. Study prepared for The Sustainable Energy and Climate Change Partnership: Johannesburg. Constantia.

APPA, 2009. *Study of the Macroeconomic Impact of Renewable Energies in Spain*. ed. Spanish Renewable Energy Association (APPA): elaborated by Deloitte.

Black & Veatch, 2004. *Economic Impact of Renewable Energy in Pennsylvania*. Report to Community Foundation for the Alleghenies and Heinz Endowments: Overland Park, Kansas.

Delphi, 2007. *Situational Analysis of the Canadian Renewable Energy Sector with a Focus on Human Resource Issues.* Final Report prepared by The Delphi Group for the Human Resources and Social Development: Canada.

DTI, 2004. *Renewable Supply Chain Gap Analysis*. Department of Trade and Industry: (ed.) London.

EPIA, 2009. *Solar Photovoltaic Employment in Europe: PV employment.* EPIA, WIP, Uni Flensburg, NTUA.

EPRI, 2001. *California Renewable Technology Market and Benefits Assessment*. Electric Power Research Institute: Palo Alto.

European Commission, 2011. *Communication from the Commission to the European Parliament and the Council, Renewable Energy: Progressing towards the 2020 target*: SEC(2011) 129 final, SEC(2011) 130 final, SEC(2011) 131 final.

Eurostat et al, 2001. *Tourism Satellite Account: Recommended Methodological Framework*. Eurostat, OECD, WTO, UN: Luxembourg, Madrid, New York, Paris.

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU in German), 2010. *Re-newably employed: Short- and long-term impacts of the expansion of renewable energy on the German labour market*. Berlin.

FEMISE, 2010. *L'insertion des jeunes diplômés et le rendement des investissements dans l'enseignement supérieur.* Cas du Maroc et de la Tunisie. FEMISE research programme 2008–2009. Research n°FEM33-24, directed by Fayçal Lakhoua, IACE: Tunisia.

GIZ/Action, 2011. *Identification des besoins en formation dans le domaine de la maîtrise de l'énergie.*

Haas et al, 2006. *Technologien zur Nutzung Erneuerbarer Energieträger – wirtschaftliche Bedeutung für Österreich*. EEG, TU Wien, R. Haas, T. Biermyr, L. Kranzl.

Heavner/Churchill, 2002. *Renewables Work: Job Growth from Renewable Energy Development in California*. CALPIRG Charitable Trust: Sacramento.

Huber et al, 2004. *Green-X – Deriving optimal promotion strategies for increasing the share of RES-E in a dynamic European electricity market*. Final report, Energy Economics Group (EEG): Vienna University of Technology

ISI et al, 2010. *Einzel- und gesamtwirtschaftliche Analyse von Kosten- und Nutzenwirkungen des Ausbaus Erneuerbarer Energien im deutschen Strom- und Wärmemarkt*. Fh-ISI, GWS, DIW, IZES; B. Breitschopf, M. Klobasa, F. Sensfuß, J. Steinbach, M. Ragwitz, U. Lehr, J. Horst, U. Hauser, J. Diekmann, F. Braun, M. Horn.

Kammen et al, 2004, update 2006 (RAEL 2004). *Putting Renewables to work: How many jobs can the clean energy industry generate?*

Kratzat, M., Lehr, U., 2007. *International Workshop on 'Renewable Energies: employment effects'.* Models, discussions and results.

Lantz, 2009. *Economic Development Benefits from Wind Power in Nebraska: A Report for the Nebraska Energy Office*. National Renewable Energy Laboratory: Golden, Colorado.

Lehr et al, 2008. *Renewable energy and employment in Germany.* Energy Policy 36 (2008) 108-117.

Lehr et al, 2011. *Kurz- und langfristige Auswirkungen des Ausbaus der erneuerbaren Energien auf den deutschen Arbeitsmarkt (short- and long-term impacts of RE deployment on the German job market).* U. Lehr, C. Lutz, D. Edler, M. O'Sullivan, K. Nienhaus, S. Simon, J. Nitsch, B. Breitschopf, P. Bickel, M. Ottmüller: GWS, DIW, Fh-ISI, ZSW.

Lehr, U., Lutz, C., Edler, D.,2012. *Green Jobs? Economic impacts of renewable energy in Germany.* Journal of Energy Policy: DOI:10.1016/j.enpol.2012.04.076

Loomis/Hinman, 2009. *Wind Energy Development in Illinois*. Center for Renewable Energy: Illinois State University.

Miller, R.E., Blair, P.D., 2009. *Input-output analysis – Foundations and extensions*. 2nd ed. Cambridge: Cambridge University Press.

Moreno/Lopez, 2008. *The effect of renewable energy on employment. The case of Asturias (Spain).* In: Renewable and Sustainable Energy Reviews, 12 (2008) 732–751.

OECD, 1999. *The Environmental Goods and Services Industry: Manual for Data Collection and Analysis*. Paris.

Openshaw, 2010. *Biomass energy: Employment generation and its contribution to poverty alleviation*. Biomass and Bioenergy 34 (2010) 365–378.

Pembina Institute, 2004. *Canadian Renewable Electricity Development: Employment Impacts*. Prepared by Pembina Institute for the Clean Air Renewable Energy Coalition.

Pfaffenberger et al, 2003 (BEI 2003). *Ermittlung der Arbeitsplätze und Beschäftigungswirkungen im Bereich EE (Assessment of jobs and employment by using RE).*

Pfaffenberger, W., 1995. *Employment effects of energy systems, expertise.* 1st ed. Frankfurt am Main, Verl.- und Wirtschaftsgesellschaft der Elektrizit*ätswerke VWEW, Energiewirtschaft*liche Studien.

Ragwitz et al, 2009. *Impact of Renewable Energy policy on economic growth and employment in the EU (Employ-RES).* Contractor: DG TREN.

Ratliff et al, 2010. *An Analysis of State-Level Economic Impacts from the Development of Wind Power Plants in San Juan County, Utah.* Prepared for the US Department of Energy.

Rothengatter W., Schaffer A., 2008. *Macro compact. Basics of macro economics*, 2nd ed., Physica Verlag Heidelberg: Heidelberg.

Rutowitz/Atherton, 2009. *Energy sector jobs to 2030: a global analysis.* Prepared for Greenpeace International by the Institute for Sustainable Futures:Sydney. University of Technology.

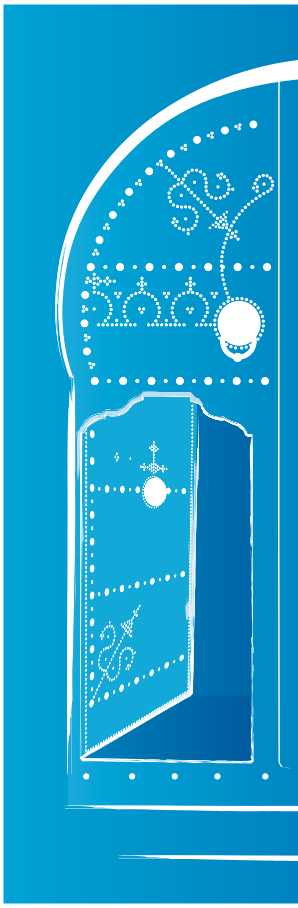
Singh/Fehrs, 2001. *The work that goes into renewable energy.* Renewable Energy Policy Project, Research report No. 13: Washington D.C.

Staiß et al, 2006. *Renewable Energies: Employment effects.* editor: BMU.

UBA, 2003. *Systematische Analyse der Eigenschaften von Energiemodellen im Hinblick auf ihre Eignung für möglichst praktische Politikberatung zur Fortentwicklung der Klimaschutzstrategie.* Umweltbundesamt.

Wei et al, 2010. *Putting renewables and energy efficiency to work: How many jobs can the clean energy industry generate in the US*? Energy Policy 38 (2010) 919–913.

Weiss et al, 2003. *Wirtschaftsfaktor Sonnenenergie*. AEE INTEC, by order of Ministry of Transportation, Innovation and Technology: Austria.



Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH

Bureau de la GIZ à Tunis
Le Grand Boulevard de la Corniche
Immeuble le Grand Boulevard
Les Berges du Lac II
Tunis
Tunisia
T +216 71 967 220
F +216 71 967 227
E GIZ-Tunesien@giz.de
I www.giz.de