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Walking the green mile in Employment

Employment projections for a green future

September 2013

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Employment projections for a green future

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Abstract - In this working paper, the employment effect triggered by a transition towards an all renewable energy system in Belgium by 2050 is scrutinized. The job impact is estimated up until the year 2030. Using a labour intensity methodology, net job gains are to be expected in each renewable trajectory for any given year. A distinction is made between construction, installation and manufacturing (CIM) and operations, maintenance and fuel processing (O&M) jobs, with the maximum amount of CIM jobs created over the reference scenario exceeding the amount of O&M jobs. This points to the fact that renewable energy sources tend to have a higher construction and installation component in employment than fossil fuels. These installation jobs, along with numerous other job types (e.g. monitoring, planning, certifying), are bound to be and remain domestic. A sensitivity analysis on the effect of applying a decreasing employment multiplier over time is modeled, accompanied by an enumeration of arguments pro and contra using this type of multiplier. All through the paper, a number of reflections are brought to the fore that may nuance the obtained figures and effects. In order for the jobs to materialize, targeted educations, preferably in close collaboration with industry, technical schooling and interest in science are crucial. Enabling policies and measures within a solid, transparent policy framework should accompany the whole process. In this regard, some policy domains and actions are described that could prove useful in tapping the vast job potential.

Jel Classification - C6, Q4

Keywords - renewable energy sources, employment, long-term energy projections, input-output analysis

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Executive summary

When it comes to unemployment, during the last 5 (crisis) years, Belgium, in sharp contrast to some other EU27 Member States, appears to be less affected: Belgian unemployment rates did not increase spectacularly, they remained below the EU27 average, even noting positive employment growth figures. The very latest statistics, however, seem to point to a weakening of the situation, demonstrating some red warning signs, especially when it comes to youth unemployment. This could be symptomatic of a delayed crisis effect caused by the specific structure of the Belgian economic fabric. Already some politicians hinted at the critical importance of jobs, jobs and jobs. This observation, combined with, at supranational level, the attention of the European Union declaring growth and jobs priorities in the Lisbon Process, the Europe 2020 Strategy for growth and jobs and the Compact for growth and jobs decided by the Heads of State, justifies the focus of the current paper.

This Working Paper looks into jobs and job creation through a very specific channel: renewable energy development, thereby linking the evolution of the energy system with potential job creation opportunities. More specifically, this paper investigates the number of job-years or full time equivalents created by a transformation of the current Belgian energy system largely based on fossil fuels towards an all (100%) renewable energy system by 2050 as described in Devogelaer et al. (2012). Such a transformation is believed to be beneficial on 3 levels: climate change (renewable energy sources (RES) do not release (net) greenhouse gas emissions), security of supply (RES can help to reduce a nation’s growing dependence on imported fossil fuels) and as a sector of the economy through which a considerable number of jobs can be created. This last statement then forms the research question at hand.

First hurdle in identifying the job potential through renewable energy development is finding an adequate definition of the renewable sector itself. The renewable sector is not a traditional sector with a separate NACE-code for which statistical data can be gathered in a standard way. So first, a literature review is performed to find an accurate definition of the sector, as well as to set the scene for further understanding. Through this literature review, some other (macro-economic) types of analyses were encountered that proved to be instructive in the comprehension of the subject, with some country specific results from macrosectoral models being cited. Second, the estimations are conducted following the same methodology as utilized in Devogelaer et al. (2012) being the application of a labour intensity or job multiplier methodology.

Using this labour intensity methodology, originally derived from a.o. input-output analyses, net job gains are to be expected in each and every renewable scenario. The renewable trajectories all create more full time equivalents (FTE) than the reference scenario for any given year. The PV scenario creates the most FTE’s in any given year. Three major causes are at the heart: first, solar PV is a variable renewable energy source demonstrating low capacity factors, hence necessitating large installed capacities for given production levels, second, solar PV exhibits a large installation component in employment, hence necessitating multiple installation teams for a given level of capacity, third, the power sector being one of the first sectors to fully transform to renewable energy within the 100% RES framework adopted in this paper, necessitates an exponential number of investments (hence capacity expansion) up to the year 2030.

In a second step, a distinction is made between Construction, Installation & Manufacturing (CIM) and Operations, Maintenance and Fuel processing (O&M) jobs, where it is obvious that the maximum amount of CIM jobs created over the reference scenario exceeds the amount of O&M jobs. This points to the fact that a lot of renewable energies have a high construction and installation component in employment. These installation jobs, along with a lot of other types of jobs (monitoring, planning, certifying), are bound to stay domestic.

It was also possible to extend the analysis and project net employment forecasts for the years up to 2020. Next to that, a sensitivity analysis on the effect of a decreasing employment multiplier throughout time was modeled. A decreasing multiplier can be seen as a proxy for increasing labour productivity in the sector. Conditional on our hypotheses, 7% (8% in the PV scenario) less jobs are created in 2020 with the declining multiplier method compared to the constant multiplier method; in 2030, the job decrease amounts to 17% (18% in PV) less jobs compared to a situation in which a constant employment multiplier is applied. Although the applied methodology is rather simplistic, we have sound arguments to take it into account. On the other hand, a higher number of jobs can be generated if one is capable of tapping the export potential.

At the end of the paper, a number of reflections on jobs and job content are brought to the fore. It then becomes obvious that targeted educations, preferably in close collaboration with industry, and training, (re)tooling and schooling with specific attention to revamping interest in science, engineering and RD&D are of utmost importance. The crucial role of installing a coherent policy framework and defining adequate measures should not be underestimated and is determining in the number of jobs actually created when shifting society towards renewable energy sources.

1. Introduction

The last couple of months, several news announcements of yet another plant closing down and hundreds of workers being laid off were aired. At the same time, but rather under the radar, new jobs and job opportunities were being created. All in all, even when the crisis is striking hard in several Member States, Belgium seems to be less hit with Belgian unemployment rates[1] below the EU27 average, even noting positive[2] employment growth[3] figures that surpass those of the EU27 (even the Euro area) and this for the last 5 years.

Even if, at first sight, we seem to get out rather undamaged, it cannot be ruled out that the Belgian economic fabric is set up in such a way that a delayed crisis effect may still occur. On top of that, growth and jobs are priorities in the European Union with its Europe 2020 strategy for growth and jobs and the Compact for Growth and Jobs decided by the Heads of State, providing a coherent framework for action at national, EU and euro area levels. Therefore, it can be inspiring to look at opportunities that tie the trend to keep providing these much needed jobs that can absorb employment that is being lost.

In order to create jobs, an often cited channel is the transition towards a so called green economy. But what exactly are green jobs? And are these jobs replacing jobs that would have been created anyway? In case they turn out to be beneficial to our economy, how can we get there and which steps should be taken in the near and medium future?

In the framework of a vast project that was undertaken by a consortium of three scientific partners (Federal Planning Bureau, ICEDD and VITO) with as main research question the feasibility of the Belgian energy system running on 100% renewable energy sources by the year 2050, a side analysis was performed on the impact this objective could have on the nation's future employment. This analysis can be situated in a stream of literature showing that renewable energy sources (abbreviated: RES) are not only interesting from the point of view of climate change (RES do not release (net) greenhouse gas emissions) and security of supply (RES can help to reduce a nation's growing dependence on imported fossil fuels), but also as a sector of the economy through which a considerable number of jobs can be created.

This paper then builds on but is also quite different from the analysis performed in the framework of the aforementioned project (Devogelaer et al., 2012) in that it extends the employment analysis on four distinct levels. First, it stretches out the analysis to also include the shorter term horizon, i.c. from 2013 onwards, second, it discusses different assumptions to scale the job creation effect (instead of utilising uniform employment multipliers over the entire time horizon), including as such a learning or cost reduction effect in job creation, third, it sketches an upper and lower bound for the creation of different

1 Following the Eurostat definition, see http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&init=1&plugin=1&language=en&pcode=tsdec450 and http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&init=1&plugin=1&language=en&pcode=tps00180.

2 With the exception of the year 2009 in which the employment growth rate was -0.2%.

3 The indicator "employment growth" gives the change in percentage from one year to another of the total number of employed persons on the economic territory of the country or the geographical area. The indicator is based on the European System of Accounts.

types of jobs for the discrete years and fourth, it points out the shortcomings of using this methodology in not considering the effect of energy price rises.

This paper consists of five distinct parts. In the first part (part 2), some definitions are given in order to set the scene. Part 3 deals with a brief literature overview to, in part 4, go ahead with the estimation of the Belgian job potential owing to the different renewable trajectories as defined in the report "Towards 100% renewable energy in Belgium by 2050" (Devogelaer et al., 2012). Part 5 is dedicated to a qualitative overview of the skills, type of jobs and educations that are indispensable in the transition towards a 100% renewable future. The sixth and last part presents some policy domains that are crucial in surmounting the identified hurdles and pave the way to RES job creation.

2. Definitions

Although the title of this working paper may lead some to think that employment projections for Belgium are in a shambles as the green mile is often associated with the short mile that a prisoner walks before he is executed, this paper on the contrary wants to point out the employment opportunities created by domestic renewable (also referred to as *green*) energy production. However, these possibilities will not happen as such, and necessitate a long walk of committed investment, competitive innovation and backing support through a number of transversal policies and measures. In order to properly examine the employment effect generated by an intense renewable energy deployment, it is indispensable to start with a brief overview of some of the concepts, definitions and methodologies used.

A first concept to be clear on is the sector itself, so the first definition given should be on the precise boundaries of the renewable energy sector. Such a description creates a first and crucial hurdle since the sector is not a traditional sector with a separate NACE-code for which statistical data can be gathered in a standard way. One can notice that firms working with (and on) renewable energy technologies are part of a variety of traditional NACE-type of industries, not one single, since the renewable activities they perform can be classified under a multiplicity of traditional economic activities. Some renewable firms are for instance categorised under the NACE-code from which they diversified into renewable activities, others are assigned to the NACE-code that corresponds to most of their (renewable) activities. Because of the fact that the renewable firms are thus scattered over different sectors, it becomes difficult to analyse the sector in a top-down manner based on available sectoral statistics[4]. Attempts are nevertheless made and efforts to estimate the current employment in the renewable energy sector were undertaken by e.g. LNE (2010) and 3E (2010) using as definition of the renewable energy sector

> *"The sector of organisations having a Belgium based location that deliver goods, services and technologies that are used in the generation of energy from renewable non-fossil energy sources, namely wind, sun, aerothermal, geothermal, hydrothermal energy and energy from oceans, hydropower, biomass, landfill gas, sewage and sludge gas and biogas."*

According to LNE, the Flemish Environment, Nature and Energy Department, the renewable energy industry in Flanders provided 8,864 direct full time jobs in 2009. A case study of 3E (2010) also included the indirect employment resulting in approximately 10,000 jobs in the Flemish renewable energy sector in 2009. For Belgium, the sum of direct and indirect jobs amounted to 22,670 in 2010 (Eurobserv'ER, 2011).

Second, it is important to define the used employment vocabulary as there is often confusion between types of jobs and job-years. One job-year (or equivalently person-year or "full time equivalent" FTE) is full time employment for one person for a duration of one year. Often, "jobs" and "job-years" are used

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4 The environment industry is confronted with an identical problem (Janssen & Vandille, 2009, Sissoko & Van den Cruyce, 2009). In the framework of Eurostat Grant Agreement No. 50904.2012.004-2012.998, the Federal Planning Bureau is currently in the process of constructing an up to date repertoire of the Belgian environment industry and its key indicators.

interchangeably; however referring to "jobs" created without stipulating a time concept can be misleading[5].

Another nontrivial difference resides between net and gross employment effects and between employment (as a stock variable) and job creation (as a flow variable). An increase in employment (hence, job creation) can come from either opening units or expanding units. A decrease in employment (job destruction) can come from either closing units or contracting firms. Gross job gains include the sum of all jobs added at either opening or expanding units. Gross job losses include the sum of all jobs lost in either closing or contracting units. The net change in employment is the difference between gross job gains and gross job losses. In this framework, the distinction between net and gross is important to bear in mind since speaking of gross employment can be deceptive, including jobs that would be created anyway and not accounting for jobs that may be lost in the coal and natural gas chains. Mentioning the amount of net jobs that can be created over and above what is projected from existing policies and accounting for any job losses that may occur from reductions in the supply chains of coal and natural gas then gives a better idea of the societal benefit of a transformation towards a renewable energy system.

Next, definitions of direct, indirect, and induced jobs vary widely across studies. In this analysis, we choose to follow the definitions and usage of these categories as described in Wei et al. (2010):

> *"Direct employment includes those jobs created in the design, manufacturing, delivery, construction/installation, project management and operation and maintenance of the different components of the technology, or power plant, under consideration. This data can be collected directly from existing facilities and manufacturers in the respective phases of operation.*
>
> *Indirect employment refers to the "supplier effect" of upstream and down-stream suppliers. For example, the task of installing wind turbines is a direct job, whereas manufacturing the steel that is used to build the wind turbine is an indirect job.*
>
> *Induced employment accounts for the expenditure-induced effects in the general economy due to the economic activity and spending of direct and indirect employees, e.g. non-industry jobs created [...]. When discussing energy efficiency, a large portion of the induced jobs are the jobs created by the household savings due to the energy efficiency measures."*

Not only job definition and type of jobs deserve attention, also the way in which they are estimated is important. Glancing through the employment literature focused on the renewable industry, two types of methodologies can be distinguished: (1) those that use input-output (I/O) models of the economy ("top-down"); and (2) those that use simpler, largely spreadsheet-based analytical models ("bottom-up"). Both types of models have advantages and disadvantages (Kammen et al., 2004) and are briefly reviewed.

I/O-based models are intended to model the entire economy as an interaction of goods and services between various industrial sectors and consumers. I/O-based models provide the most complete picture of the economy as a whole. They capture employment multiplier effects, as well as the macroe-

[5] Macro-models may function in terms of number of hours worked. Converted into an annual average duration per employee, it allows determining the quantity of jobs created.

conomic impacts of shifts between sectors; that is to say, they account for losses in one sector (e.g. coal mining) created by the growth of another sector (e.g. the wind energy industry). I/O-based models are thus designed to encompass both the direct and indirect employment effects of shifts in energy demand as brought upon by various policies as well as the induced economic effects due to economic impacts of spending by workers. In practice, I/O-based models are very complex and may be opaque to understand. Within a larger I/O model, there are also disaggregation problems in modelling the employment generated by specific technology types such as solar PV or wind and in isolating the impact of specific policies versus a suite of policies. Collecting data to build an I/O model is highly data- and labour intensive, and I/O models also can suffer from time delays (typically time lags of around 3 to 4 years) between the reference year and the time I/O compatible industry data becomes available.

Then again, most analytical models calculate direct employment impacts only, but an increasing number include indirect jobs as well. Although analytical models typically do not account for job losses in the fossil fuel sector, they are much easier to understand and model. Sensitivity analysis of specific policies or changing key assumptions can be readily modelled, and data can be collected more frequently than with I/O-based models.

Various normalization approaches for comparing the job creation potential of different technologies can be utilized. They include jobs produced for a given level of spending (Pollin, 2008) or jobs produced for a given level of output, such as jobs produced per unit of energy production. Jobs produced per unit of energy provide an indication of the job creation potential for aggressive conversion of the existing energy supply to renewable sources, a case in which we are particularly interested in this analysis.

3. Literature

3.1. General

Before going ahead with the job creation estimations of the renewable pathways, a literature review was undertaken in order to get a grasp of some first orders of magnitude of the job creation potential in Belgium. Two major inferences that came up during the review are the following.

First, all the quantitative studies that were digested in the framework of this analysis have one thing in common: although the horizon of the study may be (very) long (up to 2050), quantitative employment effects are only given up until 2030 (see e.g. European Commission, 2011, European Climate Foundation, 2010, European Commission, 2009, Wei et al., 2010). This might be due to the fact that the evolution in employment in the short to medium term is principally dictated by demand mechanisms, whilst in the long run, supply mechanisms take over[6].

Since in this paper, we are more interested in the analysis of the demand effects triggered by the renewable trajectories, we focus in what follows on the time horizon 2020-2030. Moreover, it seems especially challenging to take into account the job impact of all kinds of new, explorative technologies and processes that come available in the long term like e.g. massive storage, the hydrogen chain and smart grids. Although they can and certainly will create extra jobs, one also has to be aware of the innovation effect: industry innovation at first may create a lot of jobs (Lachenmaier and Rottmann, 2011), but over time leads to a reduced job dividend (see also Zagamé, Fougeyrollas and le Mouël, 2012).

Second, most to all studies scrutinised have as object range a rather vast territory like the European Union (European Climate Foundation, 2010, European Commission, 2011) or the United States (Wei et al., 2010). Member State level employment estimates of decarbonisation or renewable policies are rather scarce.

3.2. Belgium

When looking at Belgian job prospects, we found two studies that could be of use. The first study is the EmployRES study (Fraunhofer ISI, Ecofys et al., 2009) which cites figures per Member State: the figure for Belgium seems to be in the neighbourhood of 5,000 jobs in 2020 due to an accelerated RES deployment policy scenario with moderate exports and this compared to a reference scenario[7] (cfr. infra). Second study is the update of the study performed in 2008 by the Federal Planning Bureau on the impact of the EU Energy-Climate Package on the Belgian energy system and economy (Bossier et al.,

6 This can be seen in the long-term model MALTESE (Model for Analysis of Long-Term Evolution of Social Expenditure) developed by the Federal Planning Bureau in which the evolution of employment follows a supply logic. This logic is identical to the one followed in the Ageing Working Group of the Economic Policy Committee. In this framework, employment results from the combination of the evolution of the labour force and the unemployment rate.

7 This approximate figure is in fact the result of the combination of two figures in the cited publication, i.e. Figure 103 and 111. This was done in order to have as reference the BAU-ME scenario instead of the No Policy scenario, the latter representing the virtual case in which no further RES support is implemented until 2030, whilst the former simulates the case in which RES policies are applied as currently implemented, a situation that is closer to our Reference scenario.

2011). It mentions some employment effects calculated using the FPB's HERMES model[8]. For the year 2020, employment impacts are calculated for the 30/20 target scenarios with respect to the 20/20 target scenario and arrive in a range between 7,000 and 25,000 jobs. The 30/20 target scenarios integrate more severe greenhouse gas emission reduction targets on European level, hence implementing more energy efficiency and a slightly higher share of renewable energy sources in Gross Inland Consumption than the 20/20 target scenario.

3.3. Wei et al.

In our literature overview, we also came across an article that does not contain Belgian figures, but that presented an approach that could be useful in the attempt to assess the job creation potential of renewable energy sources in Belgium[9]. This article is written by Wei, Patadia and Kammen (2010) and contains an analytical job creation model for the US power sector from 2009 to 2030. The model synthesizes data from 15 job studies covering renewable energy (RE), energy efficiency (EE), carbon capture and storage (CCS) and nuclear power. The paper employs a consistent methodology of normalizing job data to average employment per unit energy produced over plant lifetime. Job losses in the coal and natural gas industry are modelled to project net employment impacts. Benefits and drawbacks of the methodology are assessed and the resulting model is used for job projections under various renewable portfolio standards (RPS), energy efficiency and low carbon energy scenarios.

Next to this article, it appears that an older version focusing exclusively on renewables was published in 2004 (Kammen, Kapadia & Fripp, 2004) and revised in 2006. Main conclusions boil down to

- The renewable energy sector generates more jobs per megawatt of power installed, per unit of energy produced and per dollar of investment than the fossil fuel-based energy sector.
- Embedding support for renewables in a larger policy context of support for energy efficiency, green building standards and sustainable transportation will greatly enhance the net positive impact on the economy, employment and the environment.

8 For the sake of completeness, we have to mention that this study primarily zoomed in on the employment effect triggered by a taxation shift from one factor to the other. The impact of new investments in renewable energy sources was much less the centre of attention.

9 Although the article focusses on the US power sector, it is explicitly stated that the model can be adopted and applied to other (developed) countries.

3.4. What not et al.

3.4.1. Costs

Basically, both articles are founded on a labour intensity[10] methodology. Although this methodology has its merits and is (mainly) based on underlying input-output analyses, one should also be aware of the fact that by investing in renewable energy technologies, even if additional jobs are provided, energy prices (and by extension, since energy is a production factor, other prices) may go up. This price rise may have adverse effects on total employment. The Employment in Europe 2009 report (European Commission, 2009) puts it like this:

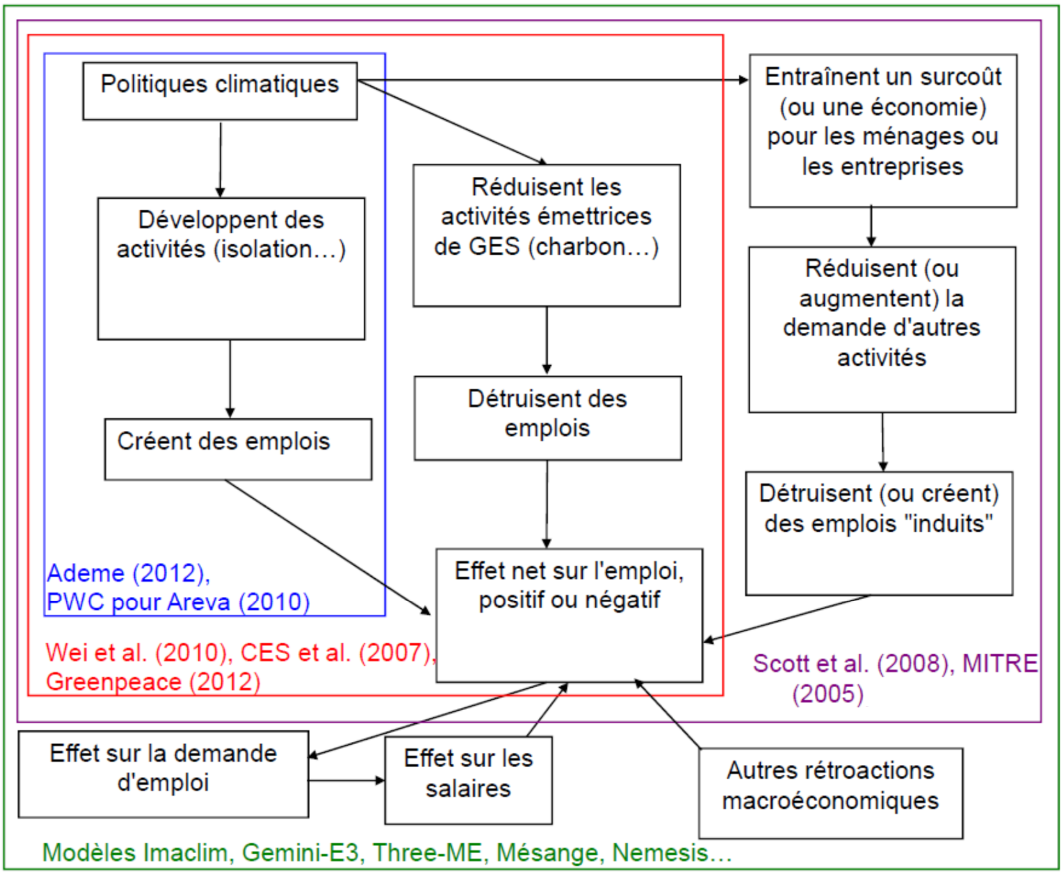
> *"Overall, the increased use of RES should be beneficial not only to the environment but also to the economy and employment, in particular due to the existence of longer supply chains and a higher labour intensity in the environmentally friendly sectors. However, especially due to the 'additional costs' in the renewable energy sector, those positive developments can be counterbalanced and therefore the actual impact of renewable energy on net employment remains uncertain."*

We should therefore point out that the analysis presented in this working paper does not include a detailed cost benefit analysis. However, two things should be brought to attention. First, when cost benefit analyses are performed, also the benefits' part should be thoroughly evaluated, which in the renewable case means a.o. better health conditions, better air quality, environmental benefits (e.g. Laleman et al., 2011) and security of supply (Devogelaer et al., 2012). Second, costs can be confined if more cost effective measures such as energy efficiency are implemented which can compensate for less cost effective parts such as solar PV. It was already stated in Devogelaer and Gusbin (2011) that, although energy costs with the implementation of the legislative Climate/Energy Package might go up for different economic agents, the total energy expenditures (or the energy related invoice) may not be severely impacted because higher energy costs per unit energy may be compensated for through a reduced consumption of energy. The net economic impacts then become highly dependent on the rate of technological innovation, but if innovation is assumed to follow historical trends and strong policies are in place to promote energy use reduction, energy invoice increases may be curtailed and significant job growth can result.

To dig a bit deeper on the point raised, we notice in fact that to accurately answer the cost question at hand, another type of approach appears to be necessary. Graph 1 depicts different types of studies and methodologies as well as the part of the research question they are able to capture.

[10] Or job multiplier (cfr. infra).

Graph 1 Main mechanisms in creation and destruction of jobs



Source: Quirion (2013).

We see that, in order to grasp the full impact on employment of adopting an energy (or climate) policy, the use of a macroeconomic or general equilibrium model becomes indispensable. The model as discussed in Wei et al. (2010) is not equipped to (fully) take on induced employment and diverse macroeconomic effects. In this regard, the already cited EmployRES study (Fraunhofer ISI et al., 2009) could be utilised since its results are obtained through the use of the Nemesis and Astra macrosectoral models. Although that study does not integrate a 100% renewable energy scenario[11], it might provide some interesting insights that may add to this analysis.

The EmployRES study provides a detailed analysis of the full macroeconomic effects of renewable energy deployment at EU and member state level. It analyses the past, present and future impacts of renewable energy policies in the EU on employment and the economy, looking at the gross effects (direct and indirect) as well as the net effects (including both conventional replacement and budget effects). The general conclusion of the study can be summarised as follows: although gross figures in terms of employment and value added are rather large, net figures are significantly smaller due to

[11] The Policy case (or Accelerated Deployment Policy scenario) arrives at a 30% share of overall RES deployment in Gross Final Energy Consumption (GFEC) in 2030 on a European scale (EU27), whereas the different 100% renewable trajectories in Devogelaer et al. (2012) reach 35% of renewable energy in Primary Energy Consumption (PEC) by 2030 in Belgium alone. Although there is a difference in denominators (major difference between GFEC and PEC is that GFEC solely describes the energy consumption of the final demand sectors, being industry, transport, households, agriculture and tertiary whereas PEC also contains the energy consumption of the transformation sectors), there is also a discrepancy in the scope: the former allows member state based RES trade securing cost efficiency whereas the latter is a stand alone target.

replaced investments in conventional energy technologies as well as due to the dampening effect of the higher cost of renewable energies compared with conventional alternatives. The effect on employment depends heavily on this energy cost increase. If there are significant cost increases, these may hamper job creation.

More in detail, the use in the EmployRES report of the macrosectoral models NEMESIS and ASTRA allows to not only account for direct effects, but also for indirect effects. At first, the additional investment demands for RES will act the part of a traditional Keynesian multiplier, increasing the demand in national production sectors mainly for sectors producing investment goods. This positive effect will be reinforced by the additional operation and maintenance due to RES deployment. This deployment will also benefit the agriculture and forestry sectors due to the increasing biomass demand. Regarding the energy sectors, the development of RES technologies will lower the demand for conventional fuels, penalising some energy sectors such as the “refined oil” and “gas distribution” sectors. The development of RES technologies will then result in decreased investment in conventional technologies as well as reduced operation and maintenance for these technologies, hence limiting the initial positive effects. The direct impact of RES deployment on external trade can be split into two different effects. The first concerns the imports and exports of the global components of RES technologies that are produced by only a few countries. The second effect concerns the trade of local components of RES technologies. Finally, RES deployment will have an impact on the electricity price, increasing the production costs of the different companies.

The indirect effects then can be seen in the additional demand in some production sectors radiating throughout the whole economy in two different ways. At first, in order to produce this demand, firms will have to increase their production factor demands (investment, intermediate consumption), which in turn will lead to a second round effect. Moreover, the increased labour demand will increase households’ final consumption in two ways: first by increasing employment, and second, depending on the initial national conditions, by increasing wages and salaries. The increase in national demand will also be exported to other European economies through external trade.

The total effect of the deployment policies in the different member states will depend on their starting conditions such as the existence of sectors producing RES technologies, the initial conditions on the labour market, the agriculture and forestry sector’s potential to produce biomass, the external trade structure, national competitiveness, the different elasticities of substitution between the production factors and the substitution elasticities in the different consumption categories for households.

The individual country results depend on the interplay of a number of important factors and the impacts on GDP and employment differ, i.e. there is no linear correlation between GDP and employment. The reason is that although both are connected, the major drivers of the two variables differ. For GDP, the most relevant driver is the additional investment in relation to total GDP, while for employment, energy cost changes above a certain threshold are of greater importance. For Belgium, the net job effect in 2020 is positive and is situated in the neighbourhood of 5,000 jobs[12].

[12] See also part 3.3.2.

3.4.2. NAIRU

The labour intensity approach that is followed in this paper also differs from the macroeconomic view that the long term unemployment rate is rather stable. This is referred to as the NAIRU, the rate of unemployment at which inflation will stabilise or, in other words, at this rate of unemployment, prices will rise at the same rate each year. Basically, what is meant here is that, because of a rather constant national unemployment rate, newly created jobs in one sector will necessarily crowd out employment (and investments) in other sectors since demographical trends are considered as given. Although this point of view acknowledges the fact that the evolution of employment in the long run is dictated by supply rather than demand mechanisms, it could be viewed from another angle, being that of a sustainable economy. In this other state of mind, it may be beneficial to alter the current economic tissue towards a more sustainable alternative, with newly created jobs in endurable sectors compensating for job losses in unsustainable industries. This reasoning can be complemented by the observation that industrial employment today is shrinking as can be witnessed in numerous business cases as to car manufacturing, steel industry and others. The paper *"De toekomst van de industrie in België"* (De Grauwe, 2003) deals with exactly this topic in stating that jobs in the Belgian industrial sectors are gradually phasing out since industrial labour productivity is increasing fast. De Grauwe (2003) predicted that the future macroeconomic environment will be one of further downgrading industrial employment, even if the industrial production could be kept up to speed. This industrial employment loss may then be compensated for by job creation in other sectors. These other sectors could well be renewable energy sectors.

3.4.3. Government spending

The labour intensity methodology also does not take into account the fact that large capital investments related to renewable energy sources by the government may be perhaps better spent elsewhere in the private sector in which more return (and jobs) could be generated. If the government's (sole) objective is to create the largest number of jobs, this line of thinking is indeed necessary, although one element is missing: the fact that, at the macroeconomic level, global warming is one of history's greatest market failures. Not (entirely) taking into account (all) global warming related externalities, hence not accounting for certain cost categories may then lead to biased conclusions as to government spending. As a result, the underlying research question could be reformulated: not whether or not to support green jobs and sustainable industries, but how best to undertake this support. Consequently, it should be more rewarding to look for policies and measures that generate the largest benefit to cost ratio, that minimize windfall profits, that balance short run costs against long term benefits, that avoid or minimize environmental leakage and dislocations of firms (and jobs) and so on.

4. Estimations

4.1. Scenarios

With this literature review in mind and given the fact that in this paper, we chose to work with the labour intensity methodology[13] as explained in Wei et al. (2010), we then proceeded to the estimations by first applying the original model to the results obtained in the reference and alternative scenarios of the study "Towards 100% renewable energy in Belgium by 2050" (Devogelaer et al., 2012). In total, there are 6 scenarios, being a reference scenario and 5 alternative scenarios. The reference scenario is no business-as-usual scenario, nor is it intended to depict a probable future of our national energy system. Its sole mission is to have a point of comparison of which technologies and solutions the system will choose if it is not bound by a 100% renewable constraint. The alternative scenarios are 5 in number and depict an energy future up to 2050 in which ultimately the system evolves towards a complete functioning on renewable energy sources. The 5 alternative scenarios all make full use of the available renewable potential on Belgian soil, but can be distinguished by the fact that one main source of renewable energy is privileged, i.c. its potential is adjusted upwards, or put differently, one 'constraint' is lifted. Only exception is the so called DEM alternative scenario which can only count on the currently available renewable potential up to 2050, hence is obliged to (drastically) reduce its demand for energy services. The other scenarios are named according to their 'loosened' constraint[14], e.g. BIO (for biomass), PV (for solar PV), WIND (for on and offshore wind) and GRID (for more electricity imports). Table 1 gives a brief overview of the scenarios.

Table 1 Description of the different scenarios

Scenario	Description
DEM	The insufficient availability of local renewable energy sources raises energy prices which in its turn affects energy service demand. The latter is reduced until a level is reached that is compatible with the Belgian renewable energy potential and the 100% RES target.
GRID	The lack of local renewable energy is compensated by larger imports of electricity.
BIO	A higher quantity of biomass can be imported.
PV	A larger surface can be covered by solar panels in Belgium.
WIND	Onshore and offshore potentials are increased.

Source: Devogelaer et al. (2012).

4.2. Jobs throughout 2030

In this setting, jobs can be created both through the deployment of renewable energy sources as through investments in energy efficiency. For all the scenarios, job impact results are produced for 2020 and 2030 with a total for the two distinct years[15]. To estimate the full time equivalents (FTE's) generated

[13] Basically to deepen the employment analysis presented in Devogelaer et al. (2012).

[14] These new upper bounds are not arbitrarily chosen but are based on sound criteria. For onshore wind, for example, this is the result of studies that envisage to override some constraints as to covisibility or some exclusion criteria as to forests or sites destined for other purposes. These potentials as well as a more elaborate description of the different scenarios can be found in annex.

[15] Note that the estimated figures are slightly higher than the figures shown in Devogelaer et al. (2012) due to a minor revision of the original results concerning a.o. certain decentralised units.

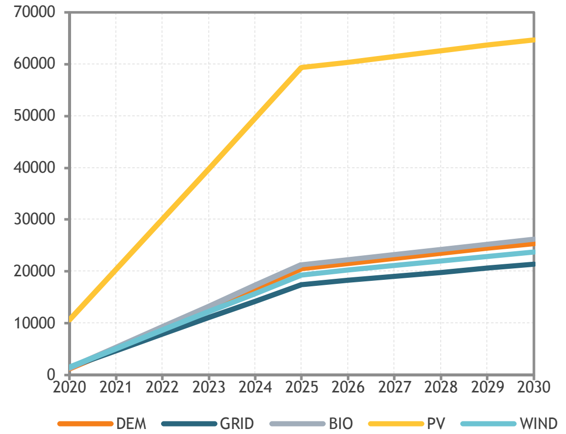
for the intermediate years between 2020 and 2030, a novel approach was adopted. This approach is based on the employment impact figures as expressed in Bossier et al. (2011) that demonstrate that although the job impact increases over time, the growth rate flattens out[16]. Depending on the assumed growth rate, the cumulative amount of FTE's can vary.

The jobs estimated are not location specific: there is no specification as to where the jobs, once created, will be stationed. So although we start from the outset that the Belgian energy system will evolve towards 100% renewable energy, (some) jobs could be located abroad. This will particularly be the case in the manufacturing of turbines, solar panels and other pieces of equipment because they can easily or less expensively be done elsewhere. Notwithstanding that, a renewable transition will also generate a lot of local jobs. The installation of any technology necessarily creates locally anchored, non-delocalizable jobs as they involve construction, planning, monitoring, certifying, installing and, at the end of the lifetime, dismantling and possibly recycling. Even when it comes to energy efficiency, a lot of local jobs can be set up. Illustrative of this is the citation of Britta Thomsen, a Danish MEP[17], on the MEPs vote for an 80% cut in buildings' energy waste by 2050:

> *"When we talk about renewables – windmills or solar cells - you can produce those in China but renovation of houses goes on in Europe and this means that you will have the jobs here."*

The graph resulting from applying the methodology as defined in Wei et al. (2010) then shows us that:

Graph 2 Annual job-years over REF due to the RES trajectories, period 2020-2030
Total FTE's



Source: Wei et al. (2010), Federal Planning Bureau.
Note: FTE=full time equivalent.

- the renewable trajectories all create more FTE's than the reference scenario;
- the PV scenario creates the most FTE's in any year, but also over the horizon. As many discrete panel installations are necessary to foster a significant solar PV development (as compared to e.g. a single location for a biomass plant or wind farm) and solar has a large installation component in employment, a lot of FTE's are being formed[18].
- BIO and DEM are the second highest job generating scenarios, the BIO scenario mainly through the increased demand for farming, the DEM scenario through the major boost that is given to the national construction sector and with it, its entire value chain.
- GRID employment seems to be at the lower end of the spectrum. This might be due to the fact that grid investments specifically destined to transborder interconnections are not particularly ac-

16 A possible explanation can be sought in the innovation effect (cfr. infra) or the learning curve effect through improvements in industry productivity and cost reduction.
17 Euractiv.com, *MEPs vote for 80% cut in buildings' energy waste by 2050*, March 15, 2013.
18 Next to installation jobs, employment in solar PV also entails a lot of jobs in research, development and demonstration, in monitoring (weather conditions, climate, meteorology), in the panels' certification and at the end of their lifetime, in dismantling and recycling.

counted for in the analytical job model, hence total employment in this scenario might be underestimated.

Three side remarks concerning this estimation can be made, all pointing to the fact that results might be higher than shown in Graph 2. First, it is important to bear in mind that the reference scenario already has a relatively large share of renewables in its power generation (30% in 2020, 39% in 2030[19]). This has to be attributed to the specific outset of the reference scenario with the nuclear phase-out and the implicit ban on coal for power generation within the existing TIMES modelling framework. This also means that renewable job creation as shown in Graph 2 might be underestimated compared to a reference scenario characterised by a more moderate share of renewable energy sources in total power generation. Second, although Wei at al. (2010) specifically mentions the fact that the model and the job multiplier data can easily be adopted by other (developed) countries, it contains some country specific features that differ from the Belgian ones. As a matter of fact, the capacity factors[20] for solar PV and wind used in the article amount to 20 and 35% respectively, whilst in Belgium these factors are more in the neighbourhood of 10 and 25% respectively, hence when performing the calculation with job multipliers expressed in total job-years per GWh, even more FTE's may be created[21]. Third, this job model relates to the power sector. Although it allows for indirect and induced jobs in other sectors of the economy, it does not include jobs created in the biofuels' (transport sector) or renewable heating and cooling sector. Even though these chains are, for the years considered, much smaller than the power sector, adding these extra jobs onto the jobs created in or through the electricity chain will further increase total employment.

4.3. Type of jobs

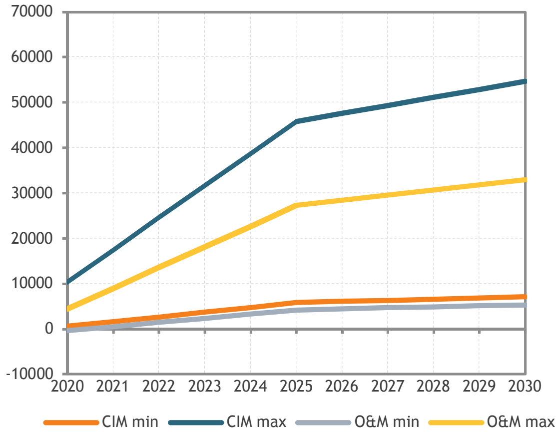
Next to this more general outlook, two specifications can be added to the above analysis. First, to construct Graph 2, average ratios of total job-years per GWh were used. Wei et al. (2010), however, contains a job model that is the result of the combination of 15 job studies with differing estimations of the job impact. It was then possible to go back to the original data and estimate the minimum and maximum, hence the range, of the job creation potential initiated by the different renewable trajectories. On top of that, the article also contains information on a subdivision between types of jobs. A distinction can be made between jobs in (1) construction, installation and manufacturing (CIM) and (2) operations, maintenance and fuel processing (O&M). So the tools were there to present a more detailed analysis for the years 2020 and 2030. Complemented by the own calculation tool to provide an estimation for the intermediate years, it became possible to construct Graph 3.

19 Where it stood at 6.9% in 2010 and 8.8% in 2011 (Eurostat, 2013).

20 The capacity factor is the fraction of a year that the facility is in operation.

21 This follows from the fact that more lower than higher capacity factor technologies will have to be built to deliver the same amount of energy.

Graph 3 Annual minimum and maximum job-years in CIM and O&M over REF, period 2020-2030
Total FTE's



Source: Wei et al. (2010), Federal Planning Bureau.
Note: CIM=construction, installation and manufacturing; O&M=operations, maintenance and fuel processing; FTE=full time equivalent.

Graph 3 then shows the minimum and maximum curves for the different types of jobs. We see that only in the year 2020 the operations, maintenance and fuel processing jobs may be lower in the renewable trajectories than in the reference scenario. This is probably due to the fact that the natural gas chain that is downgraded in the renewable trajectories and replaced by more renewable energy sources tends to have, according to some studies (EPRI, 2001, Mc Kinsey Consulting, 2006), more O&M and fuel processing jobs than solar PV and onshore wind. After the year 2020 due to the massive capacity installation, the situation is reversed and all types of jobs for all years are situated well above the reference situation, meaning that the renewable trajectories all create more jobs than would be the case in a reference setting, both in CIM as in O&M.

4.4. Sensitivity analysis

In the analysis shown up until now, constant job multipliers[22] are applied to both years (2020 and 2030). For the intermediate years, on the other hand, the implicit assumption was made that the employment effect is bigger during the first 5 years and slows down afterwards to arrive in 2030 at the same multiplier level as utilized in 2020. This hypothesis was made in order to integrate the observation made in Bossier et al. (2011) that, halfway the projection, shows a bend in the estimated job effect. This bend in fact stands for the addition of a kind of learning curve effect that could cause a decrease in the jobs dividend over time as real capital costs fall. Many studies, however, exclude this learning curve information and do not go beyond a qualitative discussion. Our attempt therefore should be seen in this light, as a mere effort to reflect the effect, but admittedly on a simple arbitrary base. Another possibility is to assume different multipliers for the different years[23]. This option was cited in Wei et al. (2010), but not quantified. Nevertheless, the article quotes figures as to solar PV learning from a study performed by the European Photo Voltaic Industry Association and Greenpeace (2006) in which CIM employment is projected to decrease by about 25% from 2010 to 2020 due to industry learning and cost reduction. NREL (2009) foresees a reduction of 55% over 17 years between 2008 and 2025, from 42 jobs per installed MW of solar PV in 2008 to 19 jobs per installed MW by 2025.

Based on this reasoning, a decrease of the employment multipliers by 1% each year was applied from 2013 to 2030. Although this percentage seems to be chosen in a random way, it is in fact based on ECB (2006) in which an annual average labour productivity growth rate of 1% was noted for Belgium for the

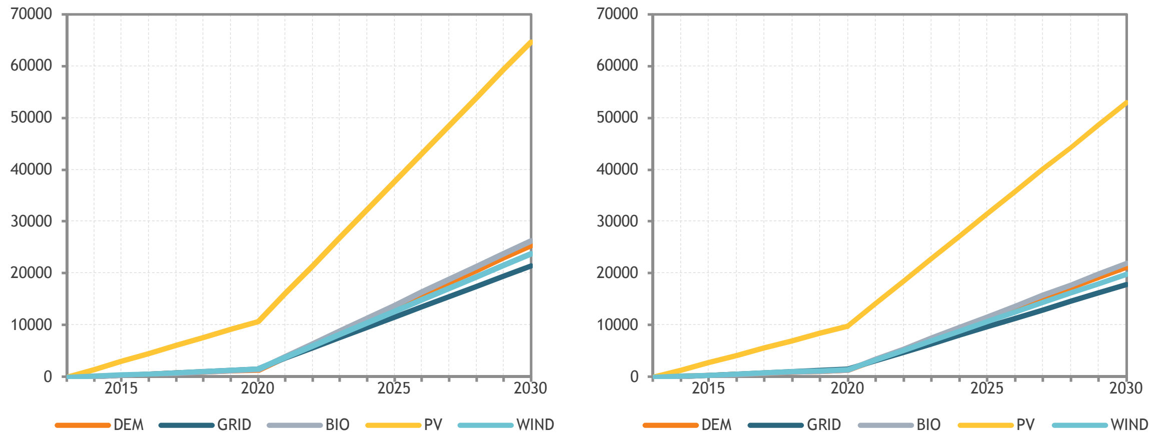
22 These job multipliers show in fact the employment that is cumulatively (directly and indirectly, in the case of energy efficiency investments even induced) used in the production process by an additional unit of output (Sissoko & Van den Cruyce, 2009). They can also be interpreted as labour *intensities*, or the ratio between labour (in volumes or FTE's) and production (in GWh).

23 This could be seen as a decrease in labour intensity or an increase in labour productivity where labour productivity is defined as the value or volume of goods and services produced in a period of time, divided by the hours of labour used to produce them, or the ratio between production (in GWh) and labour.

period 2001-2005[24]. Given that the multipliers can be seen as labour intensities and in this paper, labour intensity is defined as being the opposite of labour productivity, it follows that a decreasing employment multiplier of 1% on average every year could approximate the effect. For solar PV, we apply an even bigger percentage loss between 2013 and 2030 (-1.2%) since solar PV has generally shown a faster learning rate than other renewable sources (European Commission, 2011).

Graph 4 then brings 2 additional elements to the analysis: first, it extends the horizon from the decade 2020-2030 to also include the period before 2020, second, the impact of the assumption on the employment multiplier is shown throughout time: it has a depressing effect on job creation.

Graph 4 Annual job-years over REF using the constant multiplier method (left) and the declining multiplier method (right), period 2013-2030
Total FTE's



Source: Wei et al. (2010), Federal Planning Bureau.
Note: FTE=full time equivalent.

Conditional on our hypotheses, 7% (8% in the PV scenario) less jobs are created in 2020 with the declining multiplier method compared to the constant multiplier method; in 2030, the job decrease amounts to 17% (18% in PV) less jobs compared to a situation in which a constant employment multiplier is applied.

Although integrating a decreasing job dividend effect seems to be better in line with real life (productivity and cost reduction) observations, some effects might tilt the balance in favour of constant or even increasing employment multipliers. This could be achieved by capturing the effect export may have on the multipliers. In other words, the analytical model used does not include jobs that may be generated if Belgium develops a specific knowhow and expertise that could be exported abroad. As quoted in Wei et al. (2010), a study by the Research and Policy Center of Environment California shows that, for California alone, a renewable energy industry servicing the export market can generate up to 16 times more employment than an industry that only manufactures for domestic consumption.

[24] This labour productivity growth rate in fact encompasses all activities, so also services and mature activities typically demonstrating lower productivity growth rates than relatively newer activities. Nevertheless, in Quirion (2013) a sensitivity analysis is performed on even lower productivity growth rates: *"Dans la variante centrale, nous supposons que la productivité du travail augmente chaque année de 0,75% par an, ce qui correspond à l'évolution moyenne observée entre 2005 et 2011. Or, cette hausse est déjà plus faible que celle constatée au cours des années et décennies précédentes, et il existe de bonne raison de penser que la productivité du travail va augmenter encore moins vite dans les années qui viennent (Gadrey, 2012)".*

Since other relevant figures were not found, we were unable to take this effect into account, but it is clear that if one's goal is to maximize the number of FTE's generated, the export option can be seen as a job creation catalyst. For this, one should not concentrate on mature technologies and markets in which Belgium has little to contribute[25], but rather go for innovative value chains. For this, a first mover advantage should be constructed which in its turn could lead to strong export markets. This may be the case with the creation of the new energy island, an idea that was recently launched by the Belgian federal Minister of the North Sea[26] to build a donut shaped (or emerald like) island 3 to 4 km out of the coastal line containing a circular lake which can serve as an energy storage tool to bring into service during peak demand and to load at times when demand is down (and (offshore wind) production is present). Although plans were already exposed in the Netherlands, constructing such an enterprise would be a world's first, hence ideal for becoming an export product which, combined with Belgium's savoir-faire in far offshore and dredging, could turn into a success story. Another potential export success story could be seen in the Closing the Circle project of the Group Machiels. This undertaking is an enhanced landfill mining project envisaging the complete valorization of the waste stored at the landfill site of the group in Houthalen-Helchteren through recycling of materials and energetic valorization of the recycling residue, with sequestration or offsetting of the CO_2 generated. Not only the waste-to-materials cycle but also waste-to-energy will be implemented with the ultimate goal of restoring the landfill site to its original status and even converting it into a sustainable nature park. This undertaking is said to generate 600 to 800 direct jobs during 20 years for the one site. Exporting the knowhow and implementing it in cities worldwide with both landfill and surface scarcity issues will be up for considerable employment opportunities in the future.

[25] Due to cost elements such as the price of intermediary inputs and labour costs with high nominal wage growth and low productivity gains (European Commission, 2013).

[26] De Tijd, *Consortium plant energie-atol voor kust*, Jan 17, 2013.

5. Job content

These findings can be complemented by a number of reflections as to qualification of jobs, type of jobs and context creation of the jobs. In the next two points (point 5.1 and 5.2), the discussion on skills, professions and the underlying framework is touched upon, the latter being further elaborated in part 6 together with a short description of a number of policy domains that are highly implicated when establishing employment through the renewable value chain.

5.1. Skills

Upon determining the number of jobs created, a particular concern may be on the skilled versus unskilled jobs' debate and the fact that the renewable industry has a tendency to require rather skilled labour like engineers. According to the American Solar Energy Society green jobs report (ASES, 2008), job growth in the renewable energy and energy efficiency industries is biased towards technical, scientific, professional and skilled workers. Nonetheless, a lot of lower skilled installation jobs are indispensable in the transition towards a PV based society. As regards wind energy, the European Wind Energy Association report (EWEA, 2009) specifically states that wind proves to be a reliable job creator for both skilled and unskilled labour. The wind turbines themselves necessitate construction and installation, as well as longer-term maintenance work[27]. Additionally, the creation of wind farms requires planning, obtaining of permits and ongoing supervision of the turbines. Thus the wind industry employs a range of skilled and professional workers, from engineers, to meteorologists, to site managers, next to a significant amount of unskilled labour.

5.2. Professions

Another reflection can be made on the specific content of the cited jobs: a distinction as to type of jobs (CIM and O&M) has already been made, but our analysis can be taken a step further by filling in which professions would be advantaged and benefit most from a transition towards a renewable future. According to Kanellos (2008) there are a number of privileged sectors like the construction sector, engineering and the food and health (agricultural) industry that may prosper from a green transition, but also educations like informatics (software specialists and interface designers), biology, chemistry, land use planning, civil, mechanical and material engineers and architects will be in high demand. In sharp contrast with this finding seems to be that already today, a lot of precisely these jobs are in short supply and are called *labour shortage occupations*. Shortage occupations are professions for which employers have a hard time finding decent and suitable applicants. This can be due to 3 reasons: either a quantitative deficit due to a lack of specific education or interest (too little enrolments, hence graduates), a qualitative deficit because candidates do not possess the proper skills, or unfavourable working conditions like weekend work, low salaries, stress or other.

[27] According to 2 out of the 5 studies on wind cited in Wei et al. (2010), the total number of job-years created per GWh is the same for CIM (construction, installation and manufacturing) and for O&M (operations and maintenance), according to 2 out of the 5 studies the number of CIM job-years per GWh is approximately 2 times the number of O&M job-years and according to the last study, the number of O&M job-years per GWh produced equals 3 times the number of CIM job-years.

The first 2 reasons point out the capital importance of the need to reinforce and educate human capital because of changes in production methods, but also in consumption patterns and in the materialization of new value chains and business models in a highly renewable society. On top of that, interest in science and engineering, two major pillars in the transition towards an all renewable society, is often lacking[28] and will make an energy transformation all the more challenging. As Andrew Garrad, the chairman of GL Garrad Hassan, a renewable energy consultancy[29], puts it:

> *"There is a real risk of a shortage of suitably skilled workers"*

, singling out a particular shortfall of engineers in operations and maintenance. The same voice is heard within Agoria, the Belgian federation for the technology industry, through its general manager[30]:

> *"A well educated and technical workforce is necessary to invent and produce new things. The stream out of technicians and engineers from our educational system should therefore be amplified."*

So schooling and education, both adapted and adjusted to the needs and wants of an altering society and industry, should be the focal point of any policy accompanying a renewable transition[31]. As to the third element, workers in the fossil fuel value chain have obtained good labour conditions and receive high salaries, so when asked to switch to other (sub)sectors reticence will arise unless similar circumstances are created, pointing to the necessity of a good policy framework.

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28 See also TIMSS 2011 results. TIMSS (Trends in International Mathematics and Science Study) is an international assessment of the mathematics and science knowledge of 4th and 8th grade students around the world. TIMSS was developed by the International Association for the Evaluation of Educational Achievement to allow participating nations to compare students' educational achievement across borders. In science, Belgium (Flanders) only occupies the 27th place, in mathematics it performs better (7th place).

29 Euractiv.com, *Wind power buffeted by 'political uncertainty' but still growing*, Feb 8, 2013.

30 Vertaling van "*Goed geschoold technisch personeel is nodig om zaken uit te vinden en te produceren. De uitstroom van technici en ingenieurs uit ons onderwijs moet dan ook hoger.*"Persbericht Agoria, *Omzet hernieuwbare energiesector verdubbelt tegen 2014*, http://www.agoria.be/WWW.wsc/Agoria-Omzet-hernieuwbare-energiesector-verdubbelt-tegen-2014-124388?vWebSessionID=41287&vUserID=999999&ENewsID=70566&TopicID=6597&TopicList=6597&ComingFromResultTopic=1911.

31 In this regard, the agreement reached within the Flemish government concerning the master plan for the reform of secondary education is a step in the right direction. For further information, see http://www.scribd.com/doc/145810353/Masterplan-hervorming-secundair-onderwijs.

6. Policies for RES

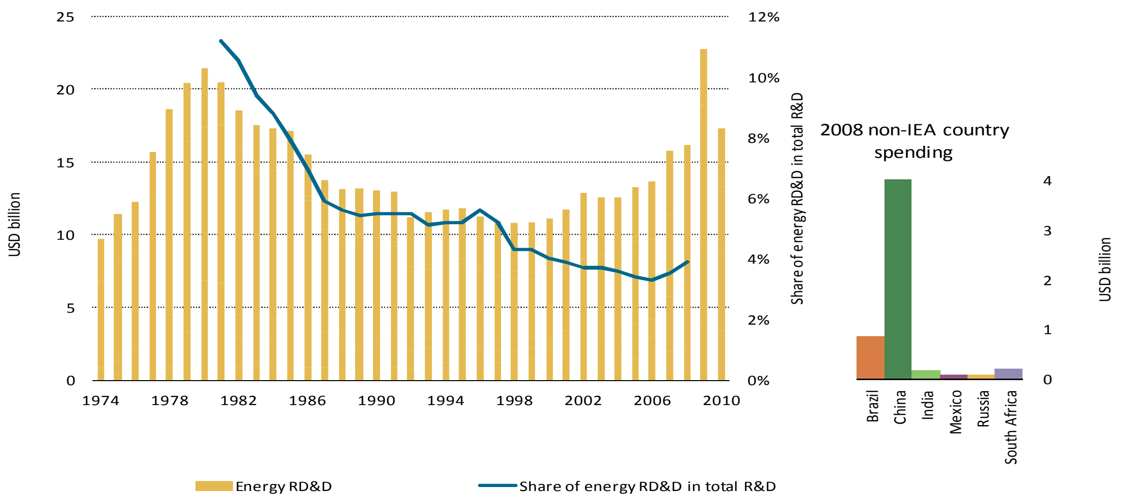
A good policy framework then is indispensable, especially because employment opportunities are predicted to rise in the coming decades. According to the technology federation Agoria, the amount of jobs in the renewable energy sector, estimated to be at 11,325 in 2009, is foreseen to evolve to 33,125 by 2020, or a tripling in the number of occupations. On top of that, greening of other industries has the potential to provide new employment opportunities, for instance, in retrofitting vehicles to cut fuel consumption, installation of water-saving equipment and adaptation to climate change.

However, when we are confronted with precarious news announcements surrounding Ford Genk or Arcelor Mittal to name just a few, green employment opportunities are not yet growing rapidly enough. This is indicatory of the fact that these jobs will not happen as a matter of cause. For these jobs to materialize, government action is required. Government action will not only determine whether or not jobs will be created, but also how many jobs could be created. For this, governments at all policy levels should establish an ambitious and clear framework. Transversal policies and shared responsibilities have to be put in place, with a specific focus on three policy domains: labour market, education and innovation.

As the first two policy domains are already touched upon in 5.2, the focus in this part is on innovation and innovation policies. In this regard, it will be crucial to build, uphold and improve the competitive position of manufacturers of RES technology[32] as well as to reduce the costs of renewable energies by exploiting their full learning potentials. Policies which promote technological innovation in RES technologies and lead to a continuous and sufficiently fast reduction of the costs will then be decisive. Governments have a crucial role in supporting the whole innovation chain through policies and legislation. Implementation of strong measures on a national and international scale is indispensable and optimally should lead to the creation of large markets capable of exploiting economies of scale and accelerating further research and development. Positive signals on a regional basis could be seen in the foundation of I-Cleantech and Energyville in Flanders and several proposals in the framework of the Walloon Plan Marshall 2.Vert, to name just a few. Other initiatives should follow. Worrying is that on the international (OECD) level, exactly the opposite movement can be observed. The picture below (Graph 5) taken from the IEA flagship publication Energy Technology Perspectives 2012 (ETP 2012) demonstrates a rather depressing view on innovation: the share of energy RD&D in total R&D (strongly) decreases throughout time. Although public RD&D hit a new high in 2009 mainly as a result of economic stimulus spending, it declined sharply in 2010 to just above 2008 levels. Overall, the energy sector only accounts for about 4% of total government R&D spending, down from well over 11% in 1980. This weakening support for energy RD&D represents a major challenge, given the strategic importance of the sector. Eurelectric (2012), the sector association of the European electricity industry, confirms and strongly recommends using innovation as catalyst for the much needed energy transition.

32 Which in its turn is highly influenced by the national labour tax policy.

Graph 5 OECD R&D spending
USD billion (left) and % (right)



Source: IEA (2012).
Note: RD&D=Research, Development and Demonstration; OECD=Organisation for Economic Co-operation and Development; IEA=International Energy Agency.

7. Conclusions

In this paper, we elaborated on the employment impact triggered by a transition towards an all renewable energy system in Belgium by 2050. The job impact is estimated up until the year 2030.

We see that, using a labour intensity methodology, net job gains are to be expected in each and every renewable scenario. The renewable trajectories all create more full-time equivalents (FTE) than the reference scenario for any given year. The PV scenario creates the most FTE's in any given year. A distinction is made between CIM and O&M jobs, where it is obvious that the maximum amount of CIM jobs created over the reference scenario exceeds the amount of O&M jobs. This points to the fact that a lot of renewable energies have a high construction and installation component in employment. These installation jobs, along with a lot of other types of jobs (monitoring, planning, certifying), are bound to remain domestic.

It was also possible to extend the analysis and project net employment forecasts for the years up to 2020. Next to that, a sensitivity analysis on the effect of a decreasing employment multiplier throughout time was modelled. Although the applied methodology is rather simplistic, we have sound arguments to take it into account. On the other hand, numerous factors that favour a constant or even increasing multiplier effect are mentioned.

At the end of the paper, a number of reflections on jobs and job content are brought to the fore. It then becomes obvious that targeted educations, preferably in close collaboration with industry, and training, (re)tooling and schooling with specific attention to revamping interest in science, engineering and RD&D are of utmost importance. The crucial role of installing a coherent policy framework and defining adequate measures should not be underestimated. Transversal and well synchronized PAM's could prove useful in tapping the vast job potential created by shifting society towards renewable energy sources.

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Annex

1. The reference scenario

The starting point of the scenario analysis is the construction of a baseline or reference scenario. It is important to stress the role of this scenario for policy analysis with the TIMES model. The reference scenario is not aimed at forecasting the development of the energy system. It gives a consistent development path for the energy system, using a cost optimisation approach and a simplified representation of the energy users' and suppliers' behaviour in TIMES. The reference scenario serves as a basis to evaluate the cost of policies and their impact on the technological choices in the energy system. The reference scenario can therefore deviate from the evolution of the energy system in recent years which reflects the behaviour of the economic agents in real life, their expectations and the dynamic adjustment of the energy system. It allows however a consistent treatment of the technologies in the policy evaluation.

The REF scenario does not imply any renewable energy target by 2050 but it takes into account the objectives of the 2020 EU Climate-Energy Package. For Belgium this means that according to Directive 2009/28, the share of renewable energy in gross final energy consumption in 2020 equals 13% but that there are no other binding targets beyond 2020.

It is important to notice that although the REF scenario is bounded by some renewable technology parameters (biomass, PV, wind), these limits are never reached. Since there is not yet clear evidence that this technology will be able to be deployed on a large scale under the current circumstances, no geothermal capacity is included in the REF scenario.

2. The 100% RES scenarios

One of the common assumptions of the RES scenarios is the share of renewable energy in intermediate periods (2030 and 2040). These are implemented exogenously at 35% in 2030, 65% in 2040 and 100% in 2050. These targets are taken as a fraction of the primary energy consumption (while the European renewable targets for 2020 are defined as a fraction of the gross final energy demand).

2.1. DEM scenario

In the demand (DEM) scenario, the only renewable energy sources that can be used in Belgium are local (except biomass and off-shore wind). Furthermore, the energy service demand is supposed to be elastic. In this scenario, the insufficient availability of local renewable energy sources raises energy prices, simultaneously lowering the energy service demand to a level that is compatible with the Belgian renewable energy potential and the 100% RES target.

2.2. GRID scenario

In the GRID scenario the lack of renewable energy is compensated by an increased possibility of importing electricity from abroad. In this scenario, the level of electricity imports is unconstrained but the interconnection capacity cannot exceed 10 GW.

Because the model is limited to the Belgian energy system, it cannot give any information about the energy mix of the electricity imported from Europe as a whole.

2.3. BIO scenario

The world biomass supply is assumed to vary between 160 and 270 EJ/year according to sustainability criteria. In all renewable scenarios (except the BIO scenario), the Belgian use of biomass is assumed to be proportional to the share of the Belgian population in the world population in 2050. Since the Belgian population is presumed to equal 0.14% of the world population in 2050, the Belgian energy system can use between 224 PJ and 377 PJ. The average between these two values (300 PJ) has been used in the model. It is important to notice that this 300 PJ comprises both local potential as well as imports.

In the BIO scenario, the world potential is left unchanged but the share of renewable consumption is no longer based on the share of the Belgian population but on the share of the Belgian GDP in the world GDP in 2050. In the BIO scenario, the Belgian use of biomass (local production + imports) cannot exceed this GDP based translation of the world potential which is equal to 1,097 PJ.

2.4. PV scenario

In all renewable energy scenarios (except the PV scenario), solar panels (both thermal and photovoltaic) are widespread on all available well oriented buildings' roofs (residential, tertiary and industrial) representing a global surface of 250 km^2 in Belgium. In the PV scenario, other additional surfaces can be mobilized (parking lots, gardens, greenfields, etc.) but the maximum surface used to install solar panels has to remain beneath 10% of the Belgian territory (i.e. not more than 3,000 km^2).

2.5. WIND scenario

The wind resources are composed of two energy sources: onshore and offshore. In all scenarios (except the WIND scenario), the onshore potential is limited to 9 GW as estimated in different regional studies, while the offshore potential equals 8 GW. The latter represents only a limited part of the Belgian offshore potential as calculated in the study of Mathys et al. (2010). In all scenarios (except the WIND scenario), a complementary 13 GW offshore capacity is supposed to be installed in maritime areas of neighbouring countries. In the WIND scenario, these limits can be exceeded by lowering the constraints related to the construction of windmills (co-visibility, etc.) or by importing more offshore electricity from the EEZ of the North Sea countries. Thus, in the WIND scenario, the onshore potential increases to 20 GW and the offshore potential is considered to be unlimited.