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Renewable energy investment and job creation; a cross-sectoral assessment for the Czech Republic with reference to EU benchmarks.

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Abstract
The development of renewable energy sources has been primarily justified on the ground of environmental policies and energy security, but new jobs opportunities and establishment of new economy sectors may be equally important co-benefits from investments in this sector. The main goal of this paper is to assess the employment benefits of investments in renewable energy in the Czech Republic. We examine the level and rate of the development of the renewable energy sector in the Czech Republic in terms of ('green') job creation for the period 2008 – 2013, in comparison to data from other EU countries, including Germany as a leading early investor in renewables. Whilst the deployment of renewable energy in the Czech Republic has succeeded to create a significant number of jobs (more than 20 000 employees in 2010), our analysis illustrates a strong dependency of job creation on the continuation of financial incentives. We also find that biomass and waste energy processing offer the highest employment per MWh, which benefits employment in (economically fragile) rural areas. We discuss the question of competitiveness of a country that was not amongst the early adopters of renewables, arguing that the technical skills of the labour force in the Czech Republic provide a potential for more sustained investments in the sector.

Key words
Renewable energy, green jobs, rural employment, financial incentives.

1. Introduction

Affordable and reliable access to energy services lies at the heart of government energy policy, but there are always several other objectives to consider, from considerations of geopolitics, industrial and social policy (e.g. extending the electricity grid to the entire population; creating and maintaining employment), to concerns about environmental sustainability (e.g. smog, acid rain and since the 1990s, greenhouse gas emissions). These multiple policy objectives come into play also when we consider investments into sub-sections of the energy system. The rapid growth of renewable energy generation in the European Union is underpinned by targets expressed in MWh and CO2 equivalents; the Europe 2020 Strategy aims for 20 % of energy from renewable sources on total energy consumption and 10 % of „green— renewable energy used in transport by 2020, whilst achieving 20 % decrease of greenhouse gases emissions until 2020 and an increase of energy efficiency by 20 % (- all in reference to 1990 levels; [1]). But the overall success of the investment in renewable energy will not only be measured in terms of achieving those targets. The support for renewable energy through tax payers‘ money will also be assessed (by proponents, opponents, government evaluators) through other criteria, such as cost-effectiveness, environmental and social impacts and energy security (e.g. in terms of national self sufficiency in energy production). This paper aims to evaluate one such criterion; the extent to which renewable energy developments have been beneficial in terms of job creation. The Czech republic is presented as a case study of a country with an economic legacy of energy intensive manufacturing and a political legacy of post-socialist transition, rapid economic restructuring and recent adjustments to EU targets and regulations.

The paper is structured as follows. First the literature on renewable energy and (green) job creation is reviewed. Secondly recent developments of renewable energy and associated financial incentives in the Czech Republic are analysed. Having collated statistics from relevant sources, quantification of the creation of employment in the renewable energy sector is performed, looking at individual renewable energy (RE) types; biomass, wind power, photovoltaics, biofuels, geothermal energy, solar thermal energy, biogas, waste, heat pumps, small hydro power. In the final part of the paper, conclusions from the analysis are drawn, and several recommendations for suitable policy actions in the renewable energy sector are provided.

2. Literature review; green growth and renewable energy

In the last few years, the concept of so called 'green growth‘ has been widely discussed within EU countries as a more sustainable and more environmentally friendly path of economic development. This concept puts the emphasis on the sustainable use of natural sources and consequent improvement of the quality of life of the population, social justice and reduction of environmental risks [2], [3], [4] and [5]. Seeking to project leadership in this field, the European Union has incorporated green growth into the Europe 2020 Strategy. At a global level this concept resonates in the Organisation for Economic Co-operation and Development [6], and the United Nations Environment Programme [7]. Public and private sector investment in green growth leads to the creation of new jobs (so called ‘green jobs‘) in various sectors of the economy in activities linked to environmental issues [8], [9], [10] and [11]. An important part of green jobs are those in the renewable energy sector. At the most basic level, employment in the renewable energy sector can be divided into construction and operation [12]. Other authors identify three job categories: technological development; installation/uninstallation; maintenance [13], or manufacturing; operation; fuel extraction and processing [14] – the latter category only being relevant to biomass energy. Employment in research and development (R&D) of renewable energie technologies may be also added as a category of employment, but the Czech Republic relies mainly on R&D carried out in other countries. Different types of renewable energy jobs contribute differently to national or regional development. Cameron and Zwaan [15] argue that the most long-term benefits for given regions are linked to the location high-tech companies and research institutes, which focus

on R&D. Factories for assembling of renewable energy facilities and units provide a less secure type of regional employment. Highly depended on the cost of low and semi-skilled labour force, such factories are easily moved to other regions [16] and [17]. Many studies discuss the problem of employment in renewable energy in the context of the life cycle of individual products/facilities (e.g. [18] or [19]).
Lehr et al. [20] argues, that the best way to increase the number of jobs in the renewable energy sector in a given region (state) is to generate power for export. On the other hand, this solution is in contradiction with the paradigmatic environmental benefits of renewable energy, which should be ideally generated within decentralized system and locally consumed to reduce transport costs and transmission losses [21] and [22]. Thus, impacts of renewable energy developments on labour markets should be assessed in the context of not only economic, but also social and environmental contributions, which are sometimes underestimated [23] and [24]. As evidenced by Waclawek et al. [25], one of difficult tasks for investors in renewable energy is to find suitable workers with appropriate science and technology skills and engineering knowledge, since boom of this sector creates high demand for highly educated workers like project managers, engineers and operating workers as well [26], [27], [28]and [29]. Such labour demand may cause problems particularly in Central European countries who suffer significant brain drain; free labour movement in the EU draws skilled professionals towards Western Europe where the salaries are much higher.
Studies from various countries, including Spain (e.g. [30]) and China [31], report gaps between the demand and supply of qualified workers in domestic RE markets. Links between employment in the RE sector and welfare impacts (multiplier effects) have been studied by [32] and rigorously reviewed by [33], pointing out that due to strong expected growth of the renewable energy sector, potential welfare impacts should be more wisely planned and managed. On the other hand, direct employment effects of the RE sector have been studied for various countries, including Germany [20] [34] and [35], Japan [36] and Jordan [37], indicating significant impacts of the RE sector on domestic labour markets.

3. Methodology and data

The aim of the paper is to analyse contribution of the RE sector to employment and thus indirectly to competitiveness of the economy of the Czech Republic. As in many countries, detailed evidence of employment in the Czech RE sector is lacking. This data gap is in part due to the official national statistics office being late to adopt the RE sector as a separate category of employment.

There are two generic approches to address this gap. First of all input-output models or analytical models might be applied [13]. Data used for analyses in this paper originate from the annually updated database EurObserv'ER and in databases of the International Renewable Energy Agency. These databases have been developed by means of application of analytical models, since they gather data from government entities (e.g. ministries, statistical agencies, energy regulatory offices), industry representatives and sectoral associations (biogas, wind or solar energy associations etc.). In comparison to the analytical models, the latter also capture data on indirect employment in the RE sector. In short, above mentioned database were utilized because (a) renewable energy is not singled out as a individual sector in the national economic, trade or labour statistics in the Czech Republic; and (b) usage of these databases enables comparability of analyses between various EU countries (a similar metodology for gathering of data was employed).

On the other hand, the data in mentioned databased are only available until 2013; an important shortcoming given the strong rates of change in the RE sector. Employment in individual types of RE technologies is surveyed (biogas, biomass, biofuels, wind, solar, geothermal energy, as well as Czech projects smaller than 10MW using heat pumps, waste and small hydro-energy). Data on installed capacities and production of electricity were supplied by the Energy Regulatory Office of the Czech Republic and the International Renewable Energy Agency

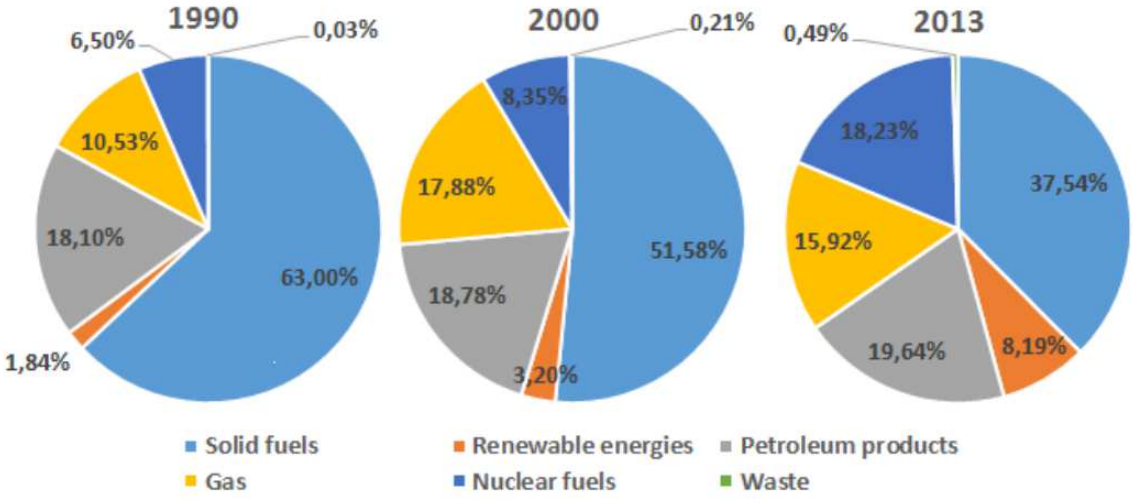
In the absence of a national database that covers changes in employment in renewable energy sector in the Czech Republic, the annually updated French database EurObserv'ER was utilized as the primary source of data. This database records both direct and indirect jobs in renewable energy sector in individual countries of the European Union. Data on employment have been gathered from a wide variety of sources, especially from the national statistical office (Czech Statistical Office – www.czso.cz) and national energy agency (Energy Regulatory Office – www.eru.cz) of the Czech Republic. Additional data on costs connected to governmental support for renewable sources in the Czech Republic originated in already mentioned the Energy Regulatory Office and Ministry of Trade and Industry of the Czech Republic (www.mpo.cz). The methods used in this paper include policy document analysis, descriptive statistics and trend analysis (spatial and temporal), coupled with a literature review to benchmark the findings.

4. The energy sector in the Czech Republic. An overview

In last 25 years the energy system of the Czech Republic has been transformed. The primary impuls was the rapid transition to a market economy and deep restructuring of energy sector and energy intensive industries, which resulted in the reduction of pressure on the environment and rationalizing resource management. The last 20 years have seen further transformations in the energy system, driven by climate protection policy, liberalisation of electricity market as well as energy security (dependence on imported oil and gas) and energy efficiency. This progress was closely linked with integration of the Czech Republic as a member state of EU in 2003.

These recent transformation of the Czech energy sector are characterised by a decreasing use of solid fuels (coal) and an increase in nuclear, gas and renewable energy (figure 1). In the period 1990-2013, energy consumption decreased by 15% (from 49 868 to 42 190 thousand of tones of oil equivalent). However, due to the continued dominance of manufacturing (47.3% of GDP), the Czech Republic remains one the most energy demanding economies in the European Union.

Fig. 1: Gross domestic energy consumption in the Czech Republic



Source: Eurostat

Nowadays more than 50 % of the consumption of primary energy sources in the Czech Republic is provided by domestic sources. The import energy dependence indicator (including nuclear fuel) is therefore less than 50% and is one of the lowest in the EU. [37]. (State Energy Policy 2015). This high level of energy self-sufficiency is primarily due to domestic coal production .

The Czech Republic is fully self-sufficient in production of electricity. Almost 60 % of electrical energy and a large proportion of heat through district heating use domestic coal as fuel. Also biomass supply some heating plant with cogeneration production of electricity. Some 33% of domestic elektricity production is provided by Dukovany and Temelín nuclear power stations (2GW installed capacity each). The export of electricity has been significantly increased after the opening of the nuclear power plant in Temelín in 2002. In 2013 around 17 TWh of electricity was exported, which exceeds Temelín's production by 2TWh. With plans to construct additional nuclear power units by 2035 and extending the lifetime of the existing Dukovany power plant up to 50 or 60 years [38], domestic electricity production is expected to continue to exceed domestic consumption in the long term.

Natural gas is used for district and individual heating, industrial uses or generation of electricity. During the last ten years gas consumption has fallen by 20 %. This is primarily the result of investments for energy saving measures in the building industry (use of more energy effective materials, windows, etc.) or more efficient use of appliances, as well as the reduction in certain types of industrial production during economy crisis.

Electricity production from renewable resources has been rising rapidly in recent years. In 2010 it was 8.3 % of domestic gross electricity consumption, in 2013 13.17 % (9.2 TWh/y), constituted mainly of PV , Hydro, solid biomass and biogass (table 1).

Table 1: Installed capacity for renewable electricity generation in the Czech republic in the period 2002-2013(in MW)

	Hydropower[a]	Onshore wind	Biogas	Solid biomass	Photovoltaic
2002	1000	3	0	3	0
2003	1004	11	25	71	0
2004	1015	17	33	106	0
2005	1020	22	36	105	1
2006	1016	44	43	136	1
2007	1024	114	50	179	4
2008	1029	150	71	216	40
2009	1037	193	96	257	465
2010	1049	213	118	314	1727
2011	1050	213	177	349	1913
2012	1065	258	300	375	2022
2013	1080	262	361	351	2064

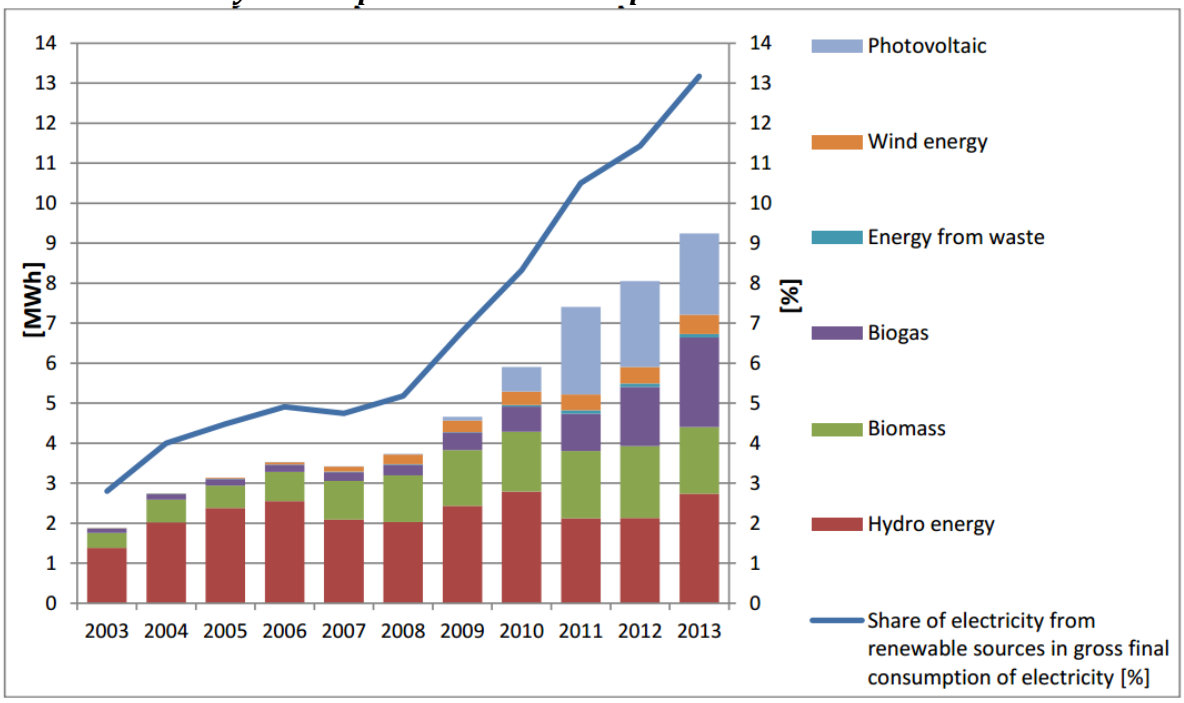
** Pumped Storage is not included*
Source: International Renewable Energy Agency

5. Results and discussion

5. 1 The development of renewable energy in the Czech Republic

The development of renewable energy has a decades long tradition in the Czech Republic; early developments included hydro power (early 20th century) and biogas (1970s). The new era for renewable energy started in 2005, when the national Act on support of renewable sources of energy (no. 180/2005) was adopted. This act supported electricity and heat generation from renewable sources through feed-in tariffs and green bonuses [39]. The year 2005 was a turning point for the development of renewable sources of energy in the Czech Republic; since then, the growth of this sector has been significant (see figure 2).

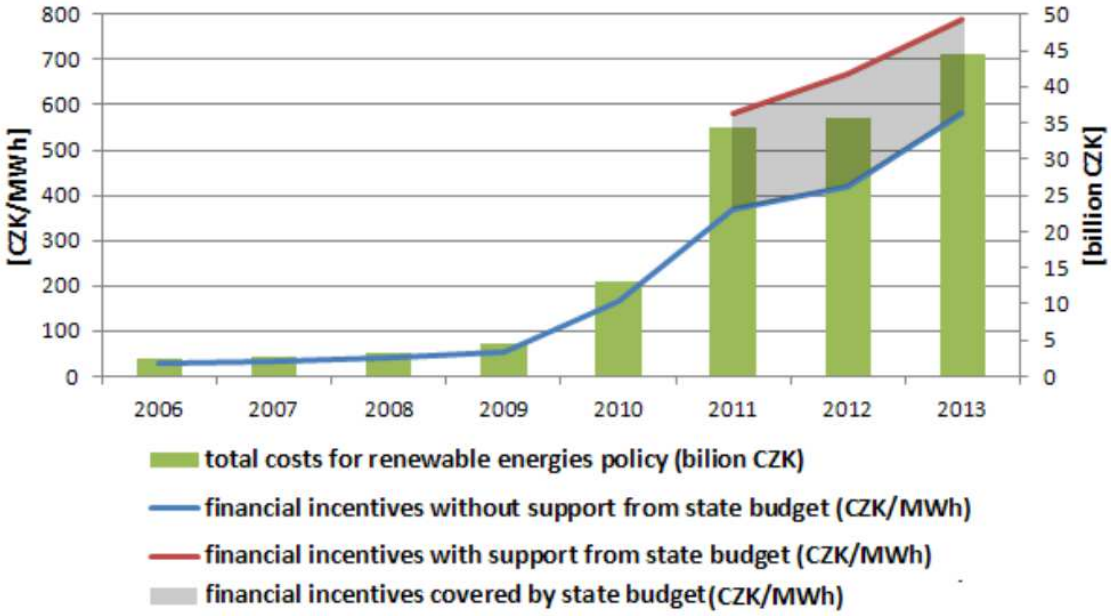
Fig. 2: Development of electricity generation from renewable sources and its share of gross domestic electricity consumption in the Czech Republic



Data source: Renewable sources of energy in 2013, Yearly Report on the Operation of the Czech Electricity Grid for 2014

But the sharp growth of renewable energy has been accompanied by a controversy about the so called solar boom, which took place in the Czech Republic in 2009-2010. Misguiding governmental supportive policy for renewable energie caused a massive increase of large scale photovoltaics (PV) farms dependent on state guaranteed purchase prices, resulting in accusations of waste of taxpayer‘s money (the profit margins were perceived to be rather high), profiteering by politicians (several of whom were associated with solar farm investments) and the siting of PV farms in less appropriate locations [41]. This controversy led to strong pressure to change the legislative framework of support for renewables and a reassessment of the level of financial incentives. Gradually direct payments were reduced and the types of supported renewable sources specified more precisely to avoid speculative investments. New tax duty has been applied for operators of PV´s, tax benefits were abolished and since early 2014, support for new installation of PV´s and biogas stations has been stopped completely. The size of financial contributions to renewable energy supportive policy shows upward trend and nowadays it creates together with distribution costs circa 50 % of the price of electricity. All consumers of electricity in the Czech Republic are made to contribute to renewable energy policy with no exceptions and no maximum contribution is specified. This contrasts with Germany where the majority of costs for renewable energy policy is paid by households [42] while large consumers (energy demanding industries) had paid just 0.05 €/MWh and maximally 500 thousands €/year until mid-2014. Since then the German policy has been changed, the list of large consumers reduced and payments for renewable energies almost doubled, but still the burden for large energy German consumers is relatively lower than it is in the Czech Republic. The overall financial support for renewable energy has grown annually by tens of percentage points since 2009 in the Czech Republic (see figure 3). The steep growth of green energy contribution was in 2011 mitigated by financial support from the state budget of the Czech Republic. High prices for energy led to negotiations with government initiated by representatives of energy-intensive industries (metallurgy, engineering, glass-making industry and chemical industry), which resulted in a lowering of consumer contributions to the development of renewable energy (to 18 Euro/MWh by 2014). Nevertheless, this decrease of contributions by private bodies was balanced by a growthing support from the state budget and thus by a deepening of public finance deficit.

Fig. 3: Development of governmental incentives for renewable sources in the Czech Republic in 2008 – 2013



Source: Energy Regulatory Office (available at http://www.eru.cz/cs/statistika), authors own processing

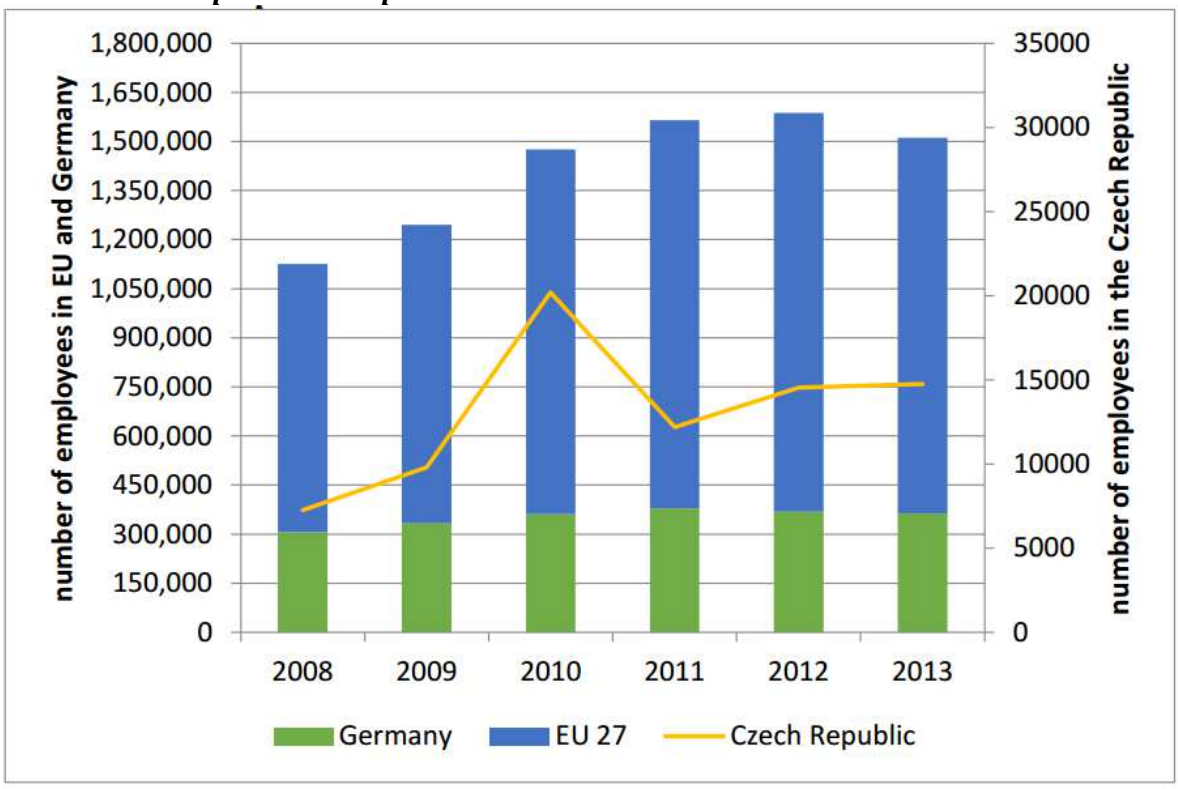
In 2013, the total cost of Czech renewable energy policy was estimated by Energy Regulatory Office at 1.65 billion Euro, 910 million Euro of which was paid by big energy consumers, 430 million Euro was paid from the state budged and 310 million Euro by households. The contribution to renewable energy policy from the state budget is quite large, when we consider that this amount represents roughly 1 % of planned expenditures of the state budget. Household contribution to renewable energy subsidies amount to 71 Euro per household per year, which represents a significant burden. The crucial role of big consumers (industry) in the financing of renewable energy developments has negative consequences in weakening of competitiveness of Czech industry in European and world wide [43]. The industrial sector in the Czech Republic employs circa 40 % of population and generates circa one third of Gross domestic product (GDP), making the Czech Republic one of the most industrialized EU countries. Industry representatives have argued that the cost of renewable energy impacts negatively on the profit margins of energy intensive industries, reducting of their ability to invest in research and development of new technologies and may ultimately result in lower rates of job creation and higher unemployment in the industrial sector.

A study of the impacts of renewable energy on the economy estimated that the contribution of renewable energy to GDP growth of the Czech Republic was 0.8% in 2010 [44]. Nevertheless, the same study refers to the important role of direct investments into the renewable energy sector; these are expected to decline in the near future and thus the share of renewable energy to national GPD will probably decrease.

5.2 Employment in the renewable energy sector

The renewable energy sector is one of the fastest growing sectors of the economy within the European Union. In 2010, when the European Commission approved the European energy strategy —Energy2020 [45], this sector employed some 1 114 210 workers (directly and indirecly). Two years later in 2012, it was up by some 10 % to 1 218 230 [46] (see Figure 4). By 2020, a further increase of employment in renewable energy sector by more than 600 thousands workers is expected [45]. When the fulfilment of the aim of 20 % increase of energy efficiency by 2020 is also taken into account, it can be assumed that more than 1 million of new jobs will be created in the period 2010-2020.

Fig. 4: Number of employees in the renewable energy sector in the European Union, Germany and the Czech Republic in the period 2008-2013



Data sourced from: The State of Renewable Energies in Europe. 9th, 10th, 11th, 12th, 13th,14th. EurObserv'ER Report

Within the European Union, the German renewable energy sector serves as a leading benchmark. Almost one third of total number of jobs in the European Union in renewable energy sector can be found in Germany and one quarter of European turnover in the RE sector is registered there. To picture of importance of renewable energy sector in Germany more clearly in numbers, in 2012 it employed 377 800 workers. This sector can be broken down (in order of size) into the production of facilities for renewable energy and their installation (227 100 jobs); direct operation and maintenance of these facilities (80 700 jobs) and workers in sector of biofuels (60 600 jobs). But the picture of the labour market of the German renewable energy sector will not be complete without mentioning workers in research, administration and for example in public promotion [47] and [48]. It is clear that the importance of the renewable energy sector for German labour market is heavily influenced by the fact that a significant part of its production (especially of facilities for generation of renewable energies) is exported to other countries both within Europe and overseas. The majority of these jobs in the production of facilities for renewable energy generation relates to wind (98 600 jobs) and solar (78 900 jobs).

Table 2: Jobs and annual turnover in the Czech renewable energy sector (2008-2013)

	2008	2009	2010	2011	2012	2013
Number of jobs	7400	9800	20,200	12,200	14,525	14,700
Turnover (millions €)	565	2025	4612	2185	1645	1650

Data sourced from: The State of Renewable Energies in Europe. 9th, 10th, 11th, 12th, 13th,14th. EurObserv'ER Report

Table 2 shows employment per unit of output in the Czech RE sector since 2008; the year when RE started its huge growth in the Czech Republic. Since then, installed capacity of renewable energy has been increased four time. The number of jobs peaked in 2010, when generous government aid for PV´s ended. The subsequent sharp fall has been partially mitigated by increase of jobs in biomass sector. During 2012 increase of jobs was experienced to 14 525 (annually by 2 325 jobs), for following year 2013 only limited growth can be seen. And again, such increase can be put in context of growth of biomass, biofuel and biogas sectors, where positive important environmental, landscape and regional development impacts and whose potential has remained underutilized until then [54] and [55]. In terms of absolute numbers of employees in renewable energy sector for individual countries of the European Union, the 17th place is occupied by the Czech Republic. This position has been stable, except for the year 2010 when the Czech Republic was in 12th place.

Table 3 Renewable energy development and employment (2008-2011)

Type of energy	**Number of jobs/installed capacity (MW)**				
	Minimum (year)	Maximum (year)	Mean	Variance	Correlation[a]
Biomass	11.2 (2010)	19.7 (2013)	15.8	9.5	0.86*
Biofuel production[b]	7.2 (2011)	19.8 (2010)	12.0	18.5	0.55
Solar-photovoltaic	0.7 (2013)	25.0 (2008)	6.1	89.5	0.21
Biogas	2.8 (2011)	3.6 (2013)	3.3	0.2	0.99*
Wind	0.9 (2013)	4.0 (2008)	2.3	1.5	−0.62
Small hydro	0.9 (2008)	1.2 (2013)	1.0	0.1	0.87**
Total	4.1 (2011)	9.6 (2008)	6.3	5.2	0.71

1 in case of biofuels, jobs per ton of biofuels are calculated

*2 Value of Pearson´s r is significant at the level of *p <0.05 or **p <0.01*

Table 3 shows that there is no statictically significant correlation between overall installed RE capacity and the number of jobs in this sector. On the other hand, large differences are found between different types of renewable energy. Significant positive correlation between installed capacity and number of jobs is found for biomass, biogas and small hydro-power. In case of wind energy, a negative correlation is identified; with a moderately growing installed capacity of wind energy, the number of jobs is decreasing. This peculiar trend would suggest that more people are engaged in wind energy projects during scoping and project preparation than during the actual building of the wind farm. Whilst this is not necessarily the case for individual projects, it has been the case on aggregate in the Czech republic where a lack of suitable sites and high level of local opposition have severely curtailed prospects for further growth of wind energy. As result, most companies which focused on development of wind energy project have now terminated their activities in the Czech Republic.

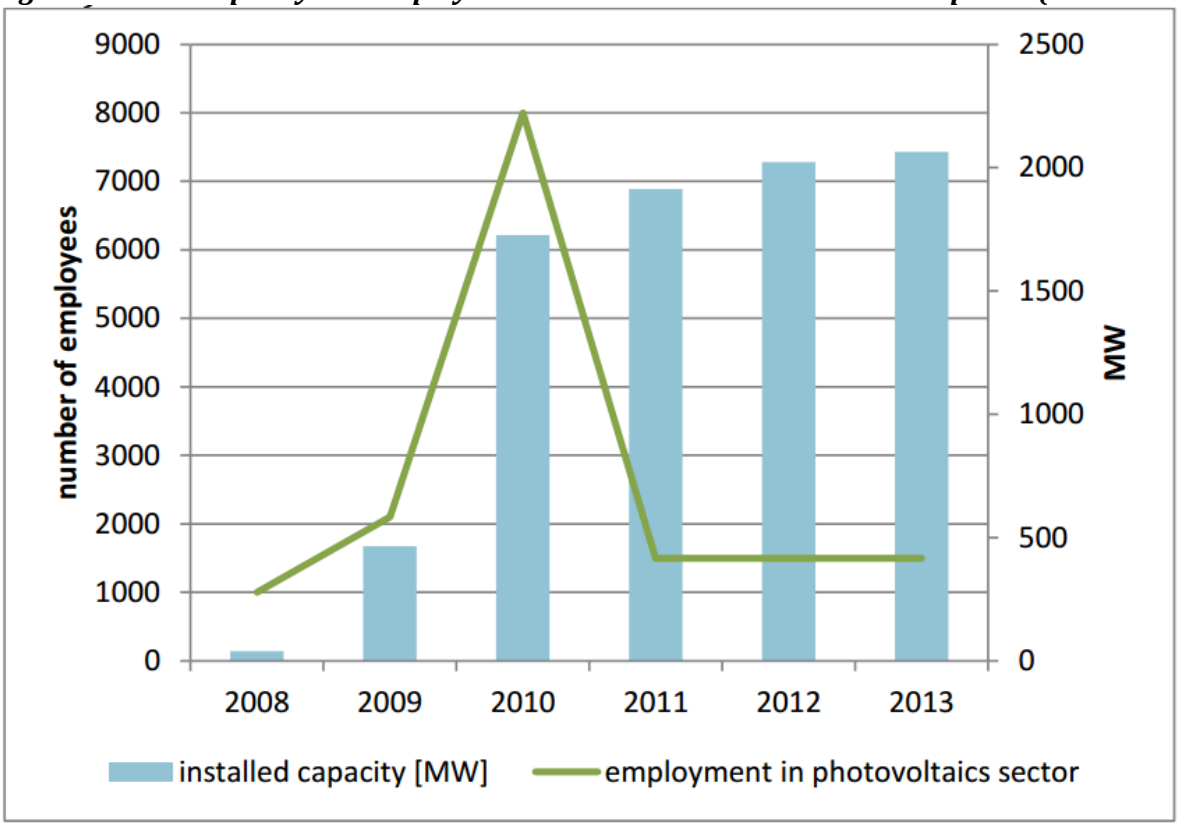
In the case of PV and biofuels the largest swings (variations) are due to significant changes in feed-in tarrifs. Increasing employment in biogas and biomass are due to increased demand for biomass energy; this trend is related to the Common Agricultural Policy and Czech rural policy [56].

Generally the largest impact on growth of employment was identified in case of biomass and biofuels sectors (15 jobs for 1 MW of biomass energy), whilst wind energy and small hydro-power generated the fewest jobs per unit of installed capacity. More jobs per unit of output could be seen as a desirable trend for regional employment, but potentially also as a negative trend in economic efficiency (i.e. more labour cost per unit of output).

5.2.1 Employment in photovoltaics

At the hight of the solar boom in 2010, 8 000 people worked in PV (for comparison, in the same year, neighbouring Slovakia employed 7 030 workers for all renewable energy technologies). The Czech solar boom ended in 2011, when governmental financial incentives were reduced. The labour market responded with a 81% decrease in PV related jobs; down to just 1 500 jobs (figure 5). Unless the government decides on a U-turn in solar subsidies, new investment in PV installations and associated employment is not likely to pick up again in the coming years.

Fig. 5: Installed capacity and employment in Photovoltaics in the Czech Republic (2008-2013)

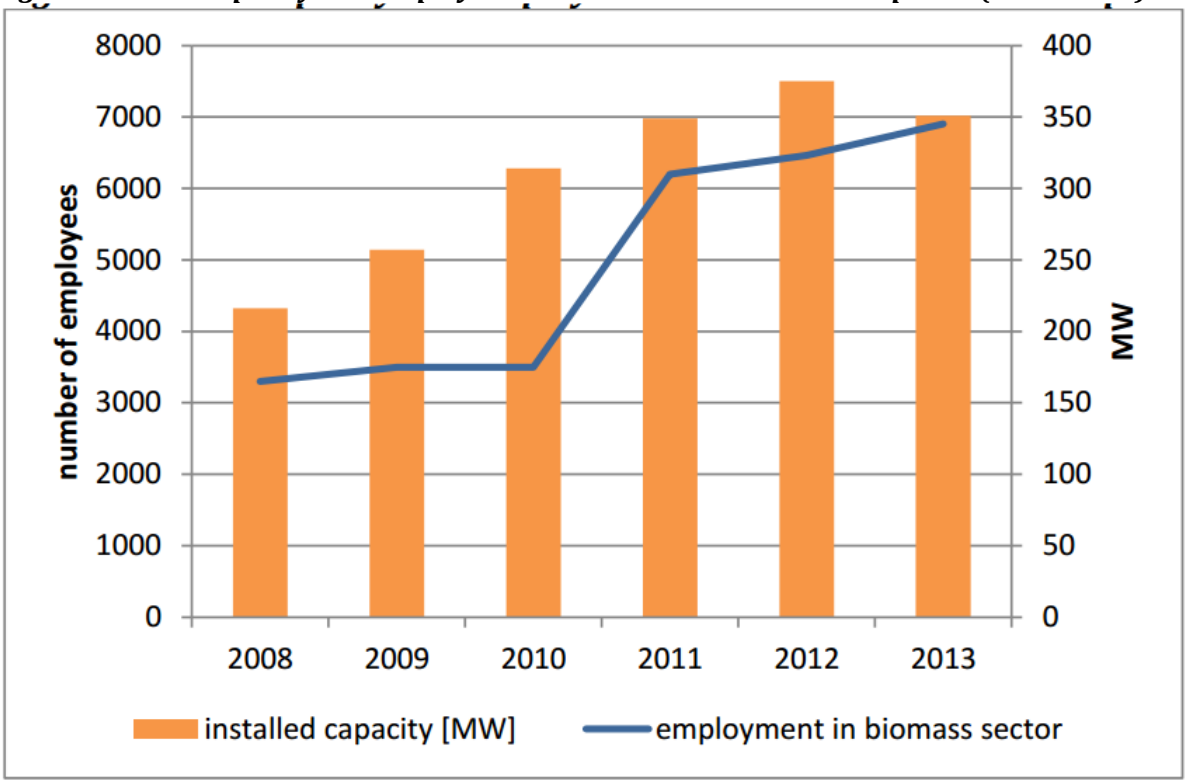


Data sourced from: The State of Renewable Energies in Europe. 9th, 10th, 11th, 12th, 13th,14th EurObserv'ER Report, International Renewable Energy Agency, authors own processing

5.2.2 Employment in Biomass

Biomass energy is the most promising renewable energy source in the Czech Republic [69], with feedstock derived from dedicated energy crops or waste from agricultural and forestry production. The growth of installed capacities and employment in the biomass sector relate to use of biomass for electricity and heat production, as well as the production of wood chips for fuel. Wood chip production is an export oriented sector in the Czech Republic; in 2013 around 170 thousands tons of wooden chips were produced but only 50 thousand tonnes were consumed within the country.. Further increase of employment in the biomass sector might be expected in near future, since both the production of wood chips and biomass installed capacities are expected to grow (figure 6).

Fig. 6: Installed capacity and employment in biomass in the Czech Republic (2008-2013)



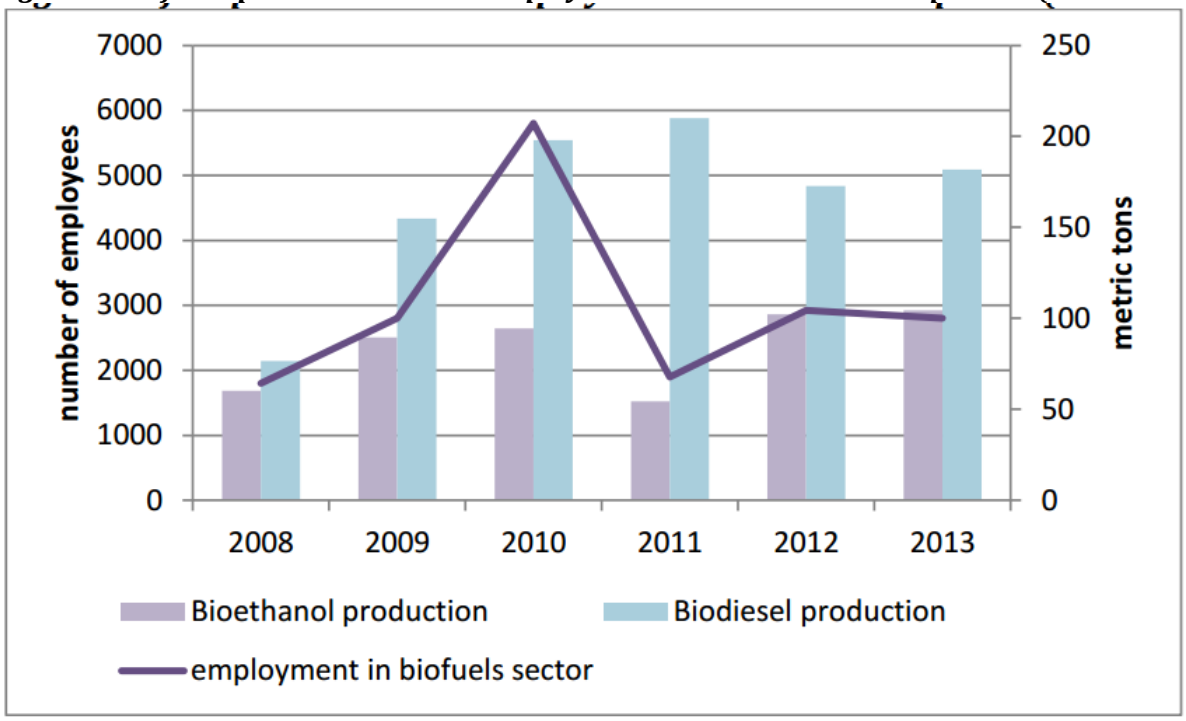
Data sourced from: The State of Renewable Energies in Europe. 9th, 10th, 11th, 12th, 13th,14th EurObserv'ER Report, International Renewable Energy Agency, authors own processing

We can observe a gradual growth in the biomass sector; up to 6.5 thousand workers in 2012. Together with the sectors of biofuels (2 925 jobs) and biogas (1 000 jobs) we can see that bioenergy is now employing more than two thirds of all RE related workers. These jobs are primarily concentrated to rural areas, which is beneficial for their economic and social stabilization [57], [58], [59] and [60].

5.2.3 Employment in biofuels

The target set by the European Commission under the Directive 2009/28/EC is to reach 10 percent share of renewable energy sources in transport by 2020. The Czech Republic in general does not have significant problems in meeting its targets. Feedstock for biofuel production is mostly local grown rapeseed for biodiesel and sugar beet and grains for ethanol production (the use of biogas as a transport fuel is rare). The Czech Republic has sufficient capacities for biofuel production but they are currently under-utilised. Only two of four ethanol plants and three of five major biosiesel plant were operating in 2013. Twothirds of the production capacity of ethanol plants and half of biodiesel plant capacity remains unused.
Employment in biofuels sector reached almost three thousand of workers in 2013 (figure 7). Further increase of employment in the biofuels sector is blocked by low global prices of biofuels, and partly also by controversies connected to use of agricultural land for non-food purposes. The Czech Republic is not (yet) involved in the production of second generation of biofuels, composed of lignocellulosic biomass or woody crops, agricultural residues or waste.

Fig. 7: Biofuel production and employment in the Czech Republic (2008-2013)

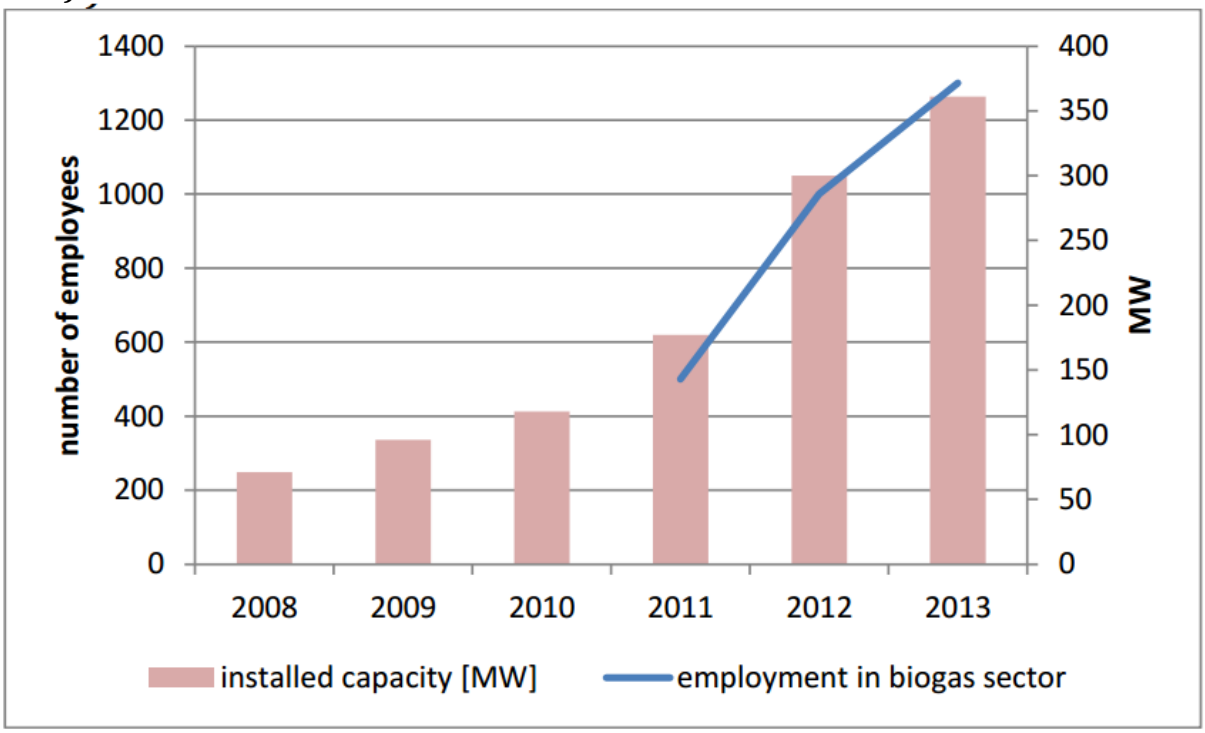


Data sourced from: The State of Renewable Energies in Europe. 9th, 10th, 11th, 12th, 13th,14th EurObserv'ER Report, International Renewable Energy Agency, authors own processing

5.2.4 Employment in the biogas sector

The biogas sector has a great potential in the Czech Republic. The production and number of biogas plants kept rising untill 2014 (to more than 500 biogas stations) when Energy Regulatory Office stopped financial incentives for new facilities. Employment in the biogas sector experienced significant growth in the studied period (1250 in total in 2013 – see figure 8) and is primarily important for rural areas, since agricultural biogas plants produce approximately 88% of all biogas in the Czech Republic. Further development of agricultural biogas plants in the coutryside have significant potential for the increase of energy self-sufficiency of rural areas. Employment in the biogas sector plays important role in creating alternative job for population in the countryside, where there is a lack of other job opportunities. On the other hand, there are no environmental benefits associated with the production of most of Czech biogas since the sector is largely based on maize as a feedstock (rather than agricultural or households wastes).

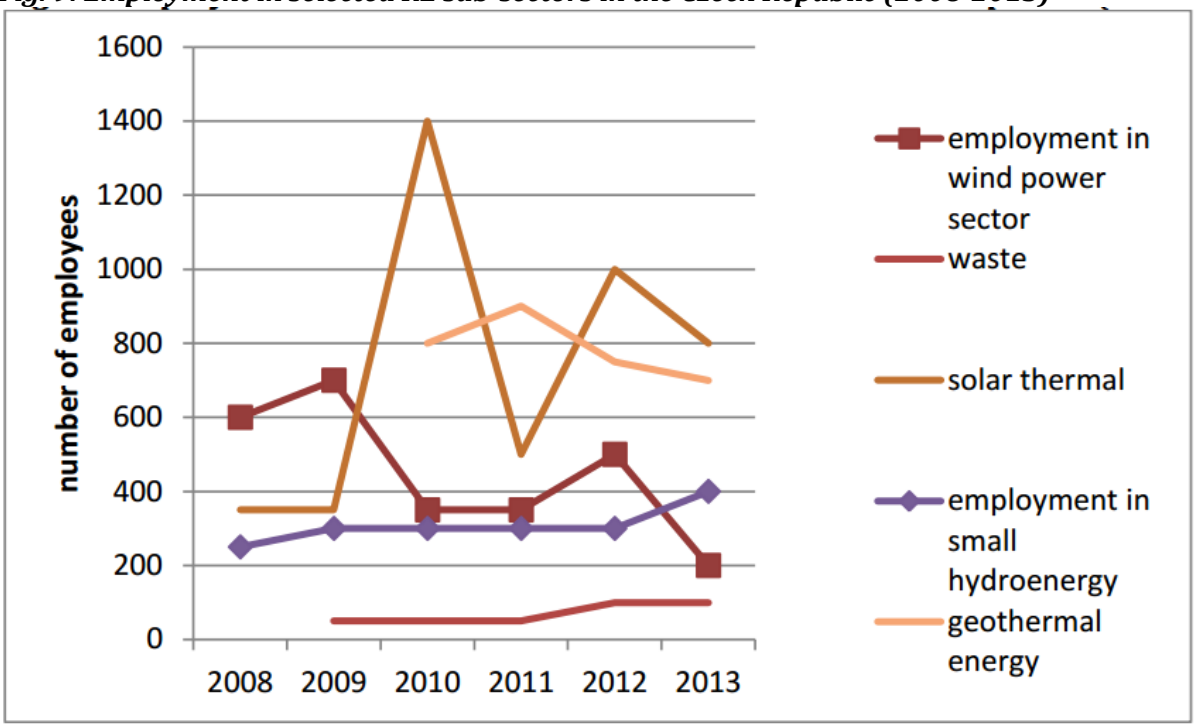
Fig. 8: Installed capacity and employment in the biogas sector in the Czech Republic (2008-2013)



Data sourced from: The State of Renewable Energies in Europe. 9th, 10th, 11th, 12th, 13th,14th EurObserv'ER Report, International Renewable Energy Agency, authors own processing

5.2.5 Employment in other renewable energy sub-sectors

Fig. 9: Employment in selected RE sub-sectors in the Czech Republic (2008-2013)



Data sourced from: The State of Renewable Energies in Europe. 9th, 10th, 11th, 12th, 13th,14th EurObserv'ER Report, International Renewable Energy Agency, authors own processing

Jobs in geothermal and solar-thermal systems are primarily related to design and installations of heat pumps and solar collectors; together they employ circa 2000 people in the Czech Republic (2010 see figure 9). By comparison, wind energy employed only 500 workers (in 2012). The limited size of the wind energy sector is partially due to lower acceptance of wind energy by representatives of regional administrations and local population in concerned communities and due to the relatively limited wind power potential in the Czech Republic [61] and [62]. Another factor lies in the complicated administration proces (Environmental Impact Assessment process) to get permission for the construction of wind turbines in comparison to other types of facilities for generation of renewable energy. Employment in energy-from-waste in the Czech Republic is quite low. The main reason is the very high share of waste which is stored at waste dumps and public opposition against the construction of new incineration plants. The sector of small hydro-power plants (less than 10 MW) employs just around 300 people with no significant changes expected in the near future.

Table 4: Generated energy (in MWh) per employee for different types of renewable energy in the period 2008-2013

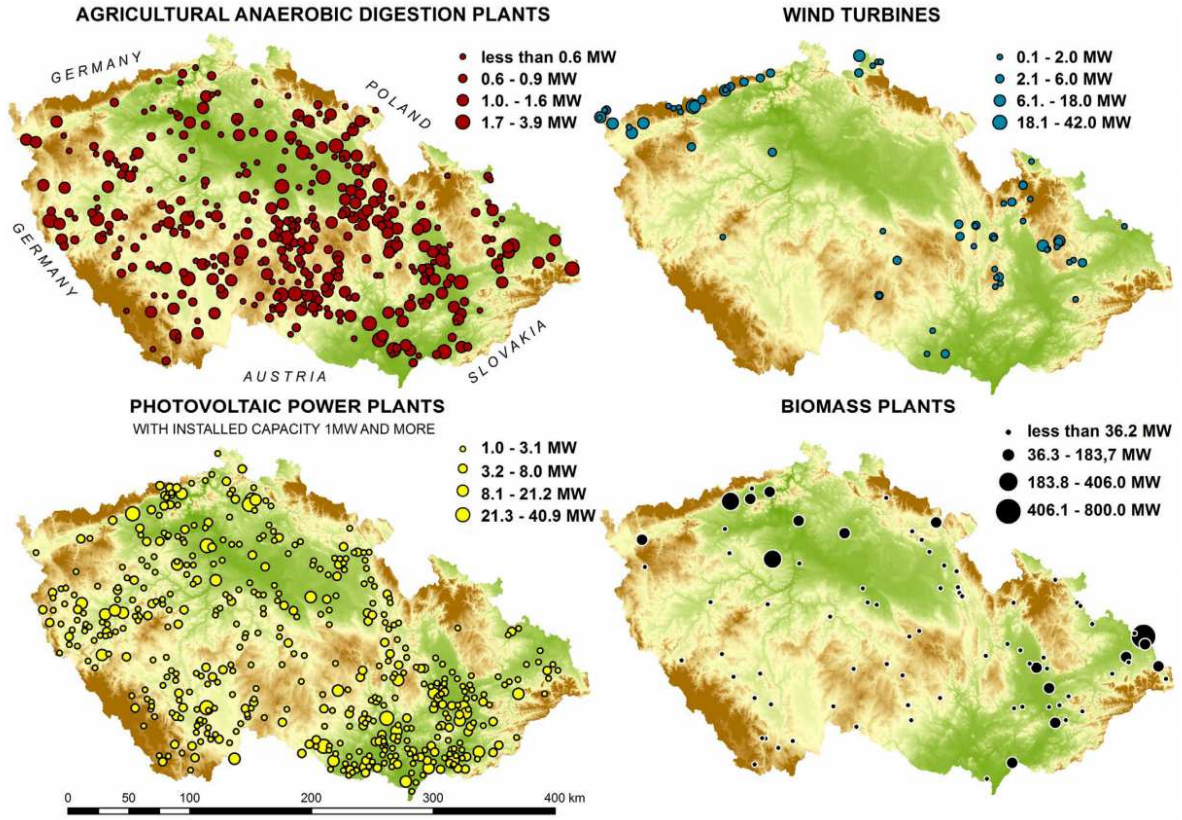
	2008	2009	2010	2011	2012	2013
Biomass	354.8	398.8	426.3	271.5	278.8	242.0
Biogas	a	a	a	1866.0	1472.0	1723.8
Wind	408.3	411.4	957.1	1134.3	832.0	1924.0
PV's	13.0	42.4	77.0	1454.7	1432.7	1355.3
Small hydro power	8096.0	8100.0	9296.7	7060.0	7096.7	6837.5

** Data not available*
Source: The State of Renewable Energies in Europe. 9th, 10th, 11th, 12th, 13th,14th EurObserv'ER Report, Renewable sources of energy in 2013, Yearly Report on the Operation of the Czech Electricity Grid for 2014*, authors own calculations and processing*

When examining employment in the renewable energy sector in terms of energy generation per employee (see table 4), we can see that the PV sub-sector has lost employment by a factor of hundred between 2008 and 2013, i.e. in the aftermath of the solar boom. However biogas and wind energy have even higher levels productivity per employee, 1 724 MWh and 1 924 MWh respectively (2013 figures). This provides a relative measure of economic efficiency for the sub-sector (higher ratio is better), but it is simultaneously a in indication of employment benefits (lower ratio is better).
If we focus on contribution of individual types of renewable energy facilities to local employment in the operational phase, we are talking about circa two or three employees per one biogas station (technical, administration and security staff), usually located within larger farms (and owned too) so that the sharing of employees is highly likely. In the case of large PV farm (more than 20 MW) s, up to ten workers can be required, although they may be non-permanent staff (technical, maintenance staff) or outsourced as external service. It is obvious that large biomass plants require more personnel. As an illustrative example large plant for biomass burning in Hodonín might be mentioned (105 MW of electric installed capacity with circa 400 employees). It seems that the least demanding as for labour force is wind energy.
The spatial distribution of installations of individual types of facilities for the generation of renewable energy is illustrated in figure 4. The maps suggest that that distribution of these facilities is quite uneven and suitable natural conditions are insufficiently taken into account in the case of PV farms (covering a total of 4 thousands of hectares of agricultural land in the Czech Republic) which were „booming' before subsidy levels were scaled back (as discussed earlier in the paper). But also the spatial distribution of biomass plants deserves closer attention. The location of large scale facilities in the Czech Republic is usually based on older (traditional) energy

infrastructure (mainly heating plants), where solid biomass is usually mixed with coal (as it is in Dětmarovice plant, 800 MW of installed capacity, located in the Moravian Silesian Region. There are several exceptions of these large facilities where only biomass is incinerated and the burning of lignite was recently abandoned (one block of heating plant in Hodonín, 107 MW of installed capacity, located in the South Moravian Region). Small scaled heating plants of this type (less than 5 MW) are in the Czech Republic entirely fuelled by biomass (circa 60 units).

Fig. 10: Distribution of renewable energy plants (and their installed capacities) in the Czech Republic in 2014



Source: authors own processing, data from the Energy Regulatory Office (www.eru.cz)

Biomass, wind energy and PV deserve a closer examination at the EU level. In terms of long term employment, biomass seems to be the most stable sub-sector, where circa 280 thousands of jobs were created without significant fluctuations over the years. The wind energy sector grows gradually, which is a consequence of the planning and installation of large off-shore wind parks located along sea coasts in the North Sea and the Baltic Sea. The PV sub-sector has reached a peak in employment in 2011 (one year later than in the Czech Republic) and followed by a decrease by more than 60 thousands jobs. This is largely due to the bankruptcies of manu PV installers when (post 'solar boom') financial support for PV was reduced in many countries. More attention can be paid to the biofuels sector, which covers circa one tenth of total renewable energy jobs in the long term. As for other sectors (biogas, geothermal energy, small hydro energy, and solar collectors systems) we are talking about very small numbers of jobs. On the other hand, there is a continuous growth over the whole studied period.

6. Conclusions and policy implications

The development of the renewable energy sector witnessed in both the Czech Republic and the European Union, has been the result of huge institutional, legislative and financial support. This state support (cost to the tax payer) has yielded significant benefits, in the form of a reduction in the dependency on fossil fuels (more climate change mitigation and energy security for energy importing countries), a contribution to the growth of GDP and a tool for creating new job

opportunities. Overall the most successful renewable energy sub-sector in the Czech Republic has been bioenergy – biomass, biogas and biofuels, which most suitably reflect the natural potential of the Czech Republic. Moreover, the utilisation of bioenergy goes beyond environmental benefits by creating multiplication effects for agriculture and rural development, especially in peripheral areas [63], [64] and [65]. The relevance of the PV and wind energy sub-sectors, in terms of job creation, has been lower for the Czech Republic. This reflects both biophysical suitability (a land-locked country with limited sun and wind but significant agricultural potential [66] and [67]) and the nature of these sub-sectors where most jobs are in the development and installation phase and relatively few jobs are required for maintenance.

Renewable energy policy requires large investments and financial incentives, which should be framed and spent wisely. On the other hand, this policy is partially designed with a concern for future citizens in mind, and it generates new job opportunities, innovations and new technologies. From the point of view of global competitiveness and additional energy costs for industry and households that are linked to application of this policy, the contribution of this policy is for both Czech Republic and the European Union quite controversial, and especially so in less wealthy member states. Renewable energy policies should be applied reasonably by using gained knowledge and experiences to avoid undesirable effects and consequences.

As for policy implications for the support of employment in the renewable energy sector, this study would suggest the following:

- Support of suitable qualification, education and training of workers is an important prerequisite for the sector to thrive and to bring economic benefits;
- The natural conditions of individual countries must be taken into account and thus, for the Czech Republic, support in biomass sector is highly recommended (in case of wind and solar energy, focus could be targeted more towards research and development or production of components for these installations);
- With respect to the traditions of industrial production and the high quality of technical education of the Czech labour force, a greater focus on the production of facilities for the generation of renewable energy should be encouraged;
- The energy potential of industrial, agricultural and household wastes is still overlooked in the energy policy of the Czech Republic (landfilling is still a primary destination of wastes);
- The spatial distribution of RE facilities is quite uneven in the Czech Republic and it is more concentrated in rural areas, where it helps to stabilise local employment generation;
- As the result of obligatory payments for renewable energy, large companies (the biggest energy consumers) complain about their reduced competitiveness, which might lead to reduction of jobs in future;
- A lot of work will be required to improve the poor image of renewable energy in the Czech Republic. The misguided policy on photovoltaics (the solar boom in the period of 2008-2010) has led to many members of the public to perceive renewable energy development as business opportunities for the elite, rather than in the context of environmental benefits.

References to environmental benefits of renewable energy are unfortunately still perceived as a smoke-screen for pumping governmental support into energy projects with sometimes unclear private ownership. A lot of educational activities concerning social and environmental benefits of renewable energy will be required to change negative public perceptions. A better understanding of other benefits, such as job creation, is therefore of great importance to both improve the performance of the sector and increase public support for it. This paper has analysed and identified important temporal and spatial trends in the employment figures for different RE sub sectors in the Czech republic, providing a step towards better contextual understanding of the RE sector and new evidence to improve RE related policies at the local and national level.

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