INTERNATIONAL ENERGY AGENCY

RENEWABLES FOR HEATING AND COOLING

Untapped Potential

RENEWABLE ENERGY TECHNOLOGY DEPLOYMENT

INTERNATIONAL ENERGY AGENCY

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It carries out a comprehensive programme of energy co-operation among twenty-six of the OECD thirty member countries. The basic aims of the IEA are:

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- To promote rational energy policies in a global context through co-operative relations with non-member countries, industry and international organisations.
- To operate a permanent information system on the international oil market.
- To improve the world's energy supply and demand structure by developing alternative energy sources and increasing the efficiency of energy use.
- To promote international collaboration on energy technology.
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The OECD member countries are: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Republic of Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom and United States. The European Commission takes part in the work of the OECD.

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Preface

In April 2006 the IEA hosted a seminar "*Renewable heating and cooling – from RD&D to deployment technology and policy*" aimed at exploring guidelines and policy initiatives that could accelerate technology development and market deployment for renewable heating and cooling (REHC). The IEA Renewable Energy Working Party (REWP) and the related Bioenergy, Geothermal, and Solar Heating and Cooling Implementing Agreements agreed to collaborate in order to present the current status of technologies, markets and successful policies and to explore future technology and policy trends. The REWP then determined that REHC is of such high importance that it merited the preparation of a full IEA report, prepared by the IEA Renewable Energy Unit, and based on the presentations and the discussions of the workshop.

Coincidentally a second report "*Renewable energy technology in heating markets - Policy status*" had been commissioned by the Implementing Agreement on Renewable Energy Technology Deployment (RETD; www.iea-retd.org). This was being researched and written by the Centre for Solar Energy and Hydrogen Research, Baden-Württemberg (ZSW) in early 2007.

It was considered that it would be most useful for the potential readership of these two reports, one emphasising technologies and markets and the other concentrating more on policies, if they were combined into one. This concept was put to the authors of the reports, members of REWP and members of the Executive Committee of the RETD implementing agreement by the IEA secretariat. There was full agreement that a single report, with due acknowledgement of all authors and organisations involved in its preparation, would be the preference. This report is the result of merging the two original studies.

By means of this report the IEA intends to emphasize the importance of renewable heating and cooling in reaching towards the renewable energy goals of energy security, climate change mitigation, reduced environmental impacts and cost competitiveness. The report aims to provide guidance to policy makers on how to successfully deploy renewable energies mainly for heating, but also for cooling purposes wherever appropriate.

This paper reflects the views of the IEA Secretariat and its Renewable Energy Unit (REU). It does not necessarily represent the views of the IEA, the RETD or their individual member countries. Nor is it intended to prejudge the views of countries participating in the RETD. Rather, it is intended to be an informative paper for IEA member countries, for the RETD audience, and for non-member countries interested in meeting their heating and cooling demands using local renewable energy sources.

Executive Summary

Renewable energy heating and cooling (REHC) has been described as the "sleeping giant" of renewable energy potentials from the global perspective. Mature REHC technologies using solar, biomass and geothermal resources are currently available as cost-effective means of reducing both carbon dioxide emissions and fossil fuel dependency under many circumstances. Other technologies are close to mass-market deployment. Governments, including those endeavouring to meet challenging greenhouse gas (GHG) emission reduction targets, could find that considerable mitigation potential exists through the displacement of fossil fuels, usually, but not always, at relatively low costs per tonne of CO_2 emission avoidance.

In recent years, and in many regions, policies developed to encourage the wider deployment of renewable electricity generation, transport biofuels and energy efficiency have over-shadowed policies aimed at REHC technology deployment. Yet heating and cooling demands by the industrial, commercial, and domestic sectors constitute around 40-50% of the total global 320 EJ (7639 Mtoe) total final energy demand in 2004. REHC technologies have the potential to gain a greater share of this large market. Several countries have already exploited this opportunity such as Sweden where biomass supplied 62% of fuel for district heating in 2006.

In broad terms, world solar thermal heat use is currently around 200 -210 PJ/yr (4.8 - 5 Mtoe), geothermal heat is 260 – 280 PJ/yr (6.2 – 6.7 Mtoe) and heat from modern bioenergy probably almost 10 times the total of solar thermal and geothermal together (~4000 PJ/yr; 80 - 100Mtoe) (excluding the use of traditional biomass which is around 9-10% of world primary energy). This compares with global biofuel production in 2006 of around 1200 PJ (28 Mtoe) and renewable electricity generation (excluding large hydro) of around 1800 PJ (500 TWh).

Based upon case study, country analyses of increased heating and cooling project deployment as a result of cost-effective policies, there appears to be good potential for many other countries with similar resources to follow suit and to significantly increase their current REHC contribution within the next decade or so.

The over-riding message from the analysis contained in this report is that, particularly where good renewable energy resources are available, governments should take strong action with respect to policy development that supports both the increased deployment of commercially available and cost competitive REHC technologies and the further development of those at the early-market stage.

This joint report, prepared by the International Energy Agency (IEA) Renewable Energy Technology Deployment (RETD) Implementing Agreement and the IEA Renewable Energy Unit with major contributions from several other relevant IEA Implementing Agreements, presents an overview of the status of available renewable technologies and markets for active heating and cooling, an analysis of their relative costs, and an evaluation of a wide range of current supporting policies. Passive solar heating and cooling of building space resulting from good design can significantly reduce the demand for imported energy, but is not included in this analysis.

In regions with favourable resources and market conditions, several mature solar thermal, biomass and geothermal heating technologies entered the mass market many years ago since they were cost competitive with electricity, oil and gas. Other technologies are near-market and yet more are under development, including solar cooling technologies. REHC systems at the small domestic scale (solar water heaters, solid-fuel stoves and geothermal heat pumps) are distributed and more flexible in terms of being able to utilise the local renewable energy resources available than at the larger industrial scale of heating demand.

The analysis shows that well designed supporting policies have been highly effective in obtaining market expansion of REHC technologies. For example, solar water heater installations can compete with conventional heating fuels and are growing rapidly in a number of regions even where solar radiation levels are relatively low. Strong national policies have proved successful in high latitude countries such as Germany and Austria for example that have relatively low solar radiation levels and cheap conventional energy alternatives. The uptake of small scale, geothermal heat pumps used for both heating and cooling could continue to increase as the technology moves from near-market to mass-market in more countries. However, due to their current higher costs, this will only be in countries where strong supporting policies exist, as exemplified by Sweden.

Current policies to support greater deployment of REHC are mainly in the form of incentives ("carrots"), although good examples also exist of successful regulatory ("stick") and education ("guidance") policies. Policies in place across 12 OECD countries (Canada, Denmark, France, Germany, Ireland, Italy, Japan, Netherlands, Norway, Spain, Sweden, and United Kingdom, selected due to their varying approaches to policy development in this area), were reviewed, along with relevant policies of the European Union. The number of policies in support of solar thermal and biomass heating appears to be increasing with less comparable support for geothermal.

Examples of good practice policies for each technology are elaborated in the report for each kind of policy. Market-led examples are given for China, New Zealand and Iceland where REHC technology deployment has occurred without the need for policy support due to particularly abundant renewable energy resources, or where conventional alternatives are relatively expensive or unavailable (especially in rural areas). The stage of maturity of a specific REHC technology can also affect the choice of policy support mechanism. Additional policy support for district heating and combined heat and power (CHP) systems can also be combined with renewable heat deployment.

Detailed analysis of policies and measures used to support REHC technology development and deployment in the 12 OECD countries, including how they have evolved over time, has enabled recommendations to be made. These are aimed at policy makers who are intent on increasing national and regional REHC markets in order to gain a range of benefits as a result.

Conclusions

Providing heating, and to a lesser degree cooling services, accounts for around 40-50% of global consumer energy demand each year, yet policies to encourage REHC technology development and deployment have often been neglected compared with those supporting energy efficiency, renewable electricity, or biofuels for transport.

There appears to be high potential for heating services to be provided from solar thermal, biomass and geothermal resources by displacing conventional fossil fuels and hence reducing greenhouse gas emissions as well as, under certain specific conditions, improving security of energy supply and reducing related risks to human health. Global REHC markets already exist (Table 1) and contribute around 1% of global primary energy each year (with possibly another 10% coming from conventional biomass used for traditional heating and cooking).

Several REHC technologies are mature, their markets are growing, and their costs relative to conventional systems continue to decline. The solar thermal market, for example, continues to grow steadily and equipment performance increases. China dominates the world market and also has the greatest solar water heater manufacturing capability. Currently modern biomass combustion (excluding traditional domestic biomass as used in many developing countries) contributes most of the renewable heating, particularly in the building and industry sectors. Deep geothermal heat is used mainly by industry and

Table 1 • *Summary of estimated installed global capacities, energy outputs and 2005 and projected costs out to 2030 of solar thermal, bioenergy (excluding traditional biomass combustion) and geothermal technologies.*

	Installed capacity GW_{th}	Energy output PJ/yr	Costs 2005		Projected average cost reduction by 2030 % 2005 costs
			Range €/GJ	Average €/GJ	
Solar thermal	**100-110**	**200-220**			
water and space heating			8 to 226	52	-42
solar assisted cooling	<0.05		11 to 307	66	-44
Bioenergy	**1000-1200**	**3000-4000**			
pellet heating			8 to 99	26	-5
CHP			7 to 67	26	-8
anaerobic digestion			6 to 32	15	-3
MSW waste-to-energy			2 to 12	5	-9
Geothermal	**25-30**	**270-280**			
deep conventional			0.5 to 11	2	+11*
deep advanced			1 to 24	3	-13
shallow geothermal					
heat only			3 to 89	19	-9
h+c: heating			2 to 75	17	-8
h+c: cooling			2 to 97	16	-8

**Increased costs due to scarcity of sites and many of the good sites already developed.*

district heating schemes in regions where resources are available, whereas shallow geothermal heat is used more extensively, mainly for small-scale domestic applications. Projections out to 2030 show a significant increase in all of these commercially available technologies.

For early-market technologies and those still under development, in countries where good resources exist, one primary policy aim should be to move appropriate REHC technologies closer to the mass-market stage. Strong policy support at the early market stage has played a key role in successful deployment in all leading countries. However specific heating and cooling costs vary widely with resource availability and location as well as the stage of development of the technology, so careful assessment is recommended prior to policy implementation. For example in countries where shallow geothermal heat pumps are in their infancy or at the early-market stage, incentive guidance policies could possibly be used to stimulate learning experience, educate potential customers and train installers. However in countries where they are already close to mass-market, as their reliability increases and costs further decline, regulatory policies may become more applicable.

Solar water heating, biomass for industrial and domestic heating, deep geothermal heat and shallow geothermal heat pumps are amongst the lowest cost options for reducing both CO_2 emissions and fossil fuel dependency. In many circumstances these technologies offer net savings as compared to conventional heating systems in terms of life-cycle costs.

Providing cooling services from renewable energy sources remains at the early development stage for many technologies (with perhaps the exception being passive solar building designs used extensively throughout some hot regions). Even the most promising technologies remain largely at the research and demonstration stage with further government and private-funded R&D support required.

Policies to support renewable heating systems have been developed in several OECD countries with varying degrees of success. Of the twelve selected countries studied in detail, the majority of policies were based on incentives (carrots) rather than regulations (sticks). Well designed policies have achieved encouraging results in leading countries. For instance, Germany has nearly 5 GW of solar water heaters installed (around 750,000 units); about 30% of houses in Sweden have geothermal heat pumps with a total capacity of nearly 4 GW; and Canada has over 3 million homes producing around 100PJ (2.4 Mtoe) of heat from woody biomass each year with four times this amount produced for industrial heat giving a total equivalent to around 12 Mt of oil each year. Yet other countries with similar conditions make minimal use of their renewable energy resources.

The more successful policies can be defined as those having the greatest effect for the lowest government investment. Measuring their effectiveness using various indicators is difficult since good databases showing annual heat demand do not usually exist because, unlike electricity or transport fuels, heat is rarely sold off-site; hence there is no need for costly metering. Comparing average annual public investment in REHC per capita with the subsequent change in average annual REHC demand per capita over time for a country where such data is available is a fairly coarse measure, but it can be a useful indicator.

Where a good natural solar, biomass or geothermal resource exists, government investment is less essential in order to bring the technology to the market. Where the resource is relatively poor, then more stringent and costly policies may be required. Regardless of the resource availability, and whether stick or carrot policies are chosen, the most effective often proved to be those where parallel investments were made in guidance and educational programmes in order for the stakeholders (including the general public) to better understand the benefits that REHC has to offer. This is particularly the case for investment in domestic heating and cooling systems such as solar water heating, wood stoves and geothermal heat pumps where personal investment decisions are made by the owner of the dwelling.

Good policies for market development have proved successful for each of solar, bioenergy and geothermal technologies, even in locations where the resource is not particularly abundant. Under these conditions energy costs can be relatively high compared with using oil-, coal- or natural gas-fired heating appliances so more stringent policies are needed. Overall the type of policy to best stimulate the market has to be developed for each energy resource, conversion technology and location. The resulting market uptake also depends on the competing prices for fossil fuels in the region. There is therefore no single solution. Therefore evaluating policies used elsewhere with varying degrees of success, but adapting them if necessary to suit the local conditions, is the approach recommended.

Recommendations

- Deployment of REHC technologies is very variable, even amongst countries with similar conditions. Costs of REHC systems vary considerably with location depending on the availability of natural resources. Local energy prices for conventional electrical and fossil fuel heating systems impact on their cost competitiveness. Undertaking local cost/benefit analyses are therefore recommended.
- In regions with good solar radiation levels, governments should consider making solar water heaters mandatory on all new buildings with limited exemptions, as is the case in Spain where, for relatively low government expenditure, installed capacity doubled in 3 to 4 years. Such mandatory regulations could be widened to include other REHC technologies to allow for least cost applications depending on the local resources available.
- For countries where the use of REHC technologies is still very limited or at the early market stage, an initial policy objective should be to move them to mass market deployment leading to

high penetration rates and sharp cost reductions. Policies should be designed to provide greater incentives for the better performing, more efficient designs of appliances.

- In countries where a lack of awareness, shortage of skilled trades people or difficulties gaining a local planning consent are a significant barrier to mass deployment of REHC technologies, governments should consider how these can be eased.
- Obtaining the greatest increase in REHC for the lowest societal cost (USD government investment /GJ heat generated) should be the goal, but also taking into account all potential co-benefits including security of energy supply, greenhouse gas reduction, industry development, employment, improved health etc.
- While the most appropriate policies will vary from country to country, the evidence suggests that a comprehensive package can be the most effective. The mix of measures could include financial incentives, certification, labeling, and minimum performance standards, as well as guidance, public information and training of trades people and installers.
- Governments are recommended to review their national policies for renewable heating and cooling in the light of these findings and to consider how they can best promote these technologies. This is especially important for countries with demanding CO_2 savings and renewable energy targets.
- Governments are encouraged to improve the accuracy of their national data collection relating to heating and cooling supply and demand in order to better inform development of policies. Due to the distributed nature of heat supply and the local demand, this may be difficult to achieve without extensive user surveys or national sales figures.
- More analytical studies are needed to develop effectiveness indicators so that successful outcomes (or otherwise) and the cost effectiveness of individual policies can be better assessed.
- Countries currently without any REHC policies in place should assess their local renewable energy resources and, where appropriate, policy-makers should review existing policies in place elsewhere (for example as outlined in this report) in order to identify the most suitable policy mix necessary to stimulate the local market.
- A review of best practices and lessons learned in developing and implementing technology standards and labelling in association with other policies would be a useful guide for countries wishing to emulate the leaders.
- Evaluation of REHC technologies deployed in the residential, industrial, commercial and institutional sectors is needed to determine which policy approaches could be most relevant for each sector.
- Replication of successful and cost-effective policies by countries with similar levels of specific renewable energy resources should be encouraged, but would first require detailed analysis of the rationale behind policy designs. (This will be undertaken within the study *Global Renewable Energy Markets and Policies – past trends and future prospects* currently under preparation by the IEA Renewable Energy Unit).

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