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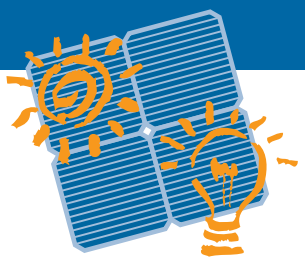

Literature survey and analysis of non-technical problems for the introduction of building integrated photovoltaic systems

Task VII

Report IEA PVPS 7-01:1999

PVPS

PHOTOVOLTAIC POWER SYSTEMS PROGRAMME

Literature survey and analysis of non-technical problems for the introduction of building integrated photovoltaic systems

IEA PVPS Task VII

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Foreword

The International Energy Agency (IEA), founded in November 1974, is an autonomous body within the framework of the Organisation for Economic co-Operation and Development (OECD) which carries out a comprehensive programme of energy co-operation amongst its 23 member countries. The European Commission also participates in the work of the Agency.

The IEA Photovoltaic Power Systems Programme (PVPS) is one of the collaborative R&D agreements established within the IEA and since 1993 its participants have been conducting a variety of joint projects concerned with the application of photovoltaic conversion of solar energy into electricity.

The twenty one members are: Australia (AUS), Austria (AUT), Canada (CAN), Denmark (DNK), European Commission, Finland (FIN), France (FRA), Germany (DEU), Israel (ISR), Italy (ITA), Japan (JPN), Korea (KOR), Mexico (MEX), Netherlands (NLD), Norway (NOR), Portugal (PRT), Spain (ESP), Sweden (SWE), Switzerland (CHE), United Kingdom (GBR), United States (USA).

This report has been prepared under the supervision of PVPS Task VII by Barbara van Mierlo and Bianca Oudshoff of IVAM Environmental Research, The Netherlands, with the assistance of Energy North West, the Netherlands, and in co-operation with Experts from Task VII of the following countries:

AUS, AUT, CAN, CHE, DNK, DEU, FIN, ITA, JPN, NLD, ESP, SWE, GBR, USA

and approved by the PVPS programme Executive Committee.

The report expresses, as nearly as possible, an international consensus of the opinions on the subject dealt with.

The objective of Task VII is to enhance the architectural quality, the technical quality and the economic viability of PV systems in the built environment. The objective is also to assess and remove non-technical barriers for their introduction as an energy-significant option.

It is expected that successful integration of PV systems into the built environment (BIPV) will contribute significantly to the future spread of PV.
For this active involvement of urban planners, architects and building engineers is required. Task VII motivates the collaboration between these groups and PV system specialists, utility specialists, PV and building industry and other professionals involved in photovoltaics.
Task VII considers all grid-connected systems other than classified as "ground based arrays". Primary focus of this Task is on the integration of PV into the architectural design of roofs and facades of residential, commercial and industrial buildings and other structures in the built environment (such as noise barriers, parking area’s and railway canopies), and on other market factors, both technical and non-technical, that need to be addressed and resolved before wide spread adoption of PV in the built environment will occur.
Task VII has officially started on January 1, 1997 and will last until end 2001.

Summary

What problems will the introduction of building integrated photovoltaic systems (BIPV) encounter before being able to enter the market on a large scale? By order of ENW Renewable Energy BV, IVAM Environmental Research conducted a literature study in the framework of task VII of the IEA photovoltaic power systems programme. Subtask 3.1 concentrates on the assessment of barriers for usage of building integrated PV. Many literature sources were screened on non-technical problems for the application of PV in the built environment and renewable energy in general and strategies to overcome these.

In the next table the problems and potential solutions are summarised. The problem categories are: financing; administration; architecture; communication; marketing and environment. They are categorised in columns by target groups, the groups which deal with these problems. The first column of the table refers to the paragraph of this report in which the problems and potential solutions are described.

problem category (paragraph)	problems ➜ potential solutions					
	PV industry	**building sector**	**energy sector**	**public**	**government**	**financial sector**
financing - costs (3.1)	• production, installation and BOS costs are high ➜ prefab systems and standardisation, lowering overhead and labour costs, prolongation of life time • bigger market needed ➜ more export		• consider PV prices too high ➜ take network costs into account, develop techniques to model costs and benefits, e.g. life cycle costing	• cost gap between PV costs and acceptable market price ➜ make use of willingness to pay; lower costs by bulk purchase or integration of PV in buildings	• PV not competitive with fossil fuels ➜ internalisation of external costs by creating quantitative values, subsidies or tax benefits; legislation for higher rates; stimulating export to developing countries	
financing - investments (3.2)	• few investments because profits are small ➜ developing financing schemes; export and niche markets					• no willingness to invest because of perceived high risks ➜ a dissemination strategy from the industry, government support
administration - financial instruments (4.1)	• no steady demand because of unstable policy ➜ long term stable policy		• rate-based incentives under pressure by deregulation of the electricity market ➜ national policy • green pricing is turning a social problem into an individual one	• subsidy procedures slow and variable ➜ a simple subsidy arrangement • tariffs for RE-electricity too low and variable ➜ cost effective fixed rates, more realistic calculation method		

problem category	PV industry	building sector	energy sector	public	government	financial sector
administration - organisation (4.3 and 4.2)			• central organisation and energy production ➜ more decentralised organisation • planning and selection tools inadequate for valuing PV ➜ adjusting tools • not enough customer orientation ➜ follow strategies to interest customers in PV		• because of liberalisation utilities will turn to cheaper and less risky options ➜ an obligated share of PV using tradable emission credits or green labelling • public policy on a fossil fuel based economy ➜ choosing for a sustainable future, internalising external costs, taxing fossil fuels • RE policy not integrated at local level ➜ local energy plans (agenda 21)	
administration - legislation and regulation (4.4)			• regulatory constraints to the selling and production of PV electricity by utilities • uncertainty about ownership and responsibilities ➜ standard contracts and agreements, standard maintenance contracts • limited grid access and discriminatory tariffs due to monopoly position ➜ separate production and distribution, allowing grid access to private producers	• procedure for permits for BIPV unclear and slow • planning procedures or building codes form constraints • uncertainty on liability ➜ standard contracts, warranties	• lack of appropriate national legal framework and economic regulations ➜ long term strategy, changing legal and institutional framework, PV mandatory for buildings and schools • lack of regulations for shadow hindrance • international lack of regulations to promote PV ➜ legal and regulatory framework	

problem category	PV industry	building sector	energy sector	public	government	financial sector
architecture - design (5.1)		• PV systems not fit for buildings ➜ PV product development meeting requirements of building elements • optimal installation PV not compatible with buildings ➜ early involvement architects • colours and sizes too limited ➜ wider range of colours and sizes		• visual hinder ➜ architectural integration of PV in buildings • low overall acceptance of PV ➜ research on relation between opinion on aesthetics and PV acceptance • theft, vandalism in public places		
architecture - standards (5.2)	• lack of guidelines for producing, installing etc. ➜ internationally agreed standards, certification of BIPV products	• PV systems do not meet requirements of building elements ➜ certification of BIPV products	• high costs and uncertainty by lack of standards ➜ certification of BIPV, internationally agreed electrotechnical standards			
communication - needs for information (6.1)		• no innovative attitude • lack of awareness of PV ➜ appropriate design tools, better information on PV products, education	• lack of experience and knowledge on PV technology, the markets and the building sector ➜ more info, gaining and exchanging experience • negative attitude ➜ greenhouse gas emission targets, more information exchange	• distrust towards planners ➜ developing local guidelines and involving local people • lack of info and awareness ➜ distinguishing target groups, info geared towards their needs and interests		• lack of confidence and awareness ➜ dissemination strategy towards banks and insurance companies, developing financial models
communication - supply of information (6.2)		• supply of information inappropriate ➜ presenting information in format and carriers that architects use • supply insufficient ➜ information on details of PV products		• no reliable, independent info source ➜ info through normally used channels, providing independent sources where the public can get more information		

problem category	PV industry	building sector	energy sector	public	government	financial sector
marketing - potential markets (7.1)	• inadequate understanding of the utility and other markets ➜ analysing market, developing marketing strategy		• inadequate understanding of their customers and their valuing of PV ➜ marketing strategy, arrange PV offerings			
marketing - reaching the market (7.2)	• lack of trust among customers because of absence of business plans • PV products unclear to customers ➜ promote and distribute products that satisfy demands		• not customer oriented, no knowledge of purchasing decisions ➜ promote and distribute wanted PV products, guarantees and service • public sceptical about motives of utilities to sell PV products			
marketing - infrastructure (7.3)			• lack of utility related distribution channels • lack of product catalogues for utilities • lack of services such as maintenance ➜ after sales support	• lack of installation and maintenance service ➜ after sales support • no ways to assess the quality of suppliers ➜ certification		
environment (8)	• high energy use at production ➜ recycling, BIPV, energy-efficient production • resource depletion • toxic and hazardous materials ➜ research on safer materials • waste ➜ recycling				• high energy use at production ➜ recycling, BIPV, energy-efficient production • resource depletion • toxic and hazardous materials ➜ research on safer materials • waste ➜ recycling	

List of abbreviations

BIPV	Building integrated PV, PV in the built environment
ENW	Energy North West (the Netherlands)
GAP	Global Accreditation Program
IEA	International Energy Agency
PV	Photovoltaic Energy
RE	Renewable Energy
UPVG	Utility Photovoltaic Group (United States of America)
WTP	Willingness To Pay

Contents

1. Literature study

1.1 Introduction

What problems will the introduction of building integrated photovoltaic systems (BIPV) encounter before being able to enter the market on a large scale? Until recently little attention was paid to non-technical barriers. In contrast with photovoltaics in developing countries attention in industrialised countries was focused on technical problems and also on the costs of photovoltaics.
A study of literature on non-technical barriers for the introduction of photovoltaics or renewable energy in general was done by IVAM Environmental Research, by order of ENW Renewable Energy BV, in the framework of task VII of the IEA photovoltaic power systems programme. Subtask 3.1 concentrates on the assessment of barriers for usage of building integrated PV. Integrating PV systems in the built environment has the advantage of reducing costs and enhancing the architectural quality.

A quick search of literature in the spring of 1998 was a first step to the goal of subtask 3.1; a survey of non-technical barriers and solutions mentioned in literature sources. This has resulted in a list of problems and solutions categorised in four subjects (financing, administration, architecture and communication) and an extensive, though not complete reading list reported in a draft document which has been presented to the members of IEA task VII.[1]

A follow-up study was carried out in order to:
- extend the inventory of relevant literature
- pay special attention to the groups confronted with the barriers
- analyse potential solutions to tackle the problems
- give recommendations on further research among target groups

This report presents the results of both the quick search and the follow-up study. It starts with a description of the approach of the literature search and the overall characteristics of relevant literature. After this the problems and solutions are discussed for each category of problems separately. Two categories have been added to the four categories already identified: Environmental problems and Marketing. The problems are described separately for the different target groups. Thereafter recommendations on further research are made. The report ends with the complete reading list[2].

[1] *Non-technical barriers for the introduction of building integrated photovoltaic systems. A search for literature*. (draft) Amsterdam: IVAM Environmental Research, April 1998.
[2] Relevant literature which was received too late to use is mentioned in this list: Haas, s.a. and Haas, 1995.

1.2 Approach

When applying PV to buildings many parties are interdependent: the PV industry, the building sector, the energy sector, the consumers etc. Problems mentioned in the literature are often related to one or more parties which are involved in the introduction of building integrated PV. In this study six groups which experience problems (target groups) are distinguished:

1. PV industry: parties developing, producing and supplying (parts of) PV systems
2. Building sector: especially architects, but also project developers, building contractors etc.
3. Energy sector: mainly utilities, also companies producing electricity
4. Public: the general public, people living or working in PV buildings, people living near PV buildings and people buying PV-green electricity
5. Government: national government and local authorities
6. Financial sector: banks and insurance companies

The target groups can take up different roles: the energy sector for instance can be a supplier of PV systems, provide preconditions, invest in PV and/or consume PV products. The same applies to most of the other target groups.

The data of the screened literature were collected in a database. Described characteristics are[3]:
1. source (article, book, policy document, conference paper, research report)
2. country
3. subject (BIPV, PV, RE)
4. status (problems as main subject, minor subject or just indirectly mentioned)
5. problem category
6. framework of analysis (economic, psychological, sociological, technical)
7. foundations (interviews, survey, comparison, modelling, literature research, meetings, etcetera)
8. validity (good to bad)
9. barriers
10. solutions

Based on the database the barriers and strategies for the introduction of PV were grouped, summarised and described. For the description of the main problems generally the literature based on surveys or interviews and the market studies and policy evaluation were used. Special attention was paid to the problems the different target groups experience.
Six problem categories have been distinguished:
1. Financing
2. Administration
3. Architecture
4. Communication
5. Marketing
6. Environment

[3] We also tried to characterise the literature by the kind of application of BIPV (such as kind of building, ownership, size of systems etceteras). However, this attempt failed because most literature does not take the kind of application into account.

2. Description of the literature

One hundred and seven literature sources were screened. Books on the subject of non-technical barriers hardly seem to exist (3). Therefore the listing of non-technical barriers depends mainly on papers and research reports. The main sources (64) were papers from conferences and meetings, i.e. the European PV conferences, the APAS-RENA contractors meeting of November 1995 and the Altener conference of November 1996. Research reports are the next most used literature sources (37). Some of the most important and elaborated research reports are those compiled by the American Utility PhotoVoltaic Group.

The countries involved are mainly the United States and the Netherlands (see table 1). After this, a significant amount of literature stems from Great Britain and Germany.

Table 1: Countries (N=107)

United States	27
The Netherlands	24
Great Britain	10
Germany	8
Austria	6
Belgium	3
Switzerland	3
Spain	2
Australia	1
France	1
Italy	1
Japan	1
Poland	1
Portugal	1
Europe	4
Several	14

Just twelve out of the 107 sources concentrate on a description of non-technical barriers for building integrated PV (see table 2). This is partly due to the fact that most literature is very much solution-oriented instead of problem-oriented. Sound analyses of barriers, their significance and their interdependence hardly exist.

Table 2: Subject of literature (N=107)

problems	main subject	minor subject	hardly mentioned
BIPV	12	13	3
PV	18	33	8
RE	4	8	8

The problems mentioned most are financial problems (61%). Another main category are communication problems (53%). A little less attention is paid to administrative problems (40%) and architectural problems (29%). Marketing problems are mentioned in 10% of the sources. Ecological problems are the main subject of only one report, recycling of PV is the subject of three papers. Also ecological problems are mentioned four times, in terms of communication problems, such as the little or inaccurate knowledge of environmental effects of photovoltaics.

Most literature is written from a sociological or psychological (40%) point of view, an economic point of view (27%) or a combination of economy with another social science (20%) (see table 3). About two third of the literature seems to be based on more than just common sense or own experience. Foundations are: a comparison of projects; measuring programmes; surveys; literature searches; interviews; workshops; and historical analysis.
As can be seen in the table we consider almost half of the descriptions and analyses of barriers as based on valid foundations.

Table 3: Foundations of problem analyses (N=107)

viewpoint/ foundations	good	neutral	bad	Total
economic	12	10	7	29
psychological	8	9	3	20
ec + psy or soc	9	11	2	22
sociological	13	10	-	23
technical	-	6	1	7
tech + ec, psy or soc	1	2	-	3
soc + psy	-	2	1	3
Total	43	50	14	107

All hundred and seven sources were used to make a list of non-technical problems in the database. The well founded and most relevant ones, such as reports of surveys, market studies and policy evaluations were used for the description and analysis of the problems and the strategies presented in this report.

3. Financing

Financial problems are defined as the problems concerning the financing of PV, encountered by parties involved in the introduction of PV. There are several financial problems mentioned in the literature. These financial problems can be divided in two categories; initial costs are too high, and there is a lack of investments for PV. Most literature that mentions financial problems agrees that these economic problems are interdependent.
The financial instruments such as subsidies, taxes and tariff settings will be discussed in chapter four.

3.1 Costs

PV is locked in a critical "chicken-and-egg" situation between price and economy of volume. The prices are too high to generate a substantial market and a market is needed to generate economy of scale. The price mechanism does not take external costs and benefits into account. Externalities of PV projects are not easily introduced into financial decision making and it is difficult to assign economic value to externalities (Hardt, 1998). It is very difficult to create "real" prices by taking all externalities into account because these externalities are difficult to quantify.
When only the price is compared to decide between PV or fossil fuels or between PV and other renewables, PV is not competitive in a free market (Joosen, 1997b).

PV industry

A price reduction is necessary but PV suppliers say they need a bigger market to be able to reduce prices. The costs of PV systems are based upon the costs for materials, production, BOS (balance of system components) and installation. Reduction of these costs seems necessary to enhance the introduction of PV.

Solutions

There are some possibilities for the PV industry to reduce the costs for PV (Alsema, 1992). The possibilities for cost reduction as mentioned in the literature can be divided in:

- reduction of the installation costs for instance by creating prefab PV systems, standardisation of PV systems and providing packaged PV systems
- reduction of production costs by equipment standardisation and lowering of overhead costs, lowering labour costs through automation of production and technology improvement
- reduction of overall costs by prolongation of life time of PV modules

Reduction of module production cost is expected to be the most important. Already significant cost reductions have taken place and they are expected to continue in the future.

It is mentioned in the literature that when the module production becomes more efficient the Balance of System components will become more important and grid connected BIPV will have a significant

advantage (Nieuwlaar, 1997). Using BIPV will reduce material costs, because less material is needed (no constructions to hold up the modules) and materials that would have been used otherwise are replaced by the PV system. The energy requirements for PV will also be reduced and together this will make the environmental argument for PV stronger (Oliver, 1998).

Another strategy for the PV industry to reduce costs is creating a bigger market and therewith economy of scale. Production capacity can be expanded, for instance by more export (Morgan, 1996). Other possibilities to create a bigger market is to develop niche markets. There are already some applications of PV that are profitable. These options should be investigated and developed.

Energy sector

Utilities consider the price of PV to be too high. The literature mentions that utilities perception of the high price of PV stems from the fact that utilities appreciation of costs is limited by traditional thinking and conventional tools. The costs allocation prevents optimum purchase decisions by utility companies (costs are averaged for remote and close communities). Also network prices are still not cost-reflective and therefore not providing a powerful driver (Watt, 1998, UPVG, 1994d). Only a small number of utilities recognise the potential cost benefits of increasing network support through distributed generation in their current planning processes or in their longer term strategic thinking.

Solutions

There are several options for the utilities to solve the cost problem. One solution is to take the extra value that PV could have in specific situations into account. To do so utilities should change the way they model their costs and benefits in a way that makes it possible for them to take the benefits of PV into account. This can be done by using life cycle costing on a net present value basis to evaluate PV versus conventional options and by developing techniques for modelling the costs and benefits. For these methods to work it will be necessary that the utilities understand the value of PV and have confidence in the value of PV and the means by which to incorporate them. Then this can become part of their standard planning (UPVG, 1994d).

Another way to make PV more attractive is to take the network costs into account. This can be done by splitting up previously vertically integrated utilities into functional units. This should make network costs more transparent and should provide an incentive to examine the cost-benefits of distributed generation (Watt, 1998).

Also the literature mentions that utilities can lower their own costs by using customers as allies, who pay a contribution, or by attracting private finance.

The literature does not mention whether the utilities will be willing to implement different planning and cost calculation methods. The methods and models are not described in detail nor is made clear if these models and methods are possible and workable for the utilities.

Further research is necessary to determine whether utilities can use other methods that will take the benefits of PV into account and what the possible benefits may be. Also needs to be examined whether utilities are willing to change their strategy.

Public

For prospective buyers of PV systems the prices are too high, there is a cost gap between PV costs and an acceptable market price. Consumers generally prefer an economic payback time of approximately 5 years, commercial customers require a payback time of 3 years while the payback time of PV might be more than 30 years (Jansson, 1997).

Solutions
There are three solutions mentioned to overcome the price gap. One option is to make use of the price that customers are willing to pay for PV. Raising the price that potential customers are willing to pay can be done by increasing the customers awareness of PV value. The added value of PV should make people willing to pay a premium for PV (Schoen, 1997). There are several market studies concerning the willingness to pay for renewable energy or PV. The amounts people are willing to pay vary and depend on the kind of project or product and the way the projects are presented. Because of the many different kind of projects and studies it is hard to give an estimate of the amount of money that could be raised with people's willingness to pay. Important literature on the willingness to pay and price is Farhar, 1998. This report describes the results from different projects and market research on the willingness of customers to pay for electricity from renewable energy. She concludes that there are customers who are willing to pay a premium for PV based on the added values such as social and environmental benefits. The WTP can thus be used to compensate the high price of PV. However, WTP alone will not be enough. Customers often require a subsidy or other incentive to put their WTP into practise. Research on the Austrian PV programme showed that although the customers were willing to pay a premium for PV it was the subsidy that led to a higher demand for PV (Hofreither, 1998).
Also the added value might make customers willing to accept a longer payback time (Farhar, 1998). Although there clearly is a market of customers who are willing to pay for RE or PV, the WTP found in surveys or interviews usually differs from the WTP when people are actually confronted with a product or programme. This discrepancy between expressed and actual WTP is important for utilities to take into consideration.

The second option is to lower the costs for PV users. Lowering the costs of PV for potential customers can be done by customers working together on bulk purchases. Also customers who want to implement PV should try to let PV structures serve two or more functions, such as shading or cladding. The costs for PV can then be lowered by the costs otherwise made for fulfilling these functions.
A third possibility is the design of low cost financing and smart cash back systems by financial institutions or the government (Nordman, 1997). This will make the investment customers have to make more attractive and easier to bear.

Government
The government does not seem to have any specific problems with the high costs of PV other than maybe that it hinders them in reaching their goals. Government is mentioned here because it is a target group that can contribute to tackling the price difference between PV and conventional sources.

Solutions
One option for the government to reduce the price difference between renewable energy (and thus also PV) and fossil fuels is to stimulate the internalisation of external costs. They could do so by creating quantitative values for all indicators and easy concepts how to take them into account. However, it is not specified in the literature how the externalities should be taken into account nor what these externalities are.
Another option for the government mentioned is the creation of incentives such as subsidies or tax benefits (see also paragraph 4.3) or legislation concerning higher rates for PV generated electricity. Current decision making should reflect the external societal costs and environmental costs of other energy sources and thus subsidise PV or put taxes on non-renewable energy. However, it is not

described whether such a policy can be implemented and whether the government would be willing to do so.
A third option for the government is to stimulate PV projects for developing countries aid. This will increase the export of PV and thereby create a bigger market. It is not known if this will create a substantial bigger market.

3.2 Investments

Investments for PV are very difficult to obtain. There is a lack of investments from the PV industry and the government as well as from private investors and financial institutions.

PV industry and Government

Several parties have made long term investments in other energy sources, these investments can not be used for solar energy. A limited amount of money is available for investments in solar energy, only money that does not have to compete with other investments (Scheer, 1993).
Another problem mentioned is that the market for PV is too small and therefore the profits are small and the needed investments to increase production are difficult to come by. A bigger market is needed to generate investments.
The lack of appropriate financing methods also contributes to the problem (Gregory, 1997).

Solutions

Not many options are given to solve the investment problems. One solution mentioned is the development of financing schemes. However, some options mentioned to be a possible solutions for other problems, such as creating a bigger market by stimulating export or niche markets, might also be beneficial for the investment problems.
How severe the problem of lack of investments is does not become clear in the literature. The needed investments are hardly ever specified. It is difficult to determine the effect that extra investments will have in the sense of benefits for the introduction of PV.

Financial sector

The investments from the financial institutions for PV are low. The main reason for this problem is that banks and insurance companies have a problem with the high capital costs, diseconomies of scale, commercial and technical risks of PV. Many of these objections are based on false premises and inaccurate suppositions, and a lack of specialised knowledge (Hardt, 1998).
Also it is mentioned that the investments for PV have to compete with other possibilities to invest money, and usually the other options look better to the investors.

Solutions

There are several options for the PV industry, government and the energy sector to improve the amount of investments from the financial institutions.
One option for the PV industry is to help financial institutions identifying bankable projects correctly. The industry should develop a dissemination strategy towards banks and insurance companies to help the institutions with identifying bankable projects, to build safeguards in the projects, to carry out a campaign and to give presentations to decision makers of the banks.

Another option is to convince investors that PV projects are a good investment by providing them with clear, quantitative and real criteria about PV projects, such as the value in ECU's. The social, environmental and external advantages of PV could be made more explicit by incentives such as subsidies and legal and fiscal instruments.
Also relations with financiers should be established at an early stage and banks already familiar with renewable energy projects should be approached (Hardt, 1998).
Another option is to develop appropriate financial models for instance with risk sharing.
Subsidies and political will and consistent government policies and long term energy plans will help to create a beneficial climate for the introduction of PV.

4. Administration

Administrative problems result from the organisation and policies of the different parties involved in the introduction of PV. There are several administrative problems mentioned in the literature: problems concerning the organisation of the energy sector, legislation and regulation, economic problems concerning financial instruments.

4.1 Financial instruments

PV industry

The stop and go of the funding policy hinders the establishment of a steady demand which is a prerequisite for industrial involvement. Also the political decisions on demonstration programmes or general programmes for investment subsidies depend on the state of the government cash-boxes, on priorities in political issues and on the personal commitment of politicians. This is not a good basis for a stable policy (Gabler, 1997).

Solutions

Possible solutions are for the government to have a long term strategy to promote PV and set up permanent tools that are independent of political context and energy policies. The government should develop a long term stable policy, with clarity about who is paying and how long the policy will last to create confidence with the investors and developers (Joosen, 1997b).

Energy sector

The literature mentions green pricing and rate-based incentives as possibilities of utilities to make consumers more interested in PV and let them pay a part of the bill (see paragraph 4.1). However, rate-based incentives and green pricing models may be strongly supported or put under pressure by the decisions which will be taken in the deregulation process of the electricity market (Gabler, 1997).

Solutions

The literature mentioning green pricing or rate-based incentives do not pay any attention to this possible negative effect of the deregulation process. It is important to keep an eye on suggested side-effects of regulations concerning the electricity market.

Public

Mentioned problems concerning subsidies for the PV users are that the short duration of regulations are an obstacle for investors and developers in RE. Also the application procedure for subsidies is sometimes vague and the response to subsidy request can be slow and conditions for subsidies vary. Problems mentioned concerning the tariffs are mainly that the tariffs for RE-electricity are too low, partly due to the calculation method, and therefore it is not attractive to investors and developers.

Also the tariffs vary strongly because there are no fixed rates for delivered electricity. Getting higher payments for RE sometimes involves many parties which makes the process complex, also yearly negotiations about tariffs tends to lead to lower rates, late results and low use of the agreement (Joosen, 1997b).

Solutions
A solution would be to set up permanent tools that are independent of political context and energy policies and develop a long term stable policy, with clarity about who is paying and how long the policy will last to create confidence with the investors and developers. Also the government should issue a simple subsidy arrangement and tax reductions and cost effective fixed rates. A system with as little parties as possible should decide about the higher payment, fixed higher payments guidelines for state aids for renewable energy (Joosen, 1997b).
Loan guarantees or interest rate write-downs should be provided and the calculation method should be made more realistic. One option is to base the tariffs on the German "Stromeinspeisungsgesetz", this is: 90% of the normal tariff for wind and solar systems, 80% of normal tariffs for all other RE-systems, for all systems smaller than 25 MW (ODE Vlaanderen, 1997).
Also a simple, standard and independent subsidy arrangement should be created and an increased electricity sell-back rate which can establish the required continuity because they are based on 10-20 year contracts. Tax reductions are also mentioned as an option to make PV more attractive for consumers.

Government
There are two main problems concerning the government's financial policy. The first is the subsidy policy. Problems concerning subsidies are that subsidies have the disadvantage that an expensive control system is needed that will never be perfect and utilisation of the subsidy budget depends on eligibility rules. Also, when subsidy consists of a constant share of investment costs, there is no incentive for investment costs reduction during the programme (Joosen, 1997b).
The second problem is the tariff structure. A problem concerning the tariff setting is that it is discriminatory and that cross-subsidisation of conventional methods of production hinder the introduction of PV.
Another problem mentioned is that there are not enough financial instruments place to stimulate the use of PV.

Solutions
Solutions for the problems concerning the subsidy mentioned in the literature are to let financial incentives show a decreasing characteristic over time and be an amount per kW and not a percentage of the investment costs subsidies (Joosen, 1997b).
Rebates or full costs rates and fixed tariffs are mentioned to be necessary.
Financial incentives for the use of PV should be implemented. However, in many countries financial incentives for RE already exist. These financial measures are :

- increasing costs of energy from non-renewable energy sources (e.g. tax on electricity and gas in the Netherlands);
- lowering costs of RE, by investment subsidies or fiscal benefits.
- higher payments for RE

Most European countries use a mix of these incentives. The used instruments do seem to work but the extent of their results is not described (Joosen, 1997b).

4.2 Liberalisation of the energy market

Liberalisation of the energy market may present problems and opportunities for the introduction of PV. It may cause some problems because PV is not economically attractive. When confronted with a competitive situation utilities will take less risks and look for cheaper options. When utilities would have to fulfil renewable energy obligations they would turn to cheaper options such as wind energy or biomass instead of PV.
The possible impact of the liberalisation of the energy market that will create competitive markets have been most extensively studied by Watt et al, 1998. This report is used here to describe the possible advantages and disadvantages of the introduction of competitive electricity markets. The report is based on an international survey among electricity utilities in eighteen countries. The objective of the study was to ascertain current and planned strategies for the use of PV or other renewables. Competition has already been established in electricity generation markets in a number of countries, e.g. Australia, Canada, Finland, Italy, Japan, Sweden, Great Britain, and the United States. Some other countries will introduce a competitive market in the near future, e.g. Denmark, Germany, Israel, the Netherlands, Spain and Switzerland.
A positive effect is that the introduction of competitive markets is accompanied in all countries by some mechanisms for promoting the use of PV or renewables. These mechanisms vary from renewable energy-targets imposed by negotiation or legislation, greenhouse gas emission permit trading, green pricing schemes, net metering, the obligation to show what fuel mixes are used for producing electricity and initiatives to provide data on environmental impacts.
The report also describes some negative effects of the introduction of competitive markets. Due to the competition utilities might lower their prices which causes a bigger price gap between fossil fuels and PV. Extensive industry restructuring might cause the loss of expertise. Also some of the mechanisms previously used to promote PV, such as net metering, mandated IRP(integrated resource planning) processes and the use of externalities in resource selection, might no longer be applicable. In the process of introducing competitive markets, the maintenance or development of initiatives to promote PV can easily be overlooked. Also environmental legislation may be felt to lower the market value of electricity assets and this may discourage governments from imposing legislation such as re-targets or IRP.

Solutions
Watt describes some successful strategies for PV in the transition to competitive markets. There is a need for ongoing monitoring of the impact of restructuring on PV programmes. PV expertise should be retained. Emission permit trading might be a successful instrument to support the use of renewables. Strategies for utilities that have been demonstrated to be successful are: green pricing, rate-based incentives, net metering and public disclosure of fuel mixes. Strategies for the government that have been shown to be useful are: greenhouse gas reduction or RE targets, investment in RE capacity, market rules requiring retailers to publicly show fuel mixes, legislation concerning net metering rules and education, information, training and standards.

Green pricing programmes have been launched in countries such as Switserland, Germany, the United States, Austria, the Netherlands and Australia. Experiences with green power in Australia indicate that a long term target of about 2% in the domestic sector is realistic. Although this level is small it does represent a substantial increase in funds for RE projects. Other authors have also mentioned that taking into account the customers willingness to pay (WTP) and using that WTP to raise money for the introduction of renewables or PV can be a successful strategy (Haas, 1998, Farhar, 1998, also see paragraph 3.1). Experiences with green pricing programmes in the United States show that there is a

divers range of possible products and programmes. The results are difficult to compare. However, some lessons can be learned form these green pricing projects. One of the most important lessons is that research on customers preferences about programme or product design is a prerequisite. Other important factors of the programme or product design are: credibility, simplicity, marketability, tangibility, visibility and sense of community. Also the followed strategy should be long range and require perseverance (Holt, 1996).
Rate-based incentives have been used in for example Switzerland and Germany. High buy-back tariffs are being used in Italy, Germany and Switzerland. Net metering is used in the United States.
A comparison in different countries concerning different models for buy-back rates has been made by Nowak et al., 1997. Results indicate that in countries where buy-back rates are based upon tariffs that are also valid for other producers the models are more successful for other RE than for PV. In countries with competitive markets these models are not very successful. Models for buy-back rates have more difficulty in establishing themselves in countries with a centralised structure such as France than in countries with multi-utility system such as Germany. The general conclusion of this study is that high buy-back rates can be one possible way to increase the market for PV. However, the topic needs special attention in view of the great number of different models and results and the differences among countries. The influence of the liberalisation of the energy market needs to be further investigated.

4.3 Organisation

The organisation structure of the energy sector is mentioned to be one of the main administrative problems. This problem concerns mainly the energy sector. The government also experiences some organisational problems.

Energy sector

Utilities can play a significant role in the introduction of PV. They form an institutional problem that hinders the full appreciation and stimulation of PV.
The first problem is the way utilities are used to operate. Utilities are used to a central organisation and energy production. PV makes a more decentralised operation necessary.
Another problem is that the departments within an utility might be unwilling to implement PV because PV requires little maintenance and therefore will not be a major business.
Another problem related to the organisation of the energy sector is that the analytic tools used for planning and selection among power supply alternatives are not refined enough to distinguish and value all the unique attributes of many PV applications. Also the organisational structure prevents cost allocation and incorporating the extra value of PV (see paragraph 3.1) (Ridder, 1998).
A problem resulting from the organisation structure is that utilities do not have enough customer orientation while customers can be allies and form an early market potential for PV. Therefore possible opportunities to implement PV are not used (UPVG, 1994d).

solutions

Some of the organisational problems can be solved. First of all the organisation should become more decentralised.
Also utilities should use integrated resource planning, refine their planning tools and consider PV applications an option. Regulators should require utilities to use such planning. However, it is not clear what the tools should look like or who should develop them. Also it is not known whether utilities will be willing to use different planning tools or change the ways they are used to.

Utilities should gain confidence in the value of PV and the means by which to incorporate them, this should become part of their standard planning. How utilities could gain more confidence in PV is not mentioned.
Another strategy is for utilities to support PV and get the customer interested in PV. Some methods are: green pricing, rate-based incentives, net metering or public disclosure of fuel mixes. Customer orientation already becomes more and more a topic with utilities. The literature mentioning that the lack of customer orientation causes missed opportunities does not describe in detail the possible positive results of more customer orientation nor is mentioned that customer orientation is already in progress and what the results are.

Government

The literature mentions some problems resulting from the organisation and structure of the government and past policy. Described problems are the limited political motivation and support for PV. Also the policy framework is not sufficient yet to stimulate PV reaching its full market potential. Another problem is that public policy is shaped around a fossil fuel based economy (EUREC, 1996). Also renewable energy policy is not always integrated at local governmental level.

Solutions
Solutions mentioned in the literature for these problems are for the government to make clear political decisions in favour of a clean and sustainable development. Current decision making should reflect the external societal costs and environmental costs of other energy sources and thus subsidise PV. The government could put charges on transactions in the electricity industry to create a pool of investment funds and use these investments for investments in RE capacity (Watt, 1998).

4.4 Legislation and regulation

There are several legal and regulatory problems that hinder the introduction of PV. The solution for most problems lies with the government but often other target groups experience the problems.

Energy sector

The legal or regulatory problems encountered by the energy sector often occur when the utility wants to implement PV. In some countries, like the Netherlands and the United Sates, some regulatory constraints to utility participation exist, for example because participation is considered to be a commercial activity that is not permitted (UPVG, 1994d).
Other problems occur when trying to find locations for the implementation of PV and land use planning forms a barrier, also orientation of buildings can be a problem (see chapter 5).
Utilities experience difficulties involving ownership and responsibility. They are uncertain about responsibilities and management afterwards. There are no standard contracts or prescriptions how to deal with these concerns.
Another problem concerning the utilities is the monopoly position they hold. Therefore there could be a limited access to the grid for private PV producers and a discriminatory tariff setting.

solutions
There are some potential solutions to solve the experienced difficulties concerning liability and responsibility. The government can develop local or regional energy plans and area based strategies

that integrate renewable energy projects as part of local agenda 21 (Morgan, 1996). Another solution is for the government to allow testing of various utility-customer and utility-supplier relationships.
An option to reduce the experienced liability concerns is to standardise contracts and agreements, and develop standard maintenance contracts.
A possible solution for the monopoly position is the development of a framework for grid access of renewable energy. Another option is to let different bodies be responsible for the production and distribution of electricity.

Public

PV users encounter some legal or regulatory problems when they want to buy or install a PV system. One of these problems is the need for permits for the placing of PV modules on houses. Most of the time it is not clear what permits are necessary and the process of getting the required permits is usually slow. Also PV users experience difficulties in getting application of PV systems approved by utilities or local authorities.
Another problem is that there are existing regulations that form constraints for the use of PV such as planning procedures and building codes (Eichelbronner, s.a.).
Also PV users have expressed concerns over legal and regulatory uncertainties and liability.

Solutions

An option for the permit problems is to develop a standard and simple permit application procedure with fixed terms during the process.
Options for resolving the liability problems are the introduction of standard contracts concerning the responsibilities and ownership and the development of standard maintenance contracts. Warranties for complete PV systems could be given by manufacturers or utilities could control the perceived triability of the PV product by offering warranties, guarantees, maintenance programmes and leasing options.

Government

The legal and regulatory problems mentioned in the literature concerning the government are observations of the authors that the government does not use all the opportunities they have. These observations concern the government at a national and international level.
At a national level there is a lack of appropriate legal framework and economic regulations. For instance regulation policy to promote the use of PV for newly built houses or schools should be developed. Furthermore the literature describes a lack of legal regulations for shadow hindrance from trees or new buildings (EUREC, 1996 and Wiel, 1992).
At an international level there is a lack of regulations to promote PV in the EU.

Solutions

Some solutions for the legal and regulatory problems exist. National new political initiatives on the central and regional levels should be developed to vitalise economic activities. A long term strategy of PV systems implementation with necessary changes in legal and institutional framework should be developed. However, what these changes should be and if they can be implemented is not clear.
Mandatory building applications for PV through modified national building codes, regulations for mandatory PV applications in schools and other public buildings should be issued.
International a legal and regulatory framework for renewable energy in the international energy market should be created.

While most authors only reflect on the legislation and other initiatives the government should take to influence the introduction of RE or PV, there is another option for the government to stimulate the use of RE or PV mentioned by Eiffert. She mentions in her report that the government could also set an example by purchasing RE themselves. She gives several recommendations how the government could establish this. When purchasing RE the government can show that energy choices do matter and that the creation of new domestic industries for responding to global climate challenges will lead to future economic and environmental health.

5. Architecture

Architectural problems are defined as the physical problems architects, project developers and building contractors encounter when designing and engineering PV buildings. The literature which mentions architectural problems agree on the idea that more attention should be paid to the design of these buildings. The second main problem area is standardisation.

5.1 Design

Building sector

Architects encounter several problems when designing PV buildings. One of the main problems is that PV systems do not correspond with building sizes. This causes for instance roofs to look disrupted because PV systems have to be “filled in” in regular roofs.
A second problem mentioned is that the tilt and orientation which is optimal for the performance of the solar panels is often not compatible with the buildings.
A third problem mentioned concerns the aesthetics of PV systems. One finds for instance that the aluminium profiles used are in contrast with the high-tech and expensive look of the modules. Several writers with a designers point of view think that the colours and sizes of PV panels are too limited. A British study underlines the importance of the visual appearance of material to architects. Almost half of the interviewed architects mark this as their top priority in material choice (by contrast, only 25% identified cost as the key priority) (Butson, 1998).

Solutions

There are two strategies to solve designing problems for architects. The first is early involvement of architects which will facilitate the integration of solar panels in the design of the new buildings (ICB Management Consultants, 1997). Moreover to ensure that the houses and roofs are south-oriented, the involvement of architects and city planners should start at the stage of city planning.
The second strategy concerns the development of PV building products. The study of Butson and others which focuses on this topic gives many suggestions: BIPV products in a wider range of colours, having the appearance of conventional products and with increased translucency. Better detailing to improve integration with conventional building products, reduced weight, lower reflectivity and a wider choice in shape and size. The writers recommend to improve visual appeal, either by making BIPV products more like conventional materials or to give them their own favourable image. They also recommend a better choice of designers and contractors (Butson, 1998). Many writers agree on the idea that more sizes and colours should be made available.

Public

A few writers worry about the overall acceptance of PV if the public would experience visual hinder. It seems indeed that the attitude of the general public towards the aesthetics of PV buildings is not always positive. In a housing project in the Netherlands for instance, where solar panels in the roof are

combined with traditional red tiles the people living in the neighbourhood do not like the aesthetics of the houses (Mierlo, van, 1994). Other studies show that less than half of the buyers of solar houses of several PV projects in the Netherlands think that solar cells could enhance the appearance of housing (Mierlo, van, 1995, 1996). On the other hand it has been shown that integration of solar cells into a sound barrier could stimulate a positive opinion among car drivers about the appearance of the sound barrier. Car drivers passing the sound barrier at the highway A27 in the Netherlands who notice that solar energy was applied are more positive about the aesthetics of the barrier than the car drivers who did not notice that solar energy had been applied (Uitzinger, 1997).
However, there is not much proof about the relationship of the opinion of individuals about the aesthetics of PV integrated into the built environment and their overall acceptance of PV. Farhar shows in her study among 120 households interested in buying or leasing photovoltaics that 19% of them had aesthetics concerns, other concerns being financial risks (75%) and health and safety concerns (52%) (Farhar, 1998). Whether or not aesthetic concerns might hinder an overall positive attitude towards photovoltaics or might hinder deciding to purchase photovoltaics is not known.

Solutions
The main strategy mentioned in the literature is to pay more attention to the design of housing and to integrate the solar panels in an acceptable way. This strategy has been specified nowhere. We do not know which designs-concepts will find approval or disapproval among the public.

5.2 Standards

The other main subject mentioned in the setting of architectural problems is the lack of adequate standards for the application of PV systems in buildings. Although many literature sources mention this problem, hardly any one elaborates on the subject.

PV industry
The PV industry faces a lack of standards because they have no guidelines on how to produce reliable products, how to install them and how to service them.

Building sector
Also the people designing PV houses en BIPV systems face a lack of standards. The specific problem is that the PV systems do not meet the requirements of building elements. Therefor too much engineering is involved.

Energy sector, public
A lack of standards is discouraging potential purchasers from entering the PV market according to several authors. In the first place because of the uncertainty about the quality of the PV systems and in the second place because the high costs of non-standardized PV products. Utilities must be able to use standard specifications for PV systems and interconnection standards. Testing of each system installed is too difficult.

Solutions
Seemingly, a choice has to be made between a wide variation of PV products to stimulate the acceptance by architects and the public on the one hand and the standardisation of PV products and

therewith enlarging the reliability and lowering the costs on the other hand. One possible way out of this dilemma is to stimulate both ways.

Based on the screened literature we have come to next strategies to meet the problems of standardisation.
A first step could be to come to internationally agreed quality and performance standards. National or regional standards would lock imports out or make them more expensive. The standards should focus on electrotechnical aspects such as interconnection and metering. This is being done by PV GAP (Global Accreditation Program) which aims at globally accepted standards for PV systems, testing laboratories, a reference manual and a centralised organisation (Varadi, 1997). Next to this the standards should focus on the requirements for building products, so the PV systems will fully meet the requirements of everyday construction elements.
A second step would be to accredit testing laboratories which can test both electrotechnical and architectural elements.
A third step would then be to accredit and certify components of and complete BIPV systems.

Standardising PV building products (by size of modules or configuration etc.) as has been suggested by some literature does not seem to be advisable at the moment. First of all because the development of PV building products is just on its way and many more new interesting products are to be expected. Secondly as has been stated above because architects ask for more variety. Nevertheless marketing addressing end-users could concentrate on a few selected reliable products which have proven to meet user demands.
The suggestion to standardise contracts and financing options also seems to be premature. Using creativity to develop a profusion of ways to finance the high costs of PV systems as is being done in several countries seems a much more substantial strategy in the short run.

6. Communication

About half of the writers mention communication problems. The communication barrier to the wide-spread use of photovoltaics in the built environment is defined as a lack of knowledge and experience amongst parties involved in the introduction of photovoltaics and a lack of information provided. According to the literature, many groups which play a major role in the introduction of BIPV are in need for more information. The supply of information is insufficient. Insofar mentioned the authors relate the communication problems to either the newness of photovoltaics and renewables or to the competition of photovoltaics/ renewables with existing structures, ideas, fossil fuels etcetera.

6.1 Needs for information

Many writers assume that target groups do not know enough about photovoltaics, therefor are prejudiced and in need for information. Of importance is what the target groups indeed do or do not know and what they want to know.
In many cases the groups which have communication problems and the subjects on which they lack information or experience have not been specified. To the extent that target groups are mentioned the communication problems are described hereafter.

Building sector

Several authors assume that the building industry does not easily accept innovations and therefore is reluctant to implement photovoltaics. Furthermore the building sector lacks awareness of the potentials and possibilities of PV. Also a lack of information on costs, financing schemes, designing and externalities of conventional power sources is remarked.
Three studies surveyed the opinion of the building sector itself. The studies most representative for the “general” architect show that the level of awareness of PV is considerably high. More than half out of hundred Dutch architects and project developers know solar cells as an application of renewable energy (Intomart, 1997) and 82% of British architects are aware of PV (Butson, 1998). However, the level of awareness seems to be superficial. The Britisch architects know just a small number of products and applications. They are particularly ill-informed about: the reliability and lifetime, maintanance requirements, electricity produced in relation to cost of the system and visual appearance. Nine out of ten respondents are interested in more information.
The PISA-report (Photovoltaic Information System for Architects) assesses the information needs for 55 architects in 13 European countries (EUREC, s.a.). These architects mention a lack of information and lack of design expertise next to economics as the three main impediments for the use of photovoltaics. Remarkable is that a lack of information and knowledge is not experienced in the countries with an active BIPV programme. The architects want first of all information on design aspects and overall economics, next to these on available products, aesthetics and environmental issues and least of all on risks and regulations.

Solutions
According to the literature sources the following strategies could solve the lack of knowledge among architects. First of all architects need better information on system performance, costs, outputs, maintenance, sizes, shapes, weight, durability, installation, availability etc. Appropriate design tools could help them designing PV buildings.
By paying attention to photovoltaics within the education for architects, their awareness of this technology could improve. Another potential solution mentioned implicit in the PISA-report is an active national PV programme.

Energy sector
Many authors view a lack of experience and a negative attitude towards photovoltaics among utilities. Utilities have little understanding of the economics of PV and interesting niche-markets. This is regarded as a problem because utilities could play a vital role by prompting a greater acceptance of PV among their customers.
An American group of utilities, the Utility Photovoltaic Group (UPVG) carried out comprehensive studies on the possibilities of PV for utilities. They notice an overall lack of experience and a lack of insight in customers needs among utilities. They state that utilities are sceptical about PV because they think PV needs a high level of insolation (UPVG, 1994d).
To work with PV utilities not only have to know more about the PV technology and the market for PV. When commissioning large PV projects in new housing estates, utilities are found to lack an understanding of the building sector, planning of building projects etc. (Mierlo, van, 1997).

Solutions
Ways, mentioned in the literature, to tackle the lack of knowledge among utilities are first of all to provide more information. Studies of load curves and PV production matching for instance could show excellent capacity matches. With comprehensive methodology utilities could identify cost saving opportunities to use PV. UPVG points out that information for utilities should be translated into terms that utility planners find comfortable.
The second way is for utilities to gain more experience. Special budgets would allow utilities to gain experience. Utilities should share their experience with others, for instance by setting up an utility experience data base.
One writer proposes that the government sets greenhouse gas emission targets and tradable greenhouse emission credits to deal with the critical attitude of utilities (Outhred, 1997).

Public
Some problems mentioned in the framework of communication problems specifically concern the general public, the users/ customers or people living near projects. A barrier not related to photovoltaics but of importance to building integrated PV is the assumed distrust of the public towards developers and planners (Morgan, 1996). This study also reports a lack of perceived benefits of renewable energy.
Some writers mention an overall lack of awareness and knowledge of renewable energy and photovoltaics and a critical attitude towards photovoltaics. Just a few studies elaborate on this subject. Two Dutch studies for instance show that approximately half of the general public has (spontaneously) some notion of renewable energy. Wind- and solar energy are the most well-known kinds among them. The public favours solar energy the most (Intomart, 1997, Berg, van den, 1997). To a considerable amount, however, the public does not know the difference between solar thermal energy and photovoltaics (Uitzinger, 1997).

Some other studies investigated the information needs as felt by the people themselves. Indeed, there seems to be a huge need for information.
Farhar (1998) for instance had extensive interviews with 120 households interested in buying PV in Colorado. She found that a substantial part of the potential customers spontaneously mentioned the following information wants:

- the PV product their utility would be offering (92%)
- technical information about the PV system: working, efficiency, grid connection, durability and performance (68%)
- installation, operation, warranties, maintenance, repair, recycling (67%)
- financial aspects of owning or leasing: system costs, payback rates, insurance, resale value of home, subsidy (58%)
- availability of PV product, motives of utilities in offering PV (25%)
- homeowner control over the PV system: portability, ability to add up, upgrade or customize the system (23%)
- suitability of their site (17%).

Other studies among people who bought a house with a PV system already installed have an interest in information on (by order of importance) technical, financial aspects, the yield of their system, environmental and legal aspects. Only a very small percentage is interested in information about other PV applications or other PV projects (Mierlo, van, 1995, 1996).

Solutions
The distrust of the public towards developers and planners could be approached by developing local guidelines and involving local people.
The strategies mentioned to tackle the lack of information concentrate on information and education for the public. The other strategy, to adapt the PV offerings will be treated in the chapter on marketing.
To make some order out of the abundancy of recommendations on informing and educating the public we think it would be wise to distinguish the following target groups:

- the general public
- people living in the vicinity of PV projects
- people seriously interested in buying PV
- people about to buy a new house with PV installed
- people living in PV houses or users of PV buildings

It is very important to make sure the information is well addressed. It should be appealing to the target groups and it should relate to their interests, information needs and concerns. Also, one should prevent an overload of information as one of the writers points out (Kruijsen, 1998).

Financial sector

A general observation is that because of a lack of confidence or awareness on the part of investors it is difficult to find financing for renewable energy projects. Investors lack information about technology, costs, performance and planning.
One of the studies focuses on problems within the financial sector (Hardt, 1998). Hardt observes that banks and insurance companies have a problem with the high capital costs of PV projects, commercial risks and technical risks and regard economies of scale as being impossible. These barriers, however, are based on false premises and inaccurate suppositions and a lack of specialised knowledge according to the writer.

Solutions
Hardt recommends the industry to develop a dissemination strategy towards banks and insurance companies in the immediate future: to help the institutions with identifying bankable projects, to build safeguards in the projects, to carry out a campaign and to give presentations to decision makers of the banks (Hardt, 1998).
Another strategy is to develop appropriate financial models for instance with risk sharing.

6.2 Supply of information

Building sector

The PISA-report (EUREC, s,a,) that screened the available information sources for architects mentions three problems related to the supply of information on BIPV to architects:

- it is presented in a format prepared for engineers and PV specialists and therefor inappropriate for architects
- it is not available on information carriers normally used by architects
- the routes for obtaining the information are not known; the information is spread across a wide range of sources.

Another study assessed the data sheets and product brochures provided by manufacturers of PV equipment. The writers found that product literature was particularly lacking in information on: weight, fixing possibilities, visual details, durability, certification and warranties, maintenance, repair and cleaning procedures, installation practices, costs and embodied energy data (Butson, 1998)
Someone else also notes a slow osmosis of knowledge from the PV industry to architects and building service engineers (Gregory, 1996)

Solutions
The architects consulted in the PISA-report had a strong preference for architectural case studies and also some support for design guidelines and design tools. They strongly favour architectural journals they already consult as an information source. Just a few architects are willing to visit seminars and conferences (EUREC, s.a.).
It is obvious that information should be provided in a well-suited format, fitting in with the ways architects handle building products. Important information sources are the ones they usually consult, such as architectural journals. Strategic forums for the exchange of informations are education and professional organisations.

Public

According to Morgan there is a lack on independent reliable information sources to the general public. Someone else notices an absence of educational programmes due to the broad and interdisciplinary nature of renewables (Panagakis, 1995).
Who should provide information sources is another issue. Most respondents from PV project in the Netherlands favour their utility as a source of information about PV houses. Furthermore they like specialised consultants or the occupants of PV houses as sources of information. They seem to have little confidence in the project developers, local governments and their own friends and family (Mierlo, van, 1996).

solutions
There is an agreement on the idea that more information should be provided to the general public. We think a first strategy would be to integrate information on PV for a large part into information sources

which are normally used to address groups. The general public could be addressed by the mass media. People who subscribed for a PV project could be informed on PV by the normal sales information. Owners of PV houses could get information about the yield of the PV system as part of their utility bill.
A second strategy is to provide extra information in special occasions. People living in the neighbourhood of a PV project or users of a PV building might be informed about the functioning and yield of the PV system for instance by a demonstration panel.
A third strategy is to provide ways for the public to gather extra information when they want it. This extra information has to be provided by independent sources. The respondents of the study of Farhar (1998) seem to favour a single point of contact or a national phone number. Evaluation of the experience in the Netherlands where such a phone number has just opened might point out the relevance of it. Utilities must be prepared for questions of their customers.

7. Marketing

The marketing of PV seems to be inadequate. The literature mentions three main problems: the suppliers do not know the potential market; the suppliers do not know how to reach the market; and there is a lack of adequate infrastructure for successfully marketing PV.
The Utility Photovoltaic Group (UPVG) has identified some marketing problems and possibilities for PV concerning the utilities in the United States. Their reports are the most important source for the marketing problems and solutions mentioned here.

7.1 Potential markets

The most important prerequisite for successfully marketing a product is knowing the interests, wishes and needs of the customers. Knowing this, the wanted products can be developed and a strategy can be developed to assess the right price, promotion and distribution of the product. Understanding the customers makes it possible to direct the marketing efforts to the right markets or to develop new markets for a product (Verhage, 1995).

PV industry

One of the major problems faced by the PV industry is that they do not know who their customers are, how big the market is and what kind of products are of interest. The PV industry has an inadequate understanding of the utility market and of other possible niche markets (Byrnes, 1995).
Another problem is that the PV industry tends to focus on international markets because the acceptable prices are higher. This might hinder the domestic market in so far that the public and its representatives do not see a return on its R&D investment and then further funding or further technology improvement could become insecure. Also neglecting the home market will result in not taking full advantage of the possibilities.

Solutions

The solution is to develop a marketing strategy. The basis for a successful strategy is a good insight in the consumers wishes and needs and the factors influencing the consumers decision to buy a product. Developing a marketing strategy should include the following steps:

- analysis of chances and risks for PV; what possible markets exist for what PV products
- analysis of available resources; how much can be invested in developing new products
- formulation of goals; what markets should be reached

Developing a market strategy will create insight in the possibilities for PV and the possible market for PV among utilities or other prospective customers.

The UPVG reports do mention some PV products or attributes of PV that can be of interest for the utilities. The PV industry could use this information to supply the wanted products and thereby create

a market. Also they could use the arguments mentioned in the UPVG reports to sell their products to the utilities. However, it should be kept in mind that these suggestions only apply to the United States and only to utilities. For other countries and other markets research is needed to assess the possibilities.

Energy sector

The problem for the energy sector is much the same as for the PV industry when the energy sector wants to take the role of PV supplier. Utilities have an inadequate understanding of their customers and their valuing of PV. Also the possible niche markets and what market niches are most amenable to early exploitation are hardly known to the energy sector.

Solutions

Like the PV industry the utilities should develop a market strategy and this development should at least include market research on the customers wishes and needs concerning PV. Of special interest is the market segmentation. Utilities need to know which customers are interested in PV, have the money to purchase PV and are willing to pay the price for PV. Then utilities can assess what products they should offer, against what price and with what kind of service and guarantees.
There are some niche markets identified that could be profitable such as livestock watering and remote homes.

7.2 Reaching the market

Promotion and distribution of a product is just as important as having the right product to sell. Not knowing how to reach their potential market is a problem mentioned to concern the energy sector and PV industry when trying to explore the market for PV products.

PV industry

The UPVG reports mention an apparent absence of defined business plans for most suppliers. The suppliers do not make clear what their goals are and how they are planning to reach this. This causes a lack of trust among potential customers and the energy sector that makes them hesitant to buy PV products. Also it is often unclear to prospective buyers what the product offerings are. Are PV manufacturers selling equipment, power or a service ? Therefore end users are often not clear as to what it is they would be purchasing.

Solutions

To successfully market PV products the PV industry not only needs to know what products customers (utilities and others) want and what price they are willing to pay, as discussed before, but they also need to have a successful promotion and distribution of the products. The promotion and distribution of PV products needs to take the specific aspects of the utilities or other market segments into consideration. The product attributes that appeal to the utility or other customers need to be emphasised, wanted information should be made available, the product needs to be accessible and the wanted quality, guarantees and service should be offered.

Energy sector

The energy sector does not know how to reach their potential customers for PV products. Utilities are not customer orientated and do not have insight in the factors that influence the customers decision to buy a PV product.
Another problem facing the utilities when trying to sell PV products is that customers are sceptical about the motives of utilities to offer a PV product. This makes it difficult for utilities to achieve credibility about their PV offerings (Farhar, 1998).

Solutions

The solution is much the same as for the PV industry. Utilities need to have a successful promotion and distribution of the products. The promotion and distribution of PV products needs to take the specific aspects of the customer or market into consideration. In order to be able to successfully promote and distribute the PV products the utilities need to know if potential customers want to buy these products from a utility and what attributes of the PV product appeal to the customers. What quality do they expect, what kind of guarantees are necessary and what kind of service is expected are questions that the utility needs to have answers for. Research in for example the United States and Great Britain shows that customers do want to buy energy related products, such as PV, from a utility. High quality market research is needed to support the design of successful PV products and effective delivery schemes. Farhar (Farhar, 1998) gives several motives for customers to buy PV products, such as the care for the environment, the expected social benefits, and the independence from the electricity supply. Utilities could anticipate on these motives and use them to sell their PV products.

Research has been done on strategies that might be successful in selling PV products. Some recommendations are:

- Energy efficiency rebates can be used as an incentive in the marketing strategy because customers will view the PV system like many other energy-efficiency products.
- Utilities could follow a PV friendly pricing approach. Those customers willing to pay more on their electricity bills are specifically identified and marketed to. Due to the high potential on customers roofs even small customers acceptance percentages yield large PV potential. There are several studies addressing the customers willingness to pay, see also paragraph 3.1.

Although it is mentioned in the literature that it is difficult to determine why a product offering is or is not successful, there are some recommendations given by Holt (Holt, 1996) as to what a successful programme looks like and what aspects should be taken into account. Holt describes that the success of a programme may depend on the size of the premium charged but also on many other factors such as programme design, ease of participation, customer awareness and marketing effort. Some elements that are important for the success of a programme have been suggested by Holt: quality, meaning research on customer preferences about programme or product design; incorporation of added-value features such as protection against rate increase; early adopter status or discounts; credibility of both the sponsor and the product or programme; simplicity; marketability, segmentation and targeted marketing, promotion and repeated exposure; tangibility, green electricity must be made more real, e.g. by offering projects that are specific to resource, technology and site; visibility, location of the project near the market or big projects; community, community cohesion and pride in “our” project; strategy, utilities should have a strategy how green pricing fits into their long term plans and future restructuring directions, top management support and organizational plans; synergy, utilities should develop and market a full line of green services and products to appeal to different market segments; tenacity, perseverance and long term perspective, low levels of participants in the early years are realistic for new products.

7.3 Infrastructure

The literature mentions a lack of infrastructure for adequately marketing PV. This problem can partly be solved by the solutions given earlier to develop a market strategy. However, some infrastructure aspects have not been discussed before, and they will be discussed here.

Energy sector

There is a gap between the utility marketplace and PV products because there is a lack of utility related distribution channels or third parties that can deliver services such as maintenance or installation or products and product attributes.
Another problem is that due to a lack of after sales structure the buyers turn to the utility when they experience problems or have questions. This places an extra burden on utilities (Russel, 1992).
There also is a lack of product catalogues for utilities, this makes it difficult for utilities to know what products exist and could be used.

Solutions

The after sales support structures should be strengthened. This can be part of the utilities marketing strategy but also a responsibility of other parties like PV industry or intermediaries.

Public

There is no sufficient installation or maintenance service. Also potential customers cannot objectively assess the capabilities of specific organisations or individuals who offer design, installation and service. There is a need for an infrastructure that includes the manufacture of quality products, an effective distribution and service network, financing mechanisms and a trained design, installation and service network work force (Fitzgerald, 1997).
Farhar mentions in her report that customers want a reliable product with warranties, guarantees, leasing options and standard maintenance contracts.

Solutions

Quality certification is needed to allow potential customers to assess the capability of a service organisation, etcetera. A training accreditation and certification programme for systems design, installation and maintenance should be arranged (Fitzgerald, 1997).
After sales support structures should be strengthened and current offered warranties on modules or inverters should be extended to complete PV systems.

8. Environment

The problems concerning the environmental aspects of PV described here are based upon a report of the IEA PVPS Task I. This report summarises the results of an expert workshop held to address the environmental aspects of PV systems. Participants of the workshop were experts who are working on environmental aspects of PV power systems (Nieuwlaar, 1997). There were 25 participants from Europe, the United States, Japan and Australia. The experts identified the issues of environmental importance regarding PV power systems and issues that require further attention.
According to the report there are several indirect environmental impacts related to PV power systems. The environmental issues are of concern to all parties.
Environmental issues that are described to be most relevant for PV power systems in the built environment are:

- *energy use*: the production of PV power systems is relatively energy intensive, the module production requires much energy.
- *resource depletion*: the production of PV power systems involves the use of large quantities of bulk materials and the use of substances that are scarce.
- *health and safety*: the production of PV power systems involves the use of toxic substances and PV modules contain potentially hazardous materials such as cadmium, lead, selenium and silver. During operation, damaged modules or a fire may lead to the release of hazardous substances which could cause health and safety risks for workers and the public.
- *waste*: at the end of their useful life time PV power systems have to be decommissioned, resulting in waste flows that will have to be managed. Also the PV power systems can cause emissions at the end of their lifetime.

Solutions
BIPV will reduce the amount of materials used because less material is needed (no constructions to hold up the modules) and materials that would have been used otherwise are replaced by the PV system. It is mentioned in the IEA report that when the module production becomes more energy-efficient the Balance of System components will have a more important contribution to the energy use and grid connected BIPV will have a significant advantage.

Recycling is mentioned to be an option to reduce both the use of materials and energy. Several new methodologies to recycle PV power systems are described in the literature, it is also mentioned that enhanced clarity is needed regarding costs, energy consumption and environmental aspects of these processes (Nieuwlaar, 1997). Mentioned processes are:

- development of methodologies to recycle both newer, thin-film PV technologies and conventional crystalline silicon PV (Bohland, 1998).
- a new recycling technology with recovery of the silicon wafer in a fluidized bed reactor (Frisson, 1998).
- crystalline silicon wafers can be recovered out of the laminates without any degradation using a well-controlled selectively burnout process of the polymers in the module (Wambach, 1998).

If recycling is going to be successful manufacturers have to comply with disposal restrictions.

Other options mentioned in the literature to reduce the environmental impact of PV are:
- Further research and demonstration towards safer materials and safer alternatives.
- Further progress in using less material more efficiently.

The literature mentions that the potential for energy efficiency improvements is large, the energy payback times of PV power systems depends on several factors including cell technology, PV system application and irradiation (Nieuwlaar, 1997). All these factors can be made more efficient.

9. Conclusions and recommendations

Literature was studied on non-technical problems to a widespread application of PV in the built environment and on strategies to overcome these. Hundred and seven literature sources were screened to make a listing of all problems for the introduction of BIPV, PV and renewable energy in general. There is not much literature that focuses on building integrated PV and is based on solid foundations. Moreover, the way the problems are addressed is fragmented in most cases. Sometimes the problems are described in terms which are too general, sometimes in terms that are too specific. Most sources lack a detailed analytical framework in which the problems and their interdependency can be analysed. The best and most relevant studies were used for describing and analysing the problems and potential solutions.

When applying PV to buildings many parties are interdependent: the PV industry, the building sector, the energy sector, the consumers etcetera. Problems mentioned in the literature are often related to one or more parties who are involved in the introduction of building integrated PV. In this study six target groups have been distinguished:

1. PV industry
2. building sector
3. energy sector
4. public
5. government
6. financial sector

Many writers focus on problems within the energy sector. However, little attention is paid to the public and even less to the local government. The view on the role of national governments is limited, they just have to provide the right conditions. Their own partial interests are not taken into account. Entirely lacking are potential consumers other than private persons and utilities, such as small and medium sized enterprises, industries and non-profit organisations.

The problems are divided into six categories.

1. Financing. The main financing problems are high prices, small markets and a lack of investments. These problems are highly interdependent.
2. Administration. The administrative problems concern mostly the financial and legal instruments of the energy sector and the national government and the organisation of the energy sector. Policies to stimulate the introduction of PV are lacking and existing policies might hinder the introduction of PV. The liberalisation of the energy market might have advantages, but could have disadvantages as well.
3. Architecture. Architectural problems are defined as the physical problems architects, project developers and building contractors encounter when designing and engineering PV buildings. These problems concern the design of PV buildings and a lack of standards for BIPV products.
4. Communication. The communication barriers to the wide-spread use of photovoltaics in the built environment are defined as a lack of knowledge and experience amongst parties involved in the introduction of photovoltaics and a lack of information provided.

5. Marketing. Marketing problems relate to problems the PV industry and the energy sector. They lack knowledge about the BIPV markets and how to reach them.
6. Environment. Environmental problems are all problems concerning the quality of the environment.

In the table in the summary of this report the main problems and potential solutions are summarised by target group.

9.1 Recommendations

Since PV systems for the built environment comprise many different products, are relatively new products and are just hitting the market, many subjects are worthwhile investigating further. Also the many areas of problems mentioned in this study call for much further research. Here we will concentrate on the most important blanks in our knowledge of barriers and strategies to a widespread introduction of PV in the built environment. Therewith we focus on research among target groups, after addressing two other research areas.

Policy evaluation

- Evaluating policies for expanding the markets of PV and BIPV: effects of different financial instruments, successes of combining financial and communication instruments. Also attention should be paid to the moment stimulating policies could be ended.

Quantifying externalities and added value

- Investigating how to take externalities into account: how to quantify them and how to finance the difference with usual pricing.
- Investigating how to evaluate financially the value and ‘added value’ of BIPV for the different potential groups of customers.

PV industry

- Researching PV industry’s willingness to invest in market studies and product development.
- Investigating expected technical developments that could change or create new markets.
- Checking knowledge on requirements of building elements and the consequences for BIPV systems.
- Assessing the attitude towards certification and standardisation and willingness to pay for it.
- Assessing the attitude towards and possibilities for recycling, waste problems and using other materials.

Building sector

- Investigating desirable product developments for several applications of PV in the built environment.
- Researching the preconditions for project developers’ willingness to invest.

Energy sector

- Measuring acceptance of PV, policy on PV and influence of liberalisation to find out why some utilities are ahead or lagging behind in the field of the introduction of PV and to judge their future role when the market expands.
- Finding out whether utilities would be willing and able to implement planning and cost calculation methods which value PV more.

- Conducting market research to assess utilities' interests and demands.

Public

- Studying the knowledge on PV and needs for information of the public and specific groups in order to address information campaigns well.
- Studying prerequisites for the willingness to pay for BIPV in order to support the design of successful PV products and effective delivery schemes.
- Investigating the effects of PV on overall energy consumption in order to prevent an increasing consumption and the ways to manage and change the direct use of PV electricity in order to enhance the value of PV for load management.
- Researching the opinion on aesthetics of BIPV and the relation with overall acceptance of PV.

Government

- Investigating the possibilities and constraints to change national and international policies as has been recommended in the chapters above.
- Studying the acceptance of PV and the knowledge of PV of local authorities. Also their willingness to create preconditions and to remove regulations which hinder the application or an optimal yield of PV systems in their municipality.

Financial sector

Doing research among financial institutions about PV does not seem valuable because of their little experience with PV. For the PV industry and the energy sector it could be worthwhile however to find out how financial institutions usually open up for new techniques comparable to PV and on what conditions they are willing to invest or insure.

Other potential consumers of PV

- Assessing the market among small and medium sized enterprises, industries and non-profit organisations, by studying their interests and needs.

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