Wuppertal Institut
für Klima, Umwelt, Energie
GmbH

Economic Opportunities and Climate Change

Analysis of employment impacts of solar thermal energy use promotion policies in Germany

Rie Watanabe
Maike Bunse
Miriam Müller

28 December 2009, Wuppertal

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1 Introduction[1]

Germany is regarded as one of the most successful countries for renewable energy promotion. Renewable energy promotion plays at least three important roles. Its first role is to reduce CO_2 emissions from energy generation. The existing literature, most notably the IPCC fourth assessment report, warns that deep GHG emissions cuts from 60 to 85% in 2050 are required to prevent dangerous climate change (e.g. IPCC 2007). Considering that the energy sector is responsible for 60% of global CO_2 emissions, which is expected to rise further (ibid), changing energy sources from fossil fuels to renewables is one of society's most urgent tasks. For example, total CO_2 emissions avoided through the use of renewable energy sources in Germany amounted to approximately 112 million t CO_2 – 74.4 million t CO_2 in electricity generation, 25.2 million t CO_2 in heat generation and 12.0 million t CO_2 in fuels (BMU 2009). Second, renewable energy contributes to energy security. This is especially vital to countries such as Germany where domestic fossil fuels are not available, with the exception of hard coal. The third role played by renewable energy promotion is employment creation. Climate policy-making often encounters difficulties due to the expected negative impact on economic growth and development. Recent literature suggests that promoting renewable energies has a positive impact on the economy by creating new jobs (Kammen and Engel 2009, Mendonca 2009, Mills and Schleich 2009).

While the first and second roles are self-evident, the third role needs to be analysed in more detail because it often faces a counter-argument; climate policies and renewable energy policies certainly do create new jobs in the renewable energy sector but also have a negative impact on the conventional energy sector due to support given to renewable energy promotion and its budgetary effect. This paper attempts to examine whether, and if so how, climate polices and renewable energy policies have a positive impact on employment. As an empirical study, this paper takes up the solar thermal sector in Germany. In Germany, greening electricity generation has been undertaken for over a decade. Greening heat production is an urgent task, in view of the fact that around 60% of total energy use is for heating (BMWi 2009). Solar thermal technology has the technical potential to meet almost limitless water and space heating needs, depending on the country's climate. In the case of Germany, solar thermal technology has a potential to provide heat by 6 Mtoe in 2030 (figures 1 and 2). From the perspective of job creation, solar thermal is one of the sectors that create a large number of jobs per GWh (table 1). Recently, a new regulation – the Federal Renewable Heat Act – was introduced in Germany. This legislation, in combination with the Energy Saving Ordinance (Energieeinsparverordnung EnEV, enacted on February 1, 2002) which was revised for national implementation of the EU Directive on the energy performance of buildings (Directive 2002/91/EC) on October 1, 2007, promotes renewable energy use for heating, including solar thermal.

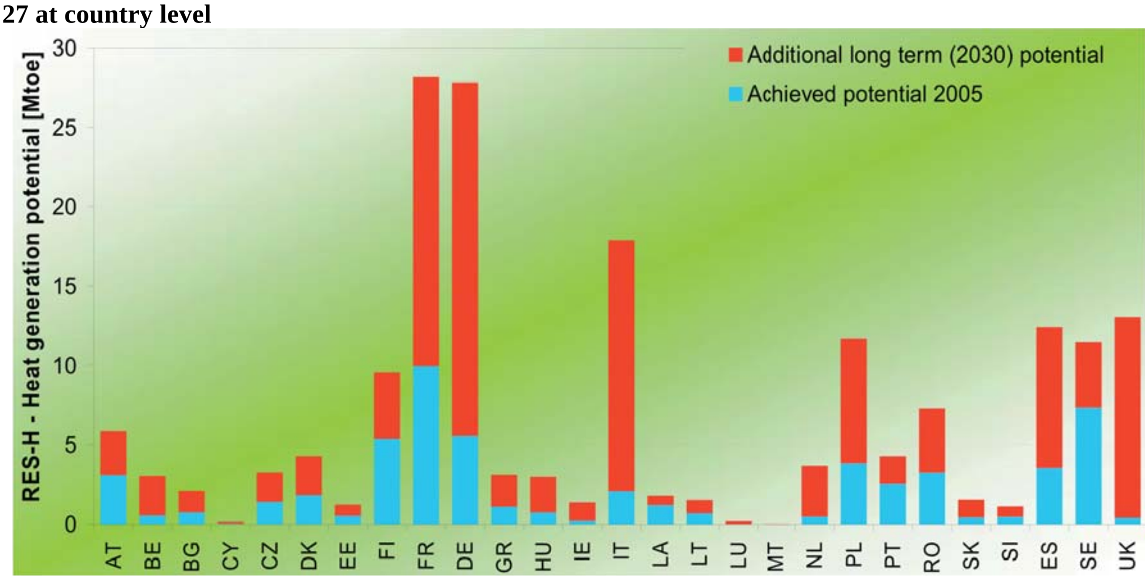
[1] The authors express their thanks to Wolfgang Irrek for his comments and inputs, and to Christiane Beuermann (both are of the Wuppertal Institute for Climate, Environment and Energy) for her comments on the draft version. As many as possible of these inputs and comments have been incorporated into the final version. Any remaining mistakes are the fault of the author.

Table 1: Total gross job years per GWh

Technology	Gross job years per GWh
Biomass	0.22
Geothermal	0.25
Solar PV	0.91
Solar Thermal	0.27
Wind	0.17
CCS	0.18
Nuclear	0.15
Coal	0.11
Natural Gas	0.11
Energy efficiency	0.38

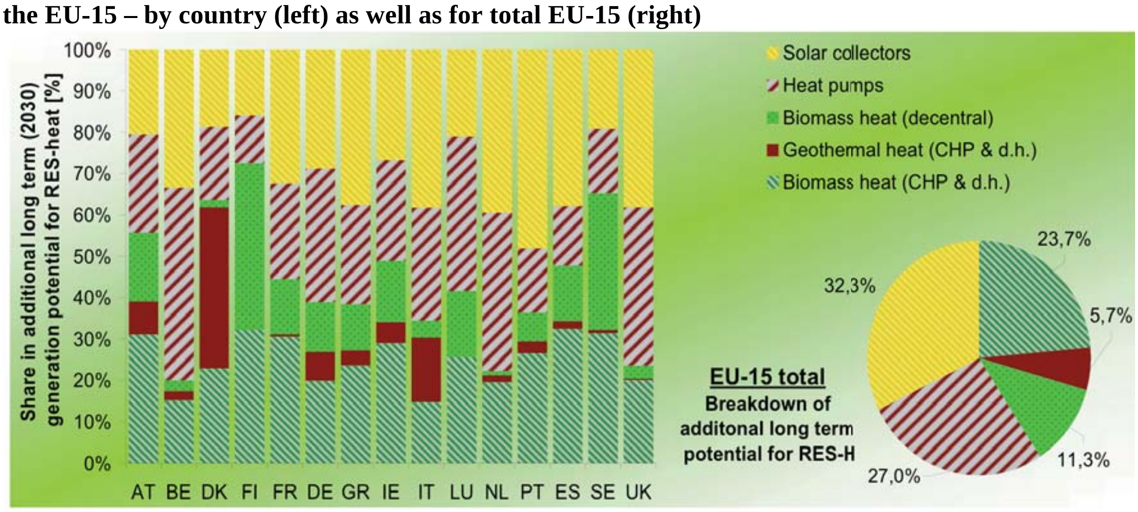
Source: Kammen and Engel 2009

Figure 1: Achieved (2005) and additional long-term potential (2030) for heat from RES in the EU-27 at country level



Source: Ragwitz et al. 2009

Figure 2: Heat from renewable energy as a share of the additional realisable potential in 2030 for the EU-15 – by country (left) as well as for total EU-15 (right)



Source: Ragwitz et al. 2009

The remaining parts of this paper are structured as follows. Section 2 provides an overview of the increase/decrease of the total number of jobs and goods/service exports in the energy sectors. Section 3 explains the various solar thermal technologies and analyses the historical development of policies and measures that promote solar thermal technologies and their impact on the solar thermal market. The conclusions return to the question posed in the above: whether, and if so how, climate policies and renewable energy have a net positive impact on employment.

2 Overview of employment impacts in renewable energy sectors in Germany

In Germany, the number of jobs in the renewable energy sector has increased in recent years while the number of jobs in the conventional energy sector has continuously declined. As a result, the total number of jobs in the energy sector increased by 100,000 between 2004 and 2008. Related to this period, renewable energy promotion has in fact had a net positive effect on employment.

Table 2: Overview of the number of jobs in Germany's conventional and renewable energy sector (electricity and heat production)

	2004	2006	2007	2008
Conventional Energy	**258,793**	**244,479**	**240,774**	**238,171**
Hard coal mining	44,928	37,724	34,774	31,510
Lignite mining	14,363	13,965	13,805	13,635
Distant heating	15,358	15,238	14,907	14,243
Petroleum processing	18,858	18,026	17,731	18,331
Extraction of petroleum	5,136	5,128	5,183	5,497
Gas supply	33,404	32,325	32,862	33,530
Electricity supply	126,746	122,073	121,512	121,425
Renewable Energy	**160,500**	**235,600**	**249,300**	**278,000**
Wind energy	63,900	82,100	84,300	85,100
Biomass	56,800	95,400	96,100	95,800
Solar energy	25,100	40,200	50,700	74,400
Hydropower	9,500	9,400	9,400	9,300
Geothermal	1,800	4,200	4,500	9,100
Total	**410,293**	**480,079**	**490,074**	**516,171**

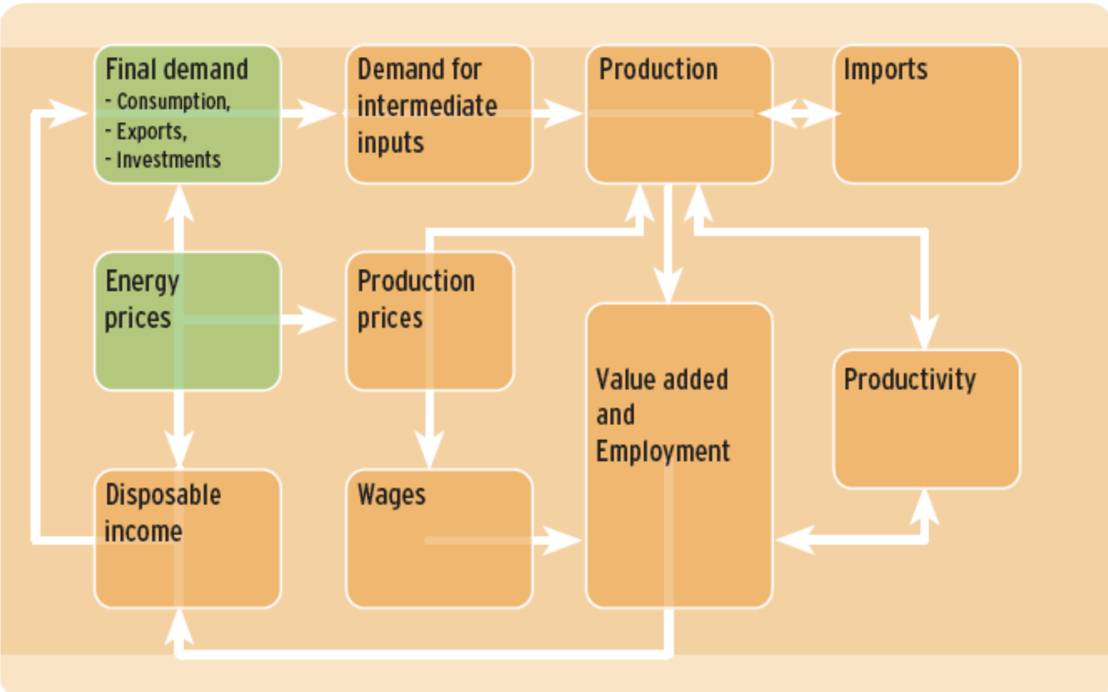
Source: BMWi 2009; BMU 2009

As the domestic market approaches saturation level, export markets become increasingly important to the maintenance of the existing employment level and the creation of further jobs. In fact, Germany's renewable energy sector is often quoted as being one of the most successful examples of the front-runner approach that invests in innovative technologies earlier and reaps the benefits later by exporting the developed technologies to other countries. The German export volume of renewable technologies was around 10 million EUR in the mid 1970s. It grew by over 150 million EUR in the first half of the 1990s, and reached 350 million EUR, assuming a 10% share of the national production of RET technologies and representing almost 30,000 direct jobs in 1999 (Fleischer, Mannsbart and Jochem 1996, Allnoch 2000). In 2006, the total export quota for renewable energies (both technology and services) was 37 per cent.

For precisely examining the impact of renewable energy promotion on employment, an examination of the longer-term trend of employment in the energy sector than being presented in the above is required. Moreover, studies that claim a positive relationship between job creation and renewable energy promotion are often criticised for their incomplete accounts. The calculation of a net employment impact requires not only direct and indirect employment effects (*gross employment*) but also possible negative effects (*net employment*). According to BMU (2006), any calculations of employment effects should include the following elements: demand through investments (+) and system operation and optimisation (+), substitution effects (-), budgetary effects (+/-) and exports/imports (+/-). The data for direct – and to some extent indirect – employment effects is available in Germany. With regard to calculating the negative effects on jobs in the conventional energy sector, however, assumptions have to be made. These assumptions include an increase of the financial support provided for promoting renewable technologies, a resulting decrease of other spendings, and imports of other spendings, which would lead to jobs being generated abroad rather than in Germany (budgetary effect).

The difficulty further increases for estimating the number of future job since the elements necessary for the calculation are intertwined with each other in a complicated manner as shown in figure 3.

Figure 3: Simplified representation of the impact relationships used to determine the net employment effects caused by the expansion of renewable energy



Source: BMU 2006

For example, energy prices do not only affect the renewable energy industry directly but will lead the budgetary effect on the economy as a whole. The fact that different assumptions of energy prices lead different estimates of net employment is illustrated by the study results undertaken by three organisations (table 3). The studies indicate that job in renewable energy sector has been steadily increasing even in a net term. However, the Bremer Energie Institut and EWI/RWI/IE report that created employment does not have a lasting effect due to dynamic adaptation processes leading to employment reduction and that a net impact will turn into negative in a long term (BMU 2006a, b).

Table 3: Overview of net employment effects through renewable energy promotion in Germany

Study	Bremer Energie Institut (2003)	EWI/RWI/IE (2004)	Institut für Wirtschaftsforschung Halle (2003)
	Excluding offshore wind		Scenario III
	1,000 person years	1,000 employees	1,000 employees
2001	n/a	n/a	5,88
2002	about 60	n/a	12,89
2003	about 55	n/a	-1,79
2004	about 52	32,62	1,57
2005	about 48	17,66	5,56
2006	about 45	14,68	7,21
2007	about 41	7,49	7,59
2008	about 38	2,41	9,29
2009	about 35	-1,12	10,41
2010	about 31	-6,10	7,20
2022	about -4	n/a	n/a

Source: BMU 2006b

Moreover, a more detailed study commissioned by BMU, which is based on the comparison between the case of expansion of renewable energy use and a reference case[2] results in net employment effects of 74,000 jobs in 2020 and of 120,000 jobs in 2030. Contrary to the results presented by the Bremer Energie Institut and EWI/RWI/IE, the BMU study shows that the figure of net employment effects keeps increasing even after 2020 due to an increasing export and a positive budgetary effect resulting from cost down of renewable energy.

[2] The study compares the differences between a “Reference” development and the “NatPlus-2005” scenario based on the PANTHA-RHEI model.

3 The case of the solar thermal sector

3.1 Solar thermal technologies

Solar thermal collector systems directly or indirectly convert solar radiation into heat. In a direct system, the water used by residents for washing or bathing is heated directly by the sun. A thermometer and controller sense when the solar collector is warm and ready to heat water. The controller starts a pump that feeds cold water into the solar collector, where it is heated. The solar-heated water is then stored in a conventional hot water tank. It is typical, especially during high-use periods with little sun, for the water to be kept warm by supplemental gas or electricity. In an indirect system, a simple pump transports an antifreeze solution through a loop into the solar collector, through the pipes of the collector and out of the solar collector. The sun-warmed antifreeze solution then flows into a heat-transfer unit where it warms the cool water that leads into a hot water tank. The antifreeze solution then returns to the pump and again flows into the solar collector without ever mixing with the building's water. Indirect systems are encouraged in climates with extended periods of below-freezing temperatures.

Solar thermal systems also differ in the type of collector used to gather and store the sun's energy. Flat plate collectors are the simplest and most common type. In Germany, almost 90% of collectors are flat plate collectors, with the solar absorber continued in an insulated and glazed box to limit heat loss (Mills and Schleich 2009). Copper pipes wind back and forth through the flat plate collector, which is painted black to absorb heat. The collector is covered with glass or glazing to prevent the heat from escaping. The pipes are often painted black and bonded to the material of the flat plate collector to maximise heat absorption. Flat collectors operate at temperatures between 60 and 90°C, making them suitable for houses and buildings.

There are three more advanced systems: evacuated tube collectors, unglazed plastic absorbers and parabolic trough collectors. The first system has multiple evacuated glass tubes that heat up solar absorbers and, ultimately, solar working fluid to heat domestic hot water or space. The evacuated tubes draw their energy from the available light other than outside heat, and can therefore be used in colder conditions. With warmer climates, however, this system requires a special instrument to prevent it from overheating. The unglazed plastic absorber system is similar to a flat plate collector without a glazing cover. It is almost exclusively used to heat pools because the temperature of water should be adjusted to the temperature outside. The last of the three more advanced systems, parabolic trough collectors, are almost exclusively used for electricity generation because they concentrate sunlight at a single, focal point, via one or more parabolic dishes, and can heat water or other fluids to much higher temperatures, as required.

Since solar radiation varies substantially over time, solar collectors are usually combined with a heat storage system. During the summer, these systems are able to meet most of the residents' hot water needs. Depending on the design of the collector and the storage systems (and the thermal insulation of the residence), combined solar space and water heating systems cover around 25% of the annual total heat demand of a residential building. In specially designed solar houses (passive houses), however, this proportion can increase up to 100%. Solar water heating systems alone can cover up to 12% of annual heating needs (Staiß 2003).

3.2 Policies and measures to promote solar thermal technologies

Overview of renewable electricity promotion policies in Germany

The development and deployment of renewable technology often encounter various obstacles. Mendonca (2009) categorises the barriers into three groups: 1) cost and pricing, 2) legal and regulatory restraints, and 3) market performance. Costs and pricing includes subsidies for competing fuels, high initial capital costs, the difficulty of fuel price risk assessment, unfavourable power pricing rules in the electricity sector, transaction costs and environmental externalities. Legal and regulatory restraints equate to a lack of a legal framework, restrictions on siting and construction, transmission access in the electricity sector, utility electricity interconnection requirements and liability insurance requirements. Market performance includes a lack of access to credit, perceived technology performance uncertainty and risk and a lack of technical or commercial skills and information. The success of Germany's renewable energy promotion is due to the introduction of policies and measures addressing these barriers and giving support to renewable energy promotion (Mendonca 2009, Kammen and Engel 2009, Lauber and Mez 2004).

The 1990 Feed-in Tariff Law particularly addressed unfavourable power pricing rules, transaction costs and transmission access. It required large electric utilities that own grids to connect RES generators to the grid and to buy the electricity at rates of 65 to 90 per cent of the average tariff for final customers. Generators did not need to negotiate contracts or otherwise engage in much bureaucratic activity (Mendonca 2009). As a result, the wind energy sector experienced rapid growth during the 1990s. However, this scheme also highlighted the importance of addressing high initial capital costs in the longer term. The support provided in the 1990 Feed-in Law was insufficient to promote photovoltaics, which require large investment sums to enable the equipment to be installed. As a result, some large German PV firms moved their production sites to the United States, which made the government aware of the need to establish new support schemes for photovoltaics (Lauber and Metz 2004). For addressing this problem as one of the main objectives, the Feed-in Law was revised and the Renewable Energy Sources Act was enacted in 2000. The law was improved in two points. First, it clearly stipulated the objective to double RES-E production by 2010. Second, while under the Feed-in Law compensation rates were expressed as percentages of average end customer tariffs, the new rates were fixed for 20 years (before there was no such guarantee, and prices declined later as a result of liberalisation). Photovoltaics acquired the increased rate in the amended Renewable Energy Act in 2004, which made them commercially attractive without additional support[3]. This led to a real boom in photovoltaics from 2004 (Figure 5).

Table 4: Feed-in rates for solar radiation under the Renewable Energy Sources Act 2000

	Rate[Cent/kWh]											Annotations
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	
Facilities on non-built up areas up to 100 kW and installations mounted on buildings up to 5 MW	50.6	50.6	48.1	45.7	43.4	41.2	39.2	37.2	35.3	33.6	31.9	Obligation to pay tariff ends for new photovoltaic facilities once a cumulative capacity of 350 MW is exceeded. In 2002, this threshold was raised to 1000 MW. IN 2003, it was abolished.

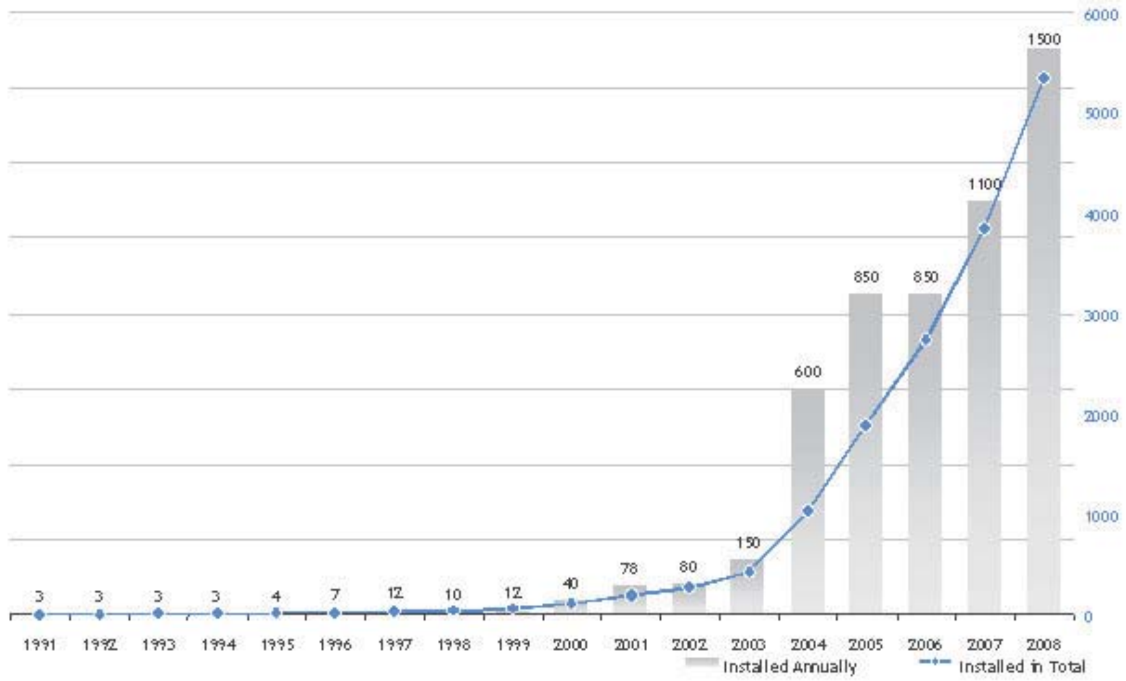
Source: Staiss 2003: II-24

Table 5: Feed-in rates for solar radiation under the Renewable Energy Sources Act of 2004

Source	Rate in cent*	Duration of support	Comments
up to 30 kW	57.40	20 years	Annual decline: 5 per cent, commencing in 2005. For non-built up areas, the decline increases to 6.5 per cent, commencing in 2006. Installations connected in subsequent years will receive a rate (for 15-30 years) which is determined by the year of installation and which declines every year for that year's new installations.
up to 100 kW	54.60		
Façade bonus (cladding)	54.00		
Non-built up area	5.00		

Source: Lauber and Mez (2004)

Figure 4: Annually and total installed PV power in Germany in MWp



Source: http://en.solarwirtschaft.de

Solar thermal technology promotion in Germany

Compared to renewable electricity promotion explained above, it is rather simple to promote solar thermal at a glance. Firstly, this is because most renewable heating systems are exclusively served on-site and do not need to be fed into the grid. This means that solar thermal does not encounter most of the legal and regulatory problems, in particular the lack of a legal framework for independent power producers, transmission access – the greatest obstacles in the case of renewable electricity promotion. Moreover, flat plate collector technology was developed as early as in the mid 1970s. In addition, installing collectors does not cost as much as installing renewable electricity – around 5000 EUR for 6 m^2 plates (the average for a four-person family home). However, this rather low average cost in absolute term compared to that for installing renewable electricity technologies does not necessarily mean that solar thermal technology is economical from the perspective of an investor. The costs strongly depend on the types of buildings and heating systems. Moreover, installing solar thermal equipments in an existing building is usually more costly than installing solar thermal technology at the time of construction of a new building. Therefore, financial incentives to end-users are often required for the development or deployment of the technology, in addition to secured access to credit and a long-term framework for market development and capacity building of qualified installers.

In Germany, the first government programme promoting solar thermal was launched in 1995. The programme ringfenced around 30 million EUR/year (Knaack 2009). The amount of support was too little to fully stimulate solar thermal technology distribution. When the programme expired in 1998, another Market Incentive Programme (MAP) was introduced in 1999 with the objective of supporting the generation of solar heat for domestic hot water and heating purposes. This programme was very effective in increasing the number of solar thermal installations. However, the programme encountered the same problem as its predecessor: once the ringfenced support had virtually been deployed, the Federal Office of Economics and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle (BAFA)), which provides private investors and SMEs with grants for investments in solar thermal technology, had to either reduce the support provided per square metre or reject applications. In 2003, for instance, the solar thermal market experienced a boom when subsidies were raised temporarily, but this was followed by a drop in 2004. The scheme was even halted – albeit temporarily – in 2005, and was not resumed until March 2006. After the scheme was relaunched, a number of applications were submitted. Due to budget constraints, however, many applications were rejected.

Recently, the Renewable Energy Heating Act was enacted with the objective of further ensuring proper financial support for end-users and of providing a long-term framework for market development and was implemented on 1 January 2009. In the new Act, a steady MAP budget of up to 500 million EUR per year was established from 2009 to 2012 by utilising the budget through auctioning the emissions trading certificates (Paar et. al 2008). The act aims that no applications are rejected due to a lack of financial support, providing the solar thermal sector with a more stable investment environment. In

2009, 400 million EUR were set aside, 83% of which has already been claimed. This means there is still a risk of applications being rejected.

An additional objective of this act has been to set the target of using 14% renewable energies in heat production in 2020 and introduces renewable energy construction obligations. These obligations require new buildings to cover a minimum share of their heat demand from renewable energy. House owners, whether private, state or commercial, must use renewable energy (solar radiation, biomass, geothermal energy or ambient heat) for a certain percentage of their heat demand. In the case of solar radiation, at least 15% of heat demand has to be covered by the renewable source. The requirement can be offset by increased energy efficiency measures, e. g. by additional insulation of the building. In addition, the Renewable Energy Heating Act interacts with the Energy Saving Ordinance, which implements the European Building Directive in Germany (Pehnt et al. 2009 for a detailed analysis of the link between both policy instruments). Due to this interaction and its scope, which covers only new buildings, the Renewable Energy Heating Act will probably only have a marginal additional impact compared to the Energy Saving Ordinance.

Given the estimates that approximately 175,000 new houses will be constructed in Germany each year (Federal Law Gazette 2008), the command and control approach in combination with a financial incentive given to end-users might contribute to a further expansion of the solar thermal market in the future. Moreover, the act provides an opportunity for German federal states to enact additional legislation to introduce construction obligations for existing buildings. In addition to the support given, the solar thermal system must be awarded the so-called ‘Solar Keymark’ certification, the first internationally accepted seal of quality for solar thermal installations.

These policies and measures with other support programmes on a local or regional level have raised the percentage of buildings equipped with a solar thermal device to 34% in 2008, up from 27% in 2007. The proportion of buildings with solar thermal heating systems has nearly doubled (Bremer Energie Institut et al. 2008).

Table 6: Promotion rates of the Market Incentive Programme for solar collectors

Implementation of solar collector for...	**Basic promotion** for existing buildings	**Basic promotion** for new buildings	Boiler exchange bonus	Combi-nation bonus[3]	Effi-ciency bonus	Circu-lation pump bonus	Solar pump bonus	**Innovation promotion**[6] for existing buildings	**Innovation promotion**[6] for new buildings
… **water heating** up to 40 sqm collector area	60 EUR/sqm collector area, at least 410 EUR	45 EUR/sqm collector area, at least 307.50 EUR	375 EUR		-			210 EUR/sqm collector area	157.50 EUR/sqm collector area
… combined **water heating and heating support**[1] up to 40 sqm collector area	105 EUR/sqm collector area	78.75 EUR/sqm collector area					50 EUR per pump	210 EUR/sqm collector area	157.50 EUR/sqm collector area
… combined **water heating and heating support**[2] with over 40 sqm collector area	105 EUR/sqm collector area up to 40 sqm + 45 EUR/sqm collector area above 40 sqm	78.75 EUR/sqm collector area + 33.75 EUR/sqm collector area above 40 sqm	750 EUR	750 EUR	Level 1[4]: 0.5 x basic support Level 2[4]: 1 x basic support	200 EUR per heating sys-tem[5]			
… provision of **process heat** up to 40 sqm collec-tor area	105 EUR/sqm collector area	105 EUR/sqm collector area						210 EUR/sqm collector area	210 EUR/sqm collector area
… solar **cooling** up to 40 sqm collector area	105 EUR/sqm collector area	78.75 EUR/sqm collector area						210 EUR/sqm collector area	157.50 EUR/sqm collector area
Extension of existing solar collectors	45 EUR/sqm of addi-tional collector area	45 EUR/sqm of addi-tional collector area	-	-	-		-	-	-

1) For flat collectors: at least 9 sqm collector area, at least 40 l/sqm thermal store volume; for vacuum tube collectors: at least 7 sqm collector area, at least 50 l/sqm thermal store volume

2) Only for detached and semi-detached houses. Thermal store volume of at least 100 l/sqm collector area necessary

3) A bonus of 750 EUR can be granted in addition to the basic promotion if an eligible biomass system or heat pump is installed.

4) Efficiency bonus level 1: if the building shell complies with EnEV standards for buildings that received planning permission prior to 1995 or if it is 30% below the EnEV standard for buildings that were granted planning permission after 1994. Efficiency bonus level 2: the building shell is 30% below the EnEV standard for buildings that were granted planning permission prior to 1995 or if it is 45% below the EnEV standard for buildings that received planning permission after 1994.

5) Circulation pumps must be included in a hydraulic and control technically optimised heating system. Provided that radiators exist, this system must be equipped with pre-set thermostatic valves and, if necessary, additional calibration taps. The bonus cannot be combined with the KfW programme "energy-efficient refurbishment".

6) At least a collector area of 20 sqm, a maximum of 40 sqm. Implementation rules of BMU of 17 April 2007 regarding innovation promotion have to be considered.

Source: BAFA 2009

3.3 The impact of policies and measures on employment in the solar thermal sector

Job creation in the solar thermal sector

Usually, when building or house owners consider installing solar thermal technologies, they consult installers or energy consultants (in the case of large buildings). Installers provide end-users with information about the available technologies, costs and support schemes. Installers order collectors from manufacturers and mount them on the roof-tops of buildings or houses. The distribution of solar thermal technologies therefore creates new jobs with component manufacturers, such as collector manufacturers and storage manufacturers, as well as in the sectors that supply component parts, installers and energy consultants. In Germany, there are around 5000 companies working in the solar thermal sector. While only 100 companies produce solar collectors, storage and relevant elements, the rest is working for operation and maintenance (Deutscher Bundestag 2008).

The gross number of jobs in the solar thermal sector increased from 6,269 in 2004 to 17,400 in 2008 (BMU 2009). The increase in the gross number of jobs from direct investment is particularly striking. They almost quadrupled from 4,030 in 2004 to 15,500 in 2008. This number already exceeds the BMU estimate (2006), which anticipated a 55% increase in the number of jobs in the German solar market between 2004 and 2010.

Table 7: Jobs in the solar thermal energy sector in Germany

	2004	**2007**	**2008**
Jobs due to investments	4,030 (excluding export)	n/a	15,500 (including export)
Jobs due to operation & maintenance	1,397	n/a	1,900
Jobs due to exports	842	n/a	n/a
Total gross jobs	6,269	12,100	17,400

Source: BMU 2006

Despite the above positive figures, we must note that as explained in section 2, the examination of whether climate and renewable energy policies create new job requires the calculation of job increase in a net term. Box 1 presents an overview of different elements necessary for calculating the net job creation in the solar thermal sector. The overview firstly shows that the net job creation might strongly depend on direction and size of the budgetary effect, i.e. development of technology costs and energy prices. Second, the positive net employment effect for total renewable energies heavily depends on an increase of technology exports. This effect however, can be expected to be lower for solar thermal and will not reach at the same level as for example in the case of wind energy. The Bremer Energieinstitut (2003), for example, published the figure of 0.06 full time person/kWh for the net employment effect. Examining and updating the figure require the detailed data for all of the aforementioned elements, which is beyond the scope of our paper. In order to further examine the impact of policies and measures

Box 1. Net job increase in the solar thermal sector

1) Employment effects due to investments; Positive (15,500 in 2008, see Table 5)

2) Operation & Maintenance; Positive (1,900 in 2008, see Table 5)

3) Substitution effects; Perhaps negative, but not as high as being caused by other renewable energies.
Job losses in the gas and oil industry, and perhaps in the electricity industry, due to solar thermal energy might not be substantial. As solar thermal is used as an add-on device for a conventional heating system, it usually exists along with the conventional systems.

4) Budgetary effects; depend on the economics of the solar thermal system.
The budgetary effect will be positive if the solar thermal system is economical, while the effect will be negative if the system is not economical. For the calculation of the economics of the solar thermal system, the additional investment and installation costs compared to a conventional heating and/or water heating system, the difference in maintenance and operation costs and the energy cost savings achieved by the system have to be balanced. The economics depend, among others, on whether the system is installed at a newly established building or at an old buildings, and on the future development of energy prices. The future development of energy prices affect payback period for a solar thermal. The payback period is currently estimated between 10 and 20 years (http://www.solifer.de/1/14/sonnenstrom.html).

5) Exports / imports; Germany exports solar thermal technologies to other countries. At present, approximately 80 to 90% of solar thermal exports goes to other European countries (Deutscher Bundestag 2008). The market created in Germany is almost exclusively for flat plate collectors and evacuated tubes used for heating. The export quota of German solar thermal technology is relatively low. The potential for increasing exports of solar thermal technology lies mostly in the European market, as the strongly growing Asian market is largely covered by the on-site manufacturers, in particular from China and Taiwan, who are well informed of the climate, the environment, building conditions, as well as regulations, and whose production cost is much cheaper than German producers. As a result, imports exceed exports by far. According to survey results, imports accounted in 2004 for 180 Million EUR, while exports only accounted for 42 Million EUR (BMU 2006). However, reduced imports of fossil fuels should be taken into account.

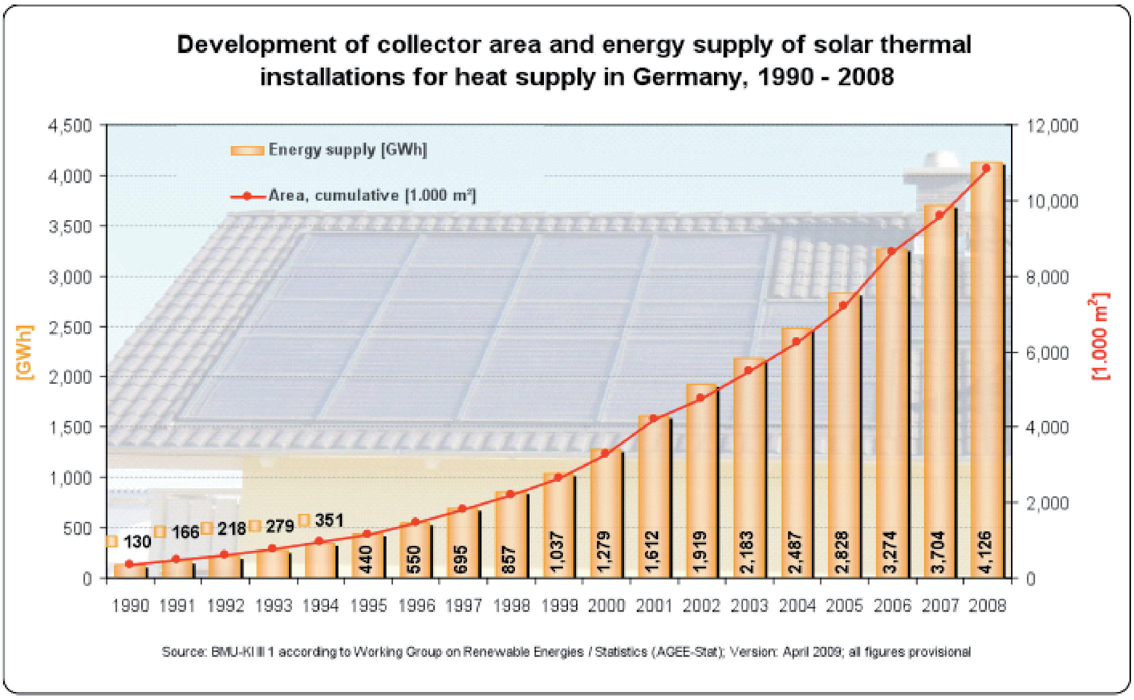
	Positive employment effect	Negative employment effect
Investment	++	
System optimisation & maintenance	+	
Substitution effect		-
Budgetary effect	+ Saving costs of fossil fuels or electricity for heating	- Additional costs for installing the system
Import / export	+ Export of solar thermal system Less import of fossil fuels	- Import of solar thermal system

on job creation while complementing lack of the figures of the net employment increase, we undertake other two examinations; the impacts of policies and measures on sales of solar thermal collectors and on the decisions of solar thermal industries to enter the market.

Sales of solar thermal collectors

The sales of solar thermal collectors have been growing since 1995, when the first market incentive programme was launched (Knaack 2009). However, sales dropped in 2002 due to a general economically tense situation, a shortage of state-specific support programmes and the discontinuation of the market incentive programme (SOLARGE 2006). The German solar thermal market recovered from 2007 to 2008, and nearly doubled with an estimated total turnover in this sector of up to 1.2 billion EUR (BMU 2009). The trend was also confirmed by our interviews with leading companies in the flat plate collector market. Many companies reported a good sales record in 2001 (ELCO 2009, Gasokol 2009, Roth Werke 2009), 2006 (Aquasol 2009, ELCO 2009, Estec 2009, Gasokol 2009, Prosolar 2009, Solarbayer 2009, Thermosolar 2009) and 2008 (Aquasol 2009, Citrin 2008, ELCO 2009, Estec 2009, Gasokol 2009, Prosolar 2009, Solarbayer 2009, Thermosolar 2009, Westfa 2009,), while they experienced difficulties in 2002 (Estec 2009) and 2007 (Citrin 2009, Estec 2009, Prosolar 2009). According to a publication by the German Copper Institute (Deutsches Kupferinstitut 2006), the solar thermal market is currently one of the biggest growth markets for handcraft with annual market growth rates of about 20%, while the average growth of the total German handcraft market is 4-5% per annum (ZDH 2009).

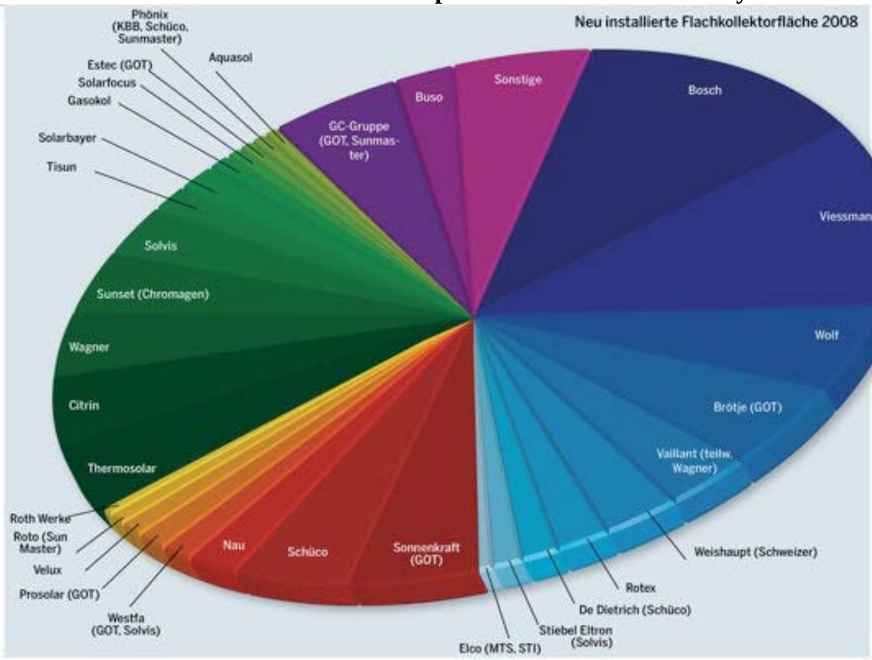
Figure 5: Development of collector area and energy supply of solar thermal installations for heat supply in Germany, 1990-2008



Source: BMU (2009)

The year in which leading manufacturers and installers of flat plate collectors entered the market

Figure 6: Manufacturers/Installers of flat plate collectors in Germany



The names of the OEM suppliers to companies that do not produce the collectors themselves are given in parentheses
Source: Sonne, Wind & Wärme (2009).

The years in which leading companies entered the market are very diverse. One group of companies entered the market in the late 1970s, while another joined it in around 1995. The entry of the first group may have been due to the promotion of research and development in renewable energy policy in Germany following the oil crisis. 10 million EUR were spent in 1974. This figure rose gradually up to 1978 (60 million EUR) and peaked at 150 million EUR in 1982, declining thereafter (Lauber and Mez 2004). The second group's entry can be regarded as the impact of the market incentive programme launched in 1995. Nevertheless, our survey did not clearly illustrate the relationship between the policies and measures introduced and the decisions made by companies to enter the market. A more detailed examination is required to conclude whether or not a positive relationship exists between the two variables.

Table 8: Year of entrance to the solar thermal market of leading manufacturers/installers of flat plate collectors

Company	**Year in which manufacturers/installers of flat plate collectors entered the solar thermal market**	**Source**
Viessmann	More than 30 years	Website, last visited on 6 Nov. 2009
Thermosolar	1973	Phone interview by Miriam Müller on 10 Nov. 2009
Stiebel Eltron (Selvis)	1977	Website, last visited on 6 Nov. 2009
Bosch	1978	Website, last visited on 6 Nov.

		2009
Sunset (Chromagen)	1979	Phone interview by Miriam Müller on 10 Nov. 2009
Wagner	1979	Phone interview by Miriam Müller on 10 Nov. 2009
Gasokol	1981	Phone interview by Miriam Müller
ELCO (MTS, STI)	1985	Phone interview by Miriam Müller on 10 Nov. 2009
Solvis	1988	Phone interview by Miriam Müller on 10 Nov. 2009
Prosolar (GOT)	1989	Phone interview by Miriam Müller on 10 Nov. 2009
TiSUN	1989	Phone interview by Miriam Müller on 10 Nov. 2009
Nau	1990	Phone interview by Miriam Müller on 10 Nov. 2009
Roth Werke	1991	Phone interview by Miriam Müller on 16. Nov. 2009
Aquasol Solartechnik	1993	Phone interview by Miriam Müller on 10 Nov. 2009
Solarfocus	1993	E-mail contact by Miriam Müller on 16 Nov. 2009
Sonnenkraft (GOT)	1993 in Austria 1994 in Germany	Website, last visited on 6 Nov. 2009
Wolf	1996	Website, last visited on 6 Nov. 2009
De Dietrich (Schüco)	1997	E-mail contact by Miriam Müller on 13 Nov. 2009
Estec (GOT)	1997	Phone interview by Miriam Müller on 10 Nov. 2009
Vaillant (partly Wagner)	1997	Website, last visited on 6 Nov. 2009
Schüco	1998	E-mail contact by Miriam Müller on 19 Nov. 2009
Westfa (GOT, Solvis)	1998	Phone interview by Miriam Müller on 10 Nov. 2009
Brötje (GOT)	1970s/1999	Phone interview by Miriam Müller on 13 Nov. 2009
Phoenix Sonnenwärme AG (KBB, Schüco, Sunmaster)	1999	Website, last visited on 6 Nov. 2009
Rotex	1999	Phone interview by Miriam Müller on 20 Nov. 2009
Roto (Sun Master)	1999	E-mail contact by Miriam Müller on 23 Nov. 2009
Weishaupt (Schweizer)	2001	Phone interview by Miriam Müller on 10 Nov. 2009
Citrin	2002	Phone interview by Miriam Müller on 10 Nov. 2009
Velux	2002	E-mail contact by Miriam Müller on 24 Nov. 2009
Solarbayer	2003	Phone interview by Miriam Müller on 17 Nov 2009
BUSO	2004	Website, last visited on 6 Nov. 2009
GC-Gruppe (GOT, Sunmaster)	No reply	---

The names of the OEM suppliers to companies that do not produce the collectors themselves are given in parentheses (Source: Sonne, Wind und Wärme 2009)

4 Conclusions

This paper attempts to analyse whether, and if so how, policies fostering solar thermal energy use can have a net positive impact on employment in Germany.

In doing so, we first gave an overview of the overall impact of climate and renewable energy policies on job creation. The study shows that climate policies or renewable energy promotion create new jobs on the one hand, but that there are different factors influencing the net impact, which could be positive or negative mainly depending on size and direction of budgetary effects and exports.

Second, we analysed the impact of policies and measures that promote solar thermal technology distribution in Germany with regard to three aspects: sales of solar thermal technologies, the number of jobs in the sector and the year in which individual companies working in the sector entered the market. There is no clear evidence that there will be a substantial positive net employment impact, although the gross employment increase in this field is obvious. Nevertheless, it can be said that there will be no new job creation resulting from renewable energy promotion and climate protection without well-designed climate or renewable energy policies and measures.

Renewable energy promotion faces a number of barriers that differ depending on the technologies distributed and developed. Policies and measures should be designed to take into account the feature of the technologies distributed and developed. For promoting solar thermal technology use for heat production, direct subsidies and credits with low rates are given to building/housing owners as an incentive on one hand while owners of new buildings are obliged to install renewable energy technologies for heat production on the other. Financial incentives cover around 15% of the necessary cost of installing solar thermal technologies. The return of investments takes perhaps 10 to 20 years, depending on the budgetary effects. Moreover, economics of solar thermal energy strongly depend on the specific building and heating system where the solar thermal technology is installed. Whether or not the combination of small financial incentives and a command and control approach (the obligation to install renewable energy technologies for heat production in new buildings) is appropriate and sufficient to stimulate individuals into using renewable energies, a close examination needs to be made of the deployment of the technologies and the ultimate creation of new jobs in the solar thermal sector. Since the new law promoting renewable energy use in heating was only introduced at the beginning of 2009, it is too early to assess its impact at this stage, but it is expected to be just a marginal one compared to the existing Energy Saving Ordinance. Moreover, this law targets only newly constructed buildings. Considering there is a large number of old buildings that require refurbishment in Germany, introducing policies and measures to promote renewable energy use for heating in old buildings besides financial incentives is also an urgent task for market sustainability. Theses are, however, the tasks to be addressed in the future.

Finally, any positive net impact at the macro level does not necessarily guarantee a positive impact at the micro level. Those who loose their jobs in the conventional energy sector will not necessarily find employment in the renewable energy sector, since different knowledge and skills are required in this sector. In order to realise a sustainable transition in the energy sector, therefore, job losses in the conventional energy sector must be addressed specially.

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