Standard Methods

Calculating Support Needs

Solar thermal Heating User Guide

RETD

IEA - RENEWABLE ENERGY TECHNOLOGY DEPLOYMENT

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For further information on the tool and user guide please contact the Operating Agent of the IEA RETD Implementing Agreement, operating.agent@iea-retd.org.

Introduction to Solar thermal Heat

Solar thermal technologies collect the energy from the sun and transform that energy into usable heat. The solar radiation intercepted by the earth far exceeds the amount of energy man consumes per year[1] (IEA, 2006). There is great potential for the sun to supply a greater share of our energy needs, in large part through an expansion of solar thermal technologies. It is important to recognize that the share of renewable heating and cooling technologies within the energy supply could increase further with improved energy efficiency measures. This introductory chapter serves to brief the reader on the available technologies, current costs and markets and the current barriers which exist in striving for increased solar thermal deployment.

Solar thermal technologies may be active or passive in nature. Active technologies relate to the use of solar collectors for heating purposes while passive techniques relate exclusively to the design of buildings collecting and transforming solar energy for heating and cooling. The Standard Methods tool and User Guide concentrates strictly on mid and low temperature solar resources for use in water and space heating through active solar technologies. Solar thermal technologies which harness energy to produce electricity or fuels and which utilize passive techniques are not covered.

Solar energy is collected through absorber plates which transfer the energy to a thermal fluid, often water. The amount of heat energy captured per square metre of solar thermal collector surface area varies with design and location but typically can range from 300-800 kWh/m²/yr (IEA, 2007). The main types of active solar thermal technologies include unglazed, glazed flat plate and evacuated tube collectors most of which (41%) are at present evacuated tube collectors and flat plate collectors (35%). Evacuated tube collectors are made up of rows of parallel, transparent glass tubes while flat plate collectors run plastic or copper tubing through an insulated, weather-proofed box (IEA, 2006). Unglazed flat plate collectors are typically used for applications requiring energy delivery at low temperatures such as swimming pool heating (RETSCREEN, 2005). Glazed flat plate collectors are better able to capture solar energy (because of the applied glaze) and are therefore more typically used for moderate temperature applications such as domestic hot water and space heating.

Combination systems or "combisystems" provide heat for both domestic hot water and space heating. These systems are generally more complex than solar systems strictly for hot water heating and often have interactions with extra subsystems. Albeit technically mature today, the design of these systems has not yet been carefully optimized, leaving great potential for cost reduction and performance improvements (SHC, 2007a).

The total solar thermal collector capacity in operation worldwide was estimated to be in the order of 111.0 GW_{th} in 2005, corresponding to 159 million m² (SHC, 2007). China has more installed capacity than any other nation with 52.5 GW_{th} and around 60% of the total global capacity installed of water heaters. However, when expressed on a per capita basis, small countries in warm climates such as Cyprus and Israel lead with 657 kW and 498 kW per 1,000 inhabitants respectively. Solar thermal penetration has generally been higher in those countries where there are stable, long term national or local policies in place.

[1] 120,000 TW of solar radiation are estimated to reach the earth's surface while man's total primary energy supply is in the order of 13.75 TW. The solar radiation is therefore roughly 8,700 times the current energy supply (IEA, 2006).

In 2006 it was estimated that the cost of solar thermal installations may be in the range of €2,500-€6,000 for hot water systems and €14,000 per system for combination systems (Rantil, 2006). System costs may vary widely depending on location and the complexity of the installation which is required. For example, the complexity and therefore the cost of the system will depend on whether or not the system must be fully protected against freeze.

Solar thermal technologies may be considered mature, but technological improvements are continuing. Barriers to the diffusion of solar thermal technologies include high investment costs, insufficient training of professional installers, permitting barriers, lack of awareness by potential customers and policy makers and a failure of the public to account for the benefits provided including security of supply and environmental benefits (IEA, 2006). This tool is focused on policies aimed to overcome the first, financial barrier by means of direct subsidies.

The Standard Methods Tool

Background

In the face of market-failures which do not account for the positive aspects of energy generated by renewable sources such as security of energy supply and reduced carbon dioxide emissions, policies are often introduced in an attempt to make up for deficiencies in the market. Policy-makers worldwide are faced with the challenge of determining an adequate level of support in the design of instruments aimed to increase the deployment of renewable heat. The Standard Methods tool was created in order to assist in this process for subsidy-based incentive schemes.

In its design, when examined from the most basic of levels, policies aim to address the cost gap between conventional fuel heating technologies and solar thermal heating technologies including investment costs and running costs. These costs may vary widely depending on the local conditions to which the policy must be suited. A first step then is to determine the cost gap between technologies in these locally specific circumstances. This tool compiles national data among 9 countries by which the cost gap of heat generation costs between active solar thermal heating and conventional heating technologies is estimated[2]. It is important that the user recognizes and fully understands that the data compiled and presented in this tool is intended be interpreted as strictly indicative.

Purpose

The Standard Methods tool provides policy-makers with assistance in determining an adequate level of support in the design of subsidy-based instruments aimed to increase the deployment of renewable heat. The results of the tool provide the user with a basis upon which they can estimate the total and annual budget of policies tailored to support solar thermal heating based on a number of country-specific considerations. However, as the tool has been overly simplified for demonstration purposes, it is important that local conditions and prices are carefully analyzed prior to policy implementation.

Subsidy schemes for renewable heat are one of many methods to increase the deployment of renewable energies. The cost effectiveness of these tools should be carefully weighted against the costs of similar, alternative policy measures. There is no over-arching solution to renewable heating policy design, but the Standard Methods tool offers a preliminary basis upon which subsidy-based policy budgets may be estimated.

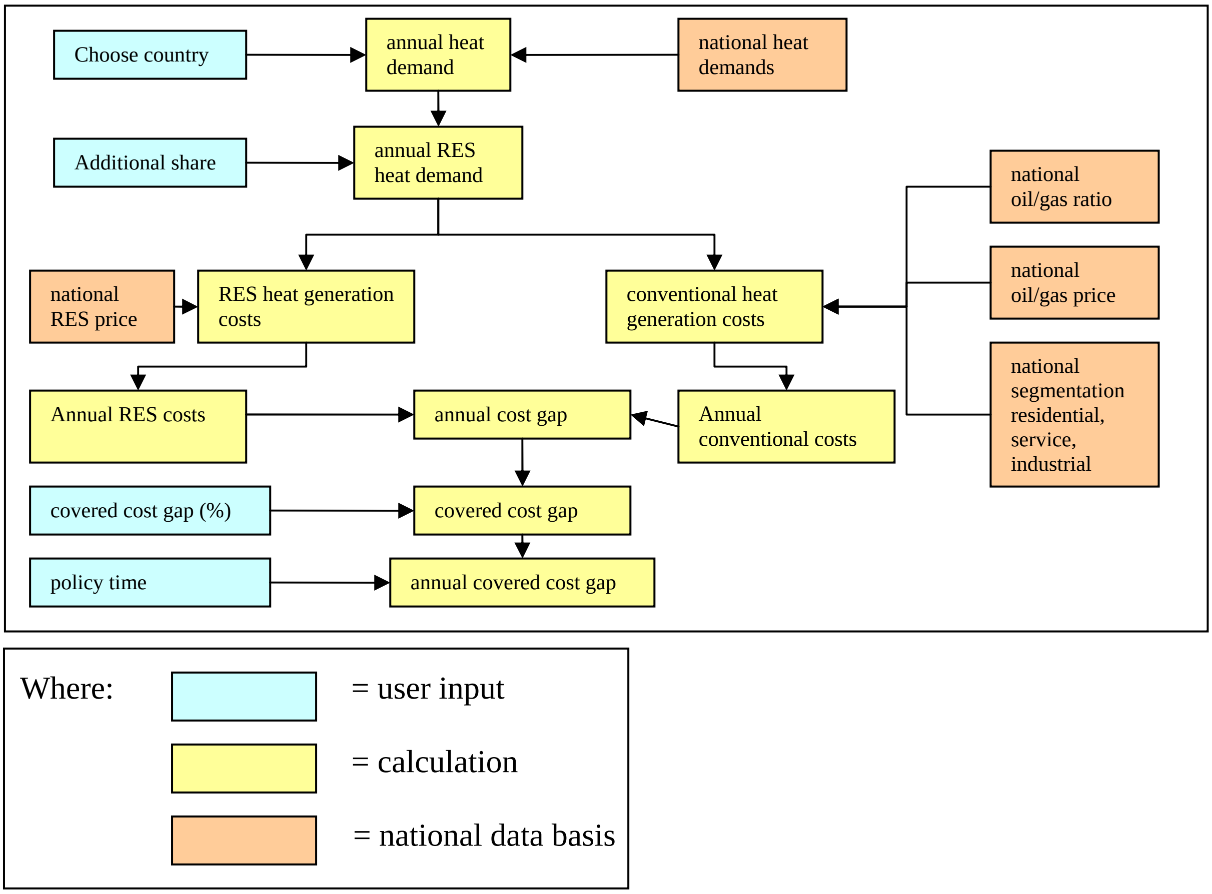
User Guide

The Standard Methods tool has been designed in a simplified, user-friendly schematic diagram in Microsoft Excel format. In using the tool, the user must recognize that it has been overly simplified for demonstration purposes. In designing policies, it is important that local conditions and prices are carefully analyzed prior to implementation. To provide an estimate of the support required, an individual may determine detailed specifics of the timeline and the targeted percentage of renewable heat to give a preliminary figure for the amount of budget

[2] Conventional heat generation costs have only included costs for oil and gas systems.

which should be allocated with the Standard Methods tool. If it is a goal of the policy to cover only a portion of the cost-gap with conventional fuels, the actor may also specify this. Finally, the importance of educational and informational campaigns to promote awareness of the tool itself has been recounted on many occasions. An option to include a certain percentage of the total policy budget for informational schemes has also been included. The methodology utilized in this support tool is represented in Figure 1.

Figure 1. Visual representation of the methodology used to calculate support need.



Via drop-down menus the policy-maker is able to select the information most relevant to their circumstances[3]. A bar-chart on the right simultaneously depicts the cost gap between solar thermal heating and conventional heating. The cost of renewable heating installations is assumed to be the same for all countries investigated[4]. The total annual cost per heating system includes the following:

- investment annuity
- annual fuel costs
- auxiliary energy costs (1 % of heat generation)
- operational costs (2,5 % of investment)

[3] Only drop-down boxes and boxes for data entry within the dialog table are available to individuals. Calculation sheets have been locked to prevent alterations.

[4] Data on the costs of solar thermal installations originated from BAFA,2007 database and ZSW,2007. Information on the annual yield and on the proportion of single family house hot water systems (6 m²), combi-systems (12 m²) and industry-scale district heating systems (50 m²) was taken from SHC, 2007.

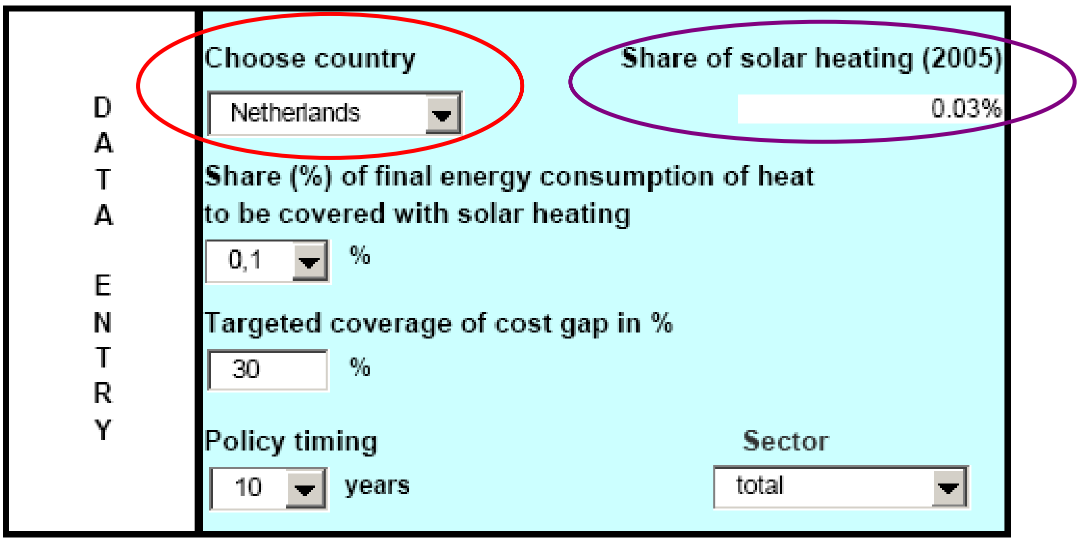
For the purposes of illustration, a typical example for the Netherlands was selected for use throughout this User Guide. Red ovals throughout the diagrams depict a point within the tool where the user is required to insert their desired policy specifics.

In order for the Standard Methods tool to function properly it is important to assure that the English decimal system has been selected before work with the tool is begun. In order to verify this, in Microsoft Excel on the Tools menu, click Options. Then, on the International tab under Number Handling, clear the Use System Separators check box. Type new separators in the Decimal Separator (.) and the Thousands Separator Box (,). Then, work with the Standard Methods tool may be begun.

The tool is broken into three user-friendly boxes. The first box, 'Data Entry' allows the user to insert unique policy design features and location specifications that produce results which are more specific to their individual circumstances. The second box, 'Results' simultaneously shows the results of the user's decisions and reflects the support need that is required to cover the cost gap (or percentage of the cost gap) with conventional fuels. The third box is a visual representation in graph format of the results of the selections.

Data Entry

First, the country of residence should be selected. The data that supports the selected country automatically includes the heat demand in that country and the national averages of conventional fuel costs[5]. In addition, for comparison of conventional fuel costs, statistics on the proportion of gas and oil heating systems typical in each country[6] have been integrated.



When the country is selected, the share of solar thermal heat in that country in 2005[7] will automatically and simultaneously appear to the right of the box under the heading titled "Share of solar heating (2005)", circled in the above graph in purple. This is provided to give the user a reference for the next step of the tool.

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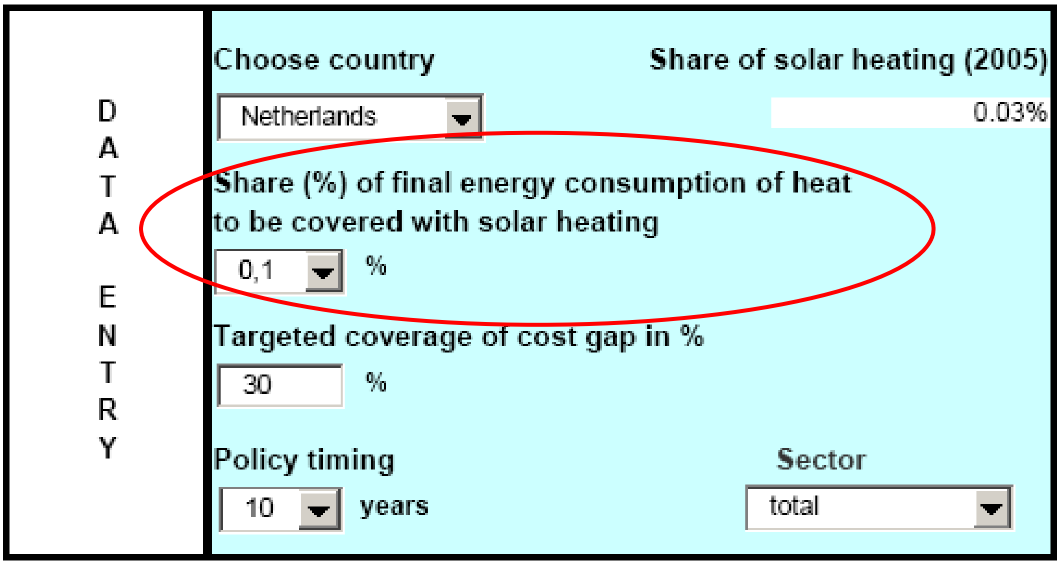
[5] Conventional fuel heating costs including oil, gas and electricity for each country originate from the EIA at www.eia.doe.gov.

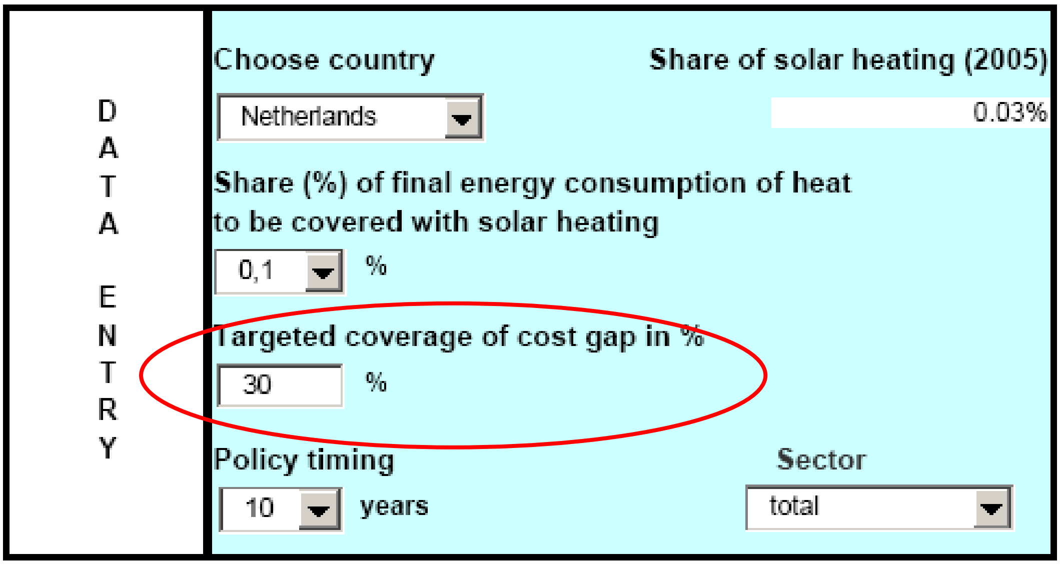
6 Proportional gas and oil heating system data originated from Eurostat yearly energy statistics at http://epp.eurostat.ec.europa.eu for all countries except Norway and Canada. Norwegian data is based on household consumption sourced from Statistics Norway at http://www.ssb.no/husenergi_en/tab-2007-05-23-08-en.html while Canadian data originates from the Statistics Canada database at http://www.statcan.ca .

[7] Data on the share of solar thermal in individual countries originates from SHC, 2007.

Next, the individual must determine what additional percentage of the total heat demand[8] they wish to be covered by solar thermal heating. A dialog box allows a selection in increments (typically of 5%) up to 50% of the total heat demand. This maximum accounts for immediate restrictions in manufacture and installation.



As mentioned above, this tool aims to address the cost gap between conventional fuel heating technologies and solar thermal heating technologies. The next box for data entry allows the user to determine to which extent they wish to cover this gap. If the aim of the policy is to address the full cost gap, the user should enter 100 in the data box (representing 100% of the cost gap). Lesser percentages may be entered in accordance with the wishes of the user.



The Standard Methods Tool has been created to allow for variations in policy timelines. The user should then select from the ‘Policy timing’ dialog box an estimated timeframe for the life of the policy. Increments of 5 years are possible, to a maximum of 20 years.

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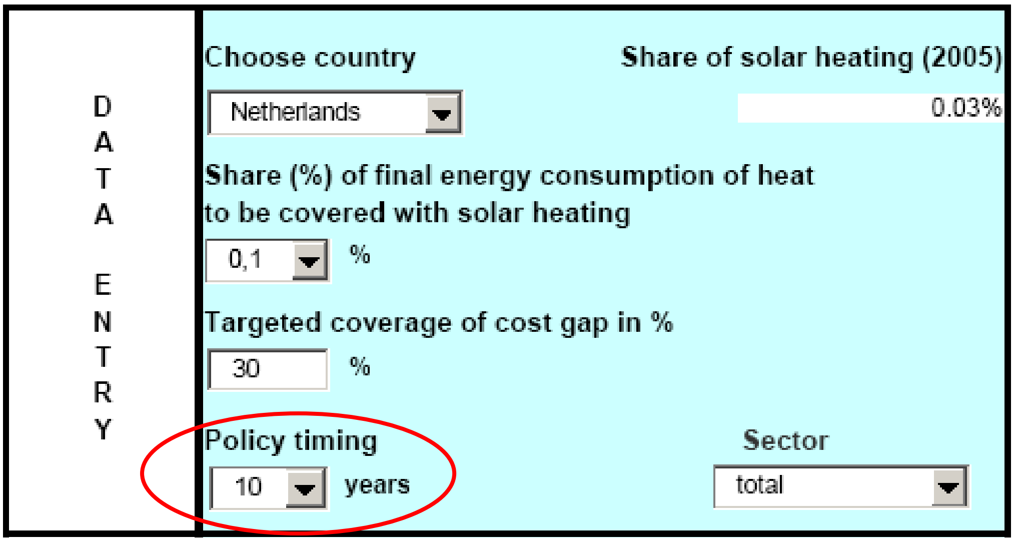
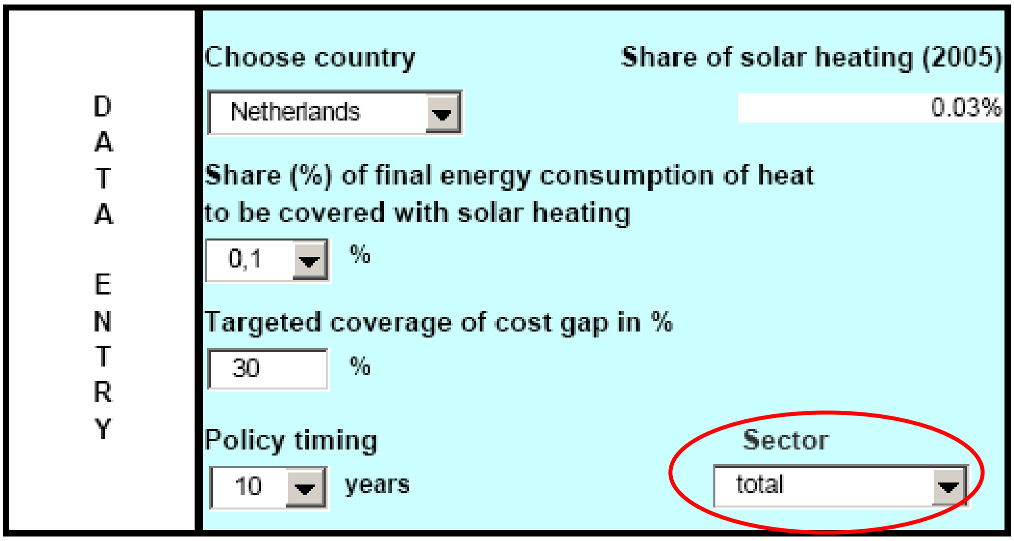
8 Heat demand data for European countries originates from Eurostat and Statistics Canada. Calculations were performed as follows: Final energy consumption – electricity consumption – energy consumption of transport sector + correction value = estimate for final heat consumption.



Prices vary considerably depending on the sizes of solar thermal systems. The next entry allows the user to decide on the size of the system upon which they wish to focus support. The dropdown list provides the following choices: 1) residential 2) service/agriculture 3) industry and 4) total. Residential systems reflect the costs for the smallest, single family house hot water systems. For this example, systems are assumed to be 6 m². Service/agriculture systems reflect the costs for middle sized combi-systems, or 12 m² systems. Industrial systems are assumed to be industry-scale district heating systems, here represented by 50 m² systems. The final choice, total, automatically selects an average mix of the system costs based upon the heat demand by sector in the country selected.



This method is based upon the assumption that annual heat demand by sector in each country[9] will be reflected in the proportions of industrial, commercial, and residential solar thermal systems installed. For example, a country with heat demands in the following proportions; residential 50%, industry 30%, commercial 20%, would reflect these demands in the installations of solar thermal systems. Half of the systems installed, therefore would be at the smallest residential scale, 30% large, industrial scale, and 20% medium, commercial scale.

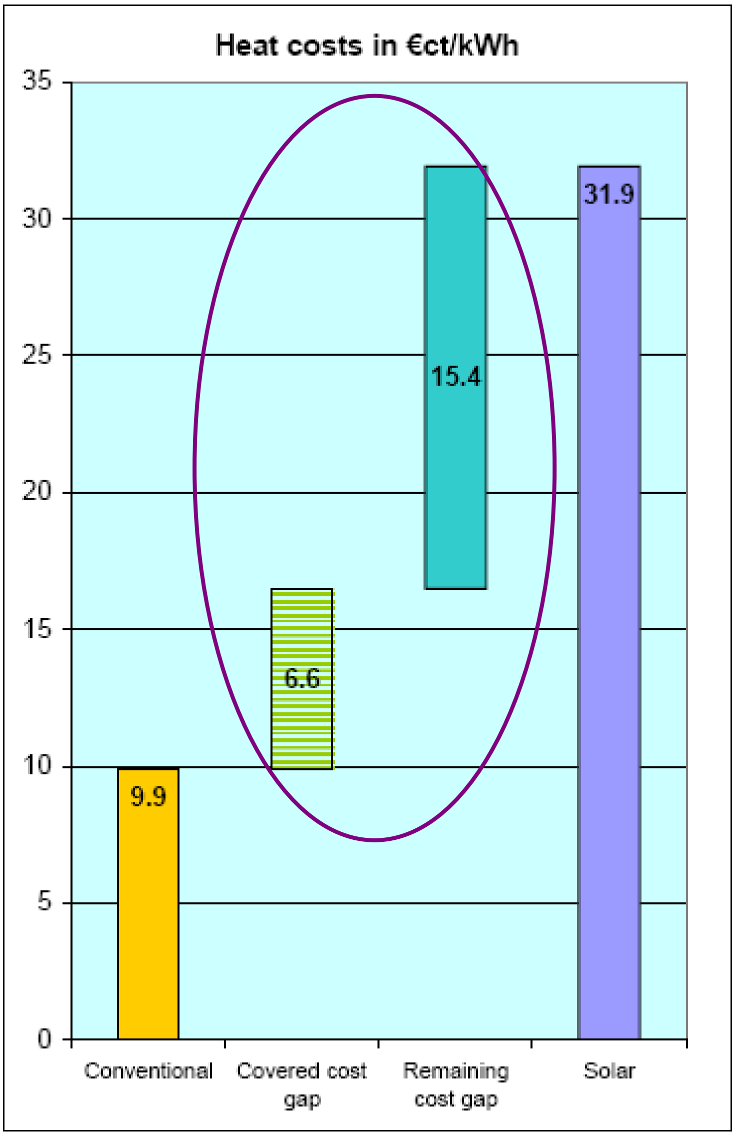
[9] Data on the composition of heat demand in each country was sourced from the IEA member country database available at: http://www.iea.org/Textbase/country/index.asp.

If the user selects the final ‘total’ choice, they must be aware that the assumptions made in the methodology may be reflected in the outcome of the results. Large solar thermal systems (>50 m²) are often more profitable (as compared to conventional heating systems of the same size) than smaller solar thermal heating systems for single family homes. It results that in countries with a high share of heat demand in the industry sector, due to the assumptions made in this tool the economic advantage of large systems compensates the economic inefficiency of small systems. In other words, in countries with a high share of heat demand in the industry sector the tool may show that less support is needed from a macro-economic point of view, even though small systems may require more support to be cost competitive.

For this example, then the user has chosen to investigate the amount of support required for a a 10-year policy in the Netherlands that aims to cover 30% of the cost gap with conventional fuels for a 0.1% over-all increase in solar thermal heating, unspecified by the size of the system.

Results

With each of the above selections, the costs of solar thermal and conventional heating in €ct/kWh are adjusted accordingly. These changes are reflected in a graph to the right of the dialog table which automatically adjusts to reflect whether the system costs selected are scaled according to residential, commercial or industrial systems (See below).



The graph depicts the costs of conventional heat (far left, yellow bar), the costs of solar thermal heat (far right, light purple bar) and the cost gap between the two (shown here inside a purple oval). The total cost gap would be a combination of the two middle bars, in this example 22 €ct/kWh. The left, green bar is a representation of how much of the cost gap the user has chosen to cover with political incentives. The right, blue bar represents the cost gap which remains to be covered.

The second box of the tool, ‘Results’, is broken into two individual sub-boxes. The first of these sub-boxes tells the user how much support is required per system, in total, and per annum according to the selected timeline.

RESULTS			
	Support need over policy time:		
	Per m²	Total	Per annum
	184 €/m²	175,367,000 €	17,537,000 €
	Additional funding for policy marketing (% total)		
	10%	total Funding:	17,537,000 €
		Funding per annum:	1,754,000 €
	Support need over policy time including funding:		
	Per m²	Total	Per annum
	184 €/m²	192,904,000 €	19,290,000 €

The final sub-box of the Standard Methods tool pushes the user to consider additional funding which may be desired for marketing of the policy tool. It has been shown that those policies which are the most effective are those where parallel investments were made in guidance and educational programmes in order for the stakeholders (including building owners making personal investment decisions) to better understand the benefits that REHC has to offer. An appropriate percentage of 10% of the total policy spending is automatically selected. As the user enters policy conditions in the "data entry" section of the tool, the budget numbers are simultaneously amended to reflect the funding which would need to be allocated strictly to marketing activities to the right of the percentage box. These totals which match the selected percentage have been given in total and per annum (See below).

Additional funding for policy marketing (% total)		
10%	total Funding:	17,537,000 €
	Funding per annum:	1,754,000 €
Support need over policy time including funding:		
Per m²	Total	Per annum
184 €/m²	192,904,000 €	19,290,000 €

The final row of funding totals represents the total funding to cover the cost gap and for marketing activities. All budget numbers in the tool are rounded to the nearest thousand.

Total support need = Cost gap support need + Marketing activities

Where marketing activities = (X%)*Cost gap support need

With the information that this tool provides, the user is able to judge with a rough indication how much funding should be allocated in total and per annum to an incentive-based policy such as a subsidy scheme for solar thermal heating.

Tool Cost Comparisons

In the Standard Methods tool, country-specific investment costs for solar thermal heating systems were used. These costs depend on 1) the national share of flat and tube collectors and

2) on the national standard proportion of solar thermal system sizes. The following cost data are used (based on data collected for the German Market Incentive Program):

	€/m²
6 m² hot water flat	770
6 m² hot water tube	1150
12 m² combi flat	820
12 m² combi tube	1060
50 m² misc flat	410
50 m² misc tube	670

The cost data in the IEA report "Renewable Energy for Heating and Cooling – Untapped Potential" are based on cost data from different countries. This report based its data on information from the ITW (Research and test centre for thermal solar systems) at Stuttgart University which states that systems with 6 m² costs 1000 €/m² and systems with 12 m² about 900 €/m². These costs are higher than those utilized in the Excel tool, which as mentioned above, were based on data from the German Market Incentive Program. In addition, the IEA report incorporates data from Austria (610 - 765 €/m²), Greece (400 €/m²) and Turkey (300 €/m²) in addition to the German cost data, thereby lowering the cost range.

In the RETScreen tool, solar thermal systems project costs can be calculated, including a differentiation between flat-plate collectors and evacuated tube solar collectors. The cost range corresponds to the range in the IEA report and to the range in the RETD Excel tool (410 €/m² to 1150 €/m², see above).

Solar heating	**Investment costs**
	€/m²
Excel Tool (excl. VAT)	
Canada	771
Denmark	773
France	758
Ireland	853
Italy	805
Germany	772
Netherlands	760
Norway	767
United Kingdom	770
IEA REHC (excl. VAT)	
Minimum	300
Average	630
Maximum	1000
RETScreen	
Flat-plate collectors	216-468
Evacuated tube solar collector	864-1152

Understanding the Results

The Standard Methods tool assists policy-makers as they face the challenge of determining an adequate level of support in the design of instruments aimed to increase the deployment of renewable heat. Focused specifically on subsidy-based incentive schemes, it clearly depicts the cost gap between conventional fuel heating technologies and solar thermal heating technologies including investment costs and running costs. Based on this information and the user inputs for policy timeline and objectives, the tool produces an estimated budget for subsidy-based incentive schemes. It is important that the user recognizes and fully understands that the data compiled and presented in this tool is intended be interpreted as strictly indicative.

The results box provides the user with the following numbers of interest: Support need over policy time (per kW, total and per annum) and Support need over policy time including funding (per kW, total and per annum) (See below).

RESULTS	**Support need over policy time:**		
	Per m²	Total	Per annum
	184 €/m²	175,367,000 €	17,537,000 €
	Additional funding for policy marketing (% total)		
	10%	total Funding:	17,537,000 €
		Funding per annum:	1,754,000 €
	Support need over policy time including funding:		
	Per m²	Total	Per annum
	184 €/m²	192,904,000 €	19,290,000 €

The first, ‘Support need over policy time’ tells the user that for the inputs entered (a 10-year policy in the Netherlands that aims to cover 30% of the cost gap with conventional fuels for a 0.1% over-all increase in solar thermal heating, unspecified by the size of the system) an estimated total budget of €175,367,000 would be required. This total, divided by its 10 year timeline therefore results in an annual budget of €17,537,000. Finally, an estimated 184 €/m² is needed. This result breaks down the total budget for the user to understand the cost gap requirements on a more tangible scale. These results show the user only the cost differences between the technologies and does not include administrative costs of the policy. When the policy itself is designed, these costs must be accounted for.

The second, ‘Support need over policy time including funding’ urges the user to incorporate educational or marketing based funding into the design of the policy tool to allow stakeholders (including building owners making personal investment decisions) to better understand the benefits that renewable energy heating and cooling has to offer. In this example, 10% of the total policy funding (€175,367,000) from the first set of results has been added for marketing purposes resulting in an estimated total policy budget of €192,904,000. This total, divided by its 10 year timeline therefore results in an annual budget of €19,290,000. The support needed per m² does not change.

While the results of the Standard Method tool are considered in the design of subsidy-based policies in support of solar thermal heating systems, the limitations of the tool and its prospects for further development must be taken into account. The cost data for renewable energy systems is assumed to be the same for all countries investigated. A more thorough approach would incorporate country-specific data on solar thermal system costs. Although a maximum of 50% has been included, solar potential has not been accurately limited based on country-specific data. More specific potential data could be incorporated incorporating information on annual solar radiation and installation manufacturing facilities. As the success of a policy depends in many cases on the how well the existing infrastructure has already been developed, a future tool could be designed to take supply chain infrastructure into consideration. Finally, the importance of a variety of renewable heating technologies must not be side-stepped as policies are designed for solar thermal heating. Other renewable heating technologies such as biomass pellet heating and heat pumps should also be given thorough consideration and adequate support.

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