Solar Thermal Energy – Comparing Framework Conditions and Support Measures in the Renewable Heat Market of Germany and Spain

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1. Introduction

The substitution of fossil fuels by renewable energy is one of the key measures in meeting the challenges of climate change. The discussion in energy politics regarding the increased use of renewable energy, however, focuses mainly on the electricity market. At the same time, nearly half of the final energy demand in the European Union (EU) is consumed in the heating sector (BMU 2009, 57). The potential for renewable energy sources in the heat market is accordingly large.

This paper examines the support measures for increasing the use of renewable energy in the heat markets of two EU member states. Using the example of solar thermal (ST) heat generation, the *external framework conditions* and the *support measures* of both Germany and Spain are compared. The aim is to clarify why the expansion of solar thermal heat in Spain is well below its own expectations and the European average (despite the advantageous climatic conditions), while the European average is clearly surpassed in Germany. Based on these two national case studies, factors for the successful promotion of solar thermal energy are determined.

In 2007 the European Solar Thermal Industry Federation (ESTIF) proposed six complementing instruments necessary for a coherent strategy to promote solar thermal energy (ESTIF 2007, 25). It was concluded that the heating market requires a comprehensive set of measures to overcome multiple barriers to growth. Four of these support measures are compared systematically for Spain and Germany. These are regulations (solar obligations), financial incentives, training and awareness raising. Some assessment criteria are then compared against the situation in Spain and Germany. Furthermore, the effectiveness of support measures depends largely on the external framework conditions. While support measures can be altered by political actors, external framework conditions are a rather static framework for environmental policies that is beyond the direct influence of political actors and will thus change only very slowly. They include, among other things, heat demand, characteristics of the building stock as well as public attitudes and knowledge of solar thermal energy. These factors were categorized based on a slightly modified political science analysis model into economic-technical and cognitive-informational framework conditions (Jänicke 2003, 88; Bechberger et al. 2003, 28).

Besides national legislation, the EU directive on the Energy Performance of Buildings (2010/31/EU)[1] and especially the Renewable Energy Directive (2009/28/EG) are increasingly relevant for solar thermal energy. Thus, the European legal framework is considered a common basis for the support policies of both countries, especially given the fact that the Renewable Energy Directive requires policy improvements in all of the four support instruments under consideration.

2. Solar Thermal Energy Markets in Spain and Germany

The share of renewable energy in the EU heating market is 10.8 %, with the vast majority provided by biomass. In 2007, solar thermal energy contributed 1.7 % (10.9 TWh) to the renewable heat market, which makes solar thermal currently a niche within a niche market (BMU 2009, 57). In 2010, there were approximately 24,114 MW_{th} of solar thermal capacity in operation within the EU (34.4 million m^2). This translates into 47.6 kW_{th} of installed capacity per 1,000 citizens (ESTIF 2011, 9). However, this average installed capacity per capita (newly installed as well as cumulative collector surface) is not evenly distributed among the member states. As the examples of Spain and Germany show, distribution does not necessarily follow climatic conditions.

In 2010, Spain had about 1,543 MW_{th} of collector capacity in operation, which is the fifth largest cumulative capacity in Europe (Figure 1). However, this corresponds to a mere 32.1 kW_{th} per 1,000 capita (ESTIF 2011, 9). The actual expansion in Spain is far behind the expectations of its Renewable Energy Plan PER 2005-2010 (*Plan de Energías Renovables*). In 2010 the newly installed collector surface amounted to 236 MW_{th}, which is a

[1] The alleged conflict between energy efficiency through modernizing the insulation of the building stock (resulting in a decreasing heat demand) and renewable heat is discussed in Nast et al. 2009, 72 and Futterlieb 2011, 32.

strong market contraction for the second year in a row (ESTIF 2011, 6).

Germany has 9,831 MW_{th} of collector surface installed, which is the largest cumulative capacity in Europe (Figure 1), translating into 118.3 kW_{th} per 1,000 capita. In 2010 the market dropped by almost 29 % compared to 2009, with only 805 MW_{th} of newly installed capacity (ESTIF 2011, 9; cf. Rentzing 2011, 59).

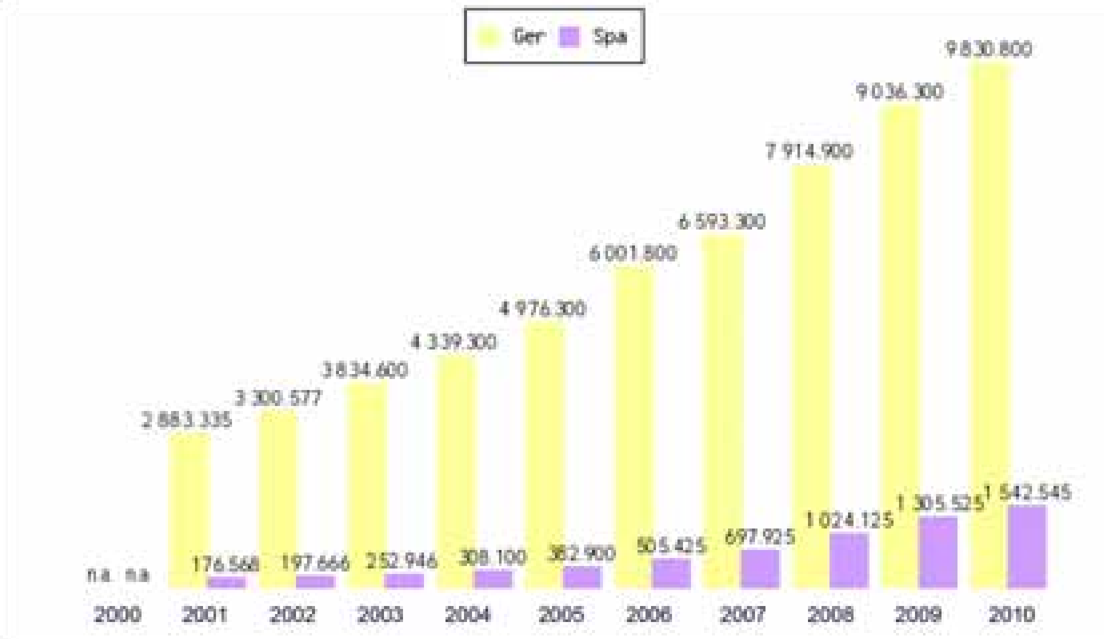

Fig. 1: Cumulative installed capacity in Spain and Germany from 2000-2010 in MW_{th} (EurObserv'ER 2011)[2]

Germany is currently the largest solar thermal market in Europe. About 31 % of the newly installed capacity in 2010 was installed there, while Spain held a share of 9 % of the European market. However, the relative share of Spain has slowly been increasing compared to the previous years, while Germany's market share fell slightly (ESTIF 2011, 9).

3. External Framework Conditions

The external framework conditions have been introduced as being not immediately alterable by political actors. One framework condition not mentioned before, yet certainly not changeable, are the climatic conditions. Suffice it to say here that the conditions for solar thermal in Spain are very favorable. Spain has even the highest potential in Europe with an average of 1,650 kWh/(m^2*a) at 2,500 hours of sunshine annually (dena 2008, 35). The climatic potential in Germany is much lower. The solar radiation ranges from 900 to 1,200 kWh/(m^2*a). The sunshine duration is between 1,300 and 1,900 hours a year (REC 2009).

a. Economic-Technical Framework

The economic-technical framework for solar thermal energy is distinguished by the composition of the heat demand, the characteristics of the building stock and by the role of plant manufacturers.

Spain

Given the higher solar radiation in Spain, the total heat demand is lower than in Germany. While the demand for domestic hot water (DHW) per inhabitant is identical with Northern Europe, the necessity for space heating is significantly lower. The market for solar thermal plants providing only DHW is correspondingly large, while Combi systems (DHW and space heating) play a minor role at the moment (Piria 2010, pers. comm.). In the residential building sector, which is the most important market for solar thermal, the final energy consumption accounted for 189 TWh (in 2005). Only 40 % was needed for space heating, 25 % for DHW and the remaining 35 % was used for electricity (AEE 2009, 27).

The building stock in Spain differs from that in Germany by the dominance of large residential buildings

2 Other statistics differ slightly (cf. ESTIF 2011, 13).

(ESTIF 2007, 51). 60 % of the existing buildings are apartment blocks with at least three tenants (Pérez in estec 2009, 11). Recalculated in inhabitants, this means that a large majority of the Spanish population lives in multi-family buildings and apartment blocks (Martínez 2010, pers. comm.). In large residential buildings, however, there are numerous technical, economic and legal barriers to the installation of solar thermal systems (ibid.), such as the need for unanimous decisions on the required investments by all tenants. More often than not, the construction company or the owner has no interest in increasing energy efficiency through solar thermal plants, because the running costs will be borne by the tenants.

Furthermore, the number of new buildings has significantly decreased in recent years. This was largely due to the strong downturn of the construction sector in the wake of the worldwide financial crisis (Rentzing 2009, 37; Pérez in estec 2009, 10). Of course the impact of the solar obligation (see section 4.a), which initiates most of the ST installations, is considerably lower when there are less new buildings constructed. The Spanish Solar Thermal Industry Federation ASIT (*Asociación Solar de la Industria Térmica*) believes that the construction sector will not recover in the years to come. While in 2008 615,000 apartments were still built, ASIT forecasts that only between 151,000 (2010) and 280,000 (2017) apartments will be built each year (Polo 2010a, 4).

The large ST manufacturers are based mainly in Germany and Austria. Out of the total collector surface installed in 2008, only 35 % was also produced in Spain, whereas 27 % originated from Germany and 18 % from Austria (Polo 2009, 12). The solar thermal industry in Spain reached its current peak in 2008 with an annual turnover of 375 million euro (EurObserv'ER 2011).

Germany

More than half of the German final energy consumption is used for heat production. The final energy demand in the residential building sector amounts to 804 TWh. The largest share of 76 % is needed for space heating, 10 % for DHW and the remaining 14 % for electricity (AEE 2009, 27). This breakdown justifies the higher emphasis on Solar Combi systems in Northern Europe, whose installation is also encouraged by the recent changes in the German financial incentives programme. Since 2010, small DHW-only plants are no longer eligible for funding (see section 4.b).

The differences between the building stock in Spain and Germany are remarkable. About 82 % of the German building stock is detached (single-family) or semidetached homes (Langniß et al. 2004, 35). New buildings of this type are mostly resident-owned. Under these conditions there will be fewer technical, economic and legal barriers to the installation of solar thermal systems (Piria 2010, pers. comm.). The impact of the financial crisis on the construction sector has been very moderate compared to Spain, yet the construction quota has been well below 1 % since 2001 (Corradini & Musso 2011, 26).

The high concentration of ST manufacturers in Germany dates back to the 1970s, when motivated do-it-yourself groups began to build handmade collectors. Today's manufacturers originated partially out of this German-Austrian do-it-yourself connection. They continued to specialize, and grew gradually into companies with a turnover of several million euros. As a side effect of this concentration, European research in solar thermal energy is located to a great extent in Germany and Austria. The annual turnover of the ST industry in Germany was relatively constant at around 1.2 billion euro during the last few years (EurObserv'ER 2011).

b. Cognitive-Informational Framework

The cognitive-informational framework conditions for solar thermal comprise public attitudes and the knowledge about solar thermal energy. For a positive cognitive-informational environment it is essential to underline, first and foremost at the local level, the non-energetic advantages of the respective technology. These include for example positive employment effects (Bechberger et al. 2003, 26). Assumptions in this area are often difficult to backup empirically, yet there was a broad consensus among the interview partners about the following assessment, which was developed further based on the work of Bechberger (2009, 720).

Spain

Compared to Germany, the big utilities in Spain started their activities in the renewable energy sector relatively early (Bechberger 2009, 708). According to their traditional approach, they were focused on large-scale projects in wind power and photovoltaics. There was little competition between the traditional energy utilities on the one hand and renewable electricity producers, who would enter the energy market as pioneers and grassroots movement, on the other hand (ibid., 720). While the vast majority of renewable energy capacity was developed in the portfolio of the traditional power supply industry, the Spanish population showed little interest in this subject matter – an ecological sensitivity of the final consumers did not evolve. While the ownership of renewable energy plants is relatively unimportant to increase the capacity in the electricity market, the renewable heating sector due to its decentralized plants depends strongly on the participation of every potential customer. Every houseowner must make individual investment decisions that have an impact on the increase of the total solar thermal capacity. Yet the awareness and positive attitude towards renewable energy is very limited, because the pioneering phase of renewables in the Spanish electricity sector did not entail the sensitization of the general public. The motivations of environmental consciousness and energy self-sufficiency are thus less intense. Yet solar thermal energy (and renewable heat in general) depends much more on this positive environment than renewable energy in the electricity sector.

As the residential building stock is composed largely of multi-family dwellings, there is mostly no direct relationship to the building or to its energy supply like there would be in a detached house that is inhabited by the owner. The retrofitting of ST in the building stock is hampered by this cognitive-informational shortcoming (Piria 2010, pers. comm.). Apparently the advantages of ST energy have not been communicated sufficiently.

Germany

The cognitive-informational framework conditions in Germany appear much more positive. Many of the solar activists of the early years came from the anti-nuclear movement. They considered renewable energy as the solution to realize the energy transition they were striving for. The growth of renewable energy sources is thus largely attributed to the private and professional commitment of citizens and citizens' initiatives, researchers and many new entrepreneurs (Hirschl 2008, 179). These small and medium-sized companies managed to professionalize their idealistic ideas and to create marketable structures (Bruns et al. 2009, 474). In contrast, the large and well-established utilities in the conventional energy sector were not involved in the production and active use of the new technologies yet (Hirschl 2008, 61). The result was two opposing and clearly defined interest coalitions of the conventional utilities and the emerging renewable energy industry. This conflict increased customers' sensitivity for renewable energy sources. The acceptance of renewables in the population serves as a stabilizing factor (Hirschl 2008, 184). Solar thermal, as a local energy source by definition, requires this positive attitude. This is why more ST plants were installed in Germany by adequately motivated homeowners. Besides this environmental awareness, the motivation to install solar thermal systems arises from rising prices of fossil fuels and the strongly rooted idea of energy self-sufficiency (Piria 2010, pers. comm.).

The large share of single-family houses stands for a direct relationship to the property. The use of solar thermal energy can expand relatively well in this kind of environment (ibid.). Altogether, the German solar thermal market has strongly benefited from the ecological awareness of its customers.

4. Support Measures

While the external framework conditions were defined as relatively steady factors, the support measures can be altered comparably easily. The support instruments that were analyzed include regulations (solar obligations), financial incentives, vocational training for installers and awareness raising activities. As there are hardly any criteria for their evaluation, ESTIF has defined some ideal characteristics for each support measure, which are introduced briefly at the beginning of each subsection (cf. ESTIF 2007, 25 et sqq.).

a. Regulations (Solar Thermal Obligations)

For the past few years, there has been the intention to promote the expansion of solar thermal energy increasingly with solar thermal obligations (STO). Article 13(4) of the renewable energy directive 2009/28/EG requires that the member states – where appropriate – establish solar obligations by 2015. In some member states, including Spain, Portugal, Italy and Germany, this has already been implemented (Nast et al. 2009, 10). The advantage of a solar thermal obligation compared to financial incentives is its continuity, which is achieved through the independence from budgetary constraints. Inspections and credible sanctions for non-compliance are vital to make the developer comply with the obligation, especially in the introductory phase of this regulative instrument (ESTIF 2007, 62).[3]

[3] Another effect of solar obligations is the guaranteed minimum market which kicks off growth towards a critical mass, which again induces economies of scale along the supply chain (ESTIF 2007, 19).

Spain

With the new technical building code CTE (*Código Técnico de la Edificación*) that was introduced in 2006, Spain was the first European country to enact an obligation to use solar thermal energy in newly constructed buildings. The success of the preceding local obligations (*Ordenanzas Municipales*), the first of which was enacted in Barcelona in 2000, served as a blueprint for the nationwide STO (cf. Futterlieb 2011, 54; Bechberger 2009, 496). Local obligations are still valid, provided they surpass the requirements of the CTE. This creates a complex web of local (and partially regional) requirements and the nationwide CTE. The legal competence for energy policy – apart from the framework legislation – lies at the level of the autonomous communities. Therefore, local solar obligations will continue to exist alongside the CTE (Bechberger 2010, pers. comm.).

The STO applies to new buildings, and to those with a total floor space above 1,000 m^2 that undergo major renovation. Between 30 % and 70 % of the annual DHW demand at a reference temperature of 60°C needs to be covered by solar thermal. The CTE refers to DHW only; space heating is not considered. The minimum solar contribution depends on the climatic zone and on the amount of DHW consumed in the building (ESTIF 2006, 15). These solar contributions are minimum values, which may be increased by local solar obligations. Exceptions from the obligation are possible only in very few cases: If other renewables provide the same amount of DHW, if the installation were inappropriate in terms of monument protection, or if the site does not provide space for collectors or insufficient sunlight exposure (Bechberger 2009, 499; ASIT 2007, 11).

The Spanish legislation, consisting of the CTE and local solar ordinances, is very sophisticated. The minimum solar contributions, which are graduated according to the climatic zone of the building site and the DHW consumption, are very ambitious (dena 2008, 36). Although by now the CTE is the key demand driver for solar thermal installations in Spain, the expectations towards this support measure were only partially fulfilled. The slow market development in recent years can partly be explained by different weaknesses of the CTE.

With the creation of a mandatory market, large construction companies are entering into the value chain, which consisted previously of manufacturers, distributors and installers. These construction companies have a lot of bargaining power that can trigger price reductions through scale effects. This however will go hand in hand with lower quality of the plants. In a market characterized by solar thermal plants on large apartment blocks, the final consumer is largely excluded from the choice of a ST system. The choice is thus left to those market participants whose primary motivation is low initial investment costs (Pérez in estec 2009, 10).

In addition to this conflict of interest, the current implementation of the CTE lacks an adequate control system of compliance and clear-cut sanctions in case of non-compliance (ESTIF 2007, 75; Bechberger 2010, pers. comm.). The responsibility for controls and, where applicable, sanctions rests with the authorities of the autonomous communities, who rarely have enough trained personnel for these tasks (Polo 2009, 20). The lack of (credible and effective) ways of sanctioning is a barrier to the enforcement of the different solar obligations in Spain (Nast et al. 2009, 24). An official monitoring system is urgently needed (Pérez 2009, 29). Another reason for the transposition deficit is according to ASIT the lack of expertise of architects, installers, developers and local authorities (Bechberger 2009, 503). Another factor, which however cannot be blamed on the CTE, is the slowdown of the Spanish construction market (Pérez 2009, 29; see section 3.a).

Germany

Obligations for solar thermal or renewable heat in general are a relatively new instrument in Germany, introduced at federal level in 2009 with the Renewable Energies Heat Act EEWärmeG (*Erneuerbare-Energien-Wärmegesetz*). Due to the delay between coming into force and measurable effects on the number of solar thermal installations, a quantitative assessment is still difficult. Local solar ordinances were not in place to a noteworthy extent, yet the state of Baden-Württemberg introduced an STO in 2008 that surpasses the national obligation in terms of its applicability in the existing building stock.

While solar thermal systems are the most popular option to meet the obligation, the law itself is not technology-specific but lets the user choose the renewable heat technology. The EEWärmeG refers to new buildings only (Art. 3(1)). At least 15 % of the heat demand (DHW and space heating) needs to be covered by solar thermal energy. Alternative measures are possible. For example the solar obligation can also be satisfied if the building insulation surpasses the requirements of the German energy savings ordinance (EnEV) by at least 15 %. Additionally there is the possibility of complete exemptions without the need for compensatory measures, for example when other requirements of the building code or monument protection apply (Art. 9). The first evaluation report will be available by the end of 2011 (Art. 18).

It was particularly the limitation to new buildings that made the obligation lag behind the expectations of the advocates for renewable heat (cf. Nast et al. 2011, 37). The solar thermal industry neither expected nor experienced a major breakthrough by the obligation (Rentzing 2009, 36; Rentzing 2011, 59). The scope is relatively small and is narrowed down further by the exceptions and alternative measures. Even if a ST heating system is installed, the obligatory minimum solar fraction is very low. A lack of controls has not been considered problematic yet. It may be concluded that the German EEWärmeG in its present form is less ambitious than its Spanish counterpart CTE. Yet the positive cognitive-informational environment for solar thermal energy (see section 3.b) could help ensure that the obligation is complied with, even if there are few actual controls of fulfillment (Piria 2010, pers. comm.). This may ultimately result in a stronger implementation and offset the negative impact of the numerous exceptions. The restriction to new buildings may no longer be possible after 2014, because Article 13(4) of directive 2009/28/EG requires – where appropriate – the inclusion of existing buildings that are subject to major renovation into the national solar obligation schemes.

b. Financial Incentives

Financial incentives are ideal for those cases in which the solar obligation cannot be applied, thus primarily in existing buildings. The renewable energy directive 2009/28/EG encourages the member states to develop financial support schemes in the renewable heat market (Art. 3(1)(a)). Incentives are mainly set in the form of direct grants, tax reductions, low-interest loans or bonus payments according to the quantity of heat generated (AEA 2009, 1). Direct grants from the federal budget have been the most common financial incentive in Europe (Nast et al. 2009, 9). Yet direct grants from the federal budget always involve the risk of irregular funding, for example when the budget is exhausted before the end of the financial year.

Essential aspects of all incentive programs are continuity and financial stability as well as a minimal administrative overhead (ESTIF 2007, 96). The amount of funding is not the only decisive criterion. The incentives must be adequate to support market growth towards a critical mass, yet large windfall gains should be avoided (ESTIF 2007, 106; Langniß et al. 2010, 97).

Spain

Financial incentives for ST systems in Spain were available in several support programs on the national, regional and sometimes even local level. In the years 2000 to 2002, solar thermal energy was supported by direct grants. A total of 24 million euros was distributed at national level during this timeframe. The grants per square meter were between 210 euro/m^2 and 300 euro/m^2 (Bechberger 2009, 478). It is obvious that the total amount did not suffice to support all solar thermal plants installed in this period of time.

Since 2003, solar thermal was included in a new support program which emerged from a cooperation between the Spanish energy agency IDAE (*Instituto para la Diversificacion y Ahorro de la Energía*) and the state's financial agency ICO (*Instituto de Credito Oficial*) (Bechberger 2009, 478). The kind of incentive was thus shifted from direct grants to low-interest loans. It provided loans of up to 812 euro/m^2 for regular domestic installations with a maximum surface of 20 m^2 (ASIT 2005, 21). The program was not renewed after 2005.

From 2006 onwards, the administration of the financial incentives was shifted to the level of the autonomous communities.[4] The method of financing was shifted back to direct grants paid per square meter of collector surface. IDAE transfers the money from the national level proportional to population to the autonomous communities. The programs are usually administered by the regional energy agencies (dena 2008, 82). The communities roughly double the financial means provided by IDAE. However, the contribution of the communities' own resources varies significantly. In 2007, the share of IDAE was 18.2 million euro; in total 38.8 million euro of direct grants were made available. The contribution of IDAE was reduced considerably in 2008 and 2009 (IDAE 2010a, 35; Futterlieb 2011, 62).

While the total amount of annual subsidies is quite low, the grants per square meter are comparably high: The total funds available in 2007 divided by the newly installed and funded collector surface of that year yields an average of 263 euro/m^2 direct grants in Catalonia, 154 euro/m^2 in Madrid and even 273 euro/m^2 in Andalusia.[5]

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[4] This development is not motivated by functional reasons, but part of the regionalization process in Spain, because the legal competence for energy policy lies at the level of the autonomous communities (Bechberger 2010, pers. comm.).

[5] This calculation can only serve as an indicator for comparably high grants per square meter, as each funding guideline supports different types of ST systems and as the actual grant decreases when large collector surfaces are installed.

The direct grants can cover an average of 40 % of the investment costs for ST installations (dena 2008, 36). Given the low total budget, this means that only a very limited number of ST plants received financial support.

Some of the funding guidelines of the regions (*Órdenes de Ayudas*) are open for applications only a few weeks. But even the guidelines that are theoretically open all year long have insufficient funding, thus applications are rejected after a short period of time. According to ASIT, most programs are closed after one or two months (Polo 2010a, 5). In general, the direct grants are intended to support ST applications in the building stock. They cannot be requested for new buildings that are subject to the CTE (Martínez 2010, pers. comm.).

ASIT assumes for 2009 that out of the newly installed collector surface of 402,000 m^2, 83 % were installed because of the solar obligation CTE and just under 14 % motivated by financial incentives (Polo 2010b, 6). Local ordinances initiated in the previous year less than 5 % of the installations (Polo 2009, 13). It is supposed that even less collector surface will receive funding through an incentive scheme in 2010 (Polo 2010b, 5).

Financial support measures in Spain to date have hardly met one of the basic principles for financial incentives. Stability is given neither in terms of financial resources, nor regarding the funding instruments. The available funds fluctuated significantly on an annual basis and have decreased constantly in recent years. Combined with very high grants per square meter (although even here, there are large differences between the regions), the total collector surface that could benefit from the direct grants was very low. The scarce funds were spent within a few months of a year. The administrative expenses are relatively high due to the lack of a central funding authority. Many regional authorities lack the manpower and the competence respectively to manage the direct grants efficiently (Polo 2010b, 5).

As an alternative to the square meter based grants, the support programme SOLCASA investigates financial incentives for large solar thermal systems. These are budget-independent schemes, where an energy services company (ESCO) builds and maintains the solar thermal plant, which is refinanced by the revenue from the heat sales. The program started in 2010 and has a budget of 5 million euro (IDAE 2010b).

Germany

Financial incentives for ST systems have existed in Germany for nearly 20 years. The most important financial incentive scheme is the Market Incentive Programme MAP (*Marktanreizprogramm*), which has been running since 1999. The ministry of the environment enacts the relevant funding guidelines (*Förderrichtlinien*). The aim is to forecast the development of demand and to continually adapt the incentives in a way that as many applicants as possible can benefit from the subsidies while guaranteeing that a maximum of collector surface is installed. The MAP consists of low-interest loans managed by the KfW bank group (*KfW Förderbank*) and on direct grants managed by the Federal Office of Economics and Export Control (BAFA). Direct grants account for more than 80 % of the total budget of the MAP (Langniß et al. 2010, 28).

While the basic structure of the MAP has been very stable since it was started, the details have been changed considerably over the course of the program to adjust to technical and economic developments (IfnE 2010, 8). If there was a decline in demand the direct grants were increased and vice versa. This proactive program steering allowed for almost every applicant to receive direct grants for his ST system (Langniß et al. 2004, 32, 83). During the last few years, about 82 % of the newly installed collector surface received grants from the MAP, the remaining collectors were largely installed due to the solar obligation (Langniß et al. 2010, 91).

The grants per square meter for small plants (Solar Combi systems below 40 m^2) ranged from only 70 euro/m^2 in 2007 to a maximum of 135 euro/m^2 in 2005. The current funding guideline of March 15, 2011 provides grants of 120 euro/m^2. The total annual subsidies for solar thermal within the MAP were between 40 million euro (2000) and 195 million euro (in 2009). These funding budgets in proportion with the triggered investments for the timeframe 2000 to 2009 show that the direct grants covered a mere 12.9 % of the investments made (Futterlieb 2011, 94).[6] Given the considerable leverage effect of low grants per square meter against very high investment volumes initiated, the MAP is a highly efficient support programme (IfnE 2010, 14).

As the funding ratio was usually well below the VAT rate (19 % since 2007, previously 16 %), the treasury incurred no additional costs, because the tax revenues generated by investments in solar thermal systems always surpassed the funding budgets (ESTIF 2007, 103). The centralized programme management by the BAFA ensures low administrative expenses, which accounted for only 2 % of the funding budgets (IfnE 2010, 7).

6 For an overview of the direct grants for flat plate collectors (up to 40 m^2) as well as the "bonus grants" introduced in 2007 which were available in addition to the square meter grants see Futterlieb 2011, 94; Corradini & Musso 2011, 23.

While there are some regional or local funding programs (cf. Futterlieb 2011, 97 et sqq.), the national MAP remains the most important funding instrument.

Like in Spain, the direct grants are primarily intended to support solar thermal systems in the building stock, while new buildings are in principle subject to the solar obligation of the EEWärmeG (IfnE 2010, 2; see section 4.a). Yet there were many exceptions like increasing the collector size above the obligatory percentage (or installing Combi systems) that permitted a reduced funding even for ST systems in new buildings. However, the funding guideline of July 12, 2010 completely excluded direct grants for ST plants in new buildings.

Compared to Spain, interruptions of the funding programme were relatively rare. The MAP had a major impetus on the increased use of solar thermal energy, and contributed strongly to the doubling of renewable heat since 1999 (Bruns et al. 2009, 92). Piria (2010, pers. comm.) sees the MAP as Europe's most stable incentive programme for solar thermal. Due to the positive cognitive-informational framework and the overall stability, the support scheme is successful in spite of the relatively low investment grants. Still, the dependence on the federal budget has repeatedly limited the steering capacity of the MAP. The low point to date was the complete stop of the MAP in May and June 2010, which caused a drastic decline of the solar thermal market within just a few weeks (cf. Corradini & Musso 2011, 25; Rentzing 2011).

c. Training

Training and advanced qualification of installers (and other professionals in the construction sector) is highly important as they have a strong influence on the investment decision of homeowners.[7] Well-trained installers are more motivated to sell solar thermal systems, even more so because the installation requires more working hours than a conventional heating system. The training standards especially in the skilled trades are very different across the EU member states (ESTIF 2007, 55). The renewable energy directive 2009/28/EG (Art. 14) requires the establishment of mutually recognized certification schemes or equivalent qualification schemes by 2013 to bridge different training standards for installers.

Spain

The vocational training of installers is completed within 1,300 to 2,000 hours (Oldach 2005, 118). While the content of the vocational training for installers of heating and cooling systems remains unchanged, in 2009 the new specialized training profile "specialist in energy efficiency and solar thermal technology" (*Técnico Superior en Eficiencia energética y energía solar térmica*) was established within the occupational category "energy and water supply". The training takes 2,000 hours and includes the basics of solar thermal systems, their dimensioning and installation, maintenance as well as the topics of energy performance certificates and energy efficiency (GOB 2011). As the occupational profile is relatively new, there is no information yet concerning the interest of trainees and training companies.

In the area of advanced training there is a broad range of distance learning courses and advanced training courses for installers who wish to extend their services to renewable heat installations. Courses are provided for example by the national center for vocational training in renewable energies CENIFER (*Centro Nacional Integrado de Formación en Energías Renovables*) and the solar energy training center CENSOLAR (*Centro de Estudios de la Energía Solar*).

A vocational training of 2,000 hours represents just over one year of full time education. So these trainings cannot be as comprehensive as a vocational training in Northern Europe that takes between two and three and a half years. According to Piria (2010, pers. comm.), the quality of training for craftsmen – not only in trades specific to solar energy – is below the level in Northern Europe. Improvements in this regard are slower than expected (ibid.). There is no report available that provides an overview of the basic and advanced training options for the skilled trades relevant for solar thermal. In general, several bottlenecks in terms of training continue to exist regarding the basic know-how and the installation of ST systems. The need for further training of engineers, architects, professional planners and retailers is equally strong (dena 2008, 86).

Germany

The vocational training for installers, or rather "plant mechanics for sanitation, heating and air conditioning

[7] The equally important university education and integration of solar thermal knowledge into existing study programmes for architects etc. is not considered here, cf. Futterlieb 2011, 65 and 103 for details.

systems" (*Anlagenmechaniker SHK*), takes three and a half years and encompasses theoretical and practical components, also regarding renewable energy systems. It thus meets the requirements of directive 2009/28/EG Annex IV concerning qualification. However in practice, the training contents regarding ST systems depend on the vocational school and the field of business of the training company, because knowledge of renewable energy systems is not yet a mandatory part of the training (WiLa 2007, 32). Only the training rules for the higher-ranking master craftsmen SHK explicitly contain systems for renewable heating like solar thermal installations (BMU 2010, 43).

In a 2007 survey, 80 % of the companies interviewed expected problems caused by the lack of skilled personnel (Vajen in estec 2009, 45). According to these companies, knowledge of ST systems is usually not part of the vocational training for installers; the same holds true for university graduates from related academic professions (Wila 2007, 16). That is why craft businesses look for employees with practical experience or are forced to develop these skills themselves through external and in-house training (Vajen in estec 2009, 46). Most installers gain their knowledge of ST systems from short training courses of the manufacturers (Vajen et al. 2008, 16).

Contrary to the federally standardized vocational training, the market for advanced training is not regulated that strictly. There is a wide and complex range of courses, with large fluctuations in quality (Oldach 2005, 50). They are organized by the chambers of crafts, guilds and associations. But also the ST manufacturers, whose concentration in Germany is quite high (see section 3.a), are active in the advanced training of installers, because craftsmen are among their most important distribution channels. The manufacturers offer free and compact training courses that are attended primarily by craftsmen (Vajen et al. 2008, 35).

The length of the basic vocational training for installers in Germany promises – relative to Spain – a high level of education, which can be a good basis for advanced training courses. Due to the newly introduced solar obligation (see section 4.a) it can be assumed that even more skilled workers will be needed. More efforts in training are necessary to ensure that the lack of qualified staff does not become a bottleneck to the growing demand for ST systems (Vajen in estec 2009, 47).

d. Awareness Raising

Public awareness campaigns are intended to reach the potential customer directly. The measures can range from simple leaflets at the heating installer to internet portals and campaign weeks for solar thermal energy. The aim is to make customers aware of solar thermal products so they will choose this technology when a window of opportunity opens up, for example because a new heating system needs to be installed urgently (ESTIF 2007, 33). As these information measures are of fundamental importance they were also enshrined in Article 14(6) of the renewable energy directive 2009/28/EG.

Spain

The disadvantageous cognitive-informational framework in Spain (see section 3.b) makes awareness raising measures particularly important. Awareness raising is conducted mainly by IDAE and the regional energy agencies. The 2006 annual report of IDAE claims that the Spanish population has a very low awareness and knowledge of renewables and the possibilities of energy savings. Especially in the field of solar thermal energy, customers need to be made aware that the use of ST is not associated with personal losses in comfort (IDAE 2007, 39). None of the recent campaigns of IDAE was focused explicitly on solar thermal energy.

The first Solar Days in Spain (*Días Solar*) were organized by ASIT in 2008. The 50 events were attended by about 8,000 visitors. The multipliers involved were mainly ST companies and training centers as well as nine regional energy agencies and several municipalities. While the number of visitors exceeded expectations, the media coverage was still relatively modest. In 2009 the number of events was increased fivefold, which is mainly attributable to the partnership with the regional energy agencies (ESD 2010, 11 et sqq.). The budget of ASIT for the Solar Days in 2008 can be considered relatively low (Bechberger 2010, pers. comm.). ASIT managed to involve the regional energy agencies and their own resources more strongly for the campaign in 2009. The members of ASIT were apparently not able to contribute adequate resources (cf. ESD 2010, 17).

Germany

The cognitive-informational framework in Germany is quite favorable (see section 3.b), so that awareness campaigns for solar thermal energy can turn many interested parties into potential new customers. Still, campaigns that are focused exclusively on solar thermal energy are comparably rare. This paper can only address some of the measures that run over a longer period of time.

The so-called Solar National League (*Solarbundesliga*) was initiated in 2001. It is a contest with the goal to raise awareness for solar energy. The participating municipalities compete for the highest solar electricity yields (photovoltaics) and the most collector surface installed within one year (solar thermal), both of which are weighted against the number of inhabitants. The "German champion" is nominated every year by the organizers. Solar thermal energy is promoted particularly on the websites of municipalities that are using renewables (*kommunal-erneuerbar.de*) and on a website providing more general guidance on how to switch to renewable heat (*warrmewechsel.de*), both of which are run by the German Renewable Energies Agency (AEE).

In addition to national campaigns, there are several initiatives that began as local grassroots movements and later linked in cross-regional networks. Another approach to awareness raising is the exhaustive analysis of the potential of rooftops for solar systems in a certain area, which was for example conducted in the municipalities of Osnabrück, Gelsenkirchen and Freiburg. Every resident of a municipality whose potential has been investigated can easily determine whether the characteristics of his rooftop are favorable for installing a solar thermal system.

The Solar Week (*Woche der Sonne*) is the largest national campaign, which was started in 2002 in Austria, Germany and Switzerland and later on extended to other European countries (including Spain) as the "Solar Days" campaign. The many local events allow manufacturers and installers to address specifically the potential users in detached houses in rural areas. The Solar Days thus combine the advantages of a centralized campaign management and a uniform corporate design with many events arranged by initiators at the local level. The Solar Days of 2009 included 5,000 events with half a million visitors, which corresponded to a doubling over the previous year. Manufacturers and installers hosted more than 70 % of the events (ESD 2010, 17). In 2010 the Solar Days had to cope without the financial support of the ministry of the environment, as the campaign is now fully funded by the solar industry.

Awareness raising is closely linked to the already existing positive cognitive-informational framework in Germany, which creates a fertile ground for the success of campaigns. Given the fact that the awareness for solar thermal energy differs in both countries, potential campaigns have very differing starting points. While the Solar Days in Spain were newly introduced on a small scale, in Germany there is by now a broad network of companies supporting the campaign.

5. Conclusion

A successful support policy requires continuous monitoring and readjustments to the different support measures as well as the close consideration of the external framework conditions. The closing section will summarize the findings, point out further explanatory approaches and provide some recommendations, several of which were already incorporated in the renewable energy directive 2009/28/EG, and must now be transposed into national law within a certain period of time.

a. Summary: External Framework Conditions and Support Measures

The framework conditions in Germany were favorable for the diffusion of solar thermal energy. The German solar heat market has benefited from the ecological attitude of its customers, the presence of numerous large plant manufacturers and a building stock characterized by many privately owned single-family (detached) homes. Financial incentives remained relatively stable for more than ten years, with the highly efficient funding quota allowing for a high number of ST plants to be installed. Taking into account the tax revenues generated by investments in solar thermal systems, the treasury incurred little to no costs. The market incentive program persists alongside the solar obligation and can continue to lift the high potentials for solar thermal systems in the building stock (Nast et al. 2009, 111). The long-term success of the newly established German solar obligation remains to be seen.

Despite climatic advantages, the remaining framework conditions for solar thermal energy in Spain are rather unfavorable. The building stock consists to a great extent of large (residential) buildings, whilst the interest of consumers in a renewable heat supply is low. The solar obligation is currently the strongest support instrument in Spain. Its technical requirements go well beyond the German counterpart. However, it is not sufficiently integrated into a coherent mix of support measures. In addition, lack of implementation of the existing legislation and the downturn in the construction sector in the wake of the financial crisis prevented the fulfillment of the predicted expansion rates. Financial incentives are available on a rather irregular basis. Their configuration differs regionally and the total budget is comparably low. Yet as the grants per square meter are relatively high, the budget is mostly exhausted within a few months after the subsidy guidelines were opened for applications – the resulting fluctuations in demand are problematic for the manufacturers of solar thermal systems. Financial incentives supported the Spanish solar thermal market only marginally (cf. Bechberger 2009, 183). The higher solar radiation as Spain's obvious advantage could not compensate for the relative weakness of the support measures and for the disadvantageous framework conditions.

Up until now, neither of the two countries has adequately incorporated renewable heating into the vocational training and further qualification of installers and architects. The awareness raising campaigns that were carried out in Germany had better preconditions, more financial contributors and thus reached higher visibility.

Figure 2 illustrates the findings regarding the initial research question. The external framework conditions, support measures and some further explanatory approaches are listed under the question of whether they were rather drivers (+) or barriers (-) to the expansion of solar thermal energy. The role of factors marked with an "o" is unclear, either because more research would be needed to assess their influence, or because they have been introduced too recently to be evaluated adequately.

Research Area	Element	Spain	Germany
External framework conditions	Economic-technical framework	-	+
	Cognitive-informational framework	-	+
Support measures	Regulations / solar thermal obligations	+	o
	Financial incentives	o	+
	Training	o	-
	Awareness raising	-	+
Further explanatory approaches	Market structure	-	-
	Administration	o	o
	Support instruments on regional and local level	+ (obligation) - (fin. incentive)	o
	Mix of instruments	-	+

Fig. 2: Drivers and Barriers in the Spanish and German Solar Thermal Energy Market (author's illustration)

This synopsis shows that the support for solar thermal energy requires a broad mix of support measures and advantageous framework conditions. The strong focus on the solar thermal obligation in Spain is contrasted in Germany by a policy mix of obligations and financial incentives, which is additionally supported by favorable framework conditions.

b. Further Explanatory Approaches

Some additional factors of explanatory value appeared significant in the research process (cf. Futterlieb 2011, 118 for a more detailed overview). While they are provisionally included in Figure 2, more research is needed to come to a well-established evaluation of their impact.

They include the complexity of the renewable heat market, where millions of actors – practically every homeowner – have to make investment decisions, which often do not include energy efficiency or the choice of a renewable energy source as guiding principles (Nitsch & Wenzel 2009, 51). The complexity of the market and the multitude of actors involved turned out as a barrier to the rapid diffusion of ST in both countries.

Furthermore, the administrative requirements regarding building permits for ST plants may have a considerable impact. The approval procedure for small ST systems is apparently more burdensome in Spain than in Germany (AEA 2009, 2). In Germany there is generally no approval required for small solar systems on buildings.

Support instruments on the regional and local administrative level can be drivers or barriers to the growth of the solar thermal market. The solar obligations on the local (e.g. Barcelona) and regional (e.g. Baden-Württemberg) level were important forerunners and thereby initiators for subsequent regulations on the national level. At the same time, regional measures should not develop into a jungle of additional requirements (local solar obligations) and incentives (regional support schemes) whose complexity may become a barrier.

Even more than in the electricity market, the optimized interaction of the support instruments is essential for a successful support policy. It became apparent that all components of the instrument mix affect each other and need to be meaningfully connected. This strong interdependence renders meaningless the question, which of the four support measures is the most important one. None of them is dispensable and the right mix of measures forms a success criterion in itself. While Spain tackled this task very well for renewables in the electricity market (cf. Bechberger 2009, 719), the entry into force of the solar thermal obligation caused a strong focus on this core instrument. Compared to Germany, support measures in the building stock were neglected.

c. Recommendations

Regarding the optimization of solar obligations, it is too soon for Germany to suggest improvements based on past experience. An evaluation report is scheduled for the end of 2011. Yet it seems appropriate to point out that Germany should have considered following the example of Spain regarding the (partial) inclusion of the building stock and the reduction of exceptions to the obligation (cf. Nast et al. 2011). Spain should introduce clear controls and effective sanctioning measures.

The budget for financial incentives should be increased and the schemes should be developed further in both countries. In addition to more stable funding conditions, Spain needs to urgently optimize the management of its incentive programme to prevent sporadic over-funding and the resulting dry spells after the funds have been exhausted. The decentralized allocation of funds by the autonomous communities complicates the optimization.

Measures regarding training and further education are frequently in the field of non-binding conventions and declarations of intent. Within the broad discussion about renewable energy, there is still too little focus on this subject. More appeals to the self-interest of the construction sector as well as the skilled trades and installers are necessary, who in turn need to advocate improved standards for vocational training and further education in their chambers of trade and guilds.

Especially in Spain more emphasis on awareness raising is needed, as campaigns for solar thermal have been running since only a few years and additionally need to compensate for unfavorable cognitive-informational framework conditions. The fact that particularly in Spain, financial payback of ST systems can be achieved within a few years of operation needs to be underlined. But despite the successful Solar Week in Germany, awareness raising campaigns still need to be strengthened there as well.

On the issue of mutual learning between both countries, it may be encouraged that Spain adopts some components of the German incentive scheme, while Germany could pick up parts of the advanced solar obligation of Spain. Yet it became apparent that every support measure is embedded in a specific context of national framework conditions. Hence any potential adoption of certain aspects of support measures needs to be preceded by a thorough evaluation.

In relative terms, the German solar thermal market achieved better results compared to Spain. This however should not obscure the fact that solar thermal energy, or renewable heat more generally, is still only a niche market in Germany too. In light of the vast potentials of the renewable heat market, support instruments need urgently to be improved and made more attractive, as the contribution from renewable heat utilization will be indispensable to reach the ambitious objectives of the European and national climate and energy policy.

6. Annex

The paper is based on a master's thesis prepared at the Environmental Policy Research Centre (FFU) of Freie Universität Berlin. The full text in German is available at the University press of Technische Universität Berlin (ISBN: 978-3-7983-2347-6) free of charge: http://opus.kobv.de/tuberlin/volltexte/2011/3112/

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