Road-map for solar energy technology and markets in Finland

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SOLPROS

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Abstract

The National Climate Strategy of Finland from spring 2001 and the Programme Promoting Renewable Energy Sources as part of it from 1999 define the national targets for renewable energy utilization and development in Finland up to year 2010. Solar energy is part of the above mentioned national programmes.

The national target for solar energy utilization by year 2010 is 100 GWh/y. Moreover, taken the strong market growth of solar energy internationally, new business should also be generated. The domestic market is considered important in helping to commercialize new technologies and products.

The objective of the development project “Road-map for solar energy technology and markets in Finland" (abbr. Solar Road Map) was to prepare an action plan to the national solar energy targets and to show the way to reach the challenging goals mentioned earlier. The project was part of the CLIMTECH-programme of the National Technology Agency (Tekes).

The action plan for solar energy developed in this project captures on the market possibilities both on a national and international level. The action plan is based on a road-map in which different activities are undertaken stepwise to achieve the milestones set and the end goal. Different market driven activities and technology development have been combined to yield market breakthrough for solar energy. By year 2010 solar energy should be competitive on the national market and the national industries should have reached a strong position on international markets. The goal of business generated by the action plan is 150 million euro/y by 2010.

The reduction potential of greenhouse gas emissions by solar energy in is still small Finland within the coming ten years but on a longer term the possibilities increase and also the costs associated show a positive trend.

Foreword

This report describes the major findings of the Tekes industry project No 594/480/00 "Road-map for solar energy technology and markets in Finland (Solar Road Map)". The objective of the project was to prepare an action plan for solar energy in Finland as a part of the national promotion programme for renewable energy sources. The project was part of the Climtech program and it was coordinated by Solpros AY.

This summary report is based on three major analysis reports (in Finnish) which can be found and downloaded from the internet site http://www.kolumbus.fi/solpros.

Helsinki, August 12, 2002

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1. Introduction

The National Climate Strategy of Finland from spring 2001 and the Programme Promoting Renewable Energy Sources (Ministry of Trade and Industry, 1999) as part of it from 1999 define the national targets for renewable energy utilization and development up to year 2010 and set indicative goals for year 2025. Solar energy, both solar heating and photovoltaics, is part of the above mentioned national programmes.

The national target for solar energy utilization by year 2010 is 100 GWh/y. Moreover, taken the strong market growth of solar energy internationally and the knowledge base of Finnish industries, the national programmes should generate new business worth 150 million euro by 2010 mainly for export markets. The domestic market is considered important in helping to commercialize new technologies and products.

The objective of the development project “Road-map for solar energy technology and markets in Finland" (abbr. Solar Road Map) was to prepare an action plan to the national solar energy targets and show the way to reach the challenging goals mentioned earlier. The project was part of the CLIMTECH-programme of the National Technology Agency (Tekes). The aim of CLIMTECH has been to analyze the possibilities and development needs of technologies for climate change mitigation and to support the commercialization of associated Finnish technology.

The Solar Road Map project (2000-2001) was co-financed by Tekes and Solpros AY. Solpros did the realization. The project focussed on analyzing the possibilities and development needs of solar energy in the light of the greenhouse gas emission reduction policies. The main technology areas of interest matching both national and international markets and their needs have been analyzed. Furthermore, areas important to strengthen Finnish industries have been identified. The project covered both solar heating and solar photovoltaics.

The Solar Road Map results comprise three major reports: a state-of-the-art review of solar energy technologies and markets, a review and analysis of solar energy and its possibilities in Finland and finally the action plan for solar energy (road map). In addition, the project resulted in establishing a national solar energy network and the Finnish Solar Industries working group (FSI).

2. International trends

2.1. Markets

Solar energy plays a negligible role in the present global energy system. Commercial solar energy utilization represents about 0.05% of world's energy. On a local level, solar may have much more importance e.g. in providing heat to the buildings. In the coming 10-20 years, the use of solar energy will increase considerable but it is not until the middle of this century that is could be recognized as an important energy source. Shell International has estimated in its energy scenarios that around 2060 solar energy could provide 30% of world's energy. Going beyond that towards the end of the century, solar-hydrogen type of fuels could be an option for a global energy economy.

Solar energy is cost-effective in several niche applications and close to competitiveness in many applications in the built environment. Compared to bulk energy production by traditional energy sources, solar energy will necessitate public support. From an environmental point of view, solar energy represents one of the best alternatives.

2.1.1. Photovoltaics

The total world-wide installed capacity of photovoltaics (PV) is over 1.500 MW_p and the production capacity is now about 350 MW_p/y. The growth of the market has been more than 30%/y over the last five years. The global PV business has a value of around 2500-3000 million euro/y of which about half is from the PV modules. Some 70% of the markets are in the industrialized countries and 30% in less-developed countries. The main market segments are off-grid stand-alone PV applications and grid-connected PV. The latter segment has grown fast and e.g. building integrated PV is becoming very important for the PV industries. In Europe, the German market is the largest one. In 2001, about 75 MW_p was installed and the German market grew by 45%. The Finnish PV market is about 0.1% of the global PV market.

The EU's goal is to increase the use of PV by 500 MWp in EU countries and by 500 MWp in developing countries. This would mean that 2% of all new buildings in EU would have a PV system. Taking a slightly lower growth estimate of 15%/y for PV would mean a business potential of 8,000-12,000 million euro/y and a production capacity of 600-900 MW_p/y in 2010. Most of the growth is anticipated to come from PV in buildings. This PV segment is not yet competitive with grid electricity and would hence need public support. Several industrialized countries have major programmes to

support PV integration into buildings. The market value of identified programmes is closer to 3000 MW_p.

2.1.2. Solar heating

The solar collector area installed world-wide corresponds to about 20 TWh/y. In Europe, some 10 million m^2 of collectors are in operation representing 3-4 TWh/y. Swimming pools and domestic hot water represent about 90% of all solar heating.

The European solar heating market grows in average 15% per annum. The major market area is central Europe and in particular Germany. The German market has grown more than 30%/y over the last years and the annual sales is around 1 million m^2 of collectors. The solar heating business corresponds in Germany to about 700 million euro/y. Germany and Austria alone represent over 60% of the EU market, south-Europe some 25%, but northern Europe less than 10%. For comparison, the Finnish solar heating markets are less than 0.1% of the present EU market.

The medium terms market trends for solar heating in Europe are positive. The EU goal for solar heating in year 2010 is 100 million m^2 of installed capacity which would require a 35% annual market growth. Based on present trends, 50-80 million m^2 seems to be more likely. A business as usual growth is around 15%/y which would mean a sales volume of 5 million m^2/y in 2010, or, a business value of 2000-3000 million euro/y. Figure 1 illustrates the market trends in Europe.

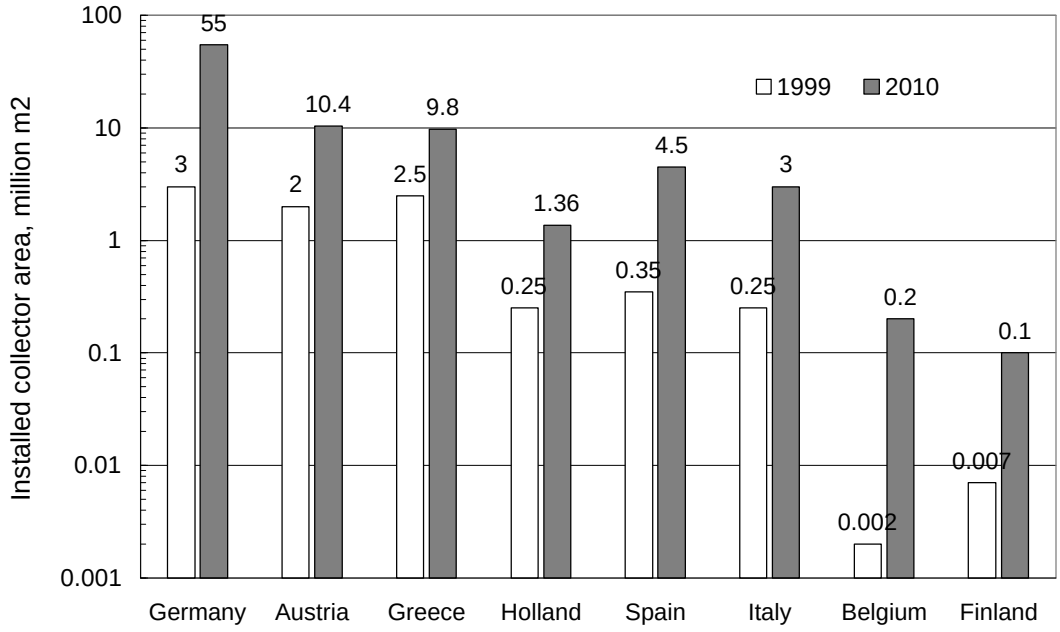

Figure 1. Solar heating market in selected EU countries in 1999 and 2010.

2.2. Possibilities of technology developments

Solar energy is a strategic innovation, which starts with a small market share (e.g. niche). If the vision materializes then this niche will grow on a long-term into prevailing business. Solar energy is thus in the beginning of its life-cycle in which developing and commercializing the technology plays a major role. Dropping the price of solar energy (or increasing its value), finding more economic applications and improving the competitiveness, are the major challenges for solar energy ahead.

For Finland, solar energy is on a short/medium term a technology driven export possibility. Even a small domestic market may support the development of industries and create competitive advantage through learning by doing and learning by using. In the following, we have summarized key technology development areas.

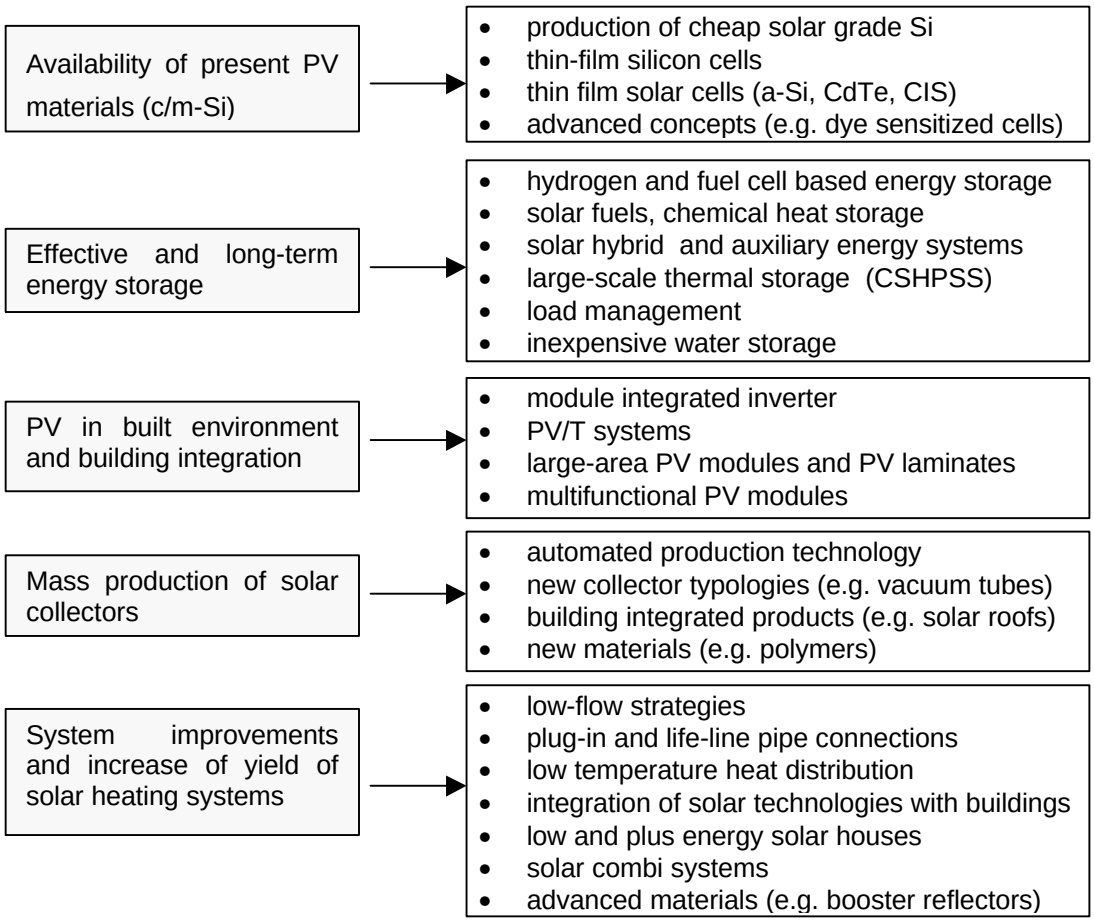

Figure 2. Key technology areas for solar energy.

In addition to direct process or technology innovations, one may recognize the possibilities of indirect technology development as well: balance of system technologies; impact of other technology trends; technology synergies (e.g. building, information technology), or utilization of existing infrastructures (e.g. building, information networks).

3. Solar energy in Finland

3.1. Solar conditions and utilization in Finland

The solar insolation in southern Finland corresponds on an annual level roughly to that of central Europe (see Figure 3), or, 1000 kWh/m^2/y on a horizontal surface. On an inclined surface, up to 1100-1200 kWh/m^2/y may be expected. The seasonal variation of solar radiation in Finland is much larger – 90% of solar radiation is obtained between March and September.

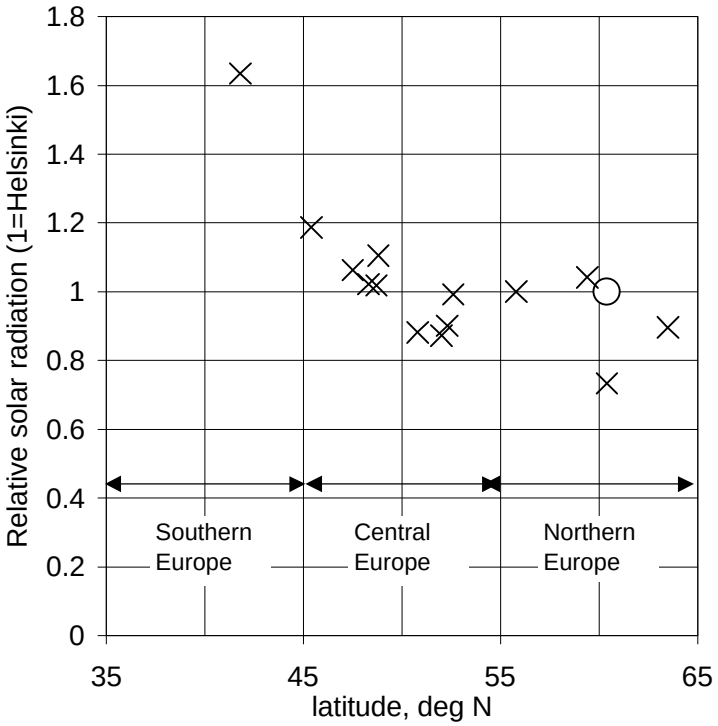

Figure 3. Yearly solar insolation on a 30^o inclined south-faced surface (1=Helsinki).

The total amount of solar collectors in houses in Finland for domestic hot water and heating is about 10,000 m^2 which corresponds to about 3 GWh/y. In addition, there are some 70,000 m^2 (10 GWh/y) of simple unglazed air collectors used for crop drying.

The installed photovoltaics is 2.8 MW$_p$ (2 GWh/y). 95% of this is off-grid PV systems in summer houses, 5% are on-grid building integrated systems.

3.2. Project examples

One of the major recent solar energy projects is in Ekoviikki, Helsinki (Faninger-Lund, 2000). The Ekoviikki area is a ecological suburb and it is a unique demonstration project for ecological and sustainable housing. The site includes the major solar projects in Finland. The largest solar heating systems with 8 subsystems of a total area of 1246 m^2 solar collector area were built in 1999-2001. In 2002, a 24 kW_p building integrated PV system will be mounted on one apartment house. The PV panels will form a part of the balcony structures. Along with other PV systems the total expected PV capacity in the area would be 35 kW_p.Building integration of the solar panels has been important in Ekoviikki.

Figure 4. Left: One of the solar heating systems (solar roof) in Ekoviikki. Right: PV balcony in Ekoviikki.

Another unique Finnish project is on long-term solar energy storage in which hydrogen technologies have been used with PV to provide 100% electricity over the year.

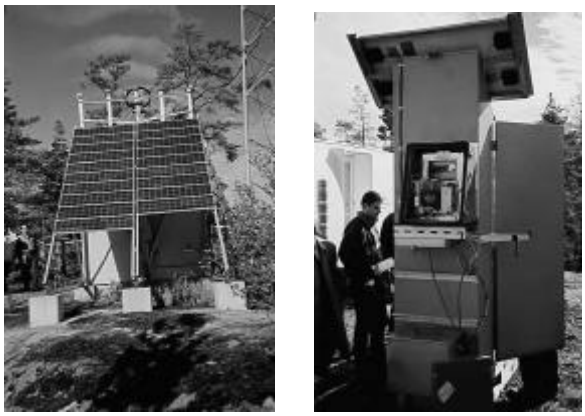

Figure 5. Solar hydrogen systems developed in Finland for stand-alone remote applications.

3.3. Cost of solar energy

The rate and magnitude of market penetration of solar energy is very much dependent on its costs. Excluding niche markets and some narrow market segments, solar energy in Finland is not yet fully competitive against traditional energy sources and fuels.

The cost of solar heat at present is around 0.1 euro/kWh. By year 2010, the price could drop to 0.05 euro/kWh. The economic conditions and requirements (life-time, interest rate) have an influence on the solar cost as shown in Figure 6. If viewing solar as part of the building or as a building component, then a lower interest rate may be justified and the cost of solar would be 0.07-0.08 euro/kWh.

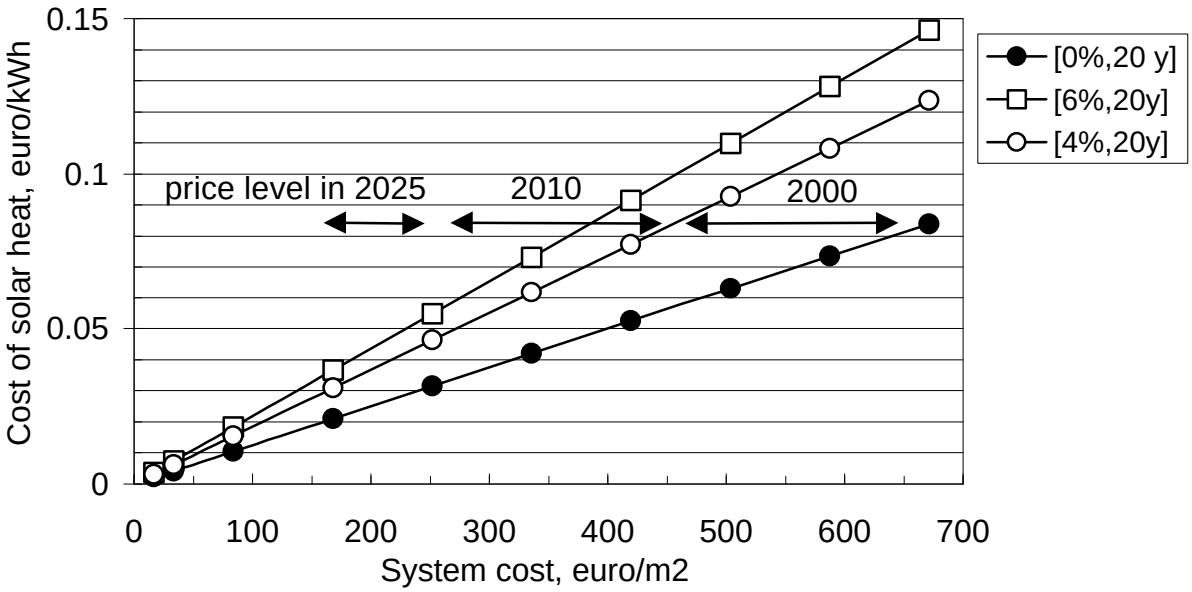

Figure 6. Cost of solar heat in Finland with different economic parameters and system costs.

A special category is large-scale solar heating applicable for larger heat loads (>300 MWh/y). Here 0.05 euro/kWh or even less is possible already today.

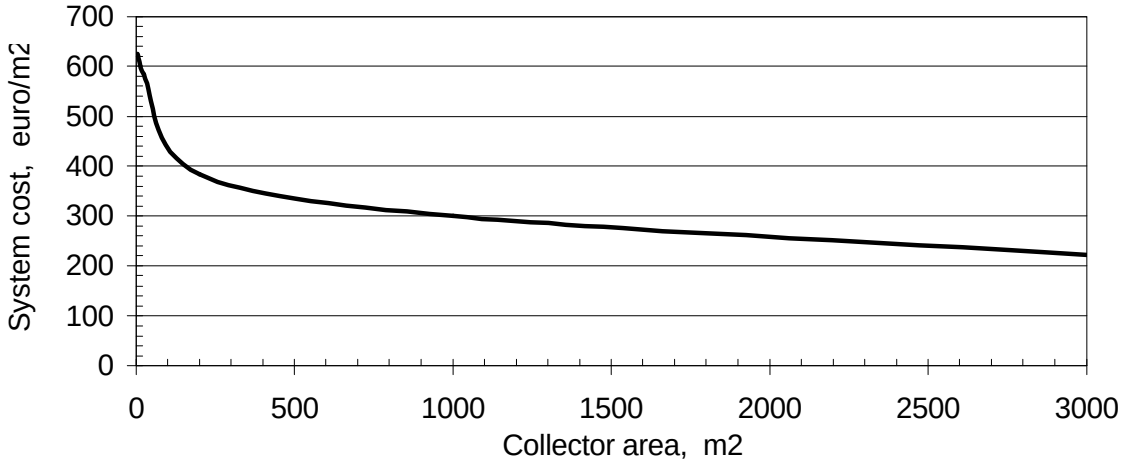

Figure 7. Present system cost of solar heating systems versus system size.

Table 1 shows how different factors may influence the price of solar heating.

Table 1 . Estimate of cost reduction in solar heat through different factors.

Price factor	**Cost effect**	**Actions needed**
Practical experience in planning, mounting and projects	10-20%	Information, training, increased volumes
Standardized system solutions	10-20%	Competition, increased volume
Logististics	10%	Cooperation
Technology development, influence of international markets	20-30%	Technology transfer, international cooperation

In case of photovoltaics, the present system cost is around 6.5-8 euro/W_p and year 2010 goal is under 4 euro/W_p. The theoretical life-time of a PV module may be 40-50 years as it does not have any moving nor mechanical parts. Cost of on-grid PV electricity is around 0.6-0.8 euro/kWh, for stand-alone off-grid systems with battery the cost is 0.8-1 euro/kWh. If PV is a part of the building structure (e.g. solar roof) and modest economic return is required, the cost of PV electricity is around 0.20 euro/kWh. In 2010, a 0.1-0.3 euro/kWh price level is anticipated (Figure 8).

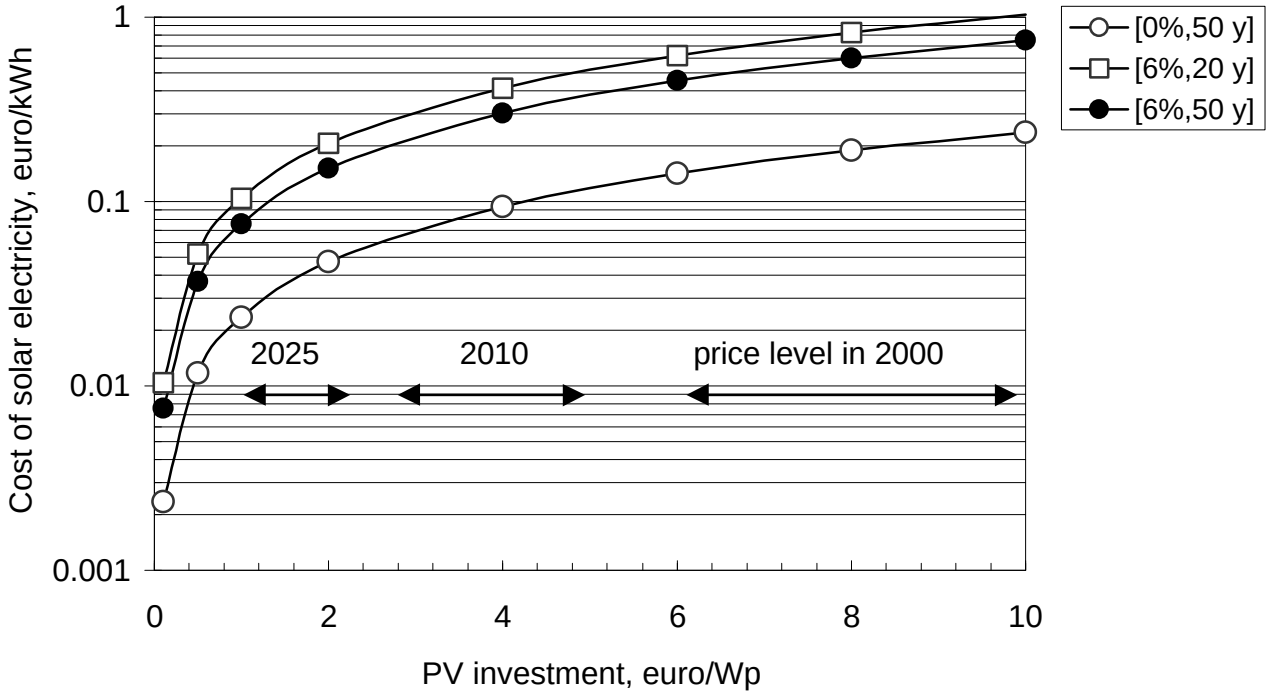

Figure 8. Cost of solar electricity in Finland with different economic parameters and system costs.

3.4. Near future market potential

Without public support, the solar energy markets in Finland are very limited. Commercially viable applications could be found in different niches, such as PV for summer cottages and remote applications and solar heating for low-temperature summertime uses e.g. for camping areas. The total size of these niches for solar heating is about 20 GWh/y corresponding to 50,000 m^2 of solar collectors and for PV we find 10 MW_p or 10 GWh/y.

The Ministry of Trade and Industry has updated in July 2002 the investment subsidies for renewable and new energy technology. Accordingly, solar energy applications will now receive a investment subsidy up to 40% of the total investment. With the existing subsidy, which is mainly meant for municipalities and companies, the near term market potential for solar heating is increased to 1,490 GWh/y (3,800,000 m^2) and PV to 100 GWh/y (100 MW_p). The potential would even grow if private householders would receive public support for their solar energy investments.

The maximum or long-term potential of solar energy in Finland has been estimated as follows: photovoltaics in buildings 5,500 GWh/y and solar heating 4,000-5,000 GWh/y.

4. Action plan for solar energy

4.1. Road Map

Based on the international trends and markets, national state-of-the art of technology and market potential, and the national goals set for solar energy, a road map has been built for solar energy in Finland. The road map is a path in which milestones are defined starting from the end. To reach the milestones, measures are set moving from start to the end.

Table 2 summarizes the key goals set in the action plan for solar energy.

Table 2. Strategic goals of the action plan for solar energy.

GOALS FOR THE ACTION PLAN ON SOLAR ENERGY			
Year	**Strategic goal**	**Turn over**	**Use of solar energy in Finland**
2010	♦ Solar energy is fully on the Finnish market ♦ Leading position in certain market segments	150 M€/y	100 GWh/y
2008	♦ Established markets in Finland ♦ Significant export in EU and LDCs	100	45
2006	♦ Solar energy is clearly on the domestic market ♦ Export grows in the EU	40	20
2004	♦ Solid growth of the national solar market ♦ New export activities established	15	15
2002	♦ Introduction of solar energy on the Finnish market ♦ Improvement of existing technologies		

The need of public support for the action plan over 2001-2010 is in total 25 million euro.

The road map for solar energy in Finland is illustrated in Figure 9.

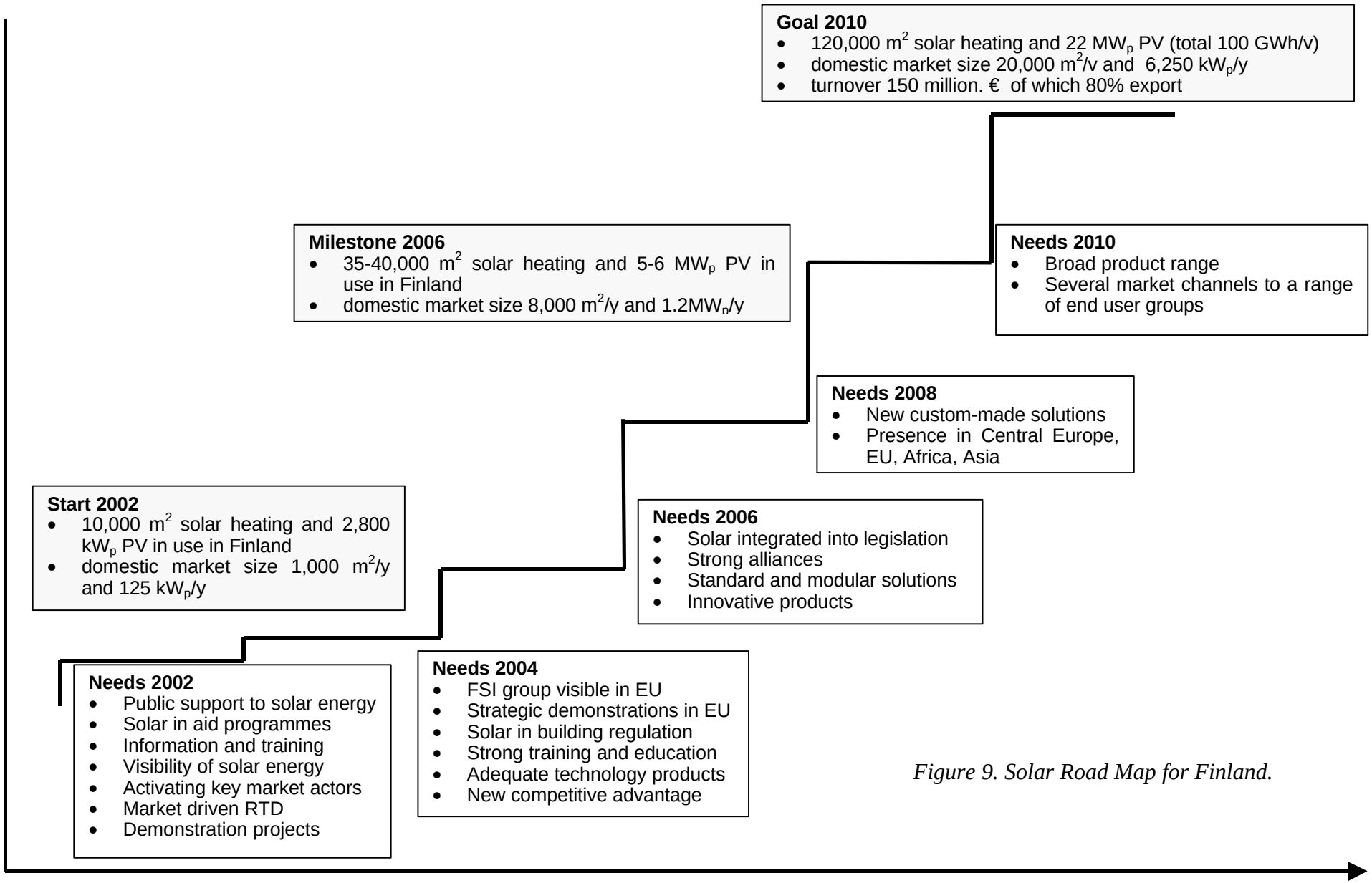

Figure 9. Solar Road Map for Finland.

4.2. Finnish Solar Industries

One important outcome of the project has been the establishment of the Finnish Solar Industries (FSI) working group which comprises strategic market actors (industries, authorities, experts). FSI has acted as support to the present project but will also be an important actor group in realizing the action plan in practice. The activities of the FSI is focussed on areas that give clear added value to the participants such as sharing common information, joint-activities to open the markets, influencing standards and norms, increasing the commitment and continuity in solar development, joint-representation in fairs and international events, etc.

Also, FSI promotes business concept innovations in which the traditional technology development as source for innovation is broadened to include also service/channel and customer target groups as well.

FSI is part of the national solar energy network established in parallel. Both networks have now about 30 organizations represented. FSI and national solar network are coordinated by SOLPROS.

4.3. First actions in year 2002

The action plan starts in 2002 and it will be open to all interested market actors. The structure at this stage is virtual and the network of actors and their activities form the core of the practical programme realization. The authorities support the activities case by case. Thus, the outcome from the action plan is very much dependent on how active the solar field itself is.

The action plan concentrates on two major segments namely solar heating and photovoltaics. First projects are focussed on activities in which solar energy gives the best added value.

Another important objective in 2002 is to increase the number of industries and key market actors in the solar programme. Cooperation is important. The Finnish Solar Industries group and solar network are seen as an important tool and asset. Training and education modules will be planned together with regional and national energy agencies.

4.4. End goal in 2010

The end goal of the action plan for solar energy is that solar energy is competitive on the national market in 2010 and that Finnish industries are strongly established on the global market.

The solar utilization in Finland would correspond to about 100 GWh/y (e.g. 120.000 m^2 solar heating and 22.000 kW_p PV)

4.5. Impact of solar energy on GHG emissions in Finland

If the action plan meets its goal, then solar energy will reduce the greenhousegas emissions in Finland by 0.02-0.04 million tons of CO_2 in 2010. In 2025, the impact could be 0.3-0.7 mill. t CO_2 Solar heat replaces mainly light fuel oil and PV coal condensate or average electricity mix.

The CO_2 reduction cost using solar energy is at the moment well over 100 euro/ton CO_2. In 2010, the cost may drop down to 10-40 euro/ton CO_2 for solar heat and 100-400 euro/ton CO_2 for PV. On a long-term run by 2025, the cost could turn negative (Figure 10).

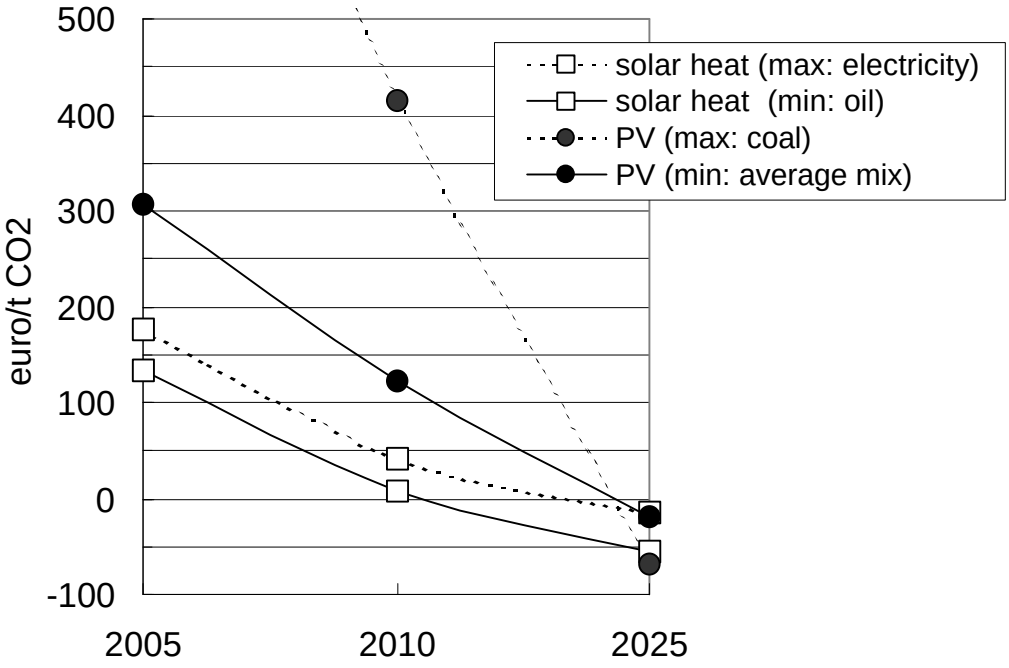

Figure 10. Cost of CO_2 reduction using solar energy in Finland.

5. Conclusions

An action plan for solar energy for Finland to meet the goals set in the National Climate Strategy and the Programme Promoting Renewable Energy Sources has been prepared. A road-map type of approach has been used.

The action plan includes specific actions and milestones during 2002-2010. The first challenge is in starting the realization of the plan and opening of the solar energy market in Finland. The plan recognizes networking and cooperation between market actors and different target groups as key elements in practical realization. The Finnish Solar Industries (FSI) working group consisting of strategic market actors was established to support the plan. In addition, a national solar energy network has been initiated.

The end goal of the action plan is 100 GWh/y solar energy in Finland and 150 million euro/y turnover by 2010. These are about 10-fold compared to present situation. The analysis done show, however, that with public support mechanisms that are almost in place, the market potential for solar energy based on costs is much larger than the targets set. This and international trends give confidence that the challenging goals can be met.

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